- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 with W_{DAI}^{UL}=1 or 2, o_j^{ACK} is determined as if PUCCH format 3 is configured for transmission of HARQ-ACK, except that spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for all serving cells configured with a downlink transmission mode that supports up to two transport blocks in case W_{DAI}^{UL}=2.

- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 with W_{DAI}^{UL}=3 or 4, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the value of M is replaced by W_{DAI}^{UL}. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission not adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 and a subframe n with M=1 or 2, o_j^{ACK} = HARQ-ACK(j), $0 \le j \le A-1$ as defined in subclause 10.1.3.2.1. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$.

- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission not adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 and a subframe n with M=3 or 4, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$.

For TDD HARQ-ACK bundling, when the UE is configured by transmission mode 3, 4, 8, 9 or 10 defined in subclause 7.1 and HARQ-ACK bits are transmitted on PUSCH, the UE shall always generate 2 HARQ-ACK bits assuming both codeword 0 and 1 are enabled. For the case that the UE detects only the PDSCH transmission associated with codeword 0 within the bundled subframes, the UE shall generate NACK for codeword 1.

Table 7.3-X: Value of Downlink Assignment Index

DAI MSB, LSB	V_{DAI}^{UL} or V_{DAI}^{DL}	Number of subframes with PDSCH transmission and with PDCCH/EPDCCH indicating DL SPS release
0,0	1	1 or 5 or 9
0,1	2	2 or 6 or 10
1,0	3	3 or 7
1,1	4	0 or 4 or 8

Table 7.3-Y: Uplink association index *k*' for TDD

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
1			6	4				6	4	
2			4					4		
3			4	4	4					
4			4	4						
5			4							
6			7	7	5			7	7	

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Table 7.3-Z: Value of W_{DAI}^{UL} determined by the DAI field in DCI format 0/4

DAI MSB, LSB	W_{DAI}^{UL}
0,0	1
0,1	2
1,0	3
1,1	4

For TDD HARQ-ACK multiplexing and a subframe n with $M > 1$, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed by a logical AND operation of all the corresponding individual HARQ-ACKs. In case the UE is transmitting on PUSCH, the UE shall determine the number of HARQ-ACK feedback bits O^{ACK} and the HARQ-ACK feedback bits o_n^{ACK}, $n = 0,\ldots,O^{ACK}-1$ to be transmitted in subframe n.

- If the PUSCH transmission is adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 intended for the UE, then $O^{ACK} = V_{DAI}^{UL}$ unless $V_{DAI}^{UL} = 4$ and $U_{DAI} + N_{SPS} = 0$ in which case the UE shall not transmit HARQ-ACK. The spatially bundled HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH or for a PDCCH/EPDCCH indicating downlink SPS release in subframe $n-k$ is associated with $o_{DAI(k)-1}^{ACK}$ where *DAI(k)* is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n-k$. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH is mapped to $o_{O^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK.
- If the PUSCH transmission is not adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 intended for the UE, $O^{ACK} = M$, and o_i^{ACK} is associated with the spatially bundled HARQ-ACK for downlink or special subframe $n-k_i$, where $k_i \in K$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK. The UE shall not transmit HARQ-ACK if $U_{DAI} + N_{SPS} = 0$.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 0*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe, first in increasing order of serving cell index and then in increasing order of subframe index within subframe(s) $n-k$ where $k \in K$; the value of the total DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the total number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH(s) or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present subframe within subframe(s) $n-k$ where $k \in K$, and shall be updated from subframe to subframe. Denote $V_{C-DAI,c,k}^{DL}$ as the value of the counter DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe $n-k$ where $k \in K$ according to table 7.3.2.1-1. Denote $V_{T-DAI,k}^{DL}$ as the value of the total DAI in subframe $n-k$ where $k \in K$, according to Table 7.3.2.1-1. The UE shall assume a same value of total DAI in all PDCCH/EPDCCH scheduling PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release in a subframe.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 0* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe n, the UE shall determine the $o_0^{ACK}, o_1^{ACK},\ldots,o_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

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Set $m = 0$ – subframe index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in K$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes within subframe(s) $n-k$ where $k \in K$

while $m < M$

while $c < N_{cells}^{DL}$

if there is a PDSCH on serving cell c in subframe m associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell c in subframe m,

if $V_{C-DAI,c,m}^{DL} \le V_{temp}$

$j = j+1$

end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

$V_{temp2} = V_{T-DAI,m}^{DL}$

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$o_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$o_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$$V_s = V_s \cup \left\{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right), 8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1\right\}$$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$o_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$$

else

$o_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$$

end if

$c = c + 1$

end while

$m = m + 1$

end while

if $V_{temp2} < V_{temp}$

$j = j+1$

end if

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$$O^{ACK} = 2 \cdot \left(4 \cdot j + V_{temp2}\right)$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

$$o_i^{ACK} = NACK \quad \text{for any} \quad i \in \left\{0,1,\ldots,O^{ACK}-1\right\} \setminus V_s$$

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = 0*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ according to the above procedure as if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCCH format 5, except that the higher layer parameter *spatialBundlingPUCCH* is replaced by *spatialBundlingPUSCH*.

Table 7.3.2.1-1: Value of counter DAI and total DAI

DAI MSB, LSB	$V_{C-DAI,c,k}^{DL}$ or $V_{T-DAI,k}^{DL}$	Number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH indicating downlink SPS release is present, denoted as Y and $Y \geq 1$
0,0	1	$\mathrm{mod}(Y-1,4)+1=1$
0,1	2	$\mathrm{mod}(Y-1,4)+1=2$
1,0	3	$\mathrm{mod}(Y-1,4)+1=3$
1,1	4	$\mathrm{mod}(Y-1,4)+1=4$

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 1* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe n, the UE shall determine the $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $m = 0$ – subframe index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in K$

Set $j = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes within subframe(s) $n-k$ where $k \in K$

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while $m < M$

while $c < N_{cells}^{DL}$

if there is a PDSCH on serving cell c in subframe m associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell c in subframe m,

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and if service cell c is configured with a transmission mode supporting two transport blocks,

o_j^{ACK} = HARQ-ACK bit corresponding to the first codeword of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

o_j^{ACK} = HARQ-ACK bit corresponding to the second codeword of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and if service cell c configured with a transmission mode supporting two transport blocks,

o_j^{ACK} = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

else

o_j^{ACK} = HARQ-ACK bit of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

end if

end if

$c = c + 1$

end while

$m = m + 1$

end while

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE*,

$O^{ACK} = \left(2 \cdot N_{cells}^{DL,2} + N_{cells}^{DL,1}\right) \cdot M$ where $N_{cells}^{DL,2}$ is the number of configured with serving cells with transmission mode(s) supporting two transport blocks for the UE, and $N_{cells}^{DL,1}$ is the number of configured with serving cells with transmission mode(s) supporting two transport blocks for the UE

else

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$$O^{ACK} = N_{cells}^{DL} \cdot M$$

end if

$$o_i^{ACK} = \text{NACK} \quad \text{for any} \quad i \in \{0,1,\ldots,O^{ACK}-1\} \setminus V_s$$

For TDD when a PUCCH format 3 or a PUCCH format 4/5 transmission of HARQ-ACK coincides with a sub-frame configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in subclause 5.2.3.1 in [4], unless the HARQ-ACK corresponds to one of the following cases

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, or
- a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in the subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1',

in which case the UE shall transmit the HARQ-ACK and scheduling request according to the procedure for PUCCH format 1b with channel selection in TDD.

For TDD when the UE is configured with HARQ-ACK bundling, HARQ-ACK multiplexing or PUCCH format 1b with channel selection, and when both HARQ-ACK and SR are transmitted in the same sub-frame, a UE shall transmit the bundled HARQ-ACK or the multiple HARQ-ACK responses (according to subclause 10.1) on its assigned HARQ-ACK PUCCH resources for a negative SR transmission. For a positive SR, the UE shall transmit $b(0),b(1)$ on its assigned SR PUCCH resource using PUCCH format 1b according to subclause 5.4.1 in [3]. The value of $b(0),b(1)$ are generated according to Table 7.3-1 from the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses including ACK in response to PDCCH/EPDCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for all serving cells N_{cells}^{DL}. For TDD UL/DL configurations 1-6, if $\sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c} > 0$ and $V_{DAI,c}^{DL} \neq (U_{DAI,c}-1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

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Table 7.3-1: Mapping between multiple HARQ-ACK responses and $b(0),b(1)$

Number of ACK among multiple ($N_{SPS}+\sum_{c=0}^{N_{cells}^{DL}-1}U_{DAI,c}$) HARQ-ACK responses	$b(0),b(1)$
0 or None (UE detect at least one DL assignment is missed)	0, 0
1	1, 1
2	1, 0
3	0, 1
4	1, 1
5	1, 0
6	0, 1
7	1, 1
8	1, 0
9	0, 1

For TDD if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with HARQ-ACK bundling, HARQ-ACK multiplexing or PUCCH format 1b with channel selection, and if the UE receives PDSCH and/or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell within subframe(s) $n-k$, where $k\in K$, a UE shall transmit the CSI and $b(0),b(1)$ using PUCCH format 2b for normal CP or PUCCH format 2 for extended CP, according to subclause 5.2.3.4 in [4] with a_0'',a_1'' replaced by $b(0),b(1)$. The value of $b(0),b(1)$ are generated according to Table 7.3-1 from the $N_{SPS}+\sum_{c=0}^{N_{cells}^{DL}-1}U_{DAI,c}$ HARQ-ACK responses including ACK in response to PDCCH/EPDCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for all serving cells N_{cells}^{DL}. For TDD UL/DL configurations 1-6, if $\sum_{c=0}^{N_{cells}^{DL}-1}U_{DAI,c}>0$ and $V_{DAI,c}^{DL}\neq\left(U_{DAI,c}-1\right)\bmod 4+1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

For TDD if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection and receives at least one PDSCH on the secondary cell within subframe(s) $n-k$, where $k\in K$, the UE shall drop the CSI and transmit HARQ-ACK according to subclause 10.1.3.

For TDD and a UE is configured with PUCCH format 3,

if the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives,

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m\in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m\in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k\in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k\in K$,

then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to subclause 5.2.3.4 in [4]; else if

- the parameter *simultaneousAckNackAndCQI-Format3-r11* is set *TRUE* and if PUCCH format 3 resource is determined according to subclause 10.1.3.1 or subclause 10.1.3.2.2 and
  - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22, or

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- if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

then the UE shall transmit the HARQ-ACKs, SR (if any) and the CSI using the determined PUCCH format 3 resource according to [4];

else,

- the UE shall drop the CSI and transmit the HARQ-ACK according to subclause 10.1.3.

For TDD and a UE configured with PUCCH format 4 or PUCCH format 5, if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe,

- if a PUCCH format 3 is determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.3 or 10.1.3.2.4, the UE shall use the determined PUCCH format 3 for transmission of the HARQ-ACK/SR and periodic CSI report(s);
- if a PUCCH format 4 is determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.3 or a PUCCH format 5 is determined to transmit the HARQ-ACK/SR according to 10.1.3.2.4, the UE shall used the determined PUCCH format 4 or PUCCH format 5 for transmission of the HARQ-ACK/SR and periodic CSI;
- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.3 and there is no PUCCH format 5 determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.4 and there are more than one periodic CSI report in the subframe,
  - if the UE is configured with a single PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, the PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
  - if the UE is configured with a PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ according to higher layer parameter *format5-MultiCSI-resourceConfiguration*, the PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
  - if the UE is configured with two PUCCH format 4 resources $n_{\text{PUCCH},1}^{(4)}$ and $n_{\text{PUCCH},2}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right)\le \min\left(M_{\text{RB},1}^{\text{PUCCH4}}, M_{\text{RB},2}^{\text{PUCCH4}}\right)\cdot N_{sc}^{RB}\cdot N_{\text{symb}}^{\text{PUCCH4}}\cdot r$, the PUCCH format 4 resource with the smaller $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH},1}^{(4)}$ and $n_{\text{PUCCH},2}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s); otherwise, the PUCCH format 4 resource with the larger $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH},1}^{(4)}$ and $n_{\text{PUCCH},2}^{(4)}$ is used for transmission of the HARQ-ACK/SR periodic CSI report(s), where
    - O^{ACK} is the total number of HARQ-ACK bits in the subframe;
    - $O^{SR}=0$ if there no scheduling request bit in the subframe and $O^{SR}=1$ otherwise
    - $O_{\text{P-CSI}}$ is the total number of CSI report bits in the subframe;
    - $M_{\text{RB},i}^{\text{PUCCH4}}$, $i=1,2$, is the number of PRBs for $n_{\text{PUCCH},1}^{(4)}$ and $n_{\text{PUCCH},2}^{(4)}$ respectively, according to higher layer parameter *numberOfPRB-format4-r13* according to Table 10.1.1-2;
    - $N_{\text{symb}}^{\text{PUCCH4}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)-1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)$ otherwise; and
    - r is the code rate given by higher layer parameter *maximumPayloadCoderate-r13* according to Table 10.1.1-1.

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- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.3 and there is no PUCCH format 5 determined to transmit the HARQ-ACK/SR according to subclause 10.1.3.2.4 and there are only one periodic CSI report in the subframe,
  - if the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives,
    - a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$, and the counter DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and the counter DAI value in the PDCCH/EPDCCH is equal to '1', or
    - a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$,

    then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to subclause 5.2.3.4 in [4];
  - else,

    the UE shall drop the CSI and transmit the HARQ-ACK according to subclause 10.1.3.2.3 or 10.1.3.2.4.
- If a UE transmits HARQ-ACK/SR and periodic CSI report(s) using either a PUCCH format 4 $n^{(4)}_{\text{PUCCH}}$ or PUCCH format 5 $n^{(5)}_{\text{PUCCH}}$ in a subframe
  - if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right) \le N_{\text{RE}} \cdot r$, the UE shall transmit the HARQ-ACK/SR and periodic CSI bits using the PUCCH format 4 $n^{(4)}_{\text{PUCCH}}$ or the PUCCH format 5 $n^{(5)}_{\text{PUCCH}}$;
  - if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right) > N_{\text{RE}} \cdot r$, the UE shall select $N_{\text{CSI,reported}}$ CSI report(s) for transmission together with HARQ-ACK/SR in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$, where $\text{Pri}_{CSI}(y,s,c,t)$, N_{RE} and r are determined according to subclause 7.2.2; the value of $N_{\text{CSI,reported}}$ satisfies $\left(O^{ACK}+O^{SR}+\sum_{n=1}^{N_{\text{CSI,reported}}} O_{P-CSI,n}\right) \le N_{\text{RE}} \cdot r$ and $\left(O^{ACK}+O^{SR}+\sum_{n=1}^{N_{\text{CSI,reported}}+1} O_{P-CSI,n}\right) > N_{\text{RE}} \cdot r$, and $O_{P-CSI,n}$ is the number of CSI report bits for the nth CSI report in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$.

7.3.2.2 TDD HARQ-ACK reporting procedure for different UL/DL configurations

For a configured serving cell, the DL-reference UL/DL configuration as defined in subclause 10.2 is referred to as the "DL-reference UL/DL configuration" in the rest of this subclause.

For a configured serving cell, if a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = 0* and if the DL-reference UL/DL configuration is 0, then the DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D is not used.

The UE shall upon detection of a PDSCH transmission or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$ for serving cell c, where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n, wherein set K_c contains values of $k \in K$ such that subframe n-k corresponds to a downlink subframe or a special subframe for serving cell c, where DL subframe or special subframe of serving cell c is according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* if the UE is configured with the higher layer parameter *EIMTA-*

MainConfigServCell-r12 for serving cell c; K defined in Table 10.1.3.1-1 (where "UL/DL configuration" in Table 10.1.3.1-1 refers to the DL-reference UL/DL configuration) is associated with subframe n. M_c is the number of elements in set K_c associated with subframe n for serving cell c.

For the remainder of this subclause $K = K_c$.

If the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for the primary cell, "UL/DL configuration of the primary cell" in the rest of this subclause refers to "DL-reference UL/DL configuration of the primary cell".

When PUCCH format 3/4/5 is configured for transmission of HARQ-ACK, for special subframe configurations 0 and 5 with normal downlink CP or configurations 0 and 4 with extended downlink CP in a serving cell, shown in table 4.2-1 [3], the special subframe of the serving cell is excluded from the HARQ-ACK codebook size determination. In this case, if the serving cell is the primary cell, there is no PDCCH/EPDCCH indicating downlink SPS release in the special subframe.

If the UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1,2,3,4,5,6} for a serving cell, a value W_{DAI}^{UL} is determined by the Downlink Assignment Index (DAI) in DCI format 0/4 corresponding to a PUSCH on the serving cell according to Table 7.3-Z in subframe $n-k'$, where k' is defined in Table 7.3-Y and the "TDD UL/DL Configuration" in Table 7.3-Y refers to the UL-reference UL/DL configuration (defined in subclause 8.0) for the serving cell. In case neither PDSCH transmission, nor PDCCH/EPDCCH indicating the downlink SPS resource release is intended to the UE, the UE can expect that the value of W_{DAI}^{UL} is set to 4 by the DAI in DCI format 0/4 if transmitted.

If a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = 0* and if the DL-reference UL/DL configuration belongs to {1,2,3,4,5,6}, the value of the DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of PDCCH/EPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release up to the present subframe within subframe(s) $n-k$ of each configured serving cell, where $k \in K$, and shall be updated from subframe to subframe. Denote $V_{DAI,c}^{DL}$ as the value of the DAI in PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D detected by the UE according to Table 7.3-X in subframe $n-k_m$ in serving cell c, where k_m is the smallest value in the set K such that the UE detects a DCI format 1/1A/1B/1D/2/2A/2B/2C/2D.

For all TDD UL/DL configurations, denote $U_{DAI,c}$ as the total number of PDCCH/EPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release detected by the UE within the subframe(s) $n-k$ in serving cell c, where $k \in K$. Denote N_{SPS}, which can be zero or one, as the number of PDSCH transmissions without a corresponding PDCCH/EPDCCH within the subframe(s) $n-k$, where $k \in K$.

If PUCCH format 3 is configured for transmission of HARQ-ACK without PUCCH format 4/5 configured for transmission of HARQ-ACK, the HARQ-ACK feedback bits $o_{c,0}^{ACK}\ o_{c,1}^{ACK},\ldots,o_{c,O_c^{ACK}-1}^{ACK}$ for the c-th serving cell configured by RRC are constructed as follows, where $c \geq 0$, $O_c^{ACK} = B_c^{DL}$ if transmission mode configured in the c-th serving cell supports one transport block or spatial HARQ-ACK bundling is applied and $O_c^{ACK} = 2B_c^{DL}$ otherwise, where B_c^{DL} is the number of downlink and special subframes for which the UE needs to feedback HARQ-ACK bits for the c-th serving cell.

- For the case that the UE is transmitting in subframe n on PUCCH or a PUSCH transmission not adjusted based on a detected DCI format 0/4 or a PUSCH transmission adjusted based on an associated detected DCI format 0/4 with UL-reference UL/DL configuration 0 (defined in Sec 8.0), then $B_c^{DL} = M_c$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$, where $k \in K$.
- If DL-reference UL/DL configuration of each of the configured serving cells belongs to {0, 1, 2, 3, 4, 6} and for a PUSCH transmission in a subframe n adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min\left(W_{DAI}^{UL}, M_c\right)$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive

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PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

- If DL-reference UL/DL configuration of at least one configured serving cell belongs to {5} and for a PUSCH transmission adjusted based on an associated detected PDCCH/EPDCCH with DCI format 0/4 using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min\left(W_{DAI}^{UL} + 4\left\lceil \left(U - W_{DAI}^{UL}\right)/4 \right\rceil, M_c\right)$, where U denotes the maximum value of U_c among all the configured serving cells, U_c is the total number of received PDSCHs and PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ for the c-th serving cell, $k \in K$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

When PUCCH format 3 is configured for transmission of HARQ-ACK without PUCCH format 4/5 configured for transmission of HARQ-ACK,

- if DL-reference UL/DL configuration belongs to {1,2,3,4,5,6}, the HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH or for a PDCCH/EPDCCH indicating downlink SPS release in subframe $n-k$ is associated with $o_{c,DAI(k)-1}^{ACK}$ if transmission mode configured in the c-th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ otherwise, where $DAI(k)$ is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n-k$, $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$ The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK;
- if DL-reference UL/DL configuration is 0, the HARQ-ACK for a PDSCH transmission or for a PDCCH/EPDCCH indicating downlink SPS release in subframe $n-k$ is associated with $o_{c,0}^{ACK}$ if transmission mode configured in the c-th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ otherwise, where $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK.

If DL-reference UL/DL configuration of each of the serving cells belongs to {0,1,2,3,4,6} and if PUCCH format 1b with channel selection is configured for transmission of HARQ-ACK and for two configured serving cells, the HARQ-ACK feedback bits $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ on PUSCH are constructed as follows

- if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 with W_{DAI}^{UL}=1 or 2, o_j^{ACK} is determined as if PUCCH format 3 is configured for transmission of HARQ-ACK, except that spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for all serving cells configured with a downlink transmission mode that supports up to two transport blocks in case W_{DAI}^{UL}=2, where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission.
- if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4 with W_{DAI}^{UL}=3 or 4, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the value of M is replaced by W_{DAI}^{UL} where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE

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does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

- if UL-reference UL/DL configuration (defined in Sec 8.0) is 0, or if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission not adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4, for a subframe n with M =1 or 2 (M defined in Sec 10.1.3.2.1), o_j^{ACK} = HARQ-ACK(j), $0 \le j \le A-1$ as defined in subclause 10.1.3.2.1, where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$.

- if UL-reference UL/DL configuration (defined in Sec 8.0) is 0, or if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6} and, for a PUSCH transmission not adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4, for a subframe n with M =3 or 4 (M defined in Sec 10.1.3.2.1), $o_j^{ACK} = o(j)$, $0 \le j \le 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n-k$ where $k \in K$.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 0*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe, first in increasing order of serving cell index and then in increasing order of subframe index within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$ and C is the set of configured serving cells; the value of the total DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the total number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH(s) or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present subframe within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$ and C is the set of configured serving cells, and shall be updated from subframe to subframe. Denote $V_{C-DAI,c,k}^{DL}$ as the value of the counter DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe $n-k$ where $k \in \bigcup_{i \in C} K_i$ according to table 7.3.2.1-1. Denote $V_{T-DAI,k}^{DL}$ as the value of the total DAI in subframe $n-k$ where $k \in \bigcup_{i \in C} K_i$, according to Table 7.3.2.1-1. The UE shall assume a same value of total DAI in all PDCCH/EPDCCH scheduling PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release in a subframe. For a serving cell c and a value $k \in \bigcup_{i \in C} K_i$ but $k \notin K_c$, the {serving cell, subframe}-pair $\{c, n-k\}$ is excluded when determining the values of counter DAI and total DAI for HARQ-ACK transmission in subframe n.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 0* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe n, the UE shall determine the $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $m = 0$ – subframe index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

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Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$

while $m < M$

while $c < N_{cells}^{DL}$

if there is a PDSCH on serving cell c in subframe m associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell c in subframe m, and if subframe m belongs to the set of subframe(s) $n-k$ where $k \in K_c$,

if $V_{C-DAI,c,m}^{DL} \le V_{temp}$

$j = j + 1$

end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

$V_{temp2} = V_{T-DAI,m}^{DL}$

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$o_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$o_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$$V_s = V_s \cup \left\{8j + 2\left(V_{C-DAI,c,m}^{DL} - 1\right), 8j + 2\left(V_{C-DAI,c,m}^{DL} - 1\right) + 1\right\}$$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$o_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$$V_s = V_s \cup \left\{4j + V_{C-DAI,c,m}^{DL} - 1\right\}$$

else

$o_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$$V_s = V_s \cup \left\{4j + V_{C-DAI,c,m}^{DL} - 1\right\}$$

end if

end if

$c = c + 1$

end while

$m = m + 1$

end while

if $V_{temp2} < V_{temp}$

$j = j+1$

end if

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$$O^{ACK} = 2 \cdot \left(4 \cdot j + V_{temp2}\right)$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

end if

$$o_i^{ACK} = \text{NACK} \quad \text{for any} \quad i \in \left\{0,1,\ldots,O^{ACK}-1\right\} \setminus V_s$$

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = 0*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ according to the above procedure as if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCCH format 5, except that the higher layer parameter *spatialBundlingPUCCH* is replaced by *spatialBundlingPUSCH*.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 1* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe n, the UE shall determine the $o_0^{ACK}, o_1^{ACK}, \ldots, o_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $m = 0$ – subframe index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$

Set $j = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$

while $m < M$

while $c <$ N_{cells}^{DL}

if there is a PDSCH on serving cell c in subframe m associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell c in subframe m, and if subframe m belongs to the set of subframe(s) $n-k$ where $k \in K_c$,

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if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and if serving cell c is configured with a transmission mode supporting two transport blocks,

o_j^{ACK} = HARQ-ACK bit corresponding to the first codeword of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

o_j^{ACK} = HARQ-ACK bit corresponding to the second codeword of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and if serving cell c is configured with a transmission mode supporting two transport blocks,

o_j^{ACK} = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

else

o_j^{ACK} = HARQ-ACK bit of this cell

$V_s = V_s \cup \{j\}$

$j = j + 1$

end if

end if

$c = c + 1$

end while

$m = m + 1$

end while

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE*,

$O^{ACK} = \sum_{c \in C^1} M_c + 2 \cdot \sum_{c \in C^2} M_c$ where C^1 is the set of configured serving cells for the UE with transmission mode(s) supporting two transport blocks and C^2 is the set of configured serving cells for the UE with transmission mode(s) supporting one transport block

else

$O^{ACK} = N_{cells}^{DL} \cdot \sum_{c \in C} M_c$

end if

$o_i^{ACK} = \text{NACK}$ for any $i \in \{0,1,\ldots,O^{ACK}-1\} \setminus V_s$

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When a PUCCH format 3/4/5 transmission of HARQ-ACK coincides with a sub-frame configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in subclause 5.2.3.1 in [4], unless the HARQ-ACK corresponds to one of the following cases

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6}, the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, or
- a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in the subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1',

in which case the UE shall transmit the HARQ-ACK and scheduling request according to the procedure for PUCCH format 1b with channel selection in TDD.

If the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection, and if the UE receives PDSCH and/or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell within subframe(s) $n-k$, where $k \in K$, a UE shall transmit the CSI and $b(0),b(1)$ using PUCCH format 2b for normal CP or PUCCH format 2 for extended CP, according to subclause 5.2.3.4 in [4] with a_0'', a_1'' replaced by $b(0),b(1)$. The value of $b(0),b(1)$ are generated according to Table 7.3-1 from the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses including ACK in response to PDCCH/EPDCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for all serving cells N_{cells}^{DL}. If DL-reference UL/DL configuration belongs to {1,2,3,4,5,6} and, if $\sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c} > 0$ and $V_{DAI,c}^{DL} \neq (U_{DAI,c}-1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

If the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection and receives at least one PDSCH on the secondary cell within subframe(s) $n-k$, where $k \in K$, the UE shall drop the CSI and transmit HARQ-ACK according to subclause 10.1.3.

When both HARQ-ACK and CSI are configured to be transmitted in the same sub-frame and if a UE is configured with PUCCH format 3 and not configured with PUCCH format 4/5,

if the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH is equal to '1', or

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- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$,

then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to subclause 5.2.3.4 in [4];

else if

- the parameter *simultaneousAckNackAndCQI-Format3-r11* is set *TRUE* and if PUCCH format 3 resource is determined according to subclause 10.1.3.1 or subclause 10.1.3.2.2 and
  - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22, or
  - if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

then the UE shall transmit the HARQ-ACKs, SR (if any) and the CSI using the determined PUCCH format 3 resource according to [4];

else,

- the UE shall drop the CSI and transmit the HARQ-ACK according to subclause 10.1.3.

For TDD and a UE configured with PUCCH format 4 or PUCCH format 5, if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe, the UE HARQ-ACK/SR and periodic CSI reporting procedure follow the procedure described in subclause 7.3.2.1 with the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*.

7.3.3 FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 1

For FDD-TDD and the primary cell is frame structure type 1, with PUCCH format 1b with channel selection,

- for a negative SR transmission,
  - UE shall transmit the HARQ-ACK on its assigned HARQ-ACK PUCCH resource with channel selection as defined in subclause 10.1.2A.
- for a positive SR transmission,
  - if one transport block or two transport blocks or a PDCCH/EPDCCH indicating downlink SPS release is detected on the primary cell in subframe i, and if subframe i is an uplink or a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP for the secondary cell according to the higher layer parameter subframeAssignment for UE not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* and according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* for UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*,
    - UE shall transmit the HARQ-ACK and SR as for FDD with PUCCH format 1a/1b as described in subclause 7.3.1.
  - otherwise
    - UE shall transmit the HARQ-ACK and SR as for FDD with PUCCH format 1b with channel selection as described in subclause 7.3.1.

For FDD-TDD and the primary cell is frame structure type 1, when PUCCH format 3/4/5 is configured for transmission of HARQ-ACK, for special subframe configurations 0 and 5 with normal downlink CP or configurations 0 and 4 with extended downlink CP in a serving cell, shown in table 4.2-1 [3], the special subframe of the serving cell is excluded from the HARQ-ACK codebook size determination.

For FDD-TDD and the primary cell is frame structure type 1, when a PUCCH format 3/4/5 transmission of HARQ-ACK coincides with a sub-frame configured to the UE by higher layers for transmission of a scheduling request, the UE

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shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in subclause 5.2.3.1 in [4], unless the HARQ-ACK corresponds to a PDSCH transmission on the primary cell only or a PDCCH/EPDCCH indicating downlink SPS release on the primary cell only, in which case the SR shall be transmitted as for FDD with PUCCH format 1a/1b as described in subclause 7.3.1.

For FDD-TDD and for a PUSCH transmission, a UE shall not transmit HARQ-ACK on PUSCH in subframe n if the UE does not receive PDSCH or PDCCH indicating downlink SPS release in subframe $n-4$.

When only a positive SR is transmitted, a UE shall use PUCCH Format 1 for the SR resource as defined in subclause 5.4.1 in [3].

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 0*, the FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in subclause 7.3.1 for a UE configured with higher layer parameter *codebooksizeDetermination-r13 = 0*.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 1*, the FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in subclause 7.3.1 for a UE configured with higher layer parameter *codebooksizeDetermination-r13 = 1*.

7.3.4 FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 2

When only a positive SR is transmitted, a UE shall use PUCCH Format 1 for the SR resource as defined in subclause 5.4.1 in [3].

The FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in subclause 7.3.2.2 with the following exceptions:

- for a serving cell with frame structure type 1, and a UE not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, K is defined in Table 10.1.3A-1, otherwise K is defined in Table 10.1.3.1-1.
- for a serving cell with frame structure type 1 and a UE not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, if the DL-reference UL/DL configuration of the serving cell in Table 10.1.3A-1 belongs to {2,3,4}, B_c^{DL} is determined as in subclause 7.3.2.2 for a serving cell with DL-reference UL/DL configuration {5}.
- for a serving cell with frame structure type 1, and if PUCCH format 3 is configured for transmission of HARQ-ACK, and for a PUSCH transmission in a subframe n adjusted based on a detected PDCCH/EPDCCH with DCI format 0/4, the UE shall assume the UL-reference UL/DL configuration of the serving cell belongs to {1,2,3,4,5,6}.
- for a serving cell with frame structure type 1, and if DL-reference UL/DL configuration of each of the serving cells belongs to {0,1,2,3,4,6}, and if PUCCH format 1b with channel selection is configured for transmission of HARQ-ACK and for two configured serving cells, the UE shall assume the UL-reference UL/DL configuration of the serving cell belongs to {1,2,3,4,6}.
- for a serving cell with frame structure type 1, a value W_{DAI}^{UL} is determined by the Downlink Assignment Index (DAI) in DCI format 0/4 corresponding to a PUSCH on the serving cell according to Table 7.3-Z in subframe $n-k'$, where k'=4.
- for a serving cell with frame structure type 1, when PUCCH format 3 is configured for transmission of HARQ-ACK, if the DL-reference UL/DL configuration of the serving cell is 0, the HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH in subframe $n-k$ is associated with $o_{c,DAI(k)-1}^{ACK}$ if transmission mode configured in the c-th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ otherwise, where *DAI(k)* is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n-k$, $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. For the case with $N_{SPS}>0$, the

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HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission are set to NACK.

8 Physical uplink shared channel related procedures

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.
- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

For FDD and transmission mode 1, there shall be 8 uplink HARQ processes per serving cell for non-subframe bundling operation, i.e. normal HARQ operation, and 3 uplink HARQ processes for subframe bundling operation when parameter *e-HARQ-Pattern-r12* is set to *TRUE* and 4 uplink HARQ processes for subframe bundling operation otherwise. For FDD and transmission mode 2, there shall be 16 uplink HARQ processes per serving cell for non-subframe bundling operation and there are two HARQ processes associated with a given subframe as described in [8]. The subframe bundling operation is configured by the parameter *ttiBundling* provided by higher layers.

In case higher layers configure the use of subframe bundling for FDD and TDD, the subframe bundling operation is only applied to UL-SCH, such that four consecutive uplink subframes are used.

8.0 UE procedure for transmitting the physical uplink shared channel

The term "UL/DL configuration" in this subclause refers to the higher layer parameter *subframeAssignment* unless specified otherwise.

For FDD and normal HARQ operation, the UE shall upon detection on a given serving cell of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For FDD-TDD and normal HARQ operation and a PUSCH for serving cell c with frame structure type 1, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission for serving cell c in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, the UE shall adjust the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, and using the number of transmission layers and precoding matrix according to the most recent PDCCH/EPDCCH, if the number of negatively acknowledged transport blocks is equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, and if the number of negatively acknowledged transport blocks is not equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH then the UE shall adjust the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, using the precoding matrix with codebook index 0 and the number of transmission layers equal to number of layers corresponding to the negatively acknowledged transport block from the most recent PDCCH/EPDCCH. In this case, the UL DMRS resources are calculated according to the cyclic shift field for DMRS [3] in the most recent PDCCH/EPDCCH with DCI format 4 associated with the corresponding PUSCH transmission and number of layers corresponding to the negatively acknowledged transport block.

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If a UE is configured with the carrier indicator field for a given serving cell, the UE shall use the carrier indicator field value from the detected PDCCH/EPDCCH with uplink DCI format to determine the serving cell for the corresponding PUSCH transmission.

For FDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+4* UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For FDD-TDD and normal HARQ operation, for a serving cell with frame structure type 1, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+4* UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For TDD, if a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, then for a given serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different, if the serving cell is a primary cell or if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different and if the serving cell is a secondary cell and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling a secondary serving cell with frame structure type 2, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, and for secondary serving cell *c* with frame structure type 2, if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, if a UE is configured with more than one serving cell with frame structure type 2, and if the serving cell is a secondary cell with frame structure type 2 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

Table 8-0A: UL-reference UL/DL Configuration for serving cell based on the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration)

Set #	(other serving cell UL/DL configuration, serving cell UL/DL configuration)	UL-reference UL/DL configuration
Set 1	(1,1),(1,2),(1,4),(1,5)	1
	(2,2),(2,5)	2
	(3,3),(3,4),(3,5)	3
	(4,4),(4,5)	4
	(5,5)	5
Set 2	(1,0),(2,0),(3,0),(4,0),(5,0)	0
	(2,1),(4,1),(5,1)	1
	(5,2)	2
	(4,3),(5,3)	3

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	(5,4)	4
	(1,6),(2,6),(3,6),(4,6),(5,6)	6
Set 3	(3,1)	1
	(3,2),(4,2)	2
	(1,3),(2,3)	3
	(2,4)	4
Set 4	(0,0),(6,0)	0
	(0,1),(0,2),(0,4),(0,5),(6,1),(6,2),(6,5)	1
	(0,3),(6,3)	3
	(6,4)	4
	(0,6),(6,6)	6

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for a serving cell, for a radio frame of the serving cell, PUSCH transmissions can occur only in subframes that are indicated by eIMTA-UL/DL-configuration as uplink subframe(s) for the serving cell unless specified otherwise.

For TDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by Table 8-2, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For FDD-TDD normal HARQ operation, for a serving cell with frame structure type 2, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report on the serving cell, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by Table 8-2 and the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration for the serving cell, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *FALSE* or not configured, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe $n-5$ intended for the UE, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *TRUE*, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe $n-1$ intended for the UE, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For both FDD and TDD serving cells, the NDI as signalled on PDCCH/EPDCCH, the RV as determined in subclause 8.6.1, and the TBS as determined in subclause 8.6.2, shall be delivered to higher layers.

For TDD and transmission mode 1, the number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in Table 8-1. For TDD and transmission mode 2, the number of HARQ processes per serving cell for non-subframe bundling operation shall be twice the number determined by the UL/DL configuration (Table 4.2-2 of [3]) as indicated in Table 8-1 and there are two HARQ processes associated with a given subframe as described in [8]. For TDD and both transmission mode 1 and transmission mode 2, the "TDD UL/DL configuration" in Table 8-1 refers to the UL-reference UL/DL configuration for the serving cell if UL-reference UL/DL configuration is defined for the serving cell and refers to the serving cell UL/DL configuration otherwise.

Table 8-1: Number of synchronous UL HARQ processes for TDD

TDD UL/DL configuration	Number of HARQ processes for normal HARQ operation	Number of HARQ processes for subframe bundling operation
0	7	3
1	4	2
2	2	N/A
3	3	N/A
4	2	N/A
5	1	N/A
6	6	3

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For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, and if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For TDD UL/DL configurations 1-6 and normal HARQ operation, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$, with k given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information.

- For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$ if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe n=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, with k given in Table 8-2. If, for TDD UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe n or a PHICH is received in subframe n=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, or PHICH is received in subframe n=1 or 6, the UE shall adjust the corresponding PUSCH transmission in subframe $n+7$. If, for TDD UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe n, the UE shall adjust the corresponding PUSCH transmission in both subframes $n+k$ and $n+7$, with k given in Table 8-2.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD,

- For a serving cell with an UL-reference UL/DL configurations belonging to {1,2,3,4,5,6} and normal HARQ operation, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$ for the serving cell, with k given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information, where the "TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.

- For a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$ for the serving cell if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe n=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, with k given in Table 8-2. If, for a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe n or a PHICH is received in subframe n=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, or PHICH is received in subframe n=1 or 6, the UE shall adjust the corresponding PUSCH transmission in subframe $n+7$ for the serving cell. If, for a serving cell with UL-reference UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe n, the UE shall adjust the corresponding PUSCH transmission in both subframes $n+k$ and $n+7$ for the serving cell, with k given in Table 8-2, where the TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.

For TDD UL/DL configurations 1 and 6 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission intended for the UE in subframe $n-l$ with l given in Table 8-2a, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+k$, with k given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information.

For TDD UL/DL configuration 0 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission intended for the UE in subframe $n-l$ with l given in Table 8-2a, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+k$, if the MSB of the UL index in the DCI format 0 is set to 1 or if $I_{PHICH} = 0$, as defined in subclause 9.1.2, with k given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information. If, for TDD UL/DL configuration 0 and subframe bundling operation, the LSB of the UL index in the PDCCH/EPDCCH with DCI format 0 is set to 1 in subframe n or if $I_{PHICH} = 1$, as defined in subclause 9.1.2, the UE shall adjust the corresponding first PUSCH transmission in the bundle in subframe $n+7$, according to the PDCCH/EPDCCH and PHICH information.

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Table 8-2 *k* for TDD configurations 0-6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	4	6				4	6			
1		6			4		6			4
2				4					4	
3	4								4	4
4									4	4
5									4	
6	7	7				7	7			5

Table 8-2a *l* for TDD configurations 0, 1 and 6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	9	6				9	6			
1		2			3		2			3
6	5	5				6	6			8

A UE is semi-statically configured via higher layer signalling to transmit PUSCH transmissions signalled via PDCCH/EPDCCH according to one of two uplink transmission modes, denoted mode 1 - 2.

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-3 and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these PDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-3A and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

Transmission mode 1 is the default uplink transmission mode for a UE until the UE is assigned an uplink transmission mode by higher layer signalling.

When a UE configured in transmission mode 2 receives a DCI Format 0 uplink scheduling grant, it shall assume that the PUSCH transmission is associated with transport block 1 and that transport block 2 is disabled.

Table 8-3: PDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
Mode 2	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
	DCI format 4	UE specific by C-RNTI	Closed-loop spatial multiplexing (see subclause 8.0.2)

Table 8-3A: EPDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to EPDCCH
Mode 1	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
Mode 2	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
	DCI format 4	UE specific by C-RNTI	Closed-loop spatial multiplexing (see subclause 8.0.2)

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If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the PDCCH according to the combination defined in Table 8-4.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the EPDCCH according to the combination defined in Table 8-4A.

Table 8-4: PDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	Common and UE specific by C-RNTI

Table 8-4A: EPDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	UE specific by C-RNTI

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-5 and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these PDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding PDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-5A and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding EPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

Table 8-5: PDCCH and PUSCH configured by SPS C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
Mode 2	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)

Table 8-5A: EPDCCH and PUSCH configured by SPS C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)
Mode 2	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see subclause 8.0.1)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-6 and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these PDCCH is by Temporary C-RNTI.

If a Temporary C-RNTI is set by higher layers, the scrambling of PUSCH corresponding to the Random Access Response Grant in subclause 6.2 and the PUSCH retransmission for the same transport block is by Temporary C-RNTI. Else, the scrambling of PUSCH corresponding to the Random Access Response Grant in subclause 6.2 and the PUSCH retransmission for the same transport block is by C-RNTI.

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Table 8-6: PDCCH configured by Temporary C-RNTI

DCI format	Search Space
DCI format 0	Common

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8-7. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-7: PDCCH configured by TPC-PUCCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8.8. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-8: PDCCH configured by TPC-PUSCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

8.0.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 10) of the PUSCH, the UE transmission on the PUSCH is performed according to subclause 5.3.2A.1 of [3].

8.0.2 Closed-loop spatial multiplexing scheme

For the closed-loop spatial multiplexing transmission scheme of the PUSCH, the UE transmission on the PUSCH is performed according to the applicable number of transmission layers as defined in subclause 5.3.2A.2 of [3].

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8.1 Resource allocation for PDCCH/EPDCCH with uplink DCI format

Two resource allocation schemes Type 0 and Type 1 are supported for PDCCH/EPDCCH with uplink DCI format.

If the resource allocation type bit is not present in the uplink DCI format, only resource allocation type 0 is supported.

If the resource allocation type bit is present in the uplink DCI format, the selected resource allocation type for a decoded PDCCH/EPDCCH is indicated by a resource allocation type bit where type 0 is indicated by 0 value and type 1 is indicated otherwise. The UE shall interpret the resource allocation field depending on the resource allocation type bit in the PDCCH/EPDCCH with uplink DCI format detected.

8.1.1 Uplink resource allocation type 0

The resource allocation information for uplink resource allocation type 0 indicates to a scheduled UE a set of contiguously allocated virtual resource block indices denoted by n_{VRB}. A resource allocation field in the scheduling grant consists of a resource indication value (RIV) corresponding to a starting resource block (RB_{START}) and a length in terms of contiguously allocated resource blocks ($L_{\mathrm{CRBs}} \geq 1$). The resource indication value is defined by

if $(L_{\mathrm{CRBs}} - 1) \leq \left\lfloor N_{\mathrm{RB}}^{\mathrm{UL}} / 2 \right\rfloor$ then

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (L_{\mathrm{CRBs}} - 1) + RB_{\mathrm{START}}$$

else

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (N_{\mathrm{RB}}^{\mathrm{UL}} - L_{\mathrm{CRBs}} + 1) + (N_{\mathrm{RB}}^{\mathrm{UL}} - 1 - RB_{\mathrm{START}})$$

8.1.2 Uplink resource allocation type 1

The resource allocation information for uplink resource allocation type 1 indicates to a scheduled UE two sets of resource blocks with each set including one or more consecutive resource block groups of size P as given in table 7.1.6.1-1 assuming $N_{\mathrm{RB}}^{\mathrm{UL}}$ as the system bandwidth. A combinatorial index r consists of $\left\lceil \log_2 \left(\binom{\left\lceil N_{RB}^{UL} / P + 1 \right\rceil}{4} \right) \right\rceil$ bits.

The bits from the resource allocation field in the scheduling grant represent r unless the number of bits in the resource allocation field in the scheduling grant is

- smaller than required to fully represent r, in which case the bits in the resource allocation field in the scheduling grant occupy the LSBs of r and the value of the remaining bits of r shall be assumed to be 0; or
- larger than required to fully represent r, in which case r occupies the LSBs of the resource allocation field in the scheduling grant.

The combinatorial index r corresponds to a starting and ending RBG index of resource block set 1, s_0 and $s_1 - 1$, and resource block set 2, s_2 and $s_3 - 1$ respectively, where r is given by equation $r = \sum_{i=0}^{M-1} \left\langle \begin{matrix} N - s_i \\ M - i \end{matrix} \right\rangle$ defined in subclause 7.2.1 with M=4 and $N = \left\lceil N_{\mathrm{RB}}^{\mathrm{UL}} / P \right\rceil + 1$. subclause 7.2.1 also defines ordering properties and range of values that s_i (RBG indices) map to. Only a single RBG is allocated for a set at the starting RBG index if the corresponding ending RBG index equals the starting RBG index.

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8.2 UE sounding procedure

If the UE is configured with a PUCCH-SCell, the UE shall apply the procedures described in this clause for both primary PUCCH group and secondary PUCCH group unless stated otherwise

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', and 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell or serving cells belonging to the primary PUCCH group respectively unless stated otherwise.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell' and 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively unless stated otherwise. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

A UE shall transmit Sounding Reference Symbol (SRS) on per serving cell SRS resources based on two trigger types:

- trigger type 0: higher layer signalling
- trigger type 1: DCI formats 0/4/1A for FDD and TDD and DCI formats 2B/2C/2D for TDD.

In case both trigger type 0 and trigger type 1 SRS transmissions would occur in the same subframe in the same serving cell, the UE shall only transmit the trigger type 1 SRS transmission.

A UE may be configured with SRS parameters for trigger type 0 and trigger type 1 on each serving cell. The following SRS parameters are serving cell specific and semi-statically configurable by higher layers for trigger type 0 and for trigger type 1.

- Number of combs K_{TC} as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1, if configured
- Transmission comb $\overline{k}_{TC}$, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Starting physical resource block assignment n_{RRC}, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- *duration*: single or indefinite (until disabled), as defined in [11] for trigger type 0
- *srs-ConfigIndex* I_{SRS} for SRS periodicity T_{SRS} and SRS subframe offset T_{offset}, as defined in Table 8.2-1 and Table 8.2-2 for trigger type 0 and SRS periodicity $T_{SRS,1}$ and SRS subframe offset $T_{offset,1}$, as defined in Table 8.2-4 and Table 8.2-5 trigger type 1
- SRS bandwidth B_{SRS}, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Frequency hopping bandwidth, b_{hop}, as defined in subclause 5.5.3.2 of [3] for trigger type 0
- Cyclic shift n_{SRS}^{cs}, as defined in subclause 5.5.3.1 of [3] for trigger type 0 and each configuration of trigger type 1
- Number of antenna ports N_p for trigger type 0 and each configuration of trigger type 1

For trigger type 1 and DCI format 4 three sets of SRS parameters, *srs-ConfigApDCI-Format4*, are configured by higher layer signalling. The 2-bit SRS request field [4] in DCI format 4 indicates the SRS parameter set given in Table 8.1-1.
For trigger type 1 and DCI format 0, a single set of SRS parameters, *srs-ConfigApDCI-Format0*, is configured by higher layer signalling. For trigger type 1 and DCI formats 1A/2B/2C/2D, a single common set of SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, is configured by higher layer signalling. The SRS request field is 1 bit [4] for DCI formats 0/1A/2B/2C/2D, with a type 1 SRS triggered if the value of the SRS request field is set to '1'.
A 1-bit SRS request field shall be included in DCI formats 0/1A for frame structure type 1 and 0/1A/2B/2C/2D for

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frame structure type 2 if the UE is configured with SRS parameters for DCI formats 0/1A/2B/2C/2D by higher-layer signalling.

Table 8.1-1: SRS request value for trigger type 1 in DCI format 4

Value of SRS request field	Description
'00'	No type 1 SRS trigger
'01'	The 1st SRS parameter set configured by higher layers
'10'	The 2nd SRS parameter set configured by higher layers
'11'	The 3rd SRS parameter set configured by higher layers

The serving cell specific SRS transmission bandwidths C_{SRS} are configured by higher layers. The allowable values are given in subclause 5.5.3.2 of [3].

The serving cell specific SRS transmission sub-frames are configured by higher layers. The allowable values are given in subclause 5.5.3.3 of [3].

For a TDD serving cell, SRS transmissions can occur in UpPTS and uplink subframes of the UL/DL configuration indicated by the higher layer parameter *subframeAssignment* for the serving cell.

When closed-loop UE transmit antenna selection is enabled for a given serving cell for a UE that supports transmit antenna selection, the index $a(n_{SRS})$, of the UE antenna that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod 2$, for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} (n_{SRS} + \lfloor n_{SRS}/2 \rfloor + \beta \cdot \lfloor n_{SRS}/K \rfloor) \bmod 2 & \text{when } K \text{ is even} \\ n_{SRS} \bmod 2 & \text{when } K \text{ is odd} \end{cases}, \quad \beta = \begin{cases} 1 & \text{where } K \bmod 4 = 0 \\ 0 & \text{otherwise} \end{cases}$$

when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$),

where values B_{SRS}, b_{hop}, N_b, and n_{SRS} are given in subclause 5.5.3.2 of [3], and $K = \prod_{b'=b_{hop}}^{B_{SRS}} N_{b'}$ (where $N_{b_{hop}} = 1$ regardless of the N_b value), except when a single SRS transmission is configured for the UE. If a UE is configured with more than one serving cell, the UE is not expected to transmit SRS on different antenna ports simultaneously.

A UE may be configured to transmit SRS on N_p antenna ports of a serving cell where N_p may be configured by higher layer signalling. For PUSCH transmission mode 1 $N_p \in \{1,2,4\}$ and for PUSCH transmission mode 2 $N_p \in \{1,2\}$ with two antenna ports configured for PUSCH and $N_p \in \{1,4\}$ with 4 antenna ports configured for PUSCH. A UE configured for SRS transmission on multiple antenna ports of a serving cell shall transmit SRS for all the configured transmit antenna ports within one SC-FDMA symbol of the same subframe of the serving cell.
The SRS transmission bandwidth and starting physical resource block assignment are the same for all the configured antenna ports of a given serving cell. The UE does not support a value of K_{TC} set to '4', if the UE is configured for SRS transmission on 4 antenna ports of a serving cell.

A UE not configured with multiple TAGs shall not transmit SRS in a symbol whenever SRS and PUSCH transmissions happen to overlap in the same symbol.

For TDD serving cell, and UE not configured with additional SC-FDMA symbols in UpPTS, when one SC-FDMA symbol exists in UpPTS of the given serving cell, it can be used for SRS transmission, when two SC-FDMA symbols exist in UpPTS of the given serving cell, both can be used for SRS transmission and for trigger type 0 SRS both can be assigned to the same UE. For TDD serving cell, and if the UE is configured with two or four additional SC-FDMA symbols in UpPTS of the given serving cell, all can be used for SRS transmission and for trigger type 0 SRS at most one can be assigned to the same UE.

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If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and SRS and PUCCH format 2/2a/2b happen to coincide in the same subframe in the same serving cell,

- The UE shall not transmit type 0 triggered SRS whenever type 0 triggered SRS and PUCCH format 2/2a/2b transmissions happen to coincide in the same subframe;
- The UE shall not transmit type 1 triggered SRS whenever type 1 triggered SRS and PUCCH format 2a/2b or format 2 with HARQ-ACK transmissions happen to coincide in the same subframe;
- The UE shall not transmit PUCCH format 2 without HARQ-ACK whenever type 1 triggered SRS and PUCCH format 2 without HARQ-ACK transmissions happen to coincide in the same subframe.

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and SRS and PUCCH happen to coincide in the same subframe in the same serving cell,

- The UE shall not transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *FALSE*;
- For FDD-TDD and primary cell frame structure 1, the UE shall not transmit SRS in a symbol whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in subclauses 5.4.1, 5.4.2A, 5.4.2B, and 5.4.2C of [3] happen to overlap in the same symbol if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.
- Unless otherwise prohibited, the UE shall transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.

A UE not configured with multiple TAGs shall not transmit SRS whenever SRS transmission on any serving cells and PUCCH transmission carrying HARQ-ACK and/or positive SR using normal PUCCH format as defined in subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe.

In UpPTS, whenever SRS transmission instance overlaps with the PRACH region for preamble format 4 or exceeds the range of uplink system bandwidth configured in the serving cell, the UE shall not transmit SRS.

The parameter *ackNackSRS-SimultaneousTransmission* provided by higher layers determines if a UE is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe. If it is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe, then in the cell specific SRS subframes of the primary cell UE shall transmit HARQ-ACK and SR using the shortened PUCCH format as defined in subclauses 5.4.1, 5.4.2A, 5.4.2B, and 5.4.2C of [3], where the HARQ-ACK or the SR symbol corresponding to the SRS location is punctured.
This shortened PUCCH format shall be used in a cell specific SRS subframe of the primary cell even if the UE does not transmit SRS in that subframe. The cell specific SRS subframes are defined in subclause 5.5.3.3 of [3]. Otherwise, the UE shall use the normal PUCCH format 1/1a/1b as defined in subclause 5.4.1 of [3] or normal PUCCH format 3 as defined in subclause 5.4.2A or normal PUCCH format 4 as defined in subclause 5.4.2B or normal PUCCH format 5 as defined in subclause 5.4.2C of [3] for the transmission of HARQ-ACK and SR.

Trigger type 0 SRS configuration of a UE in a serving cell for SRS periodicity, T_{SRS}, and SRS subframe offset, T_{offset}, is defined in Table 8.2-1 and Table 8.2-2, for FDD and TDD serving cell, respectively. The periodicity T_{SRS} of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10, 20, 40, 80, 160, 320} ms or subframes.
For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

Type 0 triggered SRS transmission instances in a given serving cell for TDD serving cell with $T_{\text{SRS}} > 2$ and for FDD serving cell are the subframes satisfying $(10 \cdot n_f + k_{\text{SRS}} - T_{offset}) \bmod T_{\text{SRS}} = 0$, where for FDD $k_{\text{SRS}} = \{0,1,\ldots,9\}$ is the subframe index within the frame, for TDD serving cell, if the UE is configured with two or four additional SC-FDMA symbols in UpPTS, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3. The SRS transmission instances for TDD serving cell with $T_{\text{SRS}} = 2$ are the subframes satisfying $(k_{\text{SRS}} - T_{offset}) \bmod 5 = 0$.

For TDD serving cell, and a UE configured for type 0 triggered SRS transmission in serving cell c, and the UE configured with the parameter *EIMTA-MainConfigServCell-r12* for serving cell c, if the UE does not detect an UL/DL configuration indication for radio frame m (as described in section 13.1), the UE shall not transmit trigger type 0 SRS in

a subframe of radio frame m that is indicated by the parameter *eimta-HARQ-ReferenceConfig-r12* as a downlink subframe unless the UE transmits PUSCH in the same subframe.

Trigger type 1 SRS configuration of a UE in a serving cell for SRS periodicity, $T_{\text{SRS},1}$, and SRS subframe offset, $T_{offset,1}$, is defined in Table 8.2-4 and Table 8.2-5, for FDD and TDD serving cell, respectively. The periodicity $T_{\text{SRS},1}$ of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10} ms or subframes.
For the SRS periodicity $T_{\text{SRS},1}$ of 2 ms in TDD serving cell, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

A UE configured for type 1 triggered SRS transmission in serving cell c and not configured with a carrier indicator field shall transmit SRS on serving cell c upon detection of a positive SRS request in PDCCH/EPDCCH scheduling PUSCH/PDSCH on serving cell c.

A UE configured for type 1 triggered SRS transmission in serving cell c and configured with a carrier indicator field shall transmit SRS on serving cell c upon detection of a positive SRS request in PDCCH/EPDCCH scheduling PUSCH/PDSCH with the value of carrier indicator field corresponding to serving cell c.

A UE configured for type 1 triggered SRS transmission on serving cell c upon detection of a positive SRS request in subframe n of serving cell c shall commence SRS transmission in the first subframe satisfying $n+k, k \geq 4$ and

$(10 \cdot n_f + k_{\text{SRS}} - T_{offset,1}) \bmod T_{\text{SRS},1} = 0$ for TDD serving cell c with $T_{\text{SRS},1} > 2$ and for FDD serving cell c,

$(k_{\text{SRS}} - T_{offset,1}) \bmod 5 = 0$ for TDD serving cell c with $T_{\text{SRS},1} = 2$

where for FDD serving cell c $k_{\text{SRS}} = \{0,1,\ldots,9\}$ is the subframe index within the frame n_f, for TDD serving cell c, if the UE is configured with two or four additional SC-FDMA symbols in UpPTS, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3.

A UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering events associated with different values of trigger type 1 SRS transmission parameters, as configured by higher layer signalling, for the same subframe and the same serving cell.

For TDD serving cell c, and a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell c, the UE shall not transmit SRS in a subframe of a radio frame that is indicated by the corresponding eIMTA-UL/DL-configuration as a downlink subframe.

A UE shall not transmit SRS whenever SRS and a PUSCH transmission corresponding to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure coincide in the same subframe.

Table 8.2-1: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, FDD

SRS Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0 – 1	2	I_{SRS}
2 – 6	5	$I_{\text{SRS}} - 2$
7 – 16	10	$I_{\text{SRS}} - 7$
17 – 36	20	$I_{\text{SRS}} - 17$
37 – 76	40	$I_{\text{SRS}} - 37$
77 – 156	80	$I_{\text{SRS}} - 77$
157 – 316	160	$I_{\text{SRS}} - 157$
317 – 636	320	$I_{\text{SRS}} - 317$
637 – 1023	reserved	reserved

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Table 8.2-2: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, TDD

SRS Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0	2	0, 1
1	2	0, 2
2	2	1, 2
3	2	0, 3
4	2	1, 3
5	2	0, 4
6	2	1, 4
7	2	2, 3
8	2	2, 4
9	2	3, 4
10 – 14	5	I_{SRS} – 10
15 – 24	10	I_{SRS} – 15
25 – 44	20	I_{SRS} – 25
45 – 84	40	I_{SRS} – 45
85 – 164	80	I_{SRS} – 85
165 – 324	160	I_{SRS} – 165
325 – 644	320	I_{SRS} – 325
645 – 1023	reserved	reserved

Table 8.2-3: k_{SRS} for TDD

	subframe index *n*											
	0	1		2	3	4	5	6		7	8	9
		1st symbol of UpPTS	2nd symbol of UpPTS					1st symbol of UpPTS	2nd symbol of UpPTS			
k_{SRS} in case UpPTS length of 2 symbols		0	1	2	3	4		5	6	7	8	9
k_{SRS} in case UpPTS length of 1 symbol		1		2	3	4		6		7	8	9

Table 8.2-4: UE Specific SRS Periodicity $T_{SRS,1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, FDD

SRS Configuration Index I_{SRS}	SRS Periodicity $T_{SRS,1}$ (ms)	SRS Subframe Offset $T_{offset,1}$
0 – 1	2	I_{SRS}
2 – 6	5	I_{SRS} – 2
7 – 16	10	I_{SRS} – 7
17 – 31	reserved	reserved

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Table 8.2-5: UE Specific SRS Periodicity $T_{SRS,1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, TDD

SRS Configuration Index I_{SRS}	SRS Periodicity $T_{SRS,1}$ (ms)	SRS Subframe Offset $T_{offset,1}$
0	reserved	reserved
1	2	0, 2
2	2	1, 2
3	2	0, 3
4	2	1, 3
5	2	0, 4
6	2	1, 4
7	2	2, 3
8	2	2, 4
9	2	3, 4
10 – 14	5	I_{SRS} – 10
15 – 24	10	I_{SRS} – 15
25 – 31	reserved	reserved

Table 8.2-6: k_{SRS} for TDD and UE configured with two or four additional SC-FDMA symbols in UpPTS

	subframe index *n*														
	0	1				2	3	4	5	6				7	8	9
		1st symbol of UpPTS	2nd symbol of UpPTS	3rd symbol of UpPTS	4th symbol of UpPTS					1st symbol of UpPTS	2nd symbol of UpPTS	3rd symbol of UpPTS	4th symbol of UpPTS			
k_{SRS} in case UpPTS length of 4 symbols		0	1	2	3					5	6	7	8			
k_{SRS} in case UpPTS length of 1 symbol		2	3							7	8					

8.3 UE HARQ-ACK procedure

For FDD, and serving cell with frame structure type 1, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in subframe i-4.

For FDD-TDD, and serving cell with frame structure type 1, and UE not configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in subframe i-4.

For FDD-TDD, if a serving cell is a secondary cell with frame structure type 1 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with PUSCH transmission on the serving cell in subframe i-6.

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For frame structure type 2 UL/DL configuration 1-6, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-k as indicated by the following Table 8.3-1.
- For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-k as indicated by the following Table 8.3-1. For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-6.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell is frame structure type 2,

- For serving cell with an UL-reference UL/DL configuration (defined in subclause 8.0) belonging to {1,2,3,4,5,6}, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-k for the serving cell as indicated by the following Table 8.3-1, where "TDD UL/DL Configuration" in Table 8.3-1 refers to the UL-reference UL/DL Configuration.
- For a serving cell with UL-reference UL/DL configuration 0 (defined in subclause 8.0), an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-k for the serving cell as indicated by the following Table 8.3-1, where "TDD UL/DL Configuration" in Table 8.3-1 refers to the UL-reference UL/DL configuration. For a serving cell with UL-reference UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe i-6 for the serving cell.
- For FDD-TDD, if a serving cell is a secondary cell with UL-reference UL/DL configuration 0 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, for downlink subframe i, if a transport block was transmitted in the associated PUSCH subframe i-6 for the serving cell then PHICH resource corresponding to that transport block is not present in subframe i.

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Table 8.3-1 *k* for TDD configurations 0-6

TDD UL/DL Configuration	subframe number *i*									
	0	1	2	3	4	5	6	7	8	9
0	7	4				7	4			
1		4			6		4			6
2				6					6	
3	6								6	6
4									6	6
5									6	
6	6	4				7	4			6

The physical layer in the UE shall deliver indications to the higher layers as follows:

For FDD, and for TDD with a UE configured with one serving cell, and for TDD with a UE configured with more than one serving cell and with TDD UL/DL configuration of all configured serving cells the same, and UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; else NACK for that transport block shall be delivered to the higher layers.

For TDD, if the UE is configured with more than one serving cell, and if at least two serving cells have different UL/DL configurations, or the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; or

if a PHICH resource corresponding to that transport block is not present in subframe *i* or if UE is not expected to receive PHICH corresponding to that transport block in subframe *i*, ACK for that transport block shall be delivered to the higher layers.

else NACK for that transport block shall be delivered to the higher layers.

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8.4 UE PUSCH hopping procedure

The UE shall perform PUSCH frequency hopping if the single bit Frequency Hopping (FH) field in a corresponding PDCCH/EPDCCH with DCI format 0 is set to 1 and the uplink resource block assignment is type 0 otherwise no PUSCH frequency hopping is performed.

A UE performing PUSCH frequency hopping shall determine its PUSCH Resource Allocation (RA) for the first slot of a subframe (SI) including the lowest index PRB ($n_{PRB}^{SI}(n)$) in subframe n from the resource allocation field in the latest PDCCH/EPDCCH with DCI format 0 for the same transport block. If there is no PDCCH/EPDCCH for the same transport block, the UE shall determine its hopping type based on

- the hopping information in the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled or
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

The resource allocation field in DCI format 0 excludes either 1 or 2 bits used for hopping information as indicated by Table 8.4-1 below where the number of PUSCH resource blocks is defined as

$$N_{RB}^{PUSCH} = \begin{cases} N_{RB}^{UL} - \tilde{N}_{RB}^{HO} - \left(N_{RB}^{UL} \bmod 2\right) & \text{Type 1 PUSCH hopping} \\ N_{RB}^{UL} & \text{Type 2 } N_{sb} = 1 \text{ PUSCH hopping} \\ N_{RB}^{UL} - \tilde{N}_{RB}^{HO} & \text{Type 2 } N_{sb} > 1 \text{ PUSCH hopping} \end{cases}$$

For type 1 and type 2 PUSCH hopping, $\tilde{N}_{RB}^{HO} = N_{RB}^{HO} + 1$ if N_{RB}^{HO} is an odd number where N_{RB}^{HO} defined in [3]. $\tilde{N}_{RB}^{HO} = N_{RB}^{HO}$ in other cases. The size of the resource allocation field in DCI format 0 after excluding either 1 or 2 bits shall be $y = \left\lceil \log_2 (N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \right\rceil - N_{UL\_hop}$, where N_{UL_hop} = 1 or 2 bits. The number of contiguous RBs that can be assigned to a type-1 hopping user is limited to $\left\lfloor 2^y / N_{RB}^{UL} \right\rfloor$. The number of contiguous RBs that can be assigned to a type-2 hopping user is limited to $\min\left(\left\lfloor 2^y / N_{RB}^{UL} \right\rfloor, \left\lfloor N_{RB}^{PUSCH} / N_{sb} \right\rfloor\right)$, where the number of sub-bands N_{sb} is given by higher layers.

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in subclause 8.4.1 and type 2 is described in subclause 8.4.2.

Table 8.4-1: Number of Hopping Bits N_{UL_hop} vs. System Bandwidth

System BW N_{RB}^{UL}	#Hopping bits for 2nd slot RA (N_{UL_hop})
6-49	1
50-110	2

The parameter *Hopping-mode* provided by higher layers determines if PUSCH frequency hopping is "inter-subframe" or "intra and inter-subframe".

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8.4.1 Type 1 PUSCH hopping

For PUSCH hopping type 1 the hopping bit or bits indicated in Table 8.4-1 determine $\tilde{n}_{PRB}(i)$ as defined in Table 8.4-2. The lowest index PRB ($n_{PRB}^{S1}(i)$) of the 1st slot RA in subframe i is defined as $n_{PRB}^{S1}(i) = \tilde{n}_{PRB}^{S1}(i) + \tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} / 2$, where $n_{PRB}^{S1}(i) = RB_{START}$, and RB_{START} is obtained from the uplink scheduling grant as in subclause 8.4 and subclause 8.1.

The lowest index PRB ($n_{PRB}(i)$) of the 2nd slot RA in subframe i is defined as $n_{PRB}(i) = \tilde{n}_{PRB}(i) + \tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} / 2$.

The set of physical resource blocks to be used for PUSCH transmission are L_{CRBs} contiguously allocated resource blocks from PRB index $n_{PRB}^{S1}(i)$ for the 1st slot, and from PRB index $n_{PRB}(i)$ for the 2nd slot, respectively, where L_{CRBs} is obtained from the uplink scheduling grant as in subclause 8.4 and subclause 8.1.

If the *Hopping-mode* is "inter-subframe", the 1st slot RA is applied to even CURRENT_TX_NB, and the 2nd slot RA is applied to odd CURRENT_TX_NB, where CURRENT_TX_NB is defined in [8].

8.4.2 Type 2 PUSCH hopping

In PUSCH hopping type 2 the set of physical resource blocks to be used for transmission in slot n_s is given by the scheduling grant together with a predefined pattern according to [3] subclause 5.3.4.
If the system frame number is not acquired by the UE yet, the UE shall not transmit PUSCH with type-2 hopping and $N_{sb} > 1$ for TDD, where N_{sb} is defined in [3].

Table 8.4-2: PDCCH/EPDCCH DCI format 0 hopping bit definition

System BW N_{RB}^{UL}	Number of Hopping bits	Information in hopping bits	$\tilde{n}_{PRB}(i)$
6 – 49	1	0	$\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$,
		1	Type 2 PUSCH Hopping
50 – 110	2	00	$\left(\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		01	$\left(-\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		10	$\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		11	Type 2 PUSCH Hopping

8.5 UE Reference Symbol (RS) procedure

If UL sequence-group hopping or sequence hopping is configured in a serving cell, it applies to all Reference Symbols (SRS, PUSCH and PUCCH RS). If disabling of the sequence-group hopping and sequence hopping is configured for the UE in the serving cell through the higher-layer parameter *Disable-sequence-group-hopping*, the sequence-group hopping and sequence hopping for PUSCH RS are disabled.

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8.6 Modulation order, redundancy version and transport block size determination

To determine the modulation order, redundancy version and transport block size for the physical uplink shared channel, the UE shall first

- read the "modulation and coding scheme and redundancy version" field (I_{MCS}), and
- check the "CSI request" bit field, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in subclause 8.1, and
- compute the number of coded symbols for control information.

8.6.1 Modulation order and redundancy version determination

For $0 \le I_{MCS} \le 28$, the modulation order (Q_m) is determined as follows:

- If the UE is capable of supporting 64QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by Q'_m in Table 8.6.1-1.
- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, Q'_m is first read from Table 8.6.1-1. The modulation order is set to $Q_m = \min(4, Q'_m)$.
- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the modulation order is set to $Q_m = 2$. Resource allocation size is restricted to $N_{PRB} \le 3$ applies in this case if the UE does not indicate support by higher layers to operate without it.

For $29 \le I_{MCS} \le 31$ the modulation order (Q_m) is determined as follows:

- if DCI format 0 is used and $I_{MCS} = 29$ or, if DCI format 4 is used and only 1 TB is enabled and $I_{MCS} = 29$ for the enabled TB and the signalled number of transmission layers is 1, and if
  - the "CSI request" bit field is 1 bit and the bit is set to trigger an aperiodic report and, $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and, $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{PRB} \le 20$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and $N_{PRB} \le 20$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 20$, or
  - the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E and $N_{PRB} \le 4$, or

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- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E and $N_{PRB} \leq x$,

then the modulation order is set to $Q_m = 2$.

- Otherwise, the modulation order shall be determined from the DCI transported in the latest PDCCH/EPDCCH with DCI format 0/4 for the same transport block using $0 \leq I_{MCS} \leq 28$. If there is no PDCCH/EPDCCH with DCI format 0/4 for the same transport block using $0 \leq I_{MCS} \leq 28$, the modulation order shall be determined from
  - the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
  - the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

The UE shall use I_{MCS} and Table 8.6.1-1 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel.

Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}	Redundancy Version rv_{idx}
0	2	0	0
1	2	1	0
2	2	2	0
3	2	3	0
4	2	4	0
5	2	5	0
6	2	6	0
7	2	7	0
8	2	8	0
9	2	9	0
10	2	10	0
11	4	10	0
12	4	11	0
13	4	12	0
14	4	13	0
15	4	14	0
16	4	15	0
17	4	16	0
18	4	17	0
19	4	18	0
20	4	19	0
21	6	19	0
22	6	20	0
23	6	21	0
24	6	22	0
25	6	23	0
26	6	24	0
27	6	25	0
28	6	26	0
29	reserved		1
30			2
31			3

8.6.2 Transport block size determination

For $0 \leq I_{MCS} \leq 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-1 except if the transport block is disabled in DCI format 4 as specified below. For a transport block that is not mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in subclause 7.17.2.2.

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For $29 \le I_{MCS} \le 31$,

- if DCI format 0 is used and $I_{MCS} = 29$ or, if DCI format 4 is used and only 1 TB is enabled and $I_{MCS} = 29$ for the enabled TB and the number of transmission layers is 1, and if
  - the "CSI request" bit field is 1 bit and is set to trigger an aperiodic CSI report and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and , $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{PRB} \le 20$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and, $N_{PRB} \le 20$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 20$,, or
  - the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E and $N_{PRB} \le 4$, or
  - the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E and $N_{PRB} \le x$,

then there is no transport block for the UL-SCH and only the control information feedback for the current PUSCH reporting mode is transmitted by the UE.

- Otherwise, the transport block size shall be determined from the initial PDCCH/EPDCCH for the same transport block using $0 \le I_{MCS} \le 28$. If there is no initial PDCCH/EPDCCH with an uplink DCI format for the same transport block using $0 \le I_{MCS} \le 28$, the transport block size shall be determined from
  - the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
  - the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

In DCI format 4 a transport block is disabled if either the combination of $I_{MCS} = 0$ and $N_{PRB} > 1$ or the combination of $I_{MCS} = 28$ and $N_{PRB} = 1$ is signalled, otherwise the transport block is enabled.

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8.6.3 Control information MCS offset determination

Offset values are defined for single codeword PUSCH transmission and multiple codeword PUSCH transmission. Single codeword PUSCH transmission offsets $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{offset}^{HARQ-ACK}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH, I_{offset}^{RI}, and I_{offset}^{CQI}, respectively. Single codeword PUSCH transmission offset $\beta_{offset}^{HARQ-ACK}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{offset,X}^{HARQ-ACK}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH. Multiple codeword PUSCH transmission offsets $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{offset,MC}^{HARQ-ACK}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH, $I_{offset,MC}^{RI}$ and $I_{offset,MC}^{CQI}$, respectively. Multiple codeword PUSCH transmission offset $\beta_{offset}^{HARQ-ACK}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{offset,MC,X}^{HARQ-ACK}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH.

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c, and if a subframe belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then for that subframe, the UE shall use

- the higher layer indexes $I_{offset,set2}^{HARQ-ACK}$, $I_{offset,set2,X}^{HARQ-ACK}$, $I_{offset,set2}^{RI}$ and $I_{offset,set2}^{CQI}$ in place of $I_{offset}^{HARQ-ACK}$, $I_{offset,X}^{HARQ-ACK}$, I_{offset}^{RI}, and I_{offset}^{CQI} respectively in Tables 8.6.3-1,2,3, to determine $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} respectively for single codeword PUSCH transmissions, and

- the higher layer indexes $I_{offset,MC,set2}^{HARQ-ACK}$, $I_{offset,MC,set2,X}^{HARQ-ACK}$, $I_{offset,MC,set2}^{RI}$ and $I_{offset,MC,set2}^{CQI}$ in place of $I_{offset,MC}^{HARQ-ACK}$, $I_{offset,MC,X}^{HARQ-ACK}$, $I_{offset,MC}^{RI}$ and $I_{offset,MC}^{CQI}$ respectively in Tables 8.6.3-1,2,3, to determine $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} respectively for multiple codeword PUSCH transmissions.

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Table 8.6.3-1: Mapping of HARQ-ACK offset values and the index signalled by higher layers

$I_{offset}^{HARQ-ACK}$ or $I_{offset,MC}^{HARQ-ACK}$	$\beta_{offset}^{HARQ-ACK}$
0	2.000
1	2.500
2	3.125
3	4.000
4	5.000
5	6.250
6	8.000
7	10.000
8	12.625
9	15.875
10	20.000
11	31.000
12	50.000
13	80.000
14	126.000
15	1.0

Table 8.6.3-2: Mapping of RI offset values and the index signalled by higher layers

I_{offset}^{RI} or $I_{offset,MC}^{RI}$	β_{offset}^{RI}
0	1.250
1	1.625
2	2.000
3	2.500
4	3.125
5	4.000
6	5.000
7	6.250
8	8.000
9	10.000
10	12.625
11	15.875
12	20.000
13	reserved
14	reserved
15	reserved

Table 8.6.3-3: Mapping of CQI offset values and the index signalled by higher layers

I_{offset}^{CQI} or $I_{offset,MC}^{CQI}$	β_{offset}^{CQI}
0	reserved
1	reserved
2	1.125
3	1.250
4	1.375
5	1.625
6	1.750
7	2.000
8	2.250
9	2.500
10	2.875
11	3.125
12	3.500
13	4.000
14	5.000
15	6.250

8.7 UE transmit antenna selection

UE transmit antenna selection is configured by higher layers via parameter *ue-TransmitAntennaSelection*.

A UE configured with transmit antenna selection for a serving cell is not expected to

- be configured with more than one antenna port for any uplink physical channel or signal for any configured serving cell, or
- be configured with trigger type 1 SRS transmission on any configured serving cell, or
- be configured with simultaneous PUCCH and PUSCH transmission, or
- be configured with demodulation reference signal for PUSCH with OCC for any configured serving cell (see [3], subclause 5.5.2.1.1), or
- receive DCI Format 0 indicating uplink resource allocation type 1 for any serving cell, or
- be configured with a SCG.

If UE transmit antenna selection is disabled or not supported by the UE, the UE shall transmit from UE port 0.

If closed-loop UE transmit antenna selection is enabled by higher layers the UE shall perform transmit antenna selection for PUSCH in response to the most recent command received via DCI Format 0 in subclause 5.3.3.2 of [4].
If a UE is configured with more than one serving cell, the UE may assume the same transmit antenna port value is indicated in each PDCCH/EPDCCH with DCI format 0 in a given subframe.

If open-loop UE transmit antenna selection is enabled by higher layers, the transmit antenna for PUSCH/SRS to be selected by the UE is not specified.

9 Physical downlink control channel procedures

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.
- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

9.1 UE procedure for determining physical downlink control channel assignment

9.1.1 PDCCH assignment procedure

The control region of each serving cell consists of a set of CCEs, numbered from 0 to $N_{\mathrm{CCE},k}-1$ according to subclause 6.8.1 in [3], where $N_{\mathrm{CCE},k}$ is the total number of CCEs in the control region of subframe k.
The UE shall monitor a set of PDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the PDCCHs in the set according to all the monitored DCI formats.

The set of PDCCH candidates to monitor are defined in terms of search spaces, where a search space $S_k^{(L)}$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidate m of the search space $S_k^{(L)}$ are given by

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$$L\cdot\{(Y_k+m')\bmod\lfloor N_{CCE,k}/L\rfloor\}+i$$

where Y_k is defined below, $i=0,\cdots,L-1$. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitoring UE is configured with carrier indicator field then $m'=m+M^{(L)}\cdot n_{CI}$ where n_{CI} is the carrier indicator field value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where $m=0,\cdots,M^{(L)}-1$. $M^{(L)}$ is the number of PDCCH candidates to monitor in the given search space.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

The UE shall monitor one common search space in every non-DRX subframe at each of the aggregation levels 4 and 8 on the primary cell.

A UE shall monitor common search space on a cell to decode the PDCCHs necessary to receive MBMS on that cell when configured by higher layers.

If a UE is not configured for EPDCCH monitoring, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on each activated serving cell in every non-DRX subframe.

If a UE is not configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on one or more activated serving cells as configured by higher layer signalling in every non-DRX subframe.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on that serving cell in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more PDCCH UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on that serving cell as configured by higher layer signalling in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

The common and PDCCH UE-specific search spaces on the primary cell may overlap.

A UE configured with the carrier indicator field associated with monitoring PDCCH on serving cell c shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the PDCCH UE specific search space of serving cell c.

A UE configured with the carrier indicator field associated with monitoring PDCCH on the primary cell shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI in the PDCCH UE specific search space of the primary cell.

The UE shall monitor the common search space for PDCCH without carrier indicator field.

For the serving cell on which PDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the PDCCH UE specific search space for PDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the PDCCH UE specific search space for PDCCH with carrier indicator field.

If the UE is not configured with a LAA Scell, the UE is not expected to monitor the PDCCH of a secondary cell if it is configured to monitor PDCCH with carrier indicator field corresponding to that secondary cell in another serving cell.

If the UE is configured with a LAA Scell, the UE is not expected to monitor the PDCCH UE specific space of the LAA SCell if it is configured to monitor PDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell.

For the serving cell on which PDCCH is monitored, the UE shall monitor PDCCH candidates at least for the same serving cell.

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A UE configured to monitor PDCCH candidates with CRC scrambled by C-RNTI or SPS C-RNTI with a common payload size and with the same first CCE index n_{CCE} (as described in subclause 10.1) but with different sets of DCI information fields as defined in [4] in the

common search space

PDCCH UE specific search space

on the primary cell shall assume that for the PDCCH candidates with CRC scrambled by C-RNTI or SPS C-RNTI,

if the UE is configured with the carrier indicator field associated with monitoring the PDCCH on the primary cell, only the PDCCH in the common search space is transmitted by the primary cell;

otherwise, only the PDCCH in the UE specific search space is transmitted by the primary cell.

A UE configured to monitor PDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the PDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that a PDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any PDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07',

- The UE monitors PDCCH UE-specific search space candidates on the Scell in both the first and second slots of a subframe, and the aggregation levels defining the search spaces are listed in Table 9.1.1-1A;

otherwise,

- The aggregation levels defining the search spaces are listed in Table 9.1.1-1.

The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in subclause 7.1.

If a UE is configured with higher layer parameter *skipMonitoringDCI-format0-1A* for a serving cell, the UE is not required to monitor the PDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a UE is configured with higher layer parameter *pdcch-candidateReductions* for a UE specific search space at aggregation level L for a serving cell, the corresponding number of PDCCH candidates is given by $M^{(L)} = \text{round}\left(a \times M_{full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{full}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{full}^{(L)}$.

Table 9.1.1-1: PDCCH candidates monitored by a UE

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

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Table 9.1.1-1A: PDCCH candidates monitored by a UE on LAA Scell

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$ in first slot	Number of PDCCH candidates $M^{(L)}$ in second slot
Type	Aggregation level L	Size [in CCEs]		
UE-specific	1	6		
	2	12		
	4	8		
	8	16		

Table 9.1.1-2: Scaling factor for PDCCH candidates reduction

pdcch-candidateReductions	Value of α
0	0
1	0.33
2	0.66
3	1

For the common search spaces, Y_k is set to 0 for the two aggregation levels $L = 4$ and $L = 8$.

For the UE-specific search space $S_k^{(L)}$ at aggregation level L, the variable Y_k is defined by

$$Y_k = (A \cdot Y_{k-1}) \bmod D$$

where $Y_{-1} = n_{\text{RNTI}} \neq 0$, $A = 39827$, $D = 65537$ and $k = \lfloor n_s/2 \rfloor$, n_s is the slot number within a radio frame.

The RNTI value used for n_{RNTI} is defined in subclause 7.1 in downlink and subclause 8 in uplink.

9.1.2 PHICH assignment procedure

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and PUSCH transmissions scheduled from serving cell c in subframe n are not scheduled by a Random Access Response Grant corresponding to a random access preamble transmission for a secondary cell

- For PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n+k_{PHICH}$, where
  - k_{PHICH} is always 4 for FDD.
  - k_{PHICH} is 6 for FDD-TDD and serving cell c frame structure type 2 and the PUSCH transmission is for another serving cell with frame structure type 1.
  - k_{PHICH} is 4 for FDD-TDD and serving cell c frame structure type 1and the PUSCH transmission is for a serving cell with frame structure type 1.
  - k_{PHICH} is given in table 9.1.2-1 for FDD-TDD and serving cell c frame structure type 1 and the PUSCH transmission is for another serving cell with frame structure type 2.
- For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if the UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, for PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n+k_{PHICH}$, where k_{PHICH} is given in table 9.1.2-1.
- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell , or for FDD-TDD and serving cell c frame structure type 2, for PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n+k_{PHICH}$, where k_{PHICH} is given in table 9.1.2-1, where the "TDD UL/DL

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Configuration" in the rest of this subclause refers to the UL-reference UL/DL configuration (defined in subclause 8.0) of the serving cell corresponding to the PUSCH transmission.

If a UE is configured with multiple TAGs, for PUSCH transmissions on subframe n for a secondary cell c scheduled by a Random Access Response grant corresponding to a random access preamble transmission for the secondary cell c,

- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell c frame structure type 2, the "TDD UL/DL Configuration" in the rest of this subclause refers to the UL-reference UL/DL configuration (defined in subclause 8.0) of secondary cell c.
- If the UE is not configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell, the UE shall determine the corresponding PHICH resource on the secondary cell c in subframe $n+k_{PHICH}$, where
  - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 for TDD.
  - k_{PHICH} is 4 for FDD-TDD and secondary cell c frame structure type 1.
  - k_{PHICH} is given in table 9.1.2-1 for FDD-TDD and secondary cell c frame structure type 2
- If the UE is configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell $c1$, the UE configured with multiple TAGs shall determine the corresponding PHICH resource on the serving cell $c1$ in subframe $n+k_{PHICH}$, where
  - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 for TDD.
  - k_{PHICH} is 4 for FDD-TDD and primary cell frame structure type 1 and frame structure type 1 for secondary cell c and serving cell $c1$
  - k_{PHICH} is given in table 9.1.2-1 for FDD-TDD and serving cell c frame structure type 2
  - k_{PHICH} is 6 for FDD-TDD and serving cell c frame structure type 1 and serving cell $c1$ frame structure type 2

For subframe bundling operation, the corresponding PHICH resource is associated with the last subframe in the bundle.

Table 9.1.2-1: k_{PHICH} for TDD

TDD UL/DL Configuration	subframe index n									
	0	1	2	3	4	5	6	7	8	9
0			4	7	6			4	7	6
1			4	6				4	6	
2			6					6		
3			6	6	6					
4			6	6						
5			6							
6			4	6	6			4	7	

The PHICH resource is identified by the index pair $(n_{PHICH}^{group}, n_{PHICH}^{seq})$ where n_{PHICH}^{group} is the PHICH group number and n_{PHICH}^{seq} is the orthogonal sequence index within the group as defined by:

$$n_{PHICH}^{group} = (I_{PRB\_RA} + n_{DMRS}) \bmod N_{PHICH}^{group} + I_{PHICH} N_{PHICH}^{group}$$

$$n_{PHICH}^{seq} = (\lfloor I_{PRB\_RA} / N_{PHICH}^{group} \rfloor + n_{DMRS}) \bmod 2N_{SF}^{PHICH}$$

where

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- n_{DMRS} is mapped from the cyclic shift for DMRS field (according to Table 9.1.2-2) in the most recent PDCCH/EPDCCH with uplink DCI format [4] for the transport block(s) associated with the corresponding PUSCH transmission. n_{DMRS} shall be set to zero, if there is no PDCCH/EPDCCH with uplink DCI format for the same transport block, and
  - if the initial PUSCH for the same transport block is semi-persistently scheduled, or
  - if the initial PUSCH for the same transport block is scheduled by the random access response grant .
- N_{SF}^{PHICH} is the spreading factor size used for PHICH modulation as described in subclause 6.9.1 in [3].
- $I_{PRB\_RA} = \begin{cases} I_{PRB\_RA}^{lowest\_index} & \text{for the first TB of a PUSCH with associated PDCCH/EPDCCH or for the case of no associated PDCCH/EPDCCH when the number of negatively acknowledged TBs is not equal to the number of TBs indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH} \\ I_{PRB\_RA}^{lowest\_index} + 1 & \text{for a second TB of a PUSCH with associated PDCCH/EPDCCH} \end{cases}$

  where $I_{PRB\_RA}^{lowest\_index}$ is the lowest PRB index in the first slot of the corresponding PUSCH transmission
- N_{PHICH}^{group} is the number of PHICH groups configured by higher layers as described in subclause 6.9 of [3],
- $I_{PHICH} = \begin{cases} 1 & \text{for TDD UL/DL configuration 0 with PUSCH transmission in subframe } n = 4 \text{ or } 9 \\ 0 & \text{otherwise} \end{cases}$

Table 9.1.2-2: Mapping between n_{DMRS} and the cyclic shift for DMRS field in PDCCH/EPDCCH with uplink DCI format in [4]

Cyclic Shift for DMRS Field in PDCCH/EPDCCH with uplink DCI format in [4]	n_{DMRS}
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

9.1.3 Control Format Indicator (CFI) assignment procedure

PHICH duration is signalled by higher layers according to Table 6.9.3-1 in [3]. The duration signalled puts a lower limit on the size of the control region determined from the control format indicator (CFI). When $N_{RB}^{DL} > 10$, if extended PHICH duration is indicated by higher layers then the UE shall assume that CFI is equal to PHICH duration.

In subframes indicated by higher layers to decode PMCH, when $N_{RB}^{DL} > 10$, a UE may assume that CFI is equal to the value of the higher layer parameter *non-MBSFNregionLength* [11].

9.1.4 EPDCCH assignment procedure

For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers as described in

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subclause 9.1.4.4. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{\mathrm{ECCE},p,k}-1$ where $N_{\mathrm{ECCE},p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the EPDCCHs in the set according to the monitored DCI formats.

The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-specific search spaces.

For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

The UE shall not monitor EPDCCH

- For TDD and normal downlink CP, in special subframes for the special subframe configurations 0 and 5 shown in Table 4.2-1 of [3].
- For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3].
- In subframes indicated by higher layers to decode PMCH.
- For TDD and if the UE is configured with different UL/DL configurations for the primary and a secondary cell, in a downlink subframe on the secondary cell when the same subframe on the primary cell is a special subframe and the UE is not capable of simultaneous reception and transmission on the primary and secondary cells.

An EPDCCH UE-specific search space $ES_k^{(L)}$ at aggregation level $L \in \{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES_k^{(L)}$ are given by

$$L\left\{(Y_{p,k}+\left\lfloor\frac{m\cdot N_{ECCE,p,k}}{L\cdot M_p^{(L)}}\right\rfloor+b)\bmod\left\lfloor N_{\mathrm{ECCE},p,k}/L\right\rfloor\right\}+i$$

where

$Y_{p,k}$ is defined below,

$i=0,\cdots,L-1$

$b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$

n_{CI} is the carrier indicator field value,

$m=0,1,\ldots M_p^{(L)}-1,$

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell on which EPDCCH is monitored, as given in Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.4.4-4b, 9.1.4-5a, 9.1.4-5b below; otherwise, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell indicated by n_{CI}.

If a UE is configured with higher layer parameter *pdcch-candidateReductions* for a specific search space at aggregation level L in EPDCCH-PRB-set p for a serving cell, the corresponding number of EPDCCH candidates is given by

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$M_p^{(L)} = \text{round}\left(a \times M_{p,full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,full}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise the carrier indicator field value is the same as *ServCellIndex* given in [11].

A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or primary or secondary synchronization signals in the same subframe.

If a UE is configured with two EPDCCH-PRB-sets with the same $n_{\text{ID},i}^{\text{EPDCCH}}$ value (where $n_{\text{ID},i}^{\text{EPDCCH}}$ is defined in subclause 6.10.3A.1 in [3]), if the UE receives an EPDCCH candidate with a given DCI payload size corresponding to one of the EPDCCH-PRB-sets and mapped only to a given set of REs (as described in subclause 6.8A.5 in [3]), and if the UE is also configured to monitor an EPDCCH candidate with the same DCI payload size and corresponding to the other EPDCCH-PRB-set and which is mapped only to the same set of REs, and if the number of the first ECCE of the received EPDCCH candidate is used for determining PUCCH resource for HARQ-ACK transmission (as described in subclause 10.1.2 and subclause 10.1.3), the number of the first ECCE shall be determined based on EPDCCH-PRB-set $p = 0$.

The variable $Y_{p,k}$ is defined by

$$Y_{p,k} = \left(A_p \cdot Y_{p,k-1}\right) \bmod D$$

where $Y_{p,-1} = n_{\text{RNTI}} \neq 0$, $A_0 = 39827$, $A_1 = 39829$, $D = 65537$ and $k = \lfloor n_s/2 \rfloor$, n_s is the slot number within a radio frame. The RNTI value used for n_{RNTI} is defined in subclause 7.1 in downlink and subclause 8 in uplink. The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in subclause 7.1.

If a UE is configured with higher layer parameter *disableDCIFormat0_1A* for a serving cell, the UE is not required to monitor the EPDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- the UE monitors EPDCCH UE-specific search space candidates on the Scell assuming they start in both the first slot and the second slot of a subframe.

The aggregation levels defining the search spaces and the number of monitored EPDCCH candidates is given as follows

- For a UE configured with only one EPDCCH-PRB-set for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-1a, Table 9.1.4-1b.
- For a UE configured with only one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-2a, Table 9.1.4-2b.
- For a UE configured with two EPDCCH-PRB-sets for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-3a, 9.1.4-3b.
- For a UE configured with two EPDCCH-PRB-sets for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-4a, 9.4.4-4b.
- For a UE configured with one EPDCCH-PRB-set for distributed transmission, and one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-5a, 9.1.4-5b.

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell on which EPDCCH is monitored. If the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell indicated by n_{CI}.

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For Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.4.4-4b, 9.1.4-5a, 9.1.4-5b

- Case 1 applies
  - for normal subframes and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\mathrm{RB}}^{\mathrm{DL}} \geq 25$, or
  - for special subframes with special subframe configuration 3,4,8 and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\mathrm{RB}}^{\mathrm{DL}} \geq 25$, or
  - for normal subframes and normal downlink CP when DCI formats 1A/1B/1D/1/2/2A/2B/2C/2D/0/4/5 are monitored, and when $n_{\mathrm{EPDCCH}} < 104$ (n_{EPDCCH} defined in subclause 6.8A.1 in [3]), or
  - for special subframes with special subframe configuration 3, 4, 8 and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/4/5 are monitored, and when $n_{\mathrm{EPDCCH}} < 104$ (n_{EPDCCH} defined in subclause 6.8A.1 in [3]);
- Case 2 applies
  - for normal subframes and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/4/5 are monitored or,
  - for special subframes with special subframe configuration 1,2,6,7,9 and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/4/5 are monitored , or
  - for special subframes with special subframe configuration 1,2,3,5,6 and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/4/5 are monitored;
- otherwise
  - Case 3 is applied.

$N_{\mathrm{RB}}^{X_p}$ is the number of PRB-pairs constituting EPDCCH-PRB-set p .

Table 9.1.4-1a: EPDCCH candidates monitored by a UE (One Distributed EPDCCH-PRB-set - Case1, Case 2)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 1					Number of EPDCCH candidates $M_p^{(L)}$ for Case 2				
	L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	4	2	1	0	0	4	2	1	0	0
4	8	4	2	1	0	8	4	2	1	0
8	6	4	3	2	1	6	4	3	2	1

Table 9.1.4-1b: EPDCCH candidates monitored by a UE (One Distributed EPDCCH-PRB-set – Case 3)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 3				
	L=1	L=2	L=4	L=8	L=16
2	8	4	2	1	0
4	4	5	4	2	1
8	4	4	4	2	2

Table 9.1.4-2a: EPDCCH candidates monitored by a UE (One Localized EPDCCH-PRB-set - Case1, Case 2)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 1				Number of EPDCCH candidates $M_p^{(L)}$ for Case 2			
	L=2	L=4	L=8	L=16	L=1	L=2	L=4	L=8

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2	4	2	1	0	4	2	1	0
4	8	4	2	1	8	4	2	1
8	6	6	2	2	6	6	2	2

Table 9.1.4-2b: EPDCCH candidates monitored by a UE (One Localized EPDCCH-PRB-set – Case 3)

$N_{RB}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 3			
	L=1	L=2	L=4	L=8
2	8	4	2	1
4	6	6	2	2
8	6	6	2	2

Table 9.1.4-3a: EPDCCH candidates monitored by a UE (Two Distributed EPDCCH-PRB-sets - Case1, Case 2)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1					Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2				
		L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	2	4,4	2,2	1,1	0,0	0,0	4,4	2,2	1,1	0,0	0,0
4	4	3,3	3,3	1,1	1,1	0,0	3,3	3,3	1,1	1,1	0,0
8	8	3,3	2,2	1,1	1,1	1,1	3,3	2,2	1,1	1,1	1,1
4	2	5,3	3,2	1,1	1,0	0,0	5,3	3,2	1,1	1,0	0,0
8	2	4,2	4,2	1,1	1,0	1,0	4,2	4,2	1,1	1,0	1,0
8	4	3,3	2,2	2,1	1,1	1,0	3,3	2,2	2,1	1,1	1,0

Table 9.1.4-3b: EPDCCH candidates monitored by a UE (Two Distributed EPDCCH-PRB-sets – Case 3)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3				
		L=1	L=2	L=4	L=8	L=16
2	2	2,2	3,3	2,2	1,1	0,0
4	4	2,2	2,2	2,2	1,1	1,1
8	8	2,2	2,2	2,2	1,1	1,1
4	2	3,1	3,2	3,1	1,1	1,0
8	2	3,1	4,1	3,1	1,1	1,0
8	4	2,2	2,2	2,2	1,1	1,1

Table 9.1.4-4a: EPDCCH candidates monitored by a UE (Two Localized EPDCCH-PRB-sets - Case1, Case 2)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1				Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2			
		L=2	L=4	L=8	L=16	L=1	L=2	L=4	L=8
2	2	4,4	2,2	1,1	0,0	4,4	2,2	1,1	0,0
4	4	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1
8	8	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1
4	2	4,3	4,2	1,1	1,0	4,3	4,2	1,1	1,0
8	2	5,2	4,2	1,1	1,0	5,2	4,2	1,1	1,0
8	4	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1

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Table 9.1.4-4b: EPDCCH candidates monitored by a UE (Two Localized EPDCCH-PRB-sets – Case 3)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3			
		L=1	L=2	L=4	L=8
2	2	3,3	3,3	1,1	1,1
4	4	3,3	3,3	1,1	1,1
8	8	3,3	3,3	1,1	1,1
4	2	4,2	4,2	1,1	1,1
8	2	4,2	4,2	1,1	1,1
8	4	3,3	3,3	1,1	1,1

Table 9.1.4-5a: EPDCCH candidates monitored by a UE (NOTE)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1					Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2				
		L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	2	4,4	2,2	1,1	0,0	0,0	4,4	2,2	1,1	0,0	0,0
4	4	4,2	4,3	0,2	0,1	0,0	4,2	4,3	0,2	0,1	0,0
8	8	4,1	4,2	0,2	0,2	0,1	4,1	4,2	0,2	0,2	0,1
2	4	4,3	2,4	0,2	0,1	0,0	4,3	2,4	0,2	0,1	0,0
2	8	4,1	2,2	0,4	0,2	0,1	4,1	2,2	0,4	0,2	0,1
4	2	5,2	4,2	1,1	1,0	0,0	5,2	4,2	1,1	1,0	0,0
4	8	4,1	4,2	0,2	0,2	0,1	4,1	4,2	0,2	0,2	0,1
8	2	5,1	4,2	2,1	1,0	0,0	5,1	4,2	2,1	1,0	0,0
8	4	6,1	4,2	0,2	0,1	0,0	6,1	4,2	0,2	0,1	0,0

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set, - Case1, Case 2;
p_1 is the identity of the localized EPDCCH-PRB-set,
p_2 is the identity of the distributed EPDCCH-PRB-set

Table 9.1.4-5b: EPDCCH candidates monitored by a UE (NOTE)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3				
		L=1	L=2	L=4	L=8	L=16
2	2	4,1	4,2	2,2	0,1	0,0
4	4	4,1	4,1	2,2	0,1	0,1
8	8	4,1	4,1	2,2	0,1	0,1
2	4	4,1	4,1	2,2	0,1	0,1
2	8	4,1	4,1	2,2	0,1	0,1
4	2	4,1	4,1	2,2	1,1	0,0
4	8	4,1	4,1	2,2	0,1	0,1
8	2	4,1	4,1	4,1	0,1	0,0
8	4	4,1	4,1	2,2	0,1	0,1

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set - Case 3);
p_1 is the identity of the localized EPDCCH-PRB-set,
p_2 is the identity of the distributed EPDCCH-PRB-set)

If the UE is not configured with a carrier indicator field, then the UE shall monitor one EPDCCH UE-specific search space at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on each activated serving cell for which it is configured to monitor EPDCCH.

If a UE is configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more EPDCCH UE-specific search spaces at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on one or more activated serving cells as configured by higher layer signalling.

A UE configured with the carrier indicator field associated with monitoring EPDCCH on serving cell c shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the EPDCCH UE specific search space of serving cell c.

A UE configured with the carrier indicator field associated with monitoring EPDCCH on the primary cell shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI in the EPDCCH UE specific search space of the primary cell.

For the serving cell on which EPDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the EPDCCH UE specific search space for EPDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the EPDCCH UE specific search space for EPDCCH with carrier indicator field.

A UE is not expected to monitor the EPDCCH of a secondary cell if it is configured to monitor EPDCCH with carrier indicator field corresponding to that secondary cell in another serving cell. For the serving cell on which EPDCCH is monitored, the UE shall monitor EPDCCH candidates at least for the same serving cell.

A UE configured to monitor EPDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the EPDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that an EPDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any EPDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

For the serving cell on which EPDCCH is monitored, a UE is not required to monitor the EPDCCH in a subframe which is configured by higher layers to be part of a positioning reference signal occasion if the positioning reference signal occasion is only configured within MBSFN subframes and the cyclic prefix length used in subframe #0 is normal cyclic prefix.

A UE may assume the same c_{init} value (described in subclause 6.10.3A.1 of [3]) is used for antenna ports 107,108 while monitoring an EPDCCH candidate associated with either antenna port 107 or antenna port 108.
A UE may assume the same c_{init} value (described in subclause 6.10.3A.1 of [3]) is used for antenna ports 109,110 while monitoring an EPDCCH candidate associated with either antenna port 109 or antenna port 110.

9.1.4.1 EPDCCH starting position

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9,

- if the UE is configured with a higher layer parameter *epdcch-StartSymbol-r11*,
  - the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStart}}$ is determined from the higher layer parameter,
- otherwise
  - the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{EPDCCHStart}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \le 10$

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, for each EPDCCH-PRB-set, the starting OFDM symbol for monitoring EPDCCH in subframe k is determined from the higher layer parameter *pdsch-Start-r11* (defined in subclause 9.1.4.3) as follows

- if the value of the parameter *pdsch-Start-r11* belongs to {1,2,3,4},
  - $l'_{EPDCCHStart}$ is given by the higher layer parameter *pdsch-Start-r11*
- otherwise

- $l'_{EPDCCHStart}$ is given by the CFI value in subframe k of the given serving cell when $N_{RB}^{DL} > 10$, and $l'_{EPDCCHStart}$ is given by the CFI value+1 in subframe k of the given serving cell when $N_{RB}^{DL} \leq 10$

- if subframe k is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* (defined in subclause 9.1.4.3), or if subframe k is subframe 1 or 6 for frame structure type 2,
  - $l_{EPDCCHStart} = \min(2, l'_{EPDCCHStart})$,
- otherwise
  - $l_{EPDCCHStart} = l'_{EPDCCHStart}$.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- for monitoring EPDCCH candidates starting in the first slot of the subframe, the starting OFDM symbol for EPDCCH given by index $l_{EPDCCHStart}$ in the first slot in a subframe;
- for monitoring EPDCCH candidates starting in the second slot of the subframe, the starting OFDM symbol for EPDCCH given by index $l_{EPDCCHStart}$ in the second slot in a subframe;

otherwise

- the starting OFDM symbol for EPDCCH given by index $l_{EPDCCHStart}$ in the first slot in a subframe.

9.1.4.2 Antenna ports quasi co-location for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9, and if the UE is configured to monitor EPDCCH,

- the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set,

- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-A as described in subclause 7.1.10
  - the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.
- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-B as described in subclause 7.1.10
  - the UE may assume antenna ports 15 – 22 corresponding to the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* (defined in subclause 9.1.4.3) and antenna ports 107-110 are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.1.4.3 Resource mapping parameters for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set, the UE shall use the parameter set indicated by the higher layer parameter *re-MappingQCL-ConfigId-r11* for determining the EPDCCH RE mapping (defined in subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location. The following parameters for determining EPDCCH RE mapping (as described in subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location are included in the parameter set:

- *crs-PortsCount-r11.*
- *crs-FreqShift-r11.*
- *mbsfn-SubframeConfigList-r11.*

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- *csi-RS-ConfigZPId-r11.*
- *pdsch-Start-r11.*
- *qcl-CSI-RS-ConfigNZPId-r11.*
- *csi-RS-ConfigZPId2-r12* if the UE is configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubframePatternConfig-r12* for the serving cell or the UE is configured with higher layer parameter *CSI-Reporting-Type* for TDD serving cell.

9.1.4.4 PRB-pair indication for EPDCCH

For a given serving cell, for each EPDCCH-PRB-pair set p, the UE is configured with a higher layer parameter *resourceBlockAssignment-r11* indicating a combinatorial index r corresponding to the PRB index $\{k_i\}_{i=0}^{N_{RB}^{X_p}-1}$, ($1 \le k_i \le N_{RB}^{DL}$, $k_i < k_{i+1}$) and given by equation $r = \sum_{i=0}^{N_{RB}^{X_p}-1} \left\langle N_{RB}^{DL} - k_i \atop N_{RB}^{X_p} - i \right\rangle$, where N_{RB}^{DL} is the number of PRB pairs associated with the downlink bandwidth, $N_{\mathrm{RB}}^{X_p}$ is the number of PRB-pairs constituting EPDCCH-PRB-set p, and is configured by the higher layer parameter *numberPRBPairs-r11*, and $\left\langle x \atop y \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label $r \in \left\{0,\ldots,\binom{N_{RB}^{DL}}{N_{RB}^{X_p}} - 1\right\}$.

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9.2 PDCCH/EPDCCH validation for semi-persistent scheduling

A UE shall validate a Semi-Persistent Scheduling assignment PDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the PDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

A UE shall validate a Semi-Persistent Scheduling assignment EPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the EPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

Validation is achieved if all the fields for the respective used DCI format are set according to Table 9.2-1 or Table 9.2-1A.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid semi-persistent activation or release.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 9.2-1: Special fields for Semi-Persistent Scheduling Activation PDCCH/EPDCCH Validation

	DCI format 0	DCI format 1/1A	DCI format 2/2A/2B/2C/2D
TPC command for scheduled PUSCH	set to '00'	N/A	N/A
Cyclic shift DM RS	set to '000'	N/A	N/A
Modulation and coding scheme and redundancy version	MSB is set to '0'	N/A	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	MSB is set to '0'	For the enabled transport block: MSB is set to '0'
Redundancy version	N/A	set to '00'	For the enabled transport block: set to '00'

Table 9.2-1A: Special fields for Semi-Persistent Scheduling Release PDCCH/EPDCCH Validation

	DCI format 0	DCI format 1A
TPC command for scheduled PUSCH	set to '00'	N/A
Cyclic shift DM RS	set to '000'	N/A
Modulation and coding scheme and redundancy version	set to '11111'	N/A
Resource block assignment and hopping resource allocation	Set to all '1's	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	set to '11111'
Redundancy version	N/A	set to '00'
Resource block assignment	N/A	Set to all '1's

For the case that the DCI format indicates a semi-persistent downlink scheduling activation, the TPC command for PUCCH field shall be used as an index to one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 9.2-2

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Table 9.2-2: PUCCH resource value for downlink semi-persistent scheduling

Value of 'TPC command for PUCCH'	$n_{PUCCH}^{(1,p)}$
'00'	The first PUCCH resource value configured by the higher layers
'01'	The second PUCCH resource value configured by the higher layers
'10'	The third PUCCH resource value configured by the higher layers
'11'	The fourth PUCCH resource value configured by the higher layers

9.3 PDCCH/EPDCCH control information procedure

A UE shall discard the PDCCH/EPDCCH if consistent control information is not detected.

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10 Physical uplink control channel procedures

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.
- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If the UE is configured with a PUCCH-SCell, the UE shall apply the procedures described in this clause for both primary PUCCH group and secondary PUCCH group

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the primary PUCCH group respectively.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

10.1 UE procedure for determining physical uplink control channel assignment

If the UE is configured for a single serving cell and is not configured for simultaneous PUSCH and PUCCH transmissions, then in subframe n uplink control information (UCI) shall be transmitted

- on PUCCH using format 1/1a/1b/3 or 2/2a/2b if the UE is not transmitting PUSCH
- on PUSCH if the UE is transmitting PUSCH in subframe n unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted

If the UE is configured for a single serving cell and simultaneous PUSCH and PUCCH transmission, then in subframe n UCI shall be transmitted

- on PUCCH using format 1/1a/1b/3 if the UCI consists only of HARQ-ACK and/or SR
- on PUCCH using format 2 if the UCI consists only of periodic CSI
- on PUCCH using format 2/2a/2b/3 if the UCI consists of periodic CSI and HARQ-ACK and if the UE is not transmitting PUSCH
- on PUCCH and PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and periodic/aperiodic CSI and if the UE is transmitting PUSCH in subframe n, in which case the HARQ-ACK/HARQ-ACK+SR/positive SR is transmitted on PUCCH using format 1/1a/1b/3 and the periodic/aperiodic CSI transmitted on PUSCH unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case periodic/aperiodic CSI is not transmitted

If the UE is configured with more than one serving cell and is not configured for simultaneous PUSCH and PUCCH transmission, then in subframe n UCI shall be transmitted

- on PUCCH using format 1/1a/1b/3/4/5 or 2/2a/2b if the UE is not transmitting PUSCH

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- on PUSCH of the serving cell given in subclause 7.2.1 if the UCI consists of aperiodic CSI or aperiodic CSI and HARQ-ACK
- on primary cell PUSCH if the UCI consists of periodic CSI and/or HARQ-ACK and if the UE is transmitting on the primary cell PUSCH in subframe n unless the primary cell PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted
- on PUSCH of the secondary cell with smallest *SCellIndex* if the UCI consists of periodic CSI and/or HARQ-ACK and if the UE is not transmitting PUSCH on primary cell but is transmitting PUSCH on at least one secondary cell

If the UE is configured with more than one serving cell and simultaneous PUSCH and PUCCH transmission, then in subframe n UCI shall be transmitted

- on PUCCH using format 1/1a/1b/3 if the UCI consists only of HARQ-ACK and/or SR
- on PUCCH using format 4/5 if the UCI consists only of HARQ-ACK and/or SR and/or periodic CSI
- on PUCCH using format 2 if the UCI consists only of periodic CSI corresponding to one serving cell
- as described in subclause 10.1.1, if the UCI consists of periodic CSI and HARQ-ACK and if the UE is not transmitting on PUSCH
- on PUCCH and primary cell PUSCH if the UCI consists of HARQ-ACK and periodic CSI and the UE is transmitting PUSCH on the primary cell, in which case the HARQ-ACK is transmitted on PUCCH using format 1a/1b/3 and the periodic CSI is transmitted on PUSCH unless the primary cell PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case periodic CSI is not transmitted
- on PUCCH and PUSCH of the secondary cell with the smallest *SCellIndex* if the UCI consists of HARQ-ACK and periodic CSI and if the UE is not transmitting PUSCH on primary cell but is transmitting PUSCH on at least one secondary cell, in which case, the HARQ-ACK is transmitted on PUCCH using format 1a/1b/3 and the periodic CSI is transmitted on PUSCH
- on PUCCH and PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and aperiodic CSI in which case the HARQ-ACK/HARQ-ACK+SR/positive SR is transmitted on PUCCH using format 1/1a/1b/3 and the aperiodic CSI is transmitted on PUSCH of the serving cell given in subclause 7.2.1

If the UE is configured with more than one serving cell, then reporting prioritization and collision handling of periodic CSI reports of a certain PUCCH reporting type is given in subclause 7.2.2.

A UE transmits PUCCH only on the primary cell.

A UE is configured by higher layers to transmit PUCCH on one antenna port $(p = p_0)$ or two antenna ports $(p \in [p_0, p_1])$. PUCCH format 4 and PUCCH format 5 can only be transmitted on one antenna port $(p = p_0)$.

For FDD or FDD-TDD and primary cell frame structure 1, with two configured serving cells and PUCCH format 1b with channel selection or for FDD with two or more configured serving cells and PUCCH format 3 and without PUCCH format 4/5 configured, $n_{\mathrm{HARQ}} = \sum_{c=0}^{N_{cells}^{DL}-1} N_c^{\mathrm{received}}$ where N_{cells}^{DL} is the number of configured cells and N_c^{received} is the number of transport blocks or the SPS release PDCCH/EPDCCH, if any, received in subframe $n-4$ in serving cell c.

For TDD and a UE not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell, if a UE is configured with one serving cell, or the UE is configured with more than one serving cell and the UL/DL configurations of all serving cells are the same, then

- For TDD with two configured serving cells and PUCCH format 1b with channel selection and a subframe n with $M = 1$, or for TDD UL/DL configuration 0 and PUCCH format 3, $n_{\mathrm{HARQ}} = \sum_{c=0}^{N_{cells}^{DL}-1} \sum_{k \in K} N_{k,c}^{\mathrm{received}}$, where

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$N_{k,c}^{\text{received}}$ is the number of transport blocks or the SPS release PDCCH/EPDCCH, if any, received in subframe $n-k$ in serving cell c, where $k \in K$, and M is the number of elements in K.

- For TDD UL/DL configurations 1-6 and PUCCH format 3 and without PUCCH format 4/5 configured, or for TDD with two configured serving cells and PUCCH format 1b with channel selection and $M = 2$, $n_{\text{HARQ}} = \sum_{c=0}^{N_{cells}^{DL}-1}\left(\left(V_{\text{DAI},c}^{\text{DL}} - U_{\text{DAI},c}\right) \bmod 4\right) \cdot n_c^{\text{ACK}} + \sum_{k \in K} N_{k,c}^{\text{received}}$ where $V_{\text{DAI},c}^{\text{DL}}$ is the $V_{\text{DAI}}^{\text{DL}}$ in serving cell c, $U_{\text{DAI},c}$ is the U_{DAI} in serving cell c, and n_c^{ACK} is the number of HARQ-ACK bits corresponding to the configured DL transmission mode on serving cell c. In case spatial HARQ-ACK bundling is applied, $n_c^{\text{ACK}} = 1$ and $N_{k,c}^{\text{received}}$ is the number of PDCCH/EPDCCH or PDSCH without a corresponding PDCCH/EPDCCH received in subframe $n-k$ and serving cell c, where $k \in K$ and M is the number of elements in K. In case spatial HARQ-ACK bundling is not applied, $N_{k,c}^{\text{received}}$ is the number of transport blocks received or the SPS release PDCCH/EPDCCH received in subframe $n-k$ in serving cell c, where $k \in K$ and M is the number of elements in K. $V_{\text{DAI},c}^{\text{DL}}$ =0 if no transport block or SPS release PDCCH/EPDCCH is detected in subframe(s) $n-k$ in serving cell c, where $k \in K$.
- For TDD with two configured serving cells and PUCCH format 1b with channel selection and $M = 3$ or 4, $n_{\text{HARQ}} = 2$ if UE receives PDSCH or PDCCH/EPDCCH indicating downlink SPS release only on one serving cell within subframes $n-k$,where $k \in K$;otherwise $n_{\text{HARQ}} = 4$.

For TDD if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and primary cell frame structure 2, then

- For PUCCH format 3 without PUCCH format 4/5 configured, or for two configured serving cells and PUCCH format 1b with channel selection and $M \le 2$ (defined in subclause 10.1.3.2.1 for TDD and subclause 10.1.3A for FDD-TDD), $n_{\text{HARQ}} = \sum_{c=0}^{N_{cells}^{DL}-1}\left(\left(V_{\text{DAI},c}^{\text{DL}} - U_{\text{DAI},c}\right) \bmod 4\right) \cdot n_c^{\text{ACK}} + \sum_{k \in K} N_{k,c}^{\text{received}}$ where $V_{\text{DAI},c}^{\text{DL}}$ is the $V_{\text{DAI}}^{\text{DL}}$ in serving cell c, $U_{\text{DAI},c}$ is the U_{DAI} in serving cell c, and n_c^{ACK} is the number of HARQ-ACK bits corresponding to the configured DL transmission mode on serving cell c. In case spatial HARQ-ACK bundling is applied, $n_c^{\text{ACK}} = 1$ and $N_{k,c}^{\text{received}}$ is the number of PDCCH/EPDCCH or PDSCH without a corresponding PDCCH/EPDCCH received in subframe $n-k$ and serving cell c, where $k \in K$ and $K = K_c$ (defined in subclause 7.3.2.2 for TDD and subclause 7.3.4 for FDD-TDD). In case spatial HARQ-ACK bundling is not applied, $N_{k,c}^{\text{received}}$ is the number of transport blocks received or the SPS release PDCCH/EPDCCH received in subframe $n-k$ in serving cell c, where $k \in K$ and $K = K_c$ (defined in subclause 7.3.2.2 for TDD and subclause 7.3.4 for FDD-TDD). $V_{\text{DAI},c}^{\text{DL}}$ =0 if no transport block or SPS release PDCCH/EPDCCH is detected in subframe(s) $n-k$ in serving cell c, where $k \in K$ and $K = K_c$ (defined in subclause 7.3.2.2 for TDD and subclause 7.3.4 for FDD-TDD). For a serving cell c, set $V_{\text{DAI},c}^{\text{DL}} = U_{\text{DAI},c}$ if the DL-reference UL/DL configuration (defined in subclause 10.2) for serving cell c is TDD UL/DL configuration 0,
- For two configured serving cells and PUCCH format 1b with channel selection and $M = 3$ or 4 (defined in subclause 10.1.3.2.1 for TDD and subclause 10.1.3A for FDD-TDD), $n_{\text{HARQ}} = 2$ if UE receives PDSCH or PDCCH/EPDCCH indicating downlink SPS release only on one serving cell within subframes $n-k$,where $k \in K$ and $K = K_c$ (defined in subclause 7.3.2.2 for TDD and subclause 7.3.4 for FDD-TDD); otherwise $n_{\text{HARQ}} = 4$.

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Throughout the following subclauses, subframes are numbered in monotonically increasing order; if the last subframe of a radio frame is denoted as k, the first subframe of the next radio frame is denoted as $k+1$.

Throughout the following subclauses, if the UE is configured with higher layer parameter *n1PUCCH-AN-r11* then $N_{\mathrm{PUCCH}}^{(1)}$ is given by *n1PUCCH-AN-r11*, else $N_{\mathrm{PUCCH}}^{(1)}$ is given by higher layer parameter *n1PUCCH-AN*.

10.1.1 PUCCH format information

Using the PUCCH formats defined in subclause 5.4.1 and 5.4.2 in [3], the following combinations of UCI on PUCCH are supported:

- Format 1a for 1-bit HARQ-ACK or in case of FDD or FDD-TDD primary cell frame structure type 1 for 1-bit HARQ-ACK with positive SR.
- Format 1b for 2-bit HARQ-ACK or for 2-bit HARQ-ACK with positive SR.
- Format 1b for up to 4-bit HARQ-ACK with channel selection when the UE is configured with more than one serving cell or, in the case of TDD, when the UE is configured with a single serving cell.
- Format 1 for positive SR.
- Format 2 for a CSI report when not multiplexed with HARQ-ACK.
- Format 2a for a CSI report multiplexed with 1-bit HARQ-ACK for normal cyclic prefix.
- Format 2b for a CSI report multiplexed with 2-bit HARQ-ACK for normal cyclic prefix.
- Format 2 for a CSI report multiplexed with HARQ-ACK for extended cyclic prefix.
- Format 3 for up to 10-bit HARQ-ACK for FDD or FDD-TDD primary cell frame structure type 1 and for up to 20-bit HARQ-ACK for TDD and for up to 21 bit HARQ-ACK for FDD-TDD primary cell frame structure type 2.
- Format 3 for up to 11-bit corresponding to 10-bit HARQ-ACK and 1-bit positive/negative SR for FDD or FDD-TDD and for up to 21-bit corresponding to 20-bit HARQ-ACK and 1-bit positive/negative SR for TDD and for up to 22-bit corresponding to 21-bit HARQ-ACK and 1-bit positive/negative SR for FDD-TDD primary cell frame structure type 2.
- Format 3 for HARQ-ACK, 1-bit positive/negative SR (if any) and a CSI report for one serving cell.
- Format 4 for more than 22 bits of UCI including HARQ-ACK and/or SR and/or periodic CSI.
- Format 5 for more than 22 bits of UCI including HARQ-ACK and/or SR and/or periodic CSI.

For a UE configured with PUCCH format 3 without PUCCH format 4/5 configured and HARQ-ACK transmission on PUSCH or using PUCCH format 3, or for a UE configured with two serving cells and PUCCH format 1b with channel selection and HARQ-ACK transmission on PUSCH, or for UE configured with one serving cell and PUCCH format 1b with channel selection according to Tables 10.1.3-5, 10.1.3-6, 10.1.3-7 and HARQ-ACK transmission on PUSCH or for a UE configured with PUCCH format 4/5 and HARQ-ACK transmission on PUSCH or using PUCCH format 3/4/5:

- if the configured downlink transmission mode for a serving cell supports up to 2 transport blocks and only one transport block is received in a subframe, the UE shall generate a NACK for the other transport block if spatial HARQ-ACK bundling is not applied.
- if neither PDSCH nor PDCCH/EPDCCH indicating downlink SPS release is detected in a subframe for a serving cell, the UE shall generate two NACKs when the configured downlink transmission mode supports up to 2 transport blocks and the UE shall generate a single NACK when the configured downlink transmission mode supports a single transport block.
- if a UE is configured with PUCCH format 4/5 and if the UE is configured with a transmission mode supporting two transport blocks in at least one serving cell, for a serving cell configured with a transmission mode supporting one transport block, the HARQ-ACK response is assumed to be associated with the first codeword. The UE shall generate a NACK for the second codeword if spatial bundling is not applied, and shall generate the same HARQ-ACK respond for the second codeword as that for the first codeword if spatial bundling is applied.

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The scrambling initialization of PUCCH format 2, 2a, 2b,3, 4 and 5 is by C-RNTI.

For a UE that is configured with a single serving cell and is not configured with PUCCH format 3, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, the periodic CSI report is multiplexed with HARQ-ACK on PUCCH if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, otherwise the CSI is dropped.

For TDD and for a UE that is configured with a single serving cell and with PUCCH format 3, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* or if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*, the periodic CSI report is multiplexed with HARQ-ACK or dropped as described in subclause 7.3, otherwise the CSI is dropped.

For FDD or for FDD-TDD and primary cell frame structure type 1 and for a UE that is configured with more than one serving cell and without PUCCH format 4/5 configured, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH,

- if the parameter simultaneousAckNackAndCQI provided by higher layers is set TRUE and if the HARQ-ACK corresponds to a PDSCH transmission or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell,

  then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using PUCCH format 2/2a/2b

- else if the UE is configured with PUCCH format 3 and if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*, and if PUCCH resource is determined according to subclause 10.1.2.2.2, and

  - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22 or

  - if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

    then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using the determined PUCCH format 3 resource according to [4]

- otherwise,

  CSI is dropped.

For FDD or for FDD-TDD and primary cell frame structure type 1, for a UE configured with PUCCH format 4 or PUCCH format 5, if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe,

- if a PUCCH format 3 is determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.3 or 10.1.2.2.4, the UE shall use the determined PUCCH format 3 for transmission of the HARQ-ACK/SR and periodic CSI report(s);

- if a PUCCH format 4 is determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.3 or a PUCCH format 5 is determined to transmit the HARQ-ACK/SR according to 10.1.2.2.4, the UE shall used the determined PUCCH format 4 or PUCCH format 5 for transmission of the HARQ-ACK/SR and periodic CSI;

- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.3 and there is no PUCCH format 5 determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.4 and there are more than one periodic CSI report in the subframe,

  - if the UE is configured with a single PUCCH format 4 resource $n^{(4)}_{\text{PUCCH}}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, the PUCCH format 4 resource $n^{(4)}_{\text{PUCCH}}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);

  - if the UE is configured with a PUCCH format 5 resource $n^{(5)}_{\text{PUCCH}}$ according to higher layer parameter *format5-MultiCSI-resourceConfiguration*, the PUCCH format 5 resource $n^{(5)}_{\text{PUCCH}}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);

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- if the UE is configured with two PUCCH format 4 resources $n^{(4)}_{\text{PUCCH},1}$ and $n^{(4)}_{\text{PUCCH},2}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right)\le \min\left(M^{\text{PUCCH4}}_{\text{RB},1}, M^{\text{PUCCH4}}_{\text{RB},2}\right)\cdot N^{RB}_{sc}\cdot N^{\text{PUCCH4}}_{\text{symb}}\cdot r$, the PUCCH format 4 resource with the smaller $M^{\text{PUCCH4}}_{\text{RB},i}$ between $n^{(4)}_{\text{PUCCH},1}$ and $n^{(4)}_{\text{PUCCH},2}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s); otherwise, the PUCCH format 4 resource with the larger $M^{\text{PUCCH4}}_{\text{RB},i}$ between $n^{(4)}_{\text{PUCCH},1}$ and $n^{(4)}_{\text{PUCCH},2}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s), where
  - O^{ACK} is the total number of HARQ-ACK bits in the subframe;
  - $O^{SR}=0$ if there no scheduling request bit in the subframe and $O^{SR}=1$ otherwise
  - $O_{\text{P-CSI}}$ is the total number of CSI report bits in the subframe;
  - $M^{\text{PUCCH4}}_{\text{RB},i}$, $i=1,2$, is the number of PRBs for $n^{(4)}_{\text{PUCCH},1}$ and $n^{(4)}_{\text{PUCCH},2}$ respectively, according to higher layer parameter *numberOfPRB-format4-r13* according to Table 10.1.1-2;
  - $N^{\text{PUCCH4}}_{\text{symb}}=2\cdot\left(N^{\text{UL}}_{\text{symb}}-1\right)-1$ if shortened PUCCH format 4 is used in the subframe and $N^{\text{PUCCH4}}_{\text{symb}}=2\cdot\left(N^{\text{UL}}_{\text{symb}}-1\right)$ otherwise; and
  - r is the code rate given by higher layer parameter *maximumPayloadCoderate-r13* according to Table 10.1.1-2.
- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.3 and there is no PUCCH format 5 determined to transmit the HARQ-ACK/SR according to subclause 10.1.2.2.4 and there are only one periodic CSI report in the subframe,
  - if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* and if the HARQ-ACK corresponds to a PDSCH transmission or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell, then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using PUCCH format 2/2a/2b
  - else, the UE shall drop the CSI and transmit the HARQ-ACK according to subclause 10.1.2.2.3 or 10.1.2.2.4.
- If a UE transmits HARQ-ACK/SR and periodic CSI report(s) using either a PUCCH format 4 $n^{(4)}_{\text{PUCCH}}$ or PUCCH format 5 $n^{(5)}_{\text{PUCCH}}$ in a subframe
  - if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right)\le N_{\text{RE}}\cdot r$, the UE shall transmit the HARQ-ACK/SR and periodic CSI bits using the PUCCH format 4 $n^{(4)}_{\text{PUCCH}}$ or the PUCCH format 5 $n^{(5)}_{\text{PUCCH}}$;
  - if $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}\right)> N_{\text{RE}}\cdot r$, the UE shall select $N_{\text{CSI,reported}}$ CSI report(s) for transmission together with HARQ-ACK/SR in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$, where $\text{Pri}_{CSI}(y,s,c,t)$, N_{RE} and r are determined according to subclause 7.2.2; the value of $N_{\text{CSI,reported}}$ satisfies $\left(O^{ACK}+O^{SR}+\sum_{n=1}^{N_{\text{CSI,reported}}}O_{P-CSI,n}\right)\le N_{\text{RE}}\cdot r$ and $\left(O^{ACK}+O^{SR}+\sum_{n=1}^{N_{\text{CSI,reported}}+1}O_{P-CSI,n}\right)> N_{\text{RE}}\cdot r$, and $O_{P-CSI,n}$ is the number of CSI report bits for the nth CSI report in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$.

For FDD or for FDD-TDD and primary cell frame structure type 1, for a UE configured with PUCCH format 4 or PUCCH format 5, if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *FALSE*, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe, the UE behaviour follows that.

For TDD or for FDD-TDD and primary cell frame structure type 2 and for a UE that is configured with more than one serving cell, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* or if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE* or if the parameter

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simultaneousAckNackAndCQI-Format4-Format5-r13 provided by higher layers is set *TRUE*, the periodic CSI report is multiplexed with HARQ-ACK or dropped as described in subclause 7.3, otherwise the CSI is dropped.

For a UE not configured with PUCCH format 4/5, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe with PUSCH, the periodic CSI is multiplexed with the HARQ-ACK in the PUSCH transmission in that subframe if the UE is not configured by higher layers for simultaneous PUCCH and PUSCH transmissions. Otherwise, if the UE is configured by higher layers for simultaneous PUCCH and PUSCH transmissions, the HARQ-ACK is transmitted in the PUCCH and the periodic CSI is transmitted in the PUSCH.

If each of the serving cells configured for the UE has frame structure type 1, UE procedures for HARQ-ACK feedback are given in subclause 10.1.2.

If each of the serving cells configured for the UE has frame structure type 2, UE procedures for HARQ-ACK feedback are given in subclause 10.1.3.

If the UE is configured for more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 1, UE procedure for HARQ-ACK feedback is given in subclause 10.1.2A.

If the UE is configured for more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 2, UE procedure for HARQ-ACK feedback is given in subclause 10.1.3A.

Table 10.1.1-1: code rate r corresponding to higher layer parameter *maximumPayloadCoderate-r13*

Value of *maximumPayloadCoderate-r13*	Code rate r
0	
1	
2	
3	
4	
5	
6	
7	

Table 10.1.1-2: Number of PRBs for PUCCCH format 4 M_{RB}^{PUCCH4} corresponding to higher layer parameter *numberOfPRB-format4-r13*

Value of *numberOfPRB-format4-r13*	M_{RB}^{PUCCH4}
0	
1	
2	
3	
4	
5	
6	
7	

10.1.2 FDD HARQ-ACK feedback procedures

For FDD and for a UE not configured with PUCCH format 4/5 and transmitting HARQ-ACK using PUCCH format 1b with channel selection or PUCCH format 3, the UE shall determine the number of HARQ-ACK bits, O, based on the number of configured serving cells and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that support up to two transport blocks; and one HARQ-ACK bit otherwise.

A UE that supports aggregating at most 2 serving cells with frame structure type 1 shall use PUCCH format 1b with channel selection for transmission of HARQ-ACK when configured with more than one serving cell with frame structure type 1.

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A UE that supports aggregating more than 2 serving cells with frame structure type 1 is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK when configured with more than one serving cell with frame structure type 1.

The FDD HARQ-ACK feedback procedure for one configured serving cell is given in subclause 10.1.2.1 and procedures for more than one configured serving cell are given in subclause 10.1.2.2.

10.1.2.1 FDD HARQ-ACK procedure for one configured serving cell

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1a/1b.

For FDD and one configured serving cell, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for $\tilde{p}$ mapped to antenna port p for PUCCH format 1a/1b [3], where

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n-4$, or for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$, the UE shall use $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding DCI assignment and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers. For two antenna port transmission the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.
- for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.
- for a PDSCH transmission indicated by the detection of a corresponding EPDCCH in subframe $n-4$, or for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$, the UE shall use
  - if EPDCCH-PRB-set q is configured for distributed transmission
    $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE,q}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$
  - if EPDCCH-PRB-set q is configured for localized transmission
    $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + n' + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$

    for antenna port p_0, where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N_{\text{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in subclause 6.8A.5 in [3]. For two antenna port transmission the PUCCH resource for antenna port p_1 is given by
  - if EPDCCH-PRB-set q is configured for distributed transmission
    $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{ECCE,q}} + 1 + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$

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- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

Table 10.1.2.1-1: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D to Δ_{ARO} values

ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D	Δ_{ARO}
0	0
1	-1
2	-2
3	2

10.1.2.2 FDD HARQ-ACK procedures for more than one configured serving cell

The FDD HARQ-ACK feedback procedures for more than one configured serving cell are either based on a PUCCH format 1b with channel selection HARQ-ACK procedure as described in subclause 10.1.2.2.1 or a PUCCH format 3 HARQ-ACK procedure as described in subclause 10.1.2.2.2 or a PUCCH format 4 HARQ-ACK procedure as described in subclause 10.1.2.2.3 or a PUCCH format 5 HARQ-ACK procedure as described in subclause 10.1.2.2.4.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and FDD with two configured serving cells.

10.1.2.2.1 PUCCH format 1b with channel selection HARQ-ACK procedure

For two configured serving cells and PUCCH format 1b with channel selection, the UE shall transmit $b(0)b(1)$ on PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ for $\tilde{p}$ mapped to antenna port p using PUCCH format 1b where

- $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} = n_{\mathrm{PUCCH}}^{(1)}$ for antenna port p_0 where $n_{\mathrm{PUCCH}}^{(1)}$ is selected from A PUCCH resources, $n_{\mathrm{PUCCH},j}^{(1)}$ where $0 \le j \le A-1$ and $A \in \{2,3,4\}$, according to Table 10.1.2.2.1-3, Table 10.1.2.2.1-4, Table 10.1.2.2.1-5 in subframe n. HARQ-ACK(j) denotes the ACK/NACK/DTX response for a transport block or SPS release PDCCH/EPDCCH associated with serving cell c, where the transport block and serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.2.2.1-1.
- $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, where $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ is selected from A PUCCH resources, $n_{\mathrm{PUCCH},j}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \le j \le A-1$ and $A \in \{2,3,4\}$, according to Table 10.1.2.2.1-3, Table 10.1.2.2.1-4, Table 10.1.2.2.1-5 by replacing $n_{\mathrm{PUCCH}}^{(1)}$ with $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ and replacing $n_{\mathrm{PUCCH},j}^{(1)}$ with $n_{\mathrm{PUCCH},j}^{(1,\tilde{p}_1)}$ in subframe n, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

A UE configured with a transmission mode that supports up to two transport blocks on serving cell, c, shall use the same HARQ-ACK response for both the transport blocks in response to a PDSCH transmission with a single transport block or a PDCCH/EPDCCH indicating downlink SPS release associated with the serving cell c.

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Table 10.1.2.2.1-1: Mapping of Transport Block and Serving Cell to HARQ-ACK(*j*) for PUCCH format 1b HARQ-ACK channel selection

A	*HARQ-ACK(j)*			
	HARQ-ACK(0)	HARQ-ACK(1)	HARQ-ACK(2)	HARQ-ACK(3)
2	TB1 Primary cell	TB1 Secondary cell	NA	NA
3	TB1 Serving cell1	TB2 Serving cell1	TB1 Serving cell2	NA
4	TB1 Primary cell	TB2 Primary cell	TB1 Secondary cell	TB2 Secondary cell

The UE shall determine the A PUCCH resources, $n^{(1)}_{\mathrm{PUCCH},j}$ associated with HARQ-ACK(j) where $0 \le j \le A-1$ in Table 10.1.2.2.1-1, according to

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n-4$ on the primary cell, or for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the PUCCH resource is $n^{(1)}_{\mathrm{PUCCH,j}} = n_{\mathrm{CCE}} + N^{(1)}_{\mathrm{PUCCH}}$, and for transmission mode that supports up to two transport blocks, the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},j+1}$ is given by $n^{(1)}_{\mathrm{PUCCH},j+1} = n_{\mathrm{CCE}} + 1 + N^{(1)}_{\mathrm{PUCCH}}$ where n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH and $N^{(1)}_{\mathrm{PUCCH}}$ is configured by higher layers.
- for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the value of $n^{(1)}_{\mathrm{PUCCH},j}$ is determined according to higher layer configuration and Table 9.2-2. For transmission mode that supports up to two transport blocks, the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},j+1}$ is given by $n^{(1)}_{\mathrm{PUCCH},j+1} = n^{(1)}_{\mathrm{PUCCH},j} + 1$
- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-4$ on the secondary cell, the value of $n^{(1)}_{\mathrm{PUCCH},j}$, and the value of $n^{(1)}_{\mathrm{PUCCH},j+1}$ for the transmission mode that supports up to two transport blocks is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. For a UE configured for a transmission mode that supports up to two transport blocks a PUCCH resource value in Table 10.1.2.2.1-2 maps to two PUCCH resources $(n^{(1)}_{\mathrm{PUCCH},j}, n^{(1)}_{\mathrm{PUCCH},j+1})$, otherwise, the PUCCH resource value maps to a single PUCCH resource $n^{(1)}_{\mathrm{PUCCH},j}$.
- for a PDSCH transmission indicated by the detection of a corresponding EPDCCH in subframe $n-4$ on the primary cell, or for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the PUCCH resource is given by
  - if EPDCCH-PRB-set q is configured for distributed transmission

    $$n^{(1)}_{\mathrm{PUCCH,j}} = n_{\mathrm{ECCE,q}} + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

    $$n^{(1)}_{\mathrm{PUCCH,j}} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + n' + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

    where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N^{(e1)}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-*

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$r11$, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in subclause 6.8A.5 in [3].

For transmission mode that supports up to two transport blocks, the PUCCH resource $n_{\mathrm{PUCCH},j+1}^{(1)}$ is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH,j+1}}^{(1)} = n_{\mathrm{ECCE,q}} + 1 + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH,j+1}}^{(1)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

Table 10.1.2.2.1-2: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

Value of 'TPC command for PUCCH'	$n_{\mathrm{PUCCH},j}^{(1)}$ or $(n_{\mathrm{PUCCH},j}^{(1)}, n_{\mathrm{PUCCH},j+1}^{(1)})$
'00'	The 1st PUCCH resource value configured by the higher layers
'01'	The 2nd PUCCH resource value configured by the higher layers
'10'	The 3rd PUCCH resource value configured by the higher layers
'11'	The 4th PUCCH resource value configured by the higher layers
NOTE: $(n_{\mathrm{PUCCH},j}^{(1)}, n_{\mathrm{PUCCH},j+1}^{(1)})$ are determined from the first and second PUCCH resource lists configured by *n1PUCCH-AN-CS-List-r10* in [11], respectively.	

Table 10.1.2.2.1-3: Transmission of Format 1b HARQ-ACK channel selection for $A = 2$

HARQ-ACK(0)	HARQ-ACK(1)	$n_{\mathrm{PUCCH}}^{(1)}$	$b(0)b(1)$
ACK	ACK	$n_{\mathrm{PUCCH},1}^{(1)}$	1,1
ACK	NACK/DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	1,1
NACK/DTX	ACK	$n_{\mathrm{PUCCH},1}^{(1)}$	0,0
NACK	NACK/DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	0,0
DTX	NACK/DTX	No Transmission	

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Table 10.1.2.2.1-4: Transmission of Format 1b HARQ-ACK channel selection for $A = 3$

HARQ-ACK(0)	HARQ-ACK(1)	HARQ-ACK(2)	$n^{(1)}_{\mathrm{PUCCH}}$	$b(0)b(1)$
ACK	ACK	ACK	$n^{(1)}_{\mathrm{PUCCH},1}$	1,1
ACK	NACK/DTX	ACK	$n^{(1)}_{\mathrm{PUCCH},1}$	1,0
NACK/DTX	ACK	ACK	$n^{(1)}_{\mathrm{PUCCH},1}$	0,1
NACK/DTX	NACK/DTX	ACK	$n^{(1)}_{\mathrm{PUCCH},2}$	1,1
ACK	ACK	NACK/DTX	$n^{(1)}_{\mathrm{PUCCH},0}$	1,1
ACK	NACK/DTX	NACK/DTX	$n^{(1)}_{\mathrm{PUCCH},0}$	1,0
NACK/DTX	ACK	NACK/DTX	$n^{(1)}_{\mathrm{PUCCH},0}$	0,1
NACK/DTX	NACK/DTX	NACK	$n^{(1)}_{\mathrm{PUCCH},2}$	0,0
NACK	NACK/DTX	DTX	$n^{(1)}_{\mathrm{PUCCH},0}$	0,0
NACK/DTX	NACK	DTX	$n^{(1)}_{\mathrm{PUCCH},0}$	0,0
DTX	DTX	DTX	No Transmission	

Table 10.1.2.2.1-5: Transmission of Format 1b HARQ-ACK channel selection for $A = 4$

HARQ-ACK(0)	HARQ-ACK(1)	HARQ-ACK(2)	HARQ-ACK(3)	$n^{(1)}_{\text{PUCCH}}$	$b(0)b(1)$
ACK	ACK	ACK	ACK	$n^{(1)}_{\text{PUCCH},1}$	1,1
ACK	NACK/DTX	ACK	ACK	$n^{(1)}_{\text{PUCCH},2}$	0,1
NACK/DTX	ACK	ACK	ACK	$n^{(1)}_{\text{PUCCH},1}$	0,1
NACK/DTX	NACK/DTX	ACK	ACK	$n^{(1)}_{\text{PUCCH},3}$	1,1
ACK	ACK	ACK	NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1,0
ACK	NACK/DTX	ACK	NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	0,0
NACK/DTX	ACK	ACK	NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	0,0
NACK/DTX	NACK/DTX	ACK	NACK/DTX	$n^{(1)}_{\text{PUCCH},3}$	1,0
ACK	ACK	NACK/DTX	ACK	$n^{(1)}_{\text{PUCCH},2}$	1,1
ACK	NACK/DTX	NACK/DTX	ACK	$n^{(1)}_{\text{PUCCH},2}$	1,0
NACK/DTX	ACK	NACK/DTX	ACK	$n^{(1)}_{\text{PUCCH},3}$	0,1
NACK/DTX	NACK/DTX	NACK/DTX	ACK	$n^{(1)}_{\text{PUCCH},3}$	0,0
ACK	ACK	NACK/DTX	NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	1,1
ACK	NACK/DTX	NACK/DTX	NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	1,0
NACK/DTX	ACK	NACK/DTX	NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	0,1
NACK/DTX	NACK	NACK/DTX	NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	0,0
NACK	NACK/DTX	NACK/DTX	NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	0,0
DTX	DTX	NACK/DTX	NACK/DTX	No Transmission	

10.1.2.2.2 PUCCH format 3 HARQ-ACK procedure

For PUCCH format 3, the UE shall use PUCCH resource $n^{(3,\tilde{p})}_{\text{PUCCH}}$ or $n^{(1,\tilde{p})}_{\text{PUCCH}}$ for transmission of HARQ-ACK in subframe n for $\tilde{p}$ mapped to antenna port p where

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-4$, or for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n^{(1,\tilde{p})}_{\text{PUCCH}}$ with $n^{(1,\tilde{p}_0)}_{\text{PUCCH}} = n_{\text{CCE}} + N^{(1)}_{\text{PUCCH}}$ for antenna port p_0, where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding PDCCH and $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n^{(1,\tilde{p}_1)}_{\text{PUCCH}} = n_{\text{CCE}} + 1 + N^{(1)}_{\text{PUCCH}}$.
- for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n^{(1,\tilde{p})}_{\text{PUCCH}}$ where the value of $n^{(1,\tilde{p})}_{\text{PUCCH}}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n^{(1,\tilde{p}_0)}_{\text{PUCCH}}$ for antenna port p_0 and the second PUCCH

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resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

- for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-4$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1.
  The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCH/EPDCCH assignments in a given subframe.
- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-4$, or for a EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE,q}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(\text{e1})}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + n' + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(\text{e1})}$$

  for antenna port p_0, where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N_{\text{PUCCH,q}}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in subclause 6.8A.5 in [3]. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by.

  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{ECCE,q}} + 1 + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(\text{e1})}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(\text{e1})}$$

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Table 10.1.2.2.2-1: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

Value of 'TPC command for PUCCH' or 'HARQ-ACK resource offset'	$n_{\text{PUCCH}}^{(3,\tilde{p})}$
'00'	The 1st PUCCH resource value configured by the higher layers
'01'	The 2nd PUCCH resource value configured by the higher layers
'10'	The 3rd PUCCH resource value configured by the higher layers
'11'	The 4th PUCCH resource value configured by the higher layers

10.1.2.2.3 PUCCH format 4 HARQ-ACK procedure

For PUCCH format 4, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(4,\tilde{p})}$ or $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe n for $\tilde{p}$ mapped to antenna port p where

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-4$, or for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding PDCCH and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.

- for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

- for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-4$,

  - if the UE is configured with *codebooksizeDetermination-r13* = 1, or if the UE is configured with *codebooksizeDetermination-r13* = *0* and the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCH resource $n_{\text{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1.
    The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCH assignments in a given subframe.

  - If the UE is configured with codebooksizeDetermination-r13 = 0 and if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. . For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0 and

the second PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCH assignments in a given subframe.

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-4$, or for a EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ given by
  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} = n_{\mathrm{ECCE,q}} + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$$

for antenna port p_0, where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in subclause 6.8A.5 in [3]. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by.

- if EPDCCH-PRB-set q is configured for distributed transmission $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{ECCE,q}} + 1 + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$
- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$$

Table 10.1.2.2.3-1: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

Value of 'TPC command for PUCCH' or 'HARQ-ACK resource offset'	$n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$
'00'	The 1st PUCCH resource value configured by the higher layers
'01'	The 2nd PUCCH resource value configured by the higher layers
'10'	The 3rd PUCCH resource value configured by the higher layers
'11'	The 4th PUCCH resource value configured by the higher layers

10.1.2.2.4 PUCCH format 5 HARQ-ACK procedure

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in subclause 10.1.2.2.3, by replacing $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ with $n_{\mathrm{PUCCH}}^{(5,\tilde{p})}$.

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10.1.2A FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 1

For a UE transmitting HARQ-ACK using PUCCH format 1b with channel selection, the UE shall determine the number of HARQ-ACK bits, O in subframe n, based on the number of configured serving cells with subframe $n-4$ configured as a downlink or special subframe according to the DL-reference UL/DL configuration (defined in subclause 10.2) of each serving cell and the downlink transmission modes configured for each serving cell. For a UE not configured with PUCCH format 4/5 and transmitting HARQ-ACK using PUCCH format 3, the UE shall determine the number of HARQ-ACK bits, O in subframe n, based on the number of configured serving cells with subframe $n-4$ configured as a downlink or special subframe except a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP according to the DL-reference UL/DL configuration (defined in subclause 10.2) of each serving cell and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that support up to two transport blocks; and one HARQ-ACK bit otherwise.

A UE that supports aggregating at most 2 serving cells shall use PUCCH format 1b with channel selection for transmission of HARQ-ACK when configured with primary cell frame structure type 1 and secondary cell frame structure type 2.

A UE that supports aggregating more than 2 serving cells with primary cell frame structure type 1 is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK when configured with more than one serving cell and primary cell frame structure type 1 and at least one secondary cell with frame structure type 2.

For HARQ-ACK transmission in subframe n with PUCCH format 1b with channel selection, the FDD-TDD HARQ-ACK procedure follows HARQ-ACK procedure described in subclause 10.1.2.1 if subframe $n-4$ is an uplink or a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP for the secondary cell according to the higher layer parameter *subframeAssignment* for UE not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* for UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and HARQ-ACK procedure described in subclause 10.1.2.2.1 otherwise.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 3 HARQ-ACK procedure as described in subclause 10.1.2.2.2.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 4 HARQ-ACK procedure is as described in subclause 10.1.2.2.3.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in subclause 10.1.2.2.4.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and with two configured serving cells.

10.1.3 TDD HARQ-ACK feedback procedures

For TDD and a UE that does not support aggregating more than one serving cell with frame structure type 2, two HARQ-ACK feedback modes are supported by higher layer configuration.

- HARQ-ACK bundling and
- HARQ-ACK multiplexing

For TDD UL/DL configuration 5 and a UE that does not support aggregating more than one serving cell with frame structure type 2 and the UE is not configured with *EIMTA-MainConfigServCell-r12* for the serving cell, only HARQ-ACK bundling is supported.

A UE that supports aggregating more than one serving cell with frame structure type 2 is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK when configured with more than one serving cell with frame structure type 2.

A UE that supports aggregating more than one serving cell with frame structure type 2 and is not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell is configured by higher layers to use HARQ-ACK bundling, PUCCH format 1b with channel selection according to the set of Tables 10.1.3-2/3/4 or according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3 for transmission of HARQ-ACK when configured with one serving cell with frame structure type 2.

A UE that is configured with the parameter *EIMTA-MainConfigServCell-r12* and configured with one serving cell is configured by higher layers to use PUCCH format 1b with channel selection according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3 for transmission of HARQ-ACK. A UE that is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and configured with more than one serving cell is configured by higher layers to use PUCCH format 1b with channel selection according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3/4/5 for transmission of HARQ-ACK.

PUCCH format 1b with channel selection according to the set of Tables 10.1.3-2/3/4 or according to the set of Tables 10.1.3-5/6/7 is not supported for TDD UL/DL configuration 5.

TDD HARQ-ACK bundling is performed per codeword across M multiple downlink or special subframes associated with a single UL subframe n, where M is the number of elements in the set K defined in Table 10.1.3.1-1, by a logical AND operation of all the individual PDSCH transmission (with and without corresponding PDCCH/EPDCCH) HARQ-ACKs and ACK in response to PDCCH/EPDCCH indicating downlink SPS release. For one configured serving cell the bundled 1 or 2 HARQ-ACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

For TDD HARQ-ACK multiplexing and a subframe n with $M > 1$, where M is the number of elements in the set K defined in Table 10.1.3.1-1, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed by a logical AND operation of all the corresponding individual HARQ-ACKs. PUCCH format 1b with channel selection is used in case of one configured serving cell. For TDD HARQ-ACK multiplexing and a subframe n with $M = 1$, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is not performed, 1 or 2 HARQ-ACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively for one configured serving cell.

In the case of TDD and more than one configured serving cell with PUCCH format 1b with channel selection and more than 4 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n, where M is defined in subclause 10.1.3.2.1, and for the configured serving cells, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe for all configured cells is performed and the bundled HARQ-ACK bits for each configured serving cell is transmitted using PUCCH format 1b with channel selection. For TDD and more than one configured serving cell with PUCCH format 1b with channel selection and up to 4 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n, where M is defined in subclause 10.1.3.2.1, and for the configured serving cells, spatial HARQ-ACK bundling is not performed and the HARQ-ACK bits are transmitted using PUCCH format 1b with channel selection.

In the case of TDD and more than one configured serving cell with PUCCH format 3 and without PUCCH format 4/5 configured and more than 20 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n, where M is the number of elements in the set K defined in subclause 10.1.3.2.2 and for the configured serving cells, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for each serving cell by a logical AND operation of all of the corresponding individual HARQ-ACKs and PUCCH format 3 is used. For TDD and more than one configured serving cell with PUCCH format 3 and up to 20 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n, where M is the number of elements in the set K defined in subclause 10.1.3.2.2 and for the configured serving cells, spatial HARQ-ACK bundling is not performed and the HARQ-ACK bits are transmitted using PUCCH format 3.

For TDD with PUCCH format 3 without PUCCH format 4/5 configured, a UE shall determine the number of HARQ-ACK bits, O, associated with an UL subframe n

according to $O = \sum_{c=1}^{N_{cells}^{DL}} O_c^{ACK}$ where N_{cells}^{DL} is the number of configured cells, and O_c^{ACK} is the number of HARQ-bits for the c-th serving cell defined in subclause 7.3.

TDD HARQ-ACK feedback procedures for one configured serving cell are given in subclause 10.1.3.1 and procedures for more than one configured serving cell are given in subclause 10.1.3.2.

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10.1.3.1 TDD HARQ-ACK procedure for one configured serving cell

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1a/1b with TDD HARQ-ACK bundling feedback mode and for PUCCH format 3.

A UE that supports aggregating more than one serving cell with frame structure type 2 can be configured by higher layers for HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) for PUCCH format 1b with channel selection.

The TDD HARQ-ACK procedure for a UE configured with PUCCH format 3 is as described in subclause 10.1.3.2.2 when the UE receives PDSCH and/or SPS release PDCCH/EPDCCH only on the primary cell.

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, for TDD HARQ-ACK bundling or TDD HARQ-ACK multiplexing for one configured serving cell and a subframe n with $M = 1$ where M is the number of elements in the set K defined in Table 10.1.3.1-1, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for $\tilde{p}$ mapped to antenna port p for PUCCH format 1a/1b, where

- If there is PDSCH transmission indicated by the detection of corresponding PDCCH/EPDCCH or there is PDCCH/EPDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K (defined in Table 10.1.3.1-1) is a set of M elements $\{k_0, k_1, \cdots k_{M-1}\}$ depending on the subframe n and the UL/DL configuration (defined in Table 4.2-2 in [3]), and if PDCCH indicating PDSCH transmission or downlink SPS release is detected in subframe $n-k_m$, where k_m is the smallest value in set K such that UE detects a PDCCH/EPDCCH indicating PDSCH transmission or downlink SPS release within subframe(s) $n-k$ and $k \in K$, the UE first selects a c value out of {0, 1, 2, 3} which makes $N_c \le n_{\text{CCE}} < N_{c+1}$ and shall use $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M-m-1)\cdot N_c + m \cdot N_{c+1} + n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, and n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ and the corresponding m. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for HARQ-ACK bundling for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = (M-m-1)\cdot N_c + m \cdot N_{c+1} + n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.
- If there is only a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1.3.1-1, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b and HARQ-ACK bundling, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.
- If there is PDSCH transmission indicated by the detection of corresponding PDCCH/EPDCCH or there is PDCCH/EPDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K (defined in Table 10.1.3.1-1) is a set of M elements $\{k_0, k_1, \cdots k_{M-1}\}$ depending on the subframe n and the UL/DL configuration (defined in Table 4.2-2 in [3]), and if EPDCCH indicating PDSCH transmission or downlink SPS release is detected in subframe $n-k_m$, where k_m is the smallest value in set K such that UE detects a PDCCH/EPDCCH indicating PDSCH transmission or downlink SPS release within subframe(s) $n-k$ and $k \in K$, the UE shall use
  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

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$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

for antenna port p_0, where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$ and the corresponding m, $N_{\mathrm{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for HARQ-ACK bundling for antenna port p_1 is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{ECCE,q}} + 1 + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

Table 10.1.3.1-1: Downlink association set $K: \{k_0, k_1, \cdots k_{M-1}\}$ for TDD

UL/DL Configuration	Subframe *n*									
	0	1	2	3	4	5	6	7	8	9
0	-	-	6	-	4	-	-	6	-	4
1	-	-	7, 6	4	-	-	-	7, 6	4	-
2	-	-	8, 7, 4, 6	-	-	-	-	8, 7, 4, 6	-	-
3	-	-	7, 6, 11	6, 5	5, 4	-	-	-	-	-
4	-	-	12, 8, 7, 11	6, 5, 4, 7	-	-	-	-	-	-
5	-	-	13, 12, 9, 8, 7, 5, 4, 11, 6	-	-	-	-	-	-	-
6	-	-	7	7	5	-	-	7	7	-

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Table 10.1.3.1-1A: eIMTA downlink association set $K^A : \{k_0^A, k_1^A, \ldots, k_{M^A-1}^A\}$ for TDD

Higher layer parameter *'eimta-HARQ-ReferenceConfig-r12'*	Higher layer parameter *'subframeAssignment'*	Subframe *n*									
		0	1	2	3	4	5	6	7	8	9
2	0	-	-	7,8,4	-	-	-	-	7,8,4	-	-
	1	-	-	8,4	-	-	-	-	8,4	-	-
	6	-	-	6,8,4	-	-	-	-	8,6,4	-	-
4	0	-	-	12,7,11,8	7,4,5,6	-	-	-	-	-	-
	1	-	-	12,8,11	7,5,6	-	-	-	-	-	-
	3	-	-	12,8	4,7	-	-	-	-	-	-
	6	-	-	12,11,8	4,5,6	-	-	-	-	-	-
5	0	-	-	12,7,11,13,8,4,9,5	-	-	-	-	-	-	-
	1	-	-	13,12,8,11,4,9,5	-	-	-	-	-	-	-
	2	-	-	13,12,9,11,5	-	-	-	-	-	-	-
	3	-	-	13,12,5,4,8,9	-	-	-	-	-	-	-
	4	-	-	13,5,4,6,9	-	-	-	-	-	-	-
	6	-	-	13,12,11,6,8,4,9,5	-	-	-	-	-	-	-

Table 10.1.3.1-2: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D to Δ_{ARO} values for TDD when $m > 0$

ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D	Δ_{ARO}
0	0
1	$-\sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} - 2$
2	$-\sum_{i1=m-\lceil m/3 \rceil}^{m-1} N_{ECCE,q,n-k_{i1}} - 1$
3	2

Table 10.1.3.1-3: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D to Δ'_{ARO} values for TDD when $i4 = M'$ and $i5 \neq 0$

ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D	Δ'_{ARO}
0	0
1	$-\sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} - \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} - 2$
2	$-\sum_{i1=\min(i4,\, i4-\delta+i5)}^{i4-1} N'_{ECCE,q,n-k'_{i1}} - \sum_{i1=\max(0,\, i5-\delta)}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} - 1 \quad , \delta = \left\lceil \frac{(i4+i5)}{3} \right\rceil$
3	2

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, for TDD HARQ-ACK multiplexing and sub-frame n with $M > 1$ and one configured serving cell, where M is the number of elements in the set K defined in Table 10.1.3.1-1, denote $n_{\mathrm{PUCCH},i}^{(1)}$ as the PUCCH resource derived from sub-frame $n-k_i$ and HARQ-ACK(i) as the ACK/NACK/DTX response from sub-frame $n-k_i$, where $k_i \in K$ (defined in Table 10.1.3.1-1) and $0 \le i \le M-1$.

- For a PDSCH transmission indicated by the detection of corresponding PDCCH or a PDCCH indicating downlink SPS release in sub-frame $n-k_i$ where $k_i \in K$, the PUCCH resource

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$n^{(1)}_{\text{PUCCH},i} = (M-i-1)\cdot N_c + i\cdot N_{c+1} + n_{\text{CCE},i} + N^{(1)}_{\text{PUCCH}}$, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},i} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\text{DL}}_{\text{RB}}\cdot(N^{\text{RB}}_{\text{sc}}\cdot c - 4)]/36 \right\rfloor\right\}$, $n_{\text{CCE},i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_i$, and $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers.

- For a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-k_i$, the value of $n^{(1)}_{\text{PUCCH},i}$ is determined according to higher layer configuration and Table 9.2-2.

- For a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n-k_i$ where $k_i \in K$, the UE shall use

  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH,i}} = n_{\text{ECCE,q}} + \sum_{i1=0}^{i-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  - if EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH,i}} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_i$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_i$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_i$ which is described in subclause 6.8A.5 in [3]. If $i=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $i>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2, where the variable m in the table is substituted with i. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K'=K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAsssignment*), and M' is the number of elements in set K'.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then the set K for the rest of this subclause is as defined in Sec 10.2, and M is the number of elements for subframe n in the set K

If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, for TDD HARQ-ACK multiplexing and sub-frame n, denote $n^{(1)}_{\text{PUCCH},i0}$ as the PUCCH resource derived from sub-frame $n-k_i$ and HARQ-ACK(i0) as the ACK/NACK/DTX response from sub-frame $n-k_i$, where $k_i \in K$, and $0 \le i \le M-1$.

- $i0$ corresponding to each subframe $n-k_i, \forall i, 0 \le i \le M-1$ is determined as follows

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Set $b = 0$;

for $i2 = 0,1,...M' - 1$

if the value of k'_{i2} is the same as the value of an element k_i in set K, where $k'_{i2} \in K'$,

$i0$ corresponding to subframe $n - k_i = b$;

$b = b + 1$

end if

end for

for $i3 = 0,1,...,M^A - 1$

if the value of k^A_{i3} is same as the value of an element k_i in set K, where $k^A_{i3} \in K^A$ (defined in Table 10.1.3.1-1A)

$i0$ corresponding to subframe $n - k_i = b$;

$b = b + 1$

end if

end for

- For a PDSCH transmission indicated by the detection of corresponding PDCCH or a PDCCH indicating downlink SPS release in sub-frame $n - k_i$,

  - if the value of k_i is same as the value of an element k'_{i2} in set K', the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},i0}$ is given by $n^{(1)}_{\mathrm{PUCCH},i0} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\mathrm{CCE},i} + N^{(1)}_{\mathrm{PUCCH}}$;

  - otherwise, if the value of k_i is same as the value of an element k^A_{i3} in set K^A, where $k^A_{i3} \in K^A$ (defined in Table 10.1.3.1-1A), the UE shall set, the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},i0}$ is given by $n^{(1)}_{PUCCH,i0} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{CCE,i} + N^{K^A}_{PUCCH}$;

  where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A , c is selected from {0, 1, 2, 3} such that $N_c \le n_{\mathrm{CCE},i} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\mathrm{DL}}_{\mathrm{RB}} \cdot (N^{\mathrm{RB}}_{\mathrm{sc}} \cdot c - 4)]/36 \right\rfloor\right\}$, $n_{\mathrm{CCE},i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_i$, and $N^{\mathrm{K^A}}_{\mathrm{PUCCH}}$, $N^{(1)}_{\mathrm{PUCCH}}$, are configured by higher layers.

- For a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected in subframe $n - k_i$, the value of $n^{(1)}_{\mathrm{PUCCH},i0}$ is determined according to higher layer configuration and Table 9.2-2.

- For a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n - k_i$ where $k_i \in K$, the UE shall use

  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\mathrm{PUCCH},i0} = n_{\mathrm{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + \Delta'_{ARO} + N^{(e1)}_{\mathrm{PUCCH},q}$$

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- if EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\mathrm{PUCCH},i0} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + n' + \Delta'_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

where

- if the value of k_i is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$ and $i5 = 0$;
- otherwise, if the value of k_i is same as the value of an index k^{A}_{i3}, where $k^{A}_{i3} \in K^{A}$, then $i4 = M'$ and $i5 = i3$;

, and where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_i$, $N^{(e1)}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_i$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_i$ which is described in subclause 6.8A.5 in [3].

Δ'_{ARO} is determined as follows

- If $i4 = 0$ and $i5 = 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1.
- If $0 < i4 < M'$ and $i5 = 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2, where the variable Δ_{ARO} in the table is substituted with Δ'_{ARO}, the variable m in the table is substituted with $i4$, the variable N in the table is substituted with N' and the variable k_{i1} in the table is substituted with k'_{i1}.
- If $i4 = M'$ and $i5 \neq 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-3.

For a given subframe u, $N'_{ECCE,q,u}$ is determined as follows

- If the UE is configured to monitor EPDCCH in subframe u, $N'_{ECCE,q,u}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe u.
- If the UE is not configured to monitor EPDCCH in subframe u, $N'_{ECCE,q,u}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe u.
- For normal downlink CP, if subframe u is a special subframe with special subframe configuration 0 or 5, $N'_{ECCE,q,u}$ is equal to 0.
- For extended downlink CP, if subframe u is a special subframe with special subframe configuration 0 or 4 or 7, $N'_{ECCE,q,u}$ is equal to 0.

If a UE is not configured with two antenna port transmission for PUCCH format 1b with channel selection, and if the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, based on higher layer signalling the UE configured with a single serving cell will perform channel selection either according to the set of Tables 10.1.3-2, 10.1.3-3, and 10.1.3-4 or according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

If a UE is configured with two antenna port transmission for PUCCH format 1b with channel selection, and if the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then the UE will perform channel selection according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

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If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, the UE configured with a single serving cell will perform channel selection according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

For the selected table set, the UE shall transmit $b(0),b(1)$ on PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ in sub-frame n for $\tilde{p}$ mapped to antenna port p using PUCCH format 1b according to subclause 5.4.1 in [3] where

- $n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = n_{\mathrm{PUCCH}}^{(1)}$ for antenna port p_0 and the value of $b(0),b(1)$ and the PUCCH resource $n_{\mathrm{PUCCH}}^{(1)}$ are generated by channel selection according to the selected set of Tables for $M = 2$, 3, and 4 respectively
- $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, where $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ is selected from PUCCH resources $n_{\mathrm{PUCCH},i}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \le i \le M-1$, according to selected set of Tables for $M = 2$, 3, and 4 respectively by replacing $n_{\mathrm{PUCCH}}^{(1)}$ with $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)}$ and replacing $n_{\mathrm{PUCCH},i}^{(1)}$ with $n_{\mathrm{PUCCH},i}^{(1,\tilde{p}_1)}$, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

Table 10.1.3-2: Transmission of HARQ-ACK multiplexing for *M* = 2

HARQ-ACK(0), HARQ-ACK(1)	$n_{\mathrm{PUCCH}}^{(1)}$	$b(0),b(1)$
ACK, ACK	$n_{\mathrm{PUCCH},1}^{(1)}$	1, 1
ACK, NACK/DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	0, 1
NACK/DTX, ACK	$n_{\mathrm{PUCCH},1}^{(1)}$	0, 0
NACK/DTX, NACK	$n_{\mathrm{PUCCH},1}^{(1)}$	1, 0
NACK, DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	1, 0
DTX, DTX	No transmission	

Table 10.1.3-3: Transmission of HARQ-ACK multiplexing for *M* = 3

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{\mathrm{PUCCH}}^{(1)}$	$b(0),b(1)$
ACK, ACK, ACK	$n_{\mathrm{PUCCH},2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{\mathrm{PUCCH},1}^{(1)}$	1, 1
ACK, NACK/DTX, ACK	$n_{\mathrm{PUCCH},0}^{(1)}$	1, 1
ACK, NACK/DTX, NACK/DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	0, 1
NACK/DTX, ACK, ACK	$n_{\mathrm{PUCCH},2}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX	$n_{\mathrm{PUCCH},1}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, ACK	$n_{\mathrm{PUCCH},2}^{(1)}$	0, 0
DTX, DTX, NACK	$n_{\mathrm{PUCCH},2}^{(1)}$	0, 1
DTX, NACK, NACK/DTX	$n_{\mathrm{PUCCH},1}^{(1)}$	1, 0
NACK, NACK/DTX, NACK/DTX	$n_{\mathrm{PUCCH},0}^{(1)}$	1, 0
DTX, DTX, DTX	No transmission	

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Table 10.1.3-4: Transmission of HARQ-ACK multiplexing for *M* = 4

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n^{(1)}_{PUCCH}$	$b(0),b(1)$
ACK, ACK, ACK, ACK	$n^{(1)}_{PUCCH,1}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
NACK/DTX,NACK/DTX,NACK,DTX	$n^{(1)}_{PUCCH,2}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,1}$	1, 0
NACK, DTX, DTX, DTX	$n^{(1)}_{PUCCH,0}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	0, 1
NACK/DTX, NACK/DTX, NACK/DTX, NACK	$n^{(1)}_{PUCCH,3}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 1
ACK, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,0}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n^{(1)}_{PUCCH,3}$	0, 1
NACK/DTX, NACK, DTX, DTX	$n^{(1)}_{PUCCH,1}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	1, 0
NACK/DTX, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	0, 0
DTX, DTX, DTX, DTX	No transmission	

Table 10.1.3-5: Transmission of HARQ-ACK multiplexing for *M* = 2

HARQ-ACK(0), HARQ-ACK(1)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK	$n^{(1)}_{PUCCH,1}$	0, 1
NACK, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX	No Transmission	

Table 10.1.3-6: Transmission of HARQ-ACK multiplexing for *M* = 3

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HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK, ACK	$n^{(1)}_{PUCCH,2}$	1, 1
ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,2}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,2}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,1}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,2}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

Table 10.1.3-7: Transmission of HARQ-ACK multiplexing for *M* = 4

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK, ACK, ACK	$n^{(1)}_{PUCCH,1}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,0}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,0}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n^{(1)}_{PUCCH,1}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission	

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10.1.3.2 TDD HARQ-ACK procedure for more than one configured serving cell

If a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell, "UL/DL configuration" of the serving cell in the rest of this subclause refers to the UL/DL configuration given by the parameter *eimta-HARQ-ReferenceConfig-r12* for the serving cell unless specified otherwise.

The TDD HARQ-ACK feedback procedures for more than one configured serving cell are either based on a PUCCH format 1b with channel selection HARQ-ACK procedure as described in subclause 10.1.3.2.1 or a PUCCH format 3 HARQ-ACK procedure as described in subclause 10.1.3.2.2 or a PUCCH format 4 HARQ-ACK procedure as described in subclause 10.1.3.2.3 or a PUCCH format 5 HARQ-ACK procedure as described in subclause 10.1.3.2.4.

HARQ-ACK transmission on two antenna ports ($p \in \{p_0, p_1\}$) is supported for PUCCH format 3 and TDD with more than one configured serving cell.

If a UE is configured with more than one serving cell and the TDD UL/DL configurations of all serving cells are the same, TDD UL/DL configuration 5 with PUCCH format 3 is only supported for up to two configured serving cells. If a UE is configured with two serving cells and the TDD UL/DL configuration of the two serving cells is the same, TDD UL/DL configuration 5 with PUCCH format 1b with channel selection for two configured serving cells is not supported. If a UE is configured with two serving cells and if the TDD UL/DL configuration of the two serving cells are not the same and if the DL-reference UL/DL configuration (as defined in subclause 10.2) of at least one serving cell is TDD UL/DL Configuration 5, PUCCH format 1b with channel selection is not supported.

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and is configured with PUCCH format 3 without PUCCH format 4/5 configured, the UE is not expected to be configured with more than two serving cells having UL/DL Configuration 5 as a DL-reference UL/DL configuration.

HARQ-ACK transmission on two antenna ports ($p \in \{p_0, p_1\}$) is supported for PUCCH format 1b with channel selection and TDD with two configured serving cells.

10.1.3.2.1 PUCCH format 1b with channel selection HARQ-ACK procedure

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K'.

If a UE is configured with two serving cells with the same UL/DL configurations, then in the rest of this subcaluse, K is as defined in Sec 10.2 and M is the number of elements for subframe n in the set K, and $M_{primary} = M$.

If a UE is configured with two serving cells with different UL/DL configurations,

- then the UE shall determine M for a subframe n in this subclause as $M = \max(M_{primary}, M_{secondary})$, where
  - $M_{primary}$ denotes the number of elements for subframe n in the set K for the primary cell (as defined in subclause 10.2)
  - $M_{secondary}$ denotes the number of elements for subframe n in the set K_c for the secondary serving cell (as defined in subclause 10.2)
- if $M_{secondary} < M$, then the UE shall, for the secondary serving cell, set HARQ-ACK(j) to DTX for $j = M_{secondary}$ to $M-1$.
- if $M_{primary} < M$, then the UE shall, for the primary cell, set HARQ-ACK(j) to DTX for $j = M_{primary}$ to $M-1$

If the UE is configured with two serving cells with different UL/DL configurations, then in the rest of this subclause, $K = K_c$ where K_c is defined in subclause 10.2.

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and two configured serving cells and a subframe n with $M = 1$, a UE shall determine the number of HARQ-ACK bits, O, based on the number of

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configured serving cells and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that supports up to two transport blocks; and one HARQ-ACK bit otherwise.

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and two configured serving cells and a subframe n with $M \leq 2$, the UE shall transmit $b(0)b(1)$ on PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for $\tilde{p}$ mapped to antenna port p using PUCCH format 1b where

- $n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources, $n_{\text{PUCCH},j}^{(1)}$ where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Tables 10.1.3.2-1, 10.1.3.2-2, and 10.1.3.2-3 in subframe n using PUCCH format 1b.
- $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, where $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ selected from A PUCCH resources, $n_{\text{PUCCH},j}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Tables 10.1.3.2-1, 10.1.3.2-2, and 10.1.3.2-3 by replacing $n_{\text{PUCCH}}^{(1)}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ and replacing $n_{\text{PUCCH},j}^{(1)}$ with $n_{\text{PUCCH},j}^{(1,\tilde{p}_1)}$ in subframe n, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection,

and for a subframe n with $M = 1$, HARQ-ACK(j) denotes the ACK/NACK/DTX response for a transport block or SPS release PDCCH/EPDCCH associated with serving cell, where the transport block and serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.2.2.1-1. For a subframe n with $M = 2$, HARQ-ACK(j) denotes the ACK/NACK/DTX response for a PDSCH transmission or SPS release PDCCH/EPDCCH within subframe(s) given by set K on each serving cell, where the subframes on each serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.3.2-4.

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, the UE shall determine the A PUCCH resources, $n_{\text{PUCCH},j}^{(1)}$ associated with HARQ-ACK(j) where $0 \leq j \leq A-1$ in Table 10.1.2.2.1-1 for $M = 1$ and Table 10.1.3.2-4 for $M = 2$, according to

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ on the primary cell, or for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ on the primary cell, the PUCCH resource is $n_{\text{PUCCH},j}^{(1)} = \left(M_{primary} - m - 1\right) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, and for a subframe n with $M = 1$ and a transmission mode that supports up to two transport blocks on the serving cell where the corresponding PDSCH transmission occurs, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by $n_{\text{PUCCH},j+1}^{(1)} = \left(M_{primary} - m - 1\right) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + 1 + N_{\text{PUCCH}}^{(1)}$ where $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding DCI assignment and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers.
- for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$, the value of $n_{\text{PUCCH},j}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.
- For a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n-k_m$ where $k_m \in K$ on the primary cell, the PUCCH resource $n_{\text{PUCCH},j}^{(1)}$ is given by
  - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH,j}}^{(1)} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

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- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH,j}}^{(1)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\mathrm{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For a subframe n with $M=1$ and a transmission mode that supports up to two transport blocks on the serving cell where the corresponding PDSCH transmission occurs, the PUCCH resource $n_{\mathrm{PUCCH},j+1}^{(1)}$ is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{ECCE,q}} + 1 + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n-k$, where $k \in K$ on the secondary cell, the value of $n_{\mathrm{PUCCH},j}^{(1)}$, and the value of $n_{\mathrm{PUCCH},j+1}^{(1)}$ for a subframe n with $M=2$ or for a subframe n with $M=1$ and a transmission mode on the secondary cell that supports up to two transport blocks is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. For a UE configured for a transmission mode on the secondary cell that supports up to two transport blocks and a subframe n with $M=1$, or for a subframe n with $M=2$, a PUCCH resource value in Table 10.1.2.2.1-2 maps to two PUCCH resources $(n_{\mathrm{PUCCH},j}^{(1)}, n_{\mathrm{PUCCH},j+1}^{(1)})$, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\mathrm{PUCCH},j}^{(1)}$. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in the TPC field on all PDCCH/EPDCCH assignments on the secondary cell within subframe(s) $n-k$, where $k \in K$.

Table 10.1.3.2-1: Transmission of HARQ-ACK multiplexing for *A* = 2

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HARQ-ACK(0), HARQ-ACK(1)	$n_{PUCCH}^{(1)}$	$b(0)b(1)$
ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	0, 1
NACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX	No Transmission	

Table 10.1.3.2-2: Transmission of HARQ-ACK multiplexing for *A* = 3

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	$b(0)b(1)$
ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

Table 10.1.3.2-3: Transmission of HARQ-ACK multiplexing for *A* = 4

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HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n^{(1)}_{\text{PUCCH}}$	$b(0)b(1)$
ACK, ACK, ACK, ACK	$n^{(1)}_{\text{PUCCH},1}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},0}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n^{(1)}_{\text{PUCCH},3}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},0}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n^{(1)}_{\text{PUCCH},1}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},3}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission	

Table 10.1.3.2-4: Mapping of subframes on each serving cell to HARQ-ACK(*j*) for PUCCH format 1b HARQ-ACK channel selection for TDD with $M = 2$

A	HARQ-ACK(j)			
	HARQ-ACK(0)	HARQ-ACK(1)	HARQ-ACK(2)	HARQ-ACK(3)
4	The first subframe of Primary cell	The second subframe of Primary cell	The first subframe of Secondary cell	The second subframe of Secondary cell

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and sub-frame n with $M > 2$ and two configured serving cells, denotes $n^{(1)}_{\text{PUCCH},i}$ $0 \le i \le 3$ as the PUCCH resource derived from the transmissions in M downlink or special sub-frames associated with the UL subframe n . $n^{(1)}_{\text{PUCCH},0}$ and $n^{(1)}_{\text{PUCCH},1}$ are associated with the PDSCH transmission(s) or a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) on the primary cell and $n^{(1)}_{\text{PUCCH},2}$ and $n^{(1)}_{\text{PUCCH},3}$ are associated with the PDSCH transmission(s) on the secondary cell.

For Primary cell:

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, and if there is a PDSCH transmission on the primary cell without a corresponding PDCCH/EPDCCH detected within the subframe(s) $n-k$, where $k \in K$,
  - the value of $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2.

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- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1', the PUCCH resource $n^{(1)}_{\text{PUCCH},1} = (M_{primary} - m - 1)\cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N^{(1)}_{\text{PUCCH}}$ where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\text{DL}}_{\text{RB}} \cdot (N^{\text{RB}}_{\text{sc}} \cdot c - 4)]/36 \right\rfloor\right\}$, where $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ and $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers.
- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1', the PUCCH resource is given by
  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},1} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},1} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, and if there is a PDSCH transmission on the primary cell without a corresponding PDCCH/EPDCCH detected within the subframe(s) $n-k$, where $k \in K$,
  - the value of $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2.

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- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_i$, where $k_i \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_i$, where $k_i \in K$ with the DAI value in the PDCCH equal to '1',
  - if the value of k_i is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},1}$ is given by $n^{(1)}_{\mathrm{PUCCH},1} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\mathrm{CCE},i} + N^{(1)}_{\mathrm{PUCCH}}$;
  - otherwise, if the value of k_i is same as the value of an element k^A_{i3} in set K^A, where $k^A_{i3} \in K^A$ (defined in Table 10.1.3.1-1A), the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},1}$ is given by $n^{(1)}_{\mathrm{PUCCH},1} = (M^A-i3-1)\cdot N_c + i3\cdot N_{c+1} + n_{\mathrm{CCE},i} + N^{\mathrm{K^A}}_{\mathrm{PUCCH}}$;

  where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\mathrm{CCE},i} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\mathrm{DL}}_{\mathrm{RB}}\cdot(N^{\mathrm{RB}}_{\mathrm{sc}}\cdot c-4)]/36 \right\rfloor\right\}$ where $N^{\mathrm{DL}}_{\mathrm{RB}}$ is determined from the primary cell, $n_{\mathrm{CCE},i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_i$, and $N^{\mathrm{K^A}}_{\mathrm{PUCCH}}$, $N^{(1)}_{\mathrm{PUCCH}}$, are configured by higher layers .
- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_i$, where $k_i \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_i$, where $k_i \in K$ with the DAI value in the EPDCCH equal to '1', the PUCCH resource is given by
  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\mathrm{PUCCH},1} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + \Delta'_{ARO} + N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\mathrm{PUCCH},1} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + n' + \Delta'_{ARO} + N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$$

  where

  - if the value of k_i is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$ and $i5 = 0$;
  - otherwise, if the value of k_i is same as the value of an index k^A_{i3}, where $k^A_{i3} \in K^A$, then $i4 = M'$ and $i5 = i3$;

  , and where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_i$, $N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_i$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^A_{i1}}$ are determined as described in section 10.1.3.1.

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- HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH transmission without a corresponding PDCCH/EPDCCH. For $1 \le j \le M-1$, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to 'j' or a PDCCH/EPDCCH indicating downlink SPS release and with DAI value in the PDCCH/EPDCCH equal to 'j' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.

- Otherwise,

  - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2' or a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resource $n^{(1)}_{\text{PUCCH},i} = \left(M_{primary}-m-1\right)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N^{(1)}_{\text{PUCCH}}$, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\text{DL}}_{\text{RB}}\cdot(N^{\text{RB}}_{\text{sc}}\cdot c-4)]/36 \right\rfloor\right\}$, where $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, $i=0$ for the corresponding PDCCH with the DAI value equal to '1' and $i=1$ for the corresponding PDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i=0$ for the corresponding PDCCH.

  - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2' or a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2',

    - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n^{(1)}_{\text{PUCCH},i}$ is given by $n^{(1)}_{\text{PUCCH},i} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N^{(1)}_{\text{PUCCH}}$;

    - otherwise, if the value of k_m is same as the value of an element k^A_{i3} in set K^A, where $k^A_{i3} \in K^A$ (defined in Table 10.1.3.1-1A), the PUCCH resource $n^{(1)}_{\text{PUCCH},i}$ is given by $n^{(1)}_{\text{PUCCH},i} = (M^A-i3-1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N^{\text{K}^{\text{A}}}_{\text{PUCCH}}$;

    where M^A is the number of elements in the set K^A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\text{DL}}_{\text{RB}}\cdot(N^{\text{RB}}_{\text{sc}}\cdot c-4)]/36 \right\rfloor\right\}$ where $N^{\text{DL}}_{\text{RB}}$ is determined from the primary cell, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N^{\text{K}^{\text{A}}}_{\text{PUCCH}}$, $N^{(1)}_{\text{PUCCH}}$, are configured by higher layers. Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, $i=0$ for the corresponding PDCCH with the DAI value equal to '1' and $i=1$ for the corresponding PDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i=0$ for the corresponding PDCCH.

  - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2' or an EPDCCH indicating downlink SPS

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release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}the DAI value in the EPDCCH equal to either '1' or '2', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\mathrm{PUCCH},i} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\mathrm{PUCCH},i} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(e1)}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} $i=0$ for the corresponding EPDCCH with the DAI value equal to '1' and $i=1$ for the corresponding EPDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i=0$ for the corresponding EPDCCH.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2' or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}the DAI value in the EPDCCH equal to either '1' or '2', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\mathrm{PUCCH},i} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{i4-1} N_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N_{ECCE,q,n-k^{A}_{i1}} + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

- If EPDCCH-PRB-set q is configured for localized transmission

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$$n^{(1)}_{\mathrm{PUCCH,i}} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N_{ECCE,q,n-k^A_{i1}} + n' + \Delta_{ARO} + N^{(e1)}_{\mathrm{PUCCH,q}}$$

where

- if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k^A_{i3}, where $k^A_{i3} \in K^A$, then $i4 = i3$;

, and where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(e1)}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3].. Δ'_{ARO}, $N_{ECCE,q,n-k'_{i1}}$, $N_{ECCE,q,n-k^A_{i1}}$ are determined as described in section 10.1.3.1. Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} $i = 0$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 1$ for the corresponding EPDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i = 0$ for the corresponding EPDCCH.

- For $0 \le j \le M-1$ and TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to '$j+1$' or a PDCCH/EPDCCH indicating downlink SPS release and with DAI value in the PDCCH/EPDCCH equal to '$j+1$' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX. For $0 \le j \le M-1$ and the primary cell with TDD UL/DL configuration 0, if a PDSCH transmission with a corresponding PDCCH/EPDCCH or a PDCCH/EPDCCH indicating downlink SPS release is received, HARQ-ACK(0) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.

For Secondary cell:

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH on the primary cell in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources $n^{(1)}_{\mathrm{PUCCH},j} = (M_{primary} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\mathrm{CCE},m} + N^{(1)}_{\mathrm{PUCCH}}$, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\mathrm{CCE,m}} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\mathrm{DL}}_{\mathrm{RB}} \cdot (N^{\mathrm{RB}}_{\mathrm{sc}} \cdot c - 4)]/36 \right\rfloor\right\}$, where $N^{\mathrm{DL}}_{\mathrm{RB}}$ is determined from the primary cell, $n_{\mathrm{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, $N^{(1)}_{\mathrm{PUCCH}}$ is configured by higher layers, $i = 2$ for the corresponding PDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding PDCCH with the DAI value equal to '2'.
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH on the primary cell in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2',
  - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n^{(1)}_{\mathrm{PUCCH},j}$ is given by $n^{(1)}_{\mathrm{PUCCH},j} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\mathrm{CCE},m} + N^{(1)}_{\mathrm{PUCCH}}$;
  - otherwise, if the value of k_m is same as the value of an element k^A_{i3} in set K^A, where $k^A_{i3} \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter

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subframeAssignment), the PUCCH resource $n^{(1)}_{\text{PUCCH},i}$ is given by

$$n^{(1)}_{\text{PUCCH},i} = (M^A - i3 - 1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N^{\text{K}^A}_{\text{PUCCH}};$$

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N^{\text{DL}}_{\text{RB}}\cdot(N^{\text{RB}}_{\text{sc}}\cdot c - 4)]/36 \right\rfloor\right\}$ where $N^{\text{DL}}_{\text{RB}}$ is determined from the primary cell, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N^{\text{K}^A}_{\text{PUCCH}}$, $N^{(1)}_{\text{PUCCH}}$, are configured by higher layers. Here, $i=2$ for the corresponding PDCCH with the DAI value equal to '1' and $i=3$ for the corresponding PDCCH the DAI value in the PDCCH equal to either '1' or '2'.

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding EPDCCH on the primary cell in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources are given by
  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH,i}} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},i} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. Here, $i=2$ for the corresponding EPDCCH with the DAI value equal to '1' and $i=3$ for the corresponding EPDCCH with the DAI value equal to '2'.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding EPDCCH on the primary cell in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources are given by
  - If EPDCCH-PRB-set q is configured for distributed transmission

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$$n^{(1)}_{\mathrm{PUCCH},i} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + \Delta'_{ARO} + N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\mathrm{PUCCH},i} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + n' + \Delta'_{ARO} + N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$$

where

- if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k^{A}_{i3}, where $k^{A}_{i3} \in K^{A}$, then $i4 = i3$;

and where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N^{(\mathrm{e1})}_{\mathrm{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^{A}_{i1}}$ are determined as described in subclause 10.1.3.1. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. Here, $i = 2$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding EPDCCH with the DAI value equal to '2'.

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH within the subframe(s) $n - k$, where $k \in K$ on the secondary cell, the value of $n^{(1)}_{\mathrm{PUCCH},2}$ and $n^{(1)}_{\mathrm{PUCCH},3}$ is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in the TPC field on all PDCCH/EPDCCH assignments on the secondary cell within subframe(s) $n - k$, where $k \in K$.
- For $0 \le j \le M - 1$, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to '$j+1$' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.

A UE shall perform channel selection according to the Tables 10.1.3.2-5, and 10.1.3.2-6 and transmit $b(0), b(1)$ on PUCCH resource $n^{(1,\tilde{p})}_{\mathrm{PUCCH}}$ for $\tilde{p}$ mapped to antenna port p using PUCCH format 1b according to subclause 5.4.1 in [3] where

- $n^{(1,\tilde{p}_0)}_{\mathrm{PUCCH}} = n^{(1)}_{\mathrm{PUCCH}}$ in sub-frame n for $\tilde{p}$ mapped to antenna port p_0 where "any" in Tables 10.1.3.2-5, and 10.1.3.2-6 represents any response of ACK, NACK, or DTX. The value of $b(0), b(1)$ and the PUCCH resource $n^{(1)}_{\mathrm{PUCCH}}$ are generated by channel selection according to Tables 10.1.3.2-5, and 10.1.3.2-6 for $M = 3$, and 4 respectively.
- $n^{(1,\tilde{p}_1)}_{\mathrm{PUCCH}}$ for antenna port p_1, where $n^{(1,\tilde{p}_1)}_{\mathrm{PUCCH}}$ selected from PUCCH resources, $n^{(1,\tilde{p}_1)}_{\mathrm{PUCCH},i}$ configured by higher layers where $0 \le i \le 3$ according Tables 10.1.3.2-5, and 10.1.3.2-6 for $M = 3$, and 4 respectively by replacing $n^{(1)}_{\mathrm{PUCCH}}$ with $n^{(1,\tilde{p}_1)}_{\mathrm{PUCCH}}$ and replacing $n^{(1)}_{\mathrm{PUCCH},i}$ with $n^{(1,\tilde{p}_1)}_{\mathrm{PUCCH},i}$, where "any" in Tables 10.1.3.2-5, and 10.1.3.2-6 represents any response of ACK, NACK, or DTX, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

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Table 10.1.3.2-5: Transmission of HARQ-ACK multiplexing for $M = 3$

Primary Cell	Secondary Cell	Resource	Constellation	RM Code Input Bits
HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	$b(0), b(1)$	$o(0), o(1), o(2), o(3)$
ACK, ACK, ACK	ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1	1,1,1,1
ACK, ACK, NACK/DTX	ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	0, 0	1,0,1,1
ACK, NACK/DTX, any	ACK, ACK, ACK	$n_{PUCCH,3}^{(1)}$	1, 1	0,1,1,1
NACK/DTX, any, any	ACK, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1	0,0,1,1
ACK, ACK, ACK	ACK, ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 0	1,1,1,0
ACK, ACK, NACK/DTX	ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 0	1,0,1,0
ACK, NACK/DTX, any	ACK, ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 1	0,1,1,0
NACK/DTX, any, any	ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 0	0,0,1,0
ACK, ACK, ACK	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, NACK/DTX	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, NACK/DTX, any	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
NACK/DTX, any, any	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
ACK, ACK, ACK	NACK/DTX, any, any	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0
ACK, ACK, NACK/DTX	NACK/DTX, any, any	$n_{PUCCH,1}^{(1)}$	0, 1	1, 0, 0, 0
ACK, NACK/DTX, any	NACK/DTX, any, any	$n_{PUCCH,0}^{(1)}$	1, 1	0, 1, 0, 0
NACK, any, any	NACK/DTX, any, any	$n_{PUCCH,0}^{(1)}$	0, 0	0, 0, 0, 0
DTX, any, any	NACK/DTX, any, any	No Transmission		0, 0, 0, 0

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Table 10.1.3.2-6: Transmission of HARQ-ACK multiplexing for $M = 4$

Primary Cell	Secondary Cell	Resource	Constellation	RM Code Input Bits
HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	$b(0),b(1)$	$o(0),o(1),o(2),o(3)$
ACK, ACK, ACK, NACK/DTX	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 1	1, 1, 1, 1
ACK, ACK, NACK/DTX, any	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 0	1, 0, 1, 1
ACK, DTX, DTX, DTX	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 1	0, 1, 1, 1
ACK, ACK, ACK, ACK	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 1	0, 1, 1, 1
NACK/DTX, any, any, any	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 1	0, 0, 1, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 1	0, 0, 1, 1
ACK, ACK, ACK, NACK/DTX	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	1, 0	1, 1, 1, 0
ACK, ACK, NACK/DTX, any	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	1, 0	1, 0, 1, 0
ACK, DTX, DTX, DTX	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	0, 1	0, 1, 1, 0
ACK, ACK, ACK, ACK	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	0, 1	0, 1, 1, 0
NACK/DTX, any, any, any	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	0, 0	0, 0, 1, 0
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	0, 0	0, 0, 1, 0
ACK, ACK, ACK, NACK/DTX	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, ACK, NACK/DTX	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, NACK/DTX, any	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, ACK, NACK/DTX, any	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, DTX, DTX, DTX	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, DTX, DTX, DTX	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, ACK, ACK, ACK	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, ACK, ACK, ACK	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
NACK/DTX, any, any, any	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
NACK/DTX, any, any, any	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
ACK, ACK, ACK, NACK/DTX	NACK/DTX, any, any, any	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0
ACK, ACK, ACK, NACK/DTX	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0
ACK, ACK, NACK/DTX, any	NACK/DTX, any, any, any	$n_{PUCCH,1}^{(1)}$	0, 1	1, 0, 0, 0

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ACK, ACK, NACK/DTX, any	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n^{(1)}_{PUCCH,1}$	0, 1	1, 0, 0, 0
ACK, DTX, DTX, DTX	NACK/DTX, any, any, any	$n^{(1)}_{PUCCH,0}$	1, 1	0, 1, 0, 0
ACK, DTX, DTX, DTX	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n^{(1)}_{PUCCH,0}$	1, 1	0, 1, 0, 0
ACK, ACK, ACK, ACK	NACK/DTX, any, any, any	$n^{(1)}_{PUCCH,0}$	1, 1	0, 1, 0, 0
ACK, ACK, ACK, ACK	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n^{(1)}_{PUCCH,0}$	1, 1	0, 1, 0, 0
NACK, any, any, any	NACK/DTX, any, any, any	$n^{(1)}_{PUCCH,0}$	0, 0	0, 0, 0, 0
NACK, any, any, any	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n^{(1)}_{PUCCH,0}$	0, 0	0, 0, 0, 0
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	NACK/DTX, any, any, any	$n^{(1)}_{PUCCH,0}$	0, 0	0, 0, 0, 0
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n^{(1)}_{PUCCH,0}$	0, 0	0, 0, 0, 0
DTX, any, any, any	NACK/DTX, any, any, any	No Transmission		0, 0, 0, 0
DTX, any, any, any	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	No Transmission		0, 0, 0, 0

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10.1.3.2.2 PUCCH format 3 HARQ-ACK procedure

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K'=K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K'.

If a UE is configured with one serving cell, or if a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this subclause K is as defined in Sec 10.2, and M is the number of elements in the set K.

If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this subclause refers to K_c (as defined in subclause 10.2), and M is the number of elements in the set K.

For TDD HARQ-ACK transmission with PUCCH format 3 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for $\tilde{p}$ mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b, and
      - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
      - otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A, where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher

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layer parameter *subframeAssignment*), the PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ is given by

$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1)\cdot N_c + i3\cdot N_{c+1} + n_{\mathrm{CCE},m} + N_{\mathrm{PUCCH}}^{\mathrm{K}^A}$;

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\mathrm{CCE},m} < N_{c+1}$,

$N_c = \max\left\{0, \left\lfloor [N_{\mathrm{RB}}^{\mathrm{DL}}\cdot(N_{\mathrm{sc}}^{\mathrm{RB}}\cdot c - 4)]/36 \right\rfloor\right\}$ where $N_{\mathrm{RB}}^{\mathrm{DL}}$ is determined from the primary cell, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N_{\mathrm{PUCCH}}^{\mathrm{K}^A}$, $N_{\mathrm{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ given by
      - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

      - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\mathrm{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5,

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$N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
      - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + \Delta'_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + n' + \Delta'_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      where
      - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
      - otherwise, if the value of k_m is same as the value of an index k^A_{i3}, where $k^A_{i3} \in K^A$, then $i4 = i3$;

      and where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\text{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^A_{i1}}$ are determined as described in section 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for

antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n-k$, where $k \in K$, and
    - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X), or
    - for an additional PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1',
      - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A=2$ and $A=3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A=3$; otherwise, $A=2$.
        - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as $n_{\text{PUCCH},1}^{(1)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$.
        - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
          - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
          - otherwise, if the value of k_m is same as the value of an element k_{i3}^{A} in set K^{A}, where $k_{i3}^{A} \in K^{A}$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M^{A}-i3-1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$;

            where M^{A} is the number of elements in the set K^{A} defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

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- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},2}$ is determined as $n^{(1)}_{\text{PUCCH},2} = n^{(1)}_{\text{PUCCH},1} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.

- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCH detected within subframe(s) $n-k$, where $k \in K$, and
    - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X), or
    - for an additional EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1',
      - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n^{(1)}_{\text{PUCCH}}$ selected from A PUCCH resources $n^{(1)}_{\text{PUCCH},i}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
        - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n^{(1)}_{\text{PUCCH},1}$ is determined as
          - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},1} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

          - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},1} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

            where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$,

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$N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n^{(1)}_{\text{PUCCH},1}$ is determined as
  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},i} = n_{\text{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + \Delta'_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},i} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + n' + \Delta'_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

    where
    - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
    - otherwise, if the value of k_m is same as the value of an index k^{A}_{i3}, where $k^{A}_{i3} \in K^{A}$, then $i4 = i3$;
  - and where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^{A}_{i1}}$ are determined as described in section 10.1.3.1.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},2}$ is determined as $n^{(1)}_{\text{PUCCH},2} = n^{(1)}_{\text{PUCCH},1} + 1$.HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.

- for $M > 1$, and

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- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1' (defined in Table 7.3-X), or
- for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1', or
- for $M=9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', or
- for $M=9$ and for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1',
  - the UE shall use PUCCH format 3 and PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in a PDCCH assignment with DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH assignment in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n-k$, where $k \in K$.

- for $M>1$, and
  - for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1' (defined in Table 7.3-X), or
  - for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1', or
  - for $M=9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', or
  - for $M=9$ and for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1',
    - the UE shall use PUCCH format 3 and PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with DAI value greater than '1' or with DAI value equal to '1' (defined in Table 7.3-X), not being the first PDCCH/EPDCCH assignment in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n-k$, where $k \in K$.

- If the UL/DL configurations of all serving cells are the same, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding

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PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For TDD UL/DL configurations 1-6, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1' (defined in Table 7.3-X), shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$. For TDD UL/DL configurations 1-6, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$.

- If the UL/DL configurations of at least two serving cells are different, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$.

- For PUCCH format 3 and PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p})}$ and a UE configured for two antenna port transmission, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\mathrm{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0.

10.1.3.2.3 PUCCH format 4 HARQ-ACK procedure

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13 = 1* is described in section 10.1.3.2.3.1.

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13 = 0* is described in section 10.1.3.2.3.2.

10.1.3.2.3.1 PUCCH format 4 HARQ-ACK procedure without adaptive codebook

The procedure in this subclause applies to a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13 = 1*.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K'=K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K'.

If a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this subclause K is as defined in Sec 10.2, and M is the number of elements in the set K.

If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this subclause refers to K_c (as defined in subclause 10.2), and M is the number of elements in the set K.

For TDD HARQ-ACK transmission with PUCCH format 4 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(4,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe n for $\tilde{p}$ mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}}\cdot(N_{\text{sc}}^{\text{RB}}\cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b, and
      - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;

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- otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A, where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{\text{K}^\wedge}$;

  where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{\text{K}^\wedge}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
      - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed

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assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ given by
      - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + \Delta'_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$$

      - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + n' + \Delta'_{ARO} + N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$$

      where
      - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
      - otherwise, if the value of k_m is same as the value of an index k^{A}_{i3}, where $k^{A}_{i3} \in K^{A}$, then $i4 = i3$;

      and where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\mathrm{PUCCH,q}}^{(\mathrm{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^{A}_{i1}}$ are determined as described in section 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ with the value of $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH

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resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n-k$, where $k \in K$, and
    - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X), or
    - for an additional PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1',
      - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A=2$ and $A=3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A=3$; otherwise, $A=2$.
        - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as $n_{\text{PUCCH},1}^{(1)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$.
        - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
          - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
          - otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A, where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M^A - i3 - 1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$;

            where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

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- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},2}$ is determined as $n^{(1)}_{\text{PUCCH},2} = n^{(1)}_{\text{PUCCH},1} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.

- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCH detected within subframe(s) $n-k$, where $k \in K$, and
    - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X), or
    - for an additional EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1',
      - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n^{(1)}_{\text{PUCCH}}$ selected from A PUCCH resources $n^{(1)}_{\text{PUCCH},i}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
        - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n^{(1)}_{\text{PUCCH},1}$ is determined as
          - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},1} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

          - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},1} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N^{(\text{e1})}_{\text{PUCCH,q}}$$

            where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(\text{e1})}_{\text{PUCCH,q}}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$,

$N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n^{(1)}_{\text{PUCCH},1}$ is determined as
  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},i} = n_{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + \Delta'_{ARO} + N^{(e1)}_{\text{PUCCH},q}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},i} = \left\lfloor \frac{n_{\text{ECCE},q}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^{A}_{i1}} + n' + \Delta'_{ARO} + N^{(e1)}_{\text{PUCCH},q}$$

    where
    - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
    - otherwise, if the value of k_m is same as the value of an index k^{A}_{i3}, where $k^{A}_{i3} \in K^{A}$, then $i4 = i3$;
  - and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(e1)}_{\text{PUCCH},q}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^{A}_{i1}}$ are determined as described in section 10.1.3.1.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},2}$ is determined as $n^{(1)}_{\text{PUCCH},2} = n^{(1)}_{\text{PUCCH},1} + 1$.HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.

- for $M > 1$, and

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- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1' (defined in Table 7.3-X), or
- for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1', or
- for $M=9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', or
- for $M=9$ and for a PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1',
  - the UE shall use PUCCH format 4 and PUCCH resource $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in a PDCCH assignment with DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH assignment in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n-k$, where $k \in K$.

- for $M>1$, and
  - for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1' (defined in Table 7.3-X), or
  - for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1', or
  - for $M=9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', or
  - for $M=9$ and for an EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1',
    - the UE shall use PUCCH format 4 and PUCCH resource $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with DAI value greater than '1' or with DAI value equal to '1' (defined in Table 7.3-X), not being the first PDCCH/EPDCCH assignment in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n-k$, where $k \in K$.

- If the UL/DL configurations of all serving cells are the same, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 4 and PUCCH resource $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values

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configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. For TDD UL/DL configurations 1-6, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1' (defined in Table 7.3-X), shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$. For TDD UL/DL configurations 1-6, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$.

- If the UL/DL configurations of at least two serving cells are different, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 4 and PUCCH resource $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\mathrm{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n-k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n-k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n-k$, where $k \in K$.

10.1.3.2.3.2 PUCCH format 4 HARQ-ACK procedure with adaptive codebook

The procedure in this subclause applies to a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13* = *0*.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K'.

If a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this subclause K is as defined in Sec 10.2, and M is the number of elements in the set K.

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If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this subclause refers to K_c (as defined in subclause 10.2), and M is the number of elements in the set K.

For TDD HARQ-ACK transmission with PUCCH format 4 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(4,\tilde{p})}$ or $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe n for $\tilde{p}$ mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE,m}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1',
    - the UE shall use PUCCH format 1a/1b, and
      - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
      - otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A, where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{\text{K}^A}$;

        where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)]/36 \right\rfloor\right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in

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subframe $n-k_m$, and $N_{\mathrm{PUCCH}}^{\mathrm{K}^{\wedge}}$, $N_{\mathrm{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
  - for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1',
    - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\mathrm{PUCCH}}^{(1,\tilde{p})}$ given by
      - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = n_{\mathrm{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

      - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\mathrm{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\mathrm{PUCCH,q}}^{(e1)}$$

      where $n_{\mathrm{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\mathrm{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\mathrm{PUCCH}}^{(1,\tilde{p}_1)} = n_{\mathrm{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
  - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1' (defined in Table 7.3.2.1-1), or

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- for a single PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1',
  - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
    - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE,q}} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + \Delta'_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

    - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + n' + \Delta'_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      where
      - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
      - otherwise, if the value of k_m is same as the value of an index k^A_{i3}, where $k^A_{i3} \in K^A$, then $i4 = i3$;

      and where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\text{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^A_{i1}}$ are determined as described in section 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n-k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n-k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n-k$, where $k \in K$, and
    - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n-k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH equal to '1' (defined in Table 7.3.2.1-1), or
    - for an additional PDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH equal to '1',

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- the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A=2$ and $A=3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A=3$; otherwise, $A=2$.
  - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as $n_{\text{PUCCH},1}^{(1)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}}\cdot(N_{\text{sc}}^{\text{RB}}\cdot c - 4)]/36 \right\rfloor\right\}$, and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ where $k_m \in K$.
  - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
    - if the value of k_m is same as the value of an element k'_{i2}, where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M'-i2-1)\cdot N_c + i2\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
    - otherwise, if the value of k_m is same as the value of an element k_{i3}^{A} in set K^{A}, where $k_{i3}^{A} \in K^{A}$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M^{A}-i3-1)\cdot N_c + i3\cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$;

      where M^{A} is the number of elements in the set K^{A} defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{\text{CCE},m} < N_{c+1}$, $N_c = \max\left\{0, \left\lfloor [N_{\text{RB}}^{\text{DL}}\cdot(N_{\text{sc}}^{\text{RB}}\cdot c - 4)]/36 \right\rfloor\right\}$, $n_{CCE,m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$, and $N_{\text{PUCCH}}^{\text{K}^{\text{A}}}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.
  - For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{\text{PUCCH},2}^{(1)}$ is determined as $n_{\text{PUCCH},2}^{(1)} = n_{\text{PUCCH},1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of both the counter DAI field and total DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of both the counter DAI field and total DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and
  - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCH detected within subframe(s) $n-k$, where $k \in K$, and

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- for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n-k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the EPDCCH equal to '1' (defined in Table 7.3.2.1-1), or
- for an additional EPDCCH indicating downlink SPS release (defined in subclause 9.2) in subframe $n-k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the EPDCCH equal to '1',
  - the UE shall transmit $b(0),b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \le i \le A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A=2$ and $A=3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A=3$; otherwise, $A=2$.
    - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
      - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE,q}} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lfloor \frac{n_{\text{ECCE,q}}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{m-1} N_{ECCE,q,n-k_{i1}} + n' + \Delta_{ARO} + N_{\text{PUCCH,q}}^{(e1)}$$

      where $n_{\text{ECCE,q}}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N_{\text{PUCCH,q}}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n-k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n-k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n-k_{i1}$. For normal downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n-k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

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- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},0}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n^{(1)}_{\text{PUCCH},1}$ is determined as

  - If EPDCCH-PRB-set q is configured for distributed transmission

$$n^{(1)}_{\text{PUCCH},i} = n_{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + \Delta'_{ARO} + N^{(e1)}_{\text{PUCCH},q}$$

  - If EPDCCH-PRB-set q is configured for localized transmission

$$n^{(1)}_{\text{PUCCH},i} = \left\lfloor \frac{n_{\text{ECCE},q}}{N^{ECCE,q}_{RB}} \right\rfloor \cdot N^{ECCE,q}_{RB} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} + n' + \Delta'_{ARO} + N^{(e1)}_{\text{PUCCH},q}$$

    where

    - if the value of k_m is same as the value of an index k'_{i2}, where $k'_{i2} \in K'$, then $i4 = i2$;
    - otherwise, if the value of k_m is same as the value of an index k^A_{i3}, where $k^A_{i3} \in K^A$, then $i4 = i3$;

  - and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n-k_m$, $N^{(e1)}_{\text{PUCCH},q}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N^{ECCE,q}_{RB}$ for EPDCCH-PRB-set q in subframe $n-k_m$ is given in subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n-k_m$ which is described in subclause 6.8A.5 in [3]. Δ'_{ARO}, $N'_{ECCE,q,n-k'_{i1}}$, $N'_{ECCE,q,n-k^A_{i1}}$ are determined as described in section 10.1.3.1.

- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n^{(1)}_{\text{PUCCH},2}$ is determined as $n^{(1)}_{\text{PUCCH},2} = n^{(1)}_{\text{PUCCH},1} + 1$.HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'.

- if a PDSCH transmission is indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_m$, where $k_m \in K$ with either the counter DAI value or the total DAI value in the PDCCH greater than '1' (defined in Table 7.3.2.1-1) on the primary cell, or
- if a PDCCH/EPDCCH indicating downlink SPS release (defined in subclause 9.2) is detected in subframe $n-k_m$, where $k_m \in K$ with either the DAI value or the total DAI value in the PDCCH greater than '1' on the primary cell, or
- if a PDSCH transmission is indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k$, where $k \in K$ on a secondary cell,

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- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCCH resource $n_{\text{PUCCH}}^{(4,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(4,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1. Denote C as the set of configured serving cells for the UE. Denote $k_{smallest}$ is the smallest value in $\bigcup_{c\in C} K_c$ such that PDCCH/EPDCCH scheduling PDSCH or indicating DL SPS release is detected in subframe $n-k_{smallest}$ on serving cell $\tilde{c}$ and $k_{smallest}\in K_{\tilde{c}}$. The TPC field in a PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n-k_{smallest}$ on a serving cell c satisfying $k_{smallest}\in K_c$ shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on any PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n-k_{smallest}$ on any serving cell c satisfying $k_{smallest}\in K_c$.

- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1. Denote C as the set of configured serving cells for the UE. Denote $k_{smallest}$ is the smallest value in $\bigcup_{c\in C} K_c$ such that PDCCH/EPDCCH scheduling PDSCH or indicating DL SPS release is detected in subframe $n-k_{smallest}$ on serving cell $\tilde{c}$ and $k_{smallest}\in K_{\tilde{c}}$. The TPC field in a PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n-k_{smallest}$ on a serving cell c satisfying $k_{smallest}\in K_c$ shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on any PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n-k_{smallest}$ on any serving cell c satisfying $k_{smallest}\in K_c$. If a UE is configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0.

10.1.3.2.4 PUCCH format 5 HARQ-ACK procedure

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 5 and *codebooksizeDetermination-r13 = 1* is described in section 10.1.3.2.4.1.

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 5 and *codebooksizeDetermination-r13 = 0* is described in section 10.1.3.2.4.2.

10.1.3.2.4.1 PUCCH format 5 HARQ-ACK procedure without adaptive codebook

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in subclause 10.1.3.2.3.1, by replacing $n_{\text{PUCCH}}^{(4,\tilde{p})}$ with $n_{\text{PUCCH}}^{(5,\tilde{p})}$.

10.1.3.2.4.2 PUCCH format 5 HARQ-ACK procedure with adaptive codebook

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in subclause 10.1.3.2.3.2, by replacing $n_{\text{PUCCH}}^{(4,\tilde{p})}$ with $n_{\text{PUCCH}}^{(5,\tilde{p})}$.

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10.1.3A FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 2

A UE is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK.

For a serving cell, if the serving cell is frame structure type 1, and a UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, set K is defined in Table 10.1.3A-1, otherwise set K is defined in Table 10.1.3.1-1.

PUCCH format 1b with channel selection is not supported if a UE is configured with more than two serving cells, or if the DL-reference UL/DL configuration 5 (as defined in subclause 10.2) is defined for any serving cell, or if the DL-reference UL/DL configuration of a serving cell with frame structure type 1 belongs to {2, 3, 4} and the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell.

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and is configured with PUCCH format 3 without PUCCH format 4/5 configured, the UE is not expected to be configured with more than two serving cells having DL-reference UL/DL configuration 5.

If a UE is configured to use PUCCH format 1b with channel selection for HARQ-ACK transmission, for the serving cells,

- if more than 4 HARQ-ACK bits for M multiple downlink and special subframes associated with a single UL subframe n, where M is as defined in subclause 10.1.3.2.1 for case where the UE is configured with two serving cells with different UL/DL configurations,
  - spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for each serving cell by a logical AND operation of all the corresponding individual HARQ-ACKs, and the bundled HARQ-ACK bits for each serving cell is transmitted using PUCCH format 1b with channel selection,
- otherwise,
  - spatial HARQ-ACK bundling is not performed, and the HARQ-ACK bits are transmitted using PUCCH format 1b with channel selection.

If a UE is configured to use PUCCH format 3 without PUCCH format 4/5 configured for HARQ-ACK transmission, for the serving cells,

- if more than 21 HARQ-ACK bits for M multiple downlink and special subframes associated with a single UL subframe n, where M as defined in subclause 10.1.3.2.2 for the case of UE configured with more than one serving cell and if at least two cells have different UL/DL configurations,
  - spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for each serving cell by a logical AND operation of all of the corresponding individual HARQ-ACKs, and PUCCH format 3 is used,
- otherwise,
  - spatial HARQ-ACK bundling is not performed, and the HARQ-ACK bits are transmitted using PUCCH format 3.
- UE shall determine the number of HARQ-ACK bits, O, associated with an UL subframe n according to $O = \sum_{c=1}^{N_{cells}^{DL}} O_c^{ACK}$ where N_{cells}^{DL} is the number of configured cells, and O_c^{ACK} is the number of HARQ-bits for the c-th serving cell defined in subclause 7.3.4. If a UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling a serving cell with frame structure type 1, and the DL-reference UL/DL configuration of the serving cell belongs to {2, 3, 4, 5}, then the UE is not expected to be configured with N_{cells}^{DL} which result in $O > 21$.

HARQ-ACK transmission on two antenna ports ($p \in \{p_0, p_1\}$) is supported for PUCCH format 3.

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HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and with two configured serving cells.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 1b with channel selection follows the HARQ-ACK procedure described in subclause 10.1.3.2.1 for the case of UE configured with two serving cells with different UL/DL configurations, and for PUCCH format 3/4/5 follows the HARQ-ACK procedure described in subclause 10.1.3.2.2/10.1.3.2.3/10.2.3.2.4 for the case of UE configured with more than one serving cell and if at least two cells have different UL/DL configurations.

Table 10.1.3A-1: Downlink association set $K : \{k_0, k_1, \cdots k_{M-1}\}$ for FDD-TDD and serving cell frame structure type 1

DL-reference UL/DL Configuration	Subframe n									
	0	1	2	3	4	5	6	7	8	9
0	-	-	6, 5	5, 4	4	-	-	6, 5	5, 4	4
1	-	-	7, 6	6, 5, 4	-	-	-	7, 6	6, 5, 4	-
2	-	-	8, 7, 6, 5, 4	-	-	-	-	8, 7, 6, 5, 4	-	-
3	-	-	11, 10, 9, 8, 7, 6	6, 5	5, 4	-	-	-	-	-
4	-	-	12, 11, 10, 9, 8, 7	7, 6, 5, 4	-	-	-	-	-	-
5	-	-	13, 12, 11, 10, 9, 8, 7, 6, 5, 4	-	-	-	-	-	-	-
6	-	-	8, 7	7, 6	6, 5	-	-	7	7, 6, 5	-

10.1.4 HARQ-ACK Repetition procedure

HARQ-ACK repetition is enabled or disabled by a UE specific parameter *ackNackRepetition* configured by higher layers. Once enabled, the UE shall repeat any HARQ-ACK transmission with a repetition factor N_{ANRep}, where N_{ANRep} is provided by higher layers and includes the initial HARQ-ACK transmission, until HARQ-ACK repetition is disabled by higher layers. For a PDSCH transmission without a corresponding PDCCH/EPDCCH detected, the UE shall transmit the corresponding HARQ-ACK response N_{ANRep} times using PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ configured by higher layers. For a PDSCH transmission with a corresponding PDCCH/EPDCCH detected, or for a PDCCH/EPDCCH indicating downlink SPS release, the UE shall first transmit the corresponding HARQ-ACK response once using PUCCH resource derived from the corresponding PDCCH CCE index or EPDCCH ECCE index (as described in subclauses 10.1.2 and 10.1.3), and repeat the transmission of the corresponding HARQ-ACK response $N_{\text{ANRep}} - 1$ times always using PUCCH resource $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p})}$, where $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p})}$ is configured by higher layers.

HARQ-ACK repetition is only applicable for UEs configured with one serving cell for FDD and TDD. For TDD, HARQ-ACK repetition is only applicable for HARQ-ACK bundling.

HARQ-ACK repetition can be enabled with PUCCH format 1a/1b on two antenna ports. For a UE configured for two antenna port transmission for HARQ-ACK repetition with PUCCH format 1a/1b, a PUCCH resource value $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p})}$ maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p}_1)}$ for antenna port p_1, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH, ANRep}}^{(1,\tilde{p}_0)}$ for antenna port p_0.

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10.1.5 Scheduling Request (SR) procedure

A UE is configured by higher layers to transmit the SR on one antenna port or two antenna ports.
The scheduling request shall be transmitted on the PUCCH resource(s) $n_{\mathrm{PUCCH}}^{(1,\tilde{p})} = n_{\mathrm{PUCCH,SRI}}^{(1,\tilde{p})}$ for $\tilde{p}$ mapped to antenna port p as defined in [3], where $n_{\mathrm{PUCCH,SRI}}^{(1,\tilde{p})}$ is configured by higher layers unless the SR coincides in time with the transmission of HARQ-ACK using PUCCH Format 3/4/5 in which case the SR is multiplexed with HARQ-ACK according to subclause 5.2.3.1 of [4]. The SR configuration for SR transmission periodicity $SR_{\mathrm{PERIODICITY}}$ and SR subframe offset $N_{\mathrm{OFFSET,SR}}$ is defined in Table 10.1.5-1 by the parameter *sr-ConfigIndex* I_{SR} given by higher layers.

SR transmission instances are the uplink subframes satisfying
$\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{\mathrm{OFFSET,SR}}\right) \bmod SR_{\mathrm{PERIODICITY}} = 0$.

Table 10.1.5-1: UE-specific SR periodicity and subframe offset configuration

SR configuration Index I_{SR}	SR periodicity (ms) $SR_{\mathrm{PERIODICITY}}$	SR subframe offset $N_{\mathrm{OFFSET,SR}}$
0 – 4	5	I_{SR}
5 – 14	10	$I_{SR} - 5$
15 – 34	20	$I_{SR} - 15$
35 – 74	40	$I_{SR} - 35$
75 – 154	80	$I_{SR} - 75$
155 – 156	2	$I_{SR} - 155$
157	1	$I_{SR} - 157$

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10.2 Uplink HARQ-ACK timing

For TDD or for FDD-TDD and primary cell frame structure type 2 or for FDD-TDD and primary cell frame structure type 1, if a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell, "UL/DL configuration" of the serving cell in subclause 10.2 refers to the UL/DL configuration given by the parameter *eimta-HARQ-ReferenceConfig-r12* for the serving cell unless specified otherwise.

For FDD or for FDD-TDD and primary cell frame structure type 1, the UE shall upon detection of a PDSCH transmission in subframe *n-4* intended for the UE and for which an HARQ-ACK shall be provided, transmit the HARQ-ACK response in subframe *n*. If HARQ-ACK repetition is enabled, upon detection of a PDSCH transmission in subframe *n-4* intended for the UE and for which HARQ-ACK response shall be provided, and if the UE is not repeating the transmission of any HARQ-ACK in subframe n corresponding to a PDSCH transmission in subframes $n-N_{\text{ANRep}}-3, \ldots, n-5$, the UE:

- shall transmit only the HARQ-ACK response (corresponding to the detected PDSCH transmission in subframe $n-4$) on PUCCH in subframes $n, n+1, \ldots, n+N_{\text{ANRep}}-1$;
- shall not transmit any other signal/channel in subframes $n, n+1, \ldots, n+N_{\text{ANRep}}-1$; and
- shall not transmit any HARQ-ACK response repetitions corresponding to any detected PDSCH transmission in subframes $n-3, \ldots, n+N_{\text{ANRep}}-5$.

For TDD and a UE configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, the DL-reference UL/DL configuration for a serving cell is the UL/DL configuration of the serving cell.

For FDD-TDD and primary cell frame structure type 1, if a serving cell is a secondary serving cell with frame structure type 2, the DL-reference UL/DL configuration for the serving cell is the UL/DL configuration of the serving cell.

For TDD, if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if a serving cell is a primary cell, then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell or if a serving cell is a secondary cell with frame structure type 1, then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For TDD and if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if the UE is not configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell, or for FDD-TDD and primary cell frame structure type 2 and if the UE is not configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell with frame structure type 2

- if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 1 in Table 10.2-1 or
- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 2 or Set 3 in Table 10.2-1 or
- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 4 or Set 5 in Table 10.2-1

then the DL-reference UL/DL configuration for the serving cell is defined in the corresponding Set in Table 10.2-1.

For TDD and if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if the UE is configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell, or for FDD-TDD and primary cell frame structure type 2 and if the UE is configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell with frame structure type 2

- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 1 or

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Set 4 or Set 5 in Table 10.2-1, then the DL-reference UL/DL configuration for the serving cell is defined in the corresponding Set in Table 10.2-1;

- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For a UE not configured with PUCCH format 4 or PUCCH format 5, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations or for FDD-TDD and primary cell frame structure type 2, if the DL-reference UL/DL configuration for at least one serving cell is TDD UL/DL Configuration 5, then the UE is not expected to be configured with more than two serving cells.

For TDD and a UE not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, if the UE is configured with one serving cell, or the UE is configured with more than one serving cell and the UL/DL configurations of all serving cells is same, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n.

For a UE not configured with *harqTimingTDD = TRUE*, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or if a UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and primary cell frame structure type 2 and if a serving cell c is frame structure type 2, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c, where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n, wherein set K_c contains values of $k \in K$ such that subframe n-k corresponds to a DL subframe or a special subframe for serving cell c, where DL subframe or special subframe of serving cell c is according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for serving cell c; K defined in Table 10.1.3.1-1 (where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n.

For a UE configured with *harqTimingTDD = TRUE*, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or for FDD-TDD and primary cell frame structure type 2 and if a serving cell c is frame structure type 2,

- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c, where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n, wherein set K_c contains values of $k \in K$ such that subframe n-k corresponds to a DL subframe or a special subframe for serving cell c, where K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n.
- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c, where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n, wherein set K_c contains values of $k \in K$ such that subframe n-k corresponds to a DL subframe or a special subframe for serving cell c, where K is defined in Table 10.1.3A-1 (where "UL/DL configuration" in Table 10.1.3A-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n.

For FDD-TDD and primary cell frame structure type 2, if a serving cell c is frame structure type 1 and a UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c, where $k \in K_c$, $K_c = K$ and K is defined in Table 10.1.3A-1 intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in subframe n.

For FDD-TDD and primary cell frame structure type 2, if a serving cell c is frame structure type 1 and a UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling serving cell c, then the UE shall upon

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detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c, where $k \in K_c$, $K_c = K$ and K is defined in Table 10.1.3.1-1, intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in subframe n, where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration" of serving cell c.

For TDD, if HARQ-ACK repetition is enabled, upon detection of a PDSCH transmission within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE and for which HARQ-ACK response shall be provided, and if the UE is not repeating the transmission of any HARQ-ACK in subframe n corresponding to a PDSCH transmission in a downlink or special subframe earlier than subframe $n-k$, the UE:

- shall transmit only the HARQ-ACK response (corresponding to the detected PDSCH transmission in subframe $n-k$) on PUCCH in UL subframe n and the next $N_{\text{ANRep}}-1$ UL subframes denoted as n_1, ..., $n_{N_{\text{ANRep}}-1}$;
- shall not transmit any other signal/channel in UL subframe n, n_1, ..., $n_{N_{\text{ANRep}}-1}$; and
- shall not transmit any HARQ-ACK response repetitions corresponding to any detected PDSCH transmission in subframes $n_i - k$, where $k \in K_i$, K_i is the set defined in Table 10.1.3.1-1 corresponding to UL subframe n_i, and $1 \le i \le N_{\text{ANRep}}-1$.

For TDD, HARQ-ACK bundling, if the UE detects that at least one downlink assignment has been missed as described in subclause 7.3, the UE shall not transmit HARQ-ACK on PUCCH if HARQ-ACK is the only UCI present in a given subframe.

The uplink timing for the ACK corresponding to a detected PDCCH/EPDCCH indicating downlink SPS release shall be the same as the uplink timing for the HARQ-ACK corresponding to a detected PDSCH, as defined above.

Table 10.2-1: DL-reference UL/DL configuration for serving cell based on pair formed by (primary cell UL/DL configuration, secondary cell UL/DL configuration)

Set #	(Primary cell UL/DL configuration, Secondary cell UL/DL configuration)	DL-reference UL/DL configuration
Set 1	(0,0)	0
	(1,0),(1,1),(1,6)	1
	(2,0),(2,2),(2,1),(2,6)	2
	(3,0),(3,3),(3,6)	3
	(4,0),(4,1),(4,3),(4,4),(4,6)	4
	(5,0),(5,1),(5,2),(5,3),(5,4),(5,5),(5,6)	5
	(6,0),(6,6)	6
Set 2	(0,1),(6,1)	1
	(0,2),(1,2),(6,2)	2
	(0,3),(6,3)	3
	(0,4),(1,4),(3,4),(6,4)	4
	(0,5),(1,5),(2,5),(3,5),(4,5),(6,5)	5
	(0,6)	6
Set 3	(3,1),(1,3)	4
	(3,2),(4,2),(2,3),(2,4)	5
Set 4	(0,1),(0,2),(0,3),(0,4),(0,5),(0,6)	0
	(1,2),(1,4),(1,5)	1
	(2,5)	2
	(3,4),(3,5)	3
	(4,5)	4
	(6,1),(6,2),(6,3),(6,4),(6,5)	6
Set 5	(1,3)	1
	(2,3),(2,4)	2
	(3,1),(3,2)	3
	(4,2)	4

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11 Physical Multicast Channel (PMCH) related procedures

11.1 UE procedure for receiving the PMCH

The UE shall decode the PMCH when configured by higher layers. The UE may assume that an eNB transmission on the PMCH is performed according to subclause 6.5 of [3].

The I_{MCS} for the PMCH is configured by higher layers. If the UE is configured by higher layers to decode the PMCH based on QPSK, 16QAM, 64QAM, and 256QAM then the UE shall use I_{MCS} and Table 7.1.7.1-1A to determine the modulation order (Q_m) and TBS index (I_{TBS}) used in the PMCH. Else the UE shall use I_{MCS} for the PMCH and Table 7.1.7.1-1 to determine the modulation order (Q_m) and TBS index (I_{TBS}) used in the PMCH.

The UE shall then follow the procedure in subclause 7.1.7.2.1 to determine the transport block size, assuming N_{PRB} is equal to N_{RB}^{DL}. The UE shall set the redundancy version to 0 for the PMCH.

11.2 UE procedure for receiving MCCH change notification

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the M-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 11.2-1.

Table 11.2-1: PDCCH configured by M-RNTI

DCI format	Search Space
DCI format 1C	Common

The 8-bit information for MCCH change notification [11], as signalled on the PDCCH, shall be delivered to higher layers.

12 Assumptions independent of physical channel

A UE shall not assume that two antenna ports are quasi co-located unless specified otherwise.

A UE may assume the antenna ports 0 – 3 of a serving cell are quasi co-located (as defined in [3]) with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

For the purpose of discovery-signal-based measurements, a UE shall not assume any other signals or physical channels are present other than the discovery signal.

If a UE supports *discoverySignalsInDeactSCell-r12*, and if the UE is configured with discovery-signal-based RRM measurements on a carrier frequency applicable for a secondary cell on the same carrier frequency, and if the secondary cell is deactivated, and if the UE is not configured by higher layers to receive MBMS on the secondary cell, the UE shall, except for discovery-signal transmissions, assume that PSS, SSS, PBCH, CRS, PCFICH, PDSCH, PDCCH, EPDCCH, PHICH, DMRS and CSI-RS may be not transmitted by the secondary cell until the subframe where an activation command is received for the secondary cell.

13 Uplink/Downlink configuration determination procedure for Frame Structure Type 2

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.

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- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

For each serving cell

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*,

- the UE shall set the UL/DL configuration equal to the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers.

If the UE is configured by higher layers with the parameter *EIMTA-MainConfigServCell-r12*, then for each radio frame,

- the UE shall determine eIMTA-UL/DL-configuration as described in subclause 13.1.
- the UE shall set the UL/DL configuration for each radio frame equal to the eIMTA-UL/DL-configuration of that radio frame.

13.1 UE procedure for determining eIMTA-uplink/downlink configuration

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the eIMTA-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 13.1-1.

Table 13.1-1: PDCCH configured by eIMTA-RNTI

DCI format	Search Space
DCI format 1C	Common

The subframes in which the UE monitors PDCCH with CRC scrambled by eIMTA-RNTI are configured by higher layers.

For each serving cell,

- if T= 10,
  - if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in subframe 0 of a radio frame m or if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in a subframe other than subframe 0 of a radio frame m-1,
    - the eIMTA-UL/DL-configuration for radio frame m is given by the UL/DL configuration indication signalled on the PDCCH as described in [4],
    - the UE may assume that the same UL/DL configuration indication is indicated by PDCCH with CRC scrambled by eIMTA-RNTI in subframe 0 of radio frame m and in all the subframes other than subframe 0 of radio frame m-1 in which PDCCH with CRC scrambled by eIMTA-RNTI is monitored,
  - otherwise
    - the eIMTA-UL/DL-configuration for radio frame m is same as the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers;
- if T is a value other than 10,
  - if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in a subframe in radio frame $mT/10$,
    - the eIMTA-UL/DL-configuration for radio frames $\{mT/10+1, mT/10+2, \ldots (m+1)T/10\}$ is given by the UL/DL configuration indication signalled on the PDCCH as described [4],
    - the UE may assume that the same UL/DL configuration indication is indicated by PDCCH with CRC scrambled by eIMTA-RNTI in all the subframes of radio frame $mT/10$ in which PDCCH with CRC scrambled by eIMTA-RNTI is monitored,

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- otherwise
  - the eIMTA-UL/DL-configuration for radio frames {$mT/10+1$, $mT/10+2$,.... ($m+1$) $T/10$} is same as the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers.

where T denotes the value of parameter *eimta-CommandPeriodicity-r12*.

For a serving cell c , if subframe i is indicated as uplink subframe or a special subframe by higher layer parameter *eimta-HARQ-ReferenceConfig-r12*, the UE is not expected to receive a PDCCH with CRC scrambled by eIMTA-RNTI containing an UL/DL configuration for serving cell c that would indicate subframe i as a downlink subframe.

For a serving cell c , if subframe i is indicated as downlink subframe or a special subframe by higher layer parameter *subframeAssignment*, the UE is not expected to receive a PDCCH with CRC scrambled by eIMTA-RNTI containing an UL/DL configuration for serving cell c that would indicate subframe i as an uplink subframe.

For a serving cell c , a UE is not expected to be configured with parameter *eimta-HARQ-ReferenceConfig-r12* if a subframe indicated as an uplink subframe by *eimta-HARQ-ReferenceConfig-r12* is not indicated as an uplink subframe by the UL-reference UL/DL configuration.

If UE is not configured with the parameter *EIMTA-MainConfigServCell-r12* for any activated serving cell, the UE is not expected to monitor PDCCH with CRC scrambled by eIMTA-RNTI.

13A Subframe configuration for Frame Structure Type 3

If a UE detects PDCCH with DCI CRC scrambled by CC-RNTI in subframe n-1 or subframe n of a LAA Scell, the UE may assume the configuration of occupied OFDM symbols in subframe n of the LAA Scell according to the 'Subframe configuration for LAA' field in the detected DCI in subframe n-1 or subframe n.

The 'Subframe configuration for LAA' field indicates the configuration of occupied OFDM symbols (i.e., OFDM symbols used for transmission of downlink physical channels and/or physical signals) in current and/or next subframe according to Table 13A-1.

If the configuration of occupied OFDM symbols for subframe n is indicated by the Subframe configuration for LAA field in both subframe n-1 and subframe n, the UE may assume that the same configuration of occupied OFDM symbols is indicated in both subframe n-1 and subframe n.

If a UE detects PDCCH with DCI CRC scrambled by CC-RNTI in subframe n, and the UE does not detect PDCCH with DCI CRC scrambled by CC-RNTI in subframe n-1, and if the number of occupied OFDM symbols for subframe n indicated by the Subframe configuration for LAA field in subframe n is less than 14, the UE is not required to receive any physical channels or signals in subframe n.

A UE is not required to use subframe n for updating CSI measurement, if the UE does not detect PDCCH with DCI CRC scrambled by CC-RNTI in subframe n-1, and in subframe n.

The UE may detect PDCCH with DCI CRC scrambled by CC-RNTI by monitoring the following PDCCH candidates according to DCI Format 1C.

- one PDCCH candidate at aggregation level L=4 with the CCEs corresponding to the PDCCH candidate given by CCEs numbered 0,1,2,3
- one PDCCH candidate at aggregation level L=8 with the CCEs corresponding to the PDCCH candidate given by CCEs numbered 0,1,2,3,4,5,6,7

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07', and if the UE detects PDCCH/EPDCCH intended for the UE starting in the second slot of a subframe, the UE may assume that OFDM symbols in the first slot of the subframe are not occupied, and all OFDM symbols in the second slot of the subframe are occupied,

If subframe n is a subframe in which OFDM symbols in the first slot are not occupied, the UE may assume that all the OFDM symbols are occupied in subframe n+1.

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Table 13A-1: Subframe configuration for LAA in current and next subframe

Value of 'Subframe configuration for LAA' field in current subframe	Configuration of occupied OFDM symbols (current subframe, next subframe)
0000	(-,14)
0001	(-,12)
0010	(-,11)
0011	(-,10)
0100	(-,9)
0101	(-,6)
0110	(-,3)
0111	(14,*)
1000	(12,-)
1001	(11,-)
1010	(10,-)
1011	(9,-)
1100	(6,-)
1101	(3,-)
1110	reserved
1111	reserved

NOTE:
- (-, Y) means UE may assume the first Y symbols are occupied in next subframe and other symbols in the next subframe are not occupied.
- (X,-) means UE may assume the first X symbols are occupied in current subframe and other symbols in the current subframe are not occupied.
- (X,*) means UE may assume the first X symbols are occupied in current subframe, and at least the first OFDM symbol of the next subframe is not occupied.

14 UE procedures related to Sidelink

A UE can be configured by higher layers with one or more PSSCH resource configuration(s). A PSSCH resource configuration can be for reception of PSSCH, or for transmission of PSSCH. The physical sidelink shared channel related procedures are described in subclause 14.1.

A UE can be configured by higher layers with one or more PSCCH resource configuration(s). A PSCCH resource configuration can be for reception of PSCCH, or for transmission of PSCCH and the PSCCH resource configuration is associated with either sidelink transmission mode 1 or sidelink transmission mode 2. The physical sidelink control channel related procedures are described in subclause 14.2.

A UE can be configured by higher layers with one or more PSDCH resource configuration(s). A PSDCH resource configuration can be for reception of PSDCH, or for transmission of PSDCH. The transmissions of PSDCH according to a PSDCH resource configuration are associated with either sidelink discovery type 1 or sidelink discovery type 2B. The physical sidelink discovery channel related procedures are described in subclause 14.3.

The physical sidelink synchronization related procedures are described in subclause 14.4.

Except in the case of secondary sidelink synchronization signal transmission, sidelink transmission power shall not change during a sidelink subframe. For a UE transmitting PSBCH, the transmit power of PSBCH (P_{PSBCH}) is same as the transmit power of primary sidelink synchronisation signal P_{PSSS}.

A UE is not expected to be configured with PSCCH resource configuration(s) such that, in a given subframe, the total number of resource blocks across the resource block pools (as described in subclause 14.2.3) indicated by the PSCCH resource configuration(s) exceeds 50.

If a UE uplink transmission in subframe n+1 of a serving cell overlaps in time domain with sidelink transmission/reception by the UE in subframe n of the serving cell, then the UE shall drop the sidelink transmission/reception in subframe n.

For a given carrier frequency, a UE is not expected to receive sidelink physical channels/signals with different cyclic prefix lengths in the same sidelink subframe.

For a given carrier frequency, in a sidelink subframe, if a UE has a sidelink transmission, the sidelink transmission shall occur only in contiguous physical resource blocks.

If a UE's sidelink transmission does not occur on a serving cell with its uplink transmission(s), and if the UE's sidelink transmission in a subframe overlaps in time with its uplink transmission(s), the UE shall adjust the sidelink transmission power such that its total transmission power does not exceed P_{CMAX} defined in [6] on any overlapped portion. In this case, calculation of the adjustment to the sidelink transmission power is not specified.

14.1 Physical Sidelink Shared Channel related procedures

14.1.1 UE procedure for transmitting the PSSCH

If the UE transmits SCI format 0 on PSCCH according to a PSCCH resource configuration in subframe n belonging to a PSCCH period (described in subclause 14.2.3), then for the corresponding PSSCH transmissions

- the transmissions occur in a set of subframes in the PSCCH period and in a set of resource blocks within the set of subframes. The first PSSCH transport block is transmitted in the first four subframes in the set, the second transport block is transmitted in the next four subframes in the set, and so on.
  - for sidelink transmission mode 1,
    - the set of subframes is determined using the subframe pool indicated by the PSSCH resource configuration (described in subclause 14.1.4) and using time resource pattern (I_{TRP}) in the SCI format 0 as described in subclause 14.1.1.1.
    - the set of resource blocks is determined using Resource block assignment and hopping allocation in the SCI format 0 as described in subclause 14.1.1.2.

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- for sidelink transmission mode 2,
  - the set of subframes is determined using the subframe pool indicated by the PSSCH resource configuration (described in subclause 14.1.3) and using time resource pattern (I_{TRP}) in the SCI format 0 as described in subclause 14.1.1.3.
  - the set of resource blocks is determined using the resource block pool indicated by the PSSCH resource configuration (described in subclause 14.1.3) and using Resource block assignment and hopping allocation in the SCI format 0 as described in subclause 14.1.1.4.

- the modulation order is determined using the "modulation and coding scheme " field (I_{MCS}) in SCI format 0. For $0 \le I_{MCS} \le 28$, the modulation order is set to $Q' = \min(4, Q'_m)$, where Q'_m is determined from Table 8.6.1-1.
- the TBS index (I_{TBS}) is determined based on I_{MCS} and Table 8.6.1-1, and the transport block size is determined using I_{TBS} and the number of allocated resource blocks (N_{PRB}) using the procedure in subclause 7.1.7.2.1.

14.1.1.1 UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 1

Within the PSCCH period (described in subclause 14.2.3), the subframes used for PSSCH are determined as follows:

- a subframe indicator bitmap $\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$ and N_{TRP} are determined using the procedure described in subclause 14.1.1.1.1.
- a bitmap $\left(b_0, b_1, \ldots b_{L_{PSSCH}-1}\right)$ is determined using $b_j = b'_{j \bmod N_{TRP}}$ and a subframe I_j^{PSSCH} in the subframe pool is used for PSSCH if $b_j = 1$, otherwise the subframe I_j^{PSSCH} is not used for PSSCH, where $\left(I_0^{PSSCH}, I_1^{PSSCH}, \ldots, I_{L_{PSSCH}-1}^{PSSCH}\right)$ and L_{PSSCH} are described in subclause 14.1.4. The subframes used for PSSCH are denoted by $\left(n_0^{PSSCH}, n_1^{PSSCH}, \ldots, n_{N_{PSSCH}-1}^{PSSCH}\right)$ arranged in increasing order of subframe index and where N_{PSSCH} is the number of subframes that can be used for PSSCH transmission in a PSCCH period and is a multiple of 4.

14.1.1.1.1 Determination of subframe indicator bitmap

For FDD and TDD with UL/DL configuration belonging to {1,2,4,5}, N_{TRP} is 8, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$ is given by table 14.1.1.1.1-1.

For TDD with UL/DL configuration 0, N_{TRP} is 7, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$ is given by table 14.1.1.1.1-2.

For TDD with UL/DL configuration belonging to {3,6}, N_{TRP} is 6, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$ is given by table 14.1.1.1.1-3.

Table 14.1.1.1.1-1: Time Resource pattern Index mapping for $N_{TRP} = 8$

I_{TRP}	k_{TRP}	$\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$	I_{TRP}	k_{TRP}	$\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$	I_{TRP}	k_{TRP}	$\left(b'_0, b'_1, \ldots b'_{N_{TRP}-1}\right)$
0	1	(1,0,0,0,0,0,0,0)	37	4	(1,1,1,0,1,0,0,0)	74	4	(0,1,1,1,0,0,0,1)
1	1	(0,1,0,0,0,0,0,0)	38	4	(1,1,0,1,1,0,0,0)	75	4	(1,1,0,0,1,0,0,1)
2	1	(0,0,1,0,0,0,0,0)	39	4	(1,0,1,1,1,0,0,0)	76	4	(1,0,1,0,1,0,0,1)
3	1	(0,0,0,1,0,0,0,0)	40	4	(0,1,1,1,1,0,0,0)	77	4	(0,1,1,0,1,0,0,1)
4	1	(0,0,0,0,1,0,0,0)	41	4	(1,1,1,0,0,1,0,0)	78	4	(1,0,0,1,1,0,0,1)

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5	1	(0,0,0,0,0,1,0,0)	42	4	(1,1,0,1,0,1,0,0)	79	4	(0,1,0,1,1,0,0,1)
6	1	(0,0,0,0,0,0,1,0)	43	4	(1,0,1,1,0,1,0,0)	80	4	(0,0,1,1,1,0,0,1)
7	1	(0,0,0,0,0,0,0,1)	44	4	(0,1,1,1,0,1,0,0)	81	4	(1,1,0,0,0,1,0,1)
8	2	(1,1,0,0,0,0,0,0)	45	4	(1,1,0,0,1,1,0,0)	82	4	(1,0,1,0,0,1,0,1)
9	2	(1,0,1,0,0,0,0,0)	46	4	(1,0,1,0,1,1,0,0)	83	4	(0,1,1,0,0,1,0,1)
10	2	(0,1,1,0,0,0,0,0)	47	4	(0,1,1,0,1,1,0,0)	84	4	(1,0,0,1,0,1,0,1)
11	2	(1,0,0,1,0,0,0,0)	48	4	(1,0,0,1,1,1,0,0)	85	4	(0,1,0,1,0,1,0,1)
12	2	(0,1,0,1,0,0,0,0)	49	4	(0,1,0,1,1,1,0,0)	86	4	(0,0,1,1,0,1,0,1)
13	2	(0,0,1,1,0,0,0,0)	50	4	(0,0,1,1,1,1,0,0)	87	4	(1,0,0,0,1,1,0,1)
14	2	(1,0,0,0,1,0,0,0)	51	4	(1,1,1,0,0,0,1,0)	88	4	(0,1,0,0,1,1,0,1)
15	2	(0,1,0,0,1,0,0,0)	52	4	(1,1,0,1,0,0,1,0)	89	4	(0,0,1,0,1,1,0,1)
16	2	(0,0,1,0,1,0,0,0)	53	4	(1,0,1,1,0,0,1,0)	90	4	(0,0,0,1,1,1,0,1)
17	2	(0,0,0,1,1,0,0,0)	54	4	(0,1,1,1,0,0,1,0)	91	4	(1,1,0,0,0,0,1,1)
18	2	(1,0,0,0,0,1,0,0)	55	4	(1,1,0,0,1,0,1,0)	92	4	(1,0,1,0,0,0,1,1)
19	2	(0,1,0,0,0,1,0,0)	56	4	(1,0,1,0,1,0,1,0)	93	4	(0,1,1,0,0,0,1,1)
20	2	(0,0,1,0,0,1,0,0)	57	4	(0,1,1,0,1,0,1,0)	94	4	(1,0,0,1,0,0,1,1)
21	2	(0,0,0,1,0,1,0,0)	58	4	(1,0,0,1,1,0,1,0)	95	4	(0,1,0,1,0,0,1,1)
22	2	(0,0,0,0,1,1,0,0)	59	4	(0,1,0,1,1,0,1,0)	96	4	(0,0,1,1,0,0,1,1)
23	2	(1,0,0,0,0,0,1,0)	60	4	(0,0,1,1,1,0,1,0)	97	4	(1,0,0,0,1,0,1,1)
24	2	(0,1,0,0,0,0,1,0)	61	4	(1,1,0,0,0,1,1,0)	98	4	(0,1,0,0,1,0,1,1)
25	2	(0,0,1,0,0,0,1,0)	62	4	(1,0,1,0,0,1,1,0)	99	4	(0,0,1,0,1,0,1,1)
26	2	(0,0,0,1,0,0,1,0)	63	4	(0,1,1,0,0,1,1,0)	100	4	(0,0,0,1,1,0,1,1)
27	2	(0,0,0,0,1,0,1,0)	64	4	(1,0,0,1,0,1,1,0)	101	4	(1,0,0,0,0,1,1,1)
28	2	(0,0,0,0,0,1,1,0)	65	4	(0,1,0,1,0,1,1,0)	102	4	(0,1,0,0,0,1,1,1)
29	2	(1,0,0,0,0,0,0,1)	66	4	(0,0,1,1,0,1,1,0)	103	4	(0,0,1,0,0,1,1,1)
30	2	(0,1,0,0,0,0,0,1)	67	4	(1,0,0,0,1,1,1,0)	104	4	(0,0,0,1,0,1,1,1)
31	2	(0,0,1,0,0,0,0,1)	68	4	(0,1,0,0,1,1,1,0)	105	4	(0,0,0,0,1,1,1,1)
32	2	(0,0,0,1,0,0,0,1)	69	4	(0,0,1,0,1,1,1,0)	106	8	(1,1,1,1,1,1,1,1)
33	2	(0,0,0,0,1,0,0,1)	70	4	(0,0,0,1,1,1,1,0)	107-127	reserved	reserved
34	2	(0,0,0,0,0,1,0,1)	71	4	(1,1,1,0,0,0,0,1)			
35	2	(0,0,0,0,0,0,1,1)	72	4	(1,1,0,1,0,0,0,1)			
36	4	(1,1,1,1,0,0,0,0)	73	4	(1,0,1,1,0,0,0,1)			

Table 14.1.1.1.1-2: Time Resource pattern index mapping for $N_{TRP} = 7$

I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$	I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$	I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$
0	reserved	reserved	44	3	(0,0,1,1,0,1,0)	88	3	(0,0,0,1,1,0,1)
1	1	(1,0,0,0,0,0,0)	45	4	(1,0,1,1,0,1,0)	89	4	(1,0,0,1,1,0,1)
2	1	(0,1,0,0,0,0,0)	46	4	(0,1,1,1,0,1,0)	90	4	(0,1,0,1,1,0,1)
3	2	(1,1,0,0,0,0,0)	47	5	(1,1,1,1,0,1,0)	91	5	(1,1,0,1,1,0,1)
4	1	(0,0,1,0,0,0,0)	48	2	(0,0,0,0,1,1,0)	92	4	(0,0,1,1,1,0,1)
5	2	(1,0,1,0,0,0,0)	49	3	(1,0,0,0,1,1,0)	93	5	(1,0,1,1,1,0,1)
6	2	(0,1,1,0,0,0,0)	50	3	(0,1,0,0,1,1,0)	94	5	(0,1,1,1,1,0,1)
7	3	(1,1,1,0,0,0,0)	51	4	(1,1,0,0,1,1,0)	95	6	(1,1,1,1,1,0,1)
8	1	(0,0,0,1,0,0,0)	52	3	(0,0,1,0,1,1,0)	96	2	(0,0,0,0,0,1,1)

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9	2	(1,0,0,1,0,0,0)	53	4	(1,0,1,0,1,1,0)	97	3	(1,0,0,0,0,1,1)
10	2	(0,1,0,1,0,0,0)	54	4	(0,1,1,0,1,1,0)	98	3	(0,1,0,0,0,1,1)
11	3	(1,1,0,1,0,0,0)	55	5	(1,1,1,0,1,1,0)	99	4	(1,1,0,0,0,1,1)
12	2	(0,0,1,1,0,0,0)	56	3	(0,0,0,1,1,1,0)	100	3	(0,0,1,0,0,1,1)
13	3	(1,0,1,1,0,0,0)	57	4	(1,0,0,1,1,1,0)	101	4	(1,0,1,0,0,1,1)
14	3	(0,1,1,1,0,0,0)	58	4	(0,1,0,1,1,1,0)	102	4	(0,1,1,0,0,1,1)
15	4	(1,1,1,1,0,0,0)	59	5	(1,1,0,1,1,1,0)	103	5	(1,1,1,0,0,1,1)
16	1	(0,0,0,0,1,0,0)	60	4	(0,0,1,1,1,1,0)	104	3	(0,0,0,1,0,1,1)
17	2	(1,0,0,0,1,0,0)	61	5	(1,0,1,1,1,1,0)	105	4	(1,0,0,1,0,1,1)
18	2	(0,1,0,0,1,0,0)	62	5	(0,1,1,1,1,1,0)	106	4	(0,1,0,1,0,1,1)
19	3	(1,1,0,0,1,0,0)	63	6	(1,1,1,1,1,1,0)	107	5	(1,1,0,1,0,1,1)
20	2	(0,0,1,0,1,0,0)	64	1	(0,0,0,0,0,0,1)	108	4	(0,0,1,1,0,1,1)
21	3	(1,0,1,0,1,0,0)	65	2	(1,0,0,0,0,0,1)	109	5	(1,0,1,1,0,1,1)
22	3	(0,1,1,0,1,0,0)	66	2	(0,1,0,0,0,0,1)	110	5	(0,1,1,1,0,1,1)
23	4	(1,1,1,0,1,0,0)	67	3	(1,1,0,0,0,0,1)	111	6	(1,1,1,1,0,1,1)
24	2	(0,0,0,1,1,0,0)	68	2	(0,0,1,0,0,0,1)	112	3	(0,0,0,0,1,1,1)
25	3	(1,0,0,1,1,0,0)	69	3	(1,0,1,0,0,0,1)	113	4	(1,0,0,0,1,1,1)
26	3	(0,1,0,1,1,0,0)	70	3	(0,1,1,0,0,0,1)	114	4	(0,1,0,0,1,1,1)
27	4	(1,1,0,1,1,0,0)	71	4	(1,1,1,0,0,0,1)	115	5	(1,1,0,0,1,1,1)
28	3	(0,0,1,1,1,0,0)	72	2	(0,0,0,1,0,0,1)	116	4	(0,0,1,0,1,1,1)
29	4	(1,0,1,1,1,0,0)	73	3	(1,0,0,1,0,0,1)	117	5	(1,0,1,0,1,1,1)
30	4	(0,1,1,1,1,0,0)	74	3	(0,1,0,1,0,0,1)	118	5	(0,1,1,0,1,1,1)
31	5	(1,1,1,1,1,0,0)	75	4	(1,1,0,1,0,0,1)	119	6	(1,1,1,0,1,1,1)
32	1	(0,0,0,0,0,1,0)	76	3	(0,0,1,1,0,0,1)	120	4	(0,0,0,1,1,1,1)
33	2	(1,0,0,0,0,1,0)	77	4	(1,0,1,1,0,0,1)	121	5	(1,0,0,1,1,1,1)
34	2	(0,1,0,0,0,1,0)	78	4	(0,1,1,1,0,0,1)	122	5	(0,1,0,1,1,1,1)
35	3	(1,1,0,0,0,1,0)	79	5	(1,1,1,1,0,0,1)	123	6	(1,1,0,1,1,1,1)
36	2	(0,0,1,0,0,1,0)	80	2	(0,0,0,0,1,0,1)	124	5	(0,0,1,1,1,1,1)
37	3	(1,0,1,0,0,1,0)	81	3	(1,0,0,0,1,0,1)	125	6	(1,0,1,1,1,1,1)
38	3	(0,1,1,0,0,1,0)	82	3	(0,1,0,0,1,0,1)	126	6	(0,1,1,1,1,1,1)
39	4	(1,1,1,0,0,1,0)	83	4	(1,1,0,0,1,0,1)	127	7	(1,1,1,1,1,1,1)
40	2	(0,0,0,1,0,1,0)	84	3	(0,0,1,0,1,0,1)			
41	3	(1,0,0,1,0,1,0)	85	4	(1,0,1,0,1,0,1)			
42	3	(0,1,0,1,0,1,0)	86	4	(0,1,1,0,1,0,1)			
43	4	(1,1,0,1,0,1,0)	87	5	(1,1,1,0,1,0,1)			

Table 14.1.1.1.1-3: Time Resource pattern index mapping for $N_{TRP} = 6$

I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$	I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$	I_{TRP}	k_{TRP}	$(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$
0	reserved	reserved	22	3	(0,1,1,0,1,0)	44	3	(0,0,1,1,0,1)
1	1	(1,0,0,0,0,0)	23	4	(1,1,1,0,1,0)	45	4	(1,0,1,1,0,1)
2	1	(0,1,0,0,0,0)	24	2	(0,0,0,1,1,0)	46	4	(0,1,1,1,0,1)
3	2	(1,1,0,0,0,0)	25	3	(1,0,0,1,1,0)	47	5	(1,1,1,1,0,1)
4	1	(0,0,1,0,0,0)	26	3	(0,1,0,1,1,0)	48	2	(0,0,0,0,1,1)
5	2	(1,0,1,0,0,0)	27	4	(1,1,0,1,1,0)	49	3	(1,0,0,0,1,1)

6	2	(0,1,1,0,0,0)	28	3	(0,0,1,1,1,0)	50	3	(0,1,0,0,1,1)
7	3	(1,1,1,0,0,0)	29	4	(1,0,1,1,1,0)	51	4	(1,1,0,0,1,1)
8	1	(0,0,0,1,0,0)	30	4	(0,1,1,1,1,0)	52	3	(0,0,1,0,1,1)
9	2	(1,0,0,1,0,0)	31	5	(1,1,1,1,1,0)	53	4	(1,0,1,0,1,1)
10	2	(0,1,0,1,0,0)	32	1	(0,0,0,0,0,1)	54	4	(0,1,1,0,1,1)
11	3	(1,1,0,1,0,0)	33	2	(1,0,0,0,0,1)	55	5	(1,1,1,0,1,1)
12	2	(0,0,1,1,0,0)	34	2	(0,1,0,0,0,1)	56	3	(0,0,0,1,1,1)
13	3	(1,0,1,1,0,0)	35	3	(1,1,0,0,0,1)	57	4	(1,0,0,1,1,1)
14	3	(0,1,1,1,0,0)	36	2	(0,0,1,0,0,1)	58	4	(0,1,0,1,1,1)
15	4	(1,1,1,1,0,0)	37	3	(1,0,1,0,0,1)	59	5	(1,1,0,1,1,1)
16	1	(0,0,0,0,1,0)	38	3	(0,1,1,0,0,1)	60	4	(0,0,1,1,1,1)
17	2	(1,0,0,0,1,0)	39	4	(1,1,1,0,0,1)	61	5	(1,0,1,1,1,1)
18	2	(0,1,0,0,1,0)	40	2	(0,0,0,1,0,1)	62	5	(0,1,1,1,1,1)
19	3	(1,1,0,0,1,0)	41	3	(1,0,0,1,0,1)	63	6	(1,1,1,1,1,1)
20	2	(0,0,1,0,1,0)	42	3	(0,1,0,1,0,1)	64-127	reserved	reserved
21	3	(1,0,1,0,1,0)	43	4	(1,1,0,1,0,1)			

14.1.1.2 UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 1

The set of resource blocks is determined using the procedure described in subclause 14.1.1.2.1 and 14.1.1.2.2.

14.1.1.2.1 PSSCH resource allocation for sidelink transmission mode 1

The resource allocation and hopping field of the SCI format 0 is used to determine a set of indices denoted by n'_{VRB} ($0 \le n'_{\text{VRB}} < N_{\text{RB}}^{\text{SL}}$), a starting index RB'_{START}, and a number of allocated PRBs L'_{CRBs} and $N_{\text{RB}}^{\text{PSSCH}}$ using the procedure in subclause 8.1.1, and 8.4 (for sidelink frequency hopping with type 1 or type 2 hopping) with the following exceptions:

- the term 'PUSCH' in subclauses 8.1.1 and 8.4 is replaced with 'PSSCH'.
- the quantity n_{VRB} in subclause 8.1.1 is replaced with n'_{VRB}.
- the quantity $N_{\text{RB}}^{\text{UL}}$ in subclauses 8.1.1 and 8.4 is replaced with $N_{\text{RB}}^{\text{SL}}$.
- the quantity RB_{START} in subclauses 8.1.1and 8.4 is replaced with RB'_{START}.
- the quantity L_{CRBs} in subclauses 8.1.1 and 8.4 is replaced with L'_{CRBs}.
- the quantity $N_{\text{RB}}^{\text{PUSCH}}$ in subclause 8.4 is replaced with $N_{\text{RB}}^{\text{PSSCH}}$.
- the quantity $N_{\text{RB}}^{\text{HO}}$ is given by higher layer parameter *rb-Offset-r12* associated with the corresponding PSSCH resource configuration.
- the quantity N_{sb} is given by higher layer parameter *numSubbands-r12* associated with the corresponding PSSCH resource configuration.

14.1.1.2.2 PSSCH frequency hopping for sidelink transmission mode 1

If sidelink frequency hopping with type 1 hopping is enabled, the set of physical resource blocks for PSSCH transmission is determined using subclause 8.4 with the following exceptions:

- the term 'PUSCH' is replaced with 'PSSCH'.
- only inter-subframe hopping shall be used.
- the quantity RB_{START} is replaced with RB'_{START}.
- the quantity $N_{\text{RB}}^{\text{UL}}$ is replaced with $N_{\text{RB}}^{\text{SL}}$.
- the quantity $N_{\text{RB}}^{\text{PUSCH}}$ is replaced with $N_{\text{RB}}^{\text{PSSCH}}$.
- the quantity $N_{\text{RB}}^{\text{HO}}$ is given by higher layer parameter *rb-Offset-r12* associated with the PSSCH resource configuration.
- the frequency hopping field in the SCI format 0 is used instead of DCI format 0.
- the quantity $n_{\text{PRB}}^{\text{S1}}(i)$ is replaced with $n_{\text{PRB}}^{\text{SL0}}$.
- the quantity $n_{\text{PRB}}(i)$ is replaced with $n_{\text{PRB}}^{\text{SL1}}$.
- for odd $n_{\text{ssf}}^{\text{PSSCH}}$ (described in subclause 9.2.4 of [3]), the set of physical resource blocks for PSSCH transmission are L'_{CRBs} contiguous resource blocks starting from PRB with index $n_{\text{PRB}}^{\text{SL0}}$.
- for even $n_{\text{ssf}}^{\text{PSSCH}}$ (described in subclause 9.2.4 of [3]), the set of physical resource blocks for PSSCH transmission are L'_{CRBs} contiguous resource blocks starting from PRB with index $n_{\text{PRB}}^{\text{SL1}}$.

14.1.1.3 UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 2

For FDD or for TDD, and the UE not configured with the higher layer parameter *trpt-Subset-r12*

- The allowed values of I_{TRP} correspond to the values of k_{TRP} satisfying $k_{TRP} = k_i$, for a value of i in $0 \le i < X_{TRP}$, where k_i and X_{TRP} are determined from table 14.1.1.3-1.

For FDD or for TDD with UL/DL configuration belonging to {0,1,2,3,4,6}, and the UE configured with the higher layer parameter *trpt-Subset-r12*

- The allowed values of I_{TRP} correspond to the values of k_{TRP} satisfying $k_{TRP} = k_i$, for values of i in $0 \le i < X_{TRP}$ satisfying $a_i = 1$, $0 \le i < X_{TRP}$ and where k_i and X_{TRP} are determined from table 14.1.1.3-1, and $(a_0, a_1, \ldots, a_{X_{TRP}-1})$ is the bitmap indicated by *trpt-Subset-r12*.

Table 14.1.1.3-1: Determination of X_{TRP} and k_i for sidelink transmission mode 2

	X_{TRP}	k_0	k_1	k_2	k_3	k_4
FDD and TDD with UL/DL configuration 1,2,4,5	3	1	2	4	-	-
TDD with UL/DL configuration 0	5	1	2	3	4	5
TDD with UL/DL configuration 3,6	4	1	2	3	4	-

Within a PSCCH period, the subframes used for PSSCH are determined as follows:

- a subframe indicator bitmap $(b'_0, b'_1, \ldots b'_{N_{TRP}-1})$ and N_{TRP} are determined using the procedure described in subclause 14.1.1.1.1 from the allowed values of I_{TRP} described in this subclause.

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- a bitmap $\left(b_0, b_1, \ldots b_{L_{PSSCH}-1}\right)$ is determined using $b_j = b'_{j \bmod N_{IRP}}$ and a subframe l_j^{PSSCH} in the subframe pool is used for PSSCH if $b_j = 1$, otherwise the subframe l_j^{PSSCH} is not used for PSSCH, where $\left(l_0^{PSSCH}, l_1^{PSSCH}, \ldots, l_{L_{PSSCH}-1}^{PSSCH}\right)$ and L_{PSSCH} are described in subclause 14.1.3. The subframes used for PSSCH are denoted by $\left(n_0^{PSSCH}, n_1^{PSSCH}, \ldots, n_{N_{PSSCH}-1}^{PSSCH}\right)$ arranged in increasing order of subframe index and where N_{PSSCH} is the number of subframes that can be used for PSSCH transmission in a PSCCH period and is a multiple of 4.

14.1.1.4 UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 2

The set of resource blocks within the resource block pool (defined in 14.1.3) is determined using the subclause 14.1.1.2.1 .

If sidelink frequency hopping with type 1 hopping is enabled, the set of physical resource blocks for PSSCH transmission is determined using subclause 14.1.1.2.2 with the following exceptions

- the quantity $N_{\mathrm{RB}}^{\mathrm{UL}}$ is replaced with $M_{RB}^{PSSCH\_RP}$ (defined in 14.1.3).
- for odd $n_{\mathrm{ssf}}^{\mathrm{PSSCH}}$, the set of physical resource blocks for PSSCH transmission are given by L'_{CRBs} contiguous resource blocks $m_x, m_{x+1}, \ldots m_{x+L'_{CRBs}-1}$ belonging to the resource block pool, where $x = n_{\mathrm{PRB}}^{\mathrm{SL0}}$.
- for even $n_{\mathrm{ssf}}^{\mathrm{PSSCH}}$, the set of physical resource blocks for PSSCH transmission are given by L'_{CRBs} contiguous resource blocks $m_x, m_{x+1}, \ldots m_{x+L'_{CRBs}-1}$ belonging to the resource block pool, where $x = n_{\mathrm{PRB}}^{\mathrm{SL1}}$.

14.1.1.5 UE procedure for PSSCH power control

For sidelink transmission mode 1 and PSCCH period *i*, the UE transmit power P_{PSSCH} for PSSCH transmission is given by the following

- if the TPC command field in configured sidelink grant (described in [8]) for PSCCH period *i* is set to 0
  - $P_{\mathrm{PSSCH}} = P_{\mathrm{CMAX},PSSCH}$
- if the TPC command field in configured sidelink grant (described in [8]) for PSCCH period *i* is set to 1
  - $P_{\mathrm{PSSCH}} = \min\left\{P_{\mathrm{CMAX},PSSCH},\ 10\log_{10}(M_{\mathrm{PSSCH}}) + P_{\mathrm{O\_PSSCH},1} + \alpha_{PSSCH,1} \cdot PL\right\}$ [dBm]

where $P_{\mathrm{CMAX},PSSCH}$ is defined in [6], and M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource block and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1. $P_{\mathrm{O\_PSSCH},1}$ and $\alpha_{PSSCH,1}$ are provided by higher layer parameters *p0-r12* and *alpha-r12*, respectively and that are associated with the corresponding PSSCH resource configuration.

For sidelink transmission mode 2, the UE transmit power P_{PSSCH} for PSSCH transmission is given by

$$P_{\mathrm{PSSCH}} = \min\left\{P_{\mathrm{CMAX},PSSCH},\ 10\log_{10}(M_{\mathrm{PSSCH}}) + P_{\mathrm{O\_PSSCH},2} + \alpha_{PSSCH,2} \cdot PL\right\} \text{ [dBm]},$$

where $P_{\mathrm{CMAX},PSSCH}$ is defined in [6], and M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource blocks and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1. $P_{\mathrm{O\_PSSCH},2}$ and $\alpha_{PSSCH,2}$ are provided by higher layer parameter *p0-r12* and *alpha-r12*, respectively and that are associated with the corresponding PSSCH resource configuration.

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14.1.2 UE procedure for receiving the PSSCH

For sidelink transmission mode 1, a UE upon detection of SCI format 0 on PSCCH can decode PSSCH according to the detected SCI format 0.

For sidelink transmission mode 2, a UE upon detection of SCI format 0 on PSCCH can decode PSSCH according to the detected SCI format 0, and associated PSSCH resource configuration configured by higher layers.

14.1.3 UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 2

For a PSCCH period associated with the PSCCH resource configuration (determined in subclause 14.2.3) which is also associated with the PSSCH resource configuration, the UE determines a PSSCH pool consisting of a subframe pool and resource block pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.

- Within the PSCCH period, the uplink subframes with subframe index greater than or equal to $j_{begin}+O_2$ are denoted by $\left(l_0, l_1, \ldots, l_{N'-1}\right)$ arranged in increasing order of subframe index, where j_{begin} is described in subclause 14.2.3 and O_2 is the *offsetIndicator-r12* indicated by the PSSCH resource configuration, where N' denotes the number of uplink subframes within the PSCCH period with subframe index greater than or equal to $j_{begin}+O_2$.

- A bitmap $b_0, b_1, b_2, \ldots, b_{N'-1}$ is determined using $b_j = a_{j \bmod N_B}$, for $0 \le j < N'$, where $a_0, a_1, a_2, \ldots, a_{N_B-1}$ and N_B are the bitmap and the length of the bitmap indicated by *subframeBitmap-r12*, respectively.

- A subframe l_j $(0 \le j < N')$ belongs to the subframe pool if $b_j = 1$. The subframes in the subframe pool are denoted by $\left(l_0^{PSSCH}, l_1^{PSSCH}, \ldots, l_{L_{PSSCH}-1}^{PSSCH}\right)$ arranged in increasing order of subframe index and L_{PSSCH} denotes the number of subframes in the subframe pool.

- A PRB with index q $(0 \le q < N_{RB}^{SL})$ belongs to the resource block pool if $S1 \le q < S1+M$ or if $S2-M < q \le S2$, where *S1*, *S2*, and *M* denote the *prb-Start-r12*, *prb-End-r12* and *prb-Num-r12* indicated by the PSSCH resource configuration respectively.

- The resource blocks in the resource block pool are denoted by $\left(m_0^{PSSCH}, m_1^{PSSCH}, \ldots, m_{M_{RB}^{PSSCH\_RP}-1}^{PSSCH}\right)$ arranged in increasing order of resource block indices and $M_{RB}^{PSSCH\_RP}$ is the number of resource blocks in the resource block pool.

14.1.4 UE procedure for determining subframe pool for sidelink transmission mode 1

For a PSCCH period associated with the PSCCH resource configuration (described in subclause 14.2.3) which is also associated with the PSSCH resource configuration, the UE determines a PSSCH pool consisting of a subframe pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.

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- Each uplink subframe with subframe index greater than or equal to $I^{PSCCH}_{L_{PSCCH}-1}+1$ belongs to the subframe pool for PSSCH, where $I^{PSCCH}_{L_{PSCCH}-1}+1$ and L_{PSCCH} are described in subclause 14.2.3.

- The subframes in the subframe pool for PSSCH are denoted by $\left\{I^{PSSCH}_0, I^{PSSCH}_1, \ldots, I^{PSSCH}_{L_{PSSCH}-1}\right\}$ arranged in increasing order of subframe index and L_{PSSCH} denotes the number of subframes in the subframe pool.

14.2 Physical Sidelink Control Channel related procedures

For sidelink transmission mode 1, if a UE is configured by higher layers to receive DCI format 5 with the CRC scrambled by the SL-RNTI, the UE shall decode the PDCCH/EPDCCH according to the combination defined in Table 14.2-1.

Table 14.2-1: PDCCH/EPDCCH configured by SL-RNTI

DCI format	Search Space
DCI format 5	For PDCCH: Common and UE specific by C-RNTI For EPDCCH: UE specific by C-RNTI

14.2.1 UE procedure for transmitting the PSCCH

For sidelink transmission mode 1and PSCCH period i,

- the UE shall determine the subframes and resource blocks for transmitting SCI format 0 as follows.
  - SCI format 0 is transmitted in two subframes in the subframe pool and one physical resource block per slot in each of the two subframes, wherein the physical resource blocks belong to the resource block pool, where the subframe pool and the resource block pool are indicated by the PSCCH resource configuration (as defined in subclause 14.2.3)
  - the two subframes and the resource blocks are determined using "Resource for PSCCH" field (n_{PSCCH}) in the configured sidelink grant (described in [8]) as described in subclause 14.2.1.1.
- the UE shall set the contents of the SCI format 0 as follows:
  - the UE shall set the Modulation and coding scheme field according to the Modulation and coding scheme indicated by the higher layer parameter *mcs-r12* if the parameter is configured by higher layers.
  - the UE shall set the Frequency hopping flag according to the "Frequency hopping flag" field in the configured sidelink grant.
  - the UE shall set the Resource block assignment and hopping resource allocation according to the "Resource block assignment and hopping resource allocation" field in the configured sidelink grant.
  - the UE shall set the Time resource pattern according to the "Time resource pattern" field in the configured sidelink grant .
  - the UE shall set the eleven-bit Timing advance indication to $I_{TAI}=\left\lfloor \frac{N_{TA}}{16} \right\rfloor$ to indicate sidelink reception timing adjustment value using the N_{TA} (defined in [3]) value for the UE in the subframe that is no earlier than subframe $I^{PSCCH}_{b1}-4$ (I^{PSCCH}_{b1} described in subclause 14.2.1.1).

For sidelink transmission mode 2,

- SCI format 0 is transmitted in two subframes in the subframe pool and one physical resource block per slot in each of the two subframes, wherein the physical resource blocks belongs to the resource block pool, where the subframe pool and the resource block pool are indicated by the PSCCH resource configuration (as defined in subclause 14.2.3)

- the two subframes and the resource blocks are determined using the procedure described in subclause 14.2.1.2
- the UE shall set the eleven-bit Timing advance indication I_{TAI} in the SCI format 0 to zero.

14.2.1.1 UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 1

For $0 \le n_{PSCCH} < \lfloor M_{RB}^{PSCCH\_RP} / 2 \rfloor \cdot L_{PSCCH}$,

- one transmission of the PSCCH is in resource block m_{a1}^{PSCCH} of subframe l_{b1}^{PSCCH} of the PSCCH period, where $a1 = \lfloor n_{PSCCH} / L_{PSCCH} \rfloor$ and $b1 = n_{PSCCH} \bmod L_{PSCCH}$.
- the other transmission of the PSCCH is in resource block m_{a2}^{PSCCH} of subframe l_{b2}^{PSCCH} of the PSCCH period, where $a2 = \lfloor n_{PSCCH} / L_{PSCCH} \rfloor + \lfloor M_{RB}^{PSCCH\_RP} / 2 \rfloor$ and $b2 = \left(n_{PSCCH} + 1 + \lfloor n_{PSCCH} / L_{PSCCH} \rfloor \bmod (L_{PSCCH} - 1)\right) \bmod L_{PSCCH}$.

where $\left(l_0^{PSCCH}, l_1^{PSCCH}, \ldots, l_{L_{PSCCH}-1}^{PSCCH}\right)$, $\left(m_0^{PSCCH}, m_1^{PSCCH}, \ldots, m_{M_{RB}^{PSCCH\_RP}-1}^{PSCCH}\right)$, L_{PSCCH} and $M_{RB}^{PSCCH\_RP}$ are described in subclause 14.2.3.

14.2.1.2 UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 2

The allowed values for PSCCH resource selection are given by $0,1,\ldots \left(\lfloor M_{RB}^{PSCCH\_RP} / 2 \rfloor \cdot L_{PSCCH} - 1\right)$ where L_{PSCCH} and $M_{RB}^{PSCCH\_RP}$ described in subclause 14.2.3. The two subframes and the resource blocks are determined using selected resource value n_{PSCCH} (described in [8]) and the procedure described in subclause 14.2.1.1.

14.2.1.3 UE procedure for PSCCH power control

For sidelink transmission mode 1 and PSCCH period *i*, the UE transmit power P_{PSCCH} for PSCCH transmission is given by the following

- if the TPC command field in the configured sidelink grant (described in [8]) for PSCCH period *i* is set to 0
  - $P_{\text{PSCCH}} = P_{\text{CMAX},PSCCH}$
- if the TPC command field in the configured sidelink grant (described in [8]) for PSCCH period *i* is set to 1
  - $P_{\text{PSCCH}} = \min\left\{P_{\text{CMAX},PSCCH},\ 10\log_{10}(M_{\text{PSCCH}}) + P_{\text{O\_PSCCH},1} + \alpha_{PSCCH,1} \cdot PL\right\}$ [dBm]

where $P_{\text{CMAX},PSCCH}$ is defined in [6], and M_{PSCCH}=1 and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1. $P_{\text{O\_PSCCH},1}$ and $\alpha_{PSCCH,1}$ are provided by higher layer parameters *p0-r12* and *alpha-r12*, respectively and are associated with the corresponding PSCCH resource configuration.

For sidelink transmission mode 2, the UE transmit power P_{PSCCH} for PSCCH transmission is given by

$$P_{\text{PSCCH}} = \min\left\{P_{\text{CMAX},PSCCH},\ 10\log_{10}(M_{\text{PSCCH}}) + P_{\text{O\_PSCCH},2} + \alpha_{PSCCH,2} \cdot PL\right\} \text{ [dBm]},$$

where $P_{\text{CMAX},PSCCH}$ is the $P_{\text{CMAX},c}$ configured by higher layers and M_{PSCCH}=1 and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1. $P_{\text{O\_PSCCH},2}$ and $\alpha_{PSCCH,2}$ are provided by higher layer parameters *p0-r12* and *alpha-r12*, respectively and are associated with the corresponding PSCCH resource configuration.

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14.2.2 UE procedure for receiving the PSCCH

For each PSCCH resource configuration associated with sidelink transmission mode 1, a UE configured by higher layers to detect SCI format 0 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration, and using the Group destination IDs indicated by higher layers.

For each PSCCH resource configuration associated with sidelink transmission mode 2, a UE configured by higher layers to detect SCI format 0 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration, and using the Group destination IDs indicated by higher layers.

14.2.3 UE procedure for determining resource block pool and subframe pool for PSCCH

A PSCCH resource configuration for transmission/reception is associated with a set of periodically occurring time-domain periods (known as PSCCH periods). The i-th PSCCH period begins at subframe with subframe index $j_{begin} = O + i \cdot P$ and ends in subframe with subframe index $j_{end} = O + (i+1) \cdot P - 1$, where

- $0 \le j_{begin}, j_{end} < 10240$,
- the subframe index is relative to subframe#0 of the radio frame corresponding to SFN 0 of the serving cell or DFN 0 (described in [11]),
- O is the *offsetIndicator-r12* indicated by the PSCCH resource configuration,
- P is the *sc-Period-r12* indicated by the PSCCH resource configuration.

For a PSCCH period, the UE determines a PSCCH pool consisting of a subframe pool and a resource block pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- The first N' uplink subframes are denoted by $(l_0, l_1, ..., l_{N'-1})$ arranged in increasing order of subframe index, where N' is the length of the bitmap *subframeBitmap-r12* indicated by the PSCCH resource configuration.
- A subframe l_j $(0 \le j < N')$ belongs to the subframe pool if $a_j = 1$, where $(a_0, a_1, a_2, ..., a_{N'-1})$ is the bitmap *subframeBitmap-r12* indicated by the PSCCH resource configuration. The subframes in the subframe pool are denoted by $(l_0^{PSCCH}, l_1^{PSCCH}, ..., l_{L_{PSCCH}-1}^{PSCCH})$ arranged in increasing order of subframe index and L_{PSCCH} is the number of subframes in the subframe pool. A PRB with index q $(0 \le q < N_{RB}^{SL})$ belongs to the resource block pool if $S1 \le q < S1 + M$ or if $S2 - M < q \le S2$, where *S1*, *S2*, and *M* denote the *prb-Start-r12, prb-End-r12 and prb-Num-r12* indicated by the PSCCH resource configuration respectively.
- The resource blocks in the resource block pool are denoted by $(m_0^{PSCCH}, m_1^{PSCCH}, ..., m_{M_{RB}^{PSCCH\_RP}-1}^{PSCCH})$ arranged in increasing order of resource block indices and $M_{RB}^{PSCCH\_RP}$ is the number of resource blocks in the resource block pool.

14.3 Physical Sidelink Discovery Channel related procedures

14.3.1 UE procedure for transmitting the PSDCH

If a UE is configured by higher layers to transmit PSDCH according to a PSDCH resource configuration, in a PSDCH period i,

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- the number of transmissions for a transport block on PSDCH is $N_{\mathrm{SLD}}^{\mathrm{TX}} = n + 1$ where n is given by the higher layer parameter *numRetx-r12*, and each transmission corresponds to one subframe belonging to a set of subframes, and in each subframe, the PSDCH is transmitted on two physical resource blocks per slot.
  - for sidelink discovery type 1,
    - the allowed values for PSDCH resource selection are given by $0,1\ldots (N_t \cdot N_f - 1)$, where $N_t = \lfloor L_{PSDCH} / N_{\mathrm{SLD}}^{\mathrm{TX}} \rfloor$ and $N_f = \lfloor M_{RB}^{PSDCH\_RP} / 2 \rfloor$, and
    - the j-th transmission ($1 \le j \le N_{\mathrm{SLD}}^{\mathrm{TX}}$) for the transport block occurs in contiguous resource blocks $m_{2\cdot a_j^{(i)}}^{PSDCH}$ and $m_{2\cdot a_j^{(i)}+1}^{PSDCH}$ of subframe $l_{N_{\mathrm{SLD}}^{\mathrm{TX}}\cdot b_1^{(i)}+j-1}^{PSDCH}$ of the PSDCH period, where
      - $a_j^{(i)} = \left((j-1)\cdot\lfloor N_f / N_{SLD}^{TX} \rfloor + \lfloor n_{PSDCH} / N_t \rfloor\right) \bmod N_f$ and $b_1^{(i)} = n_{PSDCH} \bmod N_t$ and using selected resource value n_{PSDCH} (described in [8]).
      - $\left(l_0^{PSDCH}, l_1^{PSDCH}, \ldots, l_{L_{PSDCH}-1}^{PSDCH}\right)$, $\left(m_0^{PSDCH}, m_1^{PSDCH}, \ldots, m_{M_{RB}^{PSDCH\_RP}-1}^{PSDCH}\right)$, L_{PSDCH} and $M_{RB}^{PSDCH\_RP}$ are described in subclause 14.3.3.
  - for sidelink discovery type 2B,
    - The j-th transmission ($1 \le j \le N_{\mathrm{SLD}}^{\mathrm{TX}}$) for the transport block occurs in contiguous resource blocks $m_{2\cdot a_j^{(i)}}^{PSDCH}$ and $m_{2\cdot a_j^{(i)}+1}^{PSDCH}$ of subframe $l_{N_{\mathrm{SLD}}^{\mathrm{TX}}\cdot b_1^{(i)}+j-1}^{PSDCH}$ of the PSDCH period, where
      - $a_1^{(i)} = \left((N_{PSDCH}^{(2)} + n') \bmod 10 + \lfloor \left(a_1^{(i-1)} + N_f \cdot b_1^{(i-1)}\right) / N_t \rfloor\right) \bmod N_f$
      - $b_1^{(i)} = \left(N_{PSDCH}^{(1)} + N_{PSDCH}^{(3)} \cdot a_1^{(i-1)} + N_f \cdot b_1^{(i-1)}\right) \bmod N_t$
      - $a_j^{(i)} = \left((j-1)\cdot\lfloor N_f / N_{SLD}^{TX} \rfloor + a_1^{(i)}\right) \bmod N_f$ for $1 < j \le N_{\mathrm{SLD}}^{\mathrm{TX}}$
      - $N_t = \lfloor L_{PSDCH} / N_{\mathrm{SLD}}^{\mathrm{TX}} \rfloor$ and $N_f = \lfloor M_{RB}^{PSDCH\_RP} / 2 \rfloor$, and $\left(l_0^{PSDCH}, l_1^{PSDCH}, \ldots, l_{L_{PSDCH}-1}^{PSDCH}\right)$, $\left(m_0^{PSDCH}, m_1^{PSDCH}, \ldots, m_{M_{RB}^{PSDCH\_RP}-1}^{PSDCH}\right)$, L_{PSDCH} and $M_{RB}^{PSDCH\_RP}$ are described in subclause 14.3.3.
      - $a_1^{(0)}$ and $b_1^{(0)}$ are given by higher layer parameters *discPRB-Index* and *discSF-Index*, respectively and that associated with the PSDCH resource configuration.
      - $N_{PSDCH}^{(1)}$, $N_{PSDCH}^{(2)}$ and $N_{PSDCH}^{(3)}$ are given by higher layer parameters *a-r12*, *b-r12*, and *c-r12*, repectively and that are associated with the PSDCH resource configuration.
      - n' is the number of PSDCH periods since $N_{PSDCH}^{(2)}$ was received.
- the transport block size is 232

For sidelink discovery, the UE transmit power P_{PSDCH} for PSDCH transmission is given by the following

$$P_{\mathrm{PSDCH}} = \min\left\{P_{\mathrm{CMAX},PSDCH},\ 10\log_{10}(M_{\mathrm{PSDCH}}) + P_{\mathrm{O\_PSDCH,1}} + \alpha_{PSDCH,1}\cdot PL\right\} \text{ [dBm]}$$

where $P_{\mathrm{CMAX},PSDCH}$ is defined in [6], and M_{PSDCH}=2 and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1 where c

is the serving cell if the sidelink discovery transmission occurs on the uplink carrier frequency of a serving cell, or

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is the cell indicated by higher layers on downlink carrier frequency indicated by *discCarrierRef-r13*[11] if sidelink discovery transmission does not occur on the uplink carrier frequency of a serving cell.

$P_{\text{O\_PSDCH},1}$ and $\alpha_{PSDCH,1}$ are provided by higher layer parameters *p0-r12* and *alpha-r12*, respectively and are associated with the corresponding PSDCH resource configuration.

A UE shall drop any PSDCH transmissions that are associated with sidelink discovery type 1 in a sidelink subframe if the UE has a PSDCH transmission associated with sidelink discovery type 2B in that subframe.

14.3.2 UE procedure for receiving the PSDCH

For sidelink discovery type 1, for each PSDCH resource configuration associated with reception of PSDCH, a UE configured by higher layers to detect a transport block on PSDCH can decode the PSDCH according to the PSDCH resource configuration.

For sidelink discovery type 2B, for each PSDCH resource configuration associated with reception of PSDCH, a UE configured by higher layers to detect a transport block on PSDCH can decode the PSDCH according to the PSDCH resource configuration.

14.3.3 UE procedure for determining resource block pool and subframe pool for sidelink discovery

A PSDCH resource configuration for transmission/reception is associated with a set of periodically occurring time-domain periods (known as PSDCH periods). The i-th PSDCH period begins at subframe with subframe index $j_{begin} = O_3 + i \cdot P$ and ends in subframe with subframe index $j_{end} = O_3 + (i+1) \cdot P - 1$, where

- $0 \le j_{begin} < 10240$,
- the subframe index is relative to subframe#0 of a radio frame corresponding to SFN 0 of the serving cell or DFN 0 (described in [11]),
- O_3 is the *offsetIndicator-r12* indicated by the PSDCH resource configuration
- P is the *discPeriod-r12* indicated by the PSDCH resource configuration.

For a PSDCH period, the UE determines a discovery pool consisting of a subframe pool and a resource block pool for PSDCH as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSDCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- A bitmap $b_0, b_1, b_2, \ldots, b_{N'-1}$ is obtained using $b_j = a_{j \bmod N_B}$, for $0 \le j < N'$, where $a_0, a_1, a_2, \ldots, a_{N_B-1}$ and N_B are the bitmap and the length of the bitmap indicated by *subframeBitmap-r12*, respectively, and $N' = N_B \cdot N_R$, where N_R is the *numRepetition-r12* indicated by the PSDCH resource configuration.
- The first N' uplink subframes are denoted by $(l_0, l_1, \ldots, l_{N'-1})$ arranged in increasing order of subframe index.
- A subframe l_j $(0 \le j < N')$ belongs to the subframe pool if $b_j = 1$. The subframes in the subframe pool are denoted by $(l_0^{PSDCH}, l_1^{PSDCH}, \ldots, l_{L_{PSDCH}-1}^{PSDCH})$ arranged in increasing order of subframe index and L_{PSDCH} denotes the number of subframes in the subframe pool.

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- A PRB with index q ($0 \le q < N_{RB}^{SL}$) belongs to the resource block pool if $S1 \le q < S1+M$ or if $S2-M < q \le S2$, where *S1*, *S2*, and *M* denote the *prb-Start-r12*, *prb-End-r12* and *prb-Num-r12* indicated by the PSDCH resource configuration respectively.
- The resource blocks in the resource block pool are denoted by $\left(m_0^{PSDCH}, m_1^{PSDCH}, \ldots, m_{M_{RB}^{PSDCH\_RP}-1}^{PSDCH}\right)$ arranged in increasing order of resource block indices and $M_{RB}^{PSDCH\_RP}$ is the number of resource blocks in the resource block pool.

14.4 Physical Sidelink Synchronization related procedures

The synchronization resource configuration(s) for the UE are given by the higher layer parameter *SL-SyncConfig-r12*.

A UE shall transmit sidelink synchronisation signals according to subclause 5.10.7 in [11].

A UE may assume that sidelink synchronization signals are signals transmitted by an eNB as described in subclause 6.11 of [3] or are signals transmitted by a UE as described in [11].

A UE is not expected to blindly detect the cyclic prefix length of sidelink synchronization signals transmitted by another UE.

For a sidelink synchronization resource configuration associated with PSDCH reception, if cell *c* is indicated by the parameter *physCellId-r12* and if the parameter *discSyncWindow-r12* is configured with value *w1* for cell *c*, the UE may assume that sidelink synchronization signals are transmitted in cell *c* and that they are received within a reference synchronization window of size +/-*w1* ms with respect to the sidelink synchronization resource of cell *c* indicated by higher layers. The sidelink synchronization identity associated with the sidelink synchronization resource is indicated by higher layers.

For PSDCH reception, if cell *c* is indicated by the parameter *physCellId-r12* and if the parameter *discSyncWindow-r12* is configured with value *w2* for cell *c*, the UE may assume that PSDCH of UE in cell *c* is received within a reference synchronization window of size +/-*w2* ms with respect to the discovery resource of cell *c* indicated by higher layers.

The UE transmit power of primary sidelink synchronization signal P_{PSSS} and the UE transmit power of secondary synchronization signal P_{SSSS} are given by

- If the UE is configured with sidelink transmission mode 1, and if the UE transmits sidelink synchronization signals in PSCCH period *i*, and if the TPC command field in the configured sidelink grant (described in [8]) for the PSCCH period *i* is set to 0
  - $P_{\text{PSSS}} = P_{\text{CMAX},PSBCH}$
  - $P_{\text{SSSS}} = P_{\text{CMAX},SSSS}$
- otherwise
  - $P_{\text{PSSS}} = \min\left\{P_{\text{CMAX},PSBCH},\ 10\log_{10}(M_{\text{PSSS}}) + P_{\text{O\_PSSS}} + \alpha_{PSSS} \cdot PL\right\}$ [dBm],
  - $P_{\text{SSSS}} = \min\left\{P_{\text{CMAX},SSSS},\ 10\log_{10}(M_{\text{PSSS}}) + P_{\text{O\_PSSS}} + \alpha_{PSSS} \cdot PL\right\}$ [dBm],

where $P_{\text{CMAX},PSBCH}$ and $P_{\text{CMAX},SSSS}$ are defined in [6]. $M_{\text{PSSS}} = 6$ and $PL = PL_c$ where PL_c is defined in subclause 5.1.1.1. $P_{\text{O\_PSSS}}$ and α_{PSSS} are provided by higher layer parameters associated with the corresponding sidelink synchronization signal resource configuration.

If sidelink synchronization signals are transmitted for PSDCH, and if the PSDCH transmission does not occur on any serving cell configured for the UE, c is the cell indicated by higher layers on downlink carrier frequency indicated by *discCarrierRef* [11]. Otherwise, c is the serving cell on which the sidelink synchronization signals are transmitted. If sidelink synchronization signals are transmitted for PSDCH, then PSDCH and sidelink synchronization signal transmission occur on the same carrier frequency.

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15 Channel access procedures for LAA

15.1 Downlink channel access procedures

An eNB operating LAA Scell(s) shall perform the channel access procedures described in this sub clause for accessing the channel(s) on which the LAA Scell(s) transmission(s) are performed.

15.1.1 Channel access procedure for transmission(s) including PDSCH

The eNB may transmit a transmission including PDSCH on a channel on which LAA Scell(s) transmission(s) are performed , after sensing the channel to be idle during the slot durations of a defer duration T_d ; and after the counter N is zero in step 4. The counter N is adjusted by sensing the channel for additional slot duration(s) according to the steps below:

1) set $N = N_{init}$, where N_{init} is a random number uniformly distributed between 0 and CW_p ;
2) if $N > 0$ and the eNB chooses to decrement the counter, set $N = N - 1$;
3) sense the channel for an additional slot duration, and if the additional slot duration is idle, go to step 4; else, go to step 5;
4) if $N = 0$, stop; else, go to step 2.
5) sense the channel during the slot durations of an additional defer duration T_d ;
6) if the channel is sensed to be idle during the slot durations of the additional defer duration T_d , go to step 2; else, go to step 5;

If an eNB has not transmitted a transmission including PDSCH on a channel on which LAA Scell(s) transmission(s) are performed after step 4 in the procedure above, the eNB may transmit a transmission including PDSCH on the channel, after sensing the channel to be idle at least in the slot durations of an additional defer duration T_d .

The defer duration T_d consists of duration $T_f = 16us$ immediately followed by m_p consecutive slot durations where each slot duration is $T_{sl} = 9us$, and T_f includes an idle slot duration T_{sl} at start of T_f ;

A slot duration T_{sl} is considered to be idle if the eNB senses the channel during the slot duration, and the power detected by the eNB for at least $4us$ within the slot duration is less than energy detection threshold X_{Thresh} . Otherwise, the slot duration T_{sl} is considered to be busy.

$CW_{\min,p} \le CW_p \le CW_{\max,p}$ is the contention window. CW_p adjustment is described in sub clause 15.1.3.

$CW_{\min,p}$ and $CW_{\max,p}$ are chosen during step 1 of the procedure above.

m_p , $CW_{\min,p}$, and $CW_{\max,p}$ are based on channel access priority class associated with the eNB transmission, as shown in Table 15.1.1-1.

X_{Thresh} adjustment is described in sub clause 15.1.4

If the eNB transmits discovery signal transmission(s) not including PDSCH when $N > 0$ in the procedure above, the eNB shall not decrement N during the slot duration(s) overlapping with discovery signal transmission.

The eNB shall not continuously transmit on a channel on which the LAA Scell(s) transmission(s) are performed, for a period exceeding $T_{m\text{cot},p}$ as given in Table 15.1.1-1.

For $p = 3$ and $p = 4$, if the absence of any other technology sharing the carrier can be guaranteed on a long term basis (e.g. by level of regulation), $T_{m\cot,p} = 10ms$, otherwise, $T_{m\cot,p} = 8ms$.

Table 15.1.1-1: Channel Access Priority Class

Channel Access Priority Class (p)	m_p	$CW_{\min,p}$	$CW_{\max,p}$	$T_{m\cot,p}$	allowed CW_p sizes
1	1	3	7	2 ms	{3,7}
2	1	7	15	3 ms	{7,15}
3	3	15	63	8 or 10 ms	{15,31,63}
4	7	15	1023	8 or 10 ms	{15,31,63,127,255,511,1023}

For LAA operation in Japan, if the eNB has transmitted a transmission after $N = 0$ in step 4 of the procedure above, the eNB may transmit the next continuous transmission, for duration of maximum T_j =4 msec, immediately after sensing the channel for at least a sensing interval of T_{js} =34usec, if the power detected by the eNB during T_{js} is less than X_{Thresh} , and if the total sensing and transmission time is not more than $1000 \cdot T_{\text{mcot}} + \lfloor T_{\text{mcot}} / T_j \rfloor \cdot T_{js}$ µsec.

15.1.2 Channel access procedure for transmissions including discovery signal transmission(s) and not including PDSCH

An eNB may transmit a transmission including discovery signal but not including PDSCH on a channel on which LAA Scell(s) transmission(s) are performed immediately after sensing the channel for at least a sensing interval $T_{\text{drs}} = 25us$, if the power detected by the eNB during T_{drs} is less than X_{Thresh} and if the duration of the transmission is less than 1 ms.

15.1.3 Contention window adjustment procedure

If the eNB transmits transmissions that are associated with channel access priority class p on a channel, the eNB maintains and adjusts the contention window value CW_p for those transmissions using the following steps:

1) for each priority class $p \in \{1,2,3,4\}$ set $CW_p = CW_{\min,p}$

2) if at least $Z = 80\%$ of HARQ-ACK values corresponding to PDSCH transmission(s) in reference subframe k are determined as NACK, increase CW_p for each priority class $p \in \{1,2,3,4\}$ to the next higher allowed value; otherwise, go to step 1.

Reference subframe k is the starting subframe of the most recent transmission on the channel made by the eNB, for which HARQ-ACK feedback is available.

If $CW_p = CW_{\max,p}$, the next higher allowed value for adjusting CW_p is $CW_{\max,p}$.

For determining Z ,

- if the eNB transmission(s) for which HARQ-ACK feedback is available start in the second slot of subframe k , HARQ-ACK values corresponding to PDSCH transmission(s) in subframe $k+1$ are also used in addition to the HARQ-ACK values corresponding to PDSCH transmission(s) in subframe k .

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- 'DTX' state and 'any' state are counted as NACK, if the HARQ-ACK values corresponding to the PDSCH transmission(s) are assigned by (E)PDCCH transmitted on the channel
- if a PDSCH transmission has two codewords, the HARQ-ACK value of each codeword is considered separately
- bundled HARQ-ACK across M subframes is considered as M HARQ-ACK responses.

If the $CW_p = CW_{\max,p}$ is consecutively used K times for generation of N_{init}, CW_p, is reset to $CW_{\min,p}$ for each priority class $p \in \{1,2,3,4\}$. K is selected by eNB from the set of values {1, 2, …,8}.

15.1.4 Energy detection threshold adaptation procedure

An eNB accessing a channel on which LAA Scell(s) transmission(s) are performed, shall set the energy detection threshold (X_{Thresh}) to be less than or equal to the maximum energy detection threshold $X_{\text{Thresh\_max}}$.

$X_{\text{Thresh\_max}}$ is determined as follows:

- If the absence of any other technology sharing the carrier can be guaranteed on a long term basis (e.g. by level of regulation) then:
  - $X_{\text{Thresh\_max}} = \min\begin{Bmatrix} T_{\max} + 10dB, \\ X_r \end{Bmatrix}$
    - X_r is Maximum energy detection threshold defined by regulatory requirements in dBm when such requirements are defined, otherwise $X_r = T_{\max} + 10dB$
- Otherwise,
  - $X_{\text{Thresh\_max}} = \max\begin{Bmatrix} -72\,dBm\ (20\text{MHz}), \\ \min\begin{Bmatrix} T_{\max}, \\ T_{\max} - T_A + (P_H - P_{TX}) \end{Bmatrix} \end{Bmatrix}$
- Where:
  - T_A = 10dB for transmission(s) including PDSCH;
  - T_A = 5dB for transmissions including discovery signal transmission(s) and not including PDSCH;
  - P_H = 23 dBm;
  - P_{TX} is the set maximum eNB output power in dBm for the carrier;
    - eNB uses the set maximum transmission power over a single carrier irrespective of whether single carrier or multi-carrier transmission is employed
  - $T_{\max}(\text{dBm}) = 10 \cdot \log 10\left(3.16228 \cdot 10^{-8}\,(mW/MHz) \cdot BWMHz\,(MHz)\right)$;
  - BWMHz is the single channel bandwidth in MHz.

15.1.5 Channel access procedure for transmission(s) on multiple channels

An eNB can access multiple channels on which LAA Scell(s) transmission(s) are performed, according to one of the Type A or Type B procedures described in this subclause.

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15.1.5.1 Type A multi-channel access procedures

The eNB shall perform channel access on each channel $c_i \in C$, according to the procedures described in subclause 15.1.1, where C is a set of channels on which the eNB intends to transmit, and $i = 0,1,\ldots q-1$, and q is the number of channels on which the eNB intends to transmit.

The counter N described in subclause 15.1.1 is determined for each channel c_i and is denoted as N_{c_i}. N_{c_i} is maintained according to subclause 15.1.5.1.1or 15.1.5.1.2.

15.1.5.1.1 Type A1

Counter N as described in subclause 15.1.1 is independently determined for each channel c_i and is denoted as N_{c_i}.

If the absence of any other technology sharing the carrier cannot be guaranteed on a long term basis (e.g. by level of regulation), when the eNB ceases transmission on any one channel $c_j \in C$, for each channel $c_i \neq c_j$, the eNB can resume decrementing N_{c_i} when idle slots are detected either after waiting for a duration of $4 \cdot T_{sl}$, or after reinitialising N_{c_i}.

15.1.5.1.1 Type A2

Counter N is determined as described in subclause 15.1.1 for channel $c_j \in C$, and is denoted as N_{c_j}, where c_j is the channel that has the largest CW_p value. For each channel c_i, $N_{c_i} = N_{c_j}$.

If the absence of any other technology sharing the carrier cannot be guaranteed on a long term basis (e.g. by level of regulation), when the eNB ceases transmission on any one channel for which N_{c_i} is determined, the eNB shall reinitialise N_{c_i} for all channels.

15.1.5.2 Type B multi-channel access procedure

A channel $c_j \in C$ is selected by the eNB as follows

- the eNB selects c_j by uniformly randomly choosing c_j from C before each transmission on multiple channels $c_i \in C$, or
- the eNB selects c_j no more frequently than once every 1 second,

where C is a set of channels on which the eNB intends to transmit, $i = 0,1,\ldots q-1$, and q is the number of channels on which the eNB intends to transmit.

To transmit on channel c_j

- the eNB shall perform channel access on channel c_j according to the procedures described in subclause 15.1.1 with the modifications described in 15.1.5.2.1 or 15.1.5.2.2.

To transmit on channel $c_i \neq c_j$, $c_i \in C$

- for each channel c_i, the eNB shall sense the channel c_i for at least a sensing interval $T_{\text{mc}} = 25us$ immediately before the transmitting on channel c_j, and the eNB may transmit on channel c_i immediately after sensing the channel c_i, if the power detected by the eNB on channel c_i during T_{mc} is less than X_{Thresh}.

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15.1.5.2.1 Type B1

For determining CW_p of channel c_j, step 2 of the procedure described in sub clause 15.1.3 is modified as follows

2) if at least $Z = 80\%$ of HARQ-ACK values corresponding to PDSCH transmission(s) in reference subframe k of all channels $c_i \in C$ are determined as NACK, increase CW_p of channel c_j for each priority class $p \in \{1, 2, 3, 4\}$ to the next higher allowed value; otherwise, go to step 1.

15.1.5.2.2 Type B2

A CW_p value is maintained independently for each channel $c_i \in C$ using the procedure described in subclause 15.1.3.

For determining N_{init} for channel c_j, CW_p value of channel $c_{j1} \in C$ is used, where c_{j1} is the channel with largest CW_p among all channels in set C.

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Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2006-09					Draft version created		0.0.0
2006-10					Endorsed by RAN1	0.0.0	0.1.0
2007-01					Inclusion of decisions from RAN1#46bis and RAN1#47	0.1.0	0.1.1
2007-01					Endorsed by RAN1	0.1.1	0.2.0
2007-02					Inclusion of decisions from RAN1#47bis	0.2.0	0.2.1
2007-02					Endorsed by RAN1	0.2.1	0.3.0
2007-02					Editor's version including decisions from RAN1#48 & RAN1#47bis	0.3.0	0.3.1
2007-03					Updated Editor's version	0.3.1	0.3.2
2007-03	RAN-35	RP-070171			For information at RAN#35	0.3.2	1.0.0
2007-03					Random access text modified to better reflect RAN1 scope	1.0.0	1.0.1
2007-03					Updated Editor's version	1.0.1	1.0.2
2007-03					Endorsed by RAN1	1.0.2	1.1.0
2007-05					Updated Editor's version	1.1.0	1.1.1
2007-05					Updated Editor's version	1.1.1	1.1.2
2007-05					Endorsed by RAN1	1.1.2	1.2.0
2007-08					Updated Editor's version	1.2.0	1.2.1
2007-08					Updated Editor's version – uplink power control from RAN1#49bis	1.2.1	1.2.2
2007-08					Endorsed by RAN1	1.2.2	1.3.0
2007-09					Updated Editor's version reflecting RAN#50 decisions	1.3.0	1.3.1
2007-09					Updated Editor's version reflecting comments	1.3.1	1.3.2
2007-09					Updated Editor's version reflecting further comments	1.3.2	1.3.3
2007-09					Updated Editor's version reflecting further comments	1.3.3	1.3.4
2007-09					Updated Edtior's version reflecting further comments	1.3.4	1.3.5
2007-09	RAN-37	RP-070731			Endorsed by RAN1	1.3.5	2.0.0
2007-09	RAN-37	RP-070737			For approval at RAN#37	2.0.0	2.1.0
12/09/07	RP-37	RP-070737	-	-	Approved version	2.1.0	8.0.0
28/11/07	RP-38	RP-070949	0001	2	Update of 36.213	8.0.0	8.1.0
05/03/08	RP-39	RP-080145	0002	-	Update of TS 36.213 according to changes listed in cover sheet	8.1.0	8.2.0
28/05/08	RP-40	RP-080434	0003	1	PUCCH timing and other formatting and typo corrections	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0006	1	PUCCH power control for non-unicast information	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0008	-	UE ACK/NACK Procedure	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0009	-	UL ACK/NACK timing for TDD	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0010	-	Specification of UL control channel assignment	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0011	-	Precoding Matrix for 2Tx Open-loop SM	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0012	-	Clarifications on UE selected CQI reports	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0013	1	UL HARQ Operation and Timing	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0014	-	SRS power control	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0015	1	Correction of UE PUSCH frequency hopping procedure	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0017	4	Blind PDCCH decoding	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0019	1	Tx Mode vs DCI format is clarified	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0020	-	Resource allocation for distributed VRB	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0021	2	Power Headroom	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0022	-	Clarification for RI reporting in PUCCH and PUSCH reporting modes	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0025	-	Correction of the description of PUSCH power control for TDD	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0026	-	UL ACK/NACK procedure for TDD	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0027	-	Indication of radio problem detection	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0028	-	Definition of Relative Narrowband TX Power Indicator	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0029	-	Calculation of $\Delta_{TF}(i)$ for UL-PC	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0030	-	CQI reference and set S definition, CQI mode removal, and Miscellanious	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0031	-	Modulation order and TBS determination for PDSCH and PUSCH	8.2.0	8.3.0
28/05/08	RP-40	RP-080434	0032	-	On Sounding RS	8.2.0	8.3.0
28/05/08	RP-40	RP-080426	0033	-	Multiplexing of rank and CQI/PMI reports on PUCCH	8.2.0	8.3.0
28/05/08	RP-40	RP-080466	0034	-	Timing advance command responding time	8.2.0	8.3.0
09/09/08	RP-41	RP-080670	37	2	SRS hopping pattern for closed loop antenna selection	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	39	2	Clarification on uplink power control	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	41	-	Clarification on DCI formats using resource allocation type 2	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	43	2	Clarification on tree structure of CCE aggregations	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	46	2	Correction of the description of PUCCH power control for TDD	8.3.0	8.4.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
09/09/08	RP-41	RP-080670	47	1	Removal of CR0009	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	48	1	Correction of mapping of cyclic shift value to PHICH modifier	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	49	-	TBS disabling for DCI formats 2 and 2A	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	50	-	Correction of maximum TBS sizes	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	51	-	Completion of the table specifying the number of bits for the periodic feedback	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	54	-	Clarification of RNTI for PUSCH/PUCCH power control with DCI formats 3/3A	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	55	1	Clarification on mapping of Differential CQI fields	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	59	1	PUSCH Power Control	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	60	-	RB restriction and modulation order for CQI-only transmission on PUSCH	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	61	-	Modulation order determination for uplink retransmissions	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	62	2	Introducing missing L1 parameters into 36.213	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	63	2	Correcting the range and representation of delta_TF_PUCCH	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	64	1	Adjusting TBS sizes to for VoIP	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	67	-	Correction to the downlink resource allocation	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	68	-	Removal of special handling for PUSCH mapping in PUCCH region	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	69	-	Correction to the formulas for uplink power control	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	70	1	Definition of Bit Mapping for DCI Signalling	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	71	-	Clarification on PUSCH TPC commands	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	72	1	Reference for CQI/PMI Reporting Offset	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	74	-	Correction to the downlink/uplink timing	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	75	-	Correction to the time alignment command	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	77	1	Correction of offset signalling of UL Control information MCS	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	78	2	DCI format1C	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	80	-	Correction to Precoder Cycling for Open-loop Spatial Multiplexing	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	81	1	Clarifying Periodic CQI Reporting using PUCCH	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	84	1	CQI reference measurement period	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	86	-	Correction on downlink multi-user MIMO	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	87	-	PUCCH Reporting	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	88	1	Handling of Uplink Grant in Random Access Response	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	89	-	Correction to UL Hopping operation	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	90	-	DRS EPRE	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	92	-	Uplink ACK/NACK mapping for TDD	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	93	-	UL SRI Parameters Configuration	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	94	-	Miscellaneous updates for 36.213	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	95	-	Clarifying Requirement for Max PDSCH Coding Rate	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	96	-	UE Specific SRS Configuration	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	97	-	DCI Format 1A changes needed for scheduling Broadcast Control	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	98	-	Processing of TPC bits in the random access response	8.3.0	8.4.0
09/09/08	RP-41	RP-080670	100	1	Support of multi-bit ACK/NAK transmission in TDD	8.3.0	8.4.0
03/12/08	RP-42	RP-081075	82	3	Corrections to RI for CQI reporting	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	83	2	Moving description of large delay CDD to 36.211	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	102	3	Reception of DCI formats	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	105	8	Alignment of RAN1/RAN2 specification	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	107	1	General correction of reset of power control and random access response message	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	108	2	Final details on codebook subset restrictions	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	109	-	Correction on the definition of Pmax	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	112	2	CQI/PMI reference measurement periods	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	113	-	Correction of introduction of shortened SR	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	114	-	RAN1/2 specification alignment on HARQ operation	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	115	-	Introducing other missing L1 parameters in 36.213	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	116	-	PDCCH blind decoding	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	117	-	PDCCH search space	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	119	-	Delta_TF for PUSCH	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	120	-	Delta_preamble_msg3 parameter values and TPC command in RA response	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	122	1	Correction of offset signaling of uplink control information MCS	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	124	-	Miscellaneous Corrections	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	125	-	Clarification of the uplink index in TDD mode	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	126	-	Clarification of the uplink transmission configurations	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	127	2	Correction to the PHICH index assignment	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	128	-	Clarification of type-2 PDSCH resource allocation for format 1C	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	129	-	Clarification of uplink grant in random access response	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	130	-	UE sounding procedure	8.4.0	8.5.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
03/12/08	RP-42	RP-081075	134	-	Change for determining DCI format 1A TBS table column indicator for broadcast control	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	135	-	Clarifying UL VRB Allocation	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	136	1	Correction for Aperiodic CQI	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	137	1	Correction for Aperiodic CQI Reporting	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	138	1	Correction to PUCCH CQI reporting mode for N^DL_RB <= 7	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	140	1	On sounding procedure in TDD	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	141	1	Alignment of RAN1/RAN3 specification	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	143	1	TTI bundling	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	144	1	ACK/NACK transmission on PUSCH for LTE TDD	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	145	1	Timing relationship between PHICH and its associated PUSCH	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	147	1	Definition of parameter for downlink reference signal transmit power	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	148	1	Radio link monitoring	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	149	1	Correction in 36.213 related to TDD downlink HARQ processes	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	151	-	Nominal PDSCH-to-RS EPRE Offset for CQI Reporting	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	152	1	Support of UL ACK/NAK repetition in Rel-8	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	155	-	Clarification of misconfiguration of aperiodic CQI and SR	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	156	1	Correction of control information multiplexing in subframe bundling mode	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	157	-	Correction to the PHICH index assignment	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	158	1	UE transmit antenna selection	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	159	-	Clarification of spatial different CQI for CQI reporting Mode 2-1	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	160	1	Corrections for TDD ACK/NACK bundling and multiplexing	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	161	-	Correction to RI for Open-Loop Spatial Multiplexing	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	162	-	Correction of differential CQI	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	163	-	Inconsistency between PMI definition and codebook index	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	164	-	PDCCH validation for semi-persistent scheduling	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	165	1	Correction to the UE behavior of PUCCH CQI piggybacked on PUSCH	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	166	-	Correction on SRS procedure when shortened PUCCH format is used	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	167	1	Transmission overlapping of physical channels/signals with PDSCH for transmission mode 7	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	169	-	Clarification of SRS and SR transmission	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	171	-	Clarification on UE behavior when skipping decoding	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	172	1	PUSCH Hopping operation corrections	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	173	-	Clarification on message 3 transmission timing	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	174	-	MCS handling for DwPTS	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	175	-	Clarification of UE-specific time domain position for SR transmission	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	176	1	Physical layer parameters for CQI reporting	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	177	-	A-periodic CQI clarification for TDD UL/DL configuration 0	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	179	1	Correction to the definitions of rho_A and rho_B (downlink power allocation)	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	180	-	Clarification of uplink A/N resource indication	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	181	-	PDCCH format 0 for message 3 adaptive retransmission and transmission of control information in message 3 during contention based random access procedure	8.4.0	8.5.0
03/12/08	RP-42	RP-081075	182	-	To Fix the Discrepancy of Uplink Power Control and Channel Coding of Control Information in PUSCH	8.4.0	8.5.0
03/12/08	RP-42	RP-081122	183	1	CQI reporting for antenna port 5	8.4.0	8.5.0
03/12/08	RP-42	RP-081110	168	1	Clarification on path loss definition	8.4.0	8.5.0
04/03/09	RP-43	RP-090236	184	1	Corrections to Transmitted Rank Indication	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	185	4	Corrections to transmission modes	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	186	2	Delta_TF configuration for control only PUSCH	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	187	1	Correction to concurrent SRS and ACK/NACK transmission	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	191	1	PDCCH release for semi-persistent scheduling	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	192	1	Correction on ACKNACK transmission on PUSCH for LTE TDD	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	193	-	Correction to subband differential CQI value to offset level mapping for aperiodic CQI reporting	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	194	-	Correction for DRS Collision handling	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	196	2	Alignment of RAN1/RAN4 specification on UE maximum output power	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	197	-	Transmission scheme for transmission mode 7 with SPS C-RNTI	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	198	-	Clarifying bandwidth parts for periodic CQI reporting and CQI refererence period	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	199	2	Correction to the ACK/NACK bundling in case of transmission mode 3 and 4	8.5.0	8.6.0

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Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
04/03/09	RP-43	RP-090236	200	-	ACK/NAK repetition for TDD ACK/NAK multiplexing	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	201	-	Clarifying UL ACK/NAK transmission in TDD	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	202	-	Corrections to UE Transmit Antenna Selection	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	203	-	Correction to UE PUSCH hopping procedure	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	204	-	Correction to PHICH resource association in TTI bundling	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	205	-	Clarification of the length of resource assignment	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	206	-	Correction on ACK/NACK transmission for downlink SPS resource release	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	207	-	Introduction of additional values of wideband CQI/PMI periodicities	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	208	2	Correction to CQI/PMI/RI reporting field	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	209	2	Correction to rho_A definition for CQI calculation	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	210	-	Correction to erroneous cases in PUSCH linear block codes	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	211	1	Removing RL monitoring start and stop	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	214	1	Correction to type-1 and type-2 PUSCH hopping	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	215	-	Contradicting statements on determination of CQI subband size	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	216	-	Corrections to SRS	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	219	2	Miscellaneous corrections on TDD ACKNACK	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	221	1	CR for Redundancy Version mapping function for DCI 1C	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	223	-	Scrambling of PUSCH corresponding to Random Access Response Grant	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	225	-	Removal of SRS with message 3	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	226	3	PRACH retransmission timing	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	227	-	Clarifying error handling of PDSCH and PUSCH assignments	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	228	-	Clarify PHICH index mapping	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	229	-	Correction of CQI timing	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	230	-	Alignment of CQI parameter names with RRC	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	231	1	Removal of 'Off' values for periodic reporting in L1	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	232	-	Default value of RI	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	233	1	Clarification of uplink timing adjustments	8.5.0	8.6.0
04/03/09	RP-43	RP-090236	234	-	Clarification on ACK/NAK repetition	8.5.0	8.6.0
27/05/09	RP-44	RP-090529	235	1	Correction to the condition of resetting accumulated uplink power correction	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	236	-	Correction to the random access channel parameters received from higher layer	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	237	-	Correction on TDD ACKNACK	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	238	1	Correction on CQI reporting	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	239	-	Correction on the HARQ process number	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	241	1	CR correction of the description on TTI-bundling	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	242	1	Clarify latest and initial PDCCH for PDSCH and PUSCH transmisisons, and NDI for SPS activation	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	243	-	Clarify DRS EPRE	8.6.0	8.7.0
27/05/09	RP-44	RP-090529	244	1	Clarification on TPC commands for SPS	8.6.0	8.7.0
15/09/09	RP-45	RP-090888	245	1	Correction to PUSCH hopping and PHICH mapping procedures	8.7.0	8.8.0
15/09/09	RP-45	RP-090888	246	-	Clarification on subband indexing in periodic CQI reporting	8.7.0	8.8.0
15/09/09	RP-45	RP-090888	247	2	Correction to DVRB operation in TDD transmission mode 7	8.7.0	8.8.0
15/09/09	RP-45	RP-090888	249	-	Clarification of concurrent ACKNACK and periodic PMI/RI transmission on PUCCH for TDD	8.7.0	8.8.0
15/09/09	RP-45	RP-090888	250	-	Clarify Inter-cell synchronization text	8.7.0	8.8.0
01/12/09	RP-46	RP-091172	248	1	Introduction of LTE positioning	8.8.0	9.0.0
01/12/09	RP-46	RP-091172	254	-	Clarification of PDSCH and PRS in combination for LTE positioning	8.8.0	9.0.0
01/12/09	RP-46	RP-091177	255	5	Editorial corrections to 36.213	8.8.0	9.0.0
01/12/09	RP-46	RP-091257	256	1	Introduction of enhanced dual layer transmission	8.8.0	9.0.0
01/12/09	RP-46	RP-091177	257	1	Add shorter SR periodicity	8.8.0	9.0.0
01/12/09	RP-46	RP-091256	258	-	Introduction of LTE MBMS	8.8.0	9.0.0
17/12/09	RP-46	RP-091257	256	1	Correction by MCC due to wrong implementation of CR0256r1 – Sentence is added to Single-antenna port scheme subclause 7.1.1	9.0.0	9.0.1
16/03/10	RP-47	RP-100211	259	3	UE behavior when collision of antenna port 7/8 with PBCH or SCH happened and when distributed VRB is used with antenna port 7	9.0.1	9.1.0
16/03/10	RP-47	RP-100210	260	1	MCCH change notification using DCI format 1C	9.0.1	9.1.0
16/03/10	RP-47	RP-100211	263	-	Correction on PDSCH EPRE and UE-specific RS EPRE for Rel-9 enhanced DL transmissions	9.0.1	9.1.0
01/06/10	RP-48	RP-100589	265	-	Clarification for TDD when multiplexing ACK/NACK with SR of ACK/NACK with CQI/PMI or RI	9.1.0	9.2.0
01/06/10	RP-48	RP-100590	268	1	Clarification of PRS EPRE	9.1.0	9.2.0
14/09/10	RP-49	RP-100900	269	-	Clarification on Extended CP support with Transmission Mode 8	9.2.0	9.3.0
07/12/10	RP-50	RP-101320	270	-	Introduction of Rel-10 LTE-Advanced features in 36.213	9.3.0	10.0.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
27/12/10	-	-	-	-	Editorial change to correct a copy/past error in subclause 7.2.2	10.0.0	10.0.1
15/03/11	RP-51	RP-110255	271	1	A clarification for redundancy version of PMCH	10.0.1	10.1.0
15/03/11	RP-51	RP-110258	272	-	RLM Procedure with restricted measurements	10.0.1	10.1.0
15/03/11	RP-51	RP-110256	273	-	Corrections to Rel-10 LTE-Advanced features in 36.213	10.0.1	10.1.0
01/06/11	RP-52	RP-110819	274	3	Correction to HARQ-ACK procedure for TDD mode b with M=2	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	275	3	Determination of PUSCH A/N codebook size for TDD	10.1.0	10.2.0
01/06/11	RP-52	RP-110823	276	-	The triggering of aperiodic SRS in DCI formats 2B and 2C	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	278	3	Corrections to power headroom	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	279	1	Removal of square brackets for PUCCH format 3 ACK/NACK	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	281	1	Correction of AN repetition and PUCCH format 3	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	282	2	Correction to timing for secondary cell activation and deactivation	10.1.0	10.2.0
01/06/11	RP-52	RP-110823	283	1	Correction to MCS offset for multiple TBs	10.1.0	10.2.0
01/06/11	RP-52	RP-110820	286	1	Miscellaneous Corrections	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	286	1	Corrections on UE procedure for determining PUCCH Assignment	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	289	2	Correction to Multi-cluster flag in DCI format 0	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	290	2	Joint transmission of ACK/NACK and SR with PUCCH format 3	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	291	3	Correction of uplink resource allocation type 1	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	292	1	Correction on CSI-RS configuration	10.1.0	10.2.0
01/06/11	RP-52	RP-110818	294	-	ACK/NACK and CQI simultaneous transmission in ACK/NACK bundling in TDD	10.1.0	10.2.0
01/06/11	RP-52	RP-110823	295	-	UE specific disabling of UL DMRS sequence hopping	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	296	-	PDSCH transmission in MBSFN subframes	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	297	-	Introduction of PCMAX for PUSCH power scaling	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	298	-	Power control for SR and ACK/NACK with PUCCH format 3	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	299	2	CR on power control for HARQ-ACK transmission on PUCCH	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	300	2	Correction to handling of search space overlap	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	301	1	Correction to simultaneous transmission of SRS and PUCCH format 2/2a/2b	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	302	1	Correction for Simultaneous PUCCH and SRS Transmissions on CA	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	303	-	Correction on 8Tx Codebook Sub-sampling for PUCCH Mode 1-1	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	304	1	Corrections on CQI type in PUCCH mode 2-1 and clarification on simultaneous PUCCH and PUSCH transmission for UL-SCH subframe bundling	10.1.0	10.2.0
01/06/11	RP-52	RP-110818	305	1	Correction on UE behaviour upon reporting periodic CSI using PUCCH Mode1-1	10.1.0	10.2.0
01/06/11	RP-52	RP-110818	306	-	Clarification for the definition of CQI	10.1.0	10.2.0
01/06/11	RP-52	RP-110818	307	-	Clarification for the definition of Precoding Matrix Indicator	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	308	-	Simultaneous SRS transmissions in more than one cell	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	310	1	Miscellaneous Corrections for TS 36.213	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	311	1	Configuration of pmi-RI-Report	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	312	1	Correction on the support of PUCCH format 3 and channel selection	10.1.0	10.2.0
01/06/11	RP-52	RP-110821	313	-	Correction on UE behaviour during DM-RS transmission on subframes carrying synchronization signals	10.1.0	10.2.0
01/06/11	RP-52	RP-110820	314	1	36.213 CR on antenna selection	10.1.0	10.2.0
01/06/11	RP-52	RP-110823	316	1	Number of HARQ process for UL spatial multiplexing	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	317	-	PUCCH format 3 Fallback procedure in TDD	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	318	-	Clarification on CSI reporting under an invalid downlink subframe	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	320	-	Multiple Aperiodic SRS Triggers for Same Configuration	10.1.0	10.2.0
01/06/11	RP-52	RP-110823	321	-	UE antenna switch in UL MIMO	10.1.0	10.2.0
01/06/11	RP-52	RP-110819	322	-	UE behaviour for PDSCH reception with limited soft buffer in CA	10.1.0	10.2.0
01/06/11	RP-52	RP-110859	323	-	Joint transmission of ACK/NACK and SR or CSI with PUCCH format 3 and channel selection	10.1.0	10.2.0
15/09/11	RP-53	RP-111229	277	1	Correction to reception of PRS in MBSFN subframes	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	325	3	Corrections on UE procedure for reporting HARQ-ACK	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	326	2	Corrections on Physical Uplink Control Channel Procedure	10.2.0	10.3.0
15/09/11	RP-53	RP-111231	331	1	Correction to uplink transmission scheme usage for random access response and PHICH-triggered retransmissions	10.2.0	10.3.0
15/09/11	RP-53	RP-111229	336	-	Corrections on transmission mode 9	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	339	-	Corrections on HARQ-ACK codebook size determination	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	340	-	Corrections on TDD PUCCH format 1b with channel selection and HARQ-ACK transmission on PUSCH	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	341	-	Corrections on NACK generation	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	342	-	Corrections on power headroom reporting	10.2.0	10.3.0
15/09/11	RP-53	RP-111229	346	-	Correction on TBS translation table	10.2.0	10.3.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
15/09/11	RP-53	RP-111229	347	2	Correction to the condition of enabling PMI feedback	10.2.0	10.3.0
15/09/11	RP-53	RP-111232	348	-	Miscellaneous corrections to 36.213	10.2.0	10.3.0
15/09/11	RP-53	RP-111229	349	-	Corrections on PUSCH and PUCCH modes	10.2.0	10.3.0
15/09/11	RP-53	RP-111231	350	1	CR on UL HARQ ACK determination	10.2.0	10.3.0
15/09/11	RP-53	RP-111231	351	1	Correction on UL DMRS resources for PHICH-triggered retransmission	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	352	-	Clarification on the common search space description	10.2.0	10.3.0
15/09/11	RP-53	RP-111232	353	1	Clarification on ambiguous DCI information between UE-specific search space and common search space for DCI formats 0 and 1A	10.2.0	10.3.0
15/09/11	RP-53	RP-111229	354	-	Clarification of Reference PDSCH Power for CSI-RS based CSI Feedback	10.2.0	10.3.0
15/09/11	RP-53	RP-111230	355	2	Corrections on reporting Channel State Information	10.2.0	10.3.0
05/12/11	RP-54	RP-111669	324	3	Accumulation of power control commands from DCI format 3/3A	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	357	1	Miscellaneous corrections on uplink power control	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	358	-	Corrections on N_c^{received}	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	359	-	Corrections on TDD PUCCH format 1b with channel selection and two configured serving cells	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	360	-	Corrections on the notation of k and k_m	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	361	1	Corrections on PUCCH mode 2-1	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	362	3	A correction to PDSCH transmission assumption for CQI calculation	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	363	1	Corrections on PUCCH Resource Notation	10.3.0	10.4.0
05/12/11	RP-54	RP-111667	364	-	Correction on the notation of SRS transmission comb	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	365	-	Clarification on the HARQ-ACK procedure of TDD UL-DL configuration 5	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	366	2	Clarification on the determination of resource for PUCCH Format 1b with channel selection in TDD mode	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	367	1	Correction on HARQ-ACK procedure	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	368	-	Correction for A/N on PUSCH with W=1,2 in case of TDD channel selection	10.3.0	10.4.0
05/12/11	RP-54	RP-111668	369	-	Clarification of PUCCH 2-1 Operation	10.3.0	10.4.0
05/12/11	RP-54	RP-111668	370	1	Correction on PMI index	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	371	2	Correction to periodic CSI reports for carrier aggregation	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	373	1	Removal of square bracket in HARQ-ACK procedure	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	374	1	Clarification on UE's capability of supporting PUCCH format 3	10.3.0	10.4.0
05/12/11	RP-54	RP-111666	375	1	Clarifications of UE behavior on PUSCH power control	10.3.0	10.4.0
28/02/12	RP-55	RP-120286	376	1	RNTI Configuration associated with DL Resource Allocation Type 2	10.4.0	10.5.0
28/02/12	RP-55	RP-120283	377	2	Correction for ACK/NACK related procedure in case of TDD UL-DL configuration 0	10.4.0	10.5.0
13/06/12	RP-56	RP-120737	378	3	Correction of FDD channel selection HARQ-ACK and SR transmission	10.5.0	10.6.0
13/06/12	RP-56	RP-120738	379	-	Removal of description with square brackets	10.5.0	10.6.0
13/06/12	RP-56	RP-120738	381	-	Correction on transmission mode 9 with a single antenna port transmission	10.5.0	10.6.0
04/09/12	RP-57	RP-121265	382	-	Clarification of codebook subsampling for PUCCH 2-1	10.6.0	10.7.0
04/09/12	RP-57	RP-121266	383	-	Correction to UE transmit antenna selection	10.6.0	10.7.0
04/09/12	RP-57	RP-121264	384	-	TDD HARQ-ACK procedure for PUCCH format 1b with channel selection in carrier aggregation	10.6.0	10.7.0
04/09/12	RP-57	RP-121265	385	-	Corrections for Handling CSI-RS patterns	10.6.0	10.7.0
04/09/12	RP-57	RP-121264	386	1	Reference serving cell for pathloss estimation	10.6.0	10.7.0
04/09/12	RP-57	RP-121264	387	-	Power control for PUCCH format 3 with single configured cell	10.6.0	10.7.0
04/09/12	RP-57	RP-121264	388	-	ACK/NACK resource in case of channel selection	10.6.0	10.7.0
04/09/12	RP-57	RP-121274	380	4	Introduction of an additional special subframe configuration	10.7.0	11.0.0
04/09/12	RP-57	RP-121272	389	-	Introduction of Rel-11 features	10.7.0	11.0.0
04/12/12	RP-58	RP-121839	393	-	Correction to the parameter ue-Category-v10xy	11.0.0	11.1.0
04/12/12	RP-58	RP-121837	395	-	Correction of reference signal scrambling sequence initialization for SPS in transmission mode 7	11.0.0	11.1.0
04/12/12	RP-58	RP-121846	396	-	Finalisation for introducing Rel-11 features	11.0.0	11.1.0
26/02/13	RP-59	RP-130254	398	-	Correction on UE procedure for reporting HARQ-ACK	11.1.0	11.2.0
26/02/13	RP-59	RP-130252	400	-	Corrections for SRS power scaling in UpPTS	11.1.0	11.2.0
26/02/13	RP-59	RP-130252	403	-	CR on UE specific search and Common search space overlap on PDCCH	11.1.0	11.2.0
26/02/13	RP-59	RP-130358	404	-	Additional clarifications/corrections for introducing Rel-11 features	11.1.0	11.2.0
11/06/13	RP-60	RP-130752	405	-	Correction to EPDCCH monitoring in case of cross-carrier scheduling	11.2.0	11.3.0
11/06/13	RP-60	RP-130751	407	1	Correction on the RI bit width	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	408	-	Correction on parallel reception of PDSCH and Msg 2	11.2.0	11.3.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
11/06/13	RP-60	RP-130747	409	-	Correction on zero power CSI-RS resource configuration	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	410	1	Corrections on different TDD UL-DL configurations on different bands	11.2.0	11.3.0
11/06/13	RP-60	RP-130752	411	-	Correction on EPDCCH PRB pair indication	11.2.0	11.3.0
11/06/13	RP-60	RP-130752	412	-	Correction on EPDCCH hashing function	11.2.0	11.3.0
11/06/13	RP-60	RP-130752	413	-	Correction on PUCCH resource determination for FDD EPDCCH	11.2.0	11.3.0
11/06/13	RP-60	RP-130752	414	2	CR on ambiguity in EPDCCH decoding candidates under two overlapped EPDCCH resource sets	11.2.0	11.3.0
11/06/13	RP-60	RP-130749	415	-	Removal of the case for spatial domain bundling in TDD UL/DL configuration 0	11.2.0	11.3.0
11/06/13	RP-60	RP-130752	416	-	Corrections to EPDCCH PRB pair indication	11.2.0	11.3.0
11/06/13	RP-60	RP-130753	417	1	Correction to PUSCH/PUCCH transmit power after PRACH power ramping	11.2.0	11.3.0
11/06/13	RP-60	RP-130747	418	-	CR on RI-Reference CSI Process with Subframe Sets	11.2.0	11.3.0
11/06/13	RP-60	RP-130747	420	-	Correction on UE-specific RS scrambling for SPS PDSCH in TM10	11.2.0	11.3.0
11/06/13	RP-60	RP-130747	421	-	CR on resolving ambiguous UE capability signaling for CoMP	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	422	-	Correction of valid downlink subframe	11.2.0	11.3.0
11/06/13	RP-60	RP-130749	424	-	Correction on HARQ-ACK transmission for a UE configured with PUCCH format 3	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	425	-	Correction of PHICH resource for half duplex TDD UE	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	426	-	Correction on n_{HARQ} for TDD CA with different UL-DL configurations	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	427	-	Correction on implicit HARQ-ACK resource determination for PUCCH format 1b with channel selection for TDD CA with different UL-DL configurations	11.2.0	11.3.0
11/06/13	RP-60	RP-130750	428	-	Correction on SRS power scaling with multiple TAGs	11.2.0	11.3.0
11/06/13	RP-60	RP-130747	429	-	Correction on MBSFN subframe configuration	11.2.0	11.3.0
11/06/13	RP-60	RP-130749	430	-	CR on SCell activation timing	11.2.0	11.3.0
03/09/13					MCC clean-up	11.3.0	11.4.0
03/09/13	RP-61	RP-131249	432	-	Correction for EPDCCH Search Space	11.3.0	11.4.0
03/09/13	RP-61	RP-131250	433	-	Correction to QCL behaviour on CRS	11.3.0	11.4.0
03/09/13	RP-61	RP-131250	434	-	Correction on PUCCH power control	11.3.0	11.4.0
03/09/13	RP-61	RP-131248	435	-	Correction on the ratio of PDSCH EPRE to CRS EPRE for TM10	11.3.0	11.4.0
03/09/13	RP-61	RP-131249	436	-	CR on EPDCCH Search Space for Cross-Carrier Scheduling	11.3.0	11.4.0
03/09/13	RP-61	RP-131249	437	-	Correction to the UE behaviour in case of collision between PRS and EPDCCH in different CP case	11.3.0	11.4.0
03/09/13	RP-61	RP-131249	438	-	On correction to higher layer parameter name for EPDCCH resource mapping	11.3.0	11.4.0
03/09/13	RP-61	RP-131248	439	-	Correction to PDSCH mapping for CoMP	11.3.0	11.4.0
03/12/13	RP-62	RP-131893	440	1	Correction on parameter ue-Category	11.4.0	11.5.0
03/12/13	RP-62	RP-131892	442	1	Correction on determination of modulation order and transport block size	11.4.0	11.5.0
03/12/13	RP-62	RP-132024	445	3	Correction on CSI reporting type and parameters	11.4.0	11.5.0
03/12/13	RP-62	RP-131894	446	-	Correction on deriving the length of the non-MBSFN region	11.4.0	11.5.0
03/12/13	RP-62	RP-131896	431	5	Introduction of Rel 12 feature for Downlink MIMO Enhancement	11.5.0	12.0.0
03/03/14	RP-63	RP-140286	447	-	Correction to CSI Reporting	12.0.0	12.1.0
03/03/14	RP-63	RP-140291	448	-	Clarification on PUCCH Mode 1-1 for 4Tx Dual Codebook	12.0.0	12.1.0
03/03/14	RP-63	RP-140287	450	1	Common search space monitoring for MBMS	12.0.0	12.1.0
03/03/14	RP-63	RP-140290	452	-	Introduction of new UE categories	12.0.0	12.1.0
03/03/14	RP-63	RP-140288	455	1	Modification to I_SRS = 0 for trigger type 1 SRS and TDD	12.0.0	12.1.0
03/03/14	RP-63	RP-140289	458	-	Correction to CSI processing in TM10	12.0.0	12.1.0
10/06/14	RP-64	RP-140858	459	1	Clarification on PUCCH reporting type payload size	12.1.0	12.2.0
10/06/14	RP-64	RP-140858	461	-	Clarification on SRS colliding with PUCCH in the same cell when the UE is configured with multiple TAGs	12.1.0	12.2.0
10/06/14	RP-64	RP-140858	462	1	Clarification on SRS antenna switching	12.1.0	12.2.0
10/06/14	RP-64	RP-140862	463	-	Introduction of Rel-12 LTE-Advanced features in 36.213	12.1.0	12.2.0
10/09/14	RP-65	RP-141479	464	-	Correction on SRS transmission for TDD-FDD CA	12.2.0	12.3.0
10/09/14	RP-65	RP-141478	465	-	Correction on beta_{offset}^{HARQ-ACK} determination for a UE configured with two uplink power control subframe sets	12.2.0	12.3.0
10/09/14	RP-65	RP-141478	466	-	Corrections for TDD eIMTA	12.2.0	12.3.0
10/09/14	RP-65	RP-141479	467	3	CR on HARQ-ACK Multiplexing in PUSCH for TDD-FDD CA	12.2.0	12.3.0
10/09/14	RP-65	RP-141474	469	-	Correction to UCI embedding in case of a single serving cell and simultaneous PUSCH and PUCCH transmission	12.2.0	12.3.0
10/09/14	RP-65	RP-141478	470	-	Corrections on UL-reference UL/DL configuration	12.2.0	12.3.0
10/09/14	RP-65	RP-141473	471	-	CR for Clarification of special subframe and usage alignment	12.2.0	12.3.0
10/09/14	RP-65	RP-141485	472	-	Introduction of low-cost MTC and 256QAM features	12.2.0	12.3.0
08/12/14	RP-66	RP-142104	482	5	Introduction of Dual Connectivity, Small Cell Enhancements,	12.3.0	12.4.0

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Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
					NAICS, eIMTA, and TDD-FDD CA features		
08/12/14	RP-66	RP-142097	487	1	Clarification of periodic CSI feedback for subband CQI and PMI	12.3.0	12.4.0
08/12/14	RP-66	RP-142100	491	-	Correction of the parameter CSIProcessIndex	12.3.0	12.4.0
09/03/15	RP-67	RP-150366	492	2	Introduction of D2D feature into 36.213	12.4.0	12.5.0
09/03/15	RP-67	RP-150363	494	1	Correction to PUCCH procedures in case of FDD Pcell and TDD Scell in TDD-FDD CA	12.4.0	12.5.0
09/03/15	RP-67	RP-150364	498	-	Correction on higher layer parameter names for 256QAM	12.4.0	12.5.0
09/03/15	RP-67	RP-150359	500	-	TM10 CSI-IM Interference Measurements	12.4.0	12.5.0
09/03/15	RP-67	RP-150358	502	-	Clarification on common search reception related to MBMS	12.4.0	12.5.0
09/03/15	RP-67	RP-150364	503	-	Correction to Discovery in Small Cell Enhancement feature	12.4.0	12.5.0
09/03/15	RP-67	RP-150365	504	1	Corrections to Dual Connectivity feature	12.4.0	12.5.0
15/06/15	RP-68	RP-150931	493	2	Clarification on HARQ-ACK repetition	12.5.0	12.6.0
15/06/15	RP-68	RP-150932	497	3	Clarification on PUCCH Format 3 Resource Derivation for TDD UL/DL Configuration 5	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	506	-	Clarification on the PRACH power in subframe i2-1 for PCM2	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	507	-	Clarification on the MTA operation in PCM1	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	512	-	Correction of higher layer parameter names in dual connectivity	12.5.0	12.6.0
15/06/15	RP-68	RP-150935	513	1	Correction on UE procedure of determining subframe pool for PSCCH and PSSCH in ProSe	12.5.0	12.6.0
15/06/15	RP-68	RP-150935	514	1	Correction on UE procedure of transmitting PSCCH in ProSe	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	515	1	Correction on UL Power Control for Synchronous Dual Connectivity	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	516	1	Correction on UL Power Control for Asynchronous Dual Connectivity	12.5.0	12.6.0
15/06/15	RP-68	RP-150937	517	-	Correction to Rel-12 UE category signal name	12.5.0	12.6.0
15/06/15	RP-68	RP-150936	520	-	Corrections on eIMTA RRC parameter naming	12.5.0	12.6.0
15/06/15	RP-68	RP-150933	521	-	Correction on Closed Loop Antenna Selection for Dual Connectivity	12.5.0	12.6.0
15/06/15	RP-68	RP-150935	523	-	Alignment of Prose parameter names	12.5.0	12.6.0
14/09/15	RP-69	RP-151470	525	-	UE processing time relaxation on Type 2 Power Headroom Reporting	12.6.0	12.7.0
14/09/15	RP-69	RP-151468	527	-	Correction of ProSe parameters	12.6.0	12.7.0
14/09/15	RP-69	RP-151471	528	2	Clarification on power control for PCM2	12.6.0	12.7.0
07/12/15	RP-70	RP-152034	530	1	Clarification of PUCCH resource allocation related to EPDCCH SCells	12.7.0	12.8.0
07/12/15	RP-70	RP-152037	531	-	Clarification on the parameter notations for eIMTA	12.7.0	12.8.0
07/12/15	RP-70	RP-152037	534	-	Correction on aperiodic CSI transmission without UL-SCH according to table 7.2.1-1C	12.7.0	12.8.0
07/12/15	RP-70	RP-152038	535	1	Introduction of new maximum TBS for TM9/10	12.7.0	12.8.0
07/12/15	RP-70	RP-152034	542	-	Clarification of PHICH resource assignement related to EPDCCH scheduled PUSCH	12.7.0	12.8.0
07/12/15	RP-70	RP-152036	543	1	Modify max TA for dual connectivity	12.7.0	12.8.0
07/12/15	RP-70	RP-152125	533	3	eD2D CR for 36.213	12.8.0	13.0.0
07/12/15	RP-70	RP-152031	536	-	Introduction of Rel 13 features for SC-PTM	12.8.0	13.0.0
07/12/15	RP-70	RP-152026	537	2	Introduction of LAA (PHY layer aspects)	12.8.0	13.0.0
07/12/15	RP-70	RP-152026	538	5	Introduction of LAA (eNB Channel Access Procedures)	12.8.0	13.0.0
07/12/15	RP-70	RP-152027	539	1	Introduction of Enhanced CA in Release 13	12.8.0	13.0.0
07/12/15	RP-70	RP-152025	541	1	Introduction of EB/FD-MIMO	12.8.0	13.0.0

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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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1 Scope

The present document specifies the E-UTRA MAC protocol.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer Procedures".

[3] 3GPP TS 36.322: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification".

[4] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) Specification".

[5] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".

[6] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements".

[7] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[9] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[11] 3GPP TS 36.216: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation".

[12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

[13] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

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3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Active Time: Time related to DRX operation, as defined in subclause 5.7, during which the MAC entity monitors the PDCCH.

mac-ContentionResolutionTimer: Specifies the number of consecutive subframe(s) during which the MAC entity shall monitor the PDCCH after Msg3 is transmitted.

DRX Cycle: Specifies the periodic repetition of the On Duration followed by a possible period of inactivity (see figure 3.1-1 below).

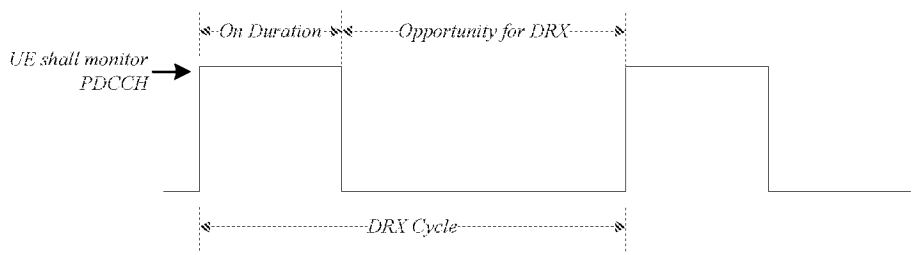


Figure 3.1-1: DRX Cycle

drx-InactivityTimer: Specifies the number of consecutive PDCCH-subframe(s) after the subframe in which a PDCCH indicates an initial UL, DL or SL user data transmission for this MAC entity.

drx-RetransmissionTimer: Specifies the maximum number of consecutive PDCCH-subframe(s) until a DL retransmission is received.

drxShortCycleTimer: Specifies the number of consecutive subframe(s) the MAC entity shall follow the Short DRX cycle.

drxStartOffset: Specifies the subframe where the DRX Cycle starts.

HARQ information: HARQ information for DL-SCH or for UL-SCH transmissions consists of New Data Indicator (NDI), Transport Block (TB) size. For DL-SCH transmissions the HARQ information also includes HARQ process ID. For UL-SCH transmission the HARQ information also includes Redundancy Version (RV). In case of spatial multiplexing on DL-SCH the HARQ information comprises a set of NDI and TB size for each transport block. HARQ information for SL-SCH and SL-DCH transmissions consists of TB size only.

HARQ RTT Timer: This parameter specifies the minimum amount of subframe(s) before a DL HARQ retransmission is expected by the MAC entity.

Msg3: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a random access procedure.

onDurationTimer: Specifies the number of consecutive PDCCH-subframe(s) at the beginning of a DRX Cycle.

PDCCH: Refers to the PDCCH [7], EPDCCH (in subframes when configured) or, for an RN with R-PDCCH configured and not suspended, to the R-PDCCH.

PDCCH-subframe: Refers to a subframe with PDCCH. For a MAC entity not configured with any TDD serving cell(s), this represents any subframe; for a MAC entity configured with at least one TDD serving cell, if a MAC entity is capable of simultaneous reception and transmission in the aggregated cells, this represents the union over all serving cells of downlink subframes and subframes including DwPTS of the TDD UL/DL configuration indicated by *tdd-Config* [8], except serving cells that are configured with *schedulingCellId* [8]; otherwise, this represents the subframes where the SpCell is configured with a downlink subframe or a subframe including DwPTS of the TDD UL/DL

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configuration indicated by *tdd-Config* [8].
For RNs with an RN subframe configuration configured and not suspended, in its communication with the E-UTRAN, this represents all downlink subframes configured for RN communication with the E-UTRAN.

PRACH Resource Index: The index of a PRACH within a system frame [7]

Primary Timing Advance Group: Timing Advance Group containing the SpCell.

PUCCH SCell: An SCell configured with PUCCH.

***ra-PRACH-MaskIndex*:** Defines in which PRACHs within a system frame the MAC entity can transmit a Random Access Preamble (see subclause 7.3).

RA-RNTI: The Random Access RNTI is used on the PDCCH when Random Access Response messages are transmitted. It unambiguously identifies which time-frequency resource was utilized by the MAC entity to transmit the Random Access preamble.

SC Period: Sidelink Control period, the time period consisting of transmission of SCI and its corresponding data.

SCI: The Sidelink Control Information contains the sidelink scheduling information such as resource block assignment, modulation and coding scheme and Group Destination ID [5].

Secondary Timing Advance Group: Timing Advance Group not containing the SpCell. A Secondary Timing Advance Group contains at least one Serving Cell with an UL configured.

Serving Cell: A Primary or a Secondary Cell [8].

Sidelink: UE to UE interface for sidelink communication and sidelink discovery. The sidelink corresponds to the PC5 interface as defined in [13].

Sidelink Discovery Gap for Reception: Time period during which the UE does not receive any channels in DL from any serving cell, except during random access procedure.

Sidelink Discovery Gap for Transmission: Time period during which the UE prioritizes transmission of sidelink discovery over transmission of channels in UL, if they occur in the same subframe, except during random access procedure.

Special Cell: For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG, otherwise the term Special Cell refers to the PCell.

Timing Advance Group: A group of Serving Cells that is configured by RRC and that, for the cells with an UL configured, using the same timing reference cell and the same Timing Advance value.

NOTE: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

BSR	Buffer Status Report
C-RNTI	Cell RNTI
CQI	Channel Quality Indicator
eIMTA	Enhanced Interference Management and Traffic Adaptation
eIMTA-RNTI	Enhanced Interference Management and Traffic Adaptation - RNTI
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
G-RNTI	Group RNTI
MAC	Medium Access Control
MCG	Master Cell Group
M-RNTI	MBMS RNTI

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LCG	Logical Channel Group
PCell	Primary Cell
PSCell	Primary Secondary Cell
PHR	Power Headroom Report
PMI	Precoding Matrix Index
PPPP	ProSe Per-Packet Priority
P-RNTI	Paging RNTI
ProSe	Proximity-based Services
pTAG	Primary Timing Advance Group
PTI	Precoding Type Indicator
RA-RNTI	Random Access RNTI
RI	Rank Indicator
RN	Relay Node
RNTI	Radio Network Temporary Identifier
SCell	Secondary Cell
SC-FDM	Single-Carrier Frequency Division Multiplexing
SCG	Secondary Cell Group
SCI	Sidelink Control Information
SC-N-RNTI	Single Cell Notification RNTI
SC-PTM	Single Cell Point to Multipoint
SC-RNTI	Single Cell RNTI
SI-RNTI	System Information RNTI
SL	Sidelink
SL-RNTI	Sidelink RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbols
SpCell	Special Cell
sTAG	Secondary Timing Advance Group
TAG	Timing Advance Group
TB	Transport Block
TPC-PUCCH-RNTI	Transmit Power Control-Physical Uplink Control Channel-RNTI
TPC-PUSCH-RNTI	Transmit Power Control-Physical Uplink Shared Channel-RNTI

4 General

4.1 Introduction

The objective is to describe the MAC architecture and the MAC entity from a functional point of view. Functionality specified for the UE equally applies to the RN for functionality necessary for the RN. There is also functionality which is only applicable to the RN, in which case the specification denotes the RN instead of the UE. RN-specific behaviour is not applicable to the UE. For TDD operation, UE behaviour follows the TDD UL/DL configuration indicated by *tdd-Config* unless specified otherwise.

4.2 MAC architecture

The description in this sub clause is a model and does not specify or restrict implementations.

RRC is in control of configuration of MAC.

4.2.1 MAC Entities

E-UTRA defines two MAC entities; one in the UE and one in the E-UTRAN. These MAC entities handle the following transport channels:

- Broadcast Channel (BCH);
- Downlink Shared Channel(s) (DL-SCH);

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- Paging Channel (PCH);
- Uplink Shared Channel(s) (UL-SCH);
- Random Access Channel(s) (RACH);
- Multicast Channel(s) (MCH);
- Sidelink Broadcast Channel (SL-BCH);
- Sidelink Discovery Channel (SL-DCH);
- Sidelink Shared Channel (SL-SCH).

The exact functions performed by the MAC entities are different in the UE from those performed in the E-UTRAN.

The RN includes both types of MAC entities; one type for communication with UEs and one type for communication with the E-UTRAN.

In Dual Connectivity, two MAC entities are configured in the UE: one for the MCG and one for the SCG. Each MAC entity is configured by RRC with a serving cell supporting PUCCH transmission and contention based Random Access. In this specification, the term SpCell refers to such cell, whereas the term SCell refers to other serving cells. The term SpCell either refers to the PCell of the MCG or the PSCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. A Timing Advance Group containing the SpCell of a MAC entity is referred to as pTAG, whereas the term sTAG refers to other TAGs.

The functions of the different MAC entities in the UE operate independently if not otherwise indicated. The timers and paramenters used in each MAC entity are configured independently if not otherwise indicated. The Serving Cells, C-RNTI, radio bearers, logical channels, upper and lower layer entities, LCGs, and HARQ entities considered by each MAC entity refer to those mapped to that MAC entity if not otherwise indicated.

If the MAC entity is configured with one or more SCells, there are multiple DL-SCH and there may be multiple UL-SCH and RACH per MAC entity; one DL-SCH and UL-SCH on the SpCell, one DL-SCH, zero or one UL-SCH and zero or one RACH for each SCell.

Figure 4.2.1-1 illustrates one possible structure for the UE side MAC entity when SCG is not configured, and it should not restrict implementation.

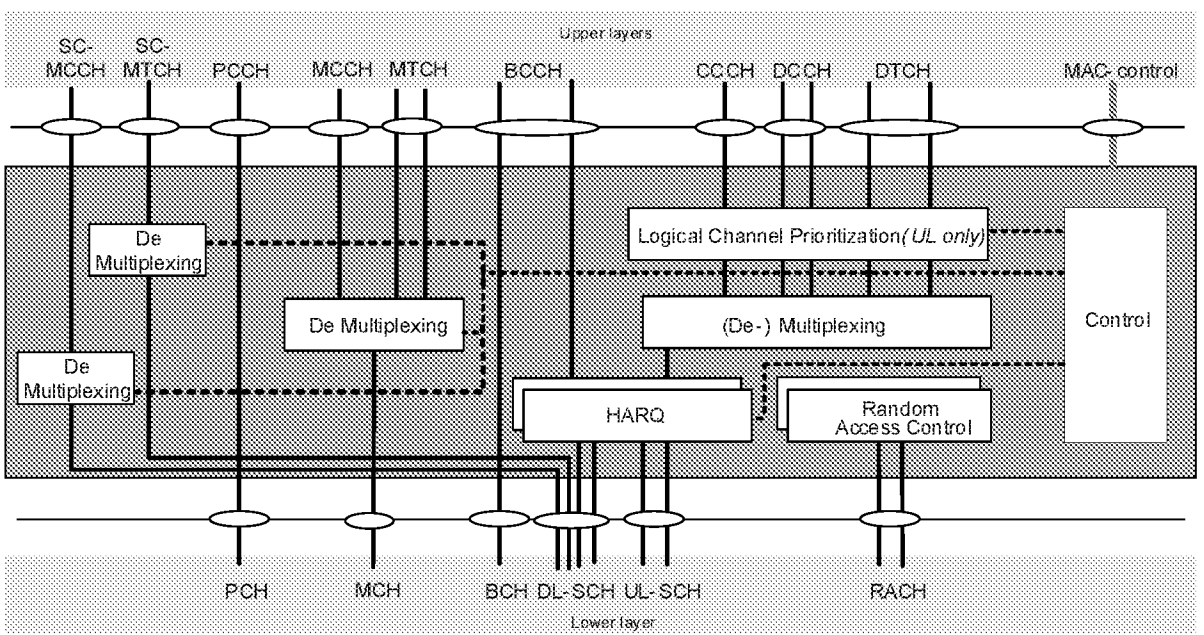


Figure 4.2.1-1: MAC structure overview, UE side

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Figure 4.2.1-2 illustrates one possible structure for the UE side MAC entities when MCG and SCG are configured, and it should not restrict implementation. MBMS reception and SC-PTM reception is excluded from this figure for simplicity.

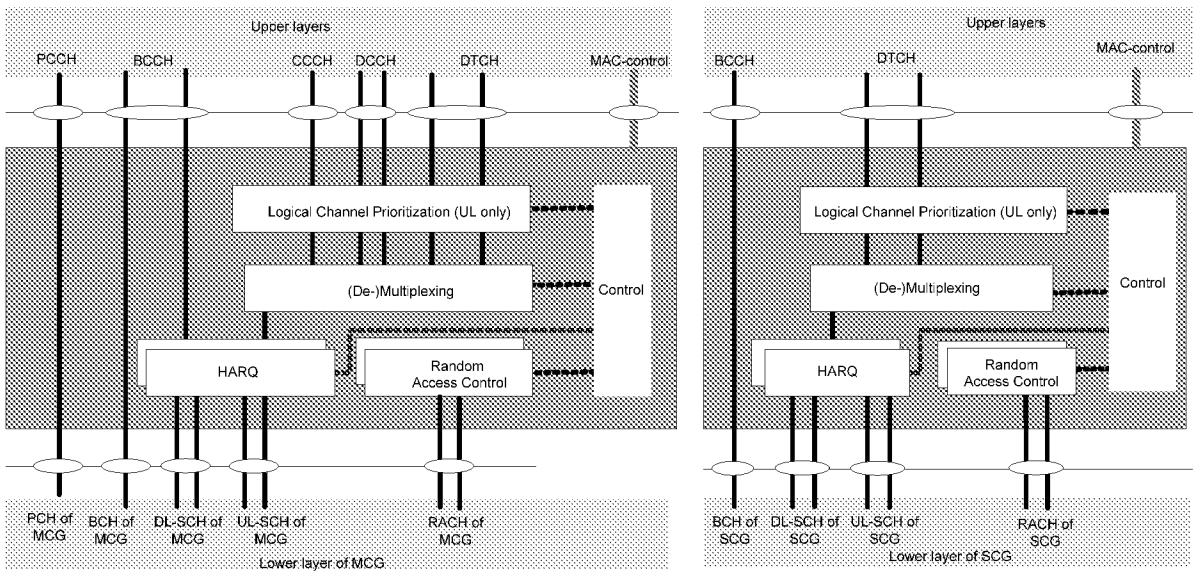


Figure 4.2.1-2: MAC structure overview with two MAC entities, UE side

Figure 4.2.1-3 illustrates one possible structure for the UE side MAC entity when sidelink is configured, and it should not restrict implementation.

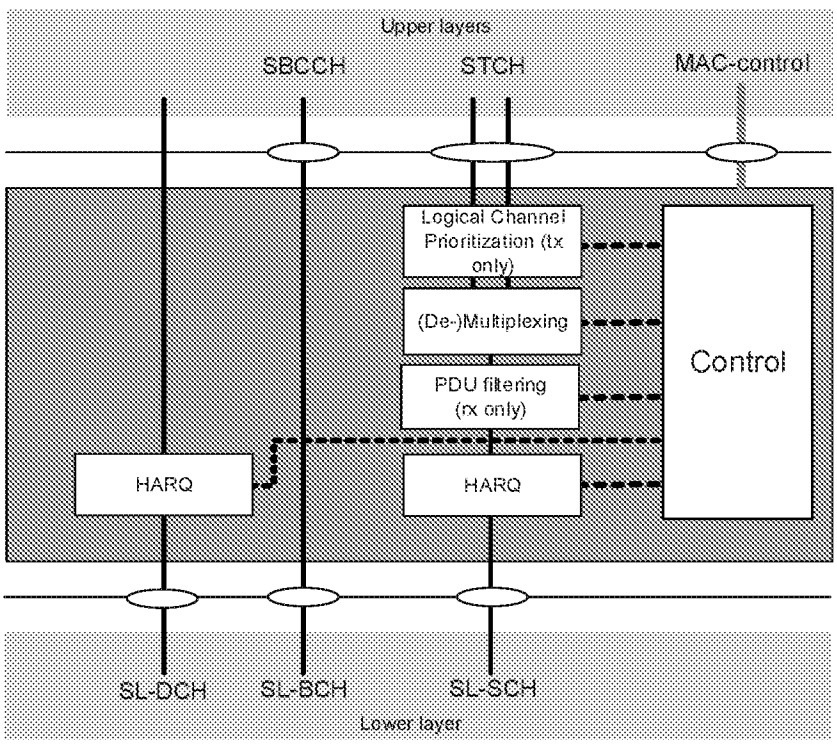


Figure 4.2.1-3: MAC structure overview for sidelink, UE side

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4.3 Services

4.3.1 Services provided to upper layers

This clause describes the different services provided by MAC sublayer to upper layers.

- data transfer
- radio resource allocation

4.3.2 Services expected from physical layer

The physical layer provides the following services to MAC:

- data transfer services;
- signalling of HARQ feedback;
- signalling of Scheduling Request;
- measurements (e.g. Channel Quality Indication (CQI)).

The access to the data transfer services is through the use of transport channels. The characteristics of a transport channel are defined by its transport format (or format set), specifying the physical layer processing to be applied to the transport channel in question, such as channel coding and interleaving, and any service-specific rate matching as needed.

4.4 Functions

The following functions are supported by MAC sublayer:

- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;
- demultiplexing of MAC SDUs from one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- scheduling information reporting;
- error correction through HARQ;
- priority handling between UEs by means of dynamic scheduling;
- priority handling between logical channels of one MAC entity;
- Logical Channel prioritisation;
- transport format selection;
- radio resource selection for SL.

The location of the different functions and their relevance for uplink and downlink respectively is illustrated in Table 4.4-1.

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Table 4.4-1: MAC function location and link direction association.

MAC function	UE	eNB	Downlink	Uplink	Sidelink tx	Sidelink rx
Mapping between logical channels and transport channels	X		X	X	X	X
		X	X	X		
Multiplexing	X			X	X	
		X	X			
Demultiplexing	X		X			X
		X		X		
Error correction through HARQ	X		X	X	X	X
		X	X	X		
Transport Format Selection		X	X	X		
	X	X			X	
Priority handling between UEs		X	X	X		
Priority handling between logical channels of one MAC entity		X	X	X		
Logical Channel prioritisation	X			X	X	
Scheduling information reporting	X			X		
Radio Resource Selection	X				X	

4.5 Channel structure

The MAC sublayer operates on the channels defined below; transport channels are SAPs between MAC and Layer 1, logical channels are SAPs between MAC and RLC.

4.5.1 Transport Channels

The transport channels used by MAC are described in Table 4.5.1-1 below.

Table 4.5.1-1: Transport channels used by MAC

Transport channel name	Acronym	Downlink	Uplink	Sidelink tx	Sidelink rx
Broadcast Channel	BCH	X			
Downlink Shared Channel	DL-SCH	X			
Paging Channel	PCH	X			
Multicast Channel	MCH	X			
Uplink Shared Channel	UL-SCH		X		
Random Access Channel	RACH		X		
Sidelink Broadcast Channel	SL-BCH			X	X
Sidelink Discovery Channel	SL-DCH			X	X
Sidelink Shared Channel	SL-SCH			X	X

4.5.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC.

Each logical channel type is defined by what type of information is transferred.

MAC provides the control and traffic channels listed in Table 4.5.2-1 below.

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Table 4.5.2-1: Logical channels provided by MAC.

Logical channel name	Acronym	Control channel	Traffic channel
Broadcast Control Channel	BCCH	X	
Paging Control Channel	PCCH	X	
Common Control Channel	CCCH	X	
Dedicated Control Channel	DCCH	X	
Multicast Control Channel	MCCH	X	
Single Cell Multicast Control Channel	SC-MCCH	X	
Dedicated Traffic Channel	DTCH		X
Multicast Traffic Channel	MTCH		X
Single-Cell Multicast Traffic Channel	SC-MTCH		X
Sidelink Traffic Channel	STCH		X
Sidelink Broadcast Control Channel	SBCCH	X	

4.5.3 Mapping of Transport Channels to Logical Channels

The mapping of logical channels on transport channels depends on the multiplexing that is configured by RRC.

4.5.3.1 Uplink mapping

The MAC entity is responsible for mapping logical channels for the uplink onto uplink transport channels. The uplink logical channels can be mapped as described in Figure 4.5.3.1-1 and Table 4.5.3.1-1.

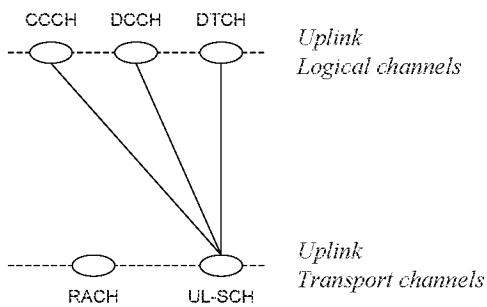


Figure 4.5.3.1-1

Table 4.5.3.1-1: Uplink channel mapping.

Transport channel / Logical channel	UL-SCH	RACH
CCCH	X	
DCCH	X	
DTCH	X	

4.5.3.2 Downlink mapping

The MAC entity is responsible for mapping the downlink logical channels to downlink transport channels. The downlink logical channels can be mapped as described in Figure 4.5.3.2-1 and Table 4.5.3.2-1.

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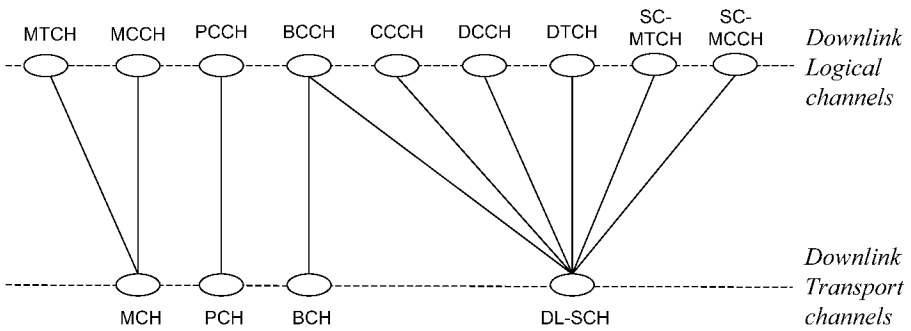


Figure 4.5.3.2-1

Table 4.5.3.2-1: Downlink channel mapping.

Logical channel \ Transport channel	BCH	PCH	DL-SCH	MCH
BCCH	X		X	
PCCH		X		
CCCH			X	
DCCH			X	
DTCH			X	
MCCH				X
MTCH				X
SC-MCCH			X	
SC-MTCH			X	

4.5.3.3 Sidelink mapping

The MAC entity is responsible for mapping the sidelink logical channels to sidelink transport channels. The sidelink logical channels can be mapped as described in Figure 4.5.3.3-1 and Table 4.5.3.3-1.

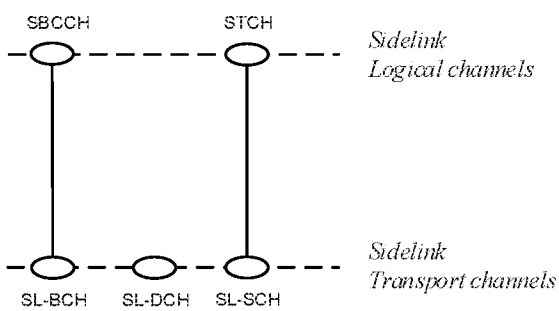


Figure 4.5.3.3-1

Table 4.5.3.3-1: Sidelink channel mapping.

Logical channel \ Transport channel	SL-SCH	SL-BCH	SL-DCH
STCH	X		
SBCCH		X	

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5 MAC procedures

5.1 Random Access procedure

5.1.1 Random Access Procedure initialization

The Random Access procedure described in this subclause is initiated by a PDCCH order, by the MAC sublayer itself or by the RRC sublayer. Random Access procedure on an SCell shall only be initiated by a PDCCH order. If a MAC entity receives a PDCCH transmission consistent with a PDCCH order [5] masked with its C-RNTI, and for a specific Serving Cell, the MAC entity shall initiate a Random Access procedure on this Serving Cell. For Random Access on the SpCell a PDCCH order or RRC optionally indicate the *ra-PreambleIndex* and the *ra-PRACH-MaskIndex*; and for Random Access on an SCell, the PDCCH order indicates the *ra-PreambleIndex* with a value different from 000000 and the *ra-PRACH-MaskIndex*. For the pTAG preamble transmission on PRACH and reception of a PDCCH order are only supported for SpCell.

Before the procedure can be initiated, the following information for related Serving Cell is assumed to be available [8]:

- the available set of PRACH resources for the transmission of the Random Access Preamble, *prach-ConfigIndex*.
- the groups of Random Access Preambles and the set of available Random Access Preambles in each group (SpCell only):

  The preambles that are contained in Random Access Preambles group A and Random Access Preambles group B are calculated from the parameters *numberOfRA-Preambles* and *sizeOfRA-PreamblesGroupA*:

  If *sizeOfRA-PreamblesGroupA* is equal to *numberOfRA-Preambles* then there is no Random Access Preambles group B. The preambles in Random Access Preamble group A are the preambles 0 to *sizeOfRA-PreamblesGroupA* – 1 and, if it exists, the preambles in Random Access Preamble group B are the preambles *sizeOfRA-PreamblesGroupA* to *numberOfRA-Preambles* – 1 from the set of 64 preambles as defined in [7].
- if Random Access Preambles group B exists, the thresholds, *messagePowerOffsetGroupB* and *messageSizeGroupA*, the configured UE transmitted power of the Serving Cell performing the Random Access Procedure, $P_{CMAX,c}$ [10], and the offset between the preamble and Msg3, *deltaPreambleMsg3*, that are required for selecting one of the two groups of Random Access Preambles (SpCell only).
- the RA response window size *ra-ResponseWindowSize*.
- the power-ramping factor *powerRampingStep*.
- the maximum number of preamble transmission *preambleTransMax*.
- the initial preamble power *preambleInitialReceivedTargetPower*.
- the preamble format based offset DELTA_PREAMBLE (see subclause 7.6).
- the maximum number of Msg3 HARQ transmissions *maxHARQ-Msg3Tx* (SpCell only).
- the Contention Resolution Timer *mac-ContentionResolutionTimer* (SpCell only).

NOTE: The above parameters may be updated from upper layers before each Random Access procedure is initiated.

The Random Access procedure shall be performed as follows:

- Flush the Msg3 buffer;
- set the PREAMBLE_TRANSMISSION_COUNTER to 1;
- set the backoff parameter value to 0 ms;
- for the RN, suspend any RN subframe configuration;
- proceed to the selection of the Random Access Resource (see subclause 5.1.2).

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NOTE: There is only one Random Access procedure ongoing at any point in time in a MAC entity. If the MAC entity receives a request for a new Random Access procedure while another is already ongoing in the MAC entity, it is up to UE implementation whether to continue with the ongoing procedure or start with the new procedure.

5.1.2 Random Access Resource selection

The Random Access Resource selection procedure shall be performed as follows:

- If *ra-PreambleIndex* (Random Access Preamble) and *ra-PRACH-MaskIndex* (PRACH Mask Index) have been explicitly signalled and *ra-PreambleIndex* is not 000000:
  - the Random Access Preamble and the PRACH Mask Index are those explicitly signalled.
- else the Random Access Preamble shall be selected by the MAC entity as follows:
  - If Msg3 has not yet been transmitted, the MAC entity shall:
    - if Random Access Preambles group B exists and if the potential message size (UL data available for transmission plus MAC header and, where required, MAC control elements) is greater than *messageSizeGroupA* and if the pathloss is less than $P_{CMAX,c}$ (of the Serving Cell performing the Random Access Procedure) – *preambleInitialReceivedTargetPower* – *deltaPreambleMsg3* – *messagePowerOffsetGroupB*, then:
      - select the Random Access Preambles group B;
    - else:
      - select the Random Access Preambles group A.
  - else, if Msg3 is being retransmitted, the MAC entity shall:
    - select the same group of Random Access Preambles as was used for the preamble transmission attempt corresponding to the first transmission of Msg3.
  - randomly select a Random Access Preamble within the selected group. The random function shall be such that each of the allowed selections can be chosen with equal probability;
  - set PRACH Mask Index to 0.
- determine the next available subframe containing PRACH permitted by the restrictions given by the *prach-ConfigIndex*, the PRACH Mask Index (see subclause 7.3) and physical layer timing requirements [2] (a MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH subframe);
- if the transmission mode is TDD and the PRACH Mask Index is equal to zero:
  - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):
    - randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe.
  - else:
    - randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe and the next two consecutive subframes.
- else:
  - determine a PRACH within the determined subframe in accordance with the requirements of the PRACH Mask Index.
- proceed to the transmission of the Random Access Preamble (see subclause 5.1.3).

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5.1.3 Random Access Preamble transmission

The random-access procedure shall be performed as follows:

- set PREAMBLE_RECEIVED_TARGET_POWER to *preambleInitialReceivedTargetPower* + DELTA_PREAMBLE + (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*;
- instruct the physical layer to transmit a preamble using the selected PRACH, corresponding RA-RNTI, preamble index and PREAMBLE_RECEIVED_TARGET_POWER.

5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap or Sidelink Discovery Gap for Reception, the MAC entity shall monitor the PDCCH of the SpCell for Random Access Response(s) identified by the RA-RNTI defined below, in the RA Response window which starts at the subframe that contains the end of the preamble transmission [7] plus three subframes and has length *ra-ResponseWindowSize* subframes. The RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

$$\text{RA-RNTI} = 1 + t\_id + 10 * f\_id$$

Where t_id is the index of the first subframe of the specified PRACH ($0 \leq t\_id < 10$), and f_id is the index of the specified PRACH within that subframe, in ascending order of frequency domain ($0 \leq f\_id < 6$). The MAC entity may stop monitoring for Random Access Response(s) after successful reception of a Random Access Response containing Random Access Preamble identifiers that matches the transmitted Random Access Preamble.

- If a downlink assignment for this TTI has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded, the MAC entity shall regardless of the possible occurrence of a measurement gap or Sidelink Discovery Gap for Transmission:
  - if the Random Access Response contains a Backoff Indicator subheader:
    - set the backoff parameter value as indicated by the BI field of the Backoff Indicator subheader and Table 7.2-1.
  - else, set the backoff parameter value to 0 ms.
  - if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see subclause 5.1.3), the MAC entity shall:
    - consider this Random Access Response reception successful and apply the following actions for the serving cell where the Random Access Preamble was transmitted:
      - process the received Timing Advance Command (see subclause 5.2);
      - indicate the *preambleInitialReceivedTargetPower* and the amount of power ramping applied to the latest preamble transmission to lower layers (i.e., (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*);
      - process the received UL grant value and indicate it to the lower layers;
    - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):
      - consider the Random Access procedure successfully completed.
    - else, if the Random Access Preamble was selected by the MAC entity:
      - set the Temporary C-RNTI to the value received in the Random Access Response message no later than at the time of the first transmission corresponding to the UL grant provided in the Random Access Response message;
      - if this is the first successfully received Random Access Response within this Random Access procedure:

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- if the transmission is not being made for the CCCH logical channel, indicate to the Multiplexing and assembly entity to include a C-RNTI MAC control element in the subsequent uplink transmission;
- obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity and store it in the Msg3 buffer.

NOTE: When an uplink transmission is required, e.g., for contention resolution, the eNB should not provide a grant smaller than 56 bits in the Random Access Response.

NOTE: If within a Random Access procedure, an uplink grant provided in the Random Access Response for the same group of Random Access Preambles has a different size than the first uplink grant allocated during that Random Access procedure, the UE behavior is not defined.

If no Random Access Response is received within the RA Response window, or if none of all received Random Access Responses contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the MAC entity shall:

- if the notification of power ramping suspension has not been received from lower layers:
  - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
- If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:
  - if the Random Access Preamble is transmitted on the SpCell:
    - indicate a Random Access problem to upper layers;
  - if the Random Access Preamble is transmitted on an SCell:
    - consider the Random Access procedure unsuccessfully completed.
- if in this Random Access procedure, the Random Access Preamble was selected by MAC:
  - based on the backoff parameter, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;
  - delay the subsequent Random Access transmission by the backoff time;
- proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.5 Contention Resolution

Contention Resolution is based on either C-RNTI on PDCCH of the SpCell or UE Contention Resolution Identity on DL-SCH.

Once Msg3 is transmitted, the MAC entity shall:

- start *mac-ContentionResolutionTimer* and restart *mac-ContentionResolutionTimer* at each HARQ retransmission;
- regardless of the possible occurrence of a measurement gap or Sidelink Discovery Gap for Reception, monitor the PDCCH until *mac-ContentionResolutionTimer* expires or is stopped;
- if notification of a reception of a PDCCH transmission is received from lower layers, the MAC entity shall:
  - if the C-RNTI MAC control element was included in Msg3:
    - if the Random Access procedure was initiated by the MAC sublayer itself or by the RRC sublayer and the PDCCH transmission is addressed to the C-RNTI and contains an UL grant for a new transmission; or
    - if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI:
      - consider this Contention Resolution successful;

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- stop *mac-ContentionResolutionTimer*;
- discard the Temporary C-RNTI;
- consider this Random Access procedure successfully completed.

- else if the CCCH SDU was included in Msg3 and the PDCCH transmission is addressed to its Temporary C-RNTI:
  - if the MAC PDU is successfully decoded:
    - stop *mac-ContentionResolutionTimer*;
    - if the MAC PDU contains a UE Contention Resolution Identity MAC control element; and
    - if the UE Contention Resolution Identity included in the MAC control element matches the CCCH SDU transmitted in Msg3:
      - consider this Contention Resolution successful and finish the disassembly and demultiplexing of the MAC PDU;
      - set the C-RNTI to the value of the Temporary C-RNTI;
      - discard the Temporary C-RNTI;
      - consider this Random Access procedure successfully completed.
    - else
      - discard the Temporary C-RNTI;
      - consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.

- if *mac-ContentionResolutionTimer* expires:
  - discard the Temporary C-RNTI;
  - consider the Contention Resolution not successful.
- if the Contention Resolution is considered not successful the MAC entity shall:
  - flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer;
  - if the notification of power ramping suspension has not been received from lower layers:
    - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
  - If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:
    - indicate a Random Access problem to upper layers.
  - based on the backoff parameter, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;
  - delay the subsequent Random Access transmission by the backoff time;
  - proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.6 Completion of the Random Access procedure

At completion of the Random Access procedure, the MAC entity shall:

- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer.

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In addition, the RN shall resume the suspended RN subframe configuration, if any.

5.2 Maintenance of Uplink Time Alignment

The MAC entity has a configurable timer *timeAlignmentTimer* per TAG. The *timeAlignmentTimer* is used to control how long the MAC entity considers the Serving Cells belonging to the associated TAG to be uplink time aligned [8].

The MAC entity shall:

- when a Timing Advance Command MAC control element is received:
  - apply the Timing Advance Command for the indicated TAG;
  - start or restart the *timeAlignmentTimer* associated with the indicated TAG.
- when a Timing Advance Command is received in a Random Access Response message for a serving cell belonging to a TAG:
  - if the Random Access Preamble was not selected by the MAC entity:
    - apply the Timing Advance Command for this TAG;
    - start or restart the *timeAlignmentTimer* associated with this TAG.
  - else, if the *timeAlignmentTimer* associated with this TAG is not running:
    - apply the Timing Advance Command for this TAG;
    - start the *timeAlignmentTimer* associated with this TAG;
    - when the contention resolution is considered not successful as described in subclause 5.1.5, stop *timeAlignmentTimer* associated with this TAG.
  - else:
    - ignore the received Timing Advance Command.
- when a *timeAlignmentTimer* expires:
  - if the *timeAlignmentTimer* is associated with the pTAG:
    - flush all HARQ buffers for all serving cells;
    - notify RRC to release PUCCH for all serving cells;
    - notify RRC to release SRS for all serving cells;
    - clear any configured downlink assignments and uplink grants;
    - consider all running *timeAlignmentTimer*s as expired;
  - else if the *timeAlignmentTimer* is associated with an sTAG, then for all Serving Cells belonging to this TAG:
    - flush all HARQ buffers;
    - notify RRC to release SRS;
    - notify RRC to release PUCCH, if configured.

When the MAC entity stops uplink transmissions for an SCell due to the fact that the maximum uplink transmission timing difference (as described in subclause 7.9.2 of TS 36.133 [9]) or the maximum uplink transmission timing difference the MAC entity can handle between TAGs of this MAC entity is exceeded, the MAC entity considers the *timeAlignmentTimer* associated with the SCell as expired.

The MAC entity shall not perform any uplink transmission on a Serving Cell except the Random Access Preamble transmission when the *timeAlignmentTimer* associated with the TAG to which this Serving Cell belongs is not running.

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Furthermore, when the *timeAlignmentTimer* associated with the pTAG is not running, the MAC entity shall not perform any uplink transmission on any Serving Cell except the Random Access Preamble transmission on the SpCell.

The MAC entity shall not perform any sidelink transmission which is performed based on UL timing of the corresponding serving cell and any associated SCI transmissions when the corresponding *timeAlignmentTimer* is not running.

NOTE: A MAC entity stores or maintains N_{TA} upon expiry of associated *timeAlignmentTimer*, where N_{TA} is defined in [7]. The MAC entity applies a received Timing Advance Command MAC control element and starts associated *timeAlignmentTimer* also when the *timeAlignmentTimer* is not running.

5.3 DL-SCH data transfer

5.3.1 DL Assignment reception

Downlink assignments transmitted on the PDCCH indicate if there is a transmission on a DL-SCH for a particular MAC entity and provide the relevant HARQ information.

When the MAC entity has a C-RNTI, Semi-Persistent Scheduling C-RNTI, or Temporary C-RNTI, the MAC entity shall for each TTI during which it monitors PDCCH and for each Serving Cell:

- if a downlink assignment for this TTI and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI, or Temporary C-RNTI:
  - if this is the first downlink assignment for this Temporary C-RNTI:
    - consider the NDI to have been toggled.
  - if the downlink assignment is for the MAC entity's C-RNTI and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the MAC entity's Semi-Persistent Scheduling C-RNTI or a configured downlink assignment:
    - consider the NDI to have been toggled regardless of the value of the NDI.
  - indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.
- else, if this Serving Cell is the SpCell and a downlink assignment for this TTI has been received for the SpCell on the PDCCH of the SpCell for the MAC entity's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:
    - consider the NDI not to have been toggled;
    - indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.
  - else, if the NDI in the received HARQ information is 0:
    - if PDCCH contents indicate SPS release:
      - clear the configured downlink assignment (if any);
      - if the *timeAlignmentTimer* associated with the pTAG is running:
        - indicate a positive acknowledgement for the downlink SPS release to the physical layer.
    - else:
      - store the downlink assignment and the associated HARQ information as configured downlink assignment;
      - initialise (if not active) or re-initialise (if already active) the configured downlink assignment to start in this TTI and to recur according to rules in subclause 5.10.1;

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- set the HARQ Process ID to the HARQ Process ID associated with this TTI;
- consider the NDI bit to have been toggled;
- indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

- else, if this Serving Cell is the SpCell and a downlink assignment for this TTI has been configured for the SpCell and there is no measurement gap in this TTI and there is no Sidelink Discovery Gap for Reception in this TTI; and
- if this TTI is not an MBSFN subframe of the SpCell or the MAC entity is configured with transmission mode *tm9* or *tm10* on the SpCell:
  - instruct the physical layer to receive, in this TTI, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;
  - set the HARQ Process ID to the HARQ Process ID associated with this TTI;
  - consider the NDI bit to have been toggled;
  - indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

For configured downlink assignments, the HARQ Process ID associated with this TTI is derived from the following equation:

HARQ Process ID = [floor(CURRENT_TTI/*semiPersistSchedIntervalDL*)] modulo *numberOfConfSPS-Processes*,

where CURRENT_TTI=[(SFN * 10) + subframe number].

When the MAC entity needs to read BCCH, the MAC entity may, based on the scheduling information from RRC:

- if a downlink assignment for this TTI has been received on the PDCCH for the SI-RNTI;
  - if the redundancy version is not defined in the PDCCH format:
    - the redundancy version of the received downlink assignment for this TTI is determined by RV_K = ceiling(3/2*k) modulo 4, where k depends on the type of system information message: for *SystemInformationBlockType1* message, k = (SFN/2) modulo 4, where SFN is the system frame number; for *SystemInformation* messages, $k=i$ modulo 4, $i=0,1,\ldots, n_s^w-1$, where i denotes the subframe number within the SI window n_s^w;
  - indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity for this TTI.

When the MAC entity has SC-RNTI and/or G-RNTI, the MAC entity shall for each TTI during which it monitors PDCCH for SC-RNTI as specified in [8] and for G-RNTI as specified in subclause 5.7a and for each Serving Cell:

- if a downlink assignment for this TTI and this Serving Cell has been received on the PDCCH for the MAC entity`s SC-RNTI or G-RNTI:
  - attempt to decode the received data.
- if the data which the MAC entity attempted to decode was successfully decoded for this TB:
  - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.

5.3.2 HARQ operation

5.3.2.1 HARQ Entity

There is one HARQ entity at the MAC entity for each Serving Cell which maintains a number of parallel HARQ processes. Each HARQ process is associated with a HARQ process identifier. The HARQ entity directs HARQ information and associated TBs received on the DL-SCH to the corresponding HARQ processes (see subclause 5.3.2.2).

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The number of DL HARQ processes per HARQ entity is specified in [2], clause 7.

When the physical layer is configured for downlink spatial multiplexing [2], one or two TBs are expected per subframe and they are associated with the same HARQ process. Otherwise, one TB is expected per subframe.

The MAC entity shall:

- If a downlink assignment has been indicated for this TTI:
  - allocate the TB(s) received from the physical layer and the associated HARQ information to the HARQ process indicated by the associated HARQ information.
- If a downlink assignment has been indicated for the broadcast HARQ process:
  - allocate the received TB to the broadcast HARQ process.

NOTE: In case of BCCH a dedicated broadcast HARQ process is used.

5.3.2.2 HARQ process

For each subframe where a transmission takes place for the HARQ process, one or two (in case of downlink spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

- if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or
- if the HARQ process is equal to the broadcast process and if this is the first received transmission for the TB according to the system information schedule indicated by RRC; or
- if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):
  - consider this transmission to be a new transmission.
- else:
  - consider this transmission to be a retransmission.

The MAC entity then shall:

- if this is a new transmission:
  - attempt to decode the received data.
- else if this is a retransmission:
  - if the data for this TB has not yet been successfully decoded:
    - combine the received data with the data currently in the soft buffer for this TB and attempt to decode the combined data.
- if the data which the MAC entity attempted to decode was successfully decoded for this TB; or
- if the data for this TB was successfully decoded before:
  - if the HARQ process is equal to the broadcast process:
    - deliver the decoded MAC PDU to upper layers.
  - else if this is the first successful decoding of the data for this TB:
    - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.
  - generate a positive acknowledgement (ACK) of the data in this TB.
- else:

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- replace the data in the soft buffer for this TB with the data which the MAC entity attempted to decode.
- generate a negative acknowledgement (NACK) of the data in this TB.

- if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and the Contention Resolution is not yet successful (see subclause 5.1.5); or
- if the HARQ process is equal to the broadcast process; or
- if the *timeAlignmentTimer*, associated with the TAG containing the serving cell on which the HARQ feedback is to be transmitted, is stopped or expired:
  - do not indicate the generated positive or negative acknowledgement to the physical layer.
- else:
  - indicate the generated positive or negative acknowledgement for this TB to the physical layer.

The MAC entity shall ignore NDI received in all downlink assignments on PDCCH for its Temporary C-RNTI when determining if NDI on PDCCH for its C-RNTI has been toggled compared to the value in the previous transmission.

NOTE: When the MAC entity is configured with more than one serving cell, UE behaviors for storing data to the soft buffer is specified in [2].

NOTE: If the MAC entity receives a retransmission with a TB size different from the last valid TB size signalled for this TB, the UE behavior is left up to UE implementation.

5.3.3 Disassembly and demultiplexing

The MAC entity shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.2.

5.4 UL-SCH data transfer

5.4.1 UL Grant reception

In order to transmit on the UL-SCH the MAC entity must have a valid uplink grant (except for non-adaptive HARQ retransmissions) which it may receive dynamically on the PDCCH or in a Random Access Response or which may be configured semi-persistently. To perform requested transmissions, the MAC layer receives HARQ information from lower layers. When the physical layer is configured for uplink spatial multiplexing, the MAC layer can receive up to two grants (one per HARQ process) for the same TTI from lower layers.

If the MAC entity has a C-RNTI, a Semi-Persistent Scheduling C-RNTI, or a Temporary C-RNTI, the MAC entity shall for each TTI and for each Serving Cell belonging to a TAG that has a running *timeAlignmentTimer* and for each grant received for this TTI:

- if an uplink grant for this TTI and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI or Temporary C-RNTI; or
- if an uplink grant for this TTI has been received in a Random Access Response:
  - if the uplink grant is for MAC entity's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the MAC entity's Semi-Persistent Scheduling C-RNTI or a configured uplink grant:
    - consider the NDI to have been toggled for the corresponding HARQ process regardless of the value of the NDI.
  - deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.
- else, if this Serving Cell is the SpCell and if an uplink grant for this TTI has been received for the SpCell on the PDCCH of the SpCell for the MAC entity's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:

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- consider the NDI for the corresponding HARQ process not to have been toggled;
- deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else if the NDI in the received HARQ information is 0:
  - if PDCCH contents indicate SPS release:
    - clear the configured uplink grant (if any).
  - else:
    - store the uplink grant and the associated HARQ information as configured uplink grant;
    - initialise (if not active) or re-initialise (if already active) the configured uplink grant to start in this TTI and to recur according to rules in subclause 5.10.2;
    - consider the NDI bit for the corresponding HARQ process to have been toggled;
    - deliver the configured uplink grant and the associated HARQ information to the HARQ entity for this TTI.
- else, if this Serving Cell is the SpCell and an uplink grant for this TTI has been configured for the SpCell:
  - consider the NDI bit for the corresponding HARQ process to have been toggled;
  - deliver the configured uplink grant, and the associated HARQ information to the HARQ entity for this TTI.

NOTE: The period of configured uplink grants is expressed in TTIs.

NOTE: If the MAC entity receives both a grant in a Random Access Response and a grant for its C-RNTI or Semi persistent scheduling C-RNTI requiring transmissions on the SpCell in the same UL subframe, the MAC entity may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI or Semi persistent scheduling C-RNTI.

NOTE: When a configured uplink grant is indicated during a measurement gap and indicates an UL-SCH transmission during a measurement gap, the MAC entity processes the grant but does not transmit on UL-SCH.

5.4.2 HARQ operation

5.4.2.1 HARQ entity

There is one HARQ entity at the MAC entity for each Serving Cell with configured uplink, which maintains a number of parallel HARQ processes allowing transmissions to take place continuously while waiting for the HARQ feedback on the successful or unsuccessful reception of previous transmissions.

The number of parallel HARQ processes per HARQ entity is specified in [2], clause 8.

When the physical layer is configured for uplink spatial multiplexing [2], there are two HARQ processes associated with a given TTI. Otherwise there is one HARQ process associated with a given TTI.

At a given TTI, if an uplink grant is indicated for the TTI, the HARQ entity identifies the HARQ process(es) for which a transmission should take place. It also routes the received HARQ feedback (ACK/NACK information), MCS and resource, relayed by the physical layer, to the appropriate HARQ process(es).

When TTI bundling is configured, the parameter TTI_BUNDLE_SIZE provides the number of TTIs of a TTI bundle. TTI bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle HARQ retransmissions are non-adaptive and triggered without waiting for feedback from previous transmissions according to TTI_BUNDLE_SIZE. The HARQ feedback of a bundle is only received for the last TTI of the bundle (i.e the TTI corresponding to TTI_BUNDLE_SIZE), regardless of whether a transmission in that TTI takes place or not (e.g. when a measurement gap occurs). A retransmission of a TTI bundle is also a TTI bundle. TTI bundling is not supported when the MAC entity is configured with one or more SCells with configured uplink.

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TTI bundling is not supported for RN communication with the E-UTRAN in combination with an RN subframe configuration.

For transmission of Msg3 during Random Access (see subclause 5.1.5) TTI bundling does not apply.

For each TTI, the HARQ entity shall:

- identify the HARQ process(es) associated with this TTI, and for each identified HARQ process:
  - if an uplink grant has been indicated for this process and this TTI:
    - if the received grant was not addressed to a Temporary C-RNTI on PDCCH and if the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this HARQ process; or
    - if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or
    - if the uplink grant was received in a Random Access Response:
      - if there is a MAC PDU in the Msg3 buffer and the uplink grant was received in a Random Access Response:
        - obtain the MAC PDU to transmit from the Msg3 buffer.
      - else:
        - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
      - deliver the MAC PDU and the uplink grant and the HARQ information to the identified HARQ process;
      - instruct the identified HARQ process to trigger a new transmission.
    - else:
      - deliver the uplink grant and the HARQ information (redundancy version) to the identified HARQ process;
      - instruct the identified HARQ process to generate an adaptive retransmission.
  - else, if the HARQ buffer of this HARQ process is not empty:
    - instruct the identified HARQ process to generate a non-adaptive retransmission.

When determining if NDI has been toggled compared to the value in the previous transmission the MAC entity shall ignore NDI received in all uplink grants on PDCCH for its Temporary C-RNTI.

5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

Each HARQ process shall maintain a state variable CURRENT_TX_NB, which indicates the number of transmissions that have taken place for the MAC PDU currently in the buffer, and a state variable HARQ_FEEDBACK, which indicates the HARQ feedback for the MAC PDU currently in the buffer. When the HARQ process is established, CURRENT_TX_NB shall be initialized to 0.

The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is up-dated modulo 4.

New transmissions are performed on the resource and with the MCS indicated on PDCCH or Random Access Response. Adaptive retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH. Non-adaptive retransmission is performed on the same resource and with the same MCS as was used for the last made transmission attempt.

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The MAC entity is configured with a Maximum number of HARQ transmissions and a Maximum number of Msg3 HARQ transmissions by RRC: *maxHARQ-Tx* and *maxHARQ-Msg3Tx* respectively. For transmissions on all HARQ processes and all logical channels except for transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Tx*. For transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Msg3Tx*.

When the HARQ feedback is received for this TB, the HARQ process shall:

- set HARQ_FEEDBACK to the received value.

If the HARQ entity requests a new transmission, the HARQ process shall:

- set CURRENT_TX_NB to 0;
- set CURRENT_IRV to 0;
- store the MAC PDU in the associated HARQ buffer;
- store the uplink grant received from the HARQ entity;
- set HARQ_FEEDBACK to NACK;
- generate a transmission as described below.

If the HARQ entity requests a retransmission, the HARQ process shall:

- increment CURRENT_TX_NB by 1;
- if the HARQ entity requests an adaptive retransmission:
  - store the uplink grant received from the HARQ entity;
  - set CURRENT_IRV to the index corresponding to the redundancy version value provided in the HARQ information;
  - set HARQ_FEEDBACK to NACK;
  - generate a transmission as described below.
- else if the HARQ entity requests a non-adaptive retransmission:
  - if HARQ_FEEDBACK = NACK:
    - generate a transmission as described below.

NOTE: When receiving a HARQ ACK alone, the MAC entity keeps the data in the HARQ buffer.

NOTE: When no UL-SCH transmission can be made due to the occurrence of a measurement gap, no HARQ feedback can be received and a non-adaptive retransmission follows.

To generate a transmission, the HARQ process shall:

- if the MAC PDU was obtained from the Msg3 buffer; or
- if Sidelink Discovery Gaps for Transmission are not configured by upper layers, and there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer in this TTI; or
- if Sidelink Discovery Gaps for Transmission are configured by upper layers, and there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a

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transmission for a MAC PDU obtained from the Msg3 buffer, and there is no Sidelink Discovery Gap for Transmission in this TTI; or

- if Sidelink Discovery Gaps for Transmission are configured by upper layers, and there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer, and there is a Sidelink Discovery Gap for Transmission, and there is no configured grant for transmission on SL-DCH in this TTI:
  - instruct the physical layer to generate a transmission according to the stored uplink grant with the redundancy version corresponding to the CURRENT_IRV value;
  - increment CURRENT_IRV by 1;
  - if there is a measurement gap or Sidelink Discovery Gap for Reception at the time of the HARQ feedback reception for this transmission and if the MAC PDU was not obtained from the Msg3 buffer:
    - set HARQ_FEEDBACK to ACK at the time of the HARQ feedback reception for this transmission.

After performing above actions, the HARQ process then shall:

- if CURRENT_TX_NB = maximum number of transmissions – 1:
  - flush the HARQ buffer;

5.4.3 Multiplexing and assembly

5.4.3.1 Logical channel prioritization

The Logical Channel Prioritization procedure is applied when a new transmission is performed.

RRC controls the scheduling of uplink data by signalling for each logical channel: *priority* where an increasing *priority* value indicates a lower priority level, *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR), *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

The MAC entity shall maintain a variable Bj for each logical channel j. Bj shall be initialized to zero when the related logical channel is established, and incremented by the product PBR × TTI duration for each TTI, where PBR is Prioritized Bit Rate of logical channel j. However, the value of Bj can never exceed the bucket size and if the value of Bj is larger than the bucket size of logical channel j, it shall be set to the bucket size. The bucket size of a logical channel is equal to PBR × BSD, where PBR and BSD are configured by upper layers.

The MAC entity shall perform the following Logical Channel Prioritization procedure when a new transmission is performed:

- The MAC entity shall allocate resources to the logical channels in the following steps:
  - Step 1: All the logical channels with Bj > 0 are allocated resources in a decreasing priority order. If the PBR of a logical channel is set to "infinity", the MAC entity shall allocate resources for all the data that is available for transmission on the logical channel before meeting the PBR of the lower priority logical channel(s);
  - Step 2: the MAC entity shall decrement Bj by the total size of MAC SDUs served to logical channel j in Step 1

NOTE: The value of Bj can be negative.

  - Step 3: if any resources remain, all the logical channels are served in a strict decreasing priority order (regardless of the value of Bj) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.
- The UE shall also follow the rules below during the scheduling procedures above:

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- the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources of the associated MAC entity;
- if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant of the associated MAC entity as much as possible;
- the UE should maximise the transmission of data.
- if the MAC entity is given an UL grant size that is equal to or larger than 4 bytes while having data available for transmission, the MAC entity shall not transmit only padding BSR and/or padding (unless the UL grant size is less than 7 bytes and an AMD PDU segment needs to be transmitted).

The MAC entity shall not transmit data for a logical channel corresponding to a radio bearer that is suspended (the conditions for when a radio bearer is considered suspended are defined in [8]).

For the Logical Channel Prioritization procedure, the MAC entity shall take into account the following relative priority in decreasing order:

- MAC control element for C-RNTI or data from UL-CCCH;
- MAC control element for BSR, with exception of BSR included for padding;
- MAC control element for PHR, Extended PHR, or Dual Connectivity PHR;
- MAC control element for Sidelink BSR, with exception of Sidelink BSR included for padding;
- data from any Logical Channel, except data from UL-CCCH;
- MAC control element for BSR included for padding;
- MAC control element for Sidelink BSR included for padding.

NOTE: When the MAC entity is requested to transmit multiple MAC PDUs in one TTI, steps 1 to 3 and the associated rules may be applied either to each grant independently or to the sum of the capacities of the grants. Also the order in which the grants are processed is left up to UE implementation. It is up to the UE implementation to decide in which MAC PDU a MAC control element is included when MAC entity is requested to transmit multiple MAC PDUs in one TTI. When the UE is requested to generate MAC PDU(s) in two MAC entities in one TTI, it is up to UE implementation in which order the grants are processed.

5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The MAC entity shall multiplex MAC control elements and MAC SDUs in a MAC PDU according to subclauses 5.4.3.1 and 6.1.2.

5.4.4 Scheduling Request

The Scheduling Request (SR) is used for requesting UL-SCH resources for new transmission.

When an SR is triggered, it shall be considered as pending until it is cancelled. All pending SR(s) shall be cancelled and *sr-ProhibitTimer* shall be stopped when a MAC PDU is assembled and this PDU includes a BSR which contains buffer status up to (and including) the last event that triggered a BSR (see subclause 5.4.5), or, if all pending SR(s) are triggered by Sidelink BSR, when a MAC PDU is assembled and this PDU includes a Sidelink BSR which contains buffer status up to (and including) the last event that triggered a Sidelink BSR (see subclause 5.14.1.4), or, if all pending SR(s) are triggered by Sidelink BSR, when upper layers configure autonomous resource selection, or when the UL grant(s) can accommodate all pending data available for transmission.

If an SR is triggered and there is no other SR pending, the MAC entity shall set the SR_COUNTER to 0.

As long as one SR is pending, the MAC entity shall for each TTI:

- if no UL-SCH resources are available for a transmission in this TTI:

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- if the MAC entity has no valid PUCCH resource for SR configured in any TTI: initiate a Random Access procedure (see subclause 5.1) on the SpCell and cancel all pending SRs;
- else if the MAC entity has at least one valid PUCCH resource for SR configured for this TTI and if this TTI is not part of a measurement gap and if *sr-ProhibitTimer* is not running:
  - if SR_COUNTER < *dsr-TransMax*:
    - increment SR_COUNTER by 1;
    - instruct the physical layer to signal the SR on one valid PUCCH resource for SR;
    - start the *sr-ProhibitTimer*.
  - else:
    - notify RRC to release PUCCH for all serving cells;
    - notify RRC to release SRS for all serving cells;
    - clear any configured downlink assignments and uplink grants;
    - initiate a Random Access procedure (see subclause 5.1) on the SpCell and cancel all pending SRs.

NOTE: The selection of which valid PUCCH resource for SR to signal SR on when the MAC entity has more than one valid PUCCH resource for SR in one TTI is left to UE implementation.

5.4.5 Buffer Status Reporting

The Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of data available for transmission in the UL buffers associated with the MAC entity. RRC controls BSR reporting by configuring the three timers *periodicBSR-Timer*, *retxBSR-Timer* and *logicalChannelSR-ProhibitTimer* and by, for each logical channel, optionally signalling *logicalChannelGroup* which allocates the logical channel to an LCG [8].

For the Buffer Status reporting procedure, the MAC entity shall consider all radio bearers which are not suspended and may consider radio bearers which are suspended.

A Buffer Status Report (BSR) shall be triggered if any of the following events occur:

- UL data, for a logical channel which belongs to a LCG, becomes available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively) and either the data belongs to a logical channel with higher priority than the priorities of the logical channels which belong to any LCG and for which data is already available for transmission, or there is no data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";
- UL resources are allocated and number of padding bits is equal to or larger than the size of the Buffer Status Report MAC control element plus its subheader, in which case the BSR is referred below to as "Padding BSR";
- *retxBSR-Timer* expires and the MAC entity has data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";
- *periodicBSR-Timer* expires, in which case the BSR is referred below to as "Periodic BSR".

For Regular BSR:

- if the BSR is triggered due to data becoming available for transmission for a logical channel for which *logicalChannelSR-ProhibitTimer* is configured by upper layers:
  - start or restart the *logicalChannelSR-ProhibitTimer*;
- else:
  - if running, stop the *logicalChannelSR-ProhibitTimer*.

For Regular and Periodic BSR:

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- if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Long BSR;
- else report Short BSR.

For Padding BSR:

- if the number of padding bits is equal to or larger than the size of the Short BSR plus its subheader but smaller than the size of the Long BSR plus its subheader:
  - if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Truncated BSR of the LCG with the highest priority logical channel with data available for transmission;
  - else report Short BSR.
- else if the number of padding bits is equal to or larger than the size of the Long BSR plus its subheader, report Long BSR.

If the Buffer Status reporting procedure determines that at least one BSR has been triggered and not cancelled:

- if the MAC entity has UL resources allocated for new transmission for this TTI:
  - instruct the Multiplexing and Assembly procedure to generate the BSR MAC control element(s);
  - start or restart *periodicBSR-Timer* except when all the generated BSRs are Truncated BSRs;
  - start or restart *retxBSR-Timer*.
- else if a Regular BSR has been triggered and *logicalChannelSR-ProhibitTimer* is not running:
  - if an uplink grant is not configured or the Regular BSR was not triggered due to data becoming available for transmission for a logical channel for which logical channel SR masking (*logicalChannelSR-Mask*) is setup by upper layers:
    - a Scheduling Request shall be triggered.

A MAC PDU shall contain at most one MAC BSR control element, even when multiple events trigger a BSR by the time a BSR can be transmitted in which case the Regular BSR and the Periodic BSR shall have precedence over the padding BSR.

The MAC entity shall restart *retxBSR-Timer* upon indication of a grant for transmission of new data on any UL-SCH.

All triggered BSRs shall be cancelled in case the UL grant(s) in this subframe can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the BSR MAC control element plus its subheader. All triggered BSRs shall be cancelled when a BSR is included in a MAC PDU for transmission.

The MAC entity shall transmit at most one Regular/Periodic BSR in a TTI. If the MAC entity is requested to transmit multiple MAC PDUs in a TTI, it may include a padding BSR in any of the MAC PDUs which do not contain a Regular/Periodic BSR.

All BSRs transmitted in a TTI always reflect the buffer status after all MAC PDUs have been built for this TTI. Each LCG shall report at the most one buffer status value per TTI and this value shall be reported in all BSRs reporting buffer status for this LCG.

NOTE: A Padding BSR is not allowed to cancel a triggered Regular/Periodic BSR. A Padding BSR is triggered for a specific MAC PDU only and the trigger is cancelled when this MAC PDU has been built.

5.4.6 Power Headroom Reporting

The Power Headroom reporting procedure is used to provide the serving eNB with information about the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH transmission per activated Serving Cell and also with information about the difference between the nominal UE maximum power and the estimated power for UL-SCH and PUCCH transmission on SpCell and PUCCH SCell.

The reporting period, delay and mapping of Power Headroom are defined in subclause 9.1.8 of [9]. RRC controls Power Headroom reporting by configuring the two timers *periodicPHR-Timer* and *prohibitPHR-Timer*, and by signalling *dl-*

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PathlossChange which sets the change in measured downlink pathloss and the required power backoff due to power management (as allowed by P-MPR$_c$ [10]) to trigger a PHR [8].

A Power Headroom Report (PHR) shall be triggered if any of the following events occur:

- *prohibitPHR-Timer* expires or has expired and the path loss has changed more than *dl-PathlossChange* dB for at least one activated Serving Cell of any MAC entity which is used as a pathloss reference since the last transmission of a PHR in this MAC entity when the MAC entity has UL resources for new transmission;
- *periodicPHR-Timer* expires;
- upon configuration or reconfiguration of the power headroom reporting functionality by upper layers [8], which is not used to disable the function;
- activation of an SCell of any MAC entity with configured uplink.
- addition of the PSCell
- *prohibitPHR-Timer* expires or has expired, when the MAC entity has UL resources for new transmission, and the following is true in this TTI for any of the activated Serving Cells of any MAC entity with configured uplink:
  - there are UL resources allocated for transmission or there is a PUCCH transmission on this cell, and the required power backoff due to power management (as allowed by P-MPR$_c$ [10]) for this cell has changed more than *dl-PathlossChange* dB since the last transmission of a PHR when the MAC entity had UL resources allocated for transmission or PUCCH transmission on this cell.

NOTE: The MAC entity should avoid triggering a PHR when the required power backoff due to power management decreases only temporarily (e.g. for up to a few tens of milliseconds) and it should avoid reflecting such temporary decrease in the values of $P_{CMAX,c}$/PH when a PHR is triggered by other triggering conditions.

If the MAC entity has UL resources allocated for new transmission for this TTI the MAC entity shall:

- if it is the first UL resource allocated for a new transmission since the last MAC reset, start *periodicPHR-Timer*;
- if the Power Headroom reporting procedure determines that at least one PHR has been triggered and not cancelled, and;
- if the allocated UL resources can accommodate a PHR MAC control element plus its subheader if neither *extendedPHR* nor *dualConnectivityPHR* is configured, or the Extended PHR MAC control element plus its subheader if *extendedPHR* is configured, or the Dual Connectivity PHR MAC control element plus its subheader if *dualConnectivityPHR* is configured, as a result of logical channel prioritization:
  - if *extendedPHR* is configured:
    - for each activated Serving Cell with configured uplink:
      - obtain the value of the Type 1 power headroom;
      - if the MAC entity has UL resources allocated for transmission on this Serving Cell for this TTI:
        - obtain the value for the corresponding $P_{CMAX,c}$ field from the physical layer;
    - if *simultaneousPUCCH-PUSCH* is configured:
      - obtain the value of the Type 2 power headroom for the PCell;
      - obtain the value for the corresponding $P_{CMAX,c}$ field from the physical layer (see subclause 5.1.1.2 of [2]);
    - instruct the Multiplexing and Assembly procedure to generate and transmit an Extended PHR MAC control element for *extendedPHR* as defined in subclause 6.1.3.6a based on the values reported by the physical layer;
  - else if *extendedPHR2* is configured:
    - for each activated Serving Cell with configured uplink:

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- obtain the value of the Type 1 power headroom;
- if the MAC entity has UL resources allocated for transmission on this Serving Cell for this TTI:
  - obtain the value for the corresponding $P_{CMAX,c}$ field from the physical layer;
- if a PUCCH SCell is configured and activated:
  - obtain the value of the Type 2 power headroom for the PCell and PUCCH SCell;
  - obtain the values for the corresponding $P_{CMAX,c}$ fields from the physical layer (see subclause 5.1.1.2 of [2]);
- else:
  - if *simultaneousPUCCH-PUSCH* is configured for the PCell:
    - obtain the value of the Type 2 power headroom for the PCell;
    - obtain the value for the corresponding PCMAX,c field from the physical layer (see subclause 5.1.1.2 of [2]);
- instruct the Multiplexing and Assembly procedure to generate and transmit an Extended PHR MAC control element for *extendedPHR2* according to configured *ServCellIndex* and the PUCCH(s) for the MAC entity as defined in subclause 6.1.3.6a based on the values reported by the physical layer;

- else if *dualConnectivityPHR* is configured:
  - for each activated Serving Cell with configured uplink associated with any MAC entity:
    - obtain the value of the Type 1 power headroom;
    - if this MAC entity has UL resources allocated for transmission on this Serving Cell for this TTI or if the other MAC entity has UL resources allocated for transmission on this Serving Cell for this TTI and *phr-ModeOtherCG* is set to *real* by upper layers:
      - obtain the value for the corresponding $P_{CMAX,c}$ field from the physical layer;
  - if *simultaneousPUCCH-PUSCH* is configured:
    - obtain the value of the Type 2 power headroom for the SpCell;
    - obtain the value for the corresponding $P_{CMAX,c}$ field for the SpCell from the physical layer (see subclause 5.1.1.2 of [2]);
  - obtain the value of the Type 2 power headroom for the SpCell of the other MAC entity;
  - if *phr-ModeOtherCG* is set to *real* by upper layers:
    - obtain the value for the corresponding $P_{CMAX,c}$ field for the SpCell of the other MAC entity from the physical layer (see subclause 5.1.1.2 of [2]);
  - instruct the Multiplexing and Assembly procedure to generate and transmit a Dual Connectivity PHR MAC control element as defined in subclause 6.1.3.6b based on the values reported by the physical layer;
- else:
  - obtain the value of the Type 1 power headroom from the physical layer;
  - instruct the Multiplexing and Assembly procedure to generate and transmit a PHR MAC control element as defined in subclause 6.1.3.6 based on the value reported by the physical layer;
- start or restart *periodicPHR-Timer*;
- start or restart *prohibitPHR-Timer*;
- cancel all triggered PHR(s).

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5.5 PCH reception

When the MAC entity needs to receive PCH, the MAC entity shall:

- if a PCH assignment has been received on the PDCCH for the P-RNTI:
  - attempt to decode the TB on the PCH as indicated by the PDCCH information.
- if a TB on the PCH has been successfully decoded:
  - deliver the decoded MAC PDU to upper layers.

5.6 BCH reception

When the MAC entity needs to receive BCH, the MAC entity shall:

- receive and attempt to decode the BCH;
- if a TB on the BCH has been successfully decoded:
  - deliver the decoded MAC PDU to upper layers.

5.7 Discontinuous Reception (DRX)

The MAC entity may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the MAC entity's C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, Semi-Persistent Scheduling C-RNTI (if configured), eIMTA-RNTI (if configured) and SL-RNTI (if configured). When in RRC_CONNECTED, if DRX is configured, the MAC entity is allowed to monitor the PDCCH discontinuously using the DRX operation specified in this subclause; otherwise the MAC entity monitors the PDCCH continuously. When using DRX operation, the MAC entity shall also monitor PDCCH according to requirements found in other subclauses of this specification. RRC controls DRX operation by configuring the timers *onDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimer* (one per DL HARQ process except for the broadcast process), the *longDRX-Cycle*, the value of the *drxStartOffset* and optionally the *drxShortCycleTimer* and *shortDRX-Cycle*. A HARQ RTT timer per DL HARQ process (except for the broadcast process) is also defined (see subclause 7.7).

When a DRX cycle is configured, the Active Time includes the time while:

- *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
- a Scheduling Request is sent on PUCCH and is pending (as described in subclause 5.4.4); or
- an uplink grant for a pending HARQ retransmission can occur and there is data in the corresponding HARQ buffer; or
- a PDCCH indicating a new transmission addressed to the C-RNTI of the MAC entity has not been received after successful reception of a Random Access Response for the preamble not selected by the MAC entity (as described in subclause 5.1.4).

When DRX is configured, the MAC entity shall for each subframe:

- if a HARQ RTT Timer expires in this subframe and the data of the corresponding HARQ process was not successfully decoded:
  - start the *drx-RetransmissionTimer* for the corresponding HARQ process.
- if a DRX Command MAC control element or a Long DRX Command MAC control element is received:
  - stop *onDurationTimer*;
  - stop *drx-InactivityTimer*.
- if *drx-InactivityTimer* expires or a DRX Command MAC control element is received in this subframe:

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- if the Short DRX cycle is configured:
  - start or restart *drxShortCycleTimer*;
  - use the Short DRX Cycle.
- else:
  - use the Long DRX cycle.

- if *drxShortCycleTimer* expires in this subframe:
  - use the Long DRX cycle.
- if a Long DRX Command MAC control element is received:
  - stop *drxShortCycleTimer*;

  use the Long DRX cycle.
- If the Short DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*shortDRX-Cycle*) = (*drxStartOffset*) modulo (*shortDRX-Cycle*); or
- if the Long DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*longDRX-Cycle*) = *drxStartOffset*:
  - start *onDurationTimer*.
- during the Active Time, for a PDCCH-subframe, if the subframe is not required for uplink transmission for half-duplex FDD UE operation, if the subframe is not a half-duplex guard subframe [7] and if the subframe is not part of a configured measurement gap and if the subframe is not part of a configured Sidelink Discovery Gap for Reception; or
- during the Active Time, for a subframe other than a PDCCH-subframe and for a UE capable of simultaneous reception and transmission in the aggregated cells, if the subframe is a downlink subframe indicated by a valid eIMTA L1 signalling for at least one serving cell not configured with *schedulingCellId* [8] and if the subframe is not part of a configured measurement gap and if the subframe is not part of a configured Sidelink Discovery Gap for Reception; or
- during the Active Time, for a subframe other than a PDCCH-subframe and for a UE not capable of simultaneous reception and transmission in the aggregated cells, if the subframe is a downlink subframe indicated by a valid eIMTA L1 signalling for the SpCell and if the subframe is not part of a configured measurement gap and if the subframe is not part of a configured Sidelink Discovery Gap for Reception:
  - monitor the PDCCH;
  - if the PDCCH indicates a DL transmission or if a DL assignment has been configured for this subframe:
    - start the HARQ RTT Timer for the corresponding HARQ process;
    - stop the *drx-RetransmissionTimer* for the corresponding HARQ process.
  - if the PDCCH indicates a new transmission (DL, UL or SL):
    - start or restart *drx-InactivityTimer*.
- in current subframe n, if the MAC entity would not be in Active Time considering grants/assignments/DRX Command MAC control elements/Long DRX Command MAC control elements received and Scheduling Request sent until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, type-0-triggered SRS [2] shall not be reported.
- if CQI masking (*cqi-Mask*) is setup by upper layers:
  - in current subframe n, if *onDurationTimer* would not be running considering grants/assignments/DRX Command MAC control elements/Long DRX Command MAC control elements received until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, CQI/PMI/RI/PTI on PUCCH shall not be reported.

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- else:
  - in current subframe n, if the MAC entity would not be in Active Time considering grants/assignments/DRX Command MAC control elements/Long DRX Command MAC control elements received and Scheduling Request sent until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, CQI/PMI/RI/PTI on PUCCH shall not be reported.

Regardless of whether the MAC entity is monitoring PDCCH or not, the MAC entity receives and transmits HARQ feedback and transmits type-1-triggered SRS [2] when such is expected.

NOTE: The same Active Time applies to all activated serving cell(s).

NOTE: In case of downlink spatial multiplexing, if a TB is received while the HARQ RTT Timer is running and the previous transmission of the same TB was received at least N subframes before the current subframe (where N corresponds to the HARQ RTT Timer), the MAC entity should process it and restart the HARQ RTT Timer.

5.7a Discontinuous Reception (DRX) for SC-PTM

Each G-RNTI of the MAC entity may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for this G-RNTI as specified in [8]. When in RRC_IDLE or RRC_CONNECTED, if DRX is configured, the MAC entity is allowed to monitor the PDCCH for this G-RNTI discontinuously using the DRX operation specified in this subclause; otherwise the MAC entity monitors the PDCCH for this G-RNTI continuously. For each G-RNTI of the MAC entity, RRC controls its DRX operation by configuring the timers *onDurationTimerSCPTM*, *drx-InactivityTimerSCPTM*, the *SC-MTCH-SchedulingCycle* and the value of the *SC-MTCH-SchedulingOffset*. The DRX operation specified in this subclause is performed independently for each G-RNTI and independently from the DRX operation specified in subcaluse 5.7.

When DRX is configured for a G-RNTI, the Active Time includes the time while:

- *onDurationTimerSCPTM* or *drx-InactivityTimerSCPTM* is running.

When DRX is configured for a G-RNTI as specified in [8], the MAC entity shall for each subframe for this G-RNTI:

- if [(SFN * 10) + subframe number] modulo (*SC-MTCH-SchedulingCycle*) = *SC-MTCH-SchedulingOffset*:
  - start *onDurationTimerSCPTM*.
- during the Active Time, for a PDCCH-subframe:
  - monitor the PDCCH;
  - if the PDCCH indicates a DL transmission:
    - start or restart *drx-InactivityTimerSCPTM*.

5.8 MAC reconfiguration

When a reconfiguration of the MAC entity is requested by upper layers, the MAC entity shall:

- upon addition of an SCell, initialize the corresponding HARQ entity;
- upon removal of an SCell, remove the corresponding HARQ entity;
- for timers apply the new value when the timer is (re)started;
- when counters are initialized apply the new maximum parameter value;
- for other parameters, apply immediately the configurations received from upper layers.

5.9 MAC Reset

If a reset of the MAC entity is requested by upper layers, the MAC entity shall:

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- initialize Bj for each logical channel to zero;
- stop (if running) all timers;
- consider all *timeAlignmentTimer*s as expired and perform the corresponding actions in subclause 5.2;
- set the NDIs for all uplink HARQ processes to the value 0;
- stop, if any, ongoing RACH procedure;
- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush Msg3 buffer;
- cancel, if any, triggered Scheduling Request procedure;
- cancel, if any, triggered Buffer Status Reporting procedure;
- cancel, if any, triggered Power Headroom Reporting procedure;
- flush the soft buffers for all DL HARQ processes;
- for each DL HARQ process, consider the next received transmission for a TB as the very first transmission;
- release, if any, Temporary C-RNTI.

5.10 Semi-Persistent Scheduling

When Semi-Persistent Scheduling is enabled by RRC, the following information is provided [8]:

- Semi-Persistent Scheduling C-RNTI;
- Uplink Semi-Persistent Scheduling interval *semiPersistSchedIntervalUL* and number of empty transmissions before implicit release *implicitReleaseAfter*, if Semi-Persistent Scheduling is enabled for the uplink;
- Whether *twoIntervalsConfig* is enabled or disabled for uplink, only for TDD;
- Downlink Semi-Persistent Scheduling interval *semiPersistSchedIntervalDL* and number of configured HARQ processes for Semi-Persistent Scheduling *numberOfConfSPS-Processes*, if Semi-Persistent Scheduling is enabled for the downlink;

When Semi-Persistent Scheduling for uplink or downlink is disabled by RRC, the corresponding configured grant or configured assignment shall be discarded.

Semi-Persistent Scheduling is supported on the SpCell only.

Semi-Persistent Scheduling is not supported for RN communication with the E-UTRAN in combination with an RN subframe configuration.

NOTE: When eIMTA is configured for the SpCell, if a configured uplink grant or a configured downlink assignment occurs on a subframe that can be reconfigured through eIMTA L1 signalling, then the UE behaviour is left unspecified.

5.10.1 Downlink

After a Semi-Persistent downlink assignment is configured, the MAC entity shall consider sequentially that the Nth assignment occurs in the subframe for which:

- $(10 * SFN + subframe) = [(10 * SFN_{start\ time} + subframe_{start\ time}) + N * semiPersistSchedIntervalDL]$ modulo 10240.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured downlink assignment were (re-)initialised.

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5.10.2 Uplink

After a Semi-Persistent Scheduling uplink grant is configured, the MAC entity shall:

- if *twoIntervalsConfig* is enabled by upper layer:
  - set the Subframe_Offset according to Table 7.4-1.
- else:
  - set Subframe_Offset to 0.
- consider sequentially that the Nth grant occurs in the subframe for which:
  - (10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * *semiPersistSchedIntervalUL* + Subframe_Offset * (N modulo 2)] modulo 10240.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured uplink grant were (re-)initialised.

The MAC entity shall clear the configured uplink grant immediately after *implicitReleaseAfter* [8] number of consecutive new MAC PDUs each containing zero MAC SDUs have been provided by the Multiplexing and Assembly entity, on the Semi-Persistent Scheduling resource.

NOTE: Retransmissions for Semi-Persistent Scheduling can continue after clearing the configured uplink grant.

5.11 Handling of unknown, unforeseen and erroneous protocol data

When a MAC entity receives a MAC PDU for the MAC entity's C-RNTI or Semi-Persistent Scheduling C-RNTI, or by the configured downlink assignment, or on SL-SCH, containing reserved or invalid values, the MAC entity shall:

- discard the received PDU.

When a MAC entity receives a MAC PDU on MCH containing reserved values, the MAC entity shall:

- ignore the MAC PDU subheaders containing reserved values and the corresponding MAC SDUs;
- in the MAC control elements, ignore the fields containing reserved values and the fields associated with the fields containing reserved values.

5.12 MCH reception

MCH transmission may occur in subframes configured by upper layer for MCCH or MTCH transmission. For each such subframe, upper layer indicates if *signallingMCS* or *dataMCS* applies. The transmission of an MCH occurs in a set of subframes defined by *PMCH-Config*. An MCH Scheduling Information MAC control element is included in the first subframe allocated to the MCH within the MCH scheduling period to indicate the position of each MTCH and unused subframes on the MCH. If *pmch-InfoListExt* is configured for an MCH, an Extended MCH Scheduling Information MAC control element is included in the first subframe allocated to the corresponding MCH within the MCH scheduling period to indicate the position of each MTCH and unused subframes on the MCH, and to indicate whether MTCH transmission is to be suspended. The MAC entity shall assume that the first scheduled MTCH starts immediately after the MCCH or the MCH Scheduling Information MAC control element or the Extended MCH Scheduling Information MAC control element if the MCCH is not present, and the other scheduled MTCH(s) start immediately after the previous MTCH, at the earliest in the subframe where the previous MTCH stops. When the MAC entity needs to receive MCH, the MAC entity shall:

- attempt to decode the TB on the MCH;
- if a TB on the MCH has been successfully decoded:
  - demultiplex the MAC PDU and deliver the MAC SDU(s) to upper layers.

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When the MAC entity receives the Extended MCH Scheduling Information MAC control element, the MAC entity shall indicate the MTCH(s) to be suspended to the upper layers.

NOTE: The MAC entity should continue receiving MCH until the MTCH is removed from the MCCH.

5.13 Activation/Deactivation of SCells

If the MAC entity is configured with one or more SCells, the network may activate and deactivate the configured SCells. The SpCell is always activated. The network activates and deactivates the SCell(s) by sending the Activation/Deactivation MAC control element described in subclause 6.1.3.8. Furthermore, the MAC entity maintains a *sCellDeactivationTimer* timer per configured SCell (except the SCell configured with PUCCH, if any) and deactivates the associated SCell upon its expiry. The same initial timer value applies to each instance of the *sCellDeactivationTimer* and it is configured by RRC. The configured SCells are initially deactivated upon addition and after a handover. The configured SCG SCells are initially deactivated after a SCG change.

The MAC entity shall for each TTI and for each configured SCell:

- if the MAC entity receives an Activation/Deactivation MAC control element in this TTI activating the SCell, the MAC entity shall in the TTI according to the timing defined in [2]:
  - activate the SCell; i.e. apply normal SCell operation including:
    - SRS transmissions on the SCell;
    - CQI/PMI/RI/PTI reporting for the SCell;
    - PDCCH monitoring on the SCell;
    - PDCCH monitoring for the SCell;
    - PUCCH transmissions on the SCell, if configured.
  - start or restart the *sCellDeactivationTimer* associated with the SCell;
  - trigger PHR according to subclause 5.4.6.
- else, if the MAC entity receives an Activation/Deactivation MAC control element in this TTI deactivating the SCell; or
- if the *sCellDeactivationTimer* associated with the activated SCell expires in this TTI:
  - in the TTI according to the timing defined in [2]:
    - deactivate the SCell;
    - stop the *sCellDeactivationTimer* associated with the SCell;
    - flush all HARQ buffers associated with the SCell.
- if PDCCH on the activated SCell indicates an uplink grant or downlink assignment; or
- if PDCCH on the Serving Cell scheduling the activated SCell indicates an uplink grant or a downlink assignment for the activated SCell:
  - restart the *sCellDeactivationTimer* associated with the SCell;
- if the SCell is deactivated:
  - not transmit SRS on the SCell;
  - not report CQI/PMI/RI/PTI for the SCell;
  - not transmit on UL-SCH on the SCell;
  - not transmit on RACH on the SCell;

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- not monitor the PDCCH on the SCell;
- not monitor the PDCCH for the SCell;
- not transmit PUCCH on the SCell.

HARQ feedback for the MAC PDU containing Activation/Deactivation MAC control element shall not be impacted by PCell interruption due to SCell activation/deactivation [9].

NOTE: When SCell is deactivated, the ongoing Random Access procedure on the SCell, if any, is aborted.

5.14 SL-SCH Data transfer

5.14.1 SL-SCH Data transmission

5.14.1.1 SL Grant reception and SCI transmission

In order to transmit on the SL-SCH the MAC entity must have at least one sidelink grant. Sidelink grants are selected as follows:

- if the MAC entity is configured to receive a single sidelink grant dynamically on the PDCCH and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall:
  - using the received sidelink grant determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
  - consider the received sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first available SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was received, overwriting a previously configured sidelink grant occurring in the same SC period, if available;
  - clear the configured sidelink grant at the end of the corresponding SC Period;
- else, if the MAC entity is configured by upper layers to receive multiple sidelink grants dynamically on the PDCCH and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall for each received sidelink grant:
  - using the received sidelink grant determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
  - consider the received sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first available SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was received, overwriting a previously configured sidelink grant received in the same subframe number but in a different radio frame as this configured sidelink grant occurring in the same SC period, if available;
  - clear the configured sidelink grant at the end of the corresponding SC Period;
- else, if the MAC entity is configured by upper layers to transmit using one or multiple pool(s) of resources as indicated in subclause 5.10.4 of [8] and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall for each sidelink grant to be selected:
  - if configured by upper layers to use a single pool of resources:
    - select that pool of resources for use;
  - else, if configured by upper layers to use multiple pools of resources:
    - select a pool of resources for use from the pools of resources configured by upper layers whose associated priority list includes the priority of the highest priority of the sidelink logical channel in the MAC PDU to be transmitted;

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NOTE: If more than one pool of resources has an associated priority list which includes the priority of the sidelink logical channel with the highest priority in the MAC PDU to be transmitted, it is left for UE implementation which one of those pools of resources to select.

- randomly select the time and frequency resources for SL-SCH and SCI of a sidelink grant from the selected resource pool. The random function shall be such that each of the allowed selections [2] can be chosen with equal probability;
- use the selected sidelink grant to determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
- consider the selected sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first available SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was selected;
- clear the configured sidelink grant at the end of the corresponding SC Period;

NOTE: Retransmissions on SL-SCH cannot occur after the configured sidelink grant has been cleared.

NOTE: If the MAC entity is configured by upper layers to transmit using one or multiple pool(s) of resources as indicated in subclause 5.10.4 of [8], it is left for UE implementation how many sidelink grants to select within one SC period taking the number of sidelink processes into account.

The MAC entity shall for each subframe:

- if the MAC entity has a configured sidelink grant occurring in this subframe:
  - if the configured sidelink grant corresponds to transmission of SCI:
    - instruct the physical layer to transmit SCI corresponding to the configured sidelink grant.
  - else if the configured sidelink grant corresponds to transmission of first transport block:
    - deliver the configured sidelink grant and the associated HARQ information to the Sidelink HARQ Entity for this subframe.

NOTE: If the MAC entity has multiple configured grants occurring in one subframe and if not all of them can be processed due to the single-cluster SC-FDM restriction, it is left for UE implementation which one of these to process according to the procedure above.

5.14.1.2 Sidelink HARQ operation

5.14.1.2.1 Sidelink HARQ Entity

There is one Sidelink HARQ Entity at the MAC entity for transmission on SL-SCH, which maintains a number of parallel Sidelink processes.

The number of transmitting Sidelink processes associated with the Sidelink HARQ Entity is defined in [8].

A delivered and configured sidelink grant and its associated HARQ information are associated with a Sidelink process.

For each subframe of the SL-SCH and each Sidelink process, the Sidelink HARQ Entity shall:

- if a sidelink grant has been indicated for this Sidelink process and there is SL data, for sidelink logical channels of ProSe destination associated with this sidelink grant, available for transmission:
  - obtain the MAC PDU from the "Multiplexing and assembly" entity;
  - deliver the MAC PDU and the sidelink grant and the HARQ information to this Sidelink process;
  - instruct this Sidelink process to trigger a new transmission.
- else, if this subframe corresponds to retransmission opportunity for this Sidelink process:

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- instruct this Sidelink process to trigger a retransmission.

NOTE: The resources for retransmission opportunities are specified in subclause 14.2.1 of [2].

5.14.1.2.2 Sidelink process

The Sidelink process is associated with a HARQ buffer.

The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is updated modulo 4.

New transmissions and retransmissions for a given SC period are performed on the resource indicated in the sidelink grant and with the MCS configured by upper layers (if configured).

If the Sidelink HARQ Entity requests a new transmission, the Sidelink process shall:

- set CURRENT_IRV to 0;
- store the MAC PDU in the associated HARQ buffer;
- store the sidelink grant received from the Sidelink HARQ Entity;
- generate a transmission as described below.

If the Sidelink HARQ Entity requests a retransmission, the Sidelink process shall:

- generate a transmission as described below.

To generate a transmission, the Sidelink process shall:

- if there is no uplink transmission or if the MAC entity is able to perform uplink transmissions and transmissions on SL-SCH simultaneously at the time of the transmission:
  - instruct the physical layer to generate a transmission according to the stored sidelink grant with the redundancy version corresponding to the CURRENT_IRV value.
- increment CURRENT_IRV by 1.

5.14.1.3 Multiplexing and assembly

For PDU(s) associated with one SCI, MAC shall consider only logical channels with the same Source Layer-2 ID-Destination Layer-2 ID pair.

Multiple transmissions within overlapping SC periods to different ProSe Destinations are allowed subject to single-cluster SC-FDM constraint.

5.14.1.3.1 Logical channel prioritization

The Logical Channel Prioritization procedure is applied when a new transmission is performed. Each sidelink logical channel has an associated priority which is the PPPP. Multiple sidelink logical channels may have the same associated priority. The mapping between priority and LCID is left for UE implementation.

The MAC entity shall perform the following Logical Channel Prioritization procedure for each SCI transmitted in an SC period:

- The MAC entity shall allocate resources to the sidelink logical channels in the following steps:
  - Step 0: Select a ProSe Destination, not previously selected for this SC period, having the sidelink logical channel with the highest priority, among the sidelink logical channels having data available for transmission;

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- Step 1: Among the sidelink logical channels belonging to the selected ProSe Destination and having data available for transmission, allocate resources to the sidelink logical channel with the highest priority;
- Step 2: if any resources remain, sidelink logical channels belonging to the selected ProSe Destination are served in decreasing order of priority until either the data for the sidelink logical channel(s) or the SL grant is exhausted, whichever comes first. Sidelink logical channels configured with equal priority should be served equally.

- The UE shall also follow the rules below during the scheduling procedures above:

The UE shall perform the following Logical Channel Prioritization procedure when a new transmission is performed:

- the UE shall allocate resources to the sidelink logical channels according to the following rules:
  - the UE should not segment an RLC SDU (or partially transmitted SDU) if the whole SDU (or partially transmitted SDU) fits into the remaining resources;
  - if the UE segments an RLC SDU from the sidelink logical channel, it shall maximize the size of the segment to fill the grant as much as possible;
  - the UE should maximise the transmission of data;
  - if the MAC entity is given an sidelink grant size that is equal to or larger than 10 bytes while having data available for transmission, the MAC entity shall not transmit only padding.

NOTE: The rules above imply that the order by which the sidelink logical channels are served is left for UE implementation.

5.14.1.3.2 Multiplexing of MAC SDUs

The MAC entity shall multiplex MAC SDUs in a MAC PDU according to subclauses 5.14.1.3.1 and 6.1.6.

5.14.1.4 Buffer Status Reporting

The sidelink Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of sidelink data available for transmission in the SL buffers associated with the MAC entity. RRC controls BSR reporting for the sidelink by configuring the two timers *periodic-BSR-TimerSL* and *retx-BSR-TimerSL*. Each sidelink logical channel belongs to a ProSe Destination. Each sidelink logical channel is allocated to an LCG depending on the priority of the sidelink logical channel and the mapping between LCG ID and priority which is provided by upper layers in *logicalChGroupInfoList* [8]. LCG is defined per ProSe Destination.

A sidelink Buffer Status Report (BSR) shall be triggered if any of the following events occur:

- if the MAC entity has a configured SL-RNTI:
  - SL data, for a sidelink logical channel of a ProSe Destination, becomes available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively) and either the data belongs to a sidelink logical channel with higher priority than the priorities of the sidelink logical channels which belong to any LCG belonging to the same ProSe Destination and for which data is already available for transmission, or there is currently no data available for transmission for any of the sidelink logical channels belonging to the same ProSe Destination, in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR";
  - UL resources are allocated and number of padding bits remaining after a Padding BSR has been triggered is equal to or larger than the size of the Sidelink BSR MAC control element containing the buffer status for at least one LCG of a ProSe Destination plus its subheader, in which case the Sidelink BSR is referred below to as "Padding Sidelink BSR";
  - *retx-BSR-TimerSL* expires and the MAC entity has data available for transmission for any of the sidelink logical channels, in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR";
  - *periodic-BSR-TimerSL* expires, in which case the Sidelink BSR is referred below to as "Periodic Sidelink BSR";
- else:

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- An SL-RNTI is configured by upper layers and SL data is available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively), in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR".

For Regular and Periodic Sidelink BSR:

- if the number of bits in the UL grant is equal to or larger than the size of a Sidelink BSR containing buffer status for all LCGs having data available for transmission plus its subheader:
  - report Sidelink BSR containing buffer status for all LCGs having data available for transmission;
- else report Truncated Sidelink BSR containing buffer status for as many LCGs having data available for transmission as possible, taking the number of bits in the UL grant into consideration.

For Padding Sidelink BSR:

- if the number of padding bits remaining after a Padding BSR has been triggered is equal to or larger than the size of a Sidelink BSR containing buffer status for all LCGs having data available for transmission plus its subheader:
  - report Sidelink BSR containing buffer status for all LCGs having data available for transmission;
- else report Truncated Sidelink BSR containing buffer status for as many LCGs having data available for transmission as possible, taking the number of bits in the UL grant into consideration.

If the Buffer Status reporting procedure determines that at least one Sidelink BSR has been triggered and not cancelled:

- if the MAC entity has UL resources allocated for new transmission for this TTI and the allocated UL resources can accommodate a Sidelink BSR MAC control element plus its subheader as a result of logical channel prioritization:
  - instruct the Multiplexing and Assembly procedure to generate the Sidelink BSR MAC control element(s);
  - start or restart *periodic-BSR-TimerSL* except when all the generated Sidelink BSRs are Truncated Sidelink BSRs;
  - start or restart *retx-BSR-TimerSL*;
- else if a Regular Sidelink BSR has been triggered:
  - if an uplink grant is not configured:
    - a Scheduling Request shall be triggered.

A MAC PDU shall contain at most one Sidelink BSR MAC control element, even when multiple events trigger a Sidelink BSR by the time a Sidelink BSR can be transmitted in which case the Regular Sidelink BSR and the Periodic Sidelink BSR shall have precedence over the padding Sidelink BSR.

The MAC entity shall restart *retx-BSR-TimerSL* upon reception of an SL grant.

All triggered regular Sidelink BSRs shall be cancelled in case the remaining configured SL grant(s) valid for this SC Period can accommodate all pending data available for transmission. All triggered Sidelink BSRs shall be cancelled in case the MAC entity has no data available for transmission for any of the sidelink logical channels. All triggered Sidelink BSRs shall be cancelled when a Sidelink BSR (except for Truncated Sidelink BSR) is included in a MAC PDU for transmission. All triggered Sidelink BSRs shall be cancelled, and *retx-BSR-TimerSL* and *periodic-BSR-TimerSL* shall be stopped, when upper layers configure autonomous resource selection.

The MAC entity shall transmit at most one Regular/Periodic Sidelink BSR in a TTI. If the MAC entity is requested to transmit multiple MAC PDUs in a TTI, it may include a padding Sidelink BSR in any of the MAC PDUs which do not contain a Regular/Periodic Sidelink BSR.

All Sidelink BSRs transmitted in a TTI always reflect the buffer status after all MAC PDUs have been built for this TTI. Each LCG shall report at the most one buffer status value per TTI and this value shall be reported in all Sidelink BSRs reporting buffer status for this LCG.

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NOTE: A Padding Sidelink BSR is not allowed to cancel a triggered Regular/Periodic Sidelink BSR. A Padding Sidelink BSR is triggered for a specific MAC PDU only and the trigger is cancelled when this MAC PDU has been built.

5.14.2 SL-SCH Data reception

5.14.2.1 SCI reception

SCI transmitted on the PSCCH indicate if there is a transmission on SL-SCH and provide the relevant HARQ information.

The MAC entity shall:

- for each subframe during which the MAC entity monitors PSCCH:
  - if SCI for this subframe has been received on the PSCCH with a Group Destination ID of interest to this MAC entity:
    - determine the set of subframes in which reception of the first transport blocks occur according to subclause 14.2.2 of [2] using the received SCI;
    - store the SCI and associated HARQ information as SCI valid for the subframes corresponding to first transmission of each transport block;
- for each subframe for which the MAC entity has a valid SCI:
  - deliver the SCI and the associated HARQ information to the Sidelink HARQ Entity.

5.14.2.2 Sidelink HARQ operation

5.14.2.2.1 Sidelink HARQ Entity

There is one Sidelink HARQ Entity at the MAC entity for reception of the SL-SCH which maintains a number of parallel Sidelink processes. Each Sidelink process is associated with SCI in which the MAC entity is interested as determined by the Group Destination ID of the SCI. The Sidelink HARQ Entity directs HARQ information and associated TBs received on the SL-SCH to the corresponding Sidelink processes.

The number of Receiving Sidelink processes associated with the Sidelink HARQ Entity is defined in [8].

For each subframe of the SL-SCH, the Sidelink HARQ Entity shall:

- for each SCI valid in this subframe:
  - allocate the TB received from the physical layer and the associated HARQ information to a Sidelink process, associate this Sidelink process with this SCI and consider this transmission to be a new transmission.
- for each Sidelink process:
  - if this subframe corresponds to retransmission opportunity for the Sidelink process according to its associated SCI:
    - allocate the TB received from the physical layer and the associated HARQ information to the Sidelink process and consider this transmission to be a retransmission.

5.14.2.2.2 Sidelink process

For each subframe where a transmission takes place for the Sidelink process, one TB and the associated HARQ information is received from the Sidelink HARQ Entity.

The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is updated modulo 4.

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For each received TB and associated HARQ information, the Sidelink process shall:

- if this is a new transmission:
  - set CURRENT_IRV to 0;
  - store the received data in the soft buffer and optionally attempt to decode the received data according to CURRENT_IRV.
- else if this is a retransmission:
  - if the data for this TB has not yet been successfully decoded:
    - increment CURRENT_IRV by 1;
    - combine the received data with the data currently in the soft buffer for this TB and optionally attempt to decode the combined data according to the CURRENT_IRV.
- if the data which the MAC entity attempted to decode was successfully decoded for this TB:
  - if this is the first successful decoding of the data for this TB:
    - if the DST field of the decoded MAC PDU subheader is equal to the 16 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 8 LSB are equal to the Group Destination ID in the corresponding SCI:
      - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.

5.14.2.3 Disassembly and demultiplexing

The MAC entity shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.6.

5.15 SL-DCH data transfer

5.15.1 SL-DCH data transmission

5.15.1.1 Resource allocation

In order to transmit MAC PDU(s) on SL-DCH, the MAC entity shall for every discovery period and each MAC PDU:

- if the MAC entity is configured by upper layers with a specific grant as specified in [8]:
  - using the specific grant determine the set of subframes in which a transmission of new MAC PDU(s) occur according to subclause 14.3.1 of [2];
  - consider the determined set of subframes to be a configured grant for the corresponding discovery period;
  - for every subframe, if the MAC entity has a configured grant occurring in that subframe, deliver the configured grant and the MAC PDU to the Sidelink HARQ Entity;
  - clear the configured grant at the end of the corresponding discovery period.

NOTE: Mapping between grant and physical resources is specified in subclause 9.5.6 of [7].

- else if the MAC entity is configured with a single pool of resources by upper layers:
  - select a random value p1 in the range from 0 to 1, where the random function shall be such that each of the allowed selections can be chosen with equal probability;
  - if p1 is less than *txProbability*:
    - select a random resource from the pool of resources (excluding any resources which are overlapping with PRACH or resources belonging to the subframes of resources already selected for transmissions on SL-

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DCH in this discovery period), where the random function shall be such that each of the allowed selections (see subclause 14.3.1 of [2]) can be chosen with equal probability;

- using the selected resource determine the set of subframes in which the transmission of a MAC PDU can occur according to subclause 14.3.1 of [2]
- consider the determined set of subframes to be a configured grant for the corresponding discovery period;
- for every subframe, if the MAC entity has a configured grant occurring in that subframe, deliver the configured grant and the MAC PDU to the Sidelink HARQ Entity;
- clear the configured grant at the end of the corresponding discovery period.

5.15.1.2 Sidelink HARQ operation

5.15.1.2.1 Sidelink HARQ Entity

There is one Sidelink HARQ Entity at the MAC entity for transmission on SL-DCH, which maintains one Sidelink process for each MAC PDU.

For each subframe of the SL-DCH the Sidelink HARQ Entity shall:

- if a grant and a MAC PDU has been delivered for this subframe to the Sidelink HARQ Entity:
  - deliver the MAC PDU and the grant to the Sidelink process;
  - instruct the Sidelink process to trigger a new transmission.
- else, if this subframe corresponds to retransmission opportunity for the Sidelink process:
  - instruct the Sidelink process to trigger a retransmission.

5.15.1.2.2 Sidelink process

The Sidelink process is associated with a HARQ buffer.

The Sidelink process shall maintain a state variable CURRENT_TX_NB, which indicates the number of transmissions that have taken place for the MAC PDU currently in the buffer. When the Sidelink process is established, CURRENT_TX_NB shall be initialized to 0.

The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is up-dated modulo 4.

The Sidelink process is configured with a maximum number of HARQ retransmissions by RRC: *numRetx*.

If the Sidelink HARQ Entity requests a new transmission, the Sidelink process shall:

- set CURRENT_TX_NB to 0;
- set CURRENT_IRV to 0;
- store the MAC PDU in the associated HARQ buffer;
- store the grant received from the Sidelink HARQ Entity;
- generate a transmission as described below.

If the Sidelink HARQ Entity requests a retransmission, the Sidelink process shall:

- increment CURRENT_TX_NB by 1;
- generate a transmission as described below.

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To generate a transmission, the Sidelink process shall:

- if there is no uplink transmission, no transmission or reception on PSCCH, and no transmission or reception on PSSCH at the time of the transmission; or
- if there is an uplink transmission, a Sidelink Discovery Gap for Transmission, no transmission or reception on PSCCH, and no transmission or reception on PSSCH at the time of transmission:
  - instruct the physical layer to generate a transmission according to the grant with the redundancy version corresponding to the CURRENT_IRV value.
- increment CURRENT_IRV by 1.

After performing above actions, the Sidelink process then shall:

- if CURRENT_TX_NB = *numRetx*:
  - flush the HARQ buffer.

5.15.2 SL-DCH data reception

5.15.2.1 Sidelink HARQ operation

5.15.2.1.1 Sidelink HARQ Entity

There is one Sidelink HARQ Entity at the MAC entity for reception on the SL-DCH which maintains a number of parallel Sidelink processes. The Sidelink HARQ Entity directs HARQ information and associated TBs received on the SL-DCH to the corresponding Sidelink processes.

The number of receiving Sidelink processes per Sidelink HARQ Entity is specified in [8].

For each subframe of the SL-DCH, the Sidelink HARQ Entity shall:

- receive the TB and the associated HARQ information from the physical layer;
- if this subframe corresponds to a new transmission opportunity:
  - allocate the received TB (if any) and the associated HARQ information to a non-running Sidelink process and consider this transmission to be a new transmission.
- else, if this subframe corresponds to a retransmission opportunity:
  - allocate the received TB (if any) and the associated HARQ information to its Sidelink process and consider this transmission to be a retransmission.

5.15.2.1.2 Sidelink process

For each subframe where a transmission takes place for the Sidelink process, one TB and the associated HARQ information is received from the Sidelink HARQ Entity.

The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is updated modulo 4.

The Sidelink process shall:

- if this subframe corresponds to a new transmission opportunity:
  - set CURRENT_IRV to 0;

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- else, if this subframe corresponds to a retransmission opportunity:
  - increment CURRENT_IRV by 1.
- if a TB was allocated to the Sidelink process:
  - if this is a new transmission:
    - optionally store the received data in the soft buffer and attempt to decode the received data according to the CURRENT_IRV.
  - else if this is a retransmission:
    - if the data for this TB has not yet been successfully decoded:
      - optionally combine the received data with the data currently in the soft buffer for this TB and attempt to decode the combined data according to the CURRENT_IRV.
  - if the data which the MAC entity attempted to decode was successfully decoded for this TB:
    - if this is the first successful decoding of the data for this TB:
      - deliver the decoded MAC PDU to upper layers.

5.16 SL-BCH data transfer

5.16.1 SL-BCH data transmission

When instructed to send SL-BCH, the MAC entity shall:

- obtain the MAC PDU to transmit from SBCCH;
- deliver the MAC PDU to the physical layer and instruct it to generate a transmission.

5.16.2 SL-BCH data reception

When the MAC entity needs to receive SL-BCH, the MAC entity shall:

- receive and attempt to decode the SL-BCH;
- if a TB on the SL-BCH has been successfully decoded:
  - deliver the decoded MAC PDU to upper layers.

6 Protocol Data Units, formats and parameters

6.1 Protocol Data Units

6.1.1 General

A MAC PDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. In the figures in subclause 6.1, bit strings are represented by tables in which the most significant bit is the leftmost bit of the first line of the table, the least significant bit is the rightmost bit on the last line of the table, and more generally the bit string is to be read from left to right and then in the reading order of the lines. The bit order of each parameter field within a MAC PDU is represented with the first and most significant bit in the leftmost bit and the last and least significant bit in the rightmost bit.

MAC SDUs are bit strings that are byte aligned (i.e. multiple of 8 bits) in length. An SDU is included into a MAC PDU from the first bit onward.

The MAC entity shall ignore the value of Reserved bits in downlink MAC PDUs.

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6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response, MCH)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC control elements, and optionally padding; as described in Figure 6.1.2-3.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader corresponds to either a MAC SDU, a MAC control element or padding.

A MAC PDU subheader consists of the five or six header fields R/F2/E/LCID/(F)/L but for the last subheader in the MAC PDU and for fixed sized MAC control elements. The last subheader in the MAC PDU and subheaders for fixed sized MAC control elements consist solely of the four header fields R/F2/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/F2/E/LCID.

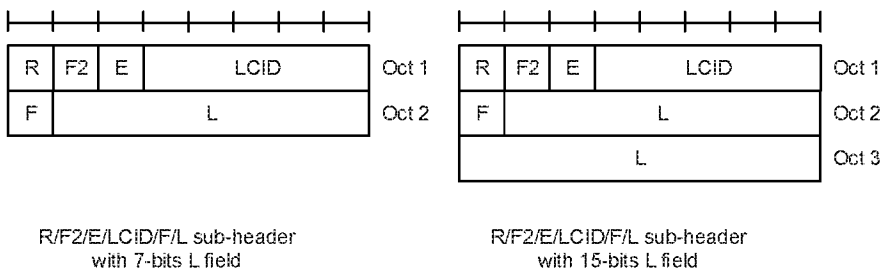


Figure 6.1.2-1: R/F2/E/LCID/F/L MAC subheader

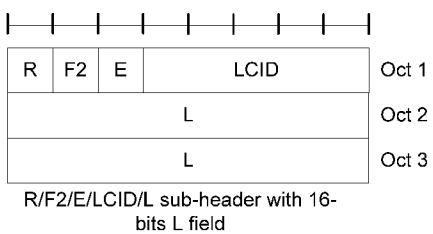


Figure 6.1.2-1a: R/F2/E/LCID/L MAC subheader

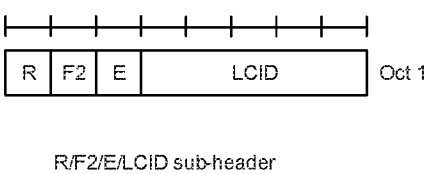


Figure 6.1.2-2: R/F2/E/LCID MAC subheader

MAC PDU subheaders have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements are always placed before any MAC SDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the MAC entity shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB per MAC entity. A maximum of one MCH MAC PDU can be transmitted per TTI.

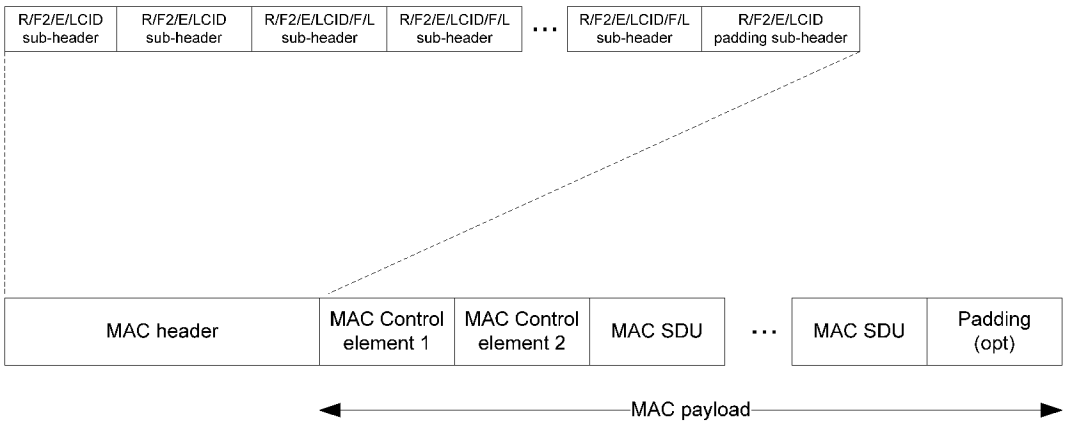


Figure 6.1.2-3: Example of MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding

6.1.3 MAC Control Elements

6.1.3.1 Buffer Status Report MAC Control Elements

Buffer Status Report (BSR) MAC control elements consist of either:

- Short BSR and Truncated BSR format: one LCG ID field and one corresponding Buffer Size field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #0 through #3 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1-2.

The fields LCG ID and Buffer Size are defined as follow:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) which buffer status is being reported. The length of the field is 2 bits;
- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a logical channel group after all MAC PDUs for the TTI have been built. The amount of data is indicated in number of bytes. It shall include all data that is available for transmission in the RLC layer and in the PDCP layer; the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively. The size of the RLC and MAC headers are not considered in the buffer size computation. The length of this field is 6 bits. If *extendedBSR-Sizes* is not configured, the values taken by the Buffer Size field are shown in Table 6.1.3.1-1. If *extendedBSR-Sizes* is configured, the values taken by the Buffer Size field are shown in Table 6.1.3.1-2.

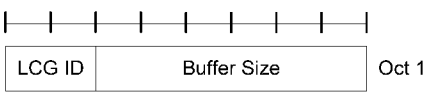


Figure 6.1.3.1-1: Short BSR and Truncated BSR MAC control element

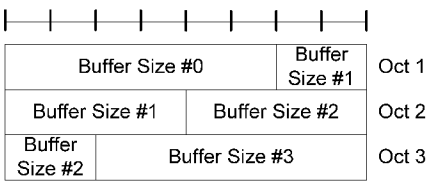


Figure 6.1.3.1-2: Long BSR MAC control element

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Table 6.1.3.1-1: Buffer size levels for BSR

Index	Buffer Size (BS) value [bytes]	Index	Buffer Size (BS) value [bytes]
0	BS = 0	32	1132 < BS <= 1326
1	0 < BS <= 10	33	1326 < BS <= 1552
2	10 < BS <= 12	34	1552 < BS <= 1817
3	12 < BS <= 14	35	1817 < BS <= 2127
4	14 < BS <= 17	36	2127 < BS <= 2490
5	17 < BS <= 19	37	2490 < BS <= 2915
6	19 < BS <= 22	38	2915 < BS <= 3413
7	22 < BS <= 26	39	3413 < BS <= 3995
8	26 < BS <= 31	40	3995 < BS <= 4677
9	31 < BS <= 36	41	4677 < BS <= 5476
10	36 < BS <= 42	42	5476 < BS <= 6411
11	42 < BS <= 49	43	6411 < BS <= 7505
12	49 < BS <= 57	44	7505 < BS <= 8787
13	57 < BS <= 67	45	8787 < BS <= 10287
14	67 < BS <= 78	46	10287 < BS <= 12043
15	78 < BS <= 91	47	12043 < BS <= 14099
16	91 < BS <= 107	48	14099 < BS <= 16507
17	107 < BS <= 125	49	16507 < BS <= 19325
18	125 < BS <= 146	50	19325 < BS <= 22624
19	146 < BS <= 171	51	22624 < BS <= 26487
20	171 < BS <= 200	52	26487 < BS <= 31009
21	200 < BS <= 234	53	31009 < BS <= 36304
22	234 < BS <= 274	54	36304 < BS <= 42502
23	274 < BS <= 321	55	42502 < BS <= 49759
24	321 < BS <= 376	56	49759 < BS <= 58255
25	376 < BS <= 440	57	58255 < BS <= 68201
26	440 < BS <= 515	58	68201 < BS <= 79846
27	515 < BS <= 603	59	79846 < BS <= 93479
28	603 < BS <= 706	60	93479 < BS <= 109439
29	706 < BS <= 826	61	109439 < BS <= 128125
30	826 < BS <= 967	62	128125 < BS <= 150000
31	967 < BS <=1132	63	BS > 150000

Table 6.1.3.1-2: Extended Buffer size levels for BSR

Index	Buffer Size (BS) value [bytes]	Index	Buffer Size (BS) value [bytes]
0	BS = 0	32	4940 < BS <= 6074
1	0 < BS <= 10	33	6074 < BS <= 7469
2	10 < BS <= 13	34	7469 < BS <= 9185
3	13 < BS <= 16	35	9185 < BS <= 11294
4	16 < BS <= 19	36	11294 < BS <= 13888
5	19 < BS <= 23	37	13888 < BS <= 17077

6	23 < BS <= 29	38	17077 < BS <= 20999
7	29 < BS <= 35	39	20999 < BS <= 25822
8	35 < BS <= 43	40	25822 < BS <= 31752
9	43 < BS <= 53	41	31752 < BS <= 39045
10	53 < BS <= 65	42	39045 < BS <= 48012
11	65 < BS <= 80	43	48012 < BS <= 59039
12	80 < BS <= 98	44	59039 < BS <= 72598
13	98 < BS <= 120	45	72598 < BS <= 89272
14	120 < BS <= 147	46	89272 < BS <= 109774
15	147 < BS <= 181	47	109774 < BS <= 134986
16	181 < BS <= 223	48	134986 < BS <= 165989
17	223 < BS <= 274	49	165989 < BS <= 204111
18	274 < BS <= 337	50	204111 < BS <= 250990
19	337 < BS <= 414	51	250990 < BS <= 308634
20	414 < BS <= 509	52	308634 < BS <= 379519
21	509 < BS <= 625	53	379519 < BS <= 466683
22	625 < BS <= 769	54	466683 < BS <= 573866
23	769 < BS <= 945	55	573866 < BS <= 705666
24	945 < BS <= 1162	56	705666 < BS <= 867737
25	1162 < BS <= 1429	57	867737 < BS <= 1067031
26	1429 < BS <= 1757	58	1067031 < BS <= 1312097
27	1757 < BS <= 2161	59	1312097 < BS <= 1613447
28	2161 < BS <= 2657	60	1613447 < BS <= 1984009
29	2657 < BS <= 3267	61	1984009 < BS <= 2439678
30	3267 < BS <= 4017	62	2439678 < BS <= 3000000
31	4017 < BS <=4940	63	BS > 3000000

6.1.3.1a Sidelink BSR MAC Control Elements

Sidelink BSR and Truncated Sidelink BSR MAC control elements consist of one Destination Index field, one LCG ID field and one corresponding Buffer Size field per reported target group.

The Sidelink BSR MAC control elements are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1-2. They have variable sizes.

For each included group, the fields are defined as follows (figures 6.1.3.1a-1 and 6.1.3.1a-2):

- Destination Index: The Destination Index field identifies the ProSe Destination. The length of this field is 4 bits. The value is set to the index of the destination reported in *destinationInfoList* and if *destinationInfoListUC* is also reported, the value is indexed sequentially across both lists specified in [8];
- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) which buffer status is being reported. The length of the field is 2 bits;
- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a LCG of a ProSe Destination after all MAC PDUs for the TTI have been built. The amount of data is indicated in number of bytes. It shall include all data that is available for transmission in the RLC layer and in the PDCP layer; the definition of what data shall be considered as available for transmission is specified in [3] and [4]

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respectively. The size of the RLC and MAC headers are not considered in the buffer size computation. The length of this field is 6 bits. The values taken by the Buffer Size field are shown in Table 6.1.3.1-1;

- R: Reserved bit, set to "0".

Buffer Sizes of LCGs are included in decreasing order of the highest priority of the sidelink logical channel belonging to the LCG irrespective of the value of the Destination Index field.

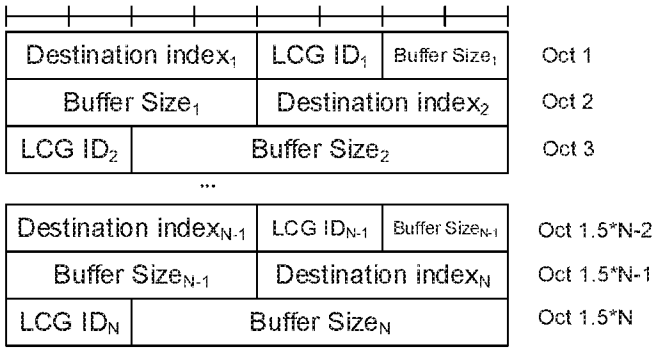


Figure 6.1.3.1a-1: Sidelink BSR and Truncated Sidelink BSR MAC control element for even N

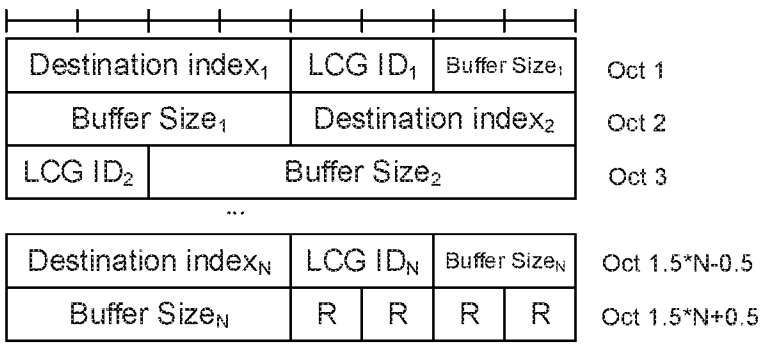


Figure 6.1.3.1a-2: Sidelink BSR and Truncated Sidelink BSR MAC control element for odd N

6.1.3.2 C-RNTI MAC Control Element

The C-RNTI MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-2.

It has a fixed size and consists of a single field defined as follows (figure 6.1.3.2-1):

- C-RNTI: This field contains the C-RNTI of the MAC entity. The length of the field is 16 bits.

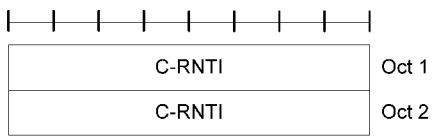


Figure 6.1.3.2-1: C-RNTI MAC control element

6.1.3.3 DRX Command MAC Control Element

The DRX Command MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1.

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It has a fixed size of zero bits.

6.1.3.4 UE Contention Resolution Identity MAC Control Element

The UE Contention Resolution Identity MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-1. This control element has a fixed 48-bit size and consists of a single field defined as follows (figure 6.1.3.4-1)

- UE Contention Resolution Identity: This field contains the uplink CCCH SDU.

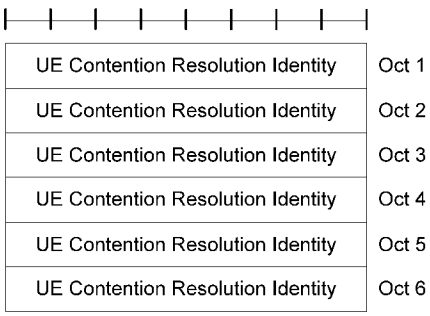


Figure 6.1.3.4-1: UE Contention Resolution Identity MAC control element

6.1.3.5 Timing Advance Command MAC Control Element

The Timing Advance Command MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-1.

It has a fixed size and consists of a single octet defined as follows (figure 6.1.3.5-1):

- TAG Identity (TAG Id): This field indicates the TAG Identity of the addressed TAG. The TAG containing the SpCell has the TAG Identity 0. The length of the field is 2 bits;
- Timing Advance Command: This field indicates the index value T_A (0, 1, 2… 63) used to control the amount of timing adjustment that MAC entity has to apply (see subclause 4.2.3 of [2]). The length of the field is 6 bits.

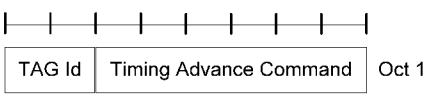


Figure 6.1.3.5-1: Timing Advance Command MAC control element

6.1.3.6 Power Headroom Report MAC Control Element

The Power Headroom Report (PHR) MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-2. It has a fixed size and consists of a single octet defined as follows (figure 6.1.3.6-1):

- R: reserved bit, set to "0";
- Power Headroom (PH): this field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.6-1 below (the corresponding measured values in dB can be found in subclause 9.1.8.4 of [9]).

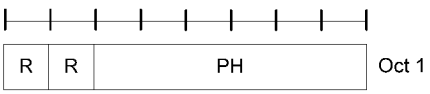


Figure 6.1.3.6-1: PHR MAC control element

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Table 6.1.3.6-1: Power Headroom levels for PHR

PH	Power Headroom Level
0	POWER_HEADROOM_0
1	POWER_HEADROOM_1
2	POWER_HEADROOM_2
3	POWER_HEADROOM_3
...	...
60	POWER_HEADROOM_60
61	POWER_HEADROOM_61
62	POWER_HEADROOM_62
63	POWER_HEADROOM_63

6.1.3.6a Extended Power Headroom Report MAC Control Elements

For *extendedPHR*, the Extended Power Headroom Report (PHR) MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-2. It has a variable size and is defined in Figure 6.1.3.6a-2. When Type 2 PH is reported, the octet containing the Type 2 PH field is included first after the octet indicating the presence of PH per SCell and followed by an octet containing the associated $P_{CMAX,c}$ field (if reported). Then follows in ascending order based on the *ServCellIndex* [8] an octet with the Type 1 PH field and an octet with the associated $P_{CMAX,c}$ field (if reported), for the PCell and for each SCell indicated in the bitmap.

For *extendedPHR2*, the Extended Power Headroom Report (PHR) MAC control elements are identified by a MAC PDU subheader with LCID as specified in table 6.2.1-2. They have variable sizes and are defined in Figure 6.1.3.6a-3, Figure 6.1.3.6a-4 and Figure 6.1.3.6a-5. One octet with C fields is used for indicating the presence of PH per SCell when the highest *SCellIndex* of SCell with configured uplink is less than 8, otherwise four octets are used. When Type 2 PH is reported for the PCell, the octet containing the Type 2 PH field is included first after the octet(s) indicating the presence of PH per SCell and followed by an octet containing the associated $P_{CMAX,c}$ field (if reported). Then follows the Type 2 PH field for the PUCCH SCell (if PUCCH on SCell is configured and Type 2 PH is reported for the PUCCH SCell), followed by an octet containing the associated $P_{CMAX,c}$ field (if reported). Then follows in ascending order based on the *ServCellIndex* [8] an octet with the Type 1 PH field and an octet with the associated $P_{CMAX,c}$ field (if reported), for the PCell and for each SCell indicated in the bitmap.

The Extended PHR MAC Control Elements are defined as follows:

- C_i: this field indicates the presence of a PH field for the SCell with *SCellIndex* i as specified in [8]. The C_i field set to "1" indicates that a PH field for the SCell with *SCellIndex* i is reported. The C_i field set to "0" indicates that a PH field for the SCell with *SCellIndex* i is not reported;
- R: reserved bit, set to "0";
- V: this field indicates if the PH value is based on a real transmission or a reference format. For Type 1 PH, V=0 indicates real transmission on PUSCH and V=1 indicates that a PUSCH reference format is used. For Type 2 PH, V=0 indicates real transmission on PUCCH and V=1 indicates that a PUCCH reference format is used. Furthermore, for both Type 1 and Type 2 PH, V=0 indicates the presence of the octet containing the associated $P_{CMAX,c}$ field, and V=1 indicates that the octet containing the associated $P_{CMAX,c}$ field is omitted;
- Power Headroom (PH): this field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.6-1 (the corresponding measured values in dB can be found in subclause 9.1.8.4 of [9]);
- P: this field indicates whether the MAC entity applies power backoff due to power management (as allowed by $P\text{-}MPR_c$ [10]). The MAC entity shall set P=1 if the corresponding $P_{CMAX,c}$ field would have had a different value if no power backoff due to power management had been applied;
- $P_{CMAX,c}$: if present, this field indicates the $P_{CMAX,c}$ or $\tilde{P}_{CMAX,c}$ [2] used for calculation of the preceding PH field. The reported $P_{CMAX,c}$ and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.6a-1 (the corresponding measured values in dBm can be found in subclause 9.6.1 of [9]).

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Figure 6.1.3.6a-1: Void

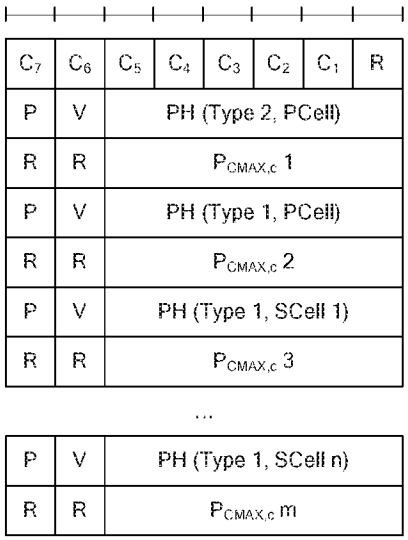


Figure 6.1.3.6a-2: Extended PHR MAC Control Element

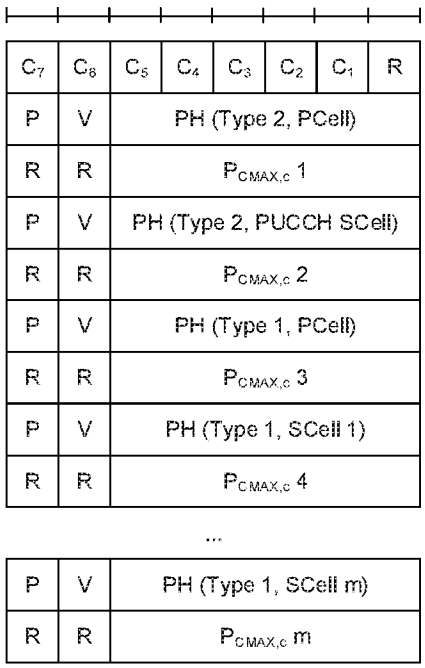
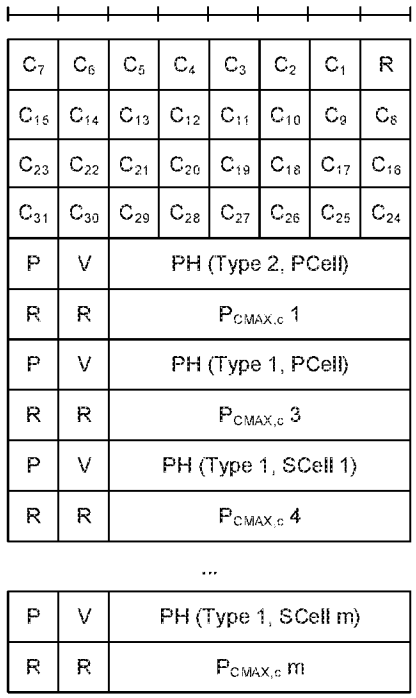
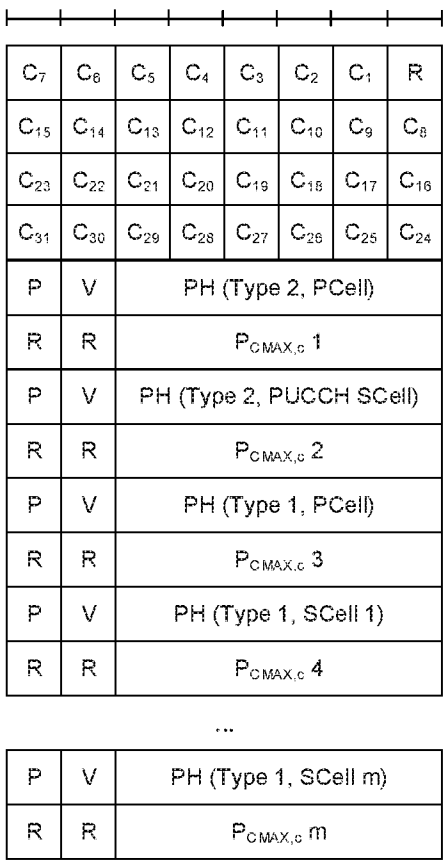


Figure 6.1.3.6a1-3: Extended PHR MAC Control Element supporting PUCCH on SCell



C_7	C_6	C_5	C_4	C_3	C_2	C_1	R
C_{15}	C_{14}	C_{13}	C_{12}	C_{11}	C_{10}	C_9	C_8
C_{23}	C_{22}	C_{21}	C_{20}	C_{19}	C_{18}	C_{17}	C_{16}
C_{31}	C_{30}	C_{29}	C_{28}	C_{27}	C_{26}	C_{25}	C_{24}
P	V	PH (Type 2, PCell)					
R	R	$P_{CMAX,c}$ 1					
P	V	PH (Type 1, PCell)					
R	R	$P_{CMAX,c}$ 3					
P	V	PH (Type 1, SCell 1)					
R	R	$P_{CMAX,c}$ 4					
...							
P	V	PH (Type 1, SCell m)					
R	R	$P_{CMAX,c}$ m					

Figure 6.1.3.6a2-4: Extended PHR MAC Control Element supporting 32 serving cells with configured uplink



C_7	C_6	C_5	C_4	C_3	C_2	C_1	R
C_{15}	C_{14}	C_{13}	C_{12}	C_{11}	C_{10}	C_9	C_8
C_{23}	C_{22}	C_{21}	C_{20}	C_{19}	C_{18}	C_{17}	C_{16}
C_{31}	C_{30}	C_{29}	C_{28}	C_{27}	C_{26}	C_{25}	C_{24}
P	V	PH (Type 2, PCell)					
R	R	$P_{CMAX,c}$ 1					
P	V	PH (Type 2, PUCCH SCell)					
R	R	$P_{CMAX,c}$ 2					
P	V	PH (Type 1, PCell)					
R	R	$P_{CMAX,c}$ 3					
P	V	PH (Type 1, SCell 1)					
R	R	$P_{CMAX,c}$ 4					
...							
P	V	PH (Type 1, SCell m)					
R	R	$P_{CMAX,c}$ m					

Figure 6.1.3.6a3-5: Extended PHR MAC Control Element supporting 32 serving cells with configured uplink and PUCCH on SCell

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Table 6.1.3.6a-1: Nominal UE transmit power level for Extended PHR and for Dual Connectivity PHR

$P_{CMAX,c}$	Nominal UE transmit power level
0	PCMAX_C_00
1	PCMAX_C_01
2	PCMAX_C_02
...	...
61	PCMAX_C_61
62	PCMAX_C_62
63	PCMAX_C_63

6.1.3.6b Dual Connectivity Power Headroom Report MAC Control Element

The Dual Connectivity Power Headroom Report (PHR) MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-2. It has a variable size and is defined in Figure 6.1.3.6b-1 and Figure 6.1.3.6b-2. One octet with C_i fields is used for indicating the presence of PH per SCell when the highest *SCellIndex* of SCell with configured uplink is less than 8, otherwise four octets are used. When Type 2 PH is reported for the PCell, the octet containing the Type 2 PH field is included first after the octet(s) indicating the presence of PH per cell (PSCell and all SCells of all MAC entities) and followed by an octet containing the associated $P_{CMAX,c}$ field (if reported). Then after that, when Type 2 PH is reported for the PSCell, the octet containing the Type 2 PH field is included followed by an octet containing the associated $P_{CMAX,c}$ field (if reported). Then follows in ascending order based on the *ServCellIndex* [8] an octet with the Type 1 PH field and an octet with the associated $P_{CMAX,c}$ field (if reported), for the PCell and for all other serving cells of all MAC entities indicated in the bitmap.

The Dual Connectivity PHR MAC Control Element is defined as follows:

- C_i: this field indicates the presence of a PH field for the serving cell of any MAC entity, except the PCell, with *SCellIndex* i as specified in [8]. The C_i field set to "1" indicates that a PH field for the serving cell with *SCellIndex* i is reported. The C_i field set to "0" indicates that a PH field for the serving cell with *SCellIndex* i is not reported;

- R: reserved bit, set to "0";

- V: this field indicates if the PH value is based on a real transmission or a reference format. For Type 1 PH, V=0 indicates real transmission on PUSCH and V=1 indicates that a PUSCH reference format is used. For Type 2 PH, V=0 indicates real transmission on PUCCH and V=1 indicates that a PUCCH reference format is used. Furthermore, for both Type 1 and Type 2 PH, V=0 indicates the presence of the octet containing the associated $P_{CMAX,c}$ field, and V=1 indicates that the octet containing the associated $P_{CMAX,c}$ field is omitted;

- Power Headroom (PH): this field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.6-1 (the corresponding measured values in dB can be found in subclause 9.1.8.4 of [9]);

- P: this field indicates whether power backoff due to power management is applied (as allowed by $P\text{-}MPR_c$ [10]). The MAC entity shall set P=1 if the corresponding $P_{CMAX,c}$ field would have had a different value if no power backoff due to power management had been applied;

- $P_{CMAX,c}$: if present, this field indicates the $P_{CMAX,c}$ or $\widetilde{P}_{CMAX,c}$ [2] used for calculation of the preceding PH field. The reported $P_{CMAX,c}$ and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.6a-1 (the corresponding measured values in dBm can be found in subclause 9.6.1 of [9]).

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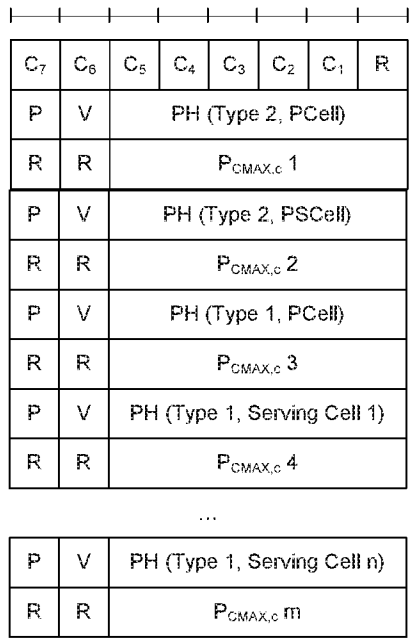


Figure 6.1.3.6b-1: Dual Connectivity PHR MAC Control Element

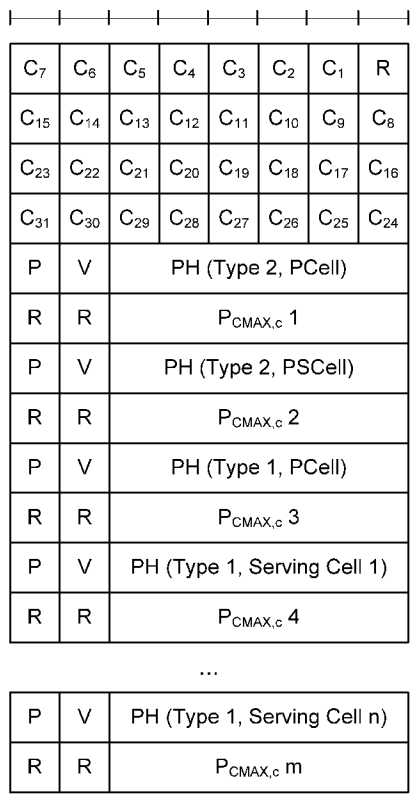


Figure 6.1.3.6b-2: Dual Connectivity PHR MAC Control Element supporting 32 serving cells with configured uplink

6.1.3.7 MCH Scheduling Information MAC Control Element

The MCH Scheduling Information MAC Control Element illustrated in Figure 6.1.3.7-1 is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-4. This control element has a variable size. For each MTCH the fields below are included:

- LCID: this field indicates the Logical Channel ID of the MTCH. The length of the field is 5 bits;
- Stop MTCH: this field indicates the ordinal number of the subframe within the MCH scheduling period, counting only the subframes allocated to the MCH, where the corresponding MTCH stops. Value 0 corresponds to the first subframe. The length of the field is 11 bits. The special Stop MTCH value 2047 indicates that the corresponding MTCH is not scheduled. The value range 2043 to 2046 is reserved.

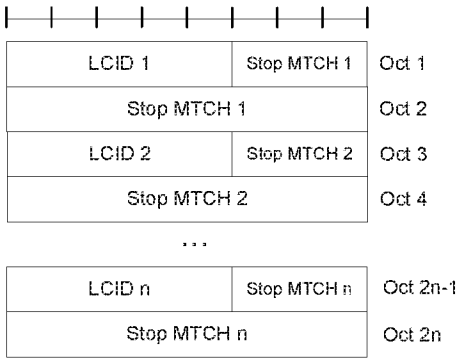


Figure 6.1.3.7-1: MCH Scheduling Information MAC control element

6.1.3.7a Extended MCH Scheduling Information MAC Control Element

The Extended MCH Scheduling Information MAC control element illustrated in Figure 6.1.3.7-2 is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-4. This control element has a variable size.

For each MTCH the fields below are included:

- LCID: this field indicates the Logical Channel ID of the MTCH. The length of the field is 5 bits;
- Stop MTCH: this field indicates the ordinal number of the subframe within the MCH scheduling period, counting only the subframes allocated to the MCH, where the corresponding MTCH stops. Value 0 corresponds to the first subframe. The length of the field is 11 bits. The special Stop MTCH value 2047 indicates that the corresponding MTCH is not scheduled. The value range 2043 to 2046 is reserved.

For each MTCH the fields below may be included:

- LCID: this field indicates the Logical Channel ID of the MTCH. The length of the field is 5 bits. LCIDs x…x+y shall be equal to or a subset of the LCIDs 1…n;
- S: this field indicates that the transmission of the corresponding MTCH is to be suspended. The S field is set to 000. All other values are reserved.

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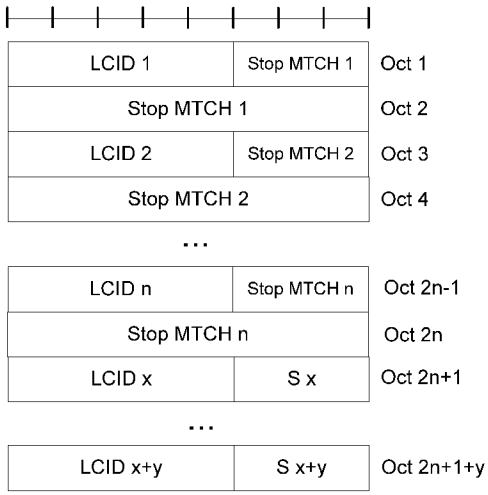


Figure 6.1.3.7a-1: Extended MCH Scheduling Information MAC control element

6.1.3.8 Activation/Deactivation MAC Control Elements

The Activation/Deactivation MAC control element of one octet is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1. It has a fixed size and consists of a single octet containing seven C-fields and one R-field. The Activation/Deactivation MAC control element with one octet is defined as follows (figure 6.1.3.8-1).

The Activation/Deactivation MAC control element of four octets is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1. It has a fixed size and consists of a four octets containing 31 C-fields and one R-field. The Activation/Deactivation MAC control element of four octets is defined as follows (figure 6.1.3.8-2).

For the case with no serving cell with a *ServCellIndex* [8] larger than 7, Activation/Deactivation MAC control element of one octet is applied, otherwise Activation/Deactivation MAC control element of four octets is applied.

- C_i: if there is an SCell configured with *SCellIndex* i as specified in [8], this field indicates the activation/deactivation status of the SCell with *SCellIndex* i , else the MAC entity shall ignore the C_i field. The C_i field is set to "1" to indicate that the SCell with *SCellIndex* i shall be activated. The C_i field is set to "0" to indicate that the SCell with *SCellIndex* i shall be deactivated;

- R: Reserved bit, set to "0".

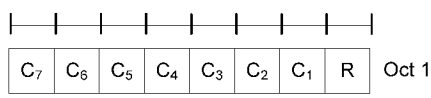


Figure 6.1.3.8-1: Activation/Deactivation MAC control element of one octet

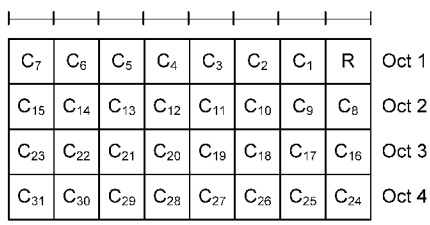


Figure 6.1.3.8-2: Activation/Deactivation MAC control element of four octets

6.1.3.9 Long DRX Command MAC Control Element

The Long DRX Command MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1.

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It has a fixed size of zero bits.

6.1.4 MAC PDU (transparent MAC)

A MAC PDU consists solely of a MAC Service Data Unit (MAC SDU) whose size is aligned to a TB; as described in figure 6.1.4-1. This MAC PDU is used for transmissions on PCH, BCH, DL-SCH including BCCH, SL-DCH and SL-BCH.

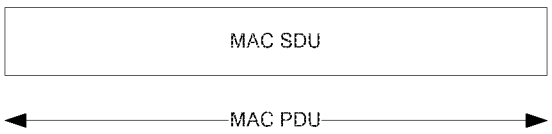


Figure 6.1.4-1: Example of MAC PDU (transparent MAC)

6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of a MAC header and zero or more MAC Random Access Responses (MAC RAR) and optionally padding as described in figure 6.1.5-4.

The MAC header is of variable size.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader corresponding to a MAC RAR except for the Backoff Indicator subheader. If included, the Backoff Indicator subheader is only included once and is the first subheader included within the MAC PDU header.

A MAC PDU subheader consists of the three header fields E/T/RAPID (as described in figure 6.1.5-1) but for the Backoff Indicator subheader which consists of the five header field E/T/R/R/BI (as described in figure 6.1.5-2).

A MAC RAR consists of the four fields R/Timing Advance Command/UL Grant/Temporary C-RNTI (as described in figure 6.1.5-3).

Padding may occur after the last MAC RAR. Presence and length of padding is implicit based on TB size, size of MAC header and number of RARs.

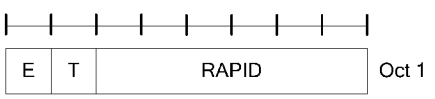


Figure 6.1.5-1: E/T/RAPID MAC subheader

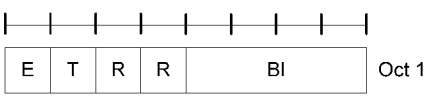


Figure 6.1.5-2: E/T/R/R/BI MAC subheader

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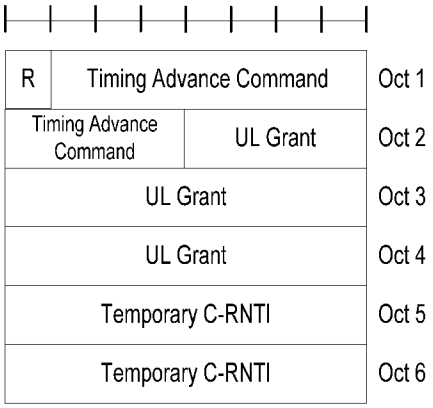


Figure 6.1.5-3: MAC RAR

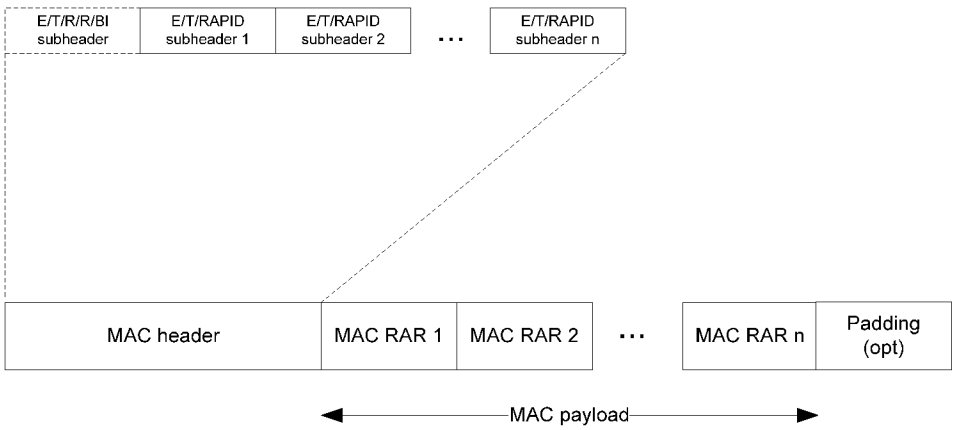


Figure 6.1.5-4: Example of MAC PDU consisting of a MAC header and MAC RARs

6.1.6 MAC PDU (SL-SCH)

A MAC PDU consists of a MAC header, one or more MAC Service Data Units (MAC SDU), and optionally padding; as described in Figure 6.1.6-4.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one SL-SCH subheader, one or more MAC PDU subheaders; each subheader except SL-SCH subheader corresponds to either a MAC SDU or padding.

The SL-SCH subheader consists of the seven header fields V/R/R/R/R/SRC/DST.

A MAC PDU subheader consists of the six header fields R/R/E/LCID/F/L but for the last subheader in the MAC PDU. The last subheader in the MAC PDU consists solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

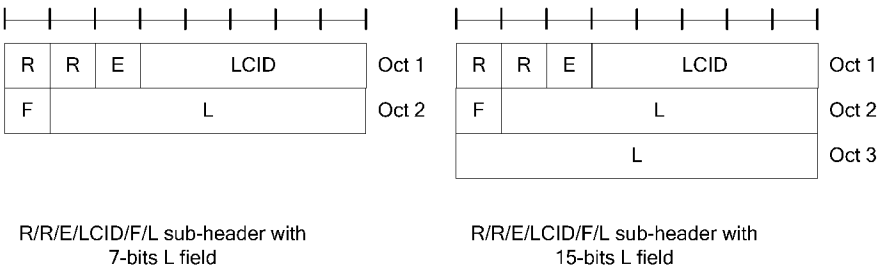


Figure 6.1.6-1: R/R/E/LCID/F/L MAC subheader

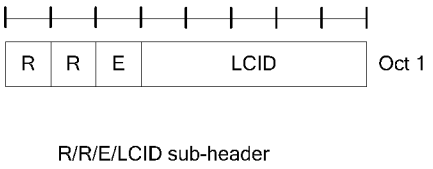


Figure 6.1.6-2: R/R/E/LCID MAC subheader

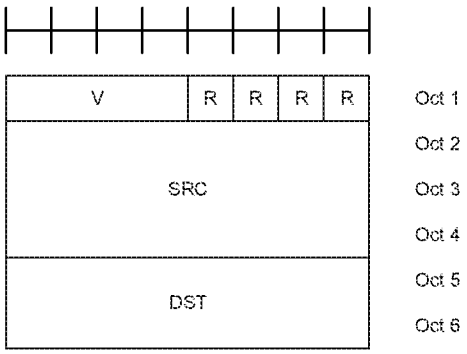


Figure 6.1.6-3: SL-SCH MAC subheader

MAC PDU subheaders have the same order as the corresponding MAC SDUs and padding.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the MAC entity shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed after the SL-SCH subheader and before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB.

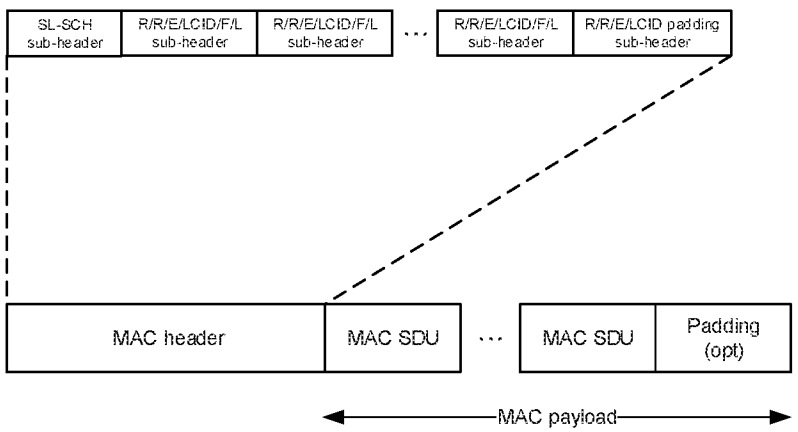


Figure 6.1.6-4: Example of MAC PDU consisting of MAC header, MAC SDUs and padding

6.2 Formats and parameters

6.2.1 MAC header for DL-SCH, UL-SCH and MCH

The MAC header is of variable size and consists of the following fields:

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- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC control element or padding as described in tables 6.2.1-1, 6.2.1-2 and 6.2.1-4 for the DL-SCH, UL-SCH and MCH respectively. There is one LCID field for each MAC SDU, MAC control element or padding included in the MAC PDU. In addition to that, one or two additional LCID fields are included in the MAC PDU, when single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU. A UE of Category 0 [12] shall indicate CCCH using LCID "01011", otherwise the UE shall indicate CCCH using LCID "00000". The LCID field size is 5 bits;

- L: The Length field indicates the length of the corresponding MAC SDU or variable-sized MAC control element in bytes. There is one L field per MAC PDU subheader except for the last subheader and subheaders corresponding to fixed-sized MAC control elements. The size of the L field is indicated by the F field and F2 field;

- F: The Format field indicates the size of the Length field as indicated in table 6.2.1-3. There is one F field per MAC PDU subheader except for the last subheader and subheaders corresponding to fixed-sized MAC control elements and expect for when F2 is set to 1. The size of the F field is 1 bit. If the F field is included; if the size of the MAC SDU or variable-sized MAC control element is less than 128 bytes, the value of the F field is set to 0, otherwise it is set to 1;

- F2: The Format2 field indicates the size of the Length field as indicated in table 6.2.1-3. There is one F2 field per MAC PDU subheader. The size of the F2 field is 1 bit. If the size of the MAC SDU or variable-sized MAC control element is larger than 32767 bytes, and if the corresponding subheader is not the last subheader, the value of the F2 field is set to 1, otherwise it is set to 0.

- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least R/F2/E/LCID fields. The E field is set to "0" to indicate that either a MAC SDU, a MAC control element or padding starts at the next byte;

- R: Reserved bit, set to "0".

The MAC header and subheaders are octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-10111	Reserved
11000	Activation/Deactivation (4 octets)
11001	SC-MCCH, SC-MTCH (see note)
11010	Long DRX Command
11011	Activation/Deactivation (1 octet)
11100	UE Contention Resolution Identity
11101	Timing Advance Command
11110	DRX Command
11111	Padding
NOTE: Both SC-MCCH and SC-MTCH cannot be multiplexed with other logical channels in the same MAC PDU except for Padding	

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Table 6.2.1-2 Values of LCID for UL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011	CCCH
01100-10101	Reserved
10110	Truncated Sidelink BSR
10111	Sidelink BSR
11000	Dual Connectivity Power Headroom Report
11001	Extended Power Headroom Report
11010	Power Headroom Report
11011	C-RNTI
11100	Truncated BSR
11101	Short BSR
11110	Long BSR
11111	Padding

Table 6.2.1-3 Values of F and F2 fields:

Index of F2	Index of F	Size of Length field (in bits)
0	0	7
	1	15
1	-	16

Table 6.2.1-4 Values of LCID for MCH

Index	LCID values
00000	MCCH (see note)
00001-11100	MTCH
11101	Reserved
11110	MCH Scheduling Information or Extended MCH Scheduling Information
11111	Padding
NOTE: If there is no MCCH on MCH, an MTCH could use this value.	

6.2.2 MAC header for Random Access Response

The MAC header is of variable size and consists of the following fields:

- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate at least another set of E/T/RAPID fields follows. The E field is set to "0" to indicate that a MAC RAR or padding starts at the next byte;
- T: The Type field is a flag indicating whether the MAC subheader contains a Random Access ID or a Backoff Indicator. The T field is set to "0" to indicate the presence of a Backoff Indicator field in the subheader (BI). The T field is set to "1" to indicate the presence of a Random Access Preamble ID field in the subheader (RAPID);
- R: Reserved bit, set to "0";
- BI: The Backoff Indicator field identifies the overload condition in the cell. The size of the BI field is 4 bits;
- RAPID: The Random Access Preamble IDentitfier field identifies the transmitted Random Access Preamble (see subclause 5.1.3). The size of the RAPID field is 6 bits.

The MAC header and subheaders are octet aligned.

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6.2.3 MAC payload for Random Access Response

The MAC RAR is of fixed size and consists of the following fields:

- R: Reserved bit, set to "0";
- Timing Advance Command: The Timing Advance Command field indicates the index value T_A (0, 1, 2… 1282) used to control the amount of timing adjustment that the MAC entity has to apply (see subclause 4.2.3 of [2]). The size of the Timing Advance Command field is 11 bits;
- UL Grant: The UpLink Grant field indicates the resources to be used on the uplink (see subclause 6.2 of [2]). The size of the UL Grant field is 20 bits;
- Temporary C-RNTI: The Temporary C-RNTI field indicates the temporary identity that is used by the MAC entity during Random Access. The size of the Temporary C-RNTI field is 16 bits.

The MAC RAR is octet aligned.

6.2.4 MAC header for SL-SCH

The MAC header is of variable size and consists of the following fields:

- V: The MAC PDU format version number field indicates which version of the SL-SCH subheader is used. In this version of the specification two format versions are defined, and this field shall therefore be set to "0001" or "0010". The V field size is 4 bits;
- SRC: The Source Layer-2 ID field carries the identity of the source. It is set to the ProSe UE ID. The SRC field size is 24 bits. If the V field is set to "0001", this identifier is a groupcast identifier. If the V field is set to "0010", this identifier is a unicast identifier;
- DST: The DST field carries the 16 most significant bits of the Destination Layer-2 ID. The Destination Layer-2 ID is set to the ProSe Layer-2 Group ID. If the V field is set to "0001", this identifier is a groupcast identifier. If the V field is set to "0010", this identifier is a unicast identifier;
- LCID: The Logical Channel ID field uniquely identifies the logical channel instance within the scope of one Source Layer-2 ID and Destination Layer-2 ID pair of the corresponding MAC SDU or padding as described in table 6.2.4-1. There is one LCID field for each MAC SDU or padding included in the MAC PDU. In addition to that, one or two additional LCID fields are included in the MAC PDU, when single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU. The LCID field size is 5 bits;
- L: The Length field indicates the length of the corresponding MAC SDU in bytes. There is one L field per MAC PDU subheader except for the last subheader. The size of the L field is indicated by the F field;
- F: The Format field indicates the size of the Length field as indicated in table 6.2.4-2. There is one F field per MAC PDU subheader except for the last subheader. The size of the F field is 1 bit. If the size of the MAC SDU is less than 128 bytes, the value of the F field is set to 0, otherwise it is set to 1;
- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least R/R/E/LCID fields. The E field is set to "0" to indicate that either a MAC SDU or padding starts at the next byte;
- R: Reserved bit, set to "0".

The MAC header and subheaders are octet aligned.

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Table 6.2.4-1 Values of LCID for SL-SCH

Index	LCID values
00000	Reserved
00001-01010	Identity of the logical channel
01011-11011	Reserved
11100	PC5-S messages that are not protected
11101	PC5-S messages "Direct Security Mode Command" and "Direct Security Mode Complete"
11110	Other PC5-S messages that are protected
11111	Padding

Table 6.2.4-2 Values of F field:

Index	Size of Length field (in bits)
0	7
1	15

7 Variables and constants

7.1 RNTI values

RNTI values are presented in Table 7.1-1 and their usage and associated Transport Channels and Logical Channels are presented in Table 7.1-2.

Table 7.1-1: RNTI values.

Value (hexa-decimal)	RNTI
0000	N/A
0001-003C	RA-RNTI, C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, eIMTA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and SL-RNTI (see note), G-RNTI
003D-FFF3	C-RNTI, Semi-Persistent Scheduling C-RNTI, eIMTA-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and SL-RNTI, G-RNTI
FFF4-FFF9	Reserved for future use
FFFA	SC-N-RNTI
FFFB	SC-RNTI
FFFC	CC-RNTI
FFFD	M-RNTI
FFFE	P-RNTI
FFFF	SI-RNTI

NOTE: A MAC entity uses the same C-RNTI on all Serving Cells.

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Table 7.1-2: RNTI usage.

RNTI	Usage	Transport Channel	Logical Channel
P-RNTI	Paging and System Information change notification	PCH	PCCH
SI-RNTI	Broadcast of System Information	DL-SCH	BCCH
M-RNTI	MCCH Information change notification	N/A	N/A
RA-RNTI	Random Access Response	DL-SCH	N/A
eIMTA-RNTI	eIMTA TDD UL/DL configuration notification	N/A	N/A
Temporary C-RNTI	Contention Resolution (when no valid C-RNTI is available)	DL-SCH	CCCH
Temporary C-RNTI	Msg3 transmission	UL-SCH	CCCH, DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	UL-SCH	DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	DL-SCH	CCCH, DCCH, DTCH
C-RNTI	Triggering of PDCCH ordered random access	N/A	N/A
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (activation, reactivation and retransmission)	DL-SCH, UL-SCH	DCCH, DTCH
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (deactivation)	N/A	N/A
TPC-PUCCH-RNTI	Physical layer Uplink power control	N/A	N/A
TPC-PUSCH-RNTI	Physical layer Uplink power control	N/A	N/A
SL-RNTI	Dynamically scheduled sidelink transmission	SL-SCH	STCH
SC-RNTI	Dynamically scheduled SC-PTM control information	DL-SCH	SC-MCCH
G-RNTI	Dynamically scheduled SC-PTM transmission	DL-SCH	SC-MTCH
SC-N-RNTI	SC-MCCH Information change notification	N/A	N/A
CC-RNTI	Providing common control PDCCH information	N/A	N/A

7.2 Backoff Parameter values

Backoff Parameter values are presented in Table 7.2-1.

Table 7.2-1: Backoff Parameter values.

Index	Backoff Parameter value (ms)
0	0
1	10
2	20
3	30
4	40
5	60
6	80
7	120
8	160
9	240
10	320
11	480
12	960
13	Reserved
14	Reserved
15	Reserved

The reserved values of the backoff parameter if received by the current release version UEs shall be taken as 960 ms.

7.3 PRACH Mask Index values

Table 7.3-1: PRACH Mask Index values

PRACH Mask Index	Allowed PRACH (FDD)	Allowed PRACH (TDD)
0	All	All
1	PRACH Resource Index 0	PRACH Resource Index 0
2	PRACH Resource Index 1	PRACH Resource Index 1
3	PRACH Resource Index 2	PRACH Resource Index 2
4	PRACH Resource Index 3	PRACH Resource Index 3
5	PRACH Resource Index 4	PRACH Resource Index 4
6	PRACH Resource Index 5	PRACH Resource Index 5
7	PRACH Resource Index 6	Reserved
8	PRACH Resource Index 7	Reserved
9	PRACH Resource Index 8	Reserved
10	PRACH Resource Index 9	Reserved
11	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe
12	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe
13	Reserved	1st PRACH Resource Index in subframe
14	Reserved	2nd PRACH Resource Index in subframe
15	Reserved	3rd PRACH Resource Index in subframe

7.4 Subframe_Offset values

Subframe_Offset values are presented in Table 7.4-1.

Table 7.4-1: Subframe_Offset values

TDD UL/DL configuration	Position of initial Semi-Persistent grant	Subframe_Offset value (ms)
0	N/A	0
1	Subframes 2 and 7	1
	Subframes 3 and 8	-1
2	Subframe 2	5
	Subframe 7	-5
3	Subframes 2 and 3	1
	Subframe 4	-2
4	Subframe 2	1
	Subframe 3	-1
5	N/A	0
6	N/A	0

7.5 TTI_BUNDLE_SIZE value

The parameter TTI_BUNDLE_SIZE is 4.

7.6 DELTA_PREAMBLE values

The DELTA_PREAMBLE preamble format based power offset values are presented in Table 7.6-1.

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Table 7.6-1: DELTA_PREAMBLE values.

Preamble Format	DELTA_PREAMBLE value
0	0 dB
1	0 dB
2	-3 dB
3	-3 dB
4	8 dB

Where the Preamble Format is given by *prach-ConfigIndex* [7].

7.7 HARQ RTT Timer

For each serving cell, in case of FDD configuration on the serving cell which carries the HARQ feedback for this serving cell the HARQ RTT Timer is set to 8 subframes. For each serving cell, in case of TDD configuration on the serving cell which carries the HARQ feedback for this serving cell the HARQ RTT Timer is set to k + 4 subframes, where k is the interval between the downlink transmission and the transmission of associated HARQ feedback, as indicated in subclauses 10.1 and 10.2 of [2] , and for an RN configured with *rn-SubframeConfig* [8] and not suspended, as indicated in Table 7.5.1-1 of [11].

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Annex A (normative): Handling of measurement gaps

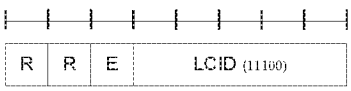
In this specification, the subframes which cannot be used for transmission according to subclause 8.1.2.1 of [9] are also considered as part of measurement gaps in uplink. Measurement gaps are defined in [9].

In a subframe that is part of a measurement gap, the UE shall not perform the transmission of HARQ feedback and CQI/PMI/RI/PTI, and SRS shall not be reported.

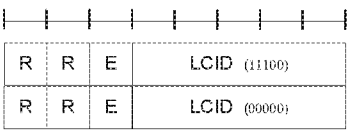
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Annex B (normative): Contention resolution for RACH access

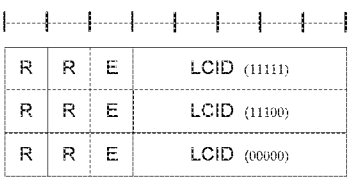
When checking whether contention resolution was successful a MAC entity considers the MAC header structures shown below for the processing of a MAC PDU containing a UE Contention Resolution Identity MAC control element.



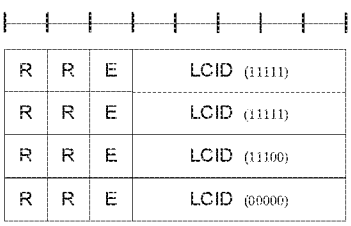
Case 1: MAC subheader for MAC control element



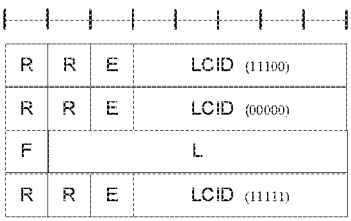
Case 2: MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



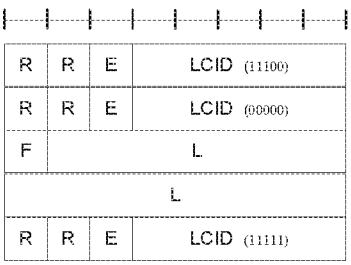
Case 3: MAC subheader for single-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 4: MAC subheaders for two-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 5: MAC subheader for MAC control element + MAC subheader (7-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding



Case 6: MAC subheader for MAC control element + MAC subheader (15-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding

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Annex C (informative): Intended UE behaviour for DRX Timers

When a DRX timer is set to a value of X, and n denotes the subframe in which the related event is triggered according to the subclause 5.7, the intended behaviours of each DRX timer are presented in the Table C-1 below:

Table C-1: Intended UE behaviour for DRX timers

DRX Timers	Intended UE behaviour ([x, y] means including subframe x and y)
drx-InactivityTimer	The MAC entity monitors PDCCH in PDCCH-subframes during the subframes [n+1, n+m]. The MAC entity starts or restarts drxShortCycleTimer, and uses Short DRX Cycle in the subframe n+m+1, if configured.
mac-ContentionResolutionTimer	The MAC entity monitors PDCCH in PDCCH-subframes during the subframes [n+1, n+X].
drx-RetransmissionTimer	The MAC entity monitors PDCCH in PDCCH-subframes during the subframes [n, n+m-1].
onDurationTimer	The MAC entity monitors PDCCH in PDCCH-subframes during the subframes [n, n+m-1].
drxShortCycleTimer	The MAC entity uses the Short DRX Cycle during the subframes [n, n+X-1]. The MAC entity starts to use the Long DRX Cycle in the subframe n+X.
HARQ RTT Timer	The MAC entity starts drx-RetransmissionTimer in the subframe n+X, if needed.
NOTE: For FDD, m is equal to X; for TDD, m is equal to the minimum number of subframes so that X PDCCH-subframes are included during the subframes [x, y]. NOTE: A MAC entity configured with eIMTA monitors PDCCH in some subframe(s) in addition to PDCCH-subframes, as specified in subclause 5.7.	

For drx-InactivityTimer and drx-RetransmissionTimer, if X=0, the timer does not make the MAC entity to monitor the PDCCH.

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Annex D (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2007-06	RAN2#58 bis	R2-072710			MAC Protocol Specification Baseline	-	
2007-06	RAN2#58 bis	R2-072912			Text Proposal for UL HARQ (Tdoc R2-072708) Text Proposal for DL HARQ (Tdoc R2-072707) Text Proposal for RACH procedure (Tdoc R2-072640) Text Proposal for Logical Channel prioritization (Tdoc R2-072643)		0.1.0
2007-06	RAN2#58 bis	R2-072994			Basic MAC PDU structure (Tdoc R2-072983) with updates Agreements on time-frequency resource configuration (Tdoc R2-072993) Agreement on RA-RNTI association (Tdoc R2-072993) Clarification on RA Response reception (Tdoc R2-072993)	0.1.0	0.1.1
2007-08	RAN2#59	R2-073715			Removed reference to non-existing table (Tdoc R2-073473) Incorrect mapping of logical to transport channel (Tdoc R2-073473) Un-necessary error checking in HARQ process procedure (Tdoc R2-073473) Removal of reference to timing relation for HARQ feedback (Tdoc R2-073473) Correction of Internal variable name (Tdoc R2-073473) Correction of procedure in case of successful HARQ reception (Tdoc R2-073473)	0.1.1	0.2.0
2007-09	RAN2#59	R2-073885			Text proposal for Random Access procedure Text proposal on HARQ clarification for TDD Text proposal on HARQ for grants	0.2.0	0.2.1
2007-09	RAN#37	RP-070688			Clean version for information	0.2.1	1.0.0
2007-10	RAN2#59 bis	R2-074530			Editorial update with Editor's notes (Tdoc R2-074211).	1.0.0	1.1.0
2007-11	RAN2#60	R2-075093			Agreements on MAC PDU format (R2-074536) Corrections on Random Access Procedure (R2-074536)	1.1.0	1.1.1
2007-11	RAN2#60	R2-075243			Endorsement of v1.1.1 Removal of FFS on DL CCCH existence	1.1.1	1.2.0
2007-11	RAN2#60	R2-075488			Agreement on identity used Random Access Response (R2-075038) Agreement on Local Nack1 (R2-074949) PUCCH Resource handling (R2-075432) UL HARQ agreements (R2-075432) Agreements on semi-persistent scheduling (R2-075432, 36.300) Agreements on BSR/SR triggers (R2-075432) Agreements on BSR contents (R2-075432) Agreements on Timing Advance principles (36.300) Agreements on DRX control (36.300) Handling of P-BCH, D-BCH, PCH (R2-075246)	1.2.0	1.3.0
2007-11	RP-38	RP-070917			Clean version, presented at TSG RAN-38 for approval	1.3.0	2.0.0
2007-12	RP-38	-			Approved at TSG RAN-38 and placed under change control	2.0.0	8.0.0
2008-03	RP-39	RP-080162	0001	2	CR to 36.321 with E-UTRA MAC protocol specification update	8.0.0	8.1.0
2008-05	RP-40	RP-080410	0002	1	36.321 CR covering agreements of RAN2 #61bis and RAN2#62	8.1.0	8.2.0
2008-09	RP-41	RP-080690	0003	-	Clarification on data available for transmission for BSR triggering	8.2.0	8.3.0
	RP-41	RP-080690	0004	-	CR to 36.321 on failure indication after maximum number of HARQ transmissions	8.2.0	8.3.0
	RP-41	RP-080690	0005	4	Clarifications and Corrections of DL and UL Data Transfer (SCH, RACH and SR)	8.2.0	8.3.0
	RP-41	RP-080690	0006	-	CR to 36.321 on Buffer size levels for BSR	8.2.0	8.3.0
	RP-41	RP-080690	0007	-	Clarifications on DRX	8.2.0	8.3.0
	RP-41	RP-080690	0008	-	Clarification on UE behavior for DRX and configured measurement gaps	8.2.0	8.3.0
	RP-41	RP-080690	0009	3	Correction to MAC Padding BSR	8.2.0	8.3.0
	RP-41	RP-080690	0010	-	Correction to UE transmission power headroom report for LTE	8.2.0	8.3.0
	RP-41	RP-080690	0011	-	Corrections on BSR	8.2.0	8.3.0
	RP-41	RP-080690	0012	-	CR to 36.321 REL-8 on Format of UL grant in Message 2	8.2.0	8.3.0
	RP-41	RP-080690	0015	-	CR to 36.321 REL-8 on PUSCH PUCCH Power Control RNTIs	8.2.0	8.3.0
	RP-41	RP-080690	0016	-	CR to 36.321 REL-8 on RACH uniform random backoff	8.2.0	8.3.0
	RP-41	RP-080690	0017	1	E-UTRA MAC protocol specification update	8.2.0	8.3.0
	RP-41	RP-080690	0020	-	TP for number of HARQ processes and MIMO	8.2.0	8.3.0
	RP-41	RP-080690	0022	-	Update of MAC dedicated preamble expiry	8.2.0	8.3.0

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	RP-41	RP-080690	0027	-	Handling of Semi-Persistent grants and assignments	8.2.0	8.3.0
	RP-41	RP-080690	0051	1	Corrections relating to RACH	8.2.0	8.3.0
	RP-41	RP-080690	0058	1	UL Channel Prioritisation	8.2.0	8.3.0
	RP-41	RP-080690	0071	2	Corrections relating to RACH partitioning	8.2.0	8.3.0
	RP-41	RP-080690	0091	-	Correction on Random Access Response reception behaviour	8.2.0	8.3.0
	RP-41	RP-080690	0103	-	Upper limit of logical channel id	8.2.0	8.3.0
	RP-41	RP-080690	0104	-	Clarifications and Corrections for HARQ operation at TAT expiry and RACH contention resolution	8.2.0	8.3.0
2008-12	RP-42	RP-081018	0105	-	CR0105 to 36.321 [Rel-8] on PHR Periodic Timer Start	8.3.0	8.4.0
	RP-42	RP-081018	0106	1	Proposed R1 of CR0106 to 36.321 [Rel-8] on PHR Reference	8.3.0	8.4.0
	RP-42	RP-081018	0107	1	CR 0107 to 36.321 Interactions between measurement gap and Msg3 transmission	8.3.0	8.4.0
	RP-42	RP-081018	0108	2	Proposed R1 of CR0108 to 36.321 [Rel-8] on PHR Reporting Values	8.3.0	8.4.0
	RP-42	RP-081018	0109	-	Correction relating to equal priorities	8.3.0	8.4.0
	RP-42	RP-081018	0110	-	CR 0110 to 36.321 on Correction to PHR	8.3.0	8.4.0
	RP-42	RP-081018	0112	1	CR0112r1 to 36.321 [Rel-8] Correction to BCCH Reception procedure	8.3.0	8.4.0
	RP-42	RP-081018	0113	-	Contention Resolution Timer	8.3.0	8.4.0
	RP-42	RP-081018	0114	-	PCH reception	8.3.0	8.4.0
	RP-42	RP-081018	0115	-	Correction to reception of assignments and grants	8.3.0	8.4.0
	RP-42	RP-081018	0116	-	Correction on Contention Resolution	8.3.0	8.4.0
	RP-42	RP-081018	0117	2	Proposed R1 of CR0117 to 36.321 [Rel-8] on on SR Clarifications and Repetitions	8.3.0	8.4.0
	RP-42	RP-081078	0118	2	Clarification on Padding value	8.3.0	8.4.0
	RP-42	RP-081018	0119	-	CR 0119 to 36.321 Correction and Clarification on TTI Bundling	8.3.0	8.4.0
	RP-42	RP-081018	0120	1	Clarification of DRX Active Time	8.3.0	8.4.0
	RP-42	RP-081018	0121	4	Text Proposal for Dedicated Preamble Assignment	8.3.0	8.4.0
	RP-42	RP-081018	0122	-	CR0122 to 36.321 [Rel-8] on Message 3 Definition	8.3.0	8.4.0
	RP-42	RP-081018	0123	1	Correction to prevent wrong contention resolution by adaptive retransmission command	8.3.0	8.4.0
	RP-42	RP-081018	0124	-	Bucket Size Parameter	8.3.0	8.4.0
	RP-42	RP-081018	0125	2	CR0125r2 to 36.321 [Rel-8] Correction to Multiple BSR	8.3.0	8.4.0
	RP-42	RP-081018	0127	-	CR0127 to 36.321 [Rel-8] RACH preambles labelling	8.3.0	8.4.0
	RP-42	RP-081018	0128	1	CR0128r1 to 36.321 [Rel-8] merging CR0126r0 and CR0128r0	8.3.0	8.4.0
	RP-42	RP-081018	0129	1	CR0129r1 to 36.321 [Rel-8] Correction to PDU Format	8.3.0	8.4.0
	RP-42	RP-081018	0130	-	CQI/ SRS/PMI/RI transmission during active time	8.3.0	8.4.0
	RP-42	RP-081018	0131	1	NDI and Msg4 Carrying Contention Resolution ID	8.3.0	8.4.0
	RP-42	RP-081018	0132	1	CR0132 to 36.321 [Rel-8] on MAC BSR trigger	8.3.0	8.4.0
	RP-42	RP-081018	0133	-	Clarification about Restarting the Periodic BSR Timer	8.3.0	8.4.0
	RP-42	RP-081018	0134	-	Correction to RA procedure initiated by eNB PDCCH order	8.3.0	8.4.0
	RP-42	RP-081018	0135	1	Correction on PHR triggering condition	8.3.0	8.4.0
	RP-42	RP-081018	0136	-	CR 0136 to 36.321 on Correction to UL HARQ Process for the transmission of Msg3	8.3.0	8.4.0
	RP-42	RP-081018	0137	2	SPS occasions	8.3.0	8.4.0
	RP-42	RP-081018	0138	-	Robustness of Buffer Status Reporting	8.3.0	8.4.0
	RP-42	RP-081018	0139	-	Proposed CR to 36.321 [Rel-8] on UL HARQ and Measurement Gaps	8.3.0	8.4.0
	RP-42	RP-081018	0142	1	TAT and RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0143	1	SRS and CQI Resources Release upon TAT Expiry	8.3.0	8.4.0
	RP-42	RP-081018	0157	1	Proposed CR to 36.321 Correction to RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0162	1	BSR format for reporting empty buffers	8.3.0	8.4.0
	RP-42	RP-081018	0165	-	TTI Bundling Configuration	8.3.0	8.4.0
	RP-42	RP-081018	0166	1	Corrections to semi-persistent scheduling	8.3.0	8.4.0
	RP-42	RP-081018	0167	2	Priotitization of MAC control elements	8.3.0	8.4.0
	RP-42	RP-081018	0168	-	Correction to starting of TA timer	8.3.0	8.4.0
	RP-42	RP-081018	0173	1	Proposed CR to 36.321 SPS implicit release on UL	8.3.0	8.4.0
	RP-42	RP-081018	0174	-	Proposed CR to 36.321 Measurement gaps and SPS	8.3.0	8.4.0
	RP-42	RP-081018	0175	-	Proposed CR to 36.321 Setting reserved bits to zero	8.3.0	8.4.0
	RP-42	RP-081018	0185	-	Proposed CR to 36.321 [Rel-8] MAC ResetReconfig Option 2	8.3.0	8.4.0
	RP-42	RP-081018	0188	2	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0189	-	Corrections to Random Access Procedure	8.3.0	8.4.0
	RP-42	RP-081018	0198	-	Number of HARQ processes for MIMO	8.3.0	8.4.0
	RP-42	RP-081018	0201	-	Corrections to power control and random access	8.3.0	8.4.0
	RP-42	RP-081018	0206	-	Correction on the definition of the PDCCH-subframe	8.3.0	8.4.0
	RP-42	RP-081018	0211	1	Correction to the coexist of SPS-RNTI and SI-RNTI or RA-RNTI	8.3.0	8.4.0
	RP-42	RP-081018	0220	-	Explicit release of SPS	8.3.0	8.4.0
	RP-42	RP-081018	0225	2	Linking HARQ process ID with the SPS resource	8.3.0	8.4.0
	RP-42	RP-081018	0231	-	Bucket Parameter Update	8.3.0	8.4.0
	RP-42	RP-081018	0232	1	Clarification on "PDCCH indicates a new transmission" for DRX	8.3.0	8.4.0
	RP-42	RP-081018	0233	1	Editorial corrections to MAC	8.3.0	8.4.0
	RP-42	RP-081018	0236	-	RB suspension and BSR contents	8.3.0	8.4.0

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	RP-42	RP-081018	0239	-	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0240	2	Preamble group selection	8.3.0	8.4.0
	RP-42	RP-081018	0241	-	Use of dedicated preambles after HO complete	8.3.0	8.4.0
	RP-42	RP-081018	0242	-	Introduction of HARQ RTT Timer	8.3.0	8.4.0
	RP-42	RP-081018	0243	-	Correction to DRX configuration	8.3.0	8.4.0
2009-03	RP-43	RP-090128	0245	-	CR to 36.321 on BSR clarification	8.4.0	8.5.0
	RP-43	RP-090128	0246	2	Freeing of reserved RNTIs	8.4.0	8.5.0
	RP-43	RP-090128	0247	-	Correction to MAC reset	8.4.0	8.5.0
	RP-43	RP-090128	0248	-	Correction to Initialization of Prioritization	8.4.0	8.5.0
	RP-43	RP-090128	0249	-	Local NACKing Optionality MAC CR	8.4.0	8.5.0
	RP-43	RP-090128	0250	1	Position of the Backoff Indicator subheader	8.4.0	8.5.0
	RP-43	RP-090128	0251	-	Missing reserved bit setting	8.4.0	8.5.0
	RP-43	RP-090128	0252	-	Expired TAT and PUSCH transmission	8.4.0	8.5.0
	RP-43	RP-090128	0253	-	Expired TAT and HARQ feedback	8.4.0	8.5.0
	RP-43	RP-090128	0254	1	Counter proposal to R2-090969 on Management for HARQ buffer with TAT	8.4.0	8.5.0
	RP-43	RP-090128	0255	-	HARQ Feedback and Contention Resolution	8.4.0	8.5.0
	RP-43	RP-090128	0256	-	Corrections to redundancy version control for system information	8.4.0	8.5.0
	RP-43	RP-090128	0257	-	Mapping of the RNTIs to different transport channels	8.4.0	8.5.0
	RP-43	RP-090128	0258	-	DRX and UL Retransmissions	8.4.0	8.5.0
	RP-43	RP-090128	0259	-	Definition of DRX Short Cycle Timer	8.4.0	8.5.0
	RP-43	RP-090128	0260	-	Small corrections to RACH	8.4.0	8.5.0
	RP-43	RP-090128	0261	-	Processing of contention resolution message	8.4.0	8.5.0
	RP-43	RP-090128	0262	-	Corrections to power control and random access	8.4.0	8.5.0
	RP-43	RP-090128	0263	-	Missing condition for unsuccessful reception of Msg2	8.4.0	8.5.0
	RP-43	RP-090128	0264	1	Corrections relating to Random Access required inputs	8.4.0	8.5.0
	RP-43	RP-090128	0265	-	Bucket Parameter Update	8.4.0	8.5.0
	RP-43	RP-090128	0266	2	Correction to Handling of triggered PHR	8.4.0	8.5.0
	RP-43	RP-090128	0267	-	SPS resource release on D-SR failure	8.4.0	8.5.0
	RP-43	RP-090128	0269	2	NDI handling when measurement gap and SPS occassion collide	8.4.0	8.5.0
	RP-43	RP-090128	0270	-	Correction relating to PDCCH order	8.4.0	8.5.0
	RP-43	RP-090128	0271	-	Error Handling	8.4.0	8.5.0
	RP-43	RP-090128	0272	-	Various clarifications/corrections to TS36.321	8.4.0	8.5.0
	RP-43	RP-090128	0273	1	Disassembly, Demultiplexing and Multiplexing functions	8.4.0	8.5.0
	RP-43	RP-090128	0274	1	Miscellaneous corrections to MAC	8.4.0	8.5.0
	RP-43	RP-090128	0275	2	CR on Interactions between Msg3 transmission and TTI bundling	8.4.0	8.5.0
	RP-43	RP-090128	0276	-	TTI Bundling	8.4.0	8.5.0
	RP-43	RP-090128	0278	1	Correction to BSR trigger at serving cell change	8.4.0	8.5.0
	RP-43	RP-090128	0279	1	Correction to Release of SPS	8.4.0	8.5.0
	RP-43	RP-090128	0280	2	Usage of RRC Parameters	8.4.0	8.5.0
	RP-43	RP-090128	0281	-	Clarification of MAC Timer status	8.4.0	8.5.0
	RP-43	RP-090128	0282	1	Correction on MAC PDU subheader description	8.4.0	8.5.0
	RP-43	RP-090128	0283	1	UE behaviour at CURRENT_TX_NB reaches maximum value	8.4.0	8.5.0
	RP-43	RP-090128	0285	-	Reporting During DRX	8.4.0	8.5.0
	RP-43	RP-090128	0289	-	NDI handling after random access procedure	8.4.0	8.5.0
	RP-43	RP-090128	0290	1	Dedicated preamble handling after random access failure	8.4.0	8.5.0
	RP-43	RP-090128	0292	-	NDI and grant in Message 2	8.4.0	8.5.0
	RP-43	RP-090128	0293	1	Correction relating to BCCH HARQ	8.4.0	8.5.0
	RP-43	RP-090128	0300	1	Corrections to Msg3 definition and usage	8.4.0	8.5.0
	RP-43	RP-090128	0303	-	PRACH selection must use prach-ConfigurationIndex	8.4.0	8.5.0
	RP-43	RP-090128	0305	-	Clarification on RETX_BSR_TIMER	8.4.0	8.5.0
	RP-43	RP-090128	0307	3	MAC Structure in UE Side	8.4.0	8.5.0
	RP-43	RP-090128	0308	-	Clarification on Random Access Procedure	8.4.0	8.5.0
	RP-43	RP-090128	0314	-	Clarification on the CR timer	8.4.0	8.5.0
	RP-43	RP-090128	0316	-	Correction on BSR	8.4.0	8.5.0
	RP-43	RP-090128	0318	1	Clarification on MAC reconfiguration of timers and counters	8.4.0	8.5.0
	RP-43	RP-090128	0320	-	HARQ feedback, CQI/PMI/RI and SRS transmissions and measurement gaps	8.4.0	8.5.0
	RP-43	RP-090128	0324	-	MAC PDU subheader corresponding to padding	8.4.0	8.5.0
	RP-43	RP-090128	0333	-	CR On Backoff table	8.4.0	8.5.0
	RP-43	RP-090128	0334	3	TTI Bundling Operation	8.4.0	8.5.0
	RP-43	RP-090128	0341	1	Enforcing new transmission after flushing HARQ process	8.4.0	8.5.0
2009-06	RP-44	RP-090513	0342	-	Correction on HARQ feedback transmission	8.5.0	8.6.0
	RP-44	RP-090513	0343	1	Clarification on the DL assignment/UL grant reception in SPS	8.5.0	8.6.0
	RP-44	RP-090513	0344	1	PHR timer handling after handover	8.5.0	8.6.0
	RP-44	RP-090513	0346	2	MAC PDU for Msg2	8.5.0	8.6.0
	RP-44	RP-090513	0347	2	MAC Error handling	8.5.0	8.6.0
	RP-44	RP-090513	0348	-	Correction on SR cancellation	8.5.0	8.6.0
	RP-44	RP-090513	0349	1	Correction to RETX_BSR_TIMER	8.5.0	8.6.0
	RP-44	RP-090513	0350	1	CR to 36.321 on UL SPS Implicit Release	8.5.0	8.6.0
	RP-44	RP-090513	0351	2	Various correction to MAC	8.5.0	8.6.0

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	RP-44	RP-090513	0369	-	Correction to Uplink grant by temporary C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0370	-	Clarification on simultaneous reception of RA-RNTI and C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0374	-	Correction on timeAlignmentTimer validity in MAC	8.5.0	8.6.0
	RP-44	RP-090513	0376	1	CR for MAC padding	8.5.0	8.6.0
	RP-44	RP-090513	0377	-	Correction to duplicate reception of TA command (2nd method)	8.5.0	8.6.0
2009-09	RP-45	RP-090906	0379	-	Correction to NDI semantics	8.6.0	8.7.0
	RP-45	RP-090906	0380	1	Minor corrections to 36.321	8.6.0	8.7.0
	RP-45	RP-090906	0381	2	UE behaviour when MBSFN subframe and a configured downlink assignment collide	8.6.0	8.7.0
	RP-45	RP-090906	0399	-	Correction to HARQ process ID for DL SPS retransmissions	8.6.0	8.7.0
2009-09	RP-45	RP-090934	0390	3	Improvement of cancellation of SR	8.7.0	9.0.0
	RP-45	RP-090934	0396	-	Periodic CQI/PMI/RI masking	8.7.0	9.0.0
2009-12	RP-46	RP-091341	0401	2	Capturing MBMS agreements in MAC	9.0.0	9.1.0
	RP-46	RP-091314	0403	2	Clarification on BSR trigger	9.0.0	9.1.0
	RP-46	RP-091346	0404	-	Correction on HARQ Process ID for DL SPS and DRX	9.0.0	9.1.0
	RP-46	RP-091314	0406	-	RNTI for CCCH	9.0.0	9.1.0
	RP-46	RP-091346	0407	1	SR prohibit mechanism for UL SPS	9.0.0	9.1.0
	RP-46	RP-091346	0409	-	Clarification on monitoring of PDCCH	9.0.0	9.1.0
	RP-46	RP-091346	0410	-	Introduction of SR prohibit timer	9.0.0	9.1.0
2010-03	RP-47	RP-100305	0414	-	Correction to MBMS scheduling terminology	9.1.0	9.2.0
	RP-47	RP-100305	0415	-	Corrections to TS 36.321 on MBMS	9.1.0	9.2.0
	RP-47	RP-100305	0421	1	Error handling for MBMS PDU	9.1.0	9.2.0
	RP-47	RP-100308	0422	-	Renaming CR as consequence of ASN.1 review	9.1.0	9.2.0
2010-06	RP-48	RP-100536	0424	-	Clarification on UE behaviour w.r.t DRX cycle change and onDurationTimer test (Procedural change)	9.2.0	9.3.0
	RP-48	RP-100554	0425	1	Correction to MBMS description	9.2.0	9.3.0
	RP-48	RP-100556	0426	-	Correction to PHR triggering	9.2.0	9.3.0
	RP-48	RP-100536	0430	-	Processing of contention resolution message	9.2.0	9.3.0
2010-12	RP-50	RP-101226	0436	2	Introduction of Carrier Aggregation	9.3.0	10.0.0
	RP-50	RP-101228	0437	1	Introduction of relays in MAC	9.3.0	10.0.0
	RP-50	RP-101225	0447	-	HARQ operation for UL multiple antenna transmission	9.3.0	10.0.0
2011-03	RP-51	RP-110280	0449	-	PHR Trigger for Power Reduction Due to Power Management	10.0.0	10.1.0
	RP-51	RP-110289	0450	1	Power Headroom Reporting	10.0.0	10.1.0
	RP-51	RP-110289	0451	-	Cancellation of BSR	10.0.0	10.1.0
	RP-51	RP-110289	0453	1	Counterproposal to Corrections to the Carrier Aggregation functionality in MAC	10.0.0	10.1.0
	RP-51	RP-110280	0454	-	Adding a Power Management indication in PHR	10.0.0	10.1.0
	RP-51	RP-110289	0457	2	CR on SCell Activation	10.0.0	10.1.0
	RP-51	RP-110289	0461	2	Unification of Extended PHR MAC CE formats	10.0.0	10.1.0
	RP-51	RP-110289	0465	1	Clarification for CA and TTI bundling in MAC	10.0.0	10.1.0
2011-06	RP-52	RP-110846	0466	-	CQI reporting and deactivation timer	10.1.0	10.2.0
	RP-52	RP-110846	0467	2	Miscellaneous Corrections	10.1.0	10.2.0
	RP-52	RP-110846	0468	-	Pcmax,c reporting for type 2 PH	10.1.0	10.2.0
	RP-52	RP-110848	0469	-	Type-1-triggered SRS transmission independent of DRX	10.1.0	10.2.0
	RP-52	RP-110839	0470	-	UL transmissions when the timeAlignmentTimer is not running	10.1.0	10.2.0
	RP-52	RP-110846	0478	1	Clarifications to Ci field in MAC CE on CA	10.1.0	10.2.0
	RP-52	RP-110846	0488	-	Clarification of padding BSR behaviour	10.1.0	10.2.0
	RP-52	RP-110834	0489	-	SPS reception in MBSFN subframes	10.1.0	10.2.0
	RP-52	RP-110839	0490	-	Power management related PHR triggering condition	10.1.0	10.2.0
	RP-52	RP-110839	0491	-	Clarifications on PHR Power Management trigger	10.1.0	10.2.0
2011-09	RP-53	RP-111280	0494	1	Clarifications on MCH reception and Stop MTCH	10.2.0	10.3.0
	RP-53	RP-111283	0496	-	Configuration of extenededBSR-sizes	10.2.0	10.3.0
	RP-53	RP-111297	0502	-	CR to 36.321 on Small correction of PHR parameter	10.2.0	10.3.0
	RP-53	RP-111283	0503	1	Corrections to PCMAX,c field in Extended PHR	10.2.0	10.3.0
2011-12	RP-54	RP-111714	0516	1	UE soft buffer handling in MAC	10.3.0	10.4.0
	RP-54	RP-111716	0523	-	Correction on determining SPS occasions	10.3.0	10.4.0
	RP-54	RP-111605	0526	1	CSI/SRS reporting at DRX state transitions	10.3.0	10.4.0
	RP-54	RP-111606	0527	-	CSI/SRS reporting at unexpected Active Time stopping	10.3.0	10.4.0
2012-03	RP-55	RP-120321	0539	-	Correction to multiplexing and assembly	10.4.0	10.5.0
2012-09	RP-57	RP-121395	0559	-	P bit in Extended PHR MAC CE	10.5.0	10.6.0
	RP-57	RP-121395	0577	1	Deadlock of PHR transmission	10.5.0	10.6.0
	RP-57	RP-121382	0558	-	Clarification on Measurement Gap	10.5.0	11.0.0
	RP-57	RP-121377	0572	1	Introduction of CA Enhancements in MAC	10.5.0	11.0.0
	RP-57	RP-121382	0581	-	Clarification of TA value maintenance at TA timer expiry	10.5.0	11.0.0
2012-12	RP-58	RP-121936	0583	-	Clarification on DRX for Relay	11.0.0	11.1.0
	RP-58	RP-121936	0585	-	Clarification on V field in Extended PHR MAC CE	11.0.0	11.1.0
	RP-58	RP-121951	0586	1	Clarification related to CA enhancement in MAC	11.0.0	11.1.0
	RP-58	RP-121957	0588	-	Clarification of the Note in 5.2	11.0.0	11.1.0
	RP-58	RP-121951	0590	-	TAG Acronym	11.0.0	11.1.0
	RP-58	RP-121951	0594	-	Corrections for CA-enhancement in MAC	11.0.0	11.1.0
	RP-58	RP-121956	0599	-	CR on MAC layer support of ePDCCH	11.0.0	11.1.0

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	RP-58	RP-121957	0624	2	CR to 36.321 on Annex for DRX Timers	11.0.0	11.1.0
2013-03	RP-59	RP-130248	0629	2	Removing optionality on CSI/SRS transmission during transient state	11.1.0	11.2.0
	RP-59	RP-130245	0630	-	Clarification on the PDCCH-subframe for half-duplex TDD UE	11.1.0	11.2.0
	RP-59	RP-130248	0649	-	Draft CR to 36 321 for Clarification of PDCCH-subframe definition in Rel-11	11.1.0	11.2.0
	RP-59	RP-130241	0659	-	Correction for TM10 unicast support in MBSFN subframes	11.1.0	11.2.0
	RP-59	RP-130291	0661	-	Clarification of DRX timers for TDD	11.1.0	11.2.0
2013-06	RP-60	RP-130805	0663	2	HARQ RTT Timer	11.2.0	11.3.0
	RP-60	RP-130808	0664	-	Clarification on the PDCCH-subframe definition for TDD UE	11.2.0	11.3.0
	RP-60	RP-130809	0665	-	Correction to the definition of drxRetransmissionTimer	11.2.0	11.3.0
	RP-60	RP-130809	0667	-	Further issues on removing optionality of CSI/SRS transmission during transient state	11.2.0	11.3.0
	RP-60	RP-130804	0670	-	Rel-11 CR on SCell activation timing	11.2.0	11.3.0
2013-12	RP-62	RP-131989	0687	-	Clarification on the HARQ feedback for SCell activation/deactivation command MAC CE	11.3.0	11.4.0
	RP-62	RP-132002	0690	-	Clarification on Power Headroom MAC CE	11.3.0	12.0.0
2014-03	RP-63	RP-140355	0709	-	BCCH reception for MBMS on any configured or configurable SCell	12.0.0	12.1.0
	RP-63	RP-140362	0705	1	Long DRX Command MAC Control Element	12.0.0	12.1.0
2014-06	RP-64	RP-140888	0714	-	Alternative 1: Introduction of FDD/TDD CA into 36.321	12.1.0	12.2.0
	RP-64	RP-140884	0713	1	Introduction of TDD eITMA	12.1.0	12.2.0
	RP-64	-	-	-	Editorial updates	12.2.0	12.2.1
2014-09	RP-65	RP-141506	0732	1	Introduction of low complexity UEs in TS 36.321	12.2.1	12.3.0
2014-12	RP-66	RP-142129	0739	-	Category 0 report in Msg3	12.3.0	12.4.0
	RP-66	RP-142140	0749	-	Correction on DRX Operation	12.3.0	12.4.0
	RP-66	RP-142140	0748	-	Prohibit timer for SR	12.3.0	12.4.0
	RP-66	RP-142135	0740	1	Introduction of dual connectivity in MAC	12.3.0	12.4.0
2015-03	RP-67	RP-150373	0751	-	Clarification on the Logical channel prioritization in DC	12.4.0	12.5.0
	RP-67	RP-150375	0762	1	Introduction of MBMS congestion management for Public Safety Group Call	12.4.0	12.5.0
	RP-67	RP-150374	0755	1	Introduction of ProSe in MAC	12.4.0	12.5.0
	RP-67	RP-150371	0763	2	Uplink transmission time difference	12.4.0	12.5.0
2015-06	RP-68	RP-150921	0764	-	SL-DCH transmission for autonomous resource allocation mode	12.5.0	12.6.0
	RP-68	RP-150921	0766	-	Minor corrections for ProSe	12.5.0	12.6.0
	RP-68	RP-150921	0767	-	Clarification on deactivation operation	12.5.0	12.6.0
	RP-68	RP-150916	0768	-	Handling of erroneous PDU on MCH	12.5.0	12.6.0
	RP-68	RP-150921	0769	-	Corrections on 36.321 for ProSe	12.5.0	12.6.0
	RP-68	RP-150921	0772	-	Correction to the figure of MAC structure overview for sidelink	12.5.0	12.6.0
	RP-68	RP-150923	0782	-	Prohibit timer for SR	12.5.0	12.6.0
	RP-68	RP-150921	0783	-	Resource selection for SL-DCH	12.5.0	12.6.0
2015-09	RP-69	RP-151438	0799	1	Correction on Type 2 PH reporting	12.6.0	12.7.0
	RP-69	RP-151441	0795	1	Corrections for reporting and cancellation of SL BSR	12.6.0	12.7.0
	RP-69	RP-151441	0785	1	Corrections to Sidelink in MAC	12.6.0	12.7.0
	RP-69	RP-151441	0790	1	Miscellaneous corrections on Sidelink	12.6.0	12.7.0
2015-12	RP-70	RP-152055	0801	-	Correction on transparent MAC PDU	12.7.0	12.8.0
	RP-70	RP-152053	0802	-	Correction on MAC header for SL-SCH	12.7.0	12.8.0
	RP-70	RP-152053	0805	-	Corrections for sidelink in TS 36.321	12.7.0	12.8.0
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	RP-70	RP-152072	0806	2	Introduction of eD2D	12.8.0	13.0.0
	RP-70	RP-152078	0821	2	Introduction of LAA in MAC	12.8.0	13.0.0
	RP-70	RP-152080	0815	2	Introduction of SC-PTM in MAC	12.8.0	13.0.0

Note: WORD version for TS 36.321 v12.4.0 was changed over from WORD 2003 to WORD 2007. Accordingly, some table formats may be converted due to the impact of compatability mode but contents in the tables were confirmed to be consistent.

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(Release 13)





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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

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1 Scope

The present document specifies the Radio Resource Control protocol for the radio interface between UE and E-UTRAN as well as for the radio interface between RN and E-UTRAN.

The scope of the present document also includes:

- the radio related information transported in a transparent container between source eNB and target eNB upon inter eNB handover;
- the radio related information transported in a transparent container between a source or target eNB and another system upon inter RAT handover.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] Void.

[3] 3GPP TS 36.302: "Evolved Universal Terrestrial Radio Access (E-UTRA); Services provided by the physical layer ".

[4] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); UE Procedures in Idle Mode".

[5] 3GPP TS 36.306 "Evolved Universal Terrestrial Radio Access (E-UTRA); UE Radio Access Capabilities".

[6] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[7] 3GPP TS 36.322:"Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification".

[8] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) Specification".

[9] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRAN); Overall description; Stage 2".

[10] 3GPP TS 22.011: "Service accessibility".

[11] 3GPP TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode".

[12] 3GPP2 C.S0002-F v1.0: "Physical Layer Standard for cdma2000 Spread Spectrum Systems".

[13] ITU-T Recommendation X.680 (07/2002) "Information Technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation" (Same as the ISO/IEC International Standard 8824-1).

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[14] ITU-T Recommendation X.681 (07/2002) "Information Technology - Abstract Syntax Notation One (ASN.1): Information object specification" (Same as the ISO/IEC International Standard 8824-2).

[15] ITU-T Recommendation X.691 (07/2002) "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)" (Same as the ISO/IEC International Standard 8825-2).

[16] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[17] 3GPP TS 25.101: "Universal Terrestrial Radio Access (UTRA); User Equipment (UE) radio transmission and reception (FDD)".

[18] 3GPP TS 25.102: "Universal Terrestrial Radio Access (UTRA); User Equipment (UE) radio transmission and reception (TDD)".

[19] 3GPP TS 25.331:"Universal Terrestrial Radio Access (UTRA); Radio Resource Control (RRC); Protocol specification".

[20] 3GPP TS 45.005: "Radio transmission and reception".

[21] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[22] 3GPP TS 36.212. "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".

[23] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

[24] 3GPP2 C.S0057-E v1.0: "Band Class Specification for cdma2000 Spread Spectrum Systems".

[25] 3GPP2 C.S0005-F v1.0: "Upper Layer (Layer 3) Signaling Standard for cdma2000 Spread Spectrum Systems".

[26] 3GPP2 C.S0024-C v2.0: "cdma2000 High Rate Packet Data Air Interface Specification".

[27] 3GPP TS 23.003: "Numbering, addressing and identification".

[28] 3GPP TS 45.008: "Radio subsystem link control".

[29] 3GPP TS 25.133: "Requirements for Support of Radio Resource Management (FDD)".

[30] 3GPP TS 25.123: "Requirements for Support of Radio Resource Management (TDD)".

[31] 3GPP TS 36.401. "Evolved Universal Terrestrial Radio Access (E-UTRA); Architecture description".

[32] 3GPP TS 33.401: "3GPP System Architecture Evolution (SAE); Security architecture".

[33] 3GPP2 A.S0008-C v4.0: "Interoperability Specification (IOS) for High Rate Packet Data (HRPD) Radio Access Network Interfaces with Session Control in the Access Network"

[34] 3GPP2 C.S0004-F v1.0: "Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems"

[35] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3"

[36] 3GPP TS 44.060: "General Packet Radio Service (GPRS); Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol".

[37] 3GPP TS 23.041: "Technical realization of Cell Broadcast Service (CBS)".

[38] 3GPP TS 23.038: "Alphabets and Language".

[39] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access (E-UTRAN); S1 Application Protocol (S1 AP)".

[40] 3GPP TS 25.304: "Universal Terrestrial Radio Access (UTRAN); User Equipment (UE) procedures in idle mode and procedures for cell reselection in connected mode".

[41] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[42] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[43] 3GPP TS 44.005: "Data Link (DL) Layer General Aspects".

[44] 3GPP2 C.S0087-A v2.0: "E-UTRAN - cdma2000 HRPD Connectivity and Interworking Air Interface Specification"

[45] 3GPP TS 44.018: "Mobile radio interface layer 3 specification; Radio Resource Control (RRC) protocol".

[46] 3GPP TS 25.223: "Spreading and modulation (TDD)".

[47] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[48] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer - Measurements".

[49] 3GPP TS 24.008: "Mobile radio interface layer 3 specification; Core network protocols; Stage 3".

[50] 3GPP TS 45.010: "Radio subsystem synchronization".

[51] 3GPP TS 23.272: "Circuit Switched Fallback in Evolved Packet System; Stage 2".

[52] 3GPP TS 29.061: "Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)".

[53] 3GPP2 C.S0097-0 v3.0: "E-UTRAN - cdma2000 1x Connectivity and Interworking Air Interface Specification".

[54] 3GPP TS 36.355: "LTE Positioning Protocol (LPP)".

[55] 3GPP TS 36.216: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation".

[56] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description".

[57] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

[58] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

[59] 3GPP TS 22.368: "Service Requirements for Machine Type Communications; Stage 1".

[60] 3GPP TS 37.320: "Universal Terrestrial Radio Access (UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRA); Radio measurement collection for Minimization of Drive Tests (MDT); Overall description; Stage 2".

[61] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC); Stage 2".

[62] 3GPP TS 22.146: "Multimedia Broadcast/Multicast Service (MBMS); Stage 1".

[63] 3GPP TR 36.816: "Evolved Universal Terrestrial Radio Access (E-UTRA); Study on signalling and procedure for interference avoidance for in-device coexistence".

[64] IS-GPS-200F: "Navstar GPS Space Segment/Navigation User Segment Interfaces".

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[65] 3GPP TS 25.307: "Requirement on User Equipments (UEs) supporting a release-independent frequency band".

[66] 3GPP TS 24.312: "Access Network Discovery and Selection Function (ANDSF) Management Object (MO)".

[67] IEEE 802.11-2012, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, IEEE Std.

[68] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

[69] 3GPP TS 24.334: "Proximity-services (ProSe) User Equipment (UE) to ProSe function protocol aspects; Stage 3".

[70] 3GPP TS 24.333: "Proximity-services (ProSe) Management Objects (MO)".

[71] 3GPP TS 36.314: "Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2-Measurements".

[72] 3GPP TS 24.105: "Application specific Congestion control for Data Communication (ACDC) Management Object (MO)".

[73] 3GPP TS 23.179: "Functional architecture and information flows to support mission critical communication services; Stage 2".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Commercial Mobile Alert System: Public Warning System that delivers *Warning Notifications* provided by *Warning Notification Providers* to CMAS capable UEs.

Common access barring parameters: The common access barring parameters refer to the access class barring parameters that are broadcast in *SystemInformationBlockType2* outside the list of PLMN specific parameters (i.e. in *ac-BarringPerPLMN-List*).

CSG member cell: A cell broadcasting the identity of the selected PLMN, registered PLMN or equivalent PLMN and for which the CSG whitelist of the UE includes an entry comprising cell's CSG ID and the respective PLMN identity.

Dual Connectivity: A UE in RRC_CONNECTED is configured with Dual Connectivity when configured with a Master and a Secondary Cell Group.

EU-Alert: Public Warning System that delivers Warning Notifications provided by Warning Notification Providers using the same AS mechanisms as defined for CMAS.

Field: The individual contents of an information element are referred as fields.

Floor: Mathematical function used to 'round down' i.e. to the nearest integer having a lower or equal value.

Information element: A structural element containing a single or multiple fields is referred as information element.

Korean Public Alert System (KPAS): Public Warning System that delivers Warning Notifications provided by Warning Notification Providers using the same AS mechanisms as defined for CMAS.

Master Cell Group: For a UE not configured with DC, the MCG comprises all serving cells. For a UE configured with DC, the MCG concerns a subset of the serving cells comprising of the PCell and zero or more secondary cells.

MBMS service: MBMS bearer service as defined in TS 23.246 [56] (i.e. provided via an MRB or an SC-MRB).

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Primary Cell: The cell, operating on the primary frequency, in which the UE either performs the initial connection establishment procedure or initiates the connection re-establishment procedure, or the cell indicated as the primary cell in the handover procedure.

Primary Secondary Cell: The SCG cell in which the UE is instructed to perform random access when performing the SCG change procedure.

Primary Timing Advance Group: Timing Advance Group containing the PCell or the PSCell.

PUCCH SCell: An SCell configured with PUCCH.

Secondary Cell: A cell, operating on a secondary frequency, which may be configured once an RRC connection is established and which may be used to provide additional radio resources.

Secondary Cell Group: For a UE configured with DC, the subset of serving cells not part of the MCG, i.e. comprising of the PSCell and zero or more other secondary cells.

Secondary Timing Advance Group: Timing Advance Group neither containing the PCell nor the PSCell. A secondary timing advance group contains at least one cell with configured uplink.

Serving Cell: For a UE in RRC_CONNECTED not configured with CA/ DC there is only one serving cell comprising of the primary cell. For a UE in RRC_CONNECTED configured with CA/ DC the term 'serving cells' is used to denote the set of one or more cells comprising of the primary cell and all secondary cells.

Sidelink: UE to UE interface for sidelink communication and sidelink discovery. The sidelink corresponds to the PC5 interface as defined in TS 23.303 [68].

Sidelink communication: AS functionality enabling ProSe Direct Communication as defined in TS 23.303 [68], between two or more nearby UEs, using E-UTRA technology but not traversing any network node.

Sidelink discovery: AS functionality enabling ProSe Direct Discovery as defined in TS 23.303 [68], using E-UTRA technology but not traversing any network node.

Timing Advance Group: A group of serving cells that is configured by RRC and that, for the cells with an UL configured, use the same timing reference cell and the same Timing Advance value. A Timing Advance Group only includes cells of the same cell group i.e. it either includes MCG cells or SCG cells.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

1xRTT	CDMA2000 1x Radio Transmission Technology
ACDC	Application specific Congestion control for Data Communication
ACK	Acknowledgement
AM	Acknowledged Mode
ANDSF	Access Network Discovery and Selection Function
ARQ	Automatic Repeat Request
AS	Access Stratum
ASN.1	Abstract Syntax Notation One
BCCH	Broadcast Control Channel
BCD	Binary Coded Decimal
BCH	Broadcast Channel
BLER	Block Error Rate
CA	Carrier Aggregation
CCCH	Common Control Channel
CCO	Cell Change Order
CG	Cell Group
CMAS	Commercial Mobile Alert Service
CP	Control Plane
C-RNTI	Cell RNTI
CRS	Cell-specific Reference Signal

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CSFB	CS fallback
CSG	Closed Subscriber Group
CSI	Channel State Information
DC	Dual Connectivity
DCCH	Dedicated Control Channel
DCI	Downlink Control Information
DFN	Direct Frame Number
DL	Downlink
DL-SCH	Downlink Shared Channel
DRB	(user) Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
EAB	Extended Access Barring
eDRX	Extended DRX
EHPLMN	Equivalent Home Public Land Mobile Network
eIMTA	Enhanced Interference Management and Traffic Adaptation
ENB	Evolved Node B
EPC	Evolved Packet Core
EPDCCH	Enhanced Physical Downlink Control Channel
EPS	Evolved Packet System
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FDD	Frequency Division Duplex
FFS	For Further Study
GERAN	GSM/EDGE Radio Access Network
GNSS	Global Navigation Satellite System
G-RNTI	Group RNTI
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat Request
HFN	Hyper Frame Number
HPLMN	Home Public Land Mobile Network
HRPD	CDMA2000 High Rate Packet Data
H-SFN	Hyper SFN
IDC	In-Device Coexistence
IE	Information element
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
ISM	Industrial, Scientific and Medical
kB	Kilobyte (1000 bytes)
L1	Layer 1
L2	Layer 2
L3	Layer 3
LAA	Licensed-Assisted Access
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MCG	Master Cell Group
MCPTT	Mission Critical Push To Talk
MDT	Minimization of Drive Tests
MIB	Master Information Block
MO	Mobile Originating
MRB	MBMS Point to Multipoint Radio Bearer
MRO	Mobility Robustness Optimisation
MSI	MCH Scheduling Information
MT	Mobile Terminating
N/A	Not Applicable
NACC	Network Assisted Cell Change
NAICS	Network Assisted Interference Cancellation/Suppression
NAS	Non Access Stratum
PCCH	Paging Control Channel
PCell	Primary Cell

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PDCCH	Physical Downlink Control Channel
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
ProSe	Proximity based Services
PSCell	Primary Secondary Cell
PTAG	Primary Timing Advance Group
PUCCH	Physical Uplink Control Channel
QCI	QoS Class Identifier
QoS	Quality of Service
RACH	Random Access CHannel
RAT	Radio Access Technology
RB	Radio Bearer
RLC	Radio Link Control
RN	Relay Node
RNTI	Radio Network Temporary Identifier
ROHC	RObust Header Compression
RPLMN	Registered Public Land Mobile Network
RRC	Radio Resource Control
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RSSI	Received Signal Strength Indicator
SAE	System Architecture Evolution
SAP	Service Access Point
SC	Sidelink Control
SCell	Secondary Cell
SCG	Secondary Cell Group
SC-MRB	Single Cell MRB
SC-RNTI	Single Cell RNTI
SFN	System Frame Number
SI	System Information
SIB	System Information Block
SI-RNTI	System Information RNTI
SL	Sidelink
SLSS	Sidelink Synchronisation Signal
SMC	Security Mode Control
SPS	Semi-Persistent Scheduling
SR	Scheduling Request
SRB	Signalling Radio Bearer
SSAC	Service Specific Access Control
SSTD	SFN and Subframe Timing Difference
STAG	Secondary Timing Advance Group
S-TMSI	SAE Temporary Mobile Station Identifier
TA	Tracking Area
TAG	Timing Advance Group
TDD	Time Division Duplex
TDM	Time Division Multiplexing
TM	Transparent Mode
TPC-RNTI	Transmit Power Control RNTI
T-RPT	Time Resource Pattern of Transmission
TTT	Time To Trigger
UE	User Equipment
UICC	Universal Integrated Circuit Card
UL	Uplink
UL-SCH	Uplink Shared Channel
UM	Unacknowledged Mode
UP	User Plane
UTC	Coordinated Universal Time
UTRAN	Universal Terrestrial Radio Access Network
VoLTE	Voice over Long Term Evolution
WLAN	Wireless Local Area Network

In the ASN.1, lower case may be used for some (parts) of the above abbreviations e.g. c-RNTI

4 General

4.1 Introduction

In this specification, (parts of) procedures and messages specified for the UE equally apply to the RN for functionality necessary for the RN. There are also (parts of) procedures and messages which are only applicable to the RN in its communication with the E-UTRAN, in which case the specification denotes the RN instead of the UE. Such RN-specific aspects are not applicable to the UE.

This specification is organised as follows:

- sub-clause 4.2 describes the RRC protocol model;
- sub-clause 4.3 specifies the services provided to upper layers as well as the services expected from lower layers;
- sub-clause 4.4 lists the RRC functions;
- clause 5 specifies RRC procedures, including UE state transitions;
- clause 6 specifies the RRC message in a mixed format (i.e. tabular & ASN.1 together);
- clause 7 specifies the variables (including protocol timers and constants) and counters to be used by the UE;
- clause 8 specifies the encoding of the RRC messages;
- clause 9 specifies the specified and default radio configurations;
- clause 10 specifies the RRC messages transferred across network nodes;
- clause 11 specifies the UE capability related constraints and performance requirements.

4.2 Architecture

4.2.1 UE states and state transitions including inter RAT

A UE is in RRC_CONNECTED when an RRC connection has been established. If this is not the case, i.e. no RRC connection is established, the UE is in RRC_IDLE state. The RRC states can further be characterised as follows:

- **RRC_IDLE**:
  - A UE specific DRX may be configured by upper layers.
  - UE controlled mobility;
  - The UE:
    - Monitors a Paging channel to detect incoming calls, system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification;
    - Performs neighbouring cell measurements and cell (re-)selection;
    - Acquires system information.
    - Performs logging of available measurements together with location and time for logged measurement configured UEs.
- **RRC_CONNECTED**:
  - Transfer of unicast data to/from UE.

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- At lower layers, the UE may be configured with a UE specific DRX.
- For UEs supporting CA, use of one or more SCells, aggregated with the PCell, for increased bandwidth;
- For UEs supporting DC, use of one SCG, aggregated with the MCG, for increased bandwidth;
- Network controlled mobility, i.e. handover and cell change order with optional network assistance (NACC) to GERAN;
- The UE:
  - Monitors a Paging channel and/ or System Information Block Type 1 contents to detect system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification;
  - Monitors control channels associated with the shared data channel to determine if data is scheduled for it;
  - Provides channel quality and feedback information;
  - Performs neighbouring cell measurements and measurement reporting;
  - Acquires system information.

The following figure not only provides an overview of the RRC states in E-UTRA, but also illustrates the mobility support between E-UTRAN, UTRAN and GERAN.

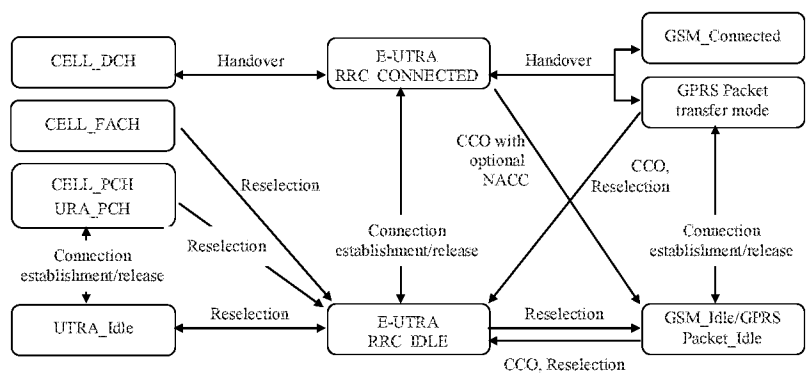


Figure 4.2.1-1: E-UTRA states and inter RAT mobility procedures, 3GPP

The following figure illustrates the mobility support between E-UTRAN, CDMA2000 1xRTT and CDMA2000 HRPD. The details of the CDMA2000 state models are out of the scope of this specification.

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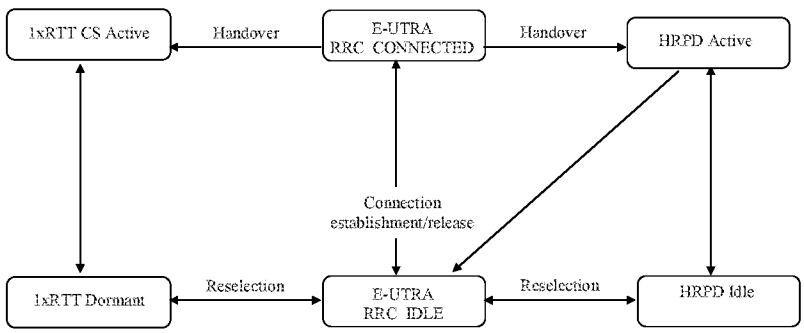


Figure 4.2.1-2: Mobility procedures between E-UTRA and CDMA2000

The inter-RAT handover procedure(s) supports the case of signalling, conversational services, non-conversational services and combinations of these.

In addition to the state transitions shown in Figure 4.2.1-1 and Figure 4.2.1-2, there is support for connection release with redirection information from E-UTRA RRC_CONNECTED to GERAN, UTRAN and CDMA2000 (HRPD Idle/ 1xRTT Dormant mode).

4.2.2 Signalling radio bearers

"Signalling Radio Bearers" (SRBs) are defined as Radio Bearers (RB) that are used only for the transmission of RRC and NAS messages. More specifically, the following three SRBs are defined:

- SRB0 is for RRC messages using the CCCH logical channel;
- SRB1 is for RRC messages (which may include a piggybacked NAS message) as well as for NAS messages prior to the establishment of SRB2, all using DCCH logical channel;
- SRB2 is for RRC messages which include logged measurement information as well as for NAS messages, all using DCCH logical channel. SRB2 has a lower-priority than SRB1 and is always configured by E-UTRAN after security activation.

In downlink piggybacking of NAS messages is used only for one dependant (i.e. with joint success/ failure) procedure: bearer establishment/ modification/ release. In uplink NAS message piggybacking is used only for transferring the initial NAS message during connection setup.

NOTE: The NAS messages transferred via SRB2 are also contained in RRC messages, which however do not include any RRC protocol control information.

Once security is activated, all RRC messages on SRB1 and SRB2, including those containing NAS or non-3GPP messages, are integrity protected and ciphered by PDCP. NAS independently applies integrity protection and ciphering to the NAS messages.

For a UE configured with DC, all RRC messages, regardless of the SRB used and both in downlink and uplink, are transferred via the MCG.

4.3 Services

4.3.1 Services provided to upper layers

The RRC protocol offers the following services to upper layers:

- Broadcast of common control information;
- Notification of UEs in RRC_IDLE, e.g. about a terminating call, for ETWS, for CMAS;
- Transfer of dedicated control information, i.e. information for one specific UE.

4.3.2 Services expected from lower layers

In brief, the following are the main services that RRC expects from lower layers:

- PDCP: integrity protection and ciphering;
- RLC: reliable and in-sequence transfer of information, without introducing duplicates and with support for segmentation and concatenation.

Further details about the services provided by Packet Data Convergence Protocol layer (e.g. integrity and ciphering) are provided in TS 36.323 [8]. The services provided by Radio Link Control layer (e.g. the RLC modes) are specified in TS 36.322 [7]. Further details about the services provided by Medium Access Control layer (e.g. the logical channels) are provided in TS 36.321 [6]. The services provided by physical layer (e.g. the transport channels) are specified in TS 36.302 [3].

4.4 Functions

The RRC protocol includes the following main functions:

- Broadcast of system information:
  - Including NAS common information;
  - Information applicable for UEs in RRC_IDLE, e.g. cell (re-)selection parameters, neighbouring cell information and information (also) applicable for UEs in RRC_CONNECTED, e.g. common channel configuration information.
  - Including ETWS notification, CMAS notification;
- RRC connection control:
  - Paging;
  - Establishment/ modification/ release of RRC connection, including e.g. assignment/ modification of UE identity (C-RNTI), establishment/ modification/ release of SRB1 and SRB2, access class barring;
  - Initial security activation, i.e. initial configuration of AS integrity protection (SRBs) and AS ciphering (SRBs, DRBs);
  - For RNs, configuration of AS integrity protection for DRBs;
  - RRC connection mobility including e.g. intra-frequency and inter-frequency handover, associated security handling, i.e. key/ algorithm change, specification of RRC context information transferred between network nodes;
  - Establishment/ modification/ release of RBs carrying user data (DRBs);
  - Radio configuration control including e.g. assignment/ modification of ARQ configuration, HARQ configuration, DRX configuration;
  - For RNs, RN-specific radio configuration control for the radio interface between RN and E-UTRAN;

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- In case of CA, cell management including e.g. change of PCell, addition/ modification/ release of SCell(s) and addition/modification/release of STAG(s);
- In case of DC, cell management including e.g. change of PSCell, addition/ modification/ release of SCG cell(s) and addition/modification/release of SCG TAG(s).
- QoS control including assignment/ modification of semi-persistent scheduling (SPS) configuration information for DL and UL, assignment/ modification of parameters for UL rate control in the UE, i.e. allocation of a priority and a prioritised bit rate (PBR) for each RB;
- Recovery from radio link failure;

- Inter-RAT mobility including e.g. security activation, transfer of RRC context information;
- Measurement configuration and reporting:
  - Establishment/ modification/ release of measurements (e.g. intra-frequency, inter-frequency and inter- RAT measurements);
  - Setup and release of measurement gaps;
  - Measurement reporting;
- Other functions including e.g. transfer of dedicated NAS information and non-3GPP dedicated information, transfer of UE radio access capability information, support for E-UTRAN sharing (multiple PLMN identities);
- Generic protocol error handling;
- Support of self-configuration and self-optimisation;
- Support of measurement logging and reporting for network performance optimisation [60];

NOTE: Random access is specified entirely in the MAC including initial transmission power estimation.

5 Procedures

5.1 General

5.1.1 Introduction

The procedural requirements are structured according to the main functional areas: system information (5.2), connection control (5.3), inter-RAT mobility (5.4) and measurements (5.5). In addition sub-clause 5.6 covers other aspects e.g. NAS dedicated information transfer, UE capability transfer, sub-clause 5.7 specifies the generic error handling, sub-clause 5.8 covers MBMS, sub-clause 5.9 covers RN-specific procedures and sub-clause 5.10 covers sidelink.

5.1.2 General requirements

The UE shall:

1> process the received messages in order of reception by RRC, i.e. the processing of a message shall be completed before starting the processing of a subsequent message;

NOTE 1: E-UTRAN may initiate a subsequent procedure prior to receiving the UE's response of a previously initiated procedure.

1> within a sub-clause execute the steps according to the order specified in the procedural description;

1> consider the term 'radio bearer' (RB) to cover SRBs and DRBs but not MRBs unless explicitly stated otherwise;

1> set the *rrc-TransactionIdentifier* in the response message, if included, to the same value as included in the message received from E-UTRAN that triggered the response message;

1> upon receiving a choice value set to *setup*:

2> apply the corresponding received configuration and start using the associated resources, unless explicitly specified otherwise;

1> upon receiving a choice value set to *release*:

2> clear the corresponding configuration and stop using the associated resources;

1> upon handover to E-UTRA; or

1> upon receiving an *RRCConnectionReconfiguration* message including the *fullConfig*:

2> apply the Conditions in the ASN.1 for inclusion of the fields for the DRB/PDCP/RLC setup during the reconfiguration of the DRBs included in the *drb-ToAddModList*;

NOTE 2: At each point in time, the UE keeps a single value for each field except for during handover when the UE temporarily stores the previous configuration so it can revert back upon handover failure. In other words: when the UE reconfigures a field, the existing value is released except for during handover.

NOTE 3: Although not explicitly stated, the UE initially considers all functionality to be deactivated/ released until it is explicitly stated that the functionality is setup/ activated. Correspondingly, the UE initially considers lists to be empty e.g. the list of radio bearers, the list of measurements.

1> upon receiving an extension field comprising the entries in addition to the ones carried by the original field (regardless of whether E-UTRAN may signal more entries in total); apply the following generic behaviour if explicitly stated to be applicable:

2> create a combined list by concatenating the additional entries included in the extension field to the original field while maintaining the order among both the original and the additional entries;

2> for the combined list, created according to the previous, apply the same behaviour as defined for the original field;

NOTE 4: A field comprising a list of entries normally includes 'list' in the field name. The typical way to extend (the size of) such a list is to introduce a field comprising the additional entries, which should include 'listExt' in the name of the field/ IE. E.g. *field1List-RAT*, *field1ListExt-RAT*.

5.2 System information

5.2.1 Introduction

5.2.1.1 General

System information is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs). The MIB includes a limited number of most essential and most frequently transmitted parameters that are needed to acquire other information from the cell, and is transmitted on BCH. SIBs other than *SystemInformationBlockType1* are carried in *SystemInformation* (SI) messages and mapping of SIBs to SI messages is flexibly configurable by *schedulingInfoList* included in *SystemInformationBlockType1*, with restrictions that: each SIB is contained only in a single SI message, and at most once in that message; only SIBs having the same scheduling requirement (periodicity) can be mapped to the same SI message; *SystemInformationBlockType2* is always mapped to the SI message that corresponds to the first entry in the list of SI messages in *schedulingInfoList*. There may be multiple SI messages transmitted with the same periodicity. *SystemInformationBlockType1* and all SI messages are transmitted on DL-SCH.

NOTE 1: The physical layer imposes a limit to the maximum size a SIB can take. When DCI format 1C is used the maximum allowed by the physical layer is 1736 bits (217 bytes) while for format 1A the limit is 2216 bits (277 bytes), see TS 36.212 [22] and TS 36.213 [23].

In addition to broadcasting, E-UTRAN may provide *SystemInformationBlockType1*, including the same parameter values, via dedicated signalling i.e., within an *RRCConnectionReconfiguration* message.

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The UE applies the system information acquisition and change monitoring procedures for the PCell. For an SCell, E-UTRAN provides, via dedicated signalling, all system information relevant for operation in RRC_CONNECTED when adding the SCell. However, a UE that is configured with DC shall aquire the *MasterInformationBlock* of the PSCell but use it only to determine the SFN timing of the SCG, which may be different from the MCG. Upon change of the relevant system information of a configured SCell, E-UTRAN releases and subsequently adds the concerned SCell, which may be done with a single *RRCConnectionReconfiguration* message. If the UE is receiving or interested to receive an MBMS service in a cell, the UE shall apply the system information acquisition and change monitoring procedure to acquire parameters relevant for MBMS operation and apply the parameters acquired from system information only for MBMS operation for this cell.

NOTE 2: E-UTRAN may configure via dedicated signalling different parameter values than the ones broadcast in the concerned SCell.

An RN configured with an RN subframe configuration does not need to apply the system information acquisition and change monitoring procedures. Upon change of any system information relevant to an RN, E-UTRAN provides the system information blocks containing the relevant system information to an RN configured with an RN subframe configuration via dedicated signalling using the *RNReconfiguration* message. For RNs configured with an RN subframe configuration, the system information contained in this dedicated signalling replaces any corresponding stored system information and takes precedence over any corresponding system information acquired through the system information acquisition procedure. The dedicated system information remains valid until overridden.

NOTE 3: E-UTRAN may configure an RN, via dedicated signalling, with different parameter values than the ones broadcast in the concerned cell.

5.2.1.2 Scheduling

The MIB uses a fixed schedule with a periodicity of 40 ms and repetitions made within 40 ms. The first transmission of the MIB is scheduled in subframe #0 of radio frames for which the SFN mod 4 = 0, and repetitions are scheduled in subframe #0 of all other radio frames.

The *SystemInformationBlockType1* uses a fixed schedule with a periodicity of 80 ms and repetitions made within 80 ms. The first transmission of *SystemInformationBlockType1* is scheduled in subframe #5 of radio frames for which the SFN mod 8 = 0, and repetitions are scheduled in subframe #5 of all other radio frames for which SFN mod 2 = 0.

The SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN subframes, uplink subframes in TDD, and subframe #5 of radio frames for which SFN mod 2 = 0. The UE acquires the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, used transport format) from decoding SI-RNTI on PDCCH (see TS 36.321 [6]).

A single SI-RNTI is used to address *SystemInformationBlockType1* as well as all SI messages.

SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

5.2.1.3 System information validity and notification of changes

Change of system information (other than for ETWS, CMAS and EAB parameters) only occurs at specific radio frames, i.e. the concept of a modification period is used. System information may be transmitted a number of times with the same content within a modification period, as defined by its scheduling. The modification period boundaries are defined by SFN values for which SFN mod m = 0, where m is the number of radio frames comprising the modification period. The modification period is configured by system information.

When the network changes (some of the) system information, it first notifies the UEs about this change, i.e. this may be done throughout a modification period. In the next modification period, the network transmits the updated system information. These general principles are illustrated in figure 5.2.1.3-1, in which different colours indicate different system information. Upon receiving a change notification, the UE configured with a DRX cycle that is smaller than or equal to the modification period acquires the new system information immediately from the start of the next modification period. Upon receiving a change notification, a UE configured with a DRX cycle that is longer than the modification period acquires the updated system information at the next H-SFN boundary defined by H-SFN mod 256 = 0. The UE applies the previously acquired system information until the UE acquires the new system information.

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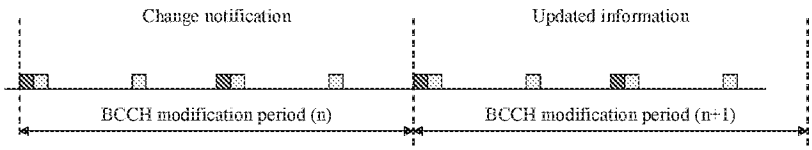


Figure 5.2.1.3-1: Change of system information

The *Paging* message is used to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change. If the UE receives a *Paging* message including the *systemInfoModification*, it knows that the system information will change at the next modification period boundary. If the UE configured with a DRX cycle longer than the modification period receives a *Paging* message including the *systemInfoModification-eDRX*, it acquires the new system information at the next H-SFN boundary defined by H-SFN mod 256 = 0. Although the UE may be informed about changes in system information, no further details are provided e.g. regarding which system information will change.

SystemInformationBlockType1 includes a value tag, *systemInfoValueTag*, that indicates if a change has occurred in the SI messages. UEs may use *systemInfoValueTag*, e.g. upon return from out of coverage, to verify if the previously stored SI messages are still valid. Additionally, the UE considers stored system information to be invalid after 3 hours from the moment it was successfully confirmed as valid, unless specified otherwise.

E-UTRAN may not update *systemInfoValueTag* upon change of some system information e.g. ETWS information, CMAS information, regularly changing parameters like time information (*SystemInformationBlockType8*, *SystemInformationBlockType16*), EAB parameters. Similarly, E-UTRAN may not include the *systemInfoModification* within the *Paging* message upon change of some system information.

The UE configured with a DRX cycle smaller than or equal to the modification period verifies that stored system information remains valid by either checking *systemInfoValueTag* in *SystemInformationBlockType1* after the modification period boundary, or attempting to find the *systemInfoModification* indication at least *modificationPeriodCoeff* times during the modification period in case no paging is received, in every modification period. If no paging message is received by the UE during a modification period, the UE may assume that no change of system information will occur at the next modification period boundary. If UE in RRC_CONNECTED, during a modification period, receives one paging message, it may deduce from the presence/ absence of *systemInfoModification* whether a change of system information other than ETWS information, CMAS information and EAB parameters will occur in the next modification period or not.

When the RRC_IDLE UE is configured with a DRX cycle that is longer than the modification period, and more than one modification period has passed since the UE last verified validity of stored system information, the UE verifies that stored system information remains valid by checking the *systemInfoValueTag* before establishing an RRC connection.

ETWS and/or CMAS capable UEs in RRC_CONNECTED shall attempt to read paging at least once every *defaultPagingCycle* to check whether ETWS and/or CMAS notification is present or not.

5.2.1.4 Indication of ETWS notification

ETWS primary notification and/ or ETWS secondary notification can occur at any point in time. The *Paging* message is used to inform ETWS capable UEs in RRC_IDLE and UEs in RRC_CONNECTED about presence of an ETWS primary notification and/ or ETWS secondary notification. If the UE receives a *Paging* message including the *etws-Indication*, it shall start receiving the ETWS primary notification and/ or ETWS secondary notification according to *schedulingInfoList* contained in *SystemInformationBlockType1*. If the UE receives *Paging* message including the *etws-Indication* while it is acquiring ETWS notification(s), the UE shall continue acquiring ETWS notification(s) based on the previously acquired *schedulingInfoList* until it re-acquires *schedulingInfoList* in *SystemInformationBlockType1*.

NOTE: The UE is not required to periodically check *schedulingInfoList* contained in *SystemInformationBlockType1*, but *Paging* message including the *etws-Indication* triggers the UE to re-acquire *schedulingInfoList* contained in *SystemInformationBlockType1* for scheduling changes for *SystemInformationBlockType10* and *SystemInformationBlockType11*. The UE may or may not receive a *Paging* message including the *etws-Indication* and/or *systemInfoModification* when ETWS is no longer scheduled.

ETWS primary notification is contained in *SystemInformationBlockType10* and ETWS secondary notification is contained in *SystemInformationBlockType11*. Segmentation can be applied for the delivery of a secondary notification.

The segmentation is fixed for transmission of a given secondary notification within a cell (i.e. the same segment size for a given segment with the same *messageIdentifier*, *serialNumber* and *warningMessageSegmentNumber*). An ETWS secondary notification corresponds to a single *CB data* IE as defined according to TS 23.041 [37].

5.2.1.5 Indication of CMAS notification

CMAS notification can occur at any point in time. The *Paging* message is used to inform CMAS capable UEs in RRC_IDLE and UEs in RRC_CONNECTED about presence of one or more CMAS notifications. If the UE receives a *Paging* message including the *cmas-Indication*, it shall start receiving the CMAS notifications according to *schedulingInfoList* contained in *SystemInformationBlockType1*. If the UE receives *Paging* message including the *cmas-Indication* while it is acquiring CMAS notification(s), the UE shall continue acquiring CMAS notification(s) based on the previously acquired *schedulingInfoList* until it re-acquires *schedulingInfoList* in *SystemInformationBlockType1*.

NOTE: The UE is not required to periodically check *schedulingInfoList* contained in *SystemInformationBlockType1*, but *Paging* message including the *cmas-Indication* triggers the UE to re-acquire *schedulingInfoList* contained in *SystemInformationBlockType1* for scheduling changes for *SystemInformationBlockType12*. The UE may or may not receive a *Paging* message including the *cmas-Indication* and/or *systemInfoModification* when *SystemInformationBlockType12* is no longer scheduled.

CMAS notification is contained in *SystemInformationBlockType12*. Segmentation can be applied for the delivery of a CMAS notification. The segmentation is fixed for transmission of a given CMAS notification within a cell (i.e. the same segment size for a given segment with the same *messageIdentifier*, *serialNumber* and *warningMessageSegmentNumber*). E-UTRAN does not interleave transmissions of CMAS notifications, i.e. all segments of a given CMAS notification transmission are transmitted prior to those of another CMAS notification. A CMAS notification corresponds to a single *CB data* IE as defined according to TS 23.041 [37].

5.2.1.6 Notification of EAB parameters change

Change of EAB parameters can occur at any point in time. The EAB parameters are contained in *SystemInformationBlockType14*. The *Paging* message is used to inform EAB capable UEs in RRC_IDLE about a change of EAB parameters or that *SystemInformationBlockType14* is no longer scheduled. If the UE receives a *Paging* message including the *eab-ParamModification*, it shall acquire *SystemInformationBlockType14* according to *schedulingInfoList* contained in *SystemInformationBlockType1*. If the UE receives a *Paging* message including the *eab-ParamModification* while it is acquiring *SystemInformationBlockType14*, the UE shall continue acquiring *SystemInformationBlockType14* based on the previously acquired *schedulingInfoList* until it re-acquires *schedulingInfoList* in *SystemInformationBlockType1*.

NOTE: The EAB capable UE is not expected to periodically check *schedulingInfoList* contained in *SystemInformationBlockType1*.

5.2.2 System information acquisition

5.2.2.1 General

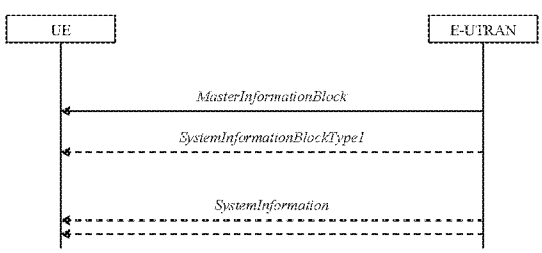


Figure 5.2.2.1-1: System information acquisition, normal

The UE applies the system information acquisition procedure to acquire the AS- and NAS- system information that is broadcasted by the E-UTRAN. The procedure applies to UEs in RRC_IDLE and UEs in RRC_CONNECTED.

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5.2.2.2 Initiation

The UE shall apply the system information acquisition procedure upon selecting (e.g. upon power on) and upon re-selecting a cell, after handover completion, after entering E-UTRA from another RAT, upon return from out of coverage, upon receiving a notification that the system information has changed, upon receiving an indication about the presence of an ETWS notification, upon receiving an indication about the presence of a CMAS notification, upon receiving a notification that the EAB parameters have changed, upon receiving a request from CDMA2000 upper layers and upon exceeding the maximum validity duration. Unless explicitly stated otherwise in the procedural specification, the system information acquisition procedure overwrites any stored system information, i.e. delta configuration is not applicable for system information and the UE discontinues using a field if it is absent in system information unless explicitly specified otherwise.

5.2.2.3 System information required by the UE

The UE shall:

1> ensure having a valid version, as defined below, of (at least) the following system information, also referred to as the 'required' system information:

2> if in RRC_IDLE:

3> the *MasterInformationBlock* and *SystemInformationBlockType1* as well as *SystemInformationBlockType2* through *SystemInformationBlockType8* (depending on support of the concerned RATs), *SystemInformationBlockType17* (depending on support of RAN-assisted WLAN interworking);

2> if in RRC_CONNECTED:

3> the *MasterInformationBlock*, *SystemInformationBlockType1* and *SystemInformationBlockType2* as well as *SystemInformationBlockType8* (depending on support of CDMA2000), *SystemInformationBlockType17* (depending on support of RAN-assisted WLAN interworking);

1> delete any stored system information after 3 hours from the moment it was confirmed to be valid as defined in 5.2.1.3, unless specified otherwise;

1> consider any stored system information except *SystemInformationBlockType10*, *SystemInformationBlockType11*, *systemInformationBlockType12* and *systemInformationBlockType14* to be invalid if *systemInfoValueTag* included in the *SystemInformationBlockType1* is different from the one of the stored system information;

5.2.2.4 System information acquisition by the UE

The UE shall:

1> apply the specified BCCH configuration defined in 9.1.1.1;

1> if the procedure is triggered by a system information change notification:

2> if the UE uses a DRX cycle longer than the modification period:

3> start acquiring the required system information, as defined in 5.2.2.3, from the next H-SFN boundary defined by H-SFN mod 256 = 0;

2> else

3> start acquiring the required system information, as defined in 5.2.2.3, from the beginning of the modification period following the one in which the change notification was received;

NOTE 1: The UE continues using the previously received system information until the new system information has been acquired.

1> if the UE is in RRC_IDLE and enters a cell for which the UE does not have stored a valid version of the system information required in RRC_IDLE, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_IDLE, as defined in 5.2.2.3;

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1> following successful handover completion to a PCell for which the UE does not have stored a valid version of the system information required in RRC_CONNECTED, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_CONNECTED, as defined in 5.2.2.3;

2> upon acquiring the concerned system information:

3> discard the corresponding radio resource configuration information included in the *radioResourceConfigCommon* previously received in a dedicated message, if any;

1> following a request from CDMA2000 upper layers:

2> acquire *SystemInformationBlockType8*, as defined in 5.2.3;

1> neither initiate the RRC connection establishment procedure nor initiate transmission of the *RRCConnectionReestablishmentRequest* message until the UE has a valid version of the *MasterInformationBlock* and *SystemInformationBlockType1* messages as well as *SystemInformationBlockType2* ;

1> not initiate the RRC connection establishment subject to EAB until the UE has a valid version of *SystemInformationBlockType14*, if broadcast;

1> if the UE is ETWS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

2> when the UE acquires *SystemInformationBlockType1* following ETWS indication, upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

4> start acquiring *SystemInformationBlockType10* immediately;

3> if *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

4> start acquiring *SystemInformationBlockType11* immediately;

NOTE 2: UEs shall start acquiring *SystemInformationBlockType10* and *SystemInformationBlockType11* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

1> if the UE is CMAS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, stored values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType12* associated with the discarded *warningMessageSegment*;

2> when the UE acquires *SystemInformationBlockType1* following CMAS indication, upon entering a cell during RRC_IDLE, following successful handover and upon connection re-establishment:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

4> acquire *SystemInformationBlockType12*;

NOTE 3: UEs shall start acquiring *SystemInformationBlockType12* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

1> if the UE is interested to receive MBMS services:

2> if *schedulingInfoList* indicates that *SystemInformationBlockType13* is present and the UE does not have stored a valid version of this system information block:

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3> acquire *SystemInformationBlockType13*;

2> if the UE is capable of SC-PTM reception:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType20* is present and the UE does not have stored a valid version of this system information block:

4> acquire *SystemInformationBlockType20*;

2> if the UE is capable of MBMS Service Continuity:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType15* is present and the UE does not have stored a valid version of this system information block:

4> acquire SystemInformationBlockType15;

1> if the UE is EAB capable:

2> when the UE does not have stored a valid version of *SystemInformationBlockType14* upon entering RRC_IDLE, or when the UE acquires *SystemInformationBlockType1* following EAB parameters change notification or upon entering a cell during RRC_IDLE:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType14* is present:

4> start acquiring *SystemInformationBlockType14* immediately;

3> else:

4> discard *SystemInformationBlockType14*, if previously received;

NOTE 4: EAB capable UEs start acquiring *SystemInformationBlockType14* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

NOTE 5: EAB capable UEs maintain an up to date *SystemInformationBlockType14* in RRC_IDLE.

1> if the UE is capable of sidelink communication and is configured by upper layers to receive or transmit sidelink communication:

2> if the cell used for sidelink communication meets the S-criteria as defined in TS 36.304 [4]; and

2> if *schedulingInfoList* indicates that *SystemInformationBlockType18* is present and the UE does not have stored a valid version of this system information block:

3> acquire *SystemInformationBlockType18*;

1> if the UE is capable of sidelink discovery and is configured by upper layers to receive or transmit sidelink discovery announcements on the primary frequency:

2> if *schedulingInfoList* indicates that *SystemInformationBlockType19* is present and the UE does not have stored a valid version of this system information block:

3> acquire *SystemInformationBlockType19*;

2> for each of the one or more frequencies included in *discInterFreqList*, if included in *SystemInformationBlockType19* and for which the UE is configured by upper layers to receive sidelink discovery announcements on:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType19* is present and the UE does not have stored a valid version of this system information block:

4> acquire *SystemInformationBlockType19*;

The UE may apply the received SIBs immediately, i.e. the UE does not need to delay using a SIB until all SI messages have been received. The UE may delay applying the received SIBs until completing lower layer procedures associated with a received or a UE originated RRC message, e.g. an ongoing random access procedure.

NOTE 6: While attempting to acquire a particular SIB, if the UE detects from *schedulingInfoList* that it is no longer present, the UE should stop trying to acquire the particular SIB.

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5.2.2.5 Essential system information missing

The UE shall:

1> if in RRC_IDLE or in RRC_CONNECTED while T311 is running:

2> if the UE is unable to acquire the *MasterInformationBlock* or the *SystemInformationBlockType1*:

3> consider the cell as barred in accordance with TS 36.304 [4]; and

3> perform barring as if *intraFreqReselection* is set to *allowed*, and as if the *csg-Indication* is set to *FALSE*;

2> else if the UE is unable to acquire the *SystemInformationBlockType2*:

3> treat the cell as barred in accordance with TS 36.304 [4];

5.2.2.6 Actions upon reception of the *MasterInformationBlock* message

Upon receiving the *MasterInformationBlock* message the UE shall:

1> apply the radio resource configuration included in the *phich-Config*;

1> if the UE is in RRC_IDLE or if the UE is in RRC_CONNECTED while T311 is running:

2> if the UE has no valid system information stored according to 5.2.2.3 for the concerned cell:

3> apply the received value of *dl-Bandwidth* to the *ul-Bandwidth* until *SystemInformationBlockType2* is received;

5.2.2.7 Actions upon reception of the *SystemInformationBlockType1* message

Upon receiving the *SystemInformationBlockType1* either via broadcast or via dedicated signalling, the UE shall:

1> if in RRC_IDLE or in RRC_CONNECTED while T311 is running; and

1> if the UE is a category 0 UE according to TS 36.306 [5]; and

1> if *category0Allowed* is not included in *SystemInformationBlockType1*:

2> consider the cell as barred in accordance with TS 36.304 [4];

1> if in RRC_CONNECTED while T311 is not running, and the UE supports multi-band cells as defined by bit 31 in *featureGroupIndicators*:

2> disregard the *freqBandIndicator* and *multiBandInfoList*, if received, while in RRC_CONNECTED;

2> forward the *cellIdentity* to upper layers;

2> forward the *trackingAreaCode* to upper layers;

1> else:

2> if the frequency band indicated in the *freqBandIndicator* is part of the frequency bands supported by the UE and it is not a downlink only band; or

2> if the UE supports *multiBandInfoList*, and if one or more of the frequency bands indicated in the *multiBandInfoList* are part of the frequency bands supported by the UE and they are not downlink only bands:

3> forward the *cellIdentity* to upper layers;

3> forward the *trackingAreaCode* to upper layers;

3> if, for the frequency band selected by the UE (from *freqBandIndicator* or *multiBandInfoList*), the *freqBandInfo* or the *multiBandInfoList-v10j0* is present and the UE capable of *multiNS-Pmax* supports at

least one *additionalSpectrumEmission* in the *NS-PmaxList* within the *freqBandInfo* or *multiBandInfoList-v10j0*:

4> apply the first listed *additionalSpectrumEmission* which it supports among the values included in *NS-PmaxList* within *freqBandInfo* or *multiBandInfolist-v10j0*;

4> if the *additionalPmax* is present in the same entry of the selected *additionalSpectrumEmission* within *NS-PmaxList*:

5> apply the *additionalPmax*;

4> else:

5> apply the *p-Max*;

3> else:

4> apply the *additionalSpectrumEmission* in *SystemInformationBlockType2* and the *p-Max*;

2> else:

3> consider the cell as barred in accordance with TS 36.304 [4]; and

3> perform barring as if *intraFreqReselection* is set to *notAllowed*, and as if the *csg-Indication* is set to *FALSE*;

5.2.2.8 Actions upon reception of *SystemInformation* messages

No UE requirements related to the contents of the *SystemInformation* messages apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.9 Actions upon reception of *SystemInformationBlockType2*

Upon receiving *SystemInformationBlockType2*, the UE shall:

1> apply the configuration included in the *radioResourceConfigCommon*;

1> if upper layers indicate that a (UE specific) paging cycle is configured:

2> apply the shortest of the (UE specific) paging cycle and the *defaultPagingCycle* included in the *radioResourceConfigCommon*;

1> if the *mbsfn-SubframeConfigList* is included:

2> consider that DL assignments may occur in the MBSFN subframes indicated in the *mbsfn-SubframeConfigList* under the conditions specified in [23, 7.1];

1> apply the specified PCCH configuration defined in 9.1.1.3;

1> not apply the *timeAlignmentTimerCommon*;

1> if in RRC_CONNECTED and UE is configured with RLF timers and constants values received within *rlf-TimersAndConstants*:

2> not update its values of the timers and constants in *ue-TimersAndConstants* except for the value of timer T300;

1> if in RRC_CONNECTED while T311 is not running; and the UE supports multi-band cells as defined by bit 31 in *featureGroupIndicators* or *multipleNS-Pmax*:

2> disregard the *additionalSpectrumEmission* and *ul-CarrierFreq*, if received, while in RRC_CONNECTED;

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5.2.2.10 Actions upon reception of *SystemInformationBlockType3*

Upon receiving *SystemInformationBlockType3*, the UE shall:

1> if *redistributionServingInfo* is included:

2> perform E-UTRAN Inter-Frequency Redistribution procedure as specified in 5.2.4.10 [4];

No further UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.11 Actions upon reception of *SystemInformationBlockType4*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.12 Actions upon reception of *SystemInformationBlockType5*

Upon receiving *SystemInformationBlockType5*, the UE shall:

1> if *redistributionInterFreqInfo* is included:

2> perform E-UTRAN Inter-Frequency Redistribution procedure as specified in 5.2.4.10 [4];

No further UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.13 Actions upon reception of *SystemInformationBlockType6*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.14 Actions upon reception of *SystemInformationBlockType7*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.15 Actions upon reception of *SystemInformationBlockType8*

Upon receiving *SystemInformationBlockType8*, the UE shall:

1> if *sib8-PerPLMN-List* is included and the UE is capable of network sharing for CDMA2000:

2> apply the CDMA2000 parameters below corresponding to the RPLMN;

1> if the *systemTimeInfo* is included:

2> forward the *systemTimeInfo* to CDMA2000 upper layers;

1> if the UE is in RRC_IDLE and if *searchWindowSize* is included:

2> forward the *searchWindowSize* to CDMA2000 upper layers;

1> if *parametersHRPD* is included:

2> forward the *preRegistrationInfoHRPD* to CDMA2000 upper layers only if the UE has not received the *preRegistrationInfoHRPD* within an *RRCConnectionReconfiguration* message after entering this cell;

2> if the *cellReselectionParametersHRPD* is included:

3> forward the *neighCellList* to the CDMA2000 upper layers;

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1> if the *parameters1XRTT* is included:

2> if the *csfb-RegistrationParam1XRTT* is included:

3> forward the *csfb-RegistrationParam1XRTT* to the CDMA2000 upper layers which will use this information to determine if a CS registration/re-registration towards CDMA2000 1xRTT in the EUTRA cell is required;

2> else:

3> indicate to CDMA2000 upper layers that CSFB Registration to CDMA2000 1xRTT is not allowed;

2> if the *longCodeState1XRTT* is included:

3> forward the *longCodeState1XRTT* to CDMA2000 upper layers;

2> if the *cellReselectionParameters1XRTT* is included:

3> forward the *neighCellList* to the CDMA2000 upper layers;

2> if the *csfb-SupportForDualRxUEs* is included:

3> forward *csfb-SupportForDualRxUEs* to the CDMA2000 upper layers;

2> else:

3> forward *csfb-SupportForDualRxUEs*, with its value set to *FALSE*, to the CDMA2000 upper layers;

2> if *ac-BarringConfig1XRTT* is included:

3> forward *ac-BarringConfig1XRTT* to the CDMA2000 upper layers;

2> if the *csfb-DualRxTxSupport* is included:

3> forward *csfb-DualRxTxSupport* to the CDMA2000 upper layers;

2> else:

3> forward *csfb-DualRxTxSupport*, with its value set to *FALSE*, to the CDMA2000 upper layers;

5.2.2.16 Actions upon reception of *SystemInformationBlockType9*

Upon receiving *SystemInformationBlockType9*, the UE shall:

1> if *hnb-Name* is included, forward the *hnb-Name* to upper layers;

5.2.2.17 Actions upon reception of *SystemInformationBlockType10*

Upon receiving *SystemInformationBlockType10*, the UE shall:

1> forward the received *warningType*, *messageIdentifier* and *serialNumber* to upper layers;

5.2.2.18 Actions upon reception of *SystemInformationBlockType11*

Upon receiving *SystemInformationBlockType11*, the UE shall:

1> if there is no current value for *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*; or

1> if either the received value of *messageIdentifier* or of *serialNumber* or of both are different from the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*:

2> use the received values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11* as the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

2> discard any previously buffered *warningMessageSegment*;

2> if all segments of a warning message have been received:

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3> assemble the warning message from the received *warningMessageSegment*;

3> forward the received warning message, *messageIdentifier*, *serialNumber* and *dataCodingScheme* to upper layers;

3> stop reception of *SystemInformationBlockType11*;

3> discard the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

2> else:

3> store the received *warningMessageSegment*;

3> continue reception of *SystemInformationBlockType11*;

1> else if all segments of a warning message have been received:

2> assemble the warning message from the received *warningMessageSegment*;

2> forward the received complete warning message, *messageIdentifier*, *serialNumber* and *dataCodingScheme* to upper layers;

2> stop reception of *SystemInformationBlockType11*;

2> discard the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

1> else:

2> store the received *warningMessageSegment*;

2> continue reception of *SystemInformationBlockType11*;

The UE should discard any stored *warningMessageSegment* and the current value of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11* if the complete warning message has not been assembled within a period of 3 hours.

5.2.2.19 Actions upon reception of *SystemInformationBlockType12*

Upon receiving *SystemInformationBlockType12*, the UE shall:

1> if the *SystemInformationBlockType12* contains a complete warning message:

2> forward the received warning message, *messageIdentifier*, *serialNumber* and *dataCodingScheme* to upper layers;

2> continue reception of *SystemInformationBlockType12*;

1> else:

2> if the received values of *messageIdentifier* and *serialNumber* are the same (each value is the same) as a pair for which a warning message is currently being assembled:

3> store the received *warningMessageSegment*;

3> if all segments of a warning message have been received:

4> assemble the warning message from the received *warningMessageSegment*;

4> forward the received warning message, *messageIdentifier*, *serialNumber* and *dataCodingScheme* to upper layers;

4> stop assembling a warning message for this *messageIdentifier* and *serialNumber* and delete all stored information held for it;

3> continue reception of *SystemInformationBlockType12*;

2> else if the received values of *messageIdentifier* and/or *serialNumber* are not the same as any of the pairs for which a warning message is currently being assembled:

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3> start assembling a warning message for this *messageIdentifier* and *serialNumber* pair;

3> store the received *warningMessageSegment*;

3> continue reception of *SystemInformationBlockType12*;

The UE should discard *warningMessageSegment* and the associated values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType12* if the complete warning message has not been assembled within a period of 3 hours.

NOTE: The number of warning messages that a UE can re-assemble simultaneously is a function of UE implementation.

5.2.2.20 Actions upon reception of *SystemInformationBlockType13*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.21 Actions upon reception of *SystemInformationBlockType14*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.22 Actions upon reception of *SystemInformationBlockType15*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.23 Actions upon reception of *SystemInformationBlockType16*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.2.24 Actions upon reception of *SystemInformationBlockType17*

Upon receiving *SystemInformationBlockType17*, the UE shall:

1> if *wlan-OffloadConfigCommon* corresponding to the RPLMN is included:

2> apply the *wlan-Id-List* corresponding to the RPLMN;

2> if not configured with the *wlan-OffloadConfigDedicated*;

3> apply the *wlan-OffloadConfigCommon* corresponding to the RPLMN;

5.2.2.25 Actions upon reception of *SystemInformationBlockType18*

Upon receiving *SystemInformationBlockType18*, the UE shall:

1> if *SystemInformationBlockType18* message includes the *commConfig*:

2> if configured to receive sidelink communication:

3> from the next SC period, as defined by *sc-Period*, use the resource pool indicated by *commRxPool* for sidelink communication monitoring, as specified in 5.10.3;

2> if configured to transmit sidelink communication:

3> from the next SC period, as defined by *sc-Period*, use the resource pool indicated by *commTxPoolNormalCommon* or by *commTxPoolExceptional* for sidelink communication transmission, as specified in 5.10.4;

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5.2.2.26 Actions upon reception of *SystemInformationBlockType19*

Upon receiving *SystemInformationBlockType19*, the UE shall:

1> if *SystemInformationBlockType19* message includes the *discConfig*:

2> from the next discovery period, as defined by *discPeriod*, use the resources indicated by *discRxPool* for sidelink discovery monitoring, as specified in 5.10.5;

2> if *SystemInformationBlockType19* message includes the *discTxPoolCommon*, and the UE is in RRC_IDLE:

3> from the next discovery period, as defined by *discPeriod*, use the resources indicated by *discTxPoolCommon* for sidelink discovery announcement, as specified in 5.10.6;

2> if the *SystemInformationBlockType19* message includes the *discTxPowerInfo*:

3> use the power information included in *discTxPowerInfo* for sidelink discovery transmission, as specified in TS 36.213 [23];

5.2.2.27 Actions upon reception of *SystemInformationBlockType20*

No UE requirements related to the contents of this *SystemInformationBlock* apply other than those specified elsewhere e.g. within procedures using the concerned system information, and/ or within the corresponding field descriptions.

5.2.3 Acquisition of an SI message

When acquiring an SI message, the UE shall:

1> determine the start of the SI-window for the concerned SI message as follows:

2> for the concerned SI message, determine the number n which corresponds to the order of entry in the list of SI messages configured by *schedulingInfoList* in *SystemInformationBlockType1*;

2> determine the integer value $x = (n - 1)*w$, where w is the *si-WindowLength*;

2> the SI-window starts at the subframe #a, where $a = x$ mod 10, in the radio frame for which SFN mod T = FLOOR(x/10), where T is the *si-Periodicity* of the concerned SI message;

NOTE: E-UTRAN should configure an SI-window of 1 ms only if all SIs are scheduled before subframe #5 in radio frames for which SFN mod 2 = 0.

1> receive DL-SCH using the SI-RNTI from the start of the SI-window and continue until the end of the SI-window whose absolute length in time is given by *si-WindowLength*, or until the SI message was received, excluding the following subframes:

2> subframe #5 in radio frames for which SFN mod 2 = 0;

2> any MBSFN subframes;

2> any uplink subframes in TDD;

1> if the SI message was not received by the end of the SI-window, repeat reception at the next SI-window occasion for the concerned SI message;

5.3 Connection control

5.3.1 Introduction

5.3.1.1 RRC connection control

RRC connection establishment involves the establishment of SRB1. E-UTRAN completes RRC connection establishment prior to completing the establishment of the S1 connection, i.e. prior to receiving the UE context

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information from the EPC. Consequently, AS security is not activated during the initial phase of the RRC connection. During this initial phase of the RRC connection, the E-UTRAN may configure the UE to perform measurement reporting, but the UE only sends the corresponding measurement reports after successful security activation. However, the UE only accepts a handover message when security has been activated.

NOTE: In case the serving frequency broadcasts multiple overlapping bands, E-UTRAN can only configure measurements after having obtained the UE capabilities, as the measurement configuration needs to be set according to the band selected by the UE.

Upon receiving the UE context from the EPC, E-UTRAN activates security (both ciphering and integrity protection) using the initial security activation procedure. The RRC messages to activate security (command and successful response) are integrity protected, while ciphering is started only after completion of the procedure. That is, the response to the message used to activate security is not ciphered, while the subsequent messages (e.g. used to establish SRB2 and DRBs) are both integrity protected and ciphered.

After having initiated the initial security activation procedure, E-UTRAN initiates the establishment of SRB2 and DRBs, i.e. E-UTRAN may do this prior to receiving the confirmation of the initial security activation from the UE. In any case, E-UTRAN will apply both ciphering and integrity protection for the RRC connection reconfiguration messages used to establish SRB2 and DRBs. E-UTRAN should release the RRC connection if the initial security activation and/ or the radio bearer establishment fails (i.e. security activation and DRB establishment are triggered by a joint S1-procedure, which does not support partial success).

For SRB2 and DRBs, security is always activated from the start, i.e. the E-UTRAN does not establish these bearers prior to activating security.

For some radio configuration fields, a critical extension has been defined. A switch from the original version of the field to the critically extended version is allowed using any connection reconfiguration. The UE reverts to the original version of some critically extended fields upon handover and re-establishment as specified elsewhere in this specification. Otherwise, switching a field from the critically extended version to the original version is only possible using the handover or re-establishment procedure with the full configuration option. This also applies for fields that are critically extended within a release (i.e. original and extended version defined in same release).

After having initiated the initial security activation procedure, E-UTRAN may configure a UE that supports CA, with one or more SCells in addition to the PCell that was initially configured during connection establishment. The PCell is used to provide the security inputs and upper layer system information (i.e. the NAS mobility information e.g. TAI). SCells are used to provide additional downlink and optionally uplink radio resources. When not configured with DC all SCells the UE is configured with, if any, are part of the MCG. When configured with DC however, some of the SCells are part of a SCG. In this case, user data carried by a DRB may either be transferred via MCG (i.e. MCG-DRB), via SCG (SCG-DRB) or via both MCG and SCG in DL while E-UTRAN configures the CG used in UL (split DRB). An RRC connection reconfiguration message may be used to change the DRB type from MCG-DRB to SCG-DRB or to split DRB, as well as from SCG-DRB or split DRB to MCG-DRB.

SCG change is a synchronous SCG reconfiguration procedure (i.e. involving RA to the PSCell) including reset/ re-establishment of layer 2 and, if SCG DRBs are configured, refresh of security. The procedure is used in a number of different scenarios e.g. SCG establishment, PSCell change, Key refresh, change of DRB type. The UE performs the SCG change related actions upon receiving an *RRCConnectionReconfiguration* message including *mobilityControlInfoSCG*, see 5.3.10.10.

The release of the RRC connection normally is initiated by E-UTRAN. The procedure may be used to re-direct the UE to an E-UTRA frequency or an inter-RAT carrier frequency. Only in exceptional cases, as specified within this specification, TS 36.300 [9], TS 36.304 [4] or TS 24.301 [35], may the UE abort the RRC connection, i.e. move to RRC_IDLE without notifying E-UTRAN.

5.3.1.2 Security

AS security comprises of the integrity protection of RRC signalling (SRBs) as well as the ciphering of RRC signalling (SRBs) and user data (DRBs).

RRC handles the configuration of the security parameters which are part of the AS configuration: the integrity protection algorithm, the ciphering algorithm and two parameters, namely the *keyChangeIndicator* and the *nextHopChainingCount*, which are used by the UE to determine the AS security keys upon handover and/ or connection re-establishment.

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The integrity protection algorithm is common for signalling radio bearers SRB1 and SRB2. The ciphering algorithm is common for all radio bearers (i.e. SRB1, SRB2 and DRBs). Neither integrity protection nor ciphering applies for SRB0.

RRC integrity and ciphering are always activated together, i.e. in one message/ procedure. RRC integrity and ciphering are never de-activated. However, it is possible to switch to a 'NULL' ciphering algorithm (eea0).

The 'NULL' integrity protection algorithm (eia0) is used only for the UE in limited service mode [32, TS33.401]. In case the 'NULL' integrity protection algorithm is used, 'NULL' ciphering algorithm is also used.

NOTE 1: Lower layers discard RRC messages for which the integrity check has failed and indicate the integrity verification check failure to RRC.

The AS applies three different security keys: one for the integrity protection of RRC signalling (K_{RRCint}), one for the ciphering of RRC signalling (K_{RRCenc}) and one for the ciphering of user data (K_{UPenc}). All three AS keys are derived from the K_{eNB} key. The K_{eNB} is based on the K_{ASME} key, which is handled by upper layers.

Upon connection establishment new AS keys are derived. No AS-parameters are exchanged to serve as inputs for the derivation of the new AS keys at connection establishment.

The integrity and ciphering of the RRC message used to perform handover is based on the security configuration used prior to the handover and is performed by the source eNB.

The integrity and ciphering algorithms can only be changed upon handover. The four AS keys (K_{eNB}, K_{RRCint}, K_{RRCenc} and K_{UPenc}) change upon every handover and connection re-establishment. The *keyChangeIndicator* is used upon handover and indicates whether the UE should use the keys associated with the K_{ASME} key taken into use with the latest successful NAS SMC procedure. The *nextHopChainingCount* parameter is used upon handover and connection re-establishment by the UE when deriving the new K_{eNB} that is used to generate K_{RRCint}, K_{RRCenc} and K_{UPenc} (see TS 33.401 [32]). An intra cell handover procedure may be used to change the keys in RRC_CONNECTED.

For each radio bearer an independent counter (COUNT, as specified in TS 36.323 [8]) is maintained for each direction. For each DRB, the COUNT is used as input for ciphering. For each SRB, the COUNT is used as input for both ciphering and integrity protection. It is not allowed to use the same COUNT value more than once for a given security key. In order to limit the signalling overhead, individual messages/ packets include a short sequence number (PDCP SN, as specified in TS 36.323 [8]). In addition, an overflow counter mechanism is used: the hyper frame number (TX_HFN and RX_HFN, as specified in TS 36.323 [8]). The HFN needs to be synchronized between the UE and the eNB. The eNB is responsible for avoiding reuse of the COUNT with the same RB identity and with the same K_{eNB}, e.g. due to the transfer of large volumes of data, release and establishment of new RBs. In order to avoid such re-use, the eNB may e.g. use different RB identities for successive RB establishments, trigger an intra cell handover or an RRC_CONNECTED to RRC_IDLE to RRC_CONNECTED transition.

For each SRB, the value provided by RRC to lower layers to derive the 5-bit BEARER parameter used as input for ciphering and for integrity protection is the value of the corresponding *srb-Identity* with the MSBs padded with zeroes.

In case of DC, a separate K_{eNB} is used for SCG-DRBs (S-K_{eNB}). This key is derived from the key used for the MCG (K_{eNB}) and an SCG counter that is used to ensure freshness. To refresh the S-K_{eNB} e.g. when the COUNT will wrap around, E-UTRAN employs an SCG change, i.e. an *RRCConnectionReconfiguration* message including *mobilityControlInfoSCG*. When performing handover, while at least one SCG-DRB remains configured, both K_{eNB} and S-K_{eNB} are refreshed. In such case E-UTRAN performs handover with SCG change i.e. an *RRCConnectionReconfiguration* message including both *mobilityControlInfo* and *mobilityControlInfoSCG*. The ciphering algorithm is common for all radio bearers within a CG but may be different between MCG and SCG. The ciphering algorithm for SCG DRBs can only be changed upon SCG change.

5.3.1.2a RN security

For RNs, AS security follows the procedures in 5.3.1.2. Furthermore, E-UTRAN may configure per DRB whether or not integrity protection is used. The use of integrity protection may be configured only upon DRB establishment and reconfigured only upon handover or upon the first reconfiguration following RRC connection re-establishment.

To provide integrity protection on DRBs between the RN and the E-UTRAN, the K_{UPint} key is derived from the K_{eNB} key as described in TS33.401 [32]. The same integrity protection algorithm used for SRBs also applies to the DRBs. The K_{UPint} changes at every handover and RRC connection re-establishment and is based on an updated K_{eNB} which is derived by taking into account the *nextHopChainingCount*. The COUNT value maintained for DRB ciphering is also used for integrity protection, if the integrity protection is configured for the DRB.

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5.3.1.3 Connected mode mobility

In RRC_CONNECTED, the network controls UE mobility, i.e. the network decides when the UE shall connect to which E-UTRA cell(s), or inter-RAT cell. For network controlled mobility in RRC_CONNECTED, the PCell can be changed using an *RRCConnectionReconfiguration* message including the *mobilityControlInfo* (handover), whereas the SCell(s) can be changed using the *RRCConnectionReconfiguration* message either with or without the *mobilityControlInfo*.

An SCG can be established, reconfigured or released by using an *RRCConnectionReconfiguration* message with or without the *mobilityControlInfo*. In case Random Access to the PSCell is required upon SCG reconfiguration, E-UTRAN employs the SCG change procedure (i.e. an *RRCConnectionReconfiguration* message including the *mobilityControlInfoSCG*). The PSCell can only be changed using the SCG change procedure.

The network triggers the handover procedure e.g. based on radio conditions, load. To facilitate this, the network may configure the UE to perform measurement reporting (possibly including the configuration of measurement gaps). The network may also initiate handover blindly, i.e. without having received measurement reports from the UE.

Before sending the handover message to the UE, the source eNB prepares one or more target cells. The source eNB selects the target PCell. The source eNB may also provide the target eNB with a list of best cells on each frequency for which measurement information is available, in order of decreasing RSRP. The source eNB may also include available measurement information for the cells provided in the list. The target eNB decides which SCells are configured for use after handover, which may include cells other than the ones indicated by the source eNB. If an SCG is configured, handover involves either SCG release or SCG change. In case the UE was configured with DC, the target eNB indicates in the handover message that the UE shall release the entire SCG configuration. Upon connection re-establishment, the UE releases the entire SCG configuration except for the DRB configuration, while E-UTRAN in the first reconfiguration message following the re-establishment either releases the DRB(s) or reconfigures the DRB(s) to MCG DRB(s).

The target eNB generates the message used to perform the handover, i.e. the message including the AS-configuration to be used in the target cell(s). The source eNB transparently (i.e. does not alter values/ content) forwards the handover message/ information received from the target to the UE. When appropriate, the source eNB may initiate data forwarding for (a subset of) the DRBs.

After receiving the handover message, the UE attempts to access the target PCell at the first available RACH occasion according to Random Access resource selection defined in TS 36.321 [6], i.e. the handover is asynchronous. Consequently, when allocating a dedicated preamble for the random access in the target PCell, E-UTRA shall ensure it is available from the first RACH occasion the UE may use. Upon successful completion of the handover, the UE sends a message used to confirm the handover.

If the target eNB does not support the release of RRC protocol which the source eNB used to configure the UE, the target eNB may be unable to comprehend the UE configuration provided by the source eNB. In this case, the target eNB should use the full configuration option to reconfigure the UE for Handover and Re-establishment. Full configuration option includes an initialization of the radio configuration, which makes the procedure independent of the configuration used in the source cell(s) with the exception that the security algorithms are continued for the RRC re-establishment.

After the successful completion of handover, PDCP SDUs may be re-transmitted in the target cell(s). This only applies for DRBs using RLC-AM mode and for handovers not involving full configuration option. The further details are specified in TS 36.323 [8]. After the successful completion of handover not involving full configuration option, the SN and the HFN are reset except for the DRBs using RLC-AM mode (for which both SN and HFN continue). For reconfigurations involving the full configuration option, the PDCP entities are newly established (SN and HFN do not continue) for all DRBs irrespective of the RLC mode. The further details are specified in TS 36.323 [8].

One UE behaviour to be performed upon handover is specified, i.e. this is regardless of the handover procedures used within the network (e.g. whether the handover includes X2 or S1 signalling procedures).

The source eNB should, for some time, maintain a context to enable the UE to return in case of handover failure. After having detected handover failure, the UE attempts to resume the RRC connection either in the source PCell or in another cell using the RRC re-establishment procedure. This connection resumption succeeds only if the accessed cell is prepared, i.e. concerns a cell of the source eNB or of another eNB towards which handover preparation has been performed. The cell in which the re-establishment procedure succeeds becomes the PCell while SCells and STAGs, if configured, are released.

Normal measurement and mobility procedures are used to support handover to cells broadcasting a CSG identity. In addition, E-UTRAN may configure the UE to report that it is entering or leaving the proximity of cell(s) included in its

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CSG whitelist. Furthermore, E-UTRAN may request the UE to provide additional information broadcast by the handover candidate cell e.g. global cell identity, CSG identity, CSG membership status.

NOTE: E-UTRAN may use the 'proximity report' to configure measurements as well as to decide whether or not to request additional information broadcast by the handover candidate cell. The additional information is used to verify whether or not the UE is authorised to access the target PCell and may also be needed to identify handover candidate cell (*PCI confusion* i.e. when the physical layer identity that is included in the measurement report does not uniquely identify the cell).

5.3.2 Paging

5.3.2.1 General

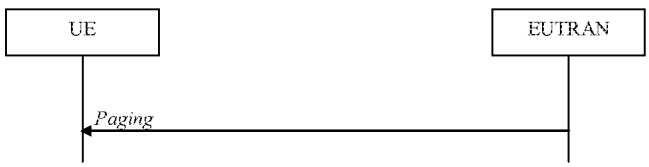


Figure 5.3.2.1-1: Paging

The purpose of this procedure is:

- to transmit paging information to a UE in RRC_IDLE and/ or;
- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change and/ or;
- to inform about an ETWS primary notification and/ or ETWS secondary notification and/ or;
- to inform about a CMAS notification and/ or;
- to inform UEs in RRC_IDLE about an EAB parameters modification and/ or;
- to inform UEs in RRC_IDLE to perform E-UTRAN inter-frequency redistribution procedure.

The paging information is provided to upper layers, which in response may initiate RRC connection establishment, e g. to receive an incoming call.

5.3.2.2 Initiation

E-UTRAN initiates the paging procedure by transmitting the *Paging* message at the UE's paging occasion as specified in TS 36.304 [4]. E-UTRAN may address multiple UEs within a *Paging* message by including one *PagingRecord* for each UE. E-UTRAN may also indicate a change of system information, and/ or provide an ETWS notification or a CMAS notification in the *Paging* message.

5.3.2.3 Reception of the *Paging* message by the UE

Upon receiving the *Paging* message, the UE shall:

1> if in RRC_IDLE, for each of the *PagingRecord*, if any, included in the *Paging* message:

2> if the *ue-Identity* included in the *PagingRecord* matches one of the UE identities allocated by upper layers:

3> forward the *ue-Identity* and the *cn-Domain* to the upper layers;

1> if the UE uses a DRX cycle longer than the modification period:

2> if the *systemInfoModification-eDRX* is included:

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3> re-acquire the required system information using the system information acquisition procedure as specified in 5.2.2.

1> else

2> if the *systemInfoModification* is included:

3> re-acquire the required system information using the system information acquisition procedure as specified in 5.2.2.

1> if the *etws-Indication* is included and the UE is ETWS capable:

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

3> acquire *SystemInformationBlockType10*;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

3> acquire *SystemInformationBlockType11*;

1> if the *cmas-Indication* is included and the UE is CMAS capable:

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary as specified in 5.2.1.5;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

3> acquire *SystemInformationBlockType12*;

1> if in RRC_IDLE, the *eab-ParamModification* is included and the UE is EAB capable:

2> consider previously stored SystemInformationBlockType14 as invalid;

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary as specified in 5.2.1.6;

2> re-acquire *SystemInformationBlockType14* using the system information acquisition procedure as specified in 5.2.2.4;

1> if in RRC_IDLE, the *redistributionIndication* is included and the UE is redistribution capable:

2> Perform E-UTRAN Inter-Frequency Redistribution procedure as specified in 5.2.4.10 [4];

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5.3.3 RRC connection establishment

5.3.3.1 General

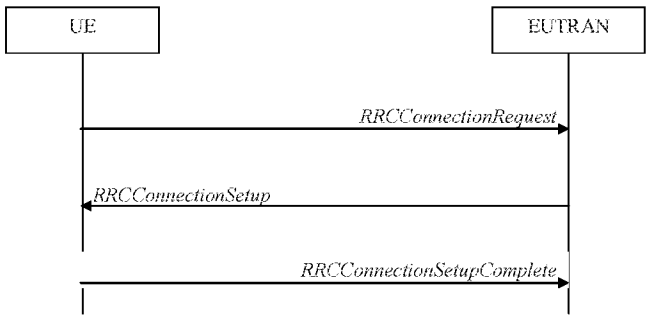


Figure 5.3.3.1-1: RRC connection establishment, successful

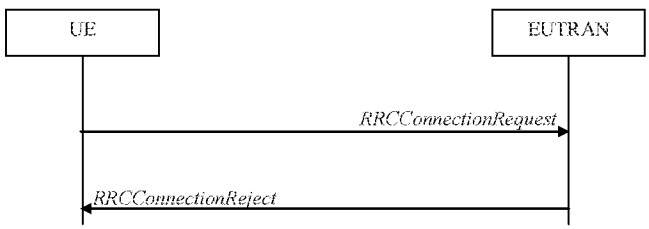


Figure 5.3.3.1-2: RRC connection establishment, network reject

The purpose of this procedure is to establish an RRC connection. RRC connection establishment involves SRB1 establishment. The procedure is also used to transfer the initial NAS dedicated information/ message from the UE to E-UTRAN.

E-UTRAN applies the procedure as follows:

- to establish SRB1 only.

5.3.3.1a Conditions for establishing RRC Connection for sidelink communication/ discovery

For sidelink communication an RRC connection is initiated only in the following case:

1> if configured by upper layers to transmit non-relay related sidelink communication and related data is available for transmission:

2> if *SystemInformationBlockType18* is broadcast by the cell on which the UE camps; and if the valid version of *SystemInformationBlockType18* does not include *commTxPoolNormalCommon*;

1> if configured by upper layers to transmit relay related sidelink communication:

2> if the UE is acting as relay; or

2> if the UE has a selected relay; and if *SystemInformationBlockType19* is broadcast by the cell on which the UE camps and includes *discConfigRelay*; and if either *discThreshHiRemoteUE* is not included in *SystemInformationBlockType19* or the RSRP measurement of the cell on which the UE camps is below *discThreshHiRemoteUE*;

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3> if *SystemInformationBlockType18* is broadcast by the cell on which the UE camps; and if the valid version of *SystemInformationBlockType18* either does not include *commTxPoolNormalCommon* or does not include *commTxAllowRelayCommon*.

For sidelink discovery an RRC connection is initiated only in the following case:

1> if configured by upper layers to transmit non-PS related sidelink discovery announcements:

2> if the frequency on which the UE is configured to transmit non-PS related sidelink discovery announcements concerns the camped frequency while *SystemInformationBlockType19* of the cell on which the UE camps does not include *discTxPoolCommon*; or

2> if the frequency on which the UE is configured to transmit non-PS related sidelink discovery announcements is included in *discInterFreqList* in *SystemInformationBlockType19* broadcast by the cell on which the UE camps, with *discTxResources* included and set to *requestDedicated*:

1> if configured by upper layers to transmit PS related sidelink discovery announcements:

2> if the frequency on which the UE is configured to transmit PS related sidelink discovery announcements concerns the camped frequency while *SystemInformationBlockType19* of the cell on which the UE camps includes *discConfigPS* but does not include *discTxPoolPS-Common*; or

2> if the frequency on which the UE is configured to transmit non-relay PS related sidelink discovery announcements (e.g. group member discovery) is included in *discInterFreqList* in *SystemInformationBlockType19* broadcast by the cell on which the UE camps, with *discTxResourcePS* included and set to *requestDedicated*:

3> if configured by upper layers to transmit non-relay PS related sidelink discovery announcements; or

3> if configured by upper layers to transmit relay related sidelink discovery announcements:

4> if the UE is acting as relay; and if the RSRP measurement of the cell on which the UE camps is below *discThreshHiRelayUE*, if included in *SystemInformationBlockType19* of the cell on which the UE camps; and above *discThreshLoRelayUE*, if included in the same *SystemInformationBlockType19*; or

4> if the UE is selecting a relay/ has a selected relay; and if the RSRP measurement of the cell on which the UE camps is below *discThreshHiRemoteUE*, if included in *SystemInformationBlockType19* of the cell on which the UE camps:

NOTE: Upper layers initiate an RRC connection. The interaction with NAS is left to UE implementation.

5.3.3.2 Initiation

The UE initiates the procedure when upper layers request establishment of an RRC connection while the UE is in RRC_IDLE.

Upon initiation of the procedure, the UE shall:

1> if *SystemInformationBlockType2* includes *ac-BarringPerPLMN-List* and the *ac-BarringPerPLMN-List* contains an *AC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]):

2> select the *AC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers;

2> in the remainder of this procedure, use the selected *AC-BarringPerPLMN* entry (i.e. presence or absence of access barring parameters in this entry) irrespective of the common access barring parameters included in *SystemInformationBlockType2;*

1> else

2> in the remainder of this procedure use the common access barring parameters (i.e. presence or absence of these parameters) included in *SystemInformationBlockType2;*

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1> if *SystemInformationBlockType2* contains *ACDC-BarringPerPLMN-List* and the *ACDC-BarringPerPLMN-List* contains an *ACDC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]):

2> select the *ACDC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers;

2> in the remainder of this procedure, use the selected *ACDC-BarringPerPLMN* entry for ACDC barring check (i.e. presence or absence of access barring parameters in this entry) irrespective of the common access barring parameters included in *SystemInformationBlockType2*;

1> else:

2> in the remainder of this procedure use the *ACDC-BarringForCommon* (i.e. presence or absence of these parameters) included in *SystemInformationBlockType2* for ACDC barring check;

1> if upper layers indicate that the RRC connection is subject to EAB (see TS 24.301 [35]):

2> if the result of the EAB check, as specified in 5.3.3.12, is that access to the cell is barred:

3> inform upper layers about the failure to establish the RRC connection and that EAB is applicable, upon which the procedure ends;

1> if upper layers indicate that the RRC connection is subject to ACDC (see TS 24.301 [35]), *SystemInformationBlockType2* contains *ac-BarringForACDC*, and *acdc-HPLMNonly* indicates that ACDC is applicable for the UE:

2> if the *ac-BarringForACDC* contains a *BarringPerACDC-Category* entry corresponding to the ACDC category selected by upper layers:

3> select the *BarringPerACDC-Category* entry corresponding to the ACDC category selected by upper layers;

2> else:

3> select the last *BarringPerACDC-Category* entry in the *BarringPerACDC-CategoryList*;

2> stop timer T308, if running;

2> perform access barring check as specified in 5.3.3.13, using T308 as "Tbarring" and *acdc-BarringConfig* in the *BarringPerACDC-Category* as "ACDC barring parameter";

2> if access to the cell is barred:

3> inform upper layers about the failure to establish the RRC connection and that access barring is applicable due to ACDC, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for mobile terminating calls:

2> if timer T302 is running:

3> inform upper layers about the failure to establish the RRC connection and that access barring for mobile terminating calls is applicable, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for emergency calls:

2> if *SystemInformationBlockType2* includes the *ac-BarringInfo*:

3> if the *ac-BarringForEmergency* is set to *TRUE*:

4> if the UE has one or more Access Classes, as stored on the USIM, with a value in the range 11..15, which is valid for the UE to use according to TS 22.011 [10] and TS 23.122 [11]:

NOTE 1: ACs 12, 13, 14 are only valid for use in the home country and ACs 11, 15 are only valid for use in the HPLMN/ EHPLMN.

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5> if the *ac-BarringInfo* includes *ac-BarringForMO-Data*, and for all of these valid Access Classes for the UE, the corresponding bit in the *ac-BarringForSpecialAC* contained in *ac-BarringForMO-Data* is set to *one*:

6> consider access to the cell as barred;

4> else:

5> consider access to the cell as barred;

2> if access to the cell is barred:

3> inform upper layers about the failure to establish the RRC connection, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for mobile originating calls:

2> perform access barring check as specified in 5.3.3.11, using T303 as "Tbarring" and *ac-BarringForMO-Data* as "AC barring parameter";

2> if access to the cell is barred:

3> if *SystemInformationBlockType2* includes *ac-BarringForCSFB* or the UE does not support CS fallback:

4> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating calls is applicable, upon which the procedure ends;

3> else (*SystemInformationBlockType2* does not include *ac-BarringForCSFB* and the UE supports CS fallback):

4> if timer T306 is not running, start T306 with the timer value of T303;

4> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating calls and mobile originating CS fallback is applicable, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for mobile originating signalling:

2> perform access barring check as specified in 5.3.3.11, using T305 as "Tbarring" and *ac-BarringForMO-Signalling* as "AC barring parameter";

2> if access to the cell is barred:

3> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating signalling is applicable, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for mobile originating CS fallback:

2> if *SystemInformationBlockType2* includes *ac-BarringForCSFB*:

3> perform access barring check as specified in 5.3.3.11, using T306 as "Tbarring" and *ac-BarringForCSFB* as "AC barring parameter";

3> if access to the cell is barred:

4> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating CS fallback is applicable, due to *ac-BarringForCSFB*, upon which the procedure ends;

2> else:

3> perform access barring check as specified in 5.3.3.11, using T306 as "Tbarring" and *ac-BarringForMO-Data* as "AC barring parameter";

3> if access to the cell is barred:

4> if timer T303 is not running, start T303 with the timer value of T306;

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4> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating CS fallback and mobile originating calls is applicable, due to *ac-BarringForMO-Data*, upon which the procedure ends;

1> else if the UE is establishing the RRC connection for mobile originating MMTEL voice, mobile originating MMTEL video, mobile originating SMSoIP or mobile originating SMS:

2> if the UE is establishing the RRC connection for mobile originating MMTEL voice and *SystemInformationBlockType2* includes *ac-BarringSkipForMMTELVoice*; or

2> if the UE is establishing the RRC connection for mobile originating MMTEL video and *SystemInformationBlockType2* includes *ac-BarringSkipForMMTELVideo*; or

2> if the UE is establishing the RRC connection for mobile originating SMSoIP or SMS and *SystemInformationBlockType2* includes *ac-BarringSkipForSMS*:

3> consider access to the cell as not barred;

2> else:

3> if *establishmentCause* received from higher layers is set to *mo-Signalling* (including the case that *mo-Signalling* is replaced by *highPriorityAccess* according to 3GPP TS 24.301 [35] or by *mo-VoiceCall* according to the subclause 5.3.3.3):

4> perform access barring check as specified in 5.3.3.11, using T305 as "Tbarring" and *ac-BarringForMO-Signalling* as "AC barring parameter";

4> if access to the cell is barred:

5> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating signalling is applicable, upon which the procedure ends;

3> if *establishmentCause* received from higher layers is set to *mo-Data* (including the case that *mo-Data* is replaced by *highPriorityAccess* according to 3GPP TS 24.301 [35] or by *mo-VoiceCall* according to the subclause 5.3.3.3):

4> perform access barring check as specified in 5.3.3.11, using T303 as "Tbarring" and *ac-BarringForMO-Data* as "AC barring parameter";

4> if access to the cell is barred:

5> if *SystemInformationBlockType2* includes *ac-BarringForCSFB* or the UE does not support CS fallback:

6> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating calls is applicable, upon which the procedure ends;

5> else (*SystemInformationBlockType2* does not include *ac-BarringForCSFB* and the UE supports CS fallback):

6> if timer T306 is not running, start T306 with the timer value of T303;

6> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating calls and mobile originating CS fallback is applicable, upon which the procedure ends;

1> apply the default physical channel configuration as specified in 9.2.4;

1> apply the default semi-persistent scheduling configuration as specified in 9.2.3;

1> apply the default MAC main configuration as specified in 9.2.2;

1> apply the CCCH configuration as specified in 9.1.1.2;

1> apply the *timeAlignmentTimerCommon* included in *SystemInformationBlockType2*;

1> start timer T300;

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1> initiate transmission of the *RRCConnectionRequest* message in accordance with 5.3.3.3;

NOTE 2: Upon initiating the connection establishment procedure, the UE is not required to ensure it maintains up to date system information applicable only for UEs in RRC_IDLE state. However, the UE needs to perform system information acquisition upon cell re-selection.

5.3.3.3 Actions related to transmission of *RRCConnectionRequest* message

The UE shall set the contents of *RRCConnectionRequest* message as follows:

1> set the *ue-Identity* as follows:

2> if upper layers provide an S-TMSI:

3> set the *ue-Identity* to the value received from upper layers;

2> else:

3> draw a random value in the range 0 .. 2^{40}-1 and set the *ue-Identity* to this value;

NOTE 1: Upper layers provide the S-TMSI if the UE is registered in the TA of the current cell.

1> if the UE supports *mo-VoiceCall* establishment cause and UE is establishing the RRC connection for mobile originating MMTEL voice and *SystemInformationBlockType2* includes *voiceServiceCauseIndication*:

2> set the *establishmentCause* to *mo-VoiceCall*;

1> else:

2> set the *establishmentCause* in accordance with the information received from upper layers;

The UE shall submit the *RRCConnectionRequest* message to lower layers for transmission.

The UE shall continue cell re-selection related measurements as well as cell re-selection evaluation. If the conditions for cell re-selection are fulfilled, the UE shall perform cell re-selection as specified in 5.3.3.5.

5.3.3.4 Reception of the *RRCConnectionSetup* by the UE

NOTE: Prior to this, lower layer signalling is used to allocate a C-RNTI. For further details see TS 36.321 [6];

The UE shall:

1> perform the radio resource configuration procedure in accordance with the received *radioResourceConfigDedicated* and as specified in 5.3.10;

1> if stored, discard the cell reselection priority information provided by the *idleModeMobilityControlInfo* or inherited from another RAT;

1> stop timer T300;

1> stop timer T302, if running;

1> stop timer T303, if running;

1> stop timer T305, if running;

1> stop timer T306, if running;

1> stop timer T308, if running;

1> perform the actions as specified in 5.3.3.7;

1> stop timer T320, if running;

1> stop timer T350, if running;

1> perform the actions as specified in 5.6.12.4;

1> stop timer T360, if running;

1> enter RRC_CONNECTED;

1> stop the cell re-selection procedure;

1> consider the current cell to be the PCell;

1> set the content of *RRCConnectionSetupComplete* message as follows:

2> set the *selectedPLMN-Identity* to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]) from the PLMN(s) included in the *plmn-IdentityList* in *SystemInformationBlockType1*;

2> if upper layers provide the 'Registered MME', include and set the *registeredMME* as follows:

3> if the PLMN identity of the 'Registered MME' is different from the PLMN selected by the upper layers:

4> include the *plmnIdentity* in the *registeredMME* and set it to the value of the PLMN identity in the 'Registered MME' received from upper layers;

3> set the *mmegi* and the *mmec* to the value received from upper layers;

2> if upper layers provided the 'Registered MME':

3> include and set the *gummei-Type* to the value provided by the upper layers;

2> if connecting as an RN:

3> include the *rn-SubframeConfigReq*;

2> set the *dedicatedInfoNAS* to include the information received from upper layers;

2> if the UE has radio link failure or handover failure information available in *VarRLF-Report* and if the RPLMN is included in *plmn-IdentityList* stored in *VarRLF-Report*:

3> include *rlf-InfoAvailable*;

2> if the UE has MBSFN logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

3> include *logMeasAvailableMBSFN*;

2> else if the UE has logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

3> include *logMeasAvailable*;

2> if the UE has connection establishment failure information available in *VarConnEstFailReport* and if the RPLMN is equal to *plmn-Identity* stored in *VarConnEstFailReport*:

3> include *connEstFailInfoAvailable*;

2> include the *mobilityState* and set it to the mobility state (as specified in TS 36.304 [4]) of the UE just prior to entering RRC_CONNECTED state;

2> if the UE supports storage of mobility history information and the UE has mobility history information available in *VarMobilityHistoryReport*:

3> include the *mobilityHistoryAvail*;

2> submit the *RRCConnectionSetupComplete* message to lower layers for transmission, upon which the procedure ends;

5.3.3.5 Cell re-selection while T300, T302, T303, T305, T306, or T308 is running

The UE shall:

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1> if cell reselection occurs while T300, T302, T303, T305, T306, or T308 is running:

2> if timer T302, T303, T305,T306, and/or T308 is running:

3> stop timer T302, T303, T305, T306, and T308, whichever ones were running;

3> perform the actions as specified in 5.3.3.7;

2> if timer T300 is running:

3> stop timer T300;

3> reset MAC, release the MAC configuration and re-establish RLC for all RBs that are established;

3> inform upper layers about the failure to establish the RRC connection;

5.3.3.6 T300 expiry

The UE shall:

1> if timer T300 expires:

2> reset MAC, release the MAC configuration and re-establish RLC for all RBs that are established;

2> if the UE supports RRC Connection Establishment failure temporary Qoffset and T300 has expired a consecutive *connEstFailCount* times on the same cell for which *txFailParams* is included in *SystemInformationBlockType2*:

3> for a period as indicated by *connEstFailOffsetValidity*:

4> use *connEstFailOffset* for the parameter $Qoffset_{hcmp}$ for the concerned cell when performing cell selection and reselection according to TS 36.304 [4] and TS 25.304 [40];

NOTE 1: When performing cell selection, if no suitable or acceptable cell can be found, it is up to UE implementation whether to stop using *connEstFailOffset* for the parameter $Qoffset_{hcmp}$ during *connEstFailOffsetValidity* for the concerned cell.

2> store the following connection establishment failure information in the *VarConnEstFailReport* by setting its fields as follows:

3> clear the information included in *VarConnEstFailReport*, if any;

3> set the *plmn-Identity* to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]) from the PLMN(s) included in the *plmn-IdentityList* in *SystemInformationBlockType1*;

3> set the *failedCellId* to the global cell identity of the cell where connection establishment failure is detected;

3> set the *measResultFailedCell* to include the RSRP and RSRQ, if available, of the cell where connection establishment failure is detected and based on measurements collected up to the moment the UE detected the failure;

3> if available, set the *measResultNeighCells*, in order of decreasing ranking-criterion as used for cell re-selection, to include neighbouring cell measurements for at most the following number of neighbouring cells: 6 intra-frequency and 3 inter-frequency neighbours per frequency as well as 3 inter-RAT neighbours, per frequency/ set of frequencies (GERAN) per RAT and according to the following:

4> for each neighbour cell included, include the optional fields that are available;

NOTE 2: The UE includes the latest results of the available measurements as used for cell reselection evaluation, which are performed in accordance with the performance requirements as specified in TS 36.133 [16].

3> if detailed location information is available, set the content of the *locationInfo* as follows:

4> include the *locationCoordinates*;

4> include the *horizontalVelocity*, if available;

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3> set the *numberOfPreamblesSent* to indicate the number of preambles sent by MAC for the failed random access procedure;

3> set *contentionDetected* to indicate whether contention resolution was not successful as specified in TS 36.321 [6] for at least one of the transmitted preambles for the failed random access procedure;

3> set *maxTxPowerReached* to indicate whether or not the maximum power level was used for the last transmitted preamble, see TS 36.321 [6];

2> inform upper layers about the failure to establish the RRC connection, upon which the procedure ends;

The UE may discard the connection establishment failure information, i.e. release the UE variable *VarConnEstFailReport*, 48 hours after the failure is detected, upon power off or upon detach.

5.3.3.7 T302, T303, T305, T306, or T308 expiry or stop

The UE shall:

1> if timer T302 expires or is stopped:

2> inform upper layers about barring alleviation for mobile terminating access;

2> if timer T303 is not running:

3> inform upper layers about barring alleviation for mobile originating calls;

2> if timer T305 is not running:

3> inform upper layers about barring alleviation for mobile originating signalling;

2> if timer T306 is not running:

3> inform upper layers about barring alleviation for mobile originating CS fallback;

1> if timer T303 expires or is stopped:

2> if timer T302 is not running:

3> inform upper layers about barring alleviation for mobile originating calls;

1> if timer T305 expires or is stopped:

2> if timer T302 is not running:

3> inform upper layers about barring alleviation for mobile originating signalling;

1> if timer T306 expires or is stopped:

2> if timer T302 is not running:

3> inform upper layers about barring alleviation for mobile originating CS fallback;

1> if timer T308 expires or is stopped:

2> if timer T302 is not running:

3> inform upper layers about barring alleviation for ACDC;

5.3.3.8 Reception of the *RRCConnectionReject* by the UE

The UE shall:

1> stop timer T300;

1> reset MAC and release the MAC configuration;

1> start timer T302, with the timer value set to the *waitTime*;

1> if the *extendedWaitTime* is present and the UE supports delay tolerant access:

2> forward the *extendedWaitTime* to upper layers;

1> if *deprioritisationReq* is included and the UE supports RRC Connection Reject with deprioritisation:

2> start or restart timer T325 with the timer value set to the *deprioritisationTimer* signalled;

2> store the *deprioritisationReq* until T325 expiry;

NOTE: The UE stores the deprioritisation request irrespective of any cell reselection absolute priority assignments (by dedicated or common signalling) and regardless of RRC connections in E-UTRAN or other RATs unless specified otherwise.

1> inform upper layers about the failure to establish the RRC connection and that access barring for mobile originating calls, mobile originating signalling, mobile terminating access and mobile originating CS fallback is applicable, upon which the procedure ends;

5.3.3.9 Abortion of RRC connection establishment

If upper layers abort the RRC connection establishment procedure while the UE has not yet entered RRC_CONNECTED, the UE shall:

1> stop timer T300, if running;

1> reset MAC, release the MAC configuration and re-establish RLC for all RBs that are established;

5.3.3.10 Handling of SSAC related parameters

Upon request from the upper layers, the UE shall:

1> if *SystemInformationBlockType2* includes *ac-BarringPerPLMN-List* and the *ac-BarringPerPLMN-List* contains an *AC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]):

2> select the *AC-BarringPerPLMN* entry with the *plmn-IdentityIndex* corresponding to the PLMN selected by upper layers;

2> in the remainder of this procedure, use the selected *AC-BarringPerPLMN* entry (i.e. presence or absence of access barring parameters in this entry) irrespective of the common access barring parameters included in *SystemInformationBlockType2*;

1> else:

2> in the remainder of this procedure use the common access barring parameters (i.e. presence or absence of these parameters) included in *SystemInformationBlockType2*;

1> set the local variables *BarringFactorForMMTEL-Voice* and *BarringTimeForMMTEL-Voice* as follows:

2> if *ssac-BarringForMMTEL-Voice* is present:

3> if the UE has one or more Access Classes, as stored on the USIM, with a value in the range 11..15, which is valid for the UE to use according to TS 22.011 [10] and TS 23.122 [11], and

NOTE: ACs 12, 13, 14 are only valid for use in the home country and ACs 11, 15 are only valid for use in the HPLMN/ EHPLMN.

3> if, for at least one of these Access Classes, the corresponding bit in the *ac-BarringForSpecialAC* contained in *ssac-BarringForMMTEL-Voice* is set to zero:

4> set *BarringFactorForMMTEL-Voice* to one and *BarringTimeForMMTEL-Voice* to zero;

3> else:

4> set *BarringFactorForMMTEL-Voice* and *BarringTimeForMMTEL-Voice* to the value of *ac-BarringFactor* and *ac-BarringTime* included in *ssac-BarringForMMTEL-Voice*, respectively;

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2> else set *BarringFactorForMMTEL-Voice* to one and *BarringTimeForMMTEL-Voice* to zero;

1> set the local variables *BarringFactorForMMTEL-Video* and *BarringTimeForMMTEL-Video* as follows:

2> if *ssac-BarringForMMTEL-Video* is present:

3> if the UE has one or more Access Classes, as stored on the USIM, with a value in the range 11..15, which is valid for the UE to use according to TS 22.011 [10] and TS 23.122 [11], and

3> if, for at least one of these Access Classes, the corresponding bit in the *ac-BarringForSpecialAC* contained in *ssac-BarringForMMTEL-Video* is set to zero:

4> set *BarringFactorForMMTEL-Video* to one and *BarringTimeForMMTEL-Video* to zero;

3> else:

4> set *BarringFactorForMMTEL-Video* and *BarringTimeForMMTEL-Video* to the value of *ac-BarringFactor* and *ac-BarringTime* included in *ssac-BarringForMMTEL-Video*, respectively;

2> else set *BarringFactorForMMTEL-Video* to one and *BarringTimeForMMTEL-Video* to zero;

1> forward the variables *BarringFactorForMMTEL-Voice*, *BarringTimeForMMTEL-Voice*, *BarringFactorForMMTEL-Video* and *BarringTimeForMMTEL-Video* to the upper layers;

5.3.3.11 Access barring check

1> if timer T302 or "Tbarring" is running:

2> consider access to the cell as barred;

1> else if *SystemInformationBlockType2* includes "AC barring parameter":

2> if the UE has one or more Access Classes, as stored on the USIM, with a value in the range 11..15, which is valid for the UE to use according to TS 22.011 [10] and TS 23.122 [11], and

NOTE: ACs 12, 13, 14 are only valid for use in the home country and ACs 11, 15 are only valid for use in the HPLMN/ EHPLMN.

2> for at least one of these valid Access Classes the corresponding bit in the *ac-BarringForSpecialAC* contained in "AC barring parameter" is set to *zero*:

3> consider access to the cell as not barred;

2> else:

3> draw a random number '*rand*' uniformly distributed in the range: $0 \leq rand < 1$;

3> if '*rand*' is lower than the value indicated by *ac-BarringFactor* included in "AC barring parameter":

4> consider access to the cell as not barred;

3> else:

4> consider access to the cell as barred;

1> else:

2> consider access to the cell as not barred;

1> if access to the cell is barred and both timers T302 and "Tbarring" are not running:

2> draw a random number '*rand*' that is uniformly distributed in the range $0 \leq rand < 1$;

2> start timer "Tbarring" with the timer value calculated as follows, using the *ac-BarringTime* included in "AC barring parameter":

"Tbarring" = $(0.7 + 0.6 * rand) * ac\text{-}BarringTime$;

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5.3.3.12 EAB check

The UE shall:

1> if *SystemInformationBlockType14* is present and includes the *eab-Param*:

2> if the *eab-Common* is included in the *eab-Param*:

3> if the UE belongs to the category of UEs as indicated in the *eab-Category* contained in *eab-Common*; and

3> if for the Access Class of the UE, as stored on the USIM and with a value in the range 0..9, the corresponding bit in the *eab-BarringBitmap* contained in *eab-Common* is set to *one*:

4> consider access to the cell as barred;

3> else:

4> consider access to the cell as not barred due to EAB;

2> else (the *eab-PerPLMN-List* is included in the *eab-Param*):

3> select the entry in the *eab-PerPLMN-List* corresponding to the PLMN selected by upper layers (see TS 23.122 [11], TS 24.301 [35]);

3> if the *eab-Config* for that PLMN is included:

4> if the UE belongs to the category of UEs as indicated in the *eab-Category* contained in *eab-Config*; and

4> if for the Access Class of the UE, as stored on the USIM and with a value in the range 0..9, the corresponding bit in the *eab-BarringBitmap* contained in *eab-Config* is set to *one*:

5> consider access to the cell as barred;

4> else:

5> consider access to the cell as not barred due to EAB;

3> else:

4> consider access to the cell as not barred due to EAB;

1> else:

2> consider access to the cell as not barred due to EAB;

5.3.3.13 Access barring check for ACDC

1> if timer T302 is running:

2> consider access to the cell as barred;

1> else if *SystemInformationBlockType2* includes "ACDC barring parameter":

2> draw a random number '*rand*' uniformly distributed in the range: $0 \leq rand < 1$;

2> if '*rand*' is lower than the value indicated by *ac-BarringFactor* included in "ACDC barring parameter":

3> consider access to the cell as not barred;

2> else:

3> consider access to the cell as barred;

1> else:

2> consider access to the cell as not barred;

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1> if access to the cell is barred and timer T302 is not running:

2> draw a random number '*rand*' that is uniformly distributed in the range $0 \leq rand < 1$;

2> start timer "Tbarring" with the timer value calculated as follows, using the *ac-BarringTime* included in "ACDC barring parameter":

"Tbarring" = $(0.7 + 0.6 * rand) * ac\text{-}BarringTime$.

5.3.4 Initial security activation

5.3.4.1 General

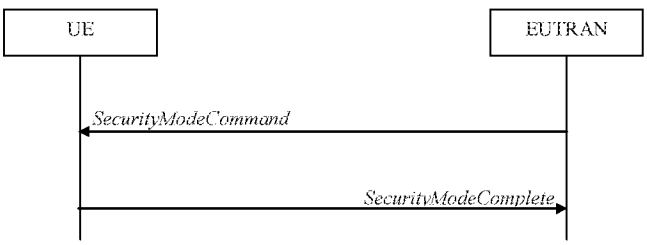


Figure 5.3.4.1-1: Security mode command, successful

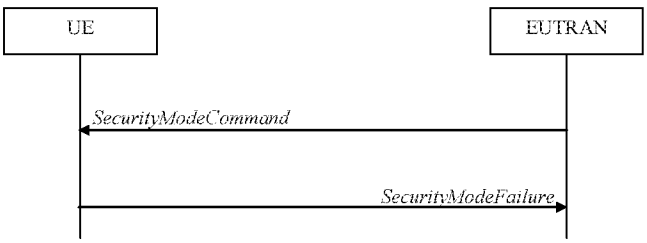


Figure 5.3.4.1-2: Security mode command, failure

The purpose of this procedure is to activate AS security upon RRC connection establishment.

5.3.4.2 Initiation

E-UTRAN initiates the security mode command procedure to a UE in RRC_CONNECTED. Moreover, E-UTRAN applies the procedure as follows:

- when only SRB1 is established, i.e. prior to establishment of SRB2 and/ or DRBs.

5.3.4.3 Reception of the *SecurityModeCommand* by the UE

The UE shall:

1> derive the K_{eNB} key, as specified in TS 33.401 [32];

1> derive the K_{RRCint} key associated with the *integrityProtAlgorithm* indicated in the *SecurityModeCommand* message, as specified in TS 33.401 [32];

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1> request lower layers to verify the integrity protection of the *SecurityModeCommand* message, using the algorithm indicated by the *integrityProtAlgorithm* as included in the *SecurityModeCommand* message and the K_{RRCint} key;

1> if the *SecurityModeCommand* message passes the integrity protection check:

2> derive the K_{RRCenc} key and the K_{UPenc} key associated with the *cipheringAlgorithm* indicated in the *SecurityModeCommand* message, as specified in TS 33.401 [32];

2> if connected as an RN:

3> derive the K_{UPint} key associated with the *integrityProtAlgorithm* indicated in the *SecurityModeCommand* message, as specified in TS 33.401 [32];

2> configure lower layers to apply integrity protection using the indicated algorithm and the K_{RRCint} key immediately, i.e. integrity protection shall be applied to all subsequent messages received and sent by the UE, including the *SecurityModeComplete* message;

2> configure lower layers to apply ciphering using the indicated algorithm, the K_{RRCenc} key and the K_{UPenc} key after completing the procedure, i.e. ciphering shall be applied to all subsequent messages received and sent by the UE, except for the *SecurityModeComplete* message which is sent unciphered;

2> if connected as an RN:

3> configure lower layers to apply integrity protection using the indicated algorithm and the K_{UPint} key, for DRBs that are subsequently configured to apply integrity protection, if any;

2> consider AS security to be activated;

2> submit the *SecurityModeComplete* message to lower layers for transmission, upon which the procedure ends;

1> else:

2> continue using the configuration used prior to the reception of the *SecurityModeCommand* message, i.e. neither apply integrity protection nor ciphering.

2> submit the *SecurityModeFailure* message to lower layers for transmission, upon which the procedure ends;

5.3.5 RRC connection reconfiguration

5.3.5.1 General

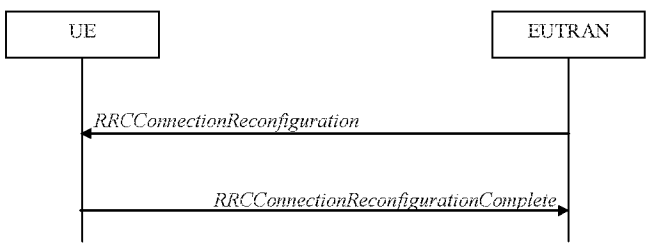


Figure 5.3.5.1-1: RRC connection reconfiguration, successful

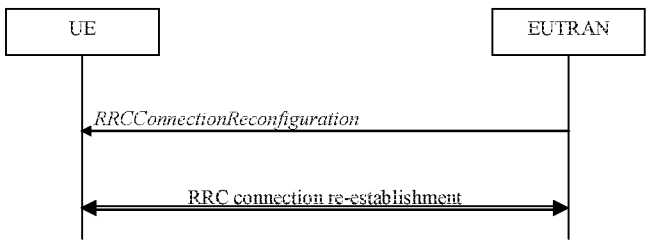


Figure 5.3.5.1-2: RRC connection reconfiguration, failure

The purpose of this procedure is to modify an RRC connection, e.g. to establish/ modify/ release RBs, to perform handover, to setup/ modify/ release measurements, to add/ modify/ release SCells. As part of the procedure, NAS dedicated information may be transferred from E-UTRAN to the UE.

5.3.5.2 Initiation

E-UTRAN may initiate the RRC connection reconfiguration procedure to a UE in RRC_CONNECTED. E-UTRAN applies the procedure as follows:

- the *mobilityControlInfo* is included only when AS-security has been activated, and SRB2 with at least one DRB are setup and not suspended;
- the establishment of RBs (other than SRB1, that is established during RRC connection establishment) is included only when AS security has been activated;
- the addition of SCells is performed only when AS security has been activated;

5.3.5.3 Reception of an *RRCConnectionReconfiguration* not including the *mobilityControlInfo* by the UE

If the *RRCConnectionReconfiguration* message does not include the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

1> if this is the first *RRCConnectionReconfiguration* message after successful completion of the RRC Connection Re-establishment procedure:

2> re-establish PDCP for SRB2 and for all DRBs that are established, if any;

2> re-establish RLC for SRB2 and for all DRBs that are established, if any;

2> if the *RRCConnectionReconfiguration* message includes the *fullConfig*:

3> perform the radio configuration procedure as specified in section 5.3.5.8;

2> if the *RRCConnectionReconfiguration* message includes the *radioResourceConfigDedicated*:

3> perform the radio resource configuration procedure as specified in 5.3.10;

2> resume SRB2 and all DRBs that are suspended, if any;

NOTE 1: The handling of the radio bearers after the successful completion of the PDCP re-establishment, e.g. the re-transmission of unacknowledged PDCP SDUs (as well as the associated status reporting), the handling of the SN and the HFN, is specified in TS 36.323 [8].

NOTE 2: The UE may discard SRB2 messages and data that it receives prior to completing the reconfiguration used to resume these bearers.

1> else:

2> if the *RRCConnectionReconfiguration* message includes the *radioResourceConfigDedicated*:

3> perform the radio resource configuration procedure as specified in 5.3.10;

NOTE 3: If the *RRCConnectionReconfiguration* message includes the establishment of radio bearers other than SRB1, the UE may start using these radio bearers immediately, i.e. there is no need to wait for an outstanding acknowledgment of the *SecurityModeComplete* message.

1> if the received *RRCConnectionReconfiguration* includes the *sCellToReleaseList*:

2> perform SCell release as specified in 5.3.10.3a;

1> if the received *RRCConnectionReconfiguration* includes the *sCellToAddModList*:

2> perform SCell addition or modification as specified in 5.3.10.3b;

1> if the received *RRCConnectionReconfiguration* includes the *scg-Configuration*; or

1> if the current UE configuration includes one or more split DRBs and the received *RRCConnectionReconfiguration* includes *radioResourceConfigDedicated* including *drb-ToAddModList*:

2> perform SCG reconfiguration as specified in 5.3.10.10;

1> if the received *RRCConnectionReconfiguration* includes the *systemInformationBlockType1Dedicated*:

2> perform the actions upon reception of the *SystemInformationBlockType1* message as specified in 5.2.2.7;

1> if the *RRCConnectionReconfiguration* message includes the *dedicatedInfoNASList*:

2> forward each element of the *dedicatedInfoNASList* to upper layers in the same order as listed;

1> if the *RRCConnectionReconfiguration* message includes the *measConfig*:

2> perform the measurement configuration procedure as specified in 5.5.2;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> if the *RRCConnectionReconfiguration* message includes the *otherConfig*:

2> perform the other configuration procedure as specified in 5.3.10.9;

1> if the *RRCConnectionReconfiguration* message includes the *sl-DiscConfig* or *sl-CommConfig*:

2> perform the sidelink dedicated configuration procedure as specified in 5.3.10.15;

1> if the *RRCConnectionReconfiguration* message includes *wlan-OffloadInfo*:

2> perform the dedicated WLAN offload configuration procedure as specified in 5.6.12.2;

1> submit the *RRCConnectionReconfigurationComplete* message to lower layers for transmission using the new configuration, upon which the procedure ends;

5.3.5.4 Reception of an *RRCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover)

If the *RRCConnectionReconfiguration* message includes the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

1> stop timer T310, if running;

1> stop timer T312, if running;

1> start timer T304 with the timer value set to *t304*, as included in the *mobilityControlInfo*;

1> if the *carrierFreq* is included:

2> consider the target PCell to be one on the frequency indicated by the *carrierFreq* with a physical cell identity indicated by the *targetPhysCellId*;

1> else:

2> consider the target PCell to be one on the frequency of the source PCell with a physical cell identity indicated by the *targetPhysCellId*;

1> start synchronising to the DL of the target PCell;

NOTE 1: The UE should perform the handover as soon as possible following the reception of the RRC message triggering the handover, which could be before confirming successful reception (HARQ and ARQ) of this message.

1> reset MCG MAC and SCG MAC, if configured;

1> re-establish PDCP for all RBs that are established;

NOTE 2: The handling of the radio bearers after the successful completion of the PDCP re-establishment, e.g. the re-transmission of unacknowledged PDCP SDUs (as well as the associated status reporting), the handling of the SN and the HFN, is specified in TS 36.323 [8].

1> re-establish MCG RLC and SCG RLC, if configured, for all RBs that are established;

1> configure lower layers to consider the SCell(s) other than the PSCell, if configured, to be in deactivated state;

1> apply the value of the *newUE-Identity* as the C-RNTI;

1> if the *RRCConnectionReconfiguration* message includes the *fullConfig*:

2> perform the radio configuration procedure as specified in section 5.3.5.8;

1> configure lower layers in accordance with the received *radioResourceConfigCommon*;

1> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *mobilityControlInfo*;

1> if the *RRCConnectionReconfiguration* message includes the *radioResourceConfigDedicated*:

2> perform the radio resource configuration procedure as specified in 5.3.10;

1> if the *keyChangeIndicator* received in the *securityConfigHO* is set to *TRUE*:

2> update the K_{eNB} key based on the K_{ASME} key taken into use with the latest successful NAS SMC procedure, as specified in TS 33.401 [32];

1> else:

2> update the K_{eNB} key based on the current K_{eNB} or the NH, using the *nextHopChainingCount* value indicated in the *securityConfigHO*, as specified in TS 33.401 [32];

1> store the *nextHopChainingCount* value;

1> if the *securityAlgorithmConfig* is included in the *securityConfigHO*:

2> derive the K_{RRCint} key associated with the *integrityProtAlgorithm*, as specified in TS 33.401 [32];

2> if connected as an RN:

3> derive the K_{UPint} key associated with the *integrityProtAlgorithm*, as specified in TS 33.401 [32];

2> derive the K_{RRCenc} key and the K_{UPenc} key associated with the *cipheringAlgorithm*, as specified in TS 33.401 [32];

1> else:

2> derive the K_{RRCint} key associated with the current integrity algorithm, as specified in TS 33.401 [32];

2> if connected as an RN:

3> derive the K_{UPint} key associated with the current integrity algorithm, as specified in TS 33.401 [32];

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2> derive the K_{RRCenc} key and the K_{UPenc} key associated with the current ciphering algorithm, as specified in TS 33.401 [32];

1> configure lower layers to apply the integrity protection algorithm and the K_{RRCint} key, i.e. the integrity protection configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> configure lower layers to apply the ciphering algorithm, the K_{RRCenc} key and the K_{UPenc} key, i.e. the ciphering configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> if connected as an RN:

2> configure lower layers to apply the integrity protection algorithm and the K_{UPint} key, for current or subsequently established DRBs that are configured to apply integrity protection, if any;

1> if the received *RRCConnectionReconfiguration* includes the *sCellToReleaseList*:

2> perform SCell release as specified in 5.3.10.3a;

1> if the received *RRCConnectionReconfiguration* includes the *sCellToAddModList*:

2> perform SCell addition or modification as specified in 5.3.10.3b;

1> if the received *RRCConnectionReconfiguration* includes the *scg-Configuration*; or

1> if the current UE configuration includes one or more split DRBs and the received *RRCConnectionReconfiguration* includes *radioResourceConfigDedicated* including *drb-ToAddModList*:

2> perform SCG reconfiguration as specified in 5.3.10.10;

1> if the received *RRCConnectionReconfiguration* includes the *systemInformationBlockType1Dedicated*:

2> perfom the actions upon reception of the *SystemInformationBlockType1* message as specified in 5.2.2.7;

1> perform the measurement related actions as specified in 5.5.6.1;

1> if the *RRCConnectionReconfiguration* message includes the *measConfig*:

2> perform the measurement configuration procedure as specified in 5.5.2;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> release *reportProximityConfig* and clear any associated proximity status reporting timer;

1> if the *RRCConnectionReconfiguration* message includes the *otherConfig*:

2> perform the other configuration procedure as specified in 5.3.10.9;

1> if the *RRCConnectionReconfiguration* message includes the *sl-DiscConfig* or *sl-CommConfig*:

2> perform the sidelink dedicated configuration procedure as specified in 5.3.10.15;

1> if the *RRCConnectionReconfiguration* message includes *wlan-OffloadInfo*:

2> perform the dedicated WLAN offload configuration procedure as specified in 5.6.12.2;

1> set the content of *RRCConnectionReconfigurationComplete* message as follows:

2> if the UE has radio link failure or handover failure information available in *VarRLF-Report* and if the RPLMN is included in *plmn-IdentityList* stored in *VarRLF-Report*:

3> include *rlf-InfoAvailable*;

2> if the UE has MBSFN logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport* and if T330 is not running:

3> include *logMeasAvailableMBSFN*;

2> else if the UE has logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

3> include the *logMeasAvailable*;

2> if the UE has connection establishment failure information available in *VarConnEstFailReport* and if the RPLMN is equal to *plmn-Identity* stored in *VarConnEstFailReport*:

3> include *connEstFailInfoAvailable*;

1> submit the *RRCConnectionReconfigurationComplete* message to lower layers for transmission;

1> if MAC successfully completes the random access procedure:

2> stop timer T304;

2> apply the parts of the CQI reporting configuration, the scheduling request configuration and the sounding RS configuration that do not require the UE to know the SFN of the target PCell, if any;

2> apply the parts of the measurement and the radio resource configuration that require the UE to know the SFN of the target PCell (e.g. measurement gaps, periodic CQI reporting, scheduling request configuration, sounding RS configuration), if any, upon acquiring the SFN of the target PCell;

NOTE 3: Whenever the UE shall setup or reconfigure a configuration in accordance with a field that is received it applies the new configuration, except for the cases addressed by the above statements.

2> if the UE is configured to provide IDC indications:

3> if the UE has transmitted an *InDeviceCoexIndication* message during the last 1 second preceding reception of the *RRCConnectionReconfiguration* message including *mobilityControlInfo*:

4> initiate transmission of the *InDeviceCoexIndication* message in accordance with 5.6.9.3;

2> if the UE is configured to provide power preference indications:

3> if the UE has transmitted a *UEAssistanceInformation* message during the last 1 second preceding reception of the *RRCConnectionReconfiguration* message including *mobilityControlInfo*:

4> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

2> if *SystemInformationBlockType15* is broadcast by the PCell:

3> if the UE has transmitted a *MBMSInterestIndication* message during the last 1 second preceding reception of the *RRCConnectionReconfiguration* message including *mobilityControlInfo*:

4> ensure having a valid version of *SystemInformationBlockType15* for the PCell;

4> determine the set of MBMS frequencies of interest in accordance with 5.8.5.3;

4> initiate transmission of the *MBMSInterestIndication* message in accordance with 5.8.5.4;

2> if *SystemInformationBlockType18* is broadcast by the target PCell; and the UE transmitted a *SidelinkUEInformation* message including *commRxInterestedFreq* or *commTxResourceReq* during the last 1 second preceding reception of the *RRCConnectionReconfiguration* message including *mobilityControlInfo*; or

2> if *SystemInformationBlockType19* is broadcast by the target PCell; and the UE transmitted a *SidelinkUEInformation* message including *discRxInterest* or *discTxResourceReq* during the last 1 second preceding reception of the *RRCConnectionReconfiguration* message including *mobilityControlInfo*:

3> initiate transmission of the *SidelinkUEInformation* message in accordance with 5.10.2.3;

2> the procedure ends;

NOTE 4: The UE is not required to determine the SFN of the target PCell by acquiring system information from that cell before performing RACH access in the target PCell.

5.3.5.5 Reconfiguration failure

The UE shall:

1> if the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message:

2> continue using the configuration used prior to the reception of *RRCConnectionReconfiguration* message;

2> if security has not been activated:

3> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause other;

2> else:

3> initiate the connection re-establishment procedure as specified in 5.3.7, upon which the connection reconfiguration procedure ends;

NOTE 1: The UE may apply above failure handling also in case the *RRCConnectionReconfiguration* message causes a protocol error for which the generic error handling as defined in 5.7 specifies that the UE shall ignore the message.

NOTE 2: If the UE is unable to comply with part of the configuration, it does not apply any part of the configuration, i.e. there is no partial success/ failure.

5.3.5.6 T304 expiry (handover failure)

The UE shall:

1> if T304 expires (handover failure):

NOTE 1: Following T304 expiry any dedicated preamble, if provided within the *rach-ConfigDedicated*, is not available for use by the UE anymore.

2> revert back to the configuration used in the source PCell, excluding the configuration configured by the *physicalConfigDedicated*, the *mac-MainConfig* and the *sps-Config*;

2> store the following handover failure information in *VarRLF-Report* by setting its fields as follows:

3> clear the information included in *VarRLF-Report*, if any;

3> set the *plmn-IdentityList* to include the list of EPLMNs stored by the UE (i.e. includes the RPLMN);

3> set the *measResultLastServCell* to include the RSRP and RSRQ, if available, of the source PCell based on measurements collected up to the moment the UE detected handover failure and in accordance with the following;

4> if the UE includes *rsrqResult*, include the *lastServCellRSRQ-Type*;

3> set the *measResultNeighCells* to include the best measured cells, other than the source PCell, ordered such that the best cell is listed first, and based on measurements collected up to the moment the UE detected handover failure, and set its fields as follows;

4> if the UE was configured to perform measurements for one or more EUTRA frequencies, include the *measResultListEUTRA*;

4> if the UE includes *rsrqResult*, include the *rsrq-Type*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring UTRA frequencies, include the *measResultListUTRA*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring GERAN frequencies, include the *measResultListGERAN*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring CDMA2000 frequencies, include the *measResultsCDMA2000*;

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4> for each neighbour cell included, include the optional fields that are available;

NOTE 2: The measured quantities are filtered by the L3 filter as configured in the mobility measurement configuration. The measurements are based on the time domain measurement resource restriction, if configured. Blacklisted cells are not required to be reported.

3> if detailed location information is available, set the content of the *locationInfo* as follows:

4> include the *locationCoordinates*;

4> include the *horizontalVelocity*, if available;

3> set the *failedPCellId* to the global cell identity, if available, and otherwise to the physical cell identity and carrier frequency of the target PCell of the failed handover;

3> include *previousPCellId* and set it to the global cell identity of the PCell where the last *RRCConnectionReconfiguration* message including *mobilityControlInfo* was received;

3> set the *timeConnFailure* to the elapsed time since reception of the last *RRCConnectionReconfiguration* message including the *mobilityControlInfo*;

3> set the *connectionFailureType* to *'hof'*;

3> set the *c-RNTI* to the C-RNTI used in the source PCell;

2> initiate the connection re-establishment procedure as specified in 5.3.7, upon which the RRC connection reconfiguration procedure ends;

The UE may discard the handover failure information, i.e. release the UE variable *VarRLF-Report*, 48 hours after the failure is detected, upon power off or upon detach.

NOTE 3: E-UTRAN may retrieve the handover failure information using the UE information procedure with *rlf-ReportReq* set to *true*, as specified in 5.6.5.3.

5.3.5.7 Void

5.3.5.7a T307 expiry (SCG change failure)

The UE shall:

1> if T307 expires:

NOTE 1: Following T307 expiry any dedicated preamble, if provided within the *rach-ConfigDedicatedSCG*, is not available for use by the UE anymore.

2> initiate the SCG failure information procedure as specified in 5.6.13 to report SCG change failure;

5.3.5.8 Radio Configuration involving full configuration option

The UE shall:

1> release/ clear all current dedicated radio configurations except the MCG C-RNTI, the MCG security configuration and the PDCP, RLC, logical channel configurations for the RBs and the logged measurement configuration;

NOTE 1: Radio configuration is not just the resource configuration but includes other configurations like *MeasConfig* and *OtherConfig*.

1> if the *RRCConnectionReconfiguration* message includes the *mobilityControlInfo*:

2> release/ clear all current common radio configurations;

2> use the default values specified in 9.2.5 for timer T310, T311 and constant N310, N311;

1> else:

2> use values for timers T301, T310, T311 and constants N310, N311, as included in *ue-TimersAndConstants* received in *SystemInformationBlockType2*;

1> apply the default physical channel configuration as specified in 9.2.4;

1> apply the default semi-persistent scheduling configuration as specified in 9.2.3;

1> apply the default MAC main configuration as specified in 9.2.2;

1> for each *srb-Identity* value included in the *srb-ToAddModList* (SRB reconfiguration):

2> apply the specified configuration defined in 9.1.2 for the corresponding SRB;

2> apply the corresponding default RLC configuration for the SRB specified in 9.2.1.1 for SRB1 or in 9.2.1.2 for SRB2;

2> apply the corresponding default logical channel configuration for the SRB as specified in 9.2.1.1 for SRB1 or in 9.2.1.2 for SRB2;

NOTE 2: This is to get the SRBs (SRB1 and SRB2 for handover and SRB2 for reconfiguration after reestablishment) to a known state from which the reconfiguration message can do further configuration.

1> for each *eps-BearerIdentity* value included in the *drb-ToAddModList* that is part of the current UE configuration:

2> release the PDCP entity;

2> release the RLC entity or entities;

2> release the DTCH logical channel;

2> release the *drb-identity*;

NOTE 3: This will retain the *eps-bearerIdentity* but remove the DRBs including *drb-identity* of these bearers from the current UE configuration and trigger the setup of the DRBs within the AS in Section 5.3.10.3 using the new configuration. The *eps-bearerIdentity* acts as the anchor for associating the released and re-setup DRB.

1> for each *eps-BearerIdentity* value that is part of the current UE configuration but not part of the *drb-ToAddModList*:

2> perform DRB release as specified in 5.3.10.2;

5.3.6 Counter check

5.3.6.1 General

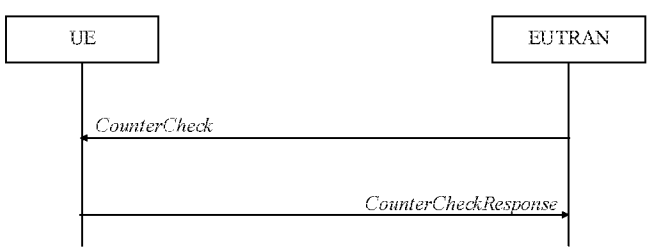


Figure 5.3.6.1-1: Counter check procedure

The counter check procedure is used by E-UTRAN to request the UE to verify the amount of data sent/ received on each DRB. More specifically, the UE is requested to check if, for each DRB, the most significant bits of the COUNT match with the values indicated by E-UTRAN.

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NOTE: The procedure enables E-UTRAN to detect packet insertion by an intruder (a 'man in the middle').

5.3.6.2 Initiation

E-UTRAN initiates the procedure by sending a *CounterCheck* message.

NOTE: E-UTRAN may initiate the procedure when any of the COUNT values reaches a specific value.

5.3.6.3 Reception of the *CounterCheck* message by the UE

Upon receiving the *CounterCheck* message, the UE shall:

1> for each DRB that is established:

2> if no COUNT exists for a given direction (uplink or downlink) because it is a uni-directional bearer configured only for the other direction:

3> assume the COUNT value to be 0 for the unused direction;

2> if the *drb-Identity* is not included in the *drb-CountMSB-InfoList*:

3> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* set to the value of the corresponding COUNT;

2> else if, for at least one direction, the most significant bits of the COUNT are different from the value indicated in the *drb-CountMSB-InfoList*:

3> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* set to the value of the corresponding COUNT;

1> for each DRB that is included in the *drb-CountMSB-InfoList* in the *CounterCheck* message that is not established:

2> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* with the most significant bits set identical to the corresponding values in the *drb-CountMSB-InfoList* and the least significant bits set to zero;

1> submit the *CounterCheckResponse* message to lower layers for transmission upon which the procedure ends;

5.3.7 RRC connection re-establishment

5.3.7.1 General

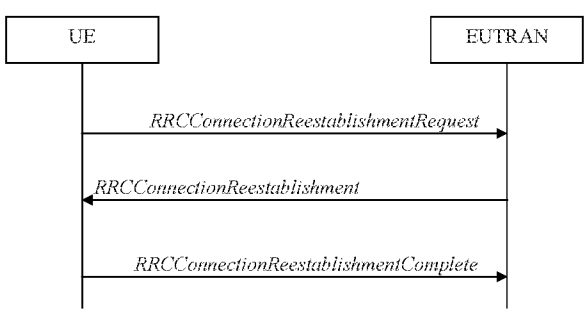


Figure 5.3.7.1-1: RRC connection re-establishment, successful

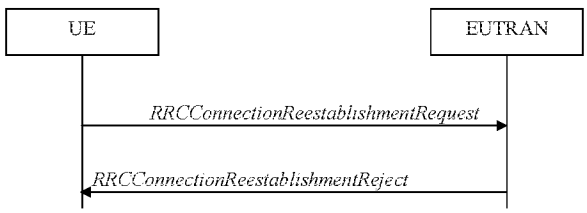


Figure 5.3.7.1-2: RRC connection re-establishment, failure

The purpose of this procedure is to re-establish the RRC connection, which involves the resumption of SRB1 operation, the re-activation of security and the configuration of only the PCell.

A UE in RRC_CONNECTED, for which security has been activated, may initiate the procedure in order to continue the RRC connection. The connection re-establishment succeeds only if the concerned cell is prepared i.e. has a valid UE context. In case E-UTRAN accepts the re-establishment, SRB1 operation resumes while the operation of other radio bearers remains suspended. If AS security has not been activated, the UE does not initiate the procedure but instead moves to RRC_IDLE directly.

E-UTRAN applies the procedure as follows:

- to reconfigure SRB1 and to resume data transfer only for this RB;
- to re-activate AS security without changing algorithms.

5.3.7.2 Initiation

The UE shall only initiate the procedure when AS security has been activated. The UE initiates the procedure when one of the following conditions is met:

1> upon detecting radio link failure, in accordance with 5.3.11; or

1> upon handover failure, in accordance with 5.3.5.6; or

1> upon mobility from E-UTRA failure, in accordance with 5.4.3.5; or

1> upon integrity check failure indication from lower layers; or

1> upon an RRC connection reconfiguration failure, in accordance with 5.3.5.5;

Upon initiation of the procedure, the UE shall:

1> stop timer T310, if running;

1> stop timer T312, if running;

1> stop timer T313, if running;

1> stop timer T307, if running;

1> start timer T311;

1> suspend all RBs except SRB0;

1> reset MAC;

1> release the MCG SCell(s), if configured, in accordance with 5.3.10.3a;

1> apply the default physical channel configuration as specified in 9.2.4;

1> for the MCG, apply the default semi-persistent scheduling configuration as specified in 9.2.3;

1> for the MCG, apply the default MAC main configuration as specified in 9.2.2;

1> release *powerPrefIndicationConfig*, if configured and stop timer T340, if running;

1> release *reportProximityConfig* and clear any associated proximity status reporting timer;

1> release *obtainLocationConfig*, if configured;

1> release *idc-Config*, if configured;

1> release *measSubframePatternPCell*, if configured;

1> release the entire SCG configuration, if configured, except for the DRB configuration (as configured by *drb-ToAddModListSCG*);

1> release *naics-Info* for the PCell, if configured;

1> if connected as an RN and configured with an RN subframe configuration:

2> release the RN subframe configuration;

1> perform cell selection in accordance with the cell selection process as specified in TS 36.304 [4];

5.3.7.3 Actions following cell selection while T311 is running

Upon selecting a suitable E-UTRA cell, the UE shall:

1> stop timer T311;

1> start timer T301;

1> apply the *timeAlignmentTimerCommon* included in *SystemInformationBlockType2*;

1> initiate transmission of the *RRCConnectionReestablishmentRequest* message in accordance with 5.3.7.4;

NOTE: This procedure applies also if the UE returns to the source PCell.

Upon selecting an inter-RAT cell, the UE shall:

1> if the selected cell is a UTRA cell, and if the UE supports Radio Link Failure Report for Inter-RAT MRO, include *selectedUTRA-CellId* in the *VarRLF-Report* and set it to the physical cell identity and carrier frequency of the selected UTRA cell;

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.7.4 Actions related to transmission of *RRCConnectionReestablishmentRequest* message

If the procedure was initiated due to radio link failure or handover failure, the UE shall:

1> set the *reestablishmentCellId* in the *VarRLF-Report* to the global cell identity of the selected cell;

The UE shall set the contents of *RRCConnectionReestablishmentRequest* message as follows:

1> set the *ue-Identity* as follows:

2> set the *c-RNTI* to the C-RNTI used in the source PCell (handover and mobility from E-UTRA failure) or used in the PCell in which the trigger for the re-establishment occurred (other cases);

2> set the *physCellId* to the physical cell identity of the source PCell (handover and mobility from E-UTRA failure) or of the PCell in which the trigger for the re-establishment occurred (other cases);

2> set the *shortMAC-I* to the 16 least significant bits of the MAC-I calculated:

3> over the ASN.1 encoded as per section 8 (i.e., a multiple of 8 bits) *VarShortMAC-Input*;

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3> with the K_{RRCint} key and integrity protection algorithm that was used in the source PCell (handover and mobility from E-UTRA failure) or of the PCell in which the trigger for the re-establishment occurred (other cases); and

3> with all input bits for COUNT, BEARER and DIRECTION set to binary ones;

1> set the *reestablishmentCause* as follows:

2> if the re-establishment procedure was initiated due to reconfiguration failure as specified in 5.3.5.5 (the UE is unable to comply with the reconfiguration):

3> set the *reestablishmentCause* to the value *reconfigurationFailure*;

2> else if the re-establishment procedure was initiated due to handover failure as specified in 5.3.5.6 (intra-LTE handover failure) or 5.4.3.5 (inter-RAT mobility from EUTRA failure):

3> set the *reestablishmentCause* to the value *handoverFailure*;

2> else:

3> set the *reestablishmentCause* to the value *otherFailure*;

The UE shall submit the *RRCConnectionReestablishmentRequest* message to lower layers for transmission.

5.3.7.5 Reception of the *RRCConnectionReestablishment* by the UE

NOTE 1: Prior to this, lower layer signalling is used to allocate a C-RNTI. For further details see TS 36.321 [6];

The UE shall:

1> stop timer T301;

1> consider the current cell to be the PCell;

1> re-establish PDCP for SRB1;

1> re-establish RLC for SRB1;

1> perform the radio resource configuration procedure in accordance with the received *radioResourceConfigDedicated* and as specified in 5.3.10;

1> resume SRB1;

NOTE 2: E-UTRAN should not transmit any message on SRB1 prior to receiving the *RRCConnectionReestablishmentComplete* message.

1> update the K_{eNB} key based on the K_{ASME} key to which the current K_{eNB} is associated, using the *nextHopChainingCount* value indicated in the *RRCConnectionReestablishment* message, as specified in TS 33.401 [32];

1> store the *nextHopChainingCount* value;

1> derive the K_{RRCint} key associated with the previously configured integrity algorithm, as specified in TS 33.401 [32];

1> derive the K_{RRCenc} key and the K_{UPenc} key associated with the previously configured ciphering algorithm, as specified in TS 33.401 [32];

1> if connected as an RN:

2> derive the K_{UPint} key associated with the previously configured integrity algorithm, as specified in TS 33.401 [32];

1> configure lower layers to activate integrity protection using the previously configured algorithm and the K_{RRCint} key immediately, i.e., integrity protection shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

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1> if connected as an RN:

2> configure lower layers to apply integrity protection using the previously configured algorithm and the K_{UPint} key, for subsequently resumed or subsequently established DRBs that are configured to apply integrity protection, if any;

1> configure lower layers to apply ciphering using the previously configured algorithm, the K_{RRCenc} key and the K_{UPenc} key immediately, i.e., ciphering shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> set the content of *RRCConnectionReestablishmentComplete* message as follows:

2> if the UE has radio link failure or handover failure information available in *VarRLF-Report* and if the RPLMN is included in *plmn-IdentityList* stored in *VarRLF-Report*:

3> include the *rlf-InfoAvailable*;

2> if the UE has MBSFN logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport* and if T330 is not running:

3> include *logMeasAvailableMBSFN*;

2> else if the UE has logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

3> include the *logMeasAvailable*;

2> if the UE has connection establishment failure information available in *VarConnEstFailReport* and if the RPLMN is equal to *plmn-Identity* stored in *VarConnEstFailReport*:

3> include the *connEstFailInfoAvailable*;

1> perform the measurement related actions as specified in 5.5.6.1;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> submit the *RRCConnectionReestablishmentComplete* message to lower layers for transmission;

1> if *SystemInformationBlockType15* is broadcast by the PCell:

2> if the UE has transmitted an *MBMSInterestIndication* message during the last 1 second preceding detection of radio link failure:

3> ensure having a valid version of *SystemInformationBlockType15* for the PCell;

3> determine the set of MBMS frequencies of interest in accordance with 5.8.5.3;

3> initiate transmission of the *MBMSInterestIndication* message in accordance with 5.8.5.4;

1> if *SystemInformationBlockType18* is broadcast by the PCell; and the UE transmitted a *SidelinkUEInformation* message including *commRxInterestedFreq* or *commTxResourceReq* during the last 1 second preceding detection of radio link failure; or

1> if *SystemInformationBlockType19* is broadcast by the PCell; and the UE transmitted a *SidelinkUEInformation* message including *discRxInterest* or *discTxResourceReq* during the last 1 second preceding detection of radio link failure:

2> initiate transmission of the *SidelinkUEInformation* message in accordance with 5.10.2.3;

1> the procedure ends;

5.3.7.6 T311 expiry

Upon T311 expiry, the UE shall:

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

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5.3.7.7 T301 expiry or selected cell no longer suitable

The UE shall:

1> if timer T301 expires; or

1> if the selected cell becomes no longer suitable according to the cell selection criteria as specified in TS 36.304 [4]:

2> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.7.8 Reception of *RRCConnectionReestablishmentReject* by the UE

Upon receiving the *RRCConnectionReestablishmentReject* message, the UE shall:

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.8 RRC connection release

5.3.8.1 General

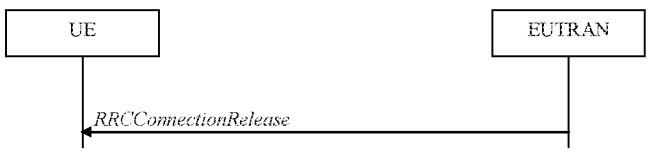


Figure 5.3.8.1-1: RRC connection release, successful

The purpose of this procedure is to release the RRC connection, which includes the release of the established radio bearers as well as all radio resources.

5.3.8.2 Initiation

E-UTRAN initiates the RRC connection release procedure to a UE in RRC_CONNECTED.

5.3.8.3 Reception of the *RRCConnectionRelease* by the UE

The UE shall:

1> delay the following actions defined in this sub-clause 60 ms from the moment the *RRCConnectionRelease* message was received or optionally when lower layers indicate that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged, whichever is earlier;

1> if the *RRCConnectionRelease* message includes the *idleModeMobilityControlInfo*:

2> store the cell reselection priority information provided by the *idleModeMobilityControlInfo*;

2> if the *t320* is included:

3> start timer T320, with the timer value set according to the value of *t320*;

1> else:

2> apply the cell reselection priority information broadcast in the system information;

1> if the *releaseCause* received in the *RRCConnectionRelease* message indicates *loadBalancingTAURequired*:

2> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'load balancing TAU required';

1> else if the *releaseCause* received in the *RRCConnectionRelease* message indicates *cs-FallbackHighPriority*:

2> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'CS Fallback High Priority';

1> else:

2> if the *extendedWaitTime* is present and the UE supports delay tolerant access:

3> forward the *extendedWaitTime* to upper layers;

2> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'other';

5.3.8.4 T320 expiry

The UE shall:

1> if T320 expires:

2> if stored, discard the cell reselection priority information provided by the *idleModeMobilityControlInfo* or inherited from another RAT;

2> apply the cell reselection priority information broadcast in the system information;

5.3.9 RRC connection release requested by upper layers

5.3.9.1 General

The purpose of this procedure is to release the RRC connection. Access to the current PCell may be barred as a result of this procedure.

NOTE: Upper layers invoke the procedure, e.g. upon determining that the network has failed an authentication check, see TS 24.301 [35].

5.3.9.2 Initiation

The UE initiates the procedure when upper layers request the release of the RRC connection. The UE shall not initiate the procedure for power saving purposes.

The UE shall:

1> if the upper layers indicate barring of the PCell:

2> treat the PCell used prior to entering RRC_IDLE as barred according to TS 36.304 [4];

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'other';

5.3.10 Radio resource configuration

5.3.10.0 General

The UE shall:

1> if the received *radioResourceConfigDedicated* includes the *srb-ToAddModList*:

2> perform the SRB addition or reconfiguration as specified in 5.3.10.1;

1> if the received *radioResourceConfigDedicated* includes the *drb-ToReleaseList*:

2> perform DRB release as specified in 5.3.10.2;

1> if the received *radioResourceConfigDedicated* includes the *drb-ToAddModList*:

2> perform DRB addition or reconfiguration as specified in 5.3.10.3;

1> if the received *radioResourceConfigDedicated* includes the *mac-MainConfig*:

2> perform MAC main reconfiguration as specified in 5.3.10.4;

1> if the received *radioResourceConfigDedicated* includes *sps-Config*:

2> perform SPS reconfiguration according to 5.3.10.5;

1> if the received *radioResourceConfigDedicated* includes the *physicalConfigDedicated*:

2> reconfigure the physical channel configuration as specified in 5.3.10.6;

1> if the received *radioResourceConfigDedicated* includes the *rlf-TimersAndConstants*:

2> reconfigure the values of timers and constants as specified in 5.3.10.7;

1> if the received *radioResourceConfigDedicated* includes the *measSubframePatternPCell*:

2> reconfigure the time domain measurement resource restriction for the serving cell as specified in 5.3.10.8;

1> if the received *radioResourceConfigDedicated* includes the *naics-Info*:

2> perform NAICS neighbour cell information reconfiguration for the PCell as specified in 5.3.10.13;

1> if the received *RadioResourceConfigDedicatedPSCell* includes the *naics-Info*:

2> perform NAICS neighbour cell information reconfiguration for the PSCell as specified in 5.3.10.13;

1> if the received *RadioResourceConfigDedicatedSCell-r10* includes the *naics-Info*:

2> perform NAICS neighbour cell information reconfiguration for the SCell as specified in 5.3.10.13;

5.3.10.1 SRB addition/ modification

The UE shall:

1> for each *srb-Identity* value included in the *srb-ToAddModList* that is not part of the current UE configuration (SRB establishment):

2> apply the specified configuration defined in 9.1.2 for the corresponding SRB;

2> establish a PDCP entity and configure it with the current (MCG) security configuration, if applicable;

2> establish an (MCG) RLC entity in accordance with the received *rlc-Config*;

2> establish a (MCG) DCCH logical channel in accordance with the received *logicalChannelConfig* and with the logical channel identity set in accordance with 9.1.2;

1> for each *srb-Identity* value included in the *srb-ToAddModList* that is part of the current UE configuration (SRB reconfiguration):

2> reconfigure the RLC entity in accordance with the received *rlc-Config*;

2> reconfigure the DCCH logical channel in accordance with the received *logicalChannelConfig*;

5.3.10.2 DRB release

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToReleaseList* that is part of the current UE configuration (DRB release); or

1> for each *drb-identity* value that is to be released as the result of full configuration option according to 5.3.5.8:

2> release the PDCP entity;

2> release the RLC entity or entities;

2> release the DTCH logical channel;

1> if the procedure was triggered due to handover:

2> indicate the release of the DRB(s) and the *eps-BearerIdentity* of the released DRB(s) to upper layers after successful handover;

1> else:

2> indicate the release of the DRB(s) and the *eps-BearerIdentity* of the released DRB(s) to upper layers immediately.

NOTE: The UE does not consider the message as erroneous if the *drb-ToReleaseList* includes any *drb-Identity* value that is not part of the current UE configuration.

5.3.10.3 DRB addition/ modification

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is not part of the current UE configuration (DRB establishment including the case when full configuration option is used):

2> if *drb-ToAddModListSCG* is not received or does not include the *drb-Identity* value (i.e. add MCG DRB):

3> establish a PDCP entity and configure it with the current MCG security configuration and in accordance with the received *pdcp-Config*;

3> establish an MCG RLC entity or entities in accordance with the received rlc-Config;

3> establish an MCG DTCH logical channel in accordance with the received *logicalChannelIdentity* and the received *logicalChannelConfig*;

2> if the *RRCConnectionReconfiguration* message includes the *fullConfig* IE:

3> associate the established DRB with corresponding included *eps-BearerIdentity*;

2> else:

3> indicate the establishment of the DRB(s) and the *eps-BearerIdentity* of the established DRB(s) to upper layers;

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is part of the current UE configuration (DRB reconfiguration):

2> if *drb-ToAddModListSCG* is not received or does not include the *drb-Identity* value:

3> if the DRB indicated by *drb-Identity* is an MCG DRB (reconfigure MCG):

4> if the *pdcp-Config* is included:

5> reconfigure the PDCP entity in accordance with the received *pdcp-Config*;

4> if the *rlc-Config* is included:

5> reconfigure the RLC entity or entities in accordance with the received *rlc-Config*;

4> if the *logicalChannelConfig* is included:

5> reconfigure the DTCH logical channel in accordance with the received *logicalChannelConfig*;

NOTE: Removal and addition of the same *drb-Identity* in single *radioResourceConfiguration* is not supported.

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5.3.10.3a1 DC specific DRB addition or reconfiguration

For the *drb-Identity* value for which this procedure is initiated, the UE shall:

1> if *drb-ToAddModListSCG* is received and includes the *drb-Identity* value; and *drb-Identity* value is not part of the current UE configuration (i.e. DC specific DRB establishment):

2> if *drb-ToAddModList* is received and includes the *drb-Identity* value (i.e. add split DRB):

3> establish a PDCP entity and configure it with the current MCG security configuration and in accordance with the *pdcp-Config* included in *drb-ToAddModList*;

3> establish an MCG RLC entity and an MCG DTCH logical channel in accordance with the *rlc-Config*, *logicalChannelIdentity* and *logicalChannelConfig* included in *drb-ToAddModList*;

3> establish an SCG RLC entity and an SCG DTCH logical channel in accordance with the *rlc-ConfigSCG*, *logicalChannelIdentitySCG* and *logicalChannelConfigSCG* included in *drb-ToAddModListSCG*;

2> else (i.e. add SCG DRB):

3> establish a PDCP entity and configure it with the current SCG security configuration and in accordance with the *pdcp-Config* included in *drb-ToAddModListSCG*;

3> establish an SCG RLC entity or entities and an SCG DTCH logical channel in accordance with the *rlc-ConfigSCG*, *logicalChannelIdentitySCG* and *logicalChannelConfigSCG* included in *drb-ToAddModListSCG*;

2> indicate the establishment of the DRB(s) and the *eps-BearerIdentity* of the established DRB(s) to upper layers;

1> else (i.e. DC specific DRB modification; *drb-ToAddModList* and/ or *drb-ToAddModListSCG* received):

2> if the DRB indicated by *drb-Identity* is a split DRB:

3> if *drb-ToAddModList* is received and includes the *drb-Identity* value, while for this entry *drb-TypeChange* is included and set to *toMCG* (i.e. split to MCG):

4> release the SCG RLC entity and the SCG DTCH logical channel;

4> reconfigure the PDCP entity in accordance with the *pdcp-Config*, if included in *drb-ToAddModList*;

4> reconfigure the MCG RLC entity and/ or the MCG DTCH logical channel in accordance with the *rlc-Config* and *logicalChannelConfig*, if included in *drb-ToAddModList*;

3> else (i.e. reconfigure split):

4> reconfigure the PDCP entity in accordance with the *pdcp-Config*, if included in *drb-ToAddModList*;

4> reconfigure the MCG RLC entity and/ or the MCG DTCH logical channel in accordance with the *rlc-Config* and *logicalChannelConfig*, if included in *drb-ToAddModList*;

4> reconfigure the SCG RLC entity and/ or the SCG DTCH logical channel in accordance with the *rlc-ConfigSCG* and *logicalChannelConfigSCG*, if included in *drb-ToAddModListSCG*;

2> if the DRB indicated by *drb-Identity* is an SCG DRB:

3> if *drb-ToAddModList* is received and includes the *drb-Identity* value, while for this entry *drb-TypeChange* is included and set to *toMCG* (i.e. SCG to MCG):

4> reconfigure the PDCP entity with the current MCG security configuration and in accordance with the *pdcp-Config*, if included in *drb-ToAddModList*;

4> reconfigure the SCG RLC entity or entities and the SCG DTCH logical channel to be an MCG RLC entity or entities and an MCG DTCH logical channel;

4> reconfigure the MCG RLC entity or entities and/ or the MCG DTCH logical channel in accordance with the *rlc-Config*, *logicalChannelIdentity* and *logicalChannelConfig*, if included in *drb-ToAddModList*;

3> else (i.e. *drb-ToAddModListSCG* is received and includes the *drb-Identity* value i.e. reconfigure SCG):

4> reconfigure the PDCP entity in accordance with the *pdcp-Config*, if included in *drb-ToAddModListSCG*;

4> reconfigure the SCG RLC entity or entities and/ or the SCG DTCH logical channel in accordance with the *rlc-ConfigSCG* and *logicalChannelConfigSCG*, if included in *drb-ToAddModListSCG*;

2> if the DRB indicated by *drb-Identity* is an MCG DRB:

3> if *drb-ToAddModListSCG* is received and includes the *drb-Identity* value, while for this entry *drb-Type* is included and set to *split* (i.e. MCG to split):

4> reconfigure the PDCP entity in accordance with the *pdcp-Config*, if included in *drb-ToAddModList*;

4> reconfigure the MCG RLC entity and/ or the MCG DTCH logical channel in accordance with the *rlc-Config* and *logicalChannelConfig*, if included in *drb-ToAddModList*;

4> establish an SCG RLC entity and an SCG DTCH logical channel in accordance with the *rlc-ConfigSCG*, *logicalChannelIdentitySCG* and *logicalChannelConfigSCG*, included in *drb-ToAddModListSCG*;

3> else (i.e. *drb-Type* is included and set to *scg* i.e. MCG to SCG):

4> reconfigure the PDCP entity with the current SCG security configuration and in accordance with the *pdcp-Config*, if included in *drb-ToAddModListSCG*;

4> reconfigure the MCG RLC entity or entities and the MCG DTCH logical channel to be an SCG RLC entity or entities and an SCG DTCH logical channel;

4> reconfigure the SCG RLC entity or entities and/ or the SCG DTCH logical channel in accordance with the *rlc-ConfigSCG*, *logicalChannelIdentitySCG* and *logicalChannelConfigSCG*, if included in *drb-ToAddModListSCG*;

5.3.10.3a SCell release

The UE shall:

1> if the release is triggered by reception of the *sCellToReleaseList* or the *sCellToReleaseListSCG*:

2> for each *sCellIndex* value included either in the *sCellToReleaseList* or in the *sCellToReleaseListSCG*:

3> if the current UE configuration includes an SCell with value *sCellIndex*:

4> release the SCell;

1> if the release is triggered by RRC connection re-establishment:

2> release all SCells that are part of the current UE configuration;

5.3.10.3b SCell addition/ modification

The UE shall:

1> for each *sCellIndex* value included either in the *sCellToAddModList* or in the *sCellToAddModListSCG* that is not part of the current UE configuration (SCell addition):

2> add the SCell, corresponding to the *cellIdentification*, in accordance with the *radioResourceConfigCommonSCell* and *radioResourceConfigDedicatedSCell*, both included either in the *sCellToAddModList* or in the *sCellToAddModListSCG*;

2> configure lower layers to consider the SCell to be in deactivated state;

2> for each *measId* included in the *measIdList* within *VarMeasConfig*:

3> if SCells are not applicable for the associated measurement; and

3> if the concerned SCell is included in *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*:

4> remove the concerned SCell from *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

1> for each *sCellIndex* value included either in the *sCellToAddModList* or in the *sCellToAddModListSCG* that is part of the current UE configuration (SCell modification):

2> modify the SCell configuration in accordance with the *radioResourceConfigDedicatedSCell*, included either in the *sCellToAddModList* or in the *sCellToAddModListSCG*;

5.3.10.3c PSCell addition or modification

The UE shall:

1> if the PSCell is not part of the current UE configuration (i.e. PSCell addition):

2> add the PSCell, corresponding to the *cellIdentification*, in accordance with the received *radioResourceConfigCommonPSCell* and *radioResourceConfigDedicatedPSCell*;

2> configure lower layers to consider the PSCell to be in activated state;

1> if the PSCell is part of the current UE configuration (i.e. PSCell modification):

2> modify the PSCell configuration in accordance with the received *radioResourceConfigDedicatedPSCell*;

5.3.10.4 MAC main reconfiguration

The UE shall:

1> if the procedure is triggered to perform SCG MAC main reconfiguration:

2> if SCG MAC is not part of the current UE configuration (i.e. SCG establishment):

3> create an SCG MAC entity;

2> reconfigure the SCG MAC main configuration as specified in the following i.e. assuming it concerns the SCG MAC whenever MAC main configuration is referenced and that it is based on the received *mac-MainConfigSCG* instead of *mac-MainConfig*:

1> reconfigure the MAC main configuration in accordance with the received *mac-MainConfig* other than *stag-ToReleaseList* and *stag-ToAddModList*;

1> if the received *mac-MainConfig* includes the *stag-ToReleaseList*:

2> for each *STAG-Id* value included in the *stag-ToReleaseList* that is part of the current UE configuration:

3> release the STAG indicated by *STAG-Id*;

1> if the received *mac-MainConfig* includes the *stag-ToAddModList*:

2> for each *stag-Id* value included in *stag-ToAddModList* that is not part of the current UE configuration (STAG addition):

3> add the STAG, corresponding to the *stag-Id*, in accordance with the received *timeAlignmentTimerSTAG*;

2> for each *stag-Id* value included in *stag-ToAddModList* that is part of the current UE configuration (STAG modification):

3> reconfigure the STAG, corresponding to the *stag-Id*, in accordance with the received *timeAlignmentTimerSTAG*;

5.3.10.5 Semi-persistent scheduling reconfiguration

The UE shall:

1> reconfigure the semi-persistent scheduling in accordance with the received *sps-Config*;

5.3.10.6 Physical channel reconfiguration

The UE shall:

1> if the *antennaInfo-r10* is included in the received *physicalConfigDedicated* and the previous version of this field that was received by the UE was *antennaInfo* (without suffix i.e. the version defined in REL-8):

2> apply the default antenna configuration as specified in section 9.2.4;

1> if the *cqi-ReportConfig-r10* is included in the received *physicalConfigDedicated* and the previous version of this field that was received by the UE was *cqi-ReportConfig* (without suffix i.e. the version defined in REL-8):

2> apply the default CQI reporting configuration as specified in 9.2.4;

NOTE: Application of the default configuration involves release of all extensions introduced in REL-9 and later.

1> reconfigure the physical channel configuration in accordance with the received *physicalConfigDedicated*;

1> if the *antennaInfo* is included and set to *explicitValue*:

2> if the configured *transmissionMode* is *tm1*, *tm2*, *tm5*, *tm6* or *tm7*; or

2> if the configured *transmissionMode* is *tm8* and *pmi-RI-Report* is not present; or

2> if the configured *transmissionMode* is *tm9* and *pmi-RI-Report* is not present; or

2> if the configured *transmissionMode* is *tm9* and *pmi-RI-Report* is present and *antennaPortsCount* within *csi-RS* is set to *an1*:

3> release *ri-ConfigIndex* in *cqi-ReportPeriodic*, if previously configured;

1> else if the *antennaInfo* is included and set to *defaultValue*:

2> release *ri-ConfigIndex* in *cqi-ReportPeriodic*, if previously configured;

5.3.10.7 Radio Link Failure Timers and Constants reconfiguration

The UE shall:

1> if the received *rlf-TimersAndConstants* is set to release:

2> use values for timers T301, T310, T311 and constants N310, N311, as included in *ue-TimersAndConstants* received in *SystemInformationBlockType2*;

1> else:

2> reconfigure the value of timers and constants in accordance with received *rlf-TimersAndConstants*;

1> if the received *rlf-TimersAndConstantsSCG* is set to release:

2> stop timer T313, if running, and

2> release the value of timer *t313* as well as constants *n313* and *n314*;

1> else:

2> reconfigure the value of timers and constants in accordance with received *rlf-TimersAndConstantsSCG*;

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5.3.10.8 Time domain measurement resource restriction for serving cell

The UE shall:

1> if the received *measSubframePatternPCell* is set to *release*:

2> release the time domain measurement resource restriction for the PCell, if previously configured

1> else:

2> apply the time domain measurement resource restriction for the PCell in accordance with the received *measSubframePatternPCell*;

5.3.10.9 Other configuration

The UE shall:

1> if the received *otherConfig* includes the *reportProximityConfig*:

2> if *proximityIndicationEUTRA* is set to *enabled*:

3> consider itself to be configured to provide proximity indications for E-UTRA frequencies in accordance with 5.3.14;

2> else:

3> consider itself not to be configured to provide proximity indications for E-UTRA frequencies;

2> if *proximityIndicationUTRA* is set to *enabled*:

3> consider itself to be configured to provide proximity indications for UTRA frequencies in accordance with 5.3.14;

2> else:

3> consider itself not to be configured to provide proximity indications for UTRA frequencies;

1> if the received *otherConfig* includes the *obtainLocation*:

2> attempt to have detailed location information available for any subsequent measurement report;

NOTE: The UE is requested to attempt to have valid detailed location information available whenever sending a measurement report for which it is configured to include available detailed location information. The UE may not succeed e.g. because the user manually disabled the GPS hardware, due to no/poor satellite coverage. Further details, e.g. regarding when to activate GNSS, are up to UE implementation.

1> if the received *otherConfig* includes the *idc-Config*:

2> if *idc-Indication* is included (i.e. set to *setup*):

3> consider itself to be configured to provide IDC indications in accordance with 5.6.9;

3> if *idc-Indication-UL-CA* is included (i.e. set to *setup*):

4> consider itself to be configured to indicate UL CA related information in IDC indications in accordance with 5.6.9;

2> else:

3> consider itself not to be configured to provide IDC indications;

2> if *autonomousDenialParameters* is included:

3> consider itself to be allowed to deny any transmission in a particular UL subframe if during the number of subframes indicated by *autonomousDenialValidity*, preceeding and including this particular subframe, it autonomously denied fewer UL subframes than indicated by *autonomousDenialSubframes*;

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2> else:

3> consider itself not to be allowed to deny any UL transmission;

1> if the received *otherConfig* includes the *powerPrefIndicationConfig*:

2> if *powerPrefIndicationConfig* is set to *setup*:

3> consider itself to be configured to provide power preference indications in accordance with 5.6.10;

2> else:

3> consider itself not to be configured to provide power preference indications;

5.3.10.10 SCG reconfiguration

The UE shall:

1> if the received *scg-Configuration* is set to *release* or includes the *mobilityControlInfoSCG* (i.e. SCG release/ change):

2> if *mobilityControlInfo* is not received (i.e. SCG release/ change without HO):

3> reset SCG MAC, if configured;

3> for each *drb-Identity* value that is part of the current UE configuration:

4> if the DRB indicated by *drb-Identity* is an SCG DRB:

5> re-establish the PDCP entity and the SCG RLC entity or entities;

4> if the DRB indicated by *drb-Identity* is a split DRB:

5> perform PDCP data recovery and re-establish the SCG RLC entity;

4> if the DRB indicated by *drb-Identity* is an MCG DRB; and

4> *drb-ToAddModListSCG* is received and includes the *drb-Identity* value, while for this entry *drb-Type* is included and set to *scg* (i.e. MCG to SCG):

5> re-establish the PDCP entity and the MCG RLC entity or entities;

3> configure lower layers to consider the SCG SCell(s), except for the PSCell, to be in deactivated state;

1> if the received *scg-Configuration* is set to *release*:

2> release the entire SCG configuration, except for the DRB configuration (i.e. as configured by *drb-ToAddModListSCG*);

2> if the current UE configuration includes one or more split or SCG DRBs and the received *RRCConnectionReconfiguration* message includes *radioResourceConfigDedicated* including *drb-ToAddModList*:

3> reconfigure the SCG or split DRB by *drb-ToAddModList* as specified in 5.3.10.12;

2> stop timer T313, if running;

2> stop timer T307, if running;

1> else:

2> if the received *scg-ConfigPartMCG* includes the *scg-Counter*:

3> update the S-K_{eNB} key based on the K_{eNB} key and using the received *scg-Counter* value, as specified in TS 33.401 [32];

3> derive the K_{UPenc} key associated with the *cipheringAlgorithmSCG* included in *mobilityControlInfoSCG* within the received *scg-ConfigPartSCG*, as specified in TS 33.401 [32];

3> configure lower layers to apply the ciphering algorithm and the K_{UPenc} key;

2> if the received *scg-ConfigPartSCG* includes the *radioResourceConfigDedicatedSCG*:

3> reconfigure the dedicated radio resource configuration for the SCG as specified in 5.3.10.11;

2> if the current UE configuration includes one or more split or SCG DRBs and the received *RRCConnectionReconfiguration* message includes *radioResourceConfigDedicated* including *drb-ToAddModList*:

3> reconfigure the SCG or split DRB by *drb-ToAddModList* as specified in 5.3.10.12;

2> if the received *scg-ConfigPartSCG* includes the *pSCellToAddMod*:

3> perform PSCell addition or modification as specified in 5.3.10.3c;

2> if the received *scg-ConfigPartSCG* includes the *sCellToReleaseListSCG*:

3> perform SCell release for the SCG as specified in 5.3.10.3a;

2> if the received *scg-ConfigPartSCG* includes the *sCellToAddModListSCG*:

3> perform SCell addition or modification as specified in 5.3.10.3b;

2> configure lower layers in accordance with *mobilityControlInfoSCG*, if received;

2> if the received *scg-ConfigPartSCG* includes the *mobilityControlInfoSCG* (i.e. SCG change):

3> resume all SCG DRBs and resume SCG transmission for split DRBs, if suspended;

3> stop timer T313, if running;

3> start timer T307 with the timer value set to *t307*, as included in the *mobilityControlInfoSCG*;

3> start synchronising to the DL of the target PSCell;

3> initiate the random access procedure on the PSCell, as specified in TS 36.321 [6]:

NOTE 1: The UE is not required to determine the SFN of the target PSCell by acquiring system information from that cell before performing RACH access in the target PSCell.

3> the procedure ends, except that the following actions are performed when MAC successfully completes the random access procedure on the PSCell:

4> stop timer T307;

4> apply the parts of the CQI reporting configuration, the scheduling request configuration and the sounding RS configuration that do not require the UE to know the SFN of the target PSCell, if any;

4> apply the parts of the measurement and the radio resource configuration that require the UE to know the SFN of the target PSCell (e.g. periodic CQI reporting, scheduling request configuration, sounding RS configuration), if any, upon acquiring the SFN of the target PSCell;

NOTE 2: Whenever the UE shall setup or reconfigure a configuration in accordance with a field that is received it applies the new configuration, except for the cases addressed by the above statements.

5.3.10.11 SCG dedicated resource configuration

The UE shall:

1> if the received *radioResourceConfigDedicatedSCG* includes the *drb-ToAddModListSCG*:

2> for each *drb-Identity* value included in the *drb-ToAddModListSCG* perform the DC specific DRB addition or reconfiguration as specified in 5.3.10.3a1

1> if the received *radioResourceConfigDedicatedSCG* includes the *mac-MainConfigSCG*:

2> perform the SCG MAC main reconfiguration as specified in 5.3.10.4;

1> if the received *radioResourceConfigDedicatedSCG* includes the *rlf-TimersAndConstantsSCG*:

2> reconfigure the values of timers and constants as specified in 5.3.10.7;

5.3.10.12 Reconfiguration SCG or split DRB by *drb-ToAddModList*

The UE shall:

1> for each split or SCG DRBs that is part of the current configuration:

2> if the corresponding *drb-Identity* value is included in the received *drb-ToAddModList*; *and*:

2> if the corresponding *drb-Identity* value is not included in the received *drb-ToAddModListSCG* (i.e. reconfigure split, split to MCG or SCG to MCG):

3> perform the DC specific DRB addition or reconfiguration as specified in 5.3.10.3a1;

5.3.10.13 Neighbour cell information reconfiguration

The UE shall:

1> if the received *naics-Info* is set to *release*:

2> instruct lower layer to release all the NAICS neighbour cell information for the concerned cell, if previously configured;

1> if the received *naics-Info* includes the *neighCellsToReleaseList-r12*:

2> for each *physCellId-r12* value included in the *neighCellsToReleaseList-r12* that is part of the current NAICS neighbour cell information of the concerned cell:

3> instruct lower layer to release the NAICS neighbour cell information for the concerned cell;

1> if the received *naics-Info* includes the *NeighCellsToAddModList-r12*:

2> for each *physCellId-r12* value included in the *neighCellsToAddModList-r12* that is not part of the current NAICS neighbour cell information of the concerned cell:

3> instruct lower layer to add the NAICS neighbour cell information for the concerned cell;

2> for each *physCellId-r12* value included in the *neighCellsToAddModList-r12* that is part of the current NAICS neighbour cell information of the concerned cell:

3> instruct lower layer to modify the NAICS neighbour cell information in accordance with the received *NeighCellsInfo* for the concerned cell;

5.3.10.14 Void

5.3.10.15 Sidelink dedicated configuration

The UE shall:

1> if the *RRCConnectionReconfiguration* message includes the *sl-CommConfig*:

2> if *commTxResources* is included and set to *setup*:

3> from the next SC period use the resources indicated by *commTxResources* for sidelink communication transmission, as specified in 5.10.4;

2> else if *commTxResources* is included and set to *release*:

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3> from the next SC period, release the resources allocated for sidelink communication transmission previously configured by *commTxResources*;

1> if the *RRCConnectionReconfiguration* message includes the *sl-DiscConfig*:

2> if *discTxResources* is included and set to *setup*:

3> from the next discovery period, as defined by *discPeriod*, use the resources indicated by *discTxResources* for sidelink discovery announcement, as specified in 5.10.6;

2> else if *discTxResources* is included and set to *release*:

3> from the next discovery period, as defined by *discPeriod*, release the resources allocated for sidelink discovery announcement previously configured by *discTxResources*;

5.3.11 Radio link failure related actions

5.3.11.1 Detection of physical layer problems in RRC_CONNECTED

The UE shall:

1> upon receiving N310 consecutive "out-of-sync" indications for the PCell from lower layers while neither T300, T301, T304 nor T311 is running:

2> start timer T310;

1> upon receiving N313 consecutive "out-of-sync" indications for the PSCell from lower layers while T307 is not running:

2> start T313;

NOTE: Physical layer monitoring and related autonomous actions do not apply to SCells except for the PSCell.

5.3.11.2 Recovery of physical layer problems

Upon receiving N311 consecutive "in-sync" indications for the PCell from lower layers while T310 is running, the UE shall:

1> stop timer T310;

1> stop timer T312, if running;

NOTE 1: In this case, the UE maintains the RRC connection without explicit signalling, i.e. the UE maintains the entire radio resource configuration.

NOTE 2: Periods in time where neither "in-sync" nor "out-of-sync" is reported by layer 1 do not affect the evaluation of the number of consecutive "in-sync" or "out-of-sync" indications.

Upon receiving N314 consecutive "in-sync" indications for the PSCell from lower layers while T313 is running, the UE shall:

1> stop timer T313;

5.3.11.3 Detection of radio link failure

The UE shall:

1> upon T310 expiry; or

1> upon T312 expiry; or

1> upon random access problem indication from MCG MAC while neither T300, T301, T304 nor T311 is running; or

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1> upon indication from MCG RLC that the maximum number of retransmissions has been reached for an SRB or for an MCG or split DRB:

2> consider radio link failure to be detected for the MCG i.e. RLF;

2> store the following radio link failure information in the *VarRLF-Report* by setting its fields as follows:

3> clear the information included in *VarRLF-Report*, if any;

3> set the *plmn-IdentityList* to include the list of EPLMNs stored by the UE (i.e. includes the RPLMN);

3> set the *measResultLastServCell* to include the RSRP and RSRQ, if available, of the PCell based on measurements collected up to the moment the UE detected radio link failure;

3> set the *measResultNeighCells* to include the best measured cells, other than the PCell, ordered such that the best cell is listed first, and based on measurements collected up to the moment the UE detected radio link failure, and set its fields as follows;

4> if the UE was configured to perform measurements for one or more EUTRA frequencies, include the *measResultListEUTRA*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring UTRA frequencies, include the *measResultListUTRA*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring GERAN frequencies, include the *measResultListGERAN*;

4> if the UE was configured to perform measurement reporting for one or more neighbouring CDMA2000 frequencies, include the *measResultsCDMA2000*;

4> for each neighbour cell included, include the optional fields that are available;

NOTE 1: The measured quantities are filtered by the L3 filter as configured in the mobility measurement configuration. The measurements are based on the time domain measurement resource restriction, if configured. Blacklisted cells are not required to be reported.

3> if detailed location information is available, set the content of the *locationInfo* as follows:

4> include the *locationCoordinates*;

4> include the *horizontalVelocity*, if available;

3> set the *failedPCellId* to the global cell identity, if available, and otherwise to the physical cell identity and carrier frequency of the PCell where radio link failure is detected;

3> set the *tac-FailedPCell* to the tracking area code, if available, of the PCell where radio link failure is detected;

3> if an *RRCConnectionReconfiguration* message including the *mobilityControlInfo* was received before the connection failure:

4> if the last *RRCConnectionReconfiguration* message including the *mobilityControlInfo* concerned an intra E-UTRA handover:

5> include the *previousPCellId* and set it to the global cell identity of the PCell where the last *RRCConnectionReconfiguration* message including *mobilityControlInfo* was received;

5> set the *timeConnFailure* to the elapsed time since reception of the last *RRCConnectionReconfiguration* message including the *mobilityControlInfo*;

4> if the last *RRCConnectionReconfiguration* message including the *mobilityControlInfo* concerned a handover to E-UTRA from UTRA and if the UE supports Radio Link Failure Report for Inter-RAT MRO:

5> include the *previousUTRA-CellId* and set it to the physical cell identity, the carrier frequency and the global cell identity, if available, of the UTRA Cell in which the last *RRCConnectionReconfiguration* message including *mobilityControlInfo* was received;

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5> set the *timeConnFailure* to the elapsed time since reception of the last *RRCConnectionReconfiguration* message including the *mobilityControlInfo*;

3> if the detected radio link failure concerns a DRB which QCI is 1:

4> include the *droppedQCI*;

3> set the *connectionFailureType* to *rlf*;

3> set the *c-RNTI* to the C-RNTI used in the PCell;

3> set the *rlf-Cause* to the trigger for detecting radio link failure;

2> if AS security has not been activated:

3> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'other';

2> else:

3> initiate the connection re-establishment procedure as specified in 5.3.7;

The UE shall:

1> upon T313 expiry; or

1> upon random access problem indication from SCG MAC; or

1> upon indication from SCG RLC that the maximum number of retransmissions has been reached for an SCG or split DRB:

2> consider radio link failure to be detected for the SCG i.e. SCG-RLF;

2> initiate the SCG failure information procedure as specified in 5.6.13 to report SCG radio link failure;

The UE may discard the radio link failure information, i.e. release the UE variable *VarRLF-Report*, 48 hours after the radio link failure is detected, upon power off or upon detach.

5.3.12 UE actions upon leaving RRC_CONNECTED

Upon leaving RRC_CONNECTED, the UE shall:

1> reset MAC;

1> stop all timers that are running except T320, T325 and T330;

1> release all radio resources, including release of the RLC entity, the MAC configuration and the associated PDCP entity for all established RBs;

1> indicate the release of the RRC connection to upper layers together with the release cause;

1> if leaving RRC_CONNECTED was triggered neither by reception of the *MobilityFromEUTRACommand* message nor by selecting an inter-RAT cell while T311 was running:

2> if timer T350 is configured:

3> start timer T350;

2> else:

3> release the *wlan-OffloadConfigDedicated*, if received;

3> if the *wlan-OffloadConfigCommon* corresponding to the RPLMN is broadcast by the cell:

4> apply the *wlan-OffloadConfigCommon* corresponding to the RPLMN included in *SystemInformationBlockType17*;

2> enter RRC_IDLE and perform procedures as specified in TS 36.304 [4, 5.2.7];

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1> else:

2> release the *wlan-OffloadConfigDedicated*, if received;

5.3.13 UE actions upon PUCCH/ SRS release request

Upon receiving a PUCCH release request from lower layers, for an indicated serving cell the UE shall:

1> apply the default physical channel configuration for *cqi-ReportConfig* for the indicated serving cell as specified in 9.2.4 and release *cqi-ReportConfigSCell*, for each SCell that sends HARQ feedback on the indicated serving cell, if any;

1> apply the default physical channel configuration for *schedulingRequestConfig* as specified in 9.2.4, for the concerned CG;

Upon receiving an SRS release request from lower layers, for an indicated serving cell the UE shall:

1> apply the default physical channel configuration for *soundingRS-UL-ConfigDedicated* as specified in 9.2.4;

NOTE: Upon PUCCH/ SRS release request, the UE does not modify the *soundingRS-UL-ConfigDedicatedAperiodic* i.e. it does not apply the default for this field (release).

5.3.14 Proximity indication

5.3.14.1 General

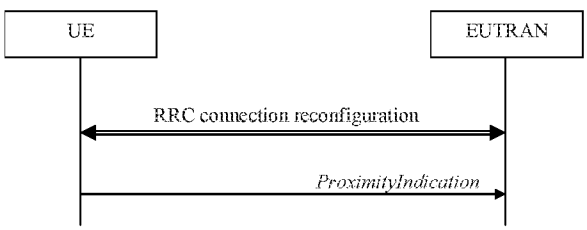


Figure 5.3.14.1-1: Proximity indication

The purpose of this procedure is to indicate that the UE is entering or leaving the proximity of one or more CSG member cells. The detection of proximity is based on an autonomous search function as defined in TS 36.304 [4].

5.3.14.2 Initiation

A UE in RRC_CONNECTED shall:

1> if the UE enters the proximity of one or more CSG member cell(s) on an E-UTRA frequency while proximity indication is enabled for such E-UTRA cells; or

1> if the UE enters the proximity of one or more CSG member cell(s) on an UTRA frequency while proximity indication is enabled for such UTRA cells; or

1> if the UE leaves the proximity of all CSG member cell(s) on an E-UTRA frequency while proximity indication is enabled for such E-UTRA cells; or

1> if the UE leaves the proximity of all CSG member cell(s) on an UTRA frequency while proximity indication is enabled for such UTRA cells:

2> if the UE has previously not transmitted a *ProximityIndication* for the RAT and frequency during the current RRC connection, or if more than 5 s has elapsed since the UE has last transmitted a *ProximityIndication* (either entering or leaving) for the RAT and frequency:

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3> initiate transmission of the *ProximityIndication* message in accordance with 5.3.14.3;

NOTE: In the conditions above, "if the UE enters the proximity of one or more CSG member cell(s)" includes the case of already being in the proximity of such cell(s) at the time proximity indication for the corresponding RAT is enabled.

5.3.14.3 Actions related to transmission of *ProximityIndication* message

The UE shall set the contents of *ProximityIndication* message as follows:

1> if the UE applies the procedure to report entering the proximity of CSG member cell(s):

2> set *type* to *entering*;

1> else if the UE applies the procedure to report leaving the proximity of CSG member cell(s):

2> set *type* to *leaving*;

1> if the proximity indication was triggered for one or more CSG member cell(s) on an E-UTRA frequency:

2> set the *carrierFreq* to *eutra* with the value set to the E-ARFCN value of the E-UTRA cell(s) for which proximity indication was triggered;

1> else if the proximity indication was triggered for one or more CSG member cell(s) on a UTRA frequency:

2> set the *carrierFreq* to *utra* with the value set to the ARFCN value of the UTRA cell(s) for which proximity indication was triggered;

The UE shall submit the *ProximityIndication* message to lower layers for transmission.

5.3.15 Void

5.4 Inter-RAT mobility

5.4.1 Introduction

The general principles of connected mode mobility are described in 5.3.1.3. The general principles of the security handling upon connected mode mobility are described in 5.3.1.2.

For the (network controlled) inter RAT mobility from E-UTRA for a UE in RRC_CONNECTED, a single procedure is defined that supports both handover, cell change order with optional network assistance (NACC) and enhanced CS fallback to CDMA2000 1xRTT. In case of mobility to CDMA2000, the eNB decides when to move to the other RAT while the target RAT determines to which cell the UE shall move.

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5.4.2 Handover to E-UTRA

5.4.2.1 General

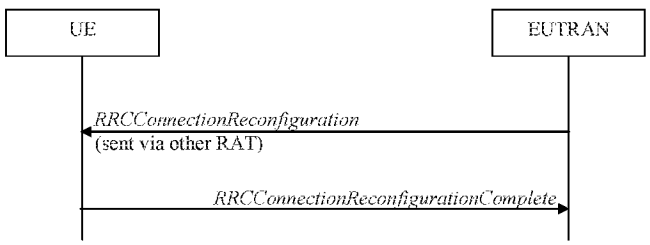


Figure 5.4.2.1-1: Handover to E-UTRA, successful

The purpose of this procedure is to, under the control of the network, transfer a connection between the UE and another Radio Access Network (e.g. GERAN or UTRAN) to E-UTRAN.

The handover to E-UTRA procedure applies when SRBs, possibly in combination with DRBs, are established in another RAT. Handover from UTRAN to E-UTRAN applies only after integrity has been activated in UTRAN.

5.4.2.2 Initiation

The RAN using another RAT initiates the Handover to E-UTRA procedure, in accordance with the specifications applicable for the other RAT, by sending the *RRCConnectionReconfiguration* message via the radio access technology from which the inter-RAT handover is performed.

E-UTRAN applies the procedure as follows:

- to activate ciphering, possibly using NULL algorithm, if not yet activated in the other RAT;
- to establish SRB1, SRB2 and one or more DRBs, i.e. at least the DRB associated with the default EPS bearer is established;

5.4.2.3 Reception of the *RRCConnectionReconfiguration* by the UE

If the UE is able to comply with the configuration included in the *RRCConnectionReconfiguration* message, the UE shall:

1> apply the default physical channel configuration as specified in 9.2.4;

1> apply the default semi-persistent scheduling configuration as specified in 9.2.3;

1> apply the default MAC main configuration as specified in 9.2.2;

1> start timer T304 with the timer value set to *t304*, as included in the *mobilityControlInfo*;

1> consider the target PCell to be one on the frequency indicated by the *carrierFreq* with a physical cell identity indicated by the *targetPhysCellId*;

1> start synchronising to the DL of the target PCell;

1> set the C-RNTI to the value of the *newUE-Identity*;

1> for the target PCell, apply the downlink bandwidth indicated by the *dl-Bandwidth*;

1> for the target PCell, apply the uplink bandwidth indicated by (the absence or presence of) the *ul-Bandwidth*;

1> configure lower layers in accordance with the received *radioResourceConfigCommon*;

1> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *mobilityControlInfo*;

1> perform the radio resource configuration procedure as specified in 5.3.10;

1> forward the *nas-SecurityParamToEUTRA* to the upper layers;

1> derive the K_{eNB} key, as specified in TS 33.401 [32];

1> derive the K_{RRCint} key associated with the *integrityProtAlgorithm*, as specified in TS 33.401 [32];

1> derive the K_{RRCenc} key and the K_{UPenc} key associated with the *cipheringAlgorithm*, as specified in TS 33.401 [32];

1> configure lower layers to apply the indicated integrity protection algorithm and the K_{RRCint} key immediately, i.e. the indicated integrity protection configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> configure lower layers to apply the indicated ciphering algorithm, the K_{RRCenc} key and the K_{UPenc} key immediately, i.e. the indicated ciphering configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> if the received *RRCConnectionReconfiguration* includes the *sCellToAddModList*:

2> perform SCell addition as specified in 5.3.10.3b;

1> if the *RRCConnectionReconfiguration* message includes the *measConfig*:

2> perform the measurement configuration procedure as specified in 5.5.2;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> if the *RRCConnectionReconfiguration* message includes the *otherConfig*:

2> perform the other configuration procedure as specified in 5.3.10.9;

1> if the *RRCConnectionReconfiguration* message includes *wlan-OffloadInfo*:

2> perform the dedicated WLAN offload configuration procedure as specified in 5.6.12.2;

1> set the content of *RRCConnectionReconfigurationComplete* message as follows:

2> if the UE has radio link failure or handover failure information available in *VarRLF-Report* and if the RPLMN is included in *plmn-IdentityList* stored in *VarRLF-Report*:

3> include *rlf-InfoAvailable*;

2> if the UE has MBSFN logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport* and if T330 is not running:

3> include *logMeasAvailableMBSFN*;

2> else if the UE has logged measurements available for E-UTRA and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

3> include the *logMeasAvailable*;

2> if the UE has connection establishment failure information available in *VarConnEstFailReport* and if the RPLMN is equal to *plmn-Identity* stored in *VarConnEstFailReport*:

3> include *connEstFailInfoAvailable*;

1> submit the *RRCConnectionReconfigurationComplete* message to lower layers for transmission using the new configuration;

1> if the *RRCConnectionReconfiguration* message does not include *rlf-TimersAndConstants* set to *setup*:

2> use the default values specified in 9.2.5 for timer T310, T311 and constant N310, N311;

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1> if MAC successfully completes the random access procedure:

2> stop timer T304;

2> apply the parts of the CQI reporting configuration, the scheduling request configuration and the sounding RS configuration that do not require the UE to know the SFN of the target PCell, if any;

2> apply the parts of the measurement and the radio resource configuration that require the UE to know the SFN of the target PCell (e.g. measurement gaps, periodic CQI reporting, scheduling request configuration, sounding RS configuration), if any, upon acquiring the SFN of the target PCell;

NOTE 1: Whenever the UE shall setup or reconfigure a configuration in accordance with a field that is received it applies the new configuration, except for the cases addressed by the above statements.

2> enter E-UTRA RRC_CONNECTED, upon which the procedure ends;

NOTE 2: The UE is not required to determine the SFN of the target PCell by acquiring system information from that cell before performing RACH access in the target PCell.

5.4.2.4 Reconfiguration failure

The UE shall:

1> if the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message:

2> perform the actions defined for this failure case as defined in the specifications applicable for the other RAT;

NOTE 1: The UE may apply above failure handling also in case the *RRCConnectionReconfiguration* message causes a protocol error for which the generic error handling as defined in 5.7 specifies that the UE shall ignore the message.

NOTE 2: If the UE is unable to comply with part of the configuration, it does not apply any part of the configuration, i.e. there is no partial success/ failure.

5.4.2.5 T304 expiry (handover to E-UTRA failure)

The UE shall:

1> upon T304 expiry (handover to E-UTRA failure):

2> reset MAC;

2> perform the actions defined for this failure case as defined in the specifications applicable for the other RAT;

5.4.3 Mobility from E-UTRA

5.4.3.1 General



Figure 5.4.3.1-1: Mobility from E-UTRA, successful

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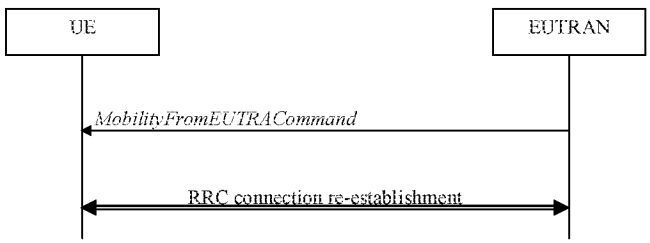


Figure 5.4.3.1-2: Mobility from E-UTRA, failure

The purpose of this procedure is to move a UE in RRC_CONNECTED to a cell using another Radio Access Technology (RAT), e.g. GERAN, UTRA or CDMA2000 systems. The mobility from E-UTRA procedure covers the following type of mobility:

- handover, i.e. the *MobilityFromEUTRACommand* message includes radio resources that have been allocated for the UE in the target cell;
- cell change order, i.e. the *MobilityFromEUTRACommand* message may include information facilitating access of and/ or connection establishment in the target cell, e.g. system information. Cell change order is applicable only to GERAN; and
- enhanced CS fallback to CDMA2000 1xRTT, i.e. the *MobilityFromEUTRACommand* message includes radio resources that have been allocated for the UE in the target cell. The enhanced CS fallback to CDMA2000 1xRTT may be combined with concurrent handover or redirection to CDMA2000 HRPD.

NOTE: For the case of dual receiver/transmitter enhanced CS fallback to CDMA2000 1xRTT, the *DLInformationTransfer* message is used instead of the *MobilityFromEUTRACommand* message (see TS 36.300 [9]).

5.4.3.2 Initiation

E-UTRAN initiates the mobility from E-UTRA procedure to a UE in RRC_CONNECTED, possibly in response to a *MeasurementReport* message or in response to reception of CS fallback indication for the UE from MME, by sending a *MobilityFromEUTRACommand* message. E-UTRAN applies the procedure as follows:

- the procedure is initiated only when AS-security has been activated, and SRB2 with at least one DRB are setup and not suspended;

5.4.3.3 Reception of the *MobilityFromEUTRACommand* by the UE

The UE shall be able to receive a *MobilityFromEUTRACommand* message and perform a cell change order to GERAN, even if no prior UE measurements have been performed on the target cell.

The UE shall:

1> stop timer T310, if running;

1> stop timer T312, if running;

1> if the *MobilityFromEUTRACommand* message includes the *purpose* set to *handover*:

2> if the *targetRAT-Type* is set to *utra* or *geran*:

3> consider inter-RAT mobility as initiated towards the RAT indicated by the *targetRAT-Type* included in the *MobilityFromEUTRACommand* message;

3> forward the *nas-SecurityParamFromEUTRA* to the upper layers;

3> access the target cell indicated in the inter-RAT message in accordance with the specifications of the target RAT;

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3> if the *targetRAT-Type* is set to *geran*:

4> use the contents of *systemInformation*, if provided for PS Handover, as the system information to begin access on the target GERAN cell;

NOTE 1: If there are DRBs for which no radio bearers are established in the target RAT as indicated in the *targetRAT-MessageContainer* in the message, the E-UTRA RRC part of the UE does not indicate the release of the concerned DRBs to the upper layers. Upper layers may derive which bearers are not established from information received from the AS of the target RAT.

NOTE 2: In case of SR-VCC, the DRB to be replaced is specified in [61].

2> else if the *targetRAT-Type* is set to *cdma2000-1XRTT* or *cdma2000-HRPD*:

3> forward the *targetRAT-Type* and the *targetRAT-MessageContainer* to the CDMA2000 upper layers for the UE to access the cell(s) indicated in the inter-RAT message in accordance with the specifications of the CDMA2000 target-RAT;

1> else if the *MobilityFromEUTRACommand* message includes the *purpose* set to *cellChangeOrder*:

2> start timer T304 with the timer value set to *t304*, as included in the *MobilityFromEUTRACommand* message;

2> if the *targetRAT-Type* is set to *geran*:

3> if *networkControlOrder* is included in the *MobilityFromEUTRACommand* message:

4> apply the value as specified in TS 44.060 [36];

3> else:

4> acquire *networkControlOrder* and apply the value as specified in TS 44.060 [36];

3> use the contents of *systemInformation*, if provided, as the system information to begin access on the target GERAN cell;

2> establish the connection to the target cell indicated in the *CellChangeOrder*;

NOTE 3: The criteria for success or failure of the cell change order to GERAN are specified in TS 44.060[36].

1> if the *MobilityFromEUTRACommand* message includes the *purpose* set to *e-CSFB*:

2> if *messageContCDMA2000-1XRTT* is present:

3> forward the *messageContCDMA2000-1XRTT* to the CDMA2000 upper layers for the UE to access the cell(s) indicated in the inter-RAT message in accordance with the specification of the target RAT;

2> if *mobilityCDMA2000-HRPD* is present and is set to *handover*:

3> forward the *messageContCDMA2000-HRPD* to the CDMA2000 upper layers for the UE to access the cell(s) indicated in the inter-RAT message in accordance with the specification of the target RAT;

2> if *mobilityCDMA2000-HRPD* is present and is set to *redirection*:

3> forward the *redirectCarrierCDMA2000-HRPD* to the CDMA2000 upper layers;

NOTE 4: When the CDMA2000 upper layers in the UE receive both the *messageContCDMA2000-1XRTT* and *messageContCDMA2000-HRPD* the UE performs concurrent access to both CDMA2000 1xRTT and CDMA2000 HRPD RAT.

NOTE 5: The UE should perform the handover, the cell change order or enhanced 1xRTT CS fallback as soon as possible following the reception of the RRC message *MobilityFromEUTRACommand*, which could be before confirming successful reception (HARQ and ARQ) of this message.

5.4.3.4 Successful completion of the mobility from E-UTRA

Upon successfully completing the handover, the cell change order or enhanced 1xRTT CS fallback, the UE shall:

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1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'other';

NOTE: If the UE performs enhanced 1xRTT CS fallback along with concurrent mobility to CDMA2000 HRPD and the connection to either CDMA2000 1xRTT or CDMA2000 HRPD succeeds, then the mobility from E-UTRA is considered successful.

5.4.3.5 Mobility from E-UTRA failure

The UE shall:

1> if T304 expires (mobility from E-UTRA failure); or

1> if the UE does not succeed in establishing the connection to the target radio access technology; or

1> if the UE is unable to comply with (part of) the configuration included in the *MobilityFromEUTRACommand* message; or

1> if there is a protocol error in the inter RAT information included in the *MobilityFromEUTRACommand* message, causing the UE to fail the procedure according to the specifications applicable for the target RAT:

2> stop T304, if running;

2> if the *cs-FallbackIndicator* in the *MobilityFromEUTRACommand* message was set to *TRUE* or *e-CSFB* was present:

3> indicate to upper layers that the CS Fallback procedure has failed;

2> revert back to the configuration used in the source PCell, excluding the configuration configured by the *physicalConfigDedicated*, *mac-MainConfig* and *sps-Config*;

2> initiate the connection re-establishment procedure as specified in 5.3.7;

NOTE: For enhanced CS fallback to CDMA2000 1xRTT, the above UE behavior applies only when the UE is attempting the enhanced 1xRTT CS fallback and connection to the target radio access technology fails or if the UE is attempting enhanced 1xRTT CS fallback along with concurrent mobility to CDMA2000 HRPD and connection to both the target radio access technologies fails.

5.4.4 Handover from E-UTRA preparation request (CDMA2000)

5.4.4.1 General

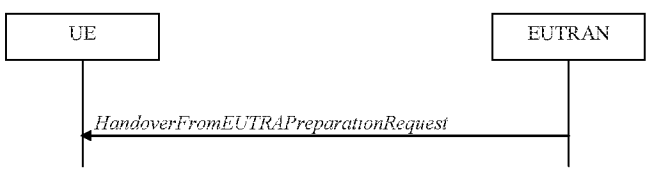


Figure 5.4.4.1-1: Handover from E-UTRA preparation request

The purpose of this procedure is to trigger the UE to prepare for handover or enhanced 1xRTT CS fallback to CDMA2000 by requesting a connection with this network. The UE may use this procedure to concurrently prepare for handover to CDMA2000 HRPD along with preparation for enhanced CS fallback to CDMA2000 1xRTT. This procedure applies to CDMA2000 capable UEs only.

This procedure is also used to trigger the UE which supports dual Rx/Tx enhanced 1xCSFB to redirect its second radio to CDMA2000 1xRTT.

The handover from E-UTRA preparation request procedure applies when signalling radio bearers are established.

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5.4.4.2 Initiation

E-UTRAN initiates the handover from E-UTRA preparation request procedure to a UE in RRC_CONNECTED, possibly in response to a *MeasurementReport* message or CS fallback indication for the UE, by sending a *HandoverFromEUTRAPreparationRequest* message. E-UTRA initiates the procedure only when AS security has been activated.

5.4.4.3 Reception of the *HandoverFromEUTRAPreparationRequest* by the UE

Upon reception of the *HandoverFromEUTRAPreparationRequest* message, the UE shall:

1> if *dualRxTxRedirectIndicator* is present in the received message:

2> forward *dualRxTxRedirectIndicator* to the CDMA2000 upper layers;

2> forward *redirectCarrierCDMA2000-1XRTT* to the CDMA2000 upper layers, if included;

1> else:

2> indicate the request to prepare handover or enhanced 1xRTT CS fallback and forward the *cdma2000-Type* to the CDMA2000 upper layers;

2> if *cdma2000-Type* is set to *type1XRTT*:

3> forward the *rand* and the *mobilityParameters* to the CDMA2000 upper layers;

2> if *concurrPrepCDMA2000-HRPD* is present in the received message:

3> forward *concurrPrepCDMA2000-HRPD* to the CDMA2000 upper layers;

2> else:

3> forward *concurrPrepCDMA2000-HRPD*, with its value set to *FALSE*, to the CDMA2000 upper layers;

5.4.5 UL handover preparation transfer (CDMA2000)

5.4.5.1 General

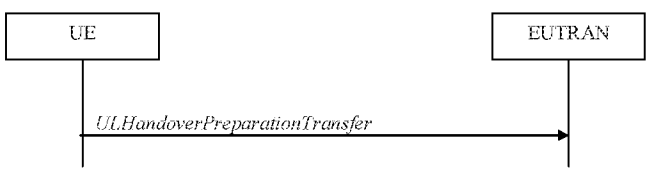


Figure 5.4.5.1-1: UL handover preparation transfer

The purpose of this procedure is to tunnel the handover related CDMA2000 dedicated information or enhanced 1xRTT CS fallback related CDMA2000 dedicated information from UE to E-UTRAN when requested by the higher layers. The procedure is triggered by the higher layers on receipt of *HandoverFromEUTRAPreparationRequest* message. If preparing for enhanced CS fallback to CDMA2000 1xRTT and handover to CDMA2000 HRPD, the UE sends two consecutive *ULHandoverPreparationTransfer* messages to E-UTRAN, one per addressed CDMA2000 RAT Type. This procedure applies to CDMA2000 capable UEs only.

5.4.5.2 Initiation

A UE in RRC_CONNECTED initiates the UL Handover Preparation Transfer procedure whenever there is a need to transfer handover or enhanced 1xRTT CS fallback related non-3GPP dedicated information. The UE initiates the UL handover preparation transfer procedure by sending the *ULHandoverPreparationTransfer* message.

5.4.5.3 Actions related to transmission of the *ULHandoverPreparationTransfer* message

The UE shall set the contents of the *ULHandoverPreparationTransfer* message as follows:

1> include the *cdma2000-Type* and the *dedicatedInfo*;

1> if the *cdma2000-Type* is set to *type1XRTT*:

2> include the *meid* and set it to the value received from the CDMA2000 upper layers;

1> submit the *ULHandoverPreparationTransfer* message to lower layers for transmission, upon which the procedure ends;

5.4.5.4 Failure to deliver the *ULHandoverPreparationTransfer* message

The UE shall:

1> if the UE is unable to guarantee successful delivery of *ULHandoverPreparationTransfer* messages:

2> inform upper layers about the possible failure to deliver the information contained in the concerned *ULHandoverPreparationTransfer* message;

5.4.6 Inter-RAT cell change order to E-UTRAN

5.4.6.1 General

The purpose of the inter-RAT cell change order to E-UTRAN procedure is to transfer, under the control of the source radio access technology, a connection between the UE and another radio access technology (e.g. GSM/ GPRS) to E-UTRAN.

5.4.6.2 Initiation

The procedure is initiated when a radio access technology other than E-UTRAN, e.g. GSM/GPRS, using procedures specific for that RAT, orders the UE to change to an E-UTRAN cell. In response, upper layers request the establishment of an RRC connection as specified in subclause 5.3.3.

NOTE: Within the message used to order the UE to change to an E-UTRAN cell, the source RAT should specify the identity of the target E-UTRAN cell as specified in the specifications for that RAT.

The UE shall:

1> upon receiving an *RRCConnectionSetup* message:

2> consider the inter-RAT cell change order procedure to have completed successfully;

5.4.6.3 UE fails to complete an inter-RAT cell change order

If the inter-RAT cell change order fails the UE shall return to the other radio access technology and proceed as specified in the appropriate specifications for that RAT.

The UE shall:

1> upon failure to establish the RRC connection as specified in subclause 5.3.3:

2> consider the inter-RAT cell change order procedure to have failed;

NOTE: The cell change was network ordered. Therefore, failure to change to the target PCell should not cause the UE to move to UE-controlled cell selection.

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5.5 Measurements

5.5.1 Introduction

The UE reports measurement information in accordance with the measurement configuration as provided by E-UTRAN. E-UTRAN provides the measurement configuration applicable for a UE in RRC_CONNECTED by means of dedicated signalling, i.e. using the *RRCConnectionReconfiguration* message.

The UE can be requested to perform the following types of measurements.

- Intra-frequency measurements: measurements at the downlink carrier frequency(ies) of the serving cell(s).
- Inter-frequency measurements: measurements at frequencies that differ from any of the downlink carrier frequency(ies) of the serving cell(s).
- Inter-RAT measurements of UTRA frequencies.
- Inter-RAT measurements of GERAN frequencies.
- Inter-RAT measurements of CDMA2000 HRPD or CDMA2000 1xRTT frequencies.

The measurement configuration includes the following parameters:

1. **Measurement objects:** The objects on which the UE shall perform the measurements.
   - For intra-frequency and inter-frequency measurements a measurement object is a single E-UTRA carrier frequency. Associated with this carrier frequency, E-UTRAN can configure a list of cell specific offsets, a list of 'blacklisted' cells and a list of 'whitelisted' cells. Blacklisted cells are not considered in event evaluation or measurement reporting.
   - For inter-RAT UTRA measurements a measurement object is a set of cells on a single UTRA carrier frequency.
   - For inter-RAT GERAN measurements a measurement object is a set of GERAN carrier frequencies.
   - For inter-RAT CDMA2000 measurements a measurement object is a set of cells on a single (HRPD or 1xRTT) carrier frequency.

   NOTE 1: Some measurements using the above mentioned measurement objects, only concern a single cell, e.g. measurements used to report neighbouring cell system information, PCell UE Rx-Tx time difference, or a pair of cells, e.g. SSTD measurements between the PCell and the PSCell.
2. **Reporting configurations**: A list of reporting configurations where each reporting configuration consists of the following:
   - Reporting criterion: The criterion that triggers the UE to send a measurement report. This can either be periodical or a single event description.
   - Reporting format: The quantities that the UE includes in the measurement report and associated information (e.g. number of cells to report).
3. **Measurement identities**: A list of measurement identities where each measurement identity links one measurement object with one reporting configuration. By configuring multiple measurement identities it is possible to link more than one measurement object to the same reporting configuration, as well as to link more than one reporting configuration to the same measurement object. The measurement identity is used as a reference number in the measurement report.
4. **Quantity configurations:** One quantity configuration is configured per RAT type. The quantity configuration defines the measurement quantities and associated filtering used for all event evaluation and related reporting of that measurement type. One filter can be configured per measurement quantity.
5. **Measurement gaps:** Periods that the UE may use to perform measurements, i.e. no (UL, DL) transmissions are scheduled.

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E-UTRAN only configures a single measurement object for a given frequency, i.e. it is not possible to configure two or more measurement objects for the same frequency with different associated parameters, e.g. different offsets and/ or blacklists. E-UTRAN may configure multiple instances of the same event e.g. by configuring two reporting configurations with different thresholds.

The UE maintains a single measurement object list, a single reporting configuration list, and a single measurement identities list. The measurement object list includes measurement objects, that are specified per RAT type, possibly including intra-frequency object(s) (i.e. the object(s) corresponding to the serving frequency(ies)), inter-frequency object(s) and inter-RAT objects. Similarly, the reporting configuration list includes E-UTRA and inter-RAT reporting configurations. Any measurement object can be linked to any reporting configuration of the same RAT type. Some reporting configurations may not be linked to a measurement object. Likewise, some measurement objects may not be linked to a reporting configuration.

The measurement procedures distinguish the following types of cells:

1. The serving cell(s)– these are the PCell and one or more SCells, if configured for a UE supporting CA.
2. Listed cells - these are cells listed within the measurement object(s).
3. Detected cells - these are cells that are not listed within the measurement object(s) but are detected by the UE on the carrier frequency(ies) indicated by the measurement object(s).

For E-UTRA, the UE measures and reports on the serving cell(s), listed cells, detected cells and, for RSSI and channel occupancy measurements, the UE measures and reports on any reception on the indicated frequency. For inter-RAT UTRA, the UE measures and reports on listed cells and optionally on cells that are within a range for which reporting is allowed by E-UTRAN. For inter-RAT GERAN, the UE measures and reports on detected cells. For inter-RAT CDMA2000, the UE measures and reports on listed cells.

NOTE 2: For inter-RAT UTRA and CDMA2000, the UE measures and reports also on detected cells for the purpose of SON.

NOTE 3: This specification is based on the assumption that typically CSG cells of home deployment type are not indicated within the neighbour list. Furthermore, the assumption is that for non-home deployments, the physical cell identity is unique within the area of a large macro cell (i.e. as for UTRAN).

Whenever the procedural specification, other than contained in sub-clause 5.5.2, refers to a field it concerns a field included in the *VarMeasConfig* unless explicitly stated otherwise i.e. only the measurement configuration procedure covers the direct UE action related to the received *measConfig*.

5.5.2 Measurement configuration

5.5.2.1 General

E-UTRAN applies the procedure as follows:

- to ensure that, whenever the UE has a *measConfig*, it includes a *measObject* for each serving frequency;
- to configure at most one measurement identity using a reporting configuration with the *purpose* set to *reportCGI*;
- for serving frequencies, set the EARFCN within the corresponding *measObject* according to the band as used for reception/ transmission;

The UE shall:

1> if the received *measConfig* includes the *measObjectToRemoveList*:

2> perform the measurement object removal procedure as specified in 5.5.2.4;

1> if the received *measConfig* includes the *measObjectToAddModList*:

2> perform the measurement object addition/ modification procedure as specified in 5.5.2.5;

1> if the received *measConfig* includes the *reportConfigToRemoveList*:

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2> perform the reporting configuration removal procedure as specified in 5.5.2.6;

1> if the received *measConfig* includes the *reportConfigToAddModList*:

2> perform the reporting configuration addition/ modification procedure as specified in 5.5.2.7;

1> if the received *measConfig* includes the *quantityConfig*:

2> perform the quantity configuration procedure as specified in 5.5.2.8;

1> if the received *measConfig* includes the *measIdToRemoveList*:

2> perform the measurement identity removal procedure as specified in 5.5.2.2;

1> if the received *measConfig* includes the *measIdToAddModList*:

2> perform the measurement identity addition/ modification procedure as specified in 5.5.2.3;

1> if the received *measConfig* includes the *measGapConfig*:

2> perform the measurement gap configuration procedure as specified in 5.5.2.9;

1> if the received *measConfig* includes the *s-Measure*:

2> set the parameter *s-Measure* within *VarMeasConfig* to the lowest value of the RSRP ranges indicated by the received value of *s-Measure*;

1> if the received *measConfig* includes the *preRegistrationInfoHRPD*:

2> forward the *preRegistrationInfoHRPD* to CDMA2000 upper layers;

1> if the received *measConfig* includes the *speedStatePars*:

2> set the parameter *speedStatePars* within *VarMeasConfig* to the received value of *speedStatePars*;

1> if the received *measConfig* includes the *allowInterruptions*:

2> set the parameter *allowInterruptions* within *VarMeasConfig* to the received value of *allowInterruptions*;

1> if the received *measConfig* includes the *ul-DelayConfig*:

2> set the parameter *ul-DelayConfig* within *VarMeasConfig* to the received value of *ul-DelayConfig*;

2> configure the PDCP layer to apply *ul-DelayConfig*;

5.5.2.2 Measurement identity removal

The UE shall:

1> for each *measId* included in the received *measIdToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *measId* from the *measIdList* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *measIdToRemoveList* includes any *measId* value that is not part of the current UE configuration.

5.5.2.2a Measurement identity autonomous removal

The UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the associated *reportConfig* concerns an event involving a serving cell while the concerned serving cell is not configured:

3> remove the *measId* from the *measIdList* within the *VarMeasConfig*;

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer if running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE 1: The above UE autonomous removal of *measId*'s applies only for measurement events A1, A2, A6, and also applies for events A3 and A5 if configured for PSCell.

NOTE 2: When performed during re-establishment, the UE is only configured with a primary frequency (i.e. the SCell(s) are released, if configured).

5.5.2.3 Measurement identity addition/ modification

E-UTRAN applies the procedure as follows:

- configure a *measId* only if the corresponding measurement object, the corresponding reporting configuration and the corresponding quantity configuration, are configured;

The UE shall:

1> for each *measId* included in the received *measIdToAddModList*:

2> if an entry with the matching *measId* exists in the *measIdList* within the *VarMeasConfig*:

3> replace the entry with the value received for this *measId*;

2> else:

3> add a new entry for this *measId* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> if the *triggerType* is set to *periodical* and the *purpose* is set to *reportCGI* in the *reportConfig* associated with this *measId*:

3> if the *measObject* associated with this *measId* concerns E-UTRA:

4> if the *si-RequestForHO* is included in the *reportConfig* associated with this *measId*:

5> start timer T321 with the timer value set to 150 ms for this *measId*;

4> else:

5> start timer T321 with the timer value set to 1 second for this *measId*;

3> else if the *measObject* associated with this *measId* concerns UTRA:

4> if the *si-RequestForHO* is included in the *reportConfig* associated with this *measId*:

5> for UTRA FDD, start timer T321 with the timer value set to 2 seconds for this *measId*;

5> for UTRA TDD, start timer T321 with the timer value set to {1 second} for this *measId*;

4> else:

5> start timer T321 with the timer value set to 8 seconds for this *measId*;

3> else:

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4> start timer T321 with the timer value set to 8 seconds for this *measId*;

5.5.2.4 Measurement object removal

The UE shall:

1> for each *measObjectId* included in the received *measObjectToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *measObjectId* from the *measObjectList* within the *VarMeasConfig*;

2> remove all *measId* associated with this *measObjectId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a *measId* is removed from the *measIdList*:

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *measObjectToRemoveList* includes any *measObjectId* value that is not part of the current UE configuration.

5.5.2.5 Measurement object addition/ modification

The UE shall:

1> for each *measObjectId* included in the received *measObjectToAddModList*:

2> if an entry with the matching *measObjectId* exists in the *measObjectList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this *measObject*, except for the fields *cellsToAddModList*, *blackCellsToAddModList*, *whiteCellsToAddModList*, *altTTT-CellsToAddModList*, *cellsToRemoveList*, *blackCellsToRemoveList*, *whiteCellsToRemoveList*, *altTTT-CellsToRemoveList*, *measSubframePatternConfigNeigh* and *measDS-Config*;

3> if the received *measObject* includes the *cellsToRemoveList*:

4> for each *cellIndex* included in the *cellsToRemoveList*:

5> remove the entry with the matching *cellIndex* from the *cellsToAddModList*;

3> if the received *measObject* includes the *cellsToAddModList*:

4> for each *cellIndex* value included in the *cellsToAddModList*:

5> if an entry with the matching *cellIndex* exists in the *cellsToAddModList*:

6> replace the entry with the value received for this *cellIndex*;

5> else:

6> add a new entry for the received *cellIndex* to the *cellsToAddModList*;

3> if the received *measObject* includes the *blackCellsToRemoveList*:

4> for each *cellIndex* included in the *blackCellsToRemoveList*:

5> remove the entry with the matching *cellIndex* from the *blackCellsToAddModList*;

NOTE 1: For each *cellIndex* included in the *blackCellsToRemoveList* that concerns overlapping ranges of cells, a cell is removed from the black list of cells only if all cell indexes containing it are removed.

3> if the received *measObject* includes the *blackCellsToAddModList*:

4> for each *cellIndex* included in the *blackCellsToAddModList*:

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5> if an entry with the matching *cellIndex* is included in the *blackCellsToAddModList*:

6> replace the entry with the value received for this *cellIndex*;

5> else:

6> add a new entry for the received *cellIndex* to the *blackCellsToAddModList*;

3> if the received *measObject* includes the *whiteCellsToRemoveList*:

4> for each *cellIndex* included in the *whiteCellsToRemoveList*:

5> remove the entry with the matching *cellIndex* from the *whiteCellsToAddModList*;

NOTE 2: For each *cellIndex* included in the *whiteCellsToRemoveList* that concerns overlapping ranges of cells, a cell is removed from the white list of cells only if all cell indexes containing it are removed.

3> if the received *measObject* includes the *whiteCellsToAddModList*:

4> for each *cellIndex* included in the *whiteCellsToAddModList*:

5> if an entry with the matching *cellIndex* is included in the *whiteCellsToAddModList*:

6> replace the entry with the value received for this *cellIndex*;

5> else:

6> add a new entry for the received *cellIndex* to the *whiteCellsToAddModList*;

3> if the received *measObject* includes the *altTTT-CellsToRemoveList*:

4> for each *cellIndex* included in the *altTTT-CellsToRemoveList*:

5> remove the entry with the matching *cellIndex* from the *altTTT-CellsToAddModList*;

NOTE 3: For each *cellIndex* included in the *altTTT-CellsToRemoveList* that concerns overlapping ranges of cells, a cell is removed from the list of cells only if all cell indexes containing it are removed.

3> if the received *measObject* includes the *altTTT-CellsToAddModList*:

4> for each *cellIndex* value included in the *altTTT-CellsToAddModList*:

5> if an entry with the matching *cellIndex* exists in the *altTTT-CellsToAddModList*:

6> replace the entry with the value received for this *cellIndex*;

5> else:

6> add a new entry for the received *cellIndex* to the *altTTT-CellsToAddModList*;

3> if the received *measObject* includes *measSubframePatternConfigNeigh*:

4> set *measSubframePatternConfigNeigh* within the *VarMeasConfig* to the value of the received field

3> if the received *measObject* includes *measDS-Config*:

4> if *measDS-Config* is set to *setup*:

5> if the received *measDS-Config* includes the *measCSI-RS-ToRemoveList*:

6> for each *measCSI-RS-Id* included in the *measCSI-RS-ToRemoveList*:

7> remove the entry with the matching *measCSI-RS-Id* from the *measCSI-RS-ToAddModList*;

5> if the received *measDS-Config* includes the *measCSI-RS-ToAddModList*, for each *measCSI-RS-Id* value included in the *measCSI-RS-ToAddModList*:

6> if an entry with the matching *measCSI-RS-Id* exists in the *measCSI-RS-ToAddModList*:

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7> replace the entry with the value received for this *measCSI-RS-Id*;

6> else:

7> add a new entry for the received *measCSI-RS-Id* to the *measCSI-RS-ToAddModList*;

5> set other fields of the *measDS-Config* within the *VarMeasConfig* to the value of the received fields;

5> perform the discovery signals measurement timing configuration procedure as specified in 5.5.2.10;

4> else:

5> release the discovery signals measurement configuration;

3> for each *measId* associated with this *measObjectId* in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

4> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received *measObject* to the *measObjectList* within *VarMeasConfig*;

NOTE 4: UE does not need to retain *cellForWhichToReportCGI* in the *measObject* after reporting *cgi-Info*.

5.5.2.6 Reporting configuration removal

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *reportConfigId* from the *reportConfigList* within the *VarMeasConfig*;

2> remove all *measId* associated with the *reportConfigId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a *measId* is removed from the *measIdList*:

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *reportConfigToRemoveList* includes any *reportConfigId* value that is not part of the current UE configuration.

5.5.2.7 Reporting configuration addition/ modification

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToAddModList*:

2> if an entry with the matching *reportConfigId* exists in the *reportConfigList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this *reportConfig*;

3> for each *measId* associated with this *reportConfigId* included in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from in *VarMeasReportList*, if included;

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4> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received *reportConfig* to the *reportConfigList* within the *VarMeasConfig*;

5.5.2.8 Quantity configuration

The UE shall:

1> for each RAT for which the received *quantityConfig* includes parameter(s):

2> set the corresponding parameter(s) in *quantityConfig* within *VarMeasConfig* to the value of the received *quantityConfig* parameter(s);

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer or timer T321, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

5.5.2.9 Measurement gap configuration

The UE shall:

1> if *measGapConfig* is set to *setup*:

2> if a measurement gap configuration is already setup, release the measurement gap configuration;

2> setup the measurement gap configuration indicated by the *measGapConfig* in accordance with the received *gapOffset*, i.e., the first subframe of each gap occurs at an SFN and subframe meeting the following condition (SFN and subframe of MCG cells):

SFN mod T = FLOOR(*gapOffset*/10);

subframe = *gapOffset* mod 10;

with T = MGRP/10 as defined in TS 36.133 [16];

NOTE: The UE applies a single gap, which timing is relative to the MCG cells, even when configured with DC.

1> else:

2> release the measurement gap configuration;

5.5.2.10 Discovery signals measurement timing configuration

The UE shall setup the discovery signals measurement timing configuration (DMTC) in accordance with the received *dmtc-PeriodOffset*, i.e., the first subframe of each DMTC occasion occurs at an SFN and subframe of the PCell meeting the following condition:

SFN mod T = FLOOR(*dmtc-Offset*/10);

subframe = *dmtc-Offset* mod 10;

with T = *dmtc-Periodicity*/10;

On the concerned frequency, the UE shall not consider discovery signals transmission in subframes outside the DMTC occasion.

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5.5.3 Performing measurements

5.5.3.1 General

For all measurements, except for UE Rx–Tx time difference measurements, RSSI and channel occupancy measurements, the UE applies the layer 3 filtering as specified in 5.5.3.2, before using the measured results for evaluation of reporting criteria or for measurement reporting.

The UE shall:

1> whenever the UE has a *measConfig*, perform RSRP, RSRQ and RS-SINR (if indicated in the associated *reportConfig*) measurements for each serving cell as follows:

2> for the PCell, apply the time domain measurement resource restriction in accordance with *measSubframePatternPCell*, if configured;

2> if the UE supports CRS based discovery signals measurement:

3> for each SCell in deactivated state, apply the discovery signals measurement timing configuration in accordance with *measDS-Config*, if configured within the *measObject* corresponding to the frequency of the SCell;

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the *purpose* for the associated *reportConfig* is set to *reportCGI*:

3> if *si-RequestForHO* is configured for the associated *reportConfig*:

4> perform the corresponding measurements on the frequency and RAT indicated in the associated *measObject* using autonomous gaps as necessary;

3> else:

4> perform the corresponding measurements on the frequency and RAT indicated in the associated *measObject* using available idle periods or using autonomous gaps as necessary;

NOTE 1: If autonomous gaps are used to perform measurements, the UE is allowed to temporarily abort communication with all serving cell(s), i.e. create autonomous gaps to perform the corresponding measurements within the limits specified in TS 36.133 [16]. Otherwise, the UE only supports the measurements with the purpose set to *reportCGI* only if E-UTRAN has provided sufficient idle periods.

3> try to acquire the global cell identity of the cell indicated by the *cellForWhichToReportCGI* in the associated *measObject* by acquiring the relevant system information from the concerned cell;

3> if the cell indicated by the *cellForWhichToReportCGI* included in the associated *measObject* is an E-UTRAN cell:

4> try to acquire the CSG identity, if the CSG identity is broadcast in the concerned cell;

4> try to acquire the *trackingAreaCode* in the concerned cell;

4> try to acquire the list of additional PLMN Identities, as included in the *plmn-IdentityList*, if multiple PLMN identities are broadcast in the concerned cell;

NOTE 2: The 'primary' PLMN is part of the global cell identity.

3> if the cell indicated by the *cellForWhichToReportCGI* included in the associated *measObject* is a UTRAN cell:

4> try to acquire the LAC, the RAC and the list of additional PLMN Identities, if multiple PLMN identities are broadcast in the concerned cell;

4> try to acquire the CSG identity, if the CSG identity is broadcast in the concerned cell;

3> if the cell indicated by the *cellForWhichToReportCGI* included in the associated *measObject* is a GERAN cell:

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4> try to acquire the RAC in the concerned cell;

3> if the cell indicated by the *cellForWhichToReportCGI* included in the associated *measObject* is a CDMA2000 cell and the *cdma2000-Type* included in the *measObject* is *typeHRPD*:

4> try to acquire the Sector ID in the concerned cell;

3> if the cell indicated by the *cellForWhichToReportCGI* included in the associated *measObject* is a CDMA2000 cell and the *cdma2000-Type* included in the *measObject* is *type1XRTT*:

4> try to acquire the BASE ID, SID and NID in the concerned cell;

2> else:

3> if a measurement gap configuration is setup; or

3> if the UE does not require measurement gaps to perform the concerned measurements:

4> if *s-Measure* is not configured; or

4> if *s-Measure* is configured and the PCell RSRP, after layer 3 filtering, is lower than this value; or

4> if *measDS-Config* is configured in the associated *measObject*:

5> if the UE supports CSI-RS based discovery signals measurement; and

5> if the *eventId* in the associated *reportConfig* is set to *eventC1* or *eventC2*, or if *reportStrongestCSI-RSs* is included in the associated *reportConfig*:

6> perform the corresponding measurements of CSI-RS resources on the frequency indicated in the concerned *measObject*, applying the discovery signals measurement timing configuration in accordance with *measDS-Config* in the concerned *measObject*;

6> if *reportCRS-Meas* is included in the associated *reportConfig*, perform the corresponding measurements of neighbouring cells on the frequencies indicated in the concerned *measObject* as follows:

7> for neighbouring cells on the primary frequency, apply the time domain measurement resource restriction in accordance with *measSubframePatternConfigNeigh*, if configured in the concerned *measObject*;

7> apply the discovery signals measurement timing configuration in accordance with *measDS-Config* in the concerned *measObject*;

5> else:

6> perform the corresponding measurements of neighbouring cells on the frequencies and RATs indicated in the concerned *measObject* as follows:

7> for neighbouring cells on the primary frequency, apply the time domain measurement resource restriction in accordance with *measSubframePatternConfigNeigh*, if configured in the concerned *measObject*;

7> if the UE supports CRS based discovery signals measurement, apply the discovery signals measurement timing configuration in accordance with *measDS-Config*, if configured in the concerned *measObject*;

4> if the *ue-RxTxTimeDiffPeriodical* is configured in the associated *reportConfig*:

5> perform the UE Rx--Tx time difference measurements on the PCell;

4> if the *reportSSTD-Meas* is set to *true* in the associated *reportConfig*:

5> perform SSTD measurements between the PCell and the PSCell;

4> if the *measRSSI-ReportConfig* is configured in the associated *reportConfig*:

5> perform the RSSI and channel occupancy measurements on the frequency indicated in the associated *measObject*;

2> perform the evaluation of reporting criteria as specified in 5.5.4;

NOTE 3: The *s-Measure* defines when the UE is required to perform measurements. The UE is however allowed to perform measurements also when the PCell RSRP exceeds *s-Measure*, e.g., to measure cells broadcasting a CSG identity following use of the autonomous search function as defined in TS 36.304 [4].

5.5.3.2 Layer 3 filtering

The UE shall:

1> for each measurement quantity that the UE performs measurements according to 5.5.3.1:

NOTE 1: This does not include quantities configured solely for UE Rx-Tx time difference, SSTD measurements and RSSI and channel occupancy measurements i.e. for those types of measurements the UE ignores the *triggerQuantity* and *reportQuantity*.

2> filter the measured result, before using for evaluation of reporting criteria or for measurement reporting, by the following formula:

$$F_n = (1 - a) \cdot F_{n-1} + a \cdot M_n$$

where

M_n is the latest received measurement result from the physical layer;

F_n is the updated filtered measurement result, that is used for evaluation of reporting criteria or for measurement reporting;

F_{n-1} is the old filtered measurement result, where F_0 is set to M_1 when the first measurement result from the physical layer is received; and

$a = 1/2^{(k/4)}$, where k is the *filterCoefficient* for the corresponding measurement quantity received by the *quantityConfig*;

2> adapt the filter such that the time characteristics of the filter are preserved at different input rates, observing that the *filterCoefficient* k assumes a sample rate equal to 200 ms;

NOTE 2: If k is set to 0, no layer 3 filtering is applicable.

NOTE 3: The filtering is performed in the same domain as used for evaluation of reporting criteria or for measurement reporting, i.e., logarithmic filtering for logarithmic measurements.

NOTE 4: The filter input rate is implementation dependent, to fulfil the performance requirements set in [16]. For further details about the physical layer measurements, see TS 36.133 [16].

5.5.4 Measurement report triggering

5.5.4.1 General

If security has been activated successfully, the UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the corresponding *reportConfig* includes a purpose set to *reportStrongestCellsForSON*:

3> consider any neighbouring cell detected on the associated frequency to be applicable;

2> else if the corresponding *reportConfig* includes a purpose set to *reportCGI*:

3> consider any neighbouring cell detected on the associated frequency/ set of frequencies (GERAN) which has a physical cell identity matching the value of the *cellForWhichToReportCGI* included in the corresponding *measObject* within the *VarMeasConfig* to be applicable;

2> else:

3> if the corresponding *measObject* concerns E-UTRA:

4> if the *ue-RxTxTimeDiffPeriodical* is configured in the corresponding *reportConfig*:

5> consider only the PCell to be applicable;

4> else if the *reportSSTD-Meas* is set to *true* in the corresponding *reportConfig*:

5> consider the PSCell to be applicable;

4> else if the *eventA1* or *eventA2* is configured in the corresponding *reportConfig*:

5> consider only the serving cell to be applicable;

4> else if *eventC1* or *eventC2* is configured in the corresponding *reportConfig*; or if *reportStrongestCSI-RSs* is included in the corresponding *reportConfig*:

5> consider a CSI-RS resource on the associated frequency to be applicable when the concerned CSI-RS resource is included in the *measCSI-RS-ToAddModList* defined within the *VarMeasConfig* for this *measId*;

4> else if *measRSSI-ReportConfig* is configured in the corresponding *reportConfig*:

5> consider the resource indicated by the *measRSSI-Config* on the associated frequency to be applicable;

4> else:

5> if *useWhiteCellList* is set to *TRUE*:

6> consider any neighbouring cell detected on the associated frequency to be applicable when the concerned cell is included in the *whiteCellsToAddModList* defined within the *VarMeasConfig* for this *measId*;

5> else:

6> consider any neighbouring cell detected on the associated frequency to be applicable when the concerned cell is not included in the *blackCellsToAddModList* defined within the *VarMeasConfig* for this *measId*;

5> for events involving a serving cell on one frequency and neighbours on another frequency, consider the serving cell on the other frequency as a neighbouring cell;

4> if the corresponding *reportConfig* includes *alternativeTimeToTrigger* and if the UE supports *alternativeTimeToTrigger*:

5> use the value of *alternativeTimeToTrigger* as the time to trigger instead of the value of *timeToTrigger* in the corresponding *reportConfig* for cells included in the *altTTT-CellsToAddModList* of the corresponding *measObject*;

3> else if the corresponding *measObject* concerns UTRA or CDMA2000:

4> consider a neighbouring cell on the associated frequency to be applicable when the concerned cell is included in the *cellsToAddModList* defined within the *VarMeasConfig* for this *measId* (i.e. the cell is included in the white-list);

NOTE 0: The UE may also consider a neighbouring cell on the associated UTRA frequency to be applicable when the concerned cell is included in the *csg-allowedReportingCells* within the *VarMeasConfig* for this *measId*, if configured in the corresponding *measObjectUTRA* (i.e. the cell is included in the range of physical cell identities for which reporting is allowed).

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3> else if the corresponding *measObject* concerns GERAN:

4> consider a neighbouring cell on the associated set of frequencies to be applicable when the concerned cell matches the *ncc-Permitted* defined within the *VarMeasConfig* for this *measId*;

2> if the *triggerType* is set to *event* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig*, while the *VarMeasReportList* does not include an measurement reporting entry for this *measId* (a first cell triggers the event):

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if *useT312* is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding *measObject*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells not included in the *cellsTriggeredList* for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig* (a subsequent cell triggers the event):

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if *useT312* is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding *measObject*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* and if the leaving condition applicable for this event is fulfilled for one or more of the cells included in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* for all measurements after layer 3 filtering taken during *timeToTrigger* defined within the *VarMeasConfig* for this event:

3> remove the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if *useT312* is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding *measObject*;

3> if *reportOnLeave* is set to *TRUE* for the corresponding reporting configuration or if *a6-ReportOnLeave* is set to *TRUE* for the corresponding reporting configuration:

4> initiate the measurement reporting procedure, as specified in 5.5.5;

3> if the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* is empty:

4> remove the measurement reporting entry within the *VarMeasReportList* for this *measId*;

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4> stop the periodical reporting timer for this *measId*, if running;

2> if the *triggerType* is set to *event* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable CSI-RS resources for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig*, while the *VarMeasReportList* does not include an measurement reporting entry for this *measId* (i.e. a first CSI-RS resource triggers the event):

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned CSI-RS resource(s) in the *csi-RS-TriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable CSI-RS resources not included in the *csi-RS-TriggeredList* for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig* (i.e. a subsequent CSI-RS resource triggers the event):

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned CSI-RS resource(s) in the *csi-RS-TriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* and if the leaving condition applicable for this event is fulfilled for one or more of the CSI-RS resources included in the *csi-RS-TriggeredList* defined within the *VarMeasReportList* for this *measId* for all measurements after layer 3 filtering taken during *timeToTrigger* defined within the *VarMeasConfig* for this event:

3> remove the concerned CSI-RS resource(s) in the *csi-RS-TriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if *c1-ReportOnLeave* is set to *TRUE* for the corresponding reporting configuration or if *c2-ReportOnLeave* is set to *TRUE* for the corresponding reporting configuration:

4> initiate the measurement reporting procedure, as specified in 5.5.5;

3> if the *csi-RS-TriggeredList* defined within the *VarMeasReportList* for this *measId* is empty:

4> remove the measurement reporting entry within the *VarMeasReportList* for this *measId*;

4> stop the periodical reporting timer for this *measId*, if running;

2> if *measRSSI-ReportConfig* is included and if a (first) measurement result is available:

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> initiate the measurement reporting procedure as specified in 5.5.5 immediately after a first RSSI sample value is reported by the physical layer;

2> if the *purpose* is included and set to *reportStrongestCells* or to *reportStrongestCellsForSON* and if a (first) measurement result is available:

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> if the *purpose* is set to *reportStrongestCells* and *reportStrongestCSI-RSs* is not included:

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4> if the *reportAmount* > 1:

5> initiate the measurement reporting procedure, as specified in 5.5.5, immediately after the quantity to be reported becomes available for the PCell;

4> else (i.e. the *reportAmount* = 1):

5> initiate the measurement reporting procedure, as specified in 5.5.5, immediately after the quantity to be reported becomes available for the PCell and for the strongest cell among the applicable cells, or becomes available for the pair of PCell and the PSCell in case of SSTD measurements;

3> else if the purpose is set to *reportStrongestCellsForSON*:

4> initiate the measurement reporting procedure, as specified in 5.5.5, when it has determined the strongest cells on the associated frequency;

2> upon expiry of the periodical reporting timer for this *measId*:

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *purpose is* included and set to *reportCGI* and if the UE acquired the information needed to set all fields of *cgi-Info* for the requested cell:

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> stop timer T321;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> upon expiry of the T321 for this *measId*:

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

NOTE 2: The UE does not stop the periodical reporting with *triggerType* set to *event* or to *periodical* while the corresponding measurement is not performed due to the PCell RSRP being equal to or better than *s-Measure* or due to the measurement gap not being setup.

NOTE 3: If the UE is configured with DRX, the UE may delay the measurement reporting for event triggered and periodical triggered measurements until the Active Time, which is defined in TS 36.321 [6].

5.5.4.2 Event A1 (Serving becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A1-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A1-2, as specified below, is fulfilled;

1> for this measurement, consider the primary or secondary cell that is configured on the frequency indicated in the associated *measObjectEUTRA* to be the serving cell;

Inequality A1-1 (Entering condition)

$Ms - Hys > Thresh$

Inequality A1-2 (Leaving condition)

$Ms + Hys < Thresh$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Thresh is the threshold parameter for this event (i.e. *a1-Threshold* as defined within *reportConfigEUTRA* for this event).

Ms is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.3 Event A2 (Serving becomes worse than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A2-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A2-2, as specified below, is fulfilled;

1> for this measurement, consider the primary or secondary cell that is configured on the frequency indicated in the associated *measObjectEUTRA* to be the serving cell;

Inequality A2-1 (Entering condition)

$Ms + Hys < Thresh$

Inequality A2-2 (Leaving condition)

$Ms - Hys > Thresh$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Thresh is the threshold parameter for this event (i.e. *a2-Threshold* as defined within *reportConfigEUTRA* for this event).

Ms is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.4 Event A3 (Neighbour becomes offset better than PCell/ PSCell)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A3-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A3-2, as specified below, is fulfilled;

1> if *usePSCell* of the corresponding *reportConfig* is set to *true*:

2> use the PSCell for *Mp, Ofp and Ocp*;

1> else:

2> use the PCell for *Mp, Ofp and Ocp*;

NOTE The cell(s) that triggers the event is on the frequency indicated in the associated *measObject* which may be different from the frequency used by the PCell/ PSCell.

Inequality A3-1 (Entering condition)

$Mn + Ofn + Ocn - Hys > Mp + Ofp + Ocp + Off$

Inequality A3-2 (Leaving condition)

$Mn + Ofn + Ocn + Hys < Mp + Ofp + Ocp + Off$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Mp is the measurement result of the PCell/ PSCell, not taking into account any offsets.

Ofp is the frequency specific offset of the frequency of the PCell/ PSCell (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the frequency of the PCell/ PSCell).

Ocp is the cell specific offset of the PCell/ PSCell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the PCell/ PSCell), and is set to zero if not configured for the PCell/ PSCell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Off is the offset parameter for this event (i.e. *a3-Offset* as defined within *reportConfigEUTRA* for this event).

Mn, Mp are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, Ocn, Ofp, Ocp, Hys, Off are expressed in dB.

5.5.4.5 Event A4 (Neighbour becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A4-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A4-2, as specified below, is fulfilled;

Inequality A4-1 (Entering condition)

$Mn + Ofn + Ocn - Hys > Thresh$

Inequality A4-2 (Leaving condition)

$Mn + Ofn + Ocn + Hys < Thresh$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Thresh is the threshold parameter for this event (i.e. *a4-Threshold* as defined within *reportConfigEUTRA* for this event).

Mn is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, Ocn, Hys are expressed in dB.

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Thresh is expressed in the same unit as ***Mn***.

5.5.4.6 Event A5 (PCell/ PSCell becomes worse than threshold1 and neighbour becomes better than threshold2)

The UE shall:

1> consider the entering condition for this event to be satisfied when both condition A5-1 and condition A5-2, as specified below, are fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A5-3 or condition A5-4, i.e. at least one of the two, as specified below, is fulfilled;

1> if *usePSCell* of the corresponding *reportConfig* is set to *true*:

2> use the PSCell for *Mp*;

1> else:

2> use the PCell for *Mp*;

NOTE: The cell(s) that triggers the event is on the frequency indicated in the associated *measObject* which may be different from the frequency used by the PCell/ PSCell.

Inequality A5-1 (Entering condition 1)

$Mp + Hys < Thresh1$

Inequality A5-2 (Entering condition 2)

$Mn + Ofn + Ocn - Hys > Thresh2$

Inequality A5-3 (Leaving condition 1)

$Mp - Hys > Thresh1$

Inequality A5-4 (Leaving condition 2)

$Mn + Ofn + Ocn + Hys < Thresh2$

The variables in the formula are defined as follows:

Mp is the measurement result of the PCell/ PSCell, not taking into account any offsets.

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Thresh1 is the threshold parameter for this event (i.e. *a5-Threshold1* as defined within *reportConfigEUTRA* for this event)

Thresh2 is the threshold parameter for this event (i.e. *a5-Threshold2* as defined within *reportConfigEUTRA* for this event).

Mn, Mp are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, Ocn, Hys are expressed in dB.

Thresh1 is expressed in the same unit as ***Mp***.

Thresh2 is expressed in the same unit as ***Mn***.

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5.5.4.6a Event A6 (Neighbour becomes offset better than SCell)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A6-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A6-2, as specified below, is fulfilled;

1> for this measurement, consider the (secondary) cell that is configured on the frequency indicated in the associated *measObjectEUTRA* to be the serving cell;

NOTE: The neighbour(s) is on the same frequency as the SCell i.e. both are on the frequency indicated in the associated *measObject*.

Inequality A6-1 (Entering condition)

$Mn + Ocn - Hys > Ms + Ocs + Off$

Inequality A6-2 (Leaving condition)

$Mn + Ocn + Hys < Ms + Ocs + Off$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Ms is the measurement result of the serving cell, not taking into account any offsets.

Ocs is the cell specific offset of the serving cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the serving frequency), and is set to zero if not configured for the serving cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Off is the offset parameter for this event (i.e. *a6-Offset* as defined within *reportConfigEUTRA* for this event).

Mn, Ms are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ocn, Ocs, Hys, Off are expressed in dB.

5.5.4.7 Event B1 (Inter RAT neighbour becomes better than threshold)

The UE shall:

1> for UTRA and CDMA2000, only trigger the event for cells included in the corresponding measurement object;

1> consider the entering condition for this event to be satisfied when condition B1-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition B1-2, as specified below, is fulfilled;

Inequality B1-1 (Entering condition)

$Mn + Ofn - Hys > Thresh$

Inequality B1-2 (Leaving condition)

$Mn + Ofn + Hys < Thresh$

The variables in the formula are defined as follows:

Mn is the measurement result of the inter-RAT neighbour cell, not taking into account any offsets. For CDMA 2000 measurement result, *pilotStrength* is divided by -2.

Ofn is the frequency specific offset of the frequency of the inter-RAT neighbour cell (i.e. *offsetFreq* as defined within the *measObject* corresponding to the frequency of the neighbour inter-RAT cell).

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigInterRAT* for this event).

Thresh is the threshold parameter for this event (i.e. *b1-Threshold* as defined within *reportConfigInterRAT* for this event). For CDMA2000, *b1-Threshold* is divided by -2.

Mn is expressed in dBm or in dB, depending on the measurement quantity of the inter-RAT neighbour cell.

Ofn, Hys are expressed in dB.

Thresh is expressed in the same unit as ***Mn***.

5.5.4.8 Event B2 (PCell becomes worse than threshold1 and inter RAT neighbour becomes better than threshold2)

The UE shall:

1> for UTRA and CDMA2000, only trigger the event for cells included in the corresponding measurement object;

1> consider the entering condition for this event to be satisfied when both condition B2-1 and condition B2-2, as specified below, are fulfilled;

1> consider the leaving condition for this event to be satisfied when condition B2-3 or condition B2-4, i.e. at least one of the two, as specified below, is fulfilled;

Inequality B2-1 (Entering condition 1)

$Mp + Hys < Thresh1$

Inequality B2-2 (Entering condition 2)

$Mn + Ofn - Hys > Thresh2$

Inequality B2-3 (Leaving condition 1)

$Mp - Hys > Thresh1$

Inequality B2-4 (Leaving condition 2)

$Mn + Ofn + Hys < Thresh2$

The variables in the formula are defined as follows:

Mp is the measurement result of the PCell, not taking into account any offsets.

Mn is the measurement result of the inter-RAT neighbour cell, not taking into account any offsets. For CDMA2000 measurement result, *pilotStrength* is divided by -2.

Ofn is the frequency specific offset of the frequency of the inter-RAT neighbour cell (i.e. *offsetFreq* as defined within the *measObject* corresponding to the frequency of the inter-RAT neighbour cell).

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigInterRAT* for this event).

Thresh1 is the threshold parameter for this event (i.e. b2-*Threshold1* as defined within *reportConfigInterRAT* for this event).

Thresh2 is the threshold parameter for this event (i.e. *b2-Threshold2* as defined within *reportConfigInterRAT* for this event). For CDMA2000, *b2-Threshold2* is divided by -2.

Mp is expressed in dBm in case of RSRP, or in dB in case of RSRQ.

Mn is expressed in dBm or dB, depending on the measurement quantity of the inter-RAT neighbour cell.

Ofn, Hys are expressed in dB.

Thresh1 is expressed in the same unit as ***Mp***.

Thresh2 is expressed in the same unit as ***Mn***.

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5.5.4.9 Event C1 (CSI-RS resource becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition C1-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition C1-2, as specified below, is fulfilled;

Inequality C1-1 (Entering condition)

$Mcr + Ocr - Hys > Thresh$

Inequality C1-2 (Leaving condition)

$Mcr + Ocr + Hys < Thresh$

The variables in the formula are defined as follows:

Mcr is the measurement result of the CSI-RS resource, not taking into account any offsets.

Ocr is the CSI-RS specific offset (i.e. *csi-RS-IndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the CSI-RS resource), and set to zero if not configured for the CSI-RS resource.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Thresh is the threshold parameter for this event (i.e. *c1-Threshold* as defined within *reportConfigEUTRA* for this event)

Mcr, Thresh are expressed in dBm.

Ocr, Hys are expressed in dB.

5.5.4.10 Event C2 (CSI-RS resource becomes offset better than reference CSI-RS resource)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition C2-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition C2-2, as specified below, is fulfilled;

NOTE: The CSI-RS resource(s) that triggers the event is on the same frequency as the reference CSI-RS resource, i.e. both are on the frequency indicated in the associated *measObject*.

Inequality C2-1 (Entering condition)

$Mcr + Ocr - Hys > Mref + Oref + Off$

Inequality C2-2 (Leaving condition)

$Mcr + Ocr + Hys < Mref + Oref + Off$

The variables in the formula are defined as follows:

Mcr is the measurement result of the CSI-RS resource, not taking into account any offsets.

Ocr is the CSI-RS specific offset of the CSI-RS resource (i.e. *csi-RS-IndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the CSI-RS resource), and set to zero if not configured for the CSI-RS resource.

Mref is the measurement result of the reference CSI-RS resource (i.e. *c2-RefCSI-RS* as defined within *reportConfigEUTRA* for this event), not taking into account any offsets.

Oref is the CSI-RS specific offset of the reference CSI-RS resource (i.e. *csi-RS-IndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the reference CSI-RS resource), and is set to zero if not configured for the reference CSI-RS resource.

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Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Off is the offset parameter for this event (i.e. *a2-Offset* as defined within *reportConfigEUTRA* for this event).

Mcr, Mref are expressed in dBm.

Ocr, Oref, Hys, Off are expressed in dB.

5.5.5 Measurement reporting

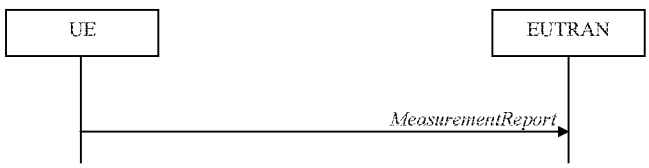


Figure 5.5.5-1: Measurement reporting

The purpose of this procedure is to transfer measurement results from the UE to E-UTRAN. The UE shall initiate this procedure only after successful security activation.

For the *measId* for which the measurement reporting procedure was triggered, the UE shall set the *measResults* within the *MeasurementReport* message as follows:

1> set the *measId* to the measurement identity that triggered the measurement reporting;

1> set the *measResultPCell* to include the quantities of the PCell;

1> set the *measResultServFreqList* to include for each SCell that is configured, if any, within *measResultSCell* the quantities of the concerned SCell, if available according to performance requirements in [16];

1> if the *reportConfig* associated with the *measId* that triggered the measurement reporting includes *reportAddNeighMeas*:

2> for each serving frequency for which *measObjectId* is referenced in the *measIdList*, other than the frequency corresponding with the *measId* that triggered the measurement reporting:

3> set the *measResultServFreqList* to include within *measResultBestNeighCell* the *physCellId* and the quantities of the best non-serving cell, based on RSRP, on the concerned serving frequency;

1> if there is at least one applicable neighbouring cell to report:

2> set the *measResultNeighCells* to include the best neighbouring cells up to *maxReportCells* in accordance with the following:

3> if the *triggerType* is set to *event*:

4> include the cells included in the *cellsTriggeredList* as defined within the *VarMeasReportList* for this *measId*;

3> else:

4> include the applicable cells for which the new measurement results became available since the last periodical reporting or since the measurement was initiated or reset;

NOTE 1: The reliability of the report (i.e. the certainty it contains the strongest cells on the concerned frequency) depends on the measurement configuration i.e. the *reportInterval*. The related performance requirements are specified in TS 36.133 [16].

3> for each cell that is included in the *measResultNeighCells*, include the *physCellId*;

3> if the *triggerType* is set to *event*, or the *purpose* is set to *reportStrongestCells* or to *reportStrongestCellsForSON*:

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4> for each included cell, include the layer 3 filtered measured results in accordance with the *reportConfig* for this *measId*, ordered as follows:

5> if the *measObject* associated with this *measId* concerns E-UTRA:

6> set the *measResult* to include the quantity(ies) indicated in the *reportQuantity* within the concerned *reportConfig* in order of decreasing *triggerQuantity*, i.e. the best cell is included first;

5> if the *measObject* associated with this *measId* concerns UTRA FDD and if *ReportConfigInterRAT* includes the *reportQuantityUTRA-FDD*:

6> set the *measResult* to include the quantities indicated by the *reportQuantityUTRA-FDD* in order of decreasing *measQuantityUTRA-FDD* within the *quantityConfig*, i.e. the best cell is included first;

5> if the *measObject* associated with this *measId* concerns UTRA FDD and if *ReportConfigInterRAT* does not include the *reportQuantityUTRA-FDD*; or

5> if the *measObject* associated with this *measId* concerns UTRA TDD, GERAN or CDMA2000:

6> set the *measResult* to the quantity as configured for the concerned RAT within the *quantityConfig* in order of either decreasing quantity for UTRA and GERAN or increasing quantity for CDMA2000 *pilotStrength*, i.e. the best cell is included first;

3> else if the *purpose* is set to *reportCGI*:

4> if the mandatory present fields of the *cgi-Info* for the cell indicated by the *cellForWhichToReportCGI* in the associated *measObject* have been obtained:

5> if the cell broadcasts a CSG identity:

6> include the *csg-Identity*;

6> include the *csg-MemberStatus* and set it to *member* if the cell is a CSG member cell;

5> if the *si-RequestForHO* is configured within the *reportConfig* associated with this *measId*:

6> include the *cgi-Info* containing all the fields that have been successfully acquired and in accordance with the following:

7> if the cell is a CSG member cell, determine the subset of the PLMN identities, starting from the second entry of PLMN identities in the broadcast information, that meet the following conditions:

a) equal to the RPLMN or an EPLMN; and

b) the CSG whitelist of the UE includes an entry comprising of the concerned PLMN identity and the CSG identity broadcast by the cell;

7> if the subset of PLMN identities determined according to the previous includes at least one PLMN identity, include the *plmn-IdentityList* and set it to include this subset of the PLMN identities;

7> if the cell is a CSG member cell, include the *primaryPLMN-Suitable* if the primary PLMN meets conditions a) and b) specified above;

5> else:

6> include the *cgi-Info* containing all the fields that have been successfully acquired and in accordance with the following:

7> include in the *plmn-IdentityList* the list of identities starting from the second entry of PLMN Identities in the broadcast information;

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1> for the cells included according to the previous (i.e. covering the PCell, the SCells, the best non-serving cells on serving frequencies as well as neighbouring EUTRA cells) include results according to the extended RSRQ if corresponding results are available according to the associated performance requirements defined in 36.133 [16];

1> if there is at least one applicable CSI-RS resource to report:

2> set the *measResultCSI-RS-List* to include the best CSI-RS resources up to *maxReportCells* in accordance with the following:

3> if the *triggerType* is set to *event*:

4> include the CSI-RS resources included in the *csi-RS-TriggeredList* as defined within the *VarMeasReportList* for this *measId*;

3> else:

4> include the applicable CSI-RS resources for which the new measurement results became available since the last periodical reporting or since the measurement was initiated or reset;

NOTE 2: The reliability of the report (i.e. the certainty it contains the strongest CSI-RS resources on the concerned frequency) depends on the measurement configuration i.e. the *reportInterval*. The related performance requirements are specified in TS 36.133 [16].

3> for each CSI-RS resource that is included in the *measResultCSI-RS-List*:

4> include the *measCSI-RS-Id*;

4> include the layer 3 filtered measured results in accordance with the *reportConfig* for this *measId*, ordered as follow:

5> set the *csi-RSRP-Result* to include the quantity indicated in the *reportQuantity* within the concerned *reportConfig* in order of decreasing *triggerQuantityCSI-RS*, i.e. the best CSI-RS resource is included first;

4> if *reportCRS-Meas* is included within the associated *reportConfig*, and the cell indicated by *physCellId* of this CSI-RS resource is not a serving cell:

5> set the *measResultNeighCells* to include the cell indicated by *physCellId* of this CSI-RS resource, and include the *physCellId*;

5> set the *rsrpResult* to include the RSRP of the concerned cell, if available according to performance requirements in [16];

5> set the *rsrqResult* to include the RSRQ of the concerned cell, if available according to performance requirements in [16];

1> if the *ue-RxTxTimeDiffPeriodical* is configured within the corresponding *reportConfig* for this *measId*;

2> set the *ue-RxTxTimeDiffResult* to the measurement result provided by lower layers;

2> set the *currentSFN*;

1> if the *measRSSI-ReportConfig* is configured within the corresponding *reportConfig* for this *measId*:

2> set the *rssi-Result* to the average of sample value(s) provided by lower layers in the *reportInterval*;

2> set the *channelOccupancy* to the rounded percentage of sample values which are beyond to the *channelOccupancyThreshold* within all the sample values in the *reportInterval*;

1> if the *includeLocationInfo* is configured in the corresponding *reportConfig* for this *measId* and detailed location information that has not been reported is available, set the content of the *locationInfo* as follows:

2> include the *locationCoordinates*;

2> if available, include the *gnss-TOD-msec*;

1> if the *reportSSTD-Meas* is set to *true* within the corresponding *reportConfig* for this *measId*:

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2> set the *measResultSSTD* to the measurement results provided by lower layers;

1> increment the *numberOfReportsSent* as defined within the *VarMeasReportList* for this *measId* by 1;

1> stop the periodical reporting timer, if running;

1> if the *numberOfReportsSent* as defined within the *VarMeasReportList* for this *measId* is less than the *reportAmount* as defined within the corresponding *reportConfig* for this *measId*:

2> start the periodical reporting timer with the value of *reportInterval* as defined within the corresponding *reportConfig* for this *measId*;

1> else:

2> if the *triggerType* is set to *periodical*:

3> remove the entry within the *VarMeasReportList* for this *measId*;

3> remove this *measId* from the *measIdList* within *VarMeasConfig*;

1> if the measured results are for CDMA2000 HRPD:

2> set the *preRegistrationStatusHRPD* to the UE's CDMA2000 upper layer's HRPD *preRegistrationStatus*;

1> if the measured results are for CDMA2000 1xRTT:

2> set the *preRegistrationStatusHRPD* to *FALSE*;

1> if there is *ul-PDCP-DelayResult* available:

2> set the *ul-PDCP-DelayResult* to the received value;

1> submit the *MeasurementReport* message to lower layers for transmission, upon which the procedure ends;

5.5.6 Measurement related actions

5.5.6.1 Actions upon handover and re-establishment

E-UTRAN applies the handover procedure as follows:

- when performing the handover procedure, as specified in 5.3.5.4, ensure that a *measObjectId* corresponding to each handover target serving frequency is configured as a result of the procedures described in this sub-clause and in 5.3.5.4;
- when changing the band while the physical frequency remains unchanged, E-UTRAN releases the *measObject* corresponding to the source frequency and adds a *measObject* corresponding to the target frequency (i.e. it does not reconfigure the *measObject*);

E-UTRAN applies the re-establishment procedure as follows:

- when performing the connection re-establishment procedure, as specified in 5.3.7, ensure that a *measObjectId* corresponding each target serving frequency is configured as a result of the procedure described in this sub-clause and the subsequent connection reconfiguration procedure immediately following the re-establishment procedure;
- in the first reconfiguration following the re-establishment when changing the band while the physical frequency remains unchanged, E-UTRAN releases the *measObject* corresponding to the source frequency and adds a *measObject* corresponding to the target frequency (i.e. it does not reconfigure the *measObject*);

The UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the *triggerType* is set to *periodical*:

3> remove this *measId* from the *measIdList* within *VarMeasConfig*:

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1> if the procedure was triggered due to a handover or successful re-establishment and the procedure involves a change of primary frequency, update the *measId* values in the *measIdList* within *VarMeasConfig* as follows:

2> if a *measObjectId* value corresponding to the target primary frequency exists in the *measObjectList* within *VarMeasConfig*:

3> for each *measId* value in the *measIdList*:

4> if the *measId* value is linked to the *measObjectId* value corresponding to the source primary frequency:

5> link this *measId* value to the *measObjectId* value corresponding to the target primary frequency;

4> else if the *measId* value is linked to the *measObjectId* value corresponding to the target primary frequency:

5> link this *measId* value to the *measObjectId* value corresponding to the source primary frequency;

2> else:

3> remove all *measId* values that are linked to the *measObjectId* value corresponding to the source primary frequency;

1> remove all measurement reporting entries within *VarMeasReportList*;

1> stop the periodical reporting timer or timer T321, whichever one is running, as well as associated information (e.g. *timeToTrigger*) for all *measId*;

1> release the measurement gaps, if activated;

NOTE: If the UE requires measurement gaps to perform inter-frequency or inter-RAT measurements, the UE resumes the inter-frequency and inter-RAT measurements after the E-UTRAN has setup the measurement gaps.

5.5.6.2 Speed dependant scaling of measurement related parameters

The UE shall adjust the value of the following parameter configured by the E-UTRAN depending on the UE speed: *timeToTrigger*. The UE shall apply 3 different levels, which are selected as follows:

The UE shall:

1> perform mobility state detection using the mobility state detection as specified in TS 36.304 [4] with the following modifications:

2> counting handovers instead of cell reselections;

2> applying the parameter applicable for RRC_CONNECTED as included in *speedStatePars* within *VarMeasConfig*;

1> if high mobility state is detected:

2> use the *timeToTrigger* value multiplied by *sf-High* within *VarMeasConfig*;

1> else if medium mobility state is detected:

2> use the *timeToTrigger* value multiplied by *sf-Medium* within *VarMeasConfig*;

1> else:

2> no scaling is applied;

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5.5.7 Inter-frequency RSTD measurement indication

5.5.7.1 General

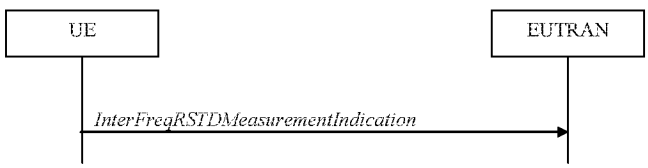


Figure 5.5.7.1-1: Inter-frequency RSTD measurement indication

The purpose of this procedure is to indicate to the network that the UE is going to start/stop OTDOA inter-frequency RSTD measurements which require measurement gaps as specified in [16, 8.1.2.6].

NOTE: It is a network decision to configure the measurement gap.

5.5.7.2 Initiation

The UE shall:

1> if and only if upper layers indicate to start performing inter-frequency RSTD measurements and the UE requires measurement gaps for these measurements while measurement gaps are either not configured or not sufficient:

2> initiate the procedure to indicate start;

NOTE 1: The UE verifies the measurement gap situation only upon receiving the indication from upper layers. If at this point in time sufficient gaps are available, the UE does not initiate the procedure. Unless it receives a new indication from upper layers, the UE is only allowed to further repeat the procedure in the same PCell once per frequency if the provided measurement gaps are insufficient.

1> if and only if upper layers indicate to stop performing inter-frequency RSTD measurements:

2> initiate the procedure to indicate stop;

NOTE 2: The UE may initiate the procedure to indicate stop even if it did not previously initiate the procedure to indicate start.

5.5.7.3 Actions related to transmission of *InterFreqRSTDMeasurementIndication* message

The UE shall set the contents of *InterFreqRSTDMeasurementIndication* message as follows:

1> set the *rstd-InterFreqIndication* as follows:

2> if the procedure is initiated to indicate start of inter-frequency RSTD measurements:

3> set the *rstd-InterFreqInfoList* according to the information received from upper layers;

2> else if the procedure is initiated to indicate stop of inter-frequency RSTD measurements:

3> set the *rstd-InterFreqIndication* to the value *stop*;

1> submit the *InterFreqRSTDMeasurementIndication* message to lower layers for transmission, upon which the procedure ends;

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5.6 Other

5.6.1 DL information transfer

5.6.1.1 General

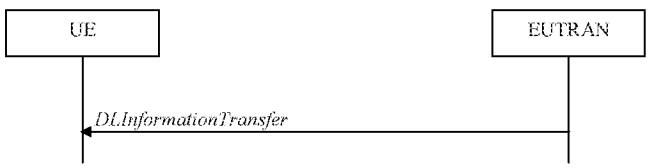


Figure 5.6.1.1-1: DL information transfer

The purpose of this procedure is to transfer NAS or (tunnelled) non-3GPP dedicated information from E-UTRAN to a UE in RRC_CONNECTED.

5.6.1.2 Initiation

E-UTRAN initiates the DL information transfer procedure whenever there is a need to transfer NAS or non-3GPP dedicated information. E-UTRAN initiates the DL information transfer procedure by sending the *DLInformationTransfer* message.

5.6.1.3 Reception of the *DLInformationTransfer* by the UE

Upon receiving *DLInformationTransfer* message, the UE shall:

1> if the *dedicatedInfoType* is set to *dedicatedInfoNAS*:

2> forward the *dedicatedInfoNAS* to the NAS upper layers.

1> if the *dedicatedInfoType* is set to *dedicatedInfoCDMA2000-1XRTT* or to *dedicatedInfoCDMA2000-HRPD*:

2> forward the *dedicatedInfoCDMA2000* to the CDMA2000 upper layers;

5.6.2 UL information transfer

5.6.2.1 General

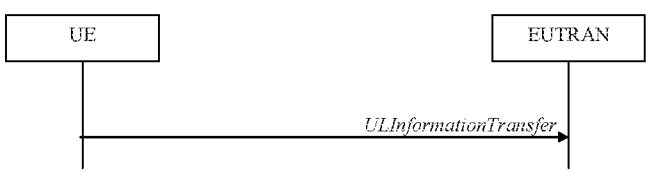


Figure 5.6.2.1-1: UL information transfer

The purpose of this procedure is to transfer NAS or (tunnelled) non-3GPP dedicated information from the UE to E-UTRAN.

5.6.2.2 Initiation

A UE in RRC_CONNECTED initiates the UL information transfer procedure whenever there is a need to transfer NAS or non-3GPP dedicated information, except at RRC connection establishment in which case the NAS information is

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piggybacked to the *RRCConnectionSetupComplete* message. The UE initiates the UL information transfer procedure by sending the *ULInformationTransfer* message. When CDMA2000 information has to be transferred, the UE shall initiate the procedure only if SRB2 is established.

5.6.2.3 Actions related to transmission of *ULInformationTransfer* message

The UE shall set the contents of the *ULInformationTransfer* message as follows:

1> if there is a need to transfer NAS information:

2> set the *dedicatedInfoType* to include the *dedicatedInfoNAS*;

1> if there is a need to transfer CDMA2000 1XRTT information:

2> set the *dedicatedInfoType* to include the *dedicatedInfoCDMA2000-1XRTT*;

1> if there is a need to transfer CDMA2000 HRPD information:

2> set the *dedicatedInfoType* to include the *dedicatedInfoCDMA2000-HRPD*;

1> submit the *ULInformationTransfer* message to lower layers for transmission, upon which the procedure ends;

5.6.2.4 Failure to deliver *ULInformationTransfer* message

The UE shall:

1> if mobility (i.e. handover, RRC connection re-establishment) occurs before the successful delivery of *ULInformationTransfer* messages has been confirmed by lower layers:

2> inform upper layers about the possible failure to deliver the information contained in the concerned *ULInformationTransfer* messages;

5.6.3 UE capability transfer

5.6.3.1 General

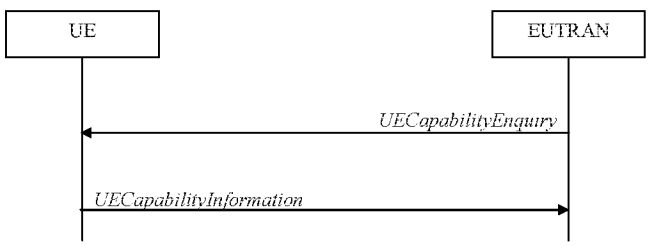


Figure 5.6.3.1-1: UE capability transfer

The purpose of this procedure is to transfer UE radio access capability information from the UE to E-UTRAN.

If the UE has changed its E-UTRAN radio access capabilities, the UE shall request higher layers to initiate the necessary NAS procedures (see TS 23.401 [41]) that would result in the update of UE radio access capabilities using a new RRC connection.

NOTE: Change of the UE's GERAN UE radio capabilities in RRC_IDLE is supported by use of Tracking Area Update.

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5.6.3.2 Initiation

E-UTRAN initiates the procedure to a UE in RRC_CONNECTED when it needs (additional) UE radio access capability information.

5.6.3.3 Reception of the *UECapabilityEnquiry* by the UE

The UE shall:

1> set the contents of *UECapabilityInformation* message as follows:

2> if the *ue-CapabilityRequest* includes *eutra*:

3> include the *UE-EUTRA-Capability* within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *eutra*;

3> if the UE supports FDD and TDD:

4> set all fields of *UECapabilityInformation*, except field *fdd-Add-UE-EUTRA-Capabilities* and *tdd-Add-UE-EUTRA-Capabilities* (including their sub-fields), to include the values applicable for both FDD and TDD (i.e. functionality supported by both modes);

4> if (some of) the UE capability fields have a different value for FDD and TDD:

5> if for FDD, the UE supports additional functionality compared to what is indicated by the previous fields of *UECapabilityInformation*:

6> include field *fdd-Add-UE-EUTRA-Capabilities* and set it to include fields reflecting the additional functionality applicable for FDD;

5> if for TDD, the UE supports additional functionality compared to what is indicated by the previous fields of *UECapabilityInformation*:

6> include field *tdd-Add-UE-EUTRA-Capabilities* and set it to include fields reflecting the additional functionality applicable for TDD;

NOTE: The UE includes fields of *XDD-Add-UE-EUTRA-Capabilities* in accordance with the following:

- The field is included only if one or more of its sub-fields has a value that is different compared to the value signalled elsewhere within *UE-EUTRA-Capability*;
  (this value signalled elsewhere is also referred to as the *Common value*, that is supported for both XDD modes)
- For the fields that are included in *XDD-Add-UE-EUTRA-Capabilities*, the UE sets:
  - the sub-fields that are not allowed to be different the same as the *Common value*;
  - the sub-fields that are allowed to be different to a value indicating at least the same functionality as indicated by the *Common value*;

3> else (UE supports single xDD mode):

4> set all fields of *UECapabilityInformation*, except field *fdd-Add-UE-EUTRA-Capabilities* and *tdd-Add-UE-EUTRA-Capabilities* (including their sub-fields), to include the values applicable for the xDD mode supported by the UE;

3> if the *UECapabilityEnquiry* message includes *requestedFrequencyBands* and UE supports *requestedFrequencyBands*:

4> determine the priority order of band combinations supported by the UE according to the following priority order (i.e. listed in order of decreasing priority):

5> include all non-CA bands, regardless of whether UE supports carrier aggregation, only:

- if the UE includes *ue-Category-v1020* (i.e. indicating category 6 to 8); or
- if for at least one of the non-CA bands, the UE supports more MIMO layers with TM9 and TM10 than implied by the UE category; or

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- if the UE supports TM10 with one or more CSI processes;

5> include all 2DL+1UL CA band combinations, only consisting of bands included in *requestedFrequencyBands*;

5> include all other CA band combinations (except where conflicting with rules defined below), only consisting of bands included in *requestedFrequencyBands*, and prioritized in the order of *requestedFrequencyBands*, (i.e. first include remaining band combinations containing the first-listed band, then include remaining band combinations containing the second-listed band, and so on);

5> if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsDL* and the *requestedMaxCCsUL* (i.e. both UL and DL maximums are given):

6> include the target band combinations for which the number of CCs in DL is up to the value indicated in the *requestedMaxCCsDL* and for which the number of CCs in UL is up to the value indicated in the *requestedMaxCCsUL*;

6> indicate value *includedBoth* in *requestedMaximumCCs*;

5> else if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsDL* (i.e. only DL maximum limit is given):

6> include the target band combinations for which the number of CCs in DL is up to the value indicated in the *requestedMaxCCsDL*;

6> indicate value *includedDL* in *requestedMaximumCCs*;

5> else if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsUL* (i.e. only UL maximum limit is given):

6> include the target band combinations for which the number of CCs in UL is up to the value indicated in the *requestedMaxCCsUL*;

6> indicate value *includedUL* in *requestedMaximumCCs*;

5> if the UE supports *requestReducedFormat* and UE supports *skipFallbackCombinations* and *UECapabilityEnquiry* message includes *skipFallbackCombinations*:

6> indicate value *included* in *skipFallbackCombinations*;

6> include CA band combinations with the highest supported number of DL and UL carriers first;

6> if a band combination is the fallback band combination (i.e. a band combination that can be obtained by release of any SCell without requiring reconfiguration of parameters related to UE radio access capabilities for the remaining serving cells, except for release of an SCell from a contiguous CA band configuration that results in a non-contiguous CA band configuration) of an already-included band combination:

7> exclude this band combination from the supported band combination list;

7> if the capabilities of this band combination are different from the already-included band combination whose fallback case this band combination is, include the *additionalFallbackSupported* in the already-included band combination whose fallback case this band combination is;

8> include the *additionalFallbackSupported* in the already-included band combination whose fallback case this band combination is;

4> if the *UECapabilityEnquiry* message includes *requestReducedFormat* and UE supports *requestReducedFormat*:

5> include in *supportedBandCombinations-r13* as many as possible of the band combinations supported by the UE, including the non-CA combinations, determined according to the rules and priority order defined above;

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4> else

5> include in *supportedBandCombination* as many of the target band combinations as possible, including the non-CA combinations, determined according to the rules and priority order defined above;

NOTE: FFS if there is a case where UE (for backward compatibility reason) includes band combinations up to 4DL+2UL (or 2DL+1ULS) in supportedBandCombination, and "higher" band combinations in supportedBandCombinations-r13 (meaning "higher" band combinations are not included in supportedBandCombination).

5> include in *supportedBandCombinationAdd* as many of the remaining target band combinations as possible, i.e. the target band combinations the UE was not able to include in *supportedBandCombination*, and limited to those consisting of bands included in *requestedFrequencyBands*, determined according to the rules and priority order defined above;

4> indicate in *requestedBands* the same bands and in the same order as included in the received *requestedFrequencyBands*;

3> else

4> determine the priority order of band combinations supported by the UE according to the following priority order (i.e. listed in order of decreasing priority):

5> include all non-CA bands, regardless of whether UE supports carrier aggregation, only:

- if the UE includes *ue-Category-v1020* (i.e. indicating category 6 to 8); or
- if for at least one of the non-CA bands, the UE supports more MIMO layers with TM9 and TM10 than implied by the UE category; or
- if the UE supports TM10 with one or more CSI processes;

5> include all 2DL+1UL CA band combinations;

5> include all other CA band combinations;

5> if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsDL* and the *requestedMaxCCsUL* (i.e. both UL and DL maximums are given):

6> include the target band combinations for which the number of CCs in DL is up to the value indicated in the *requestedMaxCCsDL* and for which the number of CCs in UL is up to the value indicated in the *requestedMaxCCsUL*;

6> indicate value *includedBoth* in *requestedMaximumCCs*;

5> else if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsDL* (i.e. only DL maximum limit is given):

6> include the target band combinations for which the number of CCs in DL is up to the value indicated in the *requestedMaxCCsDL*;

6> indicate value *includedBoth* in *requestedMaximumCCs*;

5> else if UE supports *requestedMaximumCCs* and if the *UECapabilityEnquiry* message includes the *requestedMaxCCsUL* (i.e. only UL maximum limit is given):

6> include the target band combinations for which the number of CCs in UL is up to the value indicated in the *requestedMaxCCsUL*;

6> indicate value *includedBoth* in *requestedMaximumCCs*;

5> if the UE supports *requestReducedFormat* and UE supports *skipFallbackCombinations* and *UECapabilityEnquiry* message includes *skipFallbackCombinations*:

6> indicate value *included* in *skipFallbackCombinations*;

6> include CA band combinations with the highest supported number of DL and UL carriers first;

6> if a band combination is the fallback band combination (i.e. a band combination that can be obtained by release of any SCell without requiring reconfiguration of parameters related to UE radio access capabilities for the remaining serving cells, except for release of an SCell from a contiguous CA band configuration that results in a non-contiguous CA band configuration) of an already-included band combination:

7> exclude this band combination from the supported band combination list;

7> if the capabilities of this band combination are different from the already-included band combination for which this band combination is a fallback, include the *additionalFallbackSupported* in this already-included band combination;

8> include the *additionalFallbackSupported* in the already-included band combination whose fallback case this band combination is;

4> if the *UECapabilityEnquiry* message includes *requestReducedFormat* and UE supports *requestReducedFormat*:

5> include in *supportedBandCombinations-r13* as many as possible of the band combinations supported by the UE, including the non-CA combinations, determined according to the rules and priority order defined above;

4> else

5> include in *supportedBandCombination* as many of the target band combinations as possible, including the non-CA combinations, determined according to the rules and priority order defined above;

5> if the number of non-CA and CA band combinations supported by UE exceeds the maximum number of band combinations of *supportedBandCombination*, the selection of subset of band combinations is up to UE implementation;

NOTE: If the *UECapabilityEnquiry* message does not include *requestedFrequencyBands*, UE does not include *supportedBandCombinationAdd*.

3> if the UE is a category 0 UE according to TS 36.306 [5]:

4> include *ue-RadioPagingInfo* including *ue-Category*;

2> if the *ue-CapabilityRequest* includes *geran-cs* and if the UE supports GERAN CS domain:

3> include the UE radio access capabilities for GERAN CS within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *geran-cs*;

2> if the *ue-CapabilityRequest* includes *geran-ps* and if the UE supports GERAN PS domain:

3> include the UE radio access capabilities for GERAN PS within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *geran-ps*;

2> if the *ue-CapabilityRequest* includes *utra* and if the UE supports UTRA:

3> include the UE radio access capabilities for UTRA within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *utra*;

2> if the *ue-CapabilityRequest* includes *cdma2000-1XRTT* and if the UE supports CDMA2000 1xRTT:

3> include the UE radio access capabilities for CDMA2000 within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *cdma2000-1XRTT*;

1> submit the *UECapabilityInformation* message to lower layers for transmission, upon which the procedure ends;

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5.6.4 CSFB to 1x Parameter transfer

5.6.4.1 General

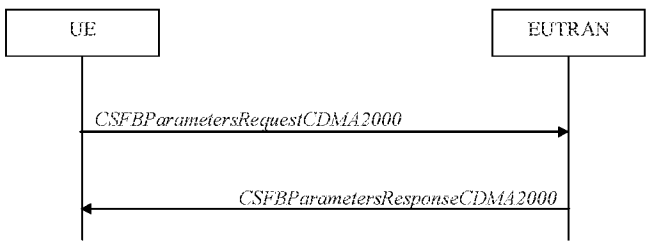


Figure 5.6.4.1-1: CSFB to 1x Parameter transfer

The purpose of this procedure is to transfer the CDMA2000 1xRTT parameters required to register the UE in the CDMA2000 1xRTT network for CSFB support.

5.6.4.2 Initiation

A UE in RRC_CONNECTED initiates the CSFB to 1x Parameter transfer procedure upon request from the CDMA2000 upper layers. The UE initiates the CSFB to 1x Parameter transfer procedure by sending the *CSFBParametersRequestCDMA2000* message.

5.6.4.3 Actions related to transmission of *CSFBParametersRequestCDMA2000* message

The UE shall:

1> submit the *CSFBParametersRequestCDMA2000* message to lower layers for transmission using the current configuration;

5.6.4.4 Reception of the *CSFBParametersResponseCDMA2000* message

Upon reception of the *CSFBParametersResponseCDMA2000* message, the UE shall:

1> forward the *rand* and the *mobilityParameters* to the CDMA2000 1xRTT upper layers;

5.6.5 UE Information

5.6.5.1 General

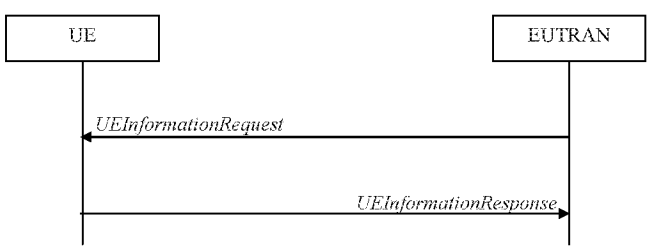


Figure 5.6.5.1-1: UE information procedure

The UE information procedure is used by E-UTRAN to request the UE to report information.

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5.6.5.2 Initiation

E-UTRAN initiates the procedure by sending the *UEInformationRequest* message. E-UTRAN should initiate this procedure only after successful security activation.

5.6.5.3 Reception of the *UEInformationRequest* message

Upon receiving the *UEInformationRequest* message, the UE shall, only after successful security activation:

1> if *rach-ReportReq* is set to *true*, set the contents of the *rach-Report* in the *UEInformationResponse* message as follows:

2> set the *numberOfPreamblesSent* to indicate the number of preambles sent by MAC for the last successfully completed random access procedure;

2> if contention resolution was not successful as specified in TS 36.321 [6] for at least one of the transmitted preambles for the last successfully completed random access procedure:

3> set the *contentionDetected* to *true*;

2> else:

3> set the *contentionDetected* to *false*;

1> if *rlf-ReportReq* is set to *true* and the UE has radio link failure information or handover failure information available in *VarRLF-Report* and if the RPLMN is included in *plmn-IdentityList* stored in *VarRLF-Report*:

2> set *timeSinceFailure* in *VarRLF-Report* to the time that elapsed since the last radio link or handover failure in E-UTRA;

2> set the *rlf-Report* in the *UEInformationResponse* message to the value of *rlf-Report* in *VarRLF-Report*;

2> discard the *rlf-Report* from *VarRLF-Report* upon successful delivery of the *UEInformationResponse* message confirmed by lower layers;

1> if *connEstFailReportReq* is set to *true* and the UE has connection establishment failure information in *VarConnEstFailReport* and if the RPLMN is equal to *plmn-Identity* stored in *VarConnEstFailReport*:

2> set *timeSinceFailure* in *VarConnEstFailReport* to the time that elapsed since the last connection establishment failure in E-UTRA;

2> set the *connEstFailReport* in the *UEInformationResponse* message to the value of *connEstFailReport* in *VarConnEstFailReport*;

2> discard the *connEstFailReport* from *VarConnEstFailReport* upon successful delivery of the *UEInformationResponse* message confirmed by lower layers;

1> if the *logMeasReportReq* is present and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*:

2> if *VarLogMeasReport* includes one or more logged measurement entries, set the contents of the *logMeasReport* in the *UEInformationResponse* message as follows:

3> include the *absoluteTimeStamp* and set it to the value of *absoluteTimeInfo* in the *VarLogMeasReport*;

3> include the *traceReference* and set it to the value of *traceReference* in the *VarLogMeasReport*;

3> include the *traceRecordingSessionRef* and set it to the value of *traceRecordingSessionRef* in the *VarLogMeasReport*;

3> include the *tce-Id* and set it to the value of *tce-Id* in the *VarLogMeasReport*;

3> include the *logMeasInfoList* and set it to include one or more entries from *VarLogMeasReport* starting from the entries logged first;

3> if the *VarLogMeasReport* includes one or more additional logged measurement entries that are not included in the *logMeasInfoList* within the *UEInformationResponse* message:

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4> include the *logMeasAvailable*;

1> if *mobilityHistoryReportReq* is set to *true*:

2> include the *mobilityHistoryReport* and set it to include entries from *VarMobilityHistoryReport*;

2> include in the *mobilityHistoryReport* an entry for the current cell, possibly after removing the oldest entry if required, and set its fields as follows:

3> set *visitedCellId* to the global cell identity of the current cell;

3> set field *timeSpent* to the time spent in the current cell;

1> if the *logMeasReport* is included in the *UEInformationResponse*:

2> submit the *UEInformationResponse* message to lower layers for transmission via SRB2;

2> discard the logged measurement entries included in the *logMeasInfoList* from *VarLogMeasReport* upon successful delivery of the *UEInformationResponse* message confirmed by lower layers;

1> else:

2> submit the *UEInformationResponse* message to lower layers for transmission via SRB1;

5.6.6 Logged Measurement Configuration

5.6.6.1 General



Figure 5.6.6.1-1: Logged measurement configuration

The purpose of this procedure is to configure the UE to perform logging of measurement results while in RRC_IDLE and to perform logging of measurement results for MBSFN in both RRC_IDLE and RRC_CONNECTED. The procedure applies to logged measurements capable UEs that are in RRC_CONNECTED.

NOTE E-UTRAN may retrieve stored logged measurement information by means of the UE Information procedure.

5.6.6.2 Initiation

E-UTRAN initiates the logged measurement configuration procedure to UE in RRC_CONNECTED by sending the *LoggedMeasurementConfiguration* message.

5.6.6.3 Reception of the *LoggedMeasurementConfiguration* by the UE

Upon receiving the *LoggedMeasurementConfiguration* message the UE shall:

1> discard the logged measurement configuration as well as the logged measurement information as specified in 5.6.7;

1> store the received *loggingDuration*, *loggingInterval* and *areaConfiguration*, if included, in *VarLogMeasConfig*;

1> if the *LoggedMeasurementConfiguration* message includes *plmn-IdentityList*:

2> set *plmn-IdentityList* in *VarLogMeasReport* to include the RPLMN as well as the PLMNs included in *plmn-IdentityList*;

1> else:

2> set *plmn-IdentityList* in *VarLogMeasReport* to include the RPLMN;

1> store the received *absoluteTimeInfo*, *traceReference*, *traceRecordingSessionRef* and *tce-Id* in *VarLogMeasReport*;

1> store the received *targetMBSFN-AreaList*, if included, in *VarLogMeasConfig*;

1> start timer T330 with the timer value set to the *loggingDuration*;

5.6.6.4 T330 expiry

Upon expiry of T330 the UE shall:

1> release *VarLogMeasConfig*;

The UE is allowed to discard stored logged measurements, i.e. to release *VarLogMeasReport*, 48 hours after T330 expiry.

5.6.7 Release of Logged Measurement Configuration

5.6.7.1 General

The purpose of this procedure is to release the logged measurement configuration as well as the logged measurement information.

5.6.7.2 Initiation

The UE shall initiate the procedure upon receiving a logged measurement configuration in another RAT. The UE shall also initiate the procedure upon power off or detach.

The UE shall:

1> stop timer T330, if running;

1> if stored, discard the logged measurement configuration as well as the logged measurement information, i.e. release the UE variables *VarLogMeasConfig* and *VarLogMeasReport*;

5.6.8 Measurements logging

5.6.8.1 General

This procedure specifies the logging of available measurements by a UE in RRC_IDLE that has a logged measurement configuration and the logging of available measurements by a UE in both RRC_IDLE and RRC_CONNECTED if *targetMBSFN-AreaList* is included in *VarLogMeasConfig*.

5.6.8.2 Initiation

While T330 is running, the UE shall:

1> perform the logging in accordance with the following:

2> if the UE detects IDC problems and the *VarLogMeasReport* is empty:

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3> suspend adding further logged measurement entries as long as the UE is experiencing IDC problems;

NOTE 0: The UE may detect the start of IDC problems as early as Phase 1 as described in section 23.4 of TS 36.300 [9].

2> if *targetMBSFN-AreaList* is included in *VarLogMeasConfig*:

3> if the UE is camping normally on an E-UTRA cell or is connected to E-UTRA; and

3> if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport*; and

3> if the PCell (in RRC_CONNECTED) or cell where the UE is camping (in RRC_IDLE) is part of the area indicated by *areaConfiguration* if configured in *VarLogMeasConfig*:

4> for MBSFN areas, indicated in *targetMBSFN-AreaList*, from which the UE is receiving MBMS service:

5> perform MBSFN measurements in accordance with the performance requirements as specified in TS 36.133 [16];

NOTE 1: When configured to perform MBSFN measurement logging by *targetMBSFN-AreaList*, the UE is not required to receive additional MBSFN subframes, i.e. logging is based on the subframes corresponding to the MBMS services the UE is receiving.

5> perform logging at regular time intervals as defined by the *loggingInterval* in *VarLogMeasConfig*, but only for those intervals for which MBSFN measurement results are available as specified in TS 36.133 [16];

2> *else* if the UE is camping normally on an E-UTRA cell and if the RPLMN is included in *plmn-IdentityList* stored in *VarLogMeasReport* and, if the cell is part of the area indicated by *areaConfiguration* if configured in *VarLogMeasConfig*:

3> perform the logging at regular time intervals, as defined by the *loggingInterval* in *VarLogMeasConfig*;

2> when adding a logged measurement entry in *VarLogMeasReport*, include the fields in accordance with the following:

3> set the *relativeTimeStamp* to indicate the elapsed time since the moment at which the logged measurement configuration was received;

3> if detailed location information became available during the last logging interval, set the content of the *locationInfo* as follows:

4> include the *locationCoordinates*;

3> if the UE detects IDC problems:

4> set the *InDeviceCoexDetected* to indicate the reason for measurement results logging suspension;

4> suspend adding further logged measurement entries as long as the UE is experiencing IDC problems;

3> else if *targetMBSFN-AreaList* is included in *VarLogMeasConfig*:

4> for each MBSFN area, for which the mandatory measurements result fields became available during the last logging interval:

5> set the *rsrpResultMBSFN*, *rsrqResultMBSFN* to include measurement results that became available during the last logging interval;

5> include the fields *signallingBLER-Result* or *dataBLER-MCH-ResultList* if the concerned BLER results are availble,

5> set the *mbsfn-AreaId* and *carrierFrequency* to indicate the MBSFN area in which the UE is receiving MBSFN transmission;

4> if in RRC_CONNECTED:

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5> set the *servCellIdentity* to indicate global cell identity of the PCell;

5> set the *measResultServCell* to include the layer 3 filtered measured results of the PCell;

5> if available, set the *measResultNeighCells* to include the layer 3 filtered measured results of SCell(s) and neighbouring cell(s) measurements that became available during the last logging interval, in order of decreasing RSRP, for at most the following number of cells: 6 intra-frequency and 3 inter-frequency cells per frequency and according to the following:

6> for each cell included, include the optional fields that are available;

5> if available, optionally set the *measResultNeighCells* to include the layer 3 filtered measured results of neighbouring cell(s) measurements that became available during the last logging interval, in order of decreasing RSCP(UTRA)/RSSI(GERAN)/PilotStrength(cdma2000), for at most the following number of cells: 3 inter-RAT cells per frequency (UTRA, cdma2000)/set of frequencies (GERAN), and according to the following:

6> for each cell included, include the optional fields that are available;

4> if in RRC_IDLE:

5> set the *servCellIdentity* to indicate global cell identity of the serving cell;

5> set the *measResultServCell* to include the quantities of the serving cell;

5> if available, set the *measResultNeighCells*, in order of decreasing ranking-criterion as used for cell re-selection, to include neighbouring cell measurements that became available during the last logging interval for at most the following number of neighbouring cells: 6 intra-frequency and 3 inter-frequency neighbours per frequency and according to the following:

6> for each neighbour cell included, include the optional fields that are available;

5> if available, optionally set the *measResultNeighCells*, in order of decreasing ranking-criterion as used for cell re-selection, to include neighbouring cell measurements that became available during the last logging interval, for at most the following number of cells: 3 inter-RAT cells per frequency (UTRA, cdma2000)/set of frequencies (GERAN), and according to the following:

6> for each cell included, include the optional fields that are available;

4> for the cells included according to the previous (i.e. covering previous and current serving cells as well as neighbouring EUTRA cells) include results according to the extended RSRQ if corresponding results are available according to the associated performance requirements defined in TS 36.133 [16];

4> for the cells included according to the previous (i.e. covering previous and current serving cells as well as neighbouring EUTRA cells) include RSRQ type if the result was based on measurements using a wider band or using all OFDM symbols;

NOTE 2: The UE includes the latest results in accordance with the performance requirements as specified in TS 36.133 [16]. E.g. RSRP and RSRQ results are available only if the UE has a sufficient number of results/ receives a sufficient number of subframes during the logging interval.

3> else if:

4> set the *servCellIdentity* to indicate global cell identity of the cell the UE is camping on;

4> set the *measResultServCell* to include the quantities of the cell the UE is camping on;

4> if available, set the *measResultNeighCells*, in order of decreasing ranking-criterion as used for cell re-selection, to include neighbouring cell measurements that became available during the last logging interval for at most the following number of neighbouring cells: 6 intra-frequency and 3 inter-frequency neighbours per frequency as well as 3 inter-RAT neighbours, per frequency/ set of frequencies (GERAN) per RAT and according to the following:

5> for each neighbour cell included, include the optional fields that are available;

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4> for the cells included according to the previous (i.e. covering previous and current serving cells as well as neighbouring EUTRA cells) include results according to the extended RSRQ if corresponding results are available according to the associated performance requirements defined in TS 36.133 [16];

4> for the cells included according to the previous (i.e. covering previous and current serving cells as well as neighbouring EUTRA cells) include RSRQ type if the result was based on measurements using a wider band or using all OFDM symbols;

NOTE 3: The UE includes the latest results of the available measurements as used for cell reselection evaluation in RRC_IDLE or as used for evaluation of reporting criteria or for measurement reporting according to 5.5.3 in RRC_CONNECTED, which are performed in accordance with the performance requirements as specified in TS 36.133 [16].

2> when the memory reserved for the logged measurement information becomes full, stop timer T330 and perform the same actions as performed upon expiry of T330, as specified in 5.6.6.4;

5.6.9 In-device coexistence indication

5.6.9.1 General

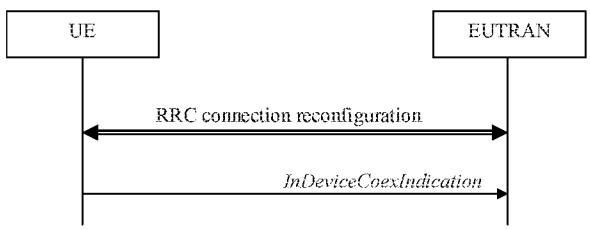


Figure 5.6.9.1-1: In-device coexistence indication

The purpose of this procedure is to inform E-UTRAN about (a change of) the In-Device Coexistence (IDC) problems experienced by the UE in RRC_CONNECTED, as described in TS 36.300 [9], and to provide the E-UTRAN with information in order to resolve them.

5.6.9.2 Initiation

A UE capable of providing IDC indications may initiate the procedure when it is configured to provide IDC indications and upon change of IDC problem information.

Upon initiating the procedure, the UE shall:

1> if configured to provide IDC indications:

2> if the UE did not transmit an *InDeviceCoexIndication* message since it was configured to provide IDC indications:

3> if on one or more frequencies for which a *measObjectEUTRA* is configured, the UE is experiencing IDC problems that it cannot solve by itself; or

3> if configured to provide IDC indications for UL CA; and if on one or more supported UL CA combination comprising of carrier frequencies for which a measurement object is configured, the UE is experiencing IDC problems that it cannot solve by itself:

4> initiate transmission of the *InDeviceCoexIndication* message in accordance with 5.6.9.3;

2> else:

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3> if the set of frequencies, for which a *measObjectEUTRA* is configured and on which the UE is experiencing IDC problems that it cannot solve by itself, is different from the set indicated in the last transmitted *InDeviceCoexIndication* message; or

3> if for one or more of the frequencies in the previously reported set of frequencies, the *interferenceDirection* is different from the value indicated in the last transmitted *InDeviceCoexIndication* message; or

3> if the TDM assistance information is different from the assistance information included in the last transmitted *InDeviceCoexIndication* message; or

3> if configured to provide IDC indications for UL CA; and if the set of supported UL CA combination comprising of carrier frequencies for which a measurement object is configured and on which the UE is experiencing IDC problems that it cannot solve by itself, is different from the set indicated in the last transmitted *InDeviceCoexIndication* message:

4> initiate transmission of the *InDeviceCoexIndication* message in accordance with 5.6.9.3;

NOTE 1: The term "IDC problems" refers to interference issues applicable across several subframes/slots where not necessarily all the subframes/slots are affected.

NOTE 2: For the frequencies on which a serving cell or serving cells is configured that is activated, IDC problems consist of interference issues that the UE cannot solve by itself, during either active data exchange or upcoming data activity which is expected in up to a few hundred milliseconds.
For frequencies on which a SCell or SCells is configured that is deactivated, reporting IDC problems indicates an anticipation that the activation of the SCell or SCells would result in interference issues that the UE would not be able to solve by itself.
For a non-serving frequency, reporting IDC problems indicates an anticipation that if the non-serving frequency or frequencies became a serving frequency or serving frequencies then this would result in interference issues that the UE would not be able to solve by itself.

5.6.9.3 Actions related to transmission of *InDeviceCoexIndication* message

The UE shall set the contents of the *InDeviceCoexIndication* message as follows:

1> if there is at least one E-UTRA carrier frequency, for which a measurement object is configured, that is affected by IDC problems:

2> include the IE *affectedCarrierFreqList* with an entry for each affected E-UTRA carrier frequency for which a measurement object is configured;

2> for each E-UTRA carrier frequency included in the IE *affectedCarrierFreqList*, include *interferenceDirection* and set it accordingly;

2> include Time Domain Multiplexing (TDM) based assistance information:

3> if the UE has DRX related assistance information that could be used to resolve the IDC problems:

4> include *drx-CycleLength*, *drx-Offset* and *drx-ActiveTime*;

3> else (the UE has desired subframe reservation patterns related assistance information that could be used to resolve the IDC problems):

4> include *idc-SubframePatternList*;

3> use the MCG as timing reference if TDM based assistance information regarding the SCG is included;

1> if the UE is configured to provide UL CA information and there is a supported UL CA combination comprising of carrier frequencies for which a measurement object is configured, that is affected by IDC problems:

2> include *victimSystemType* in *ul-CA-AssistanceInfo*;

2> if the UE sets *victimSystemType* to *wlan* or *Bluetooth*:

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3> include *affectedCarrierFreqCombList* in *ul-CA-AssistanceInfo* with an entry for each supported UL CA combination comprising of carrier frequencies for which a measurement object is configured, that is affected by IDC problems;

2> else:

3> optionally include *affectedCarrierFreqCombList* in *ul-CA-AssistanceInfo* with an entry for each supported UL CA combination comprising of carrier frequencies for which a measurement object is configured, that is affected by IDC problems;

NOTE 1: When sending an *InDeviceCoexIndication* message to inform E-UTRAN the IDC problems, the UE includes all assistance information (rather than providing e.g. the changed part(s) of the assistance information).

The UE shall submit the *InDeviceCoexIndication* message to lower layers for transmission.

5.6.10 UE Assistance Information

5.6.10.1 General

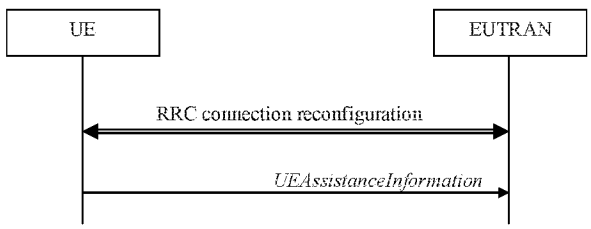


Figure 5.6.10.1-1: UE Assistance Information

The purpose of this procedure is to inform E-UTRAN of the UE's power saving preference. Upon configuring the UE to provide power preference indications E-UTRAN may consider that the UE does not prefer a configuration primarily optimised for power saving until the UE explicitly indicates otherwise.

5.6.10.2 Initiation

A UE capable of providing power preference indications in RRC_CONNECTED may initiate the procedure in several cases including upon being configured to provide power preference indications and upon change of power preference.

Upon initiating the procedure, the UE shall:

1> if configured to provide power preference indications:

2> if the UE did not transmit a *UEAssistanceInformation* message since it was configured to provide power preference indications; or

2> if the current power preference is different from the one indicated in the last transmission of the *UEAssistanceInformation* message and timer T340 is not running:

3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

5.6.10.3 Actions related to transmission of *UEAssistanceInformation* message

The UE shall set the contents of the *UEAssistanceInformation* message:

1> if the UE prefers a configuration primarily optimised for power saving:

2> set *powerPrefIndication* to *lowPowerConsumption*;

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1> else:

2> start or restart timer T340 with the timer value set to the *powerPrefIndicationTimer*;

2> set *powerPrefIndication* to *normal*;

The UE shall submit the *UEAssistanceInformation* message to lower layers for transmission.

5.6.11 Mobility history information

5.6.11.1 General

This procedure specifies how the mobility history information is stored by the UE, covering RRC_CONNECTED and RRC_IDLE.

5.6.11.2 Initiation

If the UE supports storage of mobility history information, the UE shall:

1> Upon change of cell, consisting of PCell in RRC_CONNECTED or serving cell in RRC_IDLE, to another E-UTRA or inter-RAT cell or when entering out of service:

2> include an entry in variable *VarMobilityHistoryReport* possibly after removing the oldest entry, if necessary, according to following:

3> if the global cell identity of the previous PCell/ serving cell is available:

4> include the global cell identity of that cell in the field *visitedCellId* of the entry;

3> else:

4> include the physical cell identity and carrier frequency of that cell in the field *visitedCellId* of the entry;

3> set the field *timeSpent* of the entry as the time spent in the previous PCell/ serving cell;

1> upon entering E-UTRA (in RRC_CONNECTED or RRC_IDLE) while previously out of service and/ or using another RAT:

2> include an entry in variable *VarMobilityHistoryReport* possibly after removing the oldest entry, if necessary, according to following:

3> set the field *timeSpent* of the entry as the time spent outside E-UTRA;

5.6.12 RAN-assisted WLAN interworking

5.6.12.1 General

The purpose of this procedure is to facilitate access network selection and traffic steering between E-UTRAN and WLAN.

If required by upper layers (see TS 24.312 [66]), the UE shall provide an up-to-date set of the applicable parameters provided by *wlan-OffloadConfigCommon* or *wlan-OffloadConfigDedicated* to upper layers, and inform upper layers when no parameters are configured. The parameter set from either *wlan-OffloadConfigCommon* or *wlan-OffloadConfigDedicated* is selected as specified in subclauses 5.2.2.24, 5.3.12, 5.6.12.2 and 5.6.12.4.

5.6.12.2 Dedicated WLAN offload configuration

The UE shall:

1> if the received *wlan-OffloadInfo* is set to *release*:

2> release *wlan-OffloadConfigDedicated* and *t350*;

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2> if the *wlan-OffloadConfigCommon* corresponding to the RPLMN is broadcast by the cell:

3> apply the *wlan-OffloadConfigCommon* corresponding to the RPLMN included in *SystemInformationBlockType17*;

1> else:

2> apply the received *wlan-OffloadConfigDedicated*;

5.6.12.3 WLAN offload RAN evaluation

The UE shall:

1> if the UE is configured with either *wlan-OffloadConfigCommon* or *wlan-OffloadConfigDedicated*:

2> provide measurement results required for the evaluation of the network selection and traffic steering rules as defined in TS 24.312 [66] to upper layers;

2> evaluate the network selection and traffic steering rules as defined in TS 36.304 [4];

5.6.12.4 T350 expiry or stop

The UE shall:

1> if T350 expires or is stopped:

2> release the *wlan-OffloadConfigDedicated* and *t350*;

2> if the *wlan-OffloadConfigCommon* corresponding to the RPLMN is broadcast by the cell:

3> apply the *wlan-OffloadConfigCommon* corresponding to the RPLMN included in *SystemInformationBlockType17*;

5.6.12.5 Cell selection/ re-selection while T350 is running

The UE shall:

1> if, while T350 is running, the UE selects/ reselects a cell which is not the PCell when the *wlan-OffloadDedicated* was configured:

2> stop timer T350;

2> perform the actions as specified in 5.6.12.4;

5.6.13 SCG failure information

5.6.13.1 General

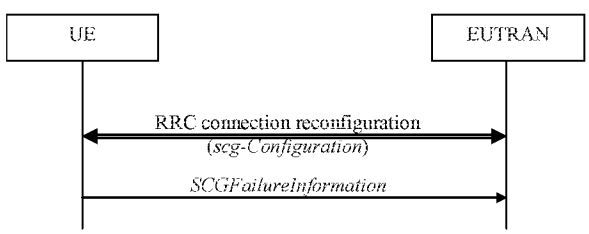


Figure 5.6.13.1-1: SCG failure information

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The purpose of this procedure is to inform E-UTRAN about an SCG failure the UE has experienced i.e. SCG radio link failure, SCG change failure.

5.6.13.2 Initiation

A UE initiates the procedure to report SCG failures when SCG transmission is not suspended and when one of the following conditions is met:

1> upon detecting radio link failure for the SCG, in accordance with 5.3.11; or

1> upon SCG change failure, in accordance with 5.3.5.7a;

Upon initiating the procedure, the UE shall:

1> suspend all SCG DRBs and suspend SCG transmission for split DRBs;

1> reset SCG-MAC;

1> stop T307;

1> initiate transmission of the *SCGFailureInformation* message in accordance with 5.6.13.3;

5.6.13.3 Actions related to transmission of *SCGFailureInformation* message

The UE shall set the contents of the *SCGFailureInformation* message as follows:

1> if the UE initiates transmission of the *SCGFailureInformation* message to provide SCG radio link failure information:

2> include *failureType* and set it to the trigger for detecting SCG radio link failure;

1> else if the UE initiates transmission of the *SCGFailureInformation* message to provide SCG change failure information:

2> include *failureType* and set it to *scg-ChangeFailure*;

1> set the *measResultServFreqList* to include for each SCG cell that is configured, if any, within *measResultSCell* the quantities of the concerned SCell, if available according to performance requirements in [16];

1> for each SCG serving frequency included in *measResultServFreqList*, include within *measResultBestNeighCell* the *physCellId* and the quantities of the best non-serving cell, based on RSRP, on the concerned serving frequency;

1> set the *measResultNeighCells* to include the best measured cells on non-serving E-UTRA frequencies, ordered such that the best cell is listed first, and based on measurements collected up to the moment the UE detected the failure, and set its fields as follows:

2> if the UE was configured to perform measurements for one or more non-serving EUTRA frequencies and measurement results are available, include the *measResultListEUTRA*;

2> for each neighbour cell included, include the optional fields that are available;

NOTE 2: The measured quantities are filtered by the L3 filter as configured in the mobility measurement configuration. The measurements are based on the time domain measurement resource restriction, if configured. Blacklisted cells are not required to be reported.

The UE shall submit the *SCGFailureInformation* message to lower layers for transmission.

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5.7 Generic error handling

5.7.1 General

The generic error handling defined in the subsequent sub-clauses applies unless explicitly specified otherwise e.g. within the procedure specific error handling.

The UE shall consider a value as not comprehended when it is set:

- to an extended value that is not defined in the version of the transfer syntax supported by the UE.
- to a spare or reserved value unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/ reserved value.

The UE shall consider a field as not comprehended when it is defined:

- as spare or reserved unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/ reserved field.

5.7.2 ASN.1 violation or encoding error

The UE shall:

1> when receiving an RRC message on the BCCH, PCCH, CCCH, MCCH or SBCCH for which the abstract syntax is invalid [13]:

2> ignore the message;

NOTE This section applies in case one or more fields is set to a value, other than a spare, reserved or extended value, not defined in this version of the transfer syntax. E.g. in the case the UE receives value 12 for a field defined as INTEGER (1..11). In cases like this, it may not be possible to reliably detect which field is in the error hence the error handling is at the message level.

5.7.3 Field set to a not comprehended value

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that has a value that the UE does not comprehend:

2> if a default value is defined for this field:

3> treat the message while using the default value defined for this field;

2> else if the concerned field is optional:

3> treat the message as if the field were absent and in accordance with the need code for absence of the concerned field;

2> else:

3> treat the message as if the field were absent and in accordance with sub-clause 5.7.4;

5.7.4 Mandatory field missing

The UE shall:

1> if the message includes a field that is mandatory to include in the message (e.g. because conditions for mandatory presence are fulfilled) and that field is absent or treated as absent:

2> if the RRC message was received on DCCH or CCCH:

3> ignore the message;

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2> else:

3> if the field concerns a (sub-field of) an entry of a list (i.e. a SEQUENCE OF):

4> treat the list as if the entry including the missing or not comprehended field was not present;

3> else if the field concerns a sub-field of another field, referred to as the 'parent' field i.e. the field that is one nesting level up compared to the erroneous field:

4> consider the 'parent' field to be set to a not comprehended value;

4> apply the generic error handling to the subsequent 'parent' field(s), until reaching the top nesting level i.e. the message level;

3> else (field at message level):

4> ignore the message.

NOTE 1: The error handling defined in these sub-clauses implies that the UE ignores a message with the message type or version set to a not comprehended value.

NOTE 2: The nested error handling for messages received on logical channels other than DCCH and CCCH applies for errors in extensions also, even for errors that can be regarded as invalid E-UTRAN operation e.g. E-UTRAN not observing conditional presence.

The following ASN.1 further clarifies the levels applicable in case of nested error handling for errors in extension fields.

```
   /example/ ASN1START

   Example with extension addition group

ItemInfoList ::=                    SEQUENCE (SIZE (1..max)) OF ItemInfo

ItemInfo ::=                        SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              field1,
    field2                              field2                  OPTIONAL,           -- Need ON
    ...
    [[  field3-r9                       field3-r9               OPTIONAL,           -- Cond Cond1
        field4-r9                       field4-r9               OPTIONAL            -- Need ON
    ]]
}

-- Example with traditional non-critical extension (empty sequence)

BroadcastInfoBlock1 ::=             SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              field1,
    field2                              field2                  OPTIONAL,           -- Need ON
    nonCriticalExtension                BroadcastInfoBlock1-v940-IEs    OPTIONAL
}

BroadcastInfoBlock1-v940-IEs::= SEQUENCE {
    field3-r9                           field3-r9               OPTIONAL,               Cond Cond1
    field4-r9                           field4-r9               OPTIONAL,           -- Need ON
    nonCriticalExtension                SEQUENCE {}             OPTIONAL            -- Need OP
}

-- ASN1STOP
```

The UE shall, apply the following principles regarding the levels applicable in case of nested error handling:

- an extension additon group is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, a error regarding the conditionality of *field3* would result in the entire itemInfo entry to be ignored (rather than just the extension addition group containing *field3* and *field4*)
- a traditional *nonCriticalExtension* is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, a error regarding the conditionality of *field3* would result in the entire *BroadcastInfoBlock1* to be ignored (rather than just the non critical extension containing *field3* and *field4*).

5.7.5 Not comprehended field

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that the UE does not comprehend:

2> treat the rest of the message as if the field was absent;

NOTE: This section does not apply to the case of an extension to the value range of a field. Such cases are addressed instead by the requirements in section 5.7.3.

5.8 MBMS

5.8.1 Introduction

5.8.1.1 General

In general the control information relevant only for UEs supporting MBMS is separated as much as possible from unicast control information. Most of the MBMS control information is provided on a logical channel specific for MBMS common control information: the MCCH. E-UTRA employs one MCCH logical channel per MBSFN area. In case the network configures multiple MBSFN areas, the UE acquires the MBMS control information from the MCCHs that are configured to identify if services it is interested to receive are ongoing. The action applicable when the UE is unable to simultaneously receive MBMS and unicast services is up to UE implementation. In this release of the specification, an MBMS capable UE is only required to support reception of a single MBMS service at a time, and reception of more than one MBMS service (also possibly on more than one MBSFN area) in parallel is left for UE implementation. The MCCH carries the *MBSFNAreaConfiguration* message, which indicates the MBMS sessions that are ongoing as well as the (corresponding) radio resource configuration. The MCCH may also carry the *MBMSCountingRequest* message, when E-UTRAN wishes to count the number of UEs in RRC_CONNECTED that are receiving or interested to receive one or more specific MBMS services.

A limited amount of MBMS control information is provided on the BCCH. This primarily concerns the information needed to acquire the MCCH(s). This information is carried by means of a single MBMS specific *SystemInformationBlock*: *SystemInformationBlockType13*. An MBSFN area is identified solely by the *mbsfn-AreaId* in *SystemInformationBlockType13*. At mobility, the UE considers that the MBSFN area is continuous when the source cell and the target cell broadcast the same value in the *mbsfn-AreaId*.

5.8.1.2 Scheduling

The MCCH information is transmitted periodically, using a configurable repetition period. Scheduling information is not provided for MCCH i.e. both the time domain scheduling as well as the lower layer configuration are semi-statically configured, as defined within *SystemInformationBlockType13*.

For MBMS user data, which is carried by the MTCH logical channel, E-UTRAN periodically provides MCH scheduling information (MSI) at lower layers (MAC). This MCH information only concerns the time domain scheduling i.e. the frequency domain scheduling and the lower layer configuration are semi-statically configured. The periodicity of the MSI is configurable and defined by the MCH scheduling period.

5.8.1.3 MCCH information validity and notification of changes

Change of MCCH information only occurs at specific radio frames, i.e. the concept of a modification period is used. Within a modification period, the same MCCH information may be transmitted a number of times, as defined by its scheduling (which is based on a repetition period). The modification period boundaries are defined by SFN values for which SFN mod m= 0, where m is the number of radio frames comprising the modification period. The modification period is configured by means of *SystemInformationBlockType13*.

When the network changes (some of) the MCCH information, it notifies the UEs about the change during a first modification period. In the next modification period, the network transmits the updated MCCH information. These general principles are illustrated in figure 5.8.1.3-1, in which different colours indicate different MCCH information. Upon receiving a change notification, a UE interested to receive MBMS services acquires the new MCCH information

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immediately from the start of the next modification period. The UE applies the previously acquired MCCH information until the UE acquires the new MCCH information.

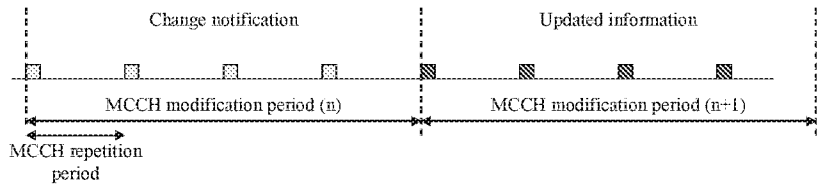


Figure 5.8.1.3-1: Change of MCCH Information

Indication of an MBMS specific RNTI, the M-RNTI (see TS 36.321 [6]), on PDCCH is used to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about an MCCH information change. When receiving an MCCH information change notification, the UE knows that the MCCH information will change at the next modification period boundary. The notification on PDCCH indicates which of the MCCHs will change, which is done by means of an 8-bit bitmap. Within this bitmap, the bit at the position indicated by the field *notificationIndicator* is used to indicate changes for that MBSFN area: if the bit is set to "1", the corresponding MCCH will change. No further details are provided e.g. regarding which MCCH information will change. The MCCH information change notification is used to inform the UE about a change of MCCH information upon session start or about the start of MBMS counting.

The MCCH information change notifications on PDCCH are transmitted periodically and are carried on MBSFN subframes only. These MCCH information change notification occasions are common for all MCCHs that are configured, and configurable by parameters included in *SystemInformationBlockType13:* a repetition coefficient, a radio frame offset and a subframe index. These common notification occasions are based on the MCCH with the shortest modification period.

NOTE 1: E-UTRAN may modify the MBMS configuration information provided on MCCH at the same time as updating the MBMS configuration information carried on BCCH i.e. at a coinciding BCCH and MCCH modification period. Upon detecting that a new MCCH is configured on BCCH, a UE interested to receive one or more MBMS services should acquire the MCCH, unless it knows that the services it is interested in are not provided by the corresponding MBSFN area.

A UE that is receiving an MBMS service shall acquire the MCCH information from the start of each modification period. A UE interested to receive MBMS from a carrier on which *dl-Bandwidth* included in *MasterInformationBlock* is set to *n6* shall acquire the MCCH information at least once every MCCH modification period. A UE that is not receiving an MBMS service, as well as UEs that are receiving an MBMS service but potentially interested to receive other services not started yet in another MBSFN area from a carrier on which *dl-Bandwidth* included in *MasterInformationBlock* is other than n6, shall verify that the stored MCCH information remains valid by attempting to find the MCCH information change notification at least *notificationRepetitionCoeff* times during the modification period of the applicable MCCH(s), if no MCCH information change notification is received.

NOTE 2: In case the UE is aware which MCCH(s) E-UTRAN uses for the service(s) it is interested to receive, the UE may only need to monitor change notifications for a subset of the MCCHs that are configured, referred to as the 'applicable MCCH(s)' in the above.

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5.8.2 MCCH information acquisition

5.8.2.1 General



Figure 5.8.2.1-1: MCCH information acquisition

The UE applies the MCCH information acquisition procedure to acquire the MBMS control information that is broadcasted by the E-UTRAN. The procedure applies to MBMS capable UEs that are in RRC_IDLE or in RRC_CONNECTED.

5.8.2.2 Initiation

A UE interested to receive MBMS services shall apply the MCCH information acquisition procedure upon entering the corresponding MBSFN area (e.g. upon power on, following UE mobility) and upon receiving a notification that the MCCH information has changed. A UE that is receiving an MBMS service shall apply the MCCH information acquisition procedure to acquire the MCCH, that corresponds with the service that is being received, at the start of each modification period.

Unless explicitly stated otherwise in the procedural specification, the MCCH information acquisition procedure overwrites any stored MCCH information, i.e. delta configuration is not applicable for MCCH information and the UE discontinues using a field if it is absent in MCCH information unless explicitly specified otherwise.

5.8.2.3 MCCH information acquisition by the UE

An MBMS capable UE shall:

1> if the procedure is triggered by an MCCH information change notification:

2> start acquiring the *MBSFNAreaConfiguration* message and the *MBMSCountingRequest* message if present, from the beginning of the modification period following the one in which the change notification was received;

NOTE 1: The UE continues using the previously received MCCH information until the new MCCH information has been acquired.

1> if the UE enters an MBSFN area:

2> acquire the *MBSFNAreaConfiguration* message and the *MBMSCountingRequest* message if present, at the next repetition period;

1> if the UE is receiving an MBMS service:

2> start acquiring the *MBSFNAreaConfiguration* message and the *MBMSCountingRequest* message if present, that both concern the MBSFN area of the service that is being received, from the beginning of each modification period;

5.8.2.4 Actions upon reception of the *MBSFNAreaConfiguration* message

No UE requirements related to the contents of this *MBSFNAreaConfiguration* apply other than those specified elsewhere e.g. within procedures using the concerned system information, the corresponding field descriptions.

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5.8.2.5 Actions upon reception of the *MBMSCountingRequest* message

Upon receiving *MBMSCountingRequest* message, the UE shall perform the MBMS Counting procedure as specified in section 5.8.4.

5.8.3 MBMS PTM radio bearer configuration

5.8.3.1 General

The MBMS PTM radio bearer configuration procedure is used by the UE to configure RLC, MAC and the physical layer upon starting and/or stopping to receive an MRB. The procedure applies to UEs interested to receive one or more MBMS services.

NOTE: In case the UE is unable to receive an MBMS service due to capability limitations, upper layers may take appropriate action e.g. terminate a lower priority unicast service.

5.8.3.2 Initiation

The UE applies the MRB establishment procedure to start receiving a session of a service it has an interest in. The procedure may be initiated e.g. upon start of the MBMS session, upon (re-)entry of the corresponding MBSFN service area, upon becoming interested in the MBMS service, upon removal of UE capability limitations inhibiting reception of the concerned service.

The UE applies the MRB release procedure to stop receiving a session. The procedure may be initiated e.g. upon stop of the MBMS session, upon leaving the corresponding MBSFN service area, upon losing interest in the MBMS service, when capability limitations start inhibiting reception of the concerned service.

5.8.3.3 MRB establishment

Upon MRB establishment, the UE shall:

1> establish an RLC entity in accordance with the configuration specified in 9.1.1.4;

1> configure an MTCH logical channel in accordance with the received *logicalChannelIdentity*, applicable for the MRB, as included in the *MBSFNAreaConfiguration* message;

1> configure the physical layer in accordance with the *pmch-Config*, applicable for the MRB, as included in the *MBSFNAreaConfiguration* message;

1> inform upper layers about the establishment of the MRB by indicating the corresponding *tmgi* and *sessionId*;

5.8.3.4 MRB release

Upon MRB release, the UE shall:

1> release the RLC entity as well as the related MAC and physical layer configuration;

1> inform upper layers about the release of the MRB by indicating the corresponding *tmgi* and *sessionId*;

5.8.4 MBMS Counting Procedure

5.8.4.1 General

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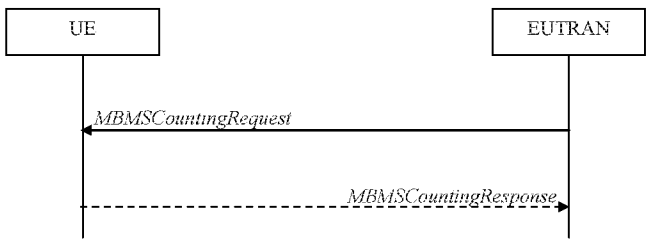


Figure 5.8.4.1-1: MBMS Counting procedure

The MBMS Counting procedure is used by the E-UTRAN to count the number of RRC_CONNECTED mode UEs which are receiving via an MRB or interested to receive via an MRB the specified MBMS services.

The UE determines interest in an MBMS service, that is identified by the TMGI, by interaction with upper layers.

5.8.4.2 Initiation

E-UTRAN initiates the procedure by sending an *MBMSCountingRequest* message.

5.8.4.3 Reception of the *MBMSCountingRequest* message by the UE

Upon receiving the *MBMSCountingRequest* message, the UE in RRC_CONNECTED mode shall:

1> if the *SystemInformationBlockType1*, that provided the scheduling information for the *systemInformationBlockType13* that included the configuration of the MCCH via which the *MBMSCountingRequest* message was received, contained the identity of the Registered PLMN; and

1> if the UE is receiving via an MRB or interested to receive via an MRB at least one of the services in the received *countingRequestList*:

2> if more than one entry is included in the *mbsfn-AreaInfoList* received in the *SystemInformationBlockType13* that included the configuration of the MCCH via which the *MBMSCountingRequest* message was received:

3> include the *mbsfn-AreaIndex* in the *MBMSCountingResponse* message and set it to the index of the entry in the *mbsfn-AreaInfoList* within the received *SystemInformationBlockType13* that corresponds with the MBSFN area used to transfer the received *MBMSCountingRequest* message;

2> for each MBMS service included in the received *countingRequestList*:

3> if the UE is receiving via an MRB or interested to receive via an MRB this MBMS service:

4> include an entry in the *countingResponseList* within the *MBMSCountingResponse* message with *countingResponseService* set it to the index of the entry in the *countingRequestList* within the received *MBMSCountingRequest* that corresponds with the MBMS service the UE is receiving or interested to receive;

2> submit the *MBMSCountingResponse* message to lower layers for transmission upon which the procedure ends;

NOTE 1: UEs that are receiving an MBMS User Service [56] by means of a Unicast Bearer Service [57] (i.e. via a DRB), but are interested to receive the concerned MBMS User Service [56] via an MBMS Bearer Service (i.e. via an MRB), respond to the counting request.

NOTE 2: If ciphering is used at upper layers, the UE does not respond to the counting request if it can not decipher the MBMS service for which counting is performed (see TS 22.146 [62, 5.3]).

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NOTE 3: The UE treats the *MBMSCountingRequest* messages received in each modification period independently. In the unlikely case E-UTRAN would repeat an *MBMSCountingRequest* (i.e. including the same services) in a subsequent modification period, the UE responds again. The UE provides at most one *MBMSCountingResponse* message to multiple transmission attempts of an *MBMSCountingRequest* messages in a given modification period.

5.8.5 MBMS interest indication

5.8.5.1 General

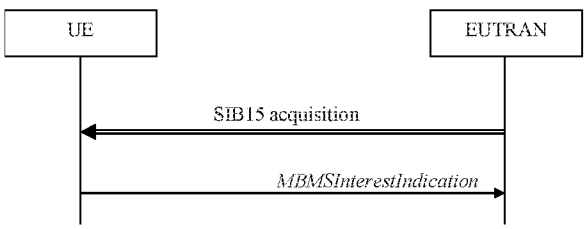


Figure 5.8.5.1-1: MBMS interest indication

The purpose of this procedure is to inform E-UTRAN that the UE is receiving or is interested to receive MBMS service(s) via an (SC-)MRB, and if so, to inform E-UTRAN about the priority of MBMS versus unicast reception.

5.8.5.2 Initiation

An MBMS or SC-PTM capable UE in RRC_CONNECTED may initiate the procedure in several cases including upon successful connection establishment, upon entering or leaving the service area, upon session start or stop, upon change of interest, upon change of priority between MBMS reception and unicast reception or upon change to a PCell broadcasting *SystemInformationBlockType15*.

Upon initiating the procedure, the UE shall:

1> if *SystemInformationBlockType15* is broadcast by the PCell:

2> ensure having a valid version of *SystemInformationBlockType15* for the PCell;

2> if the UE did not transmit an *MBMSInterestIndication* message since last entering RRC_CONNECTED state; or

2> if since the last time the UE transmitted an *MBMSInterestIndication* message, the UE connected to a PCell not broadcasting *SystemInformationBlockType15*:

3> if the set of MBMS frequencies of interest, determined in accordance with 5.8.5.3, is not empty:

4> initiate transmission of the *MBMSInterestIndication* message in accordance with 5.8.5.4;

2> else:

3> if the set of MBMS frequencies of interest, determined in accordance with 5.8 5.3, has changed since the last transmission of the *MBMSInterestIndication* message; or

3> if the prioritisation of reception of all indicated MBMS frequencies compared to reception of any of the established unicast bearers has changed since the last transmission of the *MBMSInterestIndication* message:

4> initiate transmission of the *MBMSInterestIndication* message in accordance with 5.8.5.4;

NOTE: The UE may send an *MBMSInterestIndication* even when it is able to receive the MBMS services it is interested in i.e. to avoid that the network allocates a configuration inhibiting MBMS reception.

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3> else if *SystemInformationBlockType20* is provided by the PCell:

4> if since the last time the UE transmitted an *MBMSInterestIndication* message, the UE connected to a PCell not broadcasting *SystemInformationBlockType20*; or

4> if the set of MBMS services of interest determined in accordance with 5.8.5.3a is different from *mbms-Services* included in the last transmission of the *MBMSInterestIndication* message;

5> initiate the transmission of the *MBMSInterestIndication* message in accordance with 5.8.5.4.

5.8.5.3 Determine MBMS frequencies of interest

The UE shall:

1> consider a frequency to be part of the MBMS frequencies of interest if the following conditions are met:

2> at least one MBMS session the UE is receiving or interested to receive via an (SC-)MRB is ongoing or about to start; and

NOTE 1: The UE may determine whether the session is ongoing from the start and stop time indicated in the User Service Description (USD), see 3GPP TS 36.300 [9] or 3GPP TS 26.346 [57].

2> for at least one of these MBMS sessions *SystemInformationBlockType15* acquired from the PCell includes for the concerned frequency one or more MBMS SAIs as indicated in the USD for this session; and

NOTE 2: The UE considers a frequency to be part of the MBMS frequencies of interest even though E-UTRAN may (temporarily) not employ an (SC-)MRB for the concerned session. I.e. the UE does not verify if the session is indicated on (SC-)MCCH

NOTE 3: The UE considers the frequencies of interest independently of any synchronization state, e.g. [9, Annex J.1]

2> if the UE is MBMS capable, the UE is capable of simultaneously receiving MRBs on the set of MBMS frequencies of interest, regardless of whether a serving cell is configured on each of these frequencies or not; and

2> if the UE is SC-PTM capable, at most one frequency is included; and

2> the *supportedBandCombination* the UE included in *UE-EUTRA-Capability* contains at least one band combination including the set of MBMS frequencies of interest;

NOTE 4: Indicating a frequency implies that the UE supports *SystemInformationBlockType13* acquisition for the concerned frequency i.e. the indication should be independent of whether a serving cell is configured on that frequency.

NOTE 5: When evaluating which frequencies it can receive simultaneously, the UE does not take into account the serving frequencies that are currently configured i.e. it only considers MBMS frequencies it is interested to receive.

NOTE 6: The set of MBMS frequencies of interest includes at most one frequency for a given physical frequency. The UE only considers a physical frequency to be part of the MBMS frequencies of interest if it supports at least one of the bands indicated for this physical frequency in *SystemInformationBlockType1* (for serving frequency) or *SystemInformationBlockType15* (for neighbouring frequencies). In this case, E-UTRAN may assume the UE supports MBMS reception on any of the bands supported by the UE (i.e. according to *supportedBandCombination*).

5.8.5.3a Determine MBMS services of interest

The UE shall:

1> consider a MBMS service to be part of the MBMS services of interest if the following conditions are met:

2> the UE is SC-PTM capable; and

2> the UE is receiving or interested to receive this service via an SC-MRB; and

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2> one or more MBMS SAIs in the USD for this service is included in *SystemInformationBlockType15* acquired from the PCell for a frequency belonging to the set of MBMS frequencies of interest, determined according to 5.8.5.3.

5.8.5.4 Actions related to transmission of *MBMSInterestIndication* message

The UE shall set the contents of the *MBMSInterestIndication* message as follows:

1> if the set of MBMS frequencies of interest, determined in accordance with 5.8.5.3, is not empty:

2> include *mbms-FreqList* and set it to include the MBMS frequencies of interest, using the EARFCN corresponding with *freqBandIndicator* included in *SystemInformationBlockType1* (for serving frequency), if applicable, and the EARFCN(s) as included in *SystemInformationBlockType15* (for neighbouring frequencies);

NOTE 1: The EARFCN included in *mbms-FreqList* is merely used to indicate a physical frequency the UE is interested to receive i.e. the UE may not support the band corresponding to the included EARFCN (but it does support at least one of the bands indicated in system information for the concerned physical frequency).

2> include *mbms-Priority* if the UE prioritises reception of all indicated MBMS frequencies above reception of any of the unicast bearers;

2> if *SystemInformationBlockType20* is broadcast by the PCell:

3> include *mbms-Services* and set it to indicate the set of MBMS services of interest determined in accordance with 5.8.5.3a;

NOTE 2: If the UE prioritises MBMS reception and unicast data cannot be supported because of congestion on the MBMS carrier(s), E-UTRAN may initiate release of unicast bearers. It is up to E-UTRAN implementation whether all bearers or only GBR bearers are released. E-UTRAN does not initiate re-establishment of the released unicast bearers upon alleviation of the congestion.

The UE shall submit the *MBMSInterestIndication* message to lower layers for transmission.

5.8a SC-PTM

5.8a.1 Introduction

5.8a.1.1 General

SC-PTM control information is provided on a specific logical channel, the SC-MCCH. The SC-MCCH carries the *SCPTMConfiguration* message which indicates the MBMS sessions that are ongoing as well as the (corresponding) information on when each session may be scheduled, i.e.scheduling period, scheduling window and start offset. The *SCPTMConfiguration* message also provides information about the neighbour cells transmitting the MBMS sessions which are ongoing on the current cell.

A limited amount of SC-PTM control information is provided on the BCCH. This primarily concerns the information needed to acquire the SC-MCCH.

5.8a.1.2 SC-MCCH scheduling

The SC-MCCH information (i.e. information transmitted in messages sent over SC-MCCH) is transmitted periodically, using a configurable repetition period. SC-MCCH transmissions (and the associated radio resources and MCS) are indicated on PDCCH.

5.8a.1.3 SC-MCCH information validity and notification of changes

Change of SC-MCCH information only occurs at specific radio frames, i.e. the concept of a modification period is used. Within a modification period, the same SC-MCCH information may be transmitted a number of times, as defined by its scheduling (which is based on a repetition period). The modification period boundaries are defined by SFN values for

which SFN mod m= 0, where m is the number of radio frames comprising the modification period. The modification period is configured by means of *SystemInformationBlockType20*.

When the network changes (some of) the SC-MCCH information, it notifies the UEs about the change in the same subframes which can be used for SC-MCCH transmission. Upon receiving a change notification, a UE interested to receive MBMS services transmitted using SC-PTM acquires the new SC-MCCH information starting from the same subframe. The UE applies the previously acquired SC-MCCH information until the UE acquires the new SC-MCCH information.

5.8a.1.4 Procedures

The SC-PTM capable UE receiving or interested to receive MBMS service(s) via SC-MRB applies SC-PTM procedures described in section 5.8a and the MBMS interest indication procedure as specified in 5.8.5.

5.8a.2 SC-MCCH information acquisition

5.8a.2.1 General

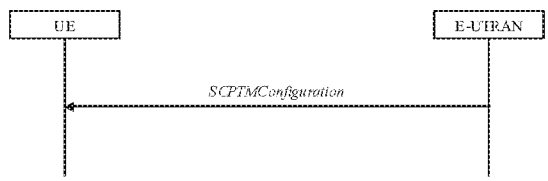


Figure 5.8a.2.1-1: SC-MCCH information acquisition

The UE applies the SC-MCCH information acquisition procedure to acquire the SC-PTM control information that is broadcast by the E-UTRAN. The procedure applies to SC-PTM capable UEs that are in RRC_IDLE or in RRC_CONNECTED

5.8a.2.2 Initiation

A UE interested to receive MBMS services via SC-MRB shall apply the SC-MCCH information acquisition procedure upon entering the cell broadcasting *SystemInformationBlockType20* (e.g. upon power on, following UE mobility) and upon receiving a notification that the SC-MCCH information has changed. A UE that is receiving an MBMS service via SC-MRB shall apply the SC-MCCH information acquisition procedure to acquire the SC-MCCH information that corresponds with the service that is being received, at the start of each modification period.

Unless explicitly stated otherwise in the procedural specification, the SC-MCCH information acquisition procedure overwrites any stored SC-MCCH information, i.e. delta configuration is not applicable for SC-MCCH information and the UE discontinues using a field if it is absent in SC-MCCH information unless explicitly specified otherwise.

5.8a.2.3 SC-MCCH information acquisition by the UE

A SC-PTM capable UE shall:

1> if the procedure is triggered by an SC-MCCH information change notification:

2> start acquiring the *SCPTMConfiguration* message from the subframe where the change notification was received;

NOTE 1: The UE continues using the previously received SC-MCCH information until the new SC-MCCH information has been acquired.

1> if the UE enters a cell broadcasting *SystemInformationBlockType20*:

2> acquire the *SCPTMConfiguration* message at the next repetition period;

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1> if the UE is receiving an MBMS service via an SC-MRB:

2> start acquiring the *SCPTMConfiguration* message from the beginning of each modification period.

5.8a.2.4 Actions upon reception of the *SCPTMConfiguration* message

No UE requirements related to the contents of this *SCPTMConfiguration* apply other than those specified elsewhere e.g. within procedures using the concerned system information, the corresponding field descriptions.

5.8a.3 SC-PTM radio bearer configuration

5.8a.3.1 General

The SC-PTM radio bearer configuration procedure is used by the UE to configure RLC, MAC and the physical layer upon starting and/or stopping to receive an SC-MRB transmitted on SC-MTCH. The procedure applies to SC-PTM capable UEs that are in RRC_CONNECTED or in RRC_IDLE and are interested to receive one or more MBMS services via an SC-MRB.

NOTE: In case the UE is unable to receive an MBMS service via an SC-MRB due to capability limitations, upper layers may take appropriate action e.g. terminate a lower priority unicast service.

5.8a.3.2 Initiation

The UE applies the SC-MRB establishment procedure to start receiving a session of a MBMS service it has an interest in. The procedure may be initiated e.g. upon start of the MBMS session, upon entering a cell providing via SC-MRB a MBMS service in which the UE has interest, upon becoming interested in the MBMS service, upon removal of UE capability limitations inhibiting reception of the concerned service.

The UE applies the SC-MRB release procedure to stop receiving a session. The procedure may be initiated e.g. upon stop of the MBMS session, upon leaving the cell where a SC-MRB is established, upon losing interest in the MBMS service, when capability limitations start inhibiting reception of the concerned service.

5.8a.3.3 SC-MRB establishment

Upon SC-MRB establishment, the UE shall:

1> establish an RLC entity in accordance with the configuration specified in 9.1.1.7;

1> configure a SC-MTCH logical channel applicable for the SC-MRB and instruct MAC to receive DL-SCH on the cell where the *SCPTMConfiguration* message was received for the MBMS service for which the SC-MRB is established and using the G-RNTI and DRX parameters (if included) in this message for this MBMS service;

1> configure the physical layer in accordance with the *sc-mtch-InfoList*, applicable for the SC-MRB, as included in the *SCPTM-Configuration* message;

1> inform upper layers about the establishment of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

5.8a.3.4 SC-MRB release

Upon SC-MRB release, the UE shall:

1> release the RLC entity as well as the related MAC and physical layer configuration;

1> inform upper layers about the release of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

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5.9 RN procedures

5.9.1 RN reconfiguration

5.9.1.1 General

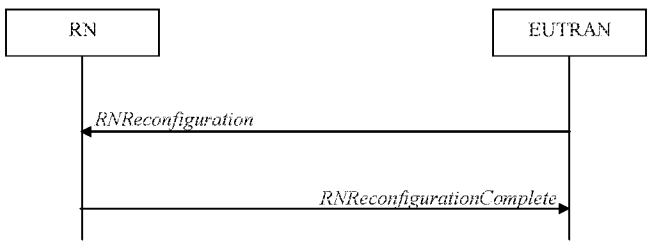


Figure 5.9.1.1-1: RN reconfiguration

The purpose of this procedure is to configure/reconfigure the RN subframe configuration and/or to update the system information relevant for the RN in RRC_CONNECTED.

5.9.1.2 Initiation

E-UTRAN may initiate the RN reconfiguration procedure to an RN in RRC_CONNECTED when AS security has been activated.

5.9.1.3 Reception of the *RNReconfiguration* by the RN

The RN shall:

1> if the *rn-SystemInfo* is included:

2> if the *systemInformationBlockType1* is included:

3> act upon the received *SystemInformationBlockType1* as specified in 5.2.2.7;

2> if the *SystemInformationBlockType2* is included:

3> act upon the received *SystemInformationBlockType2* as specified in 5.2.2.9;

1> if the *rn-SubframeConfig* is included:

2> reconfigure lower layers in accordance with the received *subframeConfigPatternFDD* or *subframeConfigPatternTDD*;

2> if the *rpdcch-Config* is included:

3> reconfigure lower layers in accordance with the received *rpdcch-Config*;

1> submit the *RNReconfigurationComplete* message to lower layers for transmission, upon which the procedure ends;

5.10 Sidelink

5.10.1 Introduction

The sidelink communication/ discovery/ synchronisation resource configuration applies for the frequency at which it was received/ acquired. Moreover, for a UE configured with one or more SCells, the sidelink communication/

discovery/ synchronisation resource configuration provided by dedicated signalling applies for the PCell/ the primary frequency.

NOTE 1: Upper layers configure the UE to receive or transmit sidelink communication on a specific frequency, to monitor sidelink discovery announcements on one or more frequencies or to transmit sidelink discovery announcements on a specific frequency, but only if the UE is authorised to perform these particular ProSe related sidelink activities.

NOTE 2: It is up to UE implementation which actions to take (e.g. termination of unicast services, detach) when it is unable to perform the desired sidelink activities, e.g. due to UE capability limitations.

The specification covers the use of UE to network sidelink relays by specifying the additional requirements that apply for a sidelink relay UE and a sidelink remote UE. I.e. for such UEs the regular sidelink UE requirements equally apply unless explicitly stated otherwise.

5.10.1a Conditions for sidelink operation

When it is specified that the UE shall perform a particular sidelink operation only if the conditions defined in this section are met, the UE shall perform the concerned sidelink operation only if:

1> if the UE's serving cell is suitable (RRC_IDLE or RRC_CONNECTED); and if either the selected cell on the frequency used for sidelink operation belongs to the registered or equivalent PLMN as specified in TS 24.334 [69] or the UE is out of coverage on the frequency used for sidelink operation as defined in TS 36.304 [4, 11.4]; or

1> if the UE is camped on a serving cell (RRC_IDLE) on which it fulfils the conditions to support sidelink communication in limited service state as specified in TS 23.303 [68, 4.5.6]; and if either the serving cell is on the frequency used for sidelink operation or the UE is out of coverage on the frequency used for sidelink operation as defined in TS 36.304 [4, 11.4]; or

1> if the UE has no serving cell (RRC_IDLE);

5.10.2 Sidelink UE information

5.10.2.1 General

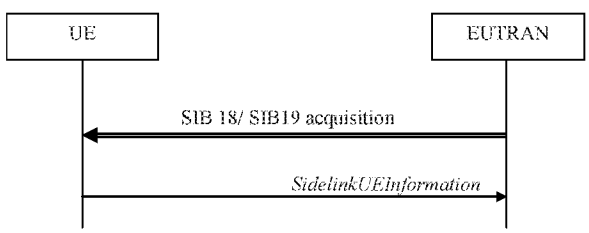


Figure 5.10.2-1: Sidelink UE information

The purpose of this procedure is to inform E-UTRAN that the UE is interested or no longer interested to receive sidelink communication or discovery, as well as to request assignment or release of transmission resources for sidelink communication or discovery announcements and to report parameters related to Sidelink operations from system information of inter-frequency cells.

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5.10.2.2 Initiation

A UE capable of sidelink communication or discovery that is in RRC_CONNECTED may initiate the procedure to indicate it is (interested in) receiving sidelink communication or discovery in several cases including upon successful connection establishment, upon change of interest, upon change to a PCell broadcasting *SystemInformationBlockType18* or *SystemInformationBlockType19*. A UE capable of sidelink communication or discovery may initiate the procedure to request assignment of dedicated resources for the concerned sidelink communication transmission or discovery announcements and to report parameters related to sidelink operations from system information of inter-frequency cells.

NOTE 1: A UE in RRC_IDLE that is configured to transmit sidelink (relay) communication/ discovery announcements, while *SystemInformationBlockType18*/ *SystemInformationBlockType19* does not include the resources for transmission (in normal conditions), initiates connection establishment in accordance with 5.3.3.1a.

Upon initiating the procedure, the UE shall:

1> if *SystemInformationBlockType18* is broadcast by the PCell:

2> ensure having a valid version of *SystemInformationBlockType18* for the PCell;

2> if configured by upper layers to receive sidelink communication:

3> if the UE did not transmit a *SidelinkUEInformation* message since last entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType18*; or

NOTE 2: After handover/ re-establishment from a source PCell not broadcasting *SystemInformationBlockType18* the UE repeats the same interest information that it provided previously as such a source PCell may not forward the interest information.

3> if the last transmission of the *SidelinkUEInformation* message did not include *commRxInterestedFreq*; or if the frequency configured by upper layers to receive sidelink communication on has changed since the last transmission of the *SidelinkUEInformation* message:

4> initiate transmission of the *SidelinkUEInformation* message to indicate the sidelink communication reception frequency of interest in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *commRxInterestedFreq*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it is no longer interested in sidelink communication reception in accordance with 5.10.2.3;

2> if configured by upper layers to transmit one to many sidelink communication:

3> if the UE did not transmit a *SidelinkUEInformation* message since entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType18*; or

3> if the last transmission of the *SidelinkUEInformation* message did not include *commTxResourceReq*; or if the information carried by the *commTxResourceReq* has changed since the last transmission of the *SidelinkUEInformation* message:

4> initiate transmission of the *SidelinkUEInformation* message to indicate the sidelink communication transmission resources required by the UE in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *commTxResourceReq*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it does no longer require sidelink communication transmission resources in accordance with 5.10.2.3;

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2> if configured by upper layers to transmit non-relay related one to one sidelink communication:

3> if the UE did not transmit a *SidelinkUEInformation* message since entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType18*; or

3> if the last transmission of the *SidelinkUEInformation* message did not include *commTxResourceReq121*; or if the information carried by the *commTxResourceReq121* has changed since the last transmission of the *SidelinkUEInformation* message:

4> initiate transmission of the *SidelinkUEInformation* message to indicate the non-relay related sidelink one to one communication transmission resources required by the UE in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *commTxResourceReq121*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it does no longer require non-relay related sidelink one to one communication transmission resources in accordance with 5.10.2.3;

2> if configured by upper layers to transmit relay related sidelink communication:

3> if the UE did not transmit a *SidelinkUEInformation* message since entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType18*; or

3> if the last transmission of the *SidelinkUEInformation* message did not include *commTxResourceReqRelay*; or if the information carried by the *commTxResourceReqRelay* has changed since the last transmission of the *SidelinkUEInformation* message:

4> if the UE is acting as relay; or:

4> if the UE has a selected relay; and if *SystemInformationBlockType19* is broadcast by the PCell and includes *discConfigRelay*; and if either *discThreshHiRemoteUE* is not included in *SystemInformationBlockType19* or the RSRP measurement of the PCell is below *discThreshHiRemoteUE*;

5> initiate transmission of the *SidelinkUEInformation* message to indicate the relay related sidelink communication transmission resources required by the UE in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *commTxResourceReqRelay*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it does no longer require relay related sidelink communication transmission resources in accordance with 5.10.2.3;

1> if *SystemInformationBlockType19* is broadcast by the PCell:

2> ensure having a valid version of *SystemInformationBlockType19* for the PCell;

2> if configured by upper layers to receive sidelink discovery announcements on a serving frequency or on one or more frequencies included in *discInterFreqList*, if included in *SystemInformationBlockType19*:

3> if the UE did not transmit a *SidelinkUEInformation* message since last entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType19*; or

3> if the last transmission of the *SidelinkUEInformation* message did not include *discRxInterest*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it is interested in sidelink discovery reception in accordance with 5.10.2.3;

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