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Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 6: Enhancements for High Efficiency WLAN(#1121)

Prepared by the 802.11 Working Group of the

LAN/MAN Standards Committee
of the
IEEE Computer Society

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Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 6 GHz.

Keywords: high efficiency, PHY, physical layer, MAC, medium access control, OFDMA, orthogonal frequency division multiple access, wireless local area network, WLAN

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This introduction is not part of IEEE P802.11ax /D0.4, August 2016, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area network—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 6: Enhancements for High Efficiency WLAN(#1121).

This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 6 GHz.

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IEEE P802.11ax™/D0.4

Draft STANDARD for Information Technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications

Amendment 6: Enhancements for High Efficiency WLAN(#1121)

[This amendment is based on IEEE P802.11REVmc/D6.0(#2111) amended by IEEE P802.11ai/D4.0, IEEE P802.11ah/D5.0, IEEE P802.11aq/D3.0, IEEE P802.11ak/D1.0 and IEEE P802.11aj/D1.0]

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editorial instructions, change markings and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

Editorial Notes

Editor's Note: Editorial Notes in the body of the standard appear like this. They will be removed before publication. They may highlight some issue that the editor has had to address during the implementation of a change. Where there may be any technical impact from an editing issue, the editor will raise a technical letter ballot comment. There is no need for voters to comment on such issues unless they have a specific resolution they wish to present.

Editor's Note: Headings with empty content or Headings preceding editing instructions that modify the contents of the referenced subclause are there to provide context to the reader of this document, they have no other significance.

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Editor's Note: Line numbering is only approximate. This is a limitation of the FrameMaker tool. Whitespace between paragraphs is part of the IEEE-SA style, as defined in their templates. The combination of these two facts leads to the appearance of blank lines in the draft between every paragraph. Please do not report this as an editorial defect as it is the unavoidable behavior.

Tags:

Tags are placed in this draft near changes to identify the source of the change. Changes resulting from incorporation of an approved proposal are shown like this: (#<number>), where <number> identifies the submission/revision that introduced that change.

These tags will be hidden in versions of the draft sent out to letter ballot - i.e., they are present only to assist the editorial review panel in checking that changes have been properly applied.

Tags are shown close to the point of change. When a whole subclause is new, the heading is tagged.

Otherwise, when a whole paragraph is new, the paragraph is tagged. Otherwise tags are placed after a section of changes within a paragraph or at the end of the paragraph if the changes are substantial.

New tables are tagged in the table caption (if there is one), or in the introductory paragraph. Otherwise, new rows in existing tables are tagged only in the first column, to avoid distraction. Otherwise, a modified cell is tagged.

Finally, any other changes made by the editor (e.g., for grammar, language, style & consistency with other comment resolutions, baseline, etc.) are tagged (#Ed).

Editor's Note: A cumulative status of the versions of this draft is shown below.

Table 1—Draft Status

Draft	Date	Status
D0.1	2016-03-03	Converted to FrameMaker from 16/0024r1 Proposed draft specification
D0.2	2016-06-06	Includes tentative resolutions for most editorials. Includes resolutions for technical comments motioned in May 2016 session.
D0.3	2016-08-11	Includes resolutions for technical comments motioned in July 2016 session.
D0.4	2016-08-26	Included motioned draft changes from July 2016 session and corrected errors

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3. Definitions, acronyms, and abbreviations

3.2 Definitions specific to IEEE 802.11

3.4 Abbreviations and acronyms

Insert the following acronym definitions (maintaining alphabetical order):

DCM	Dual carrier modulation(#2567)
DL	Downlink(#2401)
DL MU	Downlink multi-user
HE	High efficiency
OBO	Orthogonal frequency division multiple access (OFDMA) backoff(#1747)
OCW	Orthogonal frequency division multiple access (OFDMA) contention window(#1747)
OFDMA	Orthogonal frequency-division multiple access
MU-RTS	Multi-user request to send
UL	Uplink
UL MU	Uplink multi-user(#545)

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4. General description

4.3 Components of the IEEE Std 802.11 architecture

Insert a new subclause after subclause 4.3.12 as follows:

4.3.12a High efficiency (HE) STA

The IEEE 802.11 HE STA operates in frequency bands between 1 GHz and 6 GHz.

An HE STA is VHT STA or HT non-AP STA that, in addition to the features supported as a VHT STA or HT non-AP STA respectively, supports the MAC features defined in Clause 25 and the PHY features defined in Clause 26.(PHY Motion #163)

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6. Layer management

6.1 Overview of management model

6.2 Generic management primitives

6.3 MLME SAP interface

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-ASSOCIATE.request(

...

HE Capabilities,

VendorSpecificInfo

)

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm(

...,

HE Capabilities,

VendorSpecificInfo

)

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Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.8 Reassociate

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-REASSOCIATE.request(

...
HE Capabilities,
VendorSpecificInfo
)

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-REASSOCIATE.confirm(

...
HE Capabilities,

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VendorSpecificInfo
)

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

MLME-START.request(
...,
HE Capabilities,
HE Operation,
VendorSpecificInfo
)

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element.(#1122)	As defined in 9.4.2.214 (HE Operation element)	The additional HE capabilities to be advertised for the BSS. The parameter is present if BSSType = INFRASTRUCTURE and dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

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9. Frame formats

9.2 MAC frame formats

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.3 Type and Subtype fields

Change the row below and insert a new row immediately after it in Table 9-1 (Valid type and subtype combinations) as follows:

Table 9-1—Valid type and subtype combinations

Type value B3 B2	Type description	Subtype value B7 B6 B5 B4	Subtype description
01	Control	0000–~~0011~~<ANA>	Reserved
01	Control	<ANA>	Trigger

9.2.4.1.10 Order field

Change this subclause as follows:

The Order field is 1 bit in length. The setting of the Order field is as follows:

— It is set to 1 in a non-QoS Data frame transmitted by a non-QoS STA to indicate that the frame contains an MSDU, or fragment thereof, that is being transferred using the StrictlyOrdered service class.

— It is set to 1 in a QoS Data or Management frame transmitted with a value of HT_GF, HT_MF, VHT, HE or S1G for the FORMAT parameter of the TXVECTOR to indicate that the frame contains an HT Control field.

— It is set to 1 in an S1G RTS frame to indicate that the intended recipient of the frame has permission to extend the TXOP as described in 10.51.5.4 (Relay-shared TXOP protection mechanisms).

Otherwise, the Order field is set to 0.

NOTE—The Order field is always set to 0 for frames transmitted by a DMG STA.

9.2.4.5 QoS Control field

9.2.4.5.6 Queue Size subfield

Change subclause 9.2.4.5.6 as follows:

The Queue Size subfield is an 8-bit field that indicates the amount of buffered traffic for a given TC or TS at the STA sending this frame. A non-AP HE STA uses the Queue Size subfield to indicate the amount of buffered traffic intended for the STA identified by the receive address of the frame containing the QoS Control field.(MAC Motion #85) The Queue Size subfield is present in QoS Data and QoS Null frames sent by non-AP STAs with bit 4 of the QoS Control field equal to 1. The AP ~~might~~ can use information contained

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in the Queue Size subfield to determine the TXOP duration assigned to the STA or to determine the UL resources assigned to the HE STA (see 25.5.2 (UL MU operation)).(#172)

The queue size value is the total size, rounded up to the nearest multiple of 256 octets and expressed in units of 256 octets, of all MSDUs and A-MSDUs buffered at the STA (excluding the MSDU or A-MSDU of the present QoS Data frame sent by a non-HE STA and including the MSDUs or A-MSDUs contained in the present (A-)MPDU sent by an HE STA) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field. A queue size value of 0 is used solely to indicate the absence of any buffered traffic in the queue used for the specified TID. A queue size value of 254 is used for all sizes greater than 64 768 octets. A queue size value of 255 is used to indicate an unspecified or unknown size. If a QoS Data frame is fragmented and is not carried in an A-MPDU, the queue size value can remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted. If a QoS Data frame is fragmented and is carried in an A-MPDU, the queue size value is set as defined in 10.13.1 (A-MPDU contents).(#172)

9.2.4.6 HT Control field

9.2.4.6.1 General

Remove Figure 9-8 (HT Control field).

Insert Table 9-9a(#2373) as follows:

Table 9-9a—HT Control field

Variant	Bit 0 (value)	Bit 1 (value)	Bit 2-29	Bit 30	Bit 31
HT variant	VHT (0)	HT Control Middle		AC Constraint	RDG/More PPDU
VHT variant	VHT (1)	HE (0)	VHT Control Middle(#548)	AC Constraint	RDG/More PPDU
HE variant	VHT (1)	HE (1)	Aggregated Control		

Change the paragraphs below of 9.2.4.6.1 as follows:

The HT Control field has ~~two~~ three forms~~,~~:(#359)(#1878) the HT variant, ~~and~~ (#1879)the VHT variant, and the HE variant. These forms differ in the values of the VHT and(#711) HE subfields and in their formats, which are shown in Table 9-9a (HT Control field). ~~The two forms differ in the format of the HT Control Middle subfield, described in 9.2.4.6.2 (HT variant) for the HT variant and in 9.2.4.6.3 (VHT variant) for the VHT variant and in the value of the VHT subfield.~~

The VHT subfield, which is B0 of the HT Control field, and the HE subfield, which is B1 of the HT Control field, indicate the variant of the HT Control field.(#1750)(#1244) The VHT subfield is set to 0 to indicate an(#2829) HT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 0 to indicate a VHT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 1 to indicate an(#2829) HE variant HT Control field(#960)(#1127).

The HT Control Middle subfield is defined in 9.2.4.6.2 (HT variant)(#2203) and the VHT Control Middle subfield is defined in 9.2.4.6.3 (VHT variant).

The Aggregated Control subfield is defined in 9.2.4.6.4 (A-Control)(#2203)(#58).

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~~The VHT subfield of the HT Control field indicates whether the HT Control Middle subfield is the VHT Variant or the HT Variant. The VHT subfield is set to 1 to indicate that the HT Control Middle subfield is the VHT Variant and is set to 0 to indicate that the HT Control Middle subfield is the HT Variant.~~

9.2.4.6.3 VHT variant

Change the paragraph below as follows:

The format of the VHT Control Middle subfield of the VHT variant HT Control field is shown in Figure 9-13 (VHT Control Middle subfield of the VHT variant HT Control field).(#550)

Change Figure 9-13 (VHT Control Middle subfield of the VHT variant HT Control field) as follows (remove Reserved field and change title):

	~~B1~~	B2	B3 B5	B6 B8	B9 B23	B24 B26	B27	B28	B29
	~~Reserved~~	MRQ	MSI/ STBC	MFSI/ GID-L	MFB	GID-H	Coding Type	FB Tx Type	Unsolicited MFB
Bits:	~~1~~	1	3	3	15	3	1	1	1

Figure 9-13—VHT Control Middle subfield of the VHT variant HT Control field

Insert a new subclause 9.2.4.6.4 following 9.2.4.6.3:

9.2.4.6.4 A-Control

9.2.4.6.4.1 General

The format of the Aggregated Control (A-Control) subfield of the HE variant HT Control field(#1132) is shown in Figure 9-15a (Aggregated Control subfield of the HE variant HT Control field(#360)(#792)(#1711)(#2204)).

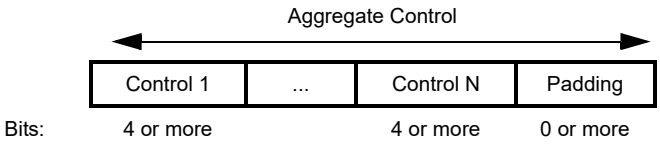


Figure 9-15a—Aggregated Control subfield of the HE variant HT Control field(#360)(#792)(#1711)(#2204)

The A-Control subfield contains a sequence of one or more Control subfields. The format of each Control subfield is defined in Figure 9-15b (Control subfield format). The Control subfield with Control ID subfield equal to 0, if present, is the first subfield of the sequence.

The Control ID subfield indicates the type of information carried in the Control Information subfield. The length of the Control Information subfield is fixed for each value of the Control ID subfield that is not

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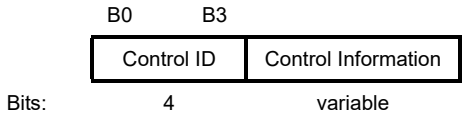


Figure 9-15b—Control subfield format

reserved.(#1251)(#1133) The values of the Control ID subfield and the associated length of the Control Information subfield are defined in Table 9-18a (Control ID subfield values).

Table 9-18a—Control ID subfield values

Control ID value	Meaning	Length of the Control Information subfield (bits)	Content of the Control Information subfield
0	UL MU response scheduling	26	See 9.2.4.6.4.2 (UL MU response scheduling)
1	Operating Mode(#2209)	16	See 9.2.4.6.4.3 (Operating Mode(#2209))
2	HE link adaptation	TBD	See 9.2.4.6.4.4 (HE link adaptation)
3	Buffer Status Report (BSR)(#824)	26	See 9.2.4.6.5 (Buffer Status Report (BSR)(#824))
4	UL Power Headroom(#340)	8	See 9.2.4.6.5.1 (UL power headroom)
5-15	Reserved		

(#1252)The Padding subfield, if present, follows the last Control subfield and is set to a sequence of zeros so that the length of the A-Control subfield carried in the HT Control field is 30 bits.(#792)(#793)(#363)

9.2.4.6.4.2 UL MU response scheduling

If the Control ID subfield is 0, the Control Information subfield contains(#1257) scheduling information for an HE trigger-based PPDU that carries an immediate acknowledgment and follows the HE MU PPDU containing the Control Information subfield (see 25.5.2.2 (Rules for soliciting UL MU frames)).(#2208)

The format of the Control Information subfield is defined in Figure 9-15c (Control Information subfield format when Control ID subfield is 0).

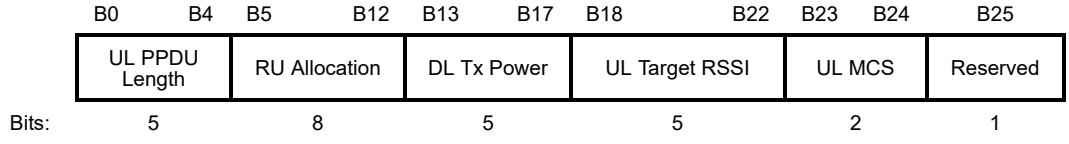


Figure 9-15c—Control Information subfield format when Control ID subfield is 0

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The UL PPDU Length subfield indicates the length of the HE trigger-based PPDU response and is set to the number of OFDM symbols the Data field of the HE trigger-based PPDU minus 1(#Ed). The duration of the HE trigger-based PPDU is calculated as defined in 26.4.3 (TXTIME and PSDU_LENGTH calculation).(#94)

(#1)The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE trigger-based PPDU response and is defined in 9.3.1.23 (Trigger frame format).

The DL TX Power subfield indicates the AP transmit power, combined over all TX antennas and averaged in 20 MHz BW, used for the soliciting frame, in units of dBm. The transmit power, P_{TX}, is calculated as $P_{TX} = -20 + 2 \times F_{Val}$, where F_{Val} is the value of the DL TX Power subfield, except for the value 31, which is reserved.

The UL Target RSSI subfield indicates the AP target receive power, i.e., averaged RSSI over all AP's antennas, for the responding STA when transmitting the HE trigger-based PPDU, in units of dBm. The target receive power, TRSSI, is calculated as $T_{RSSI} = -90 + 2 \times F_{Val}$, except for the value 31 that indicates to the STA to transmit at maximum power for the assigned MCS.

NOTE—It is possible that a STA can not satisfy the target RSSI due to its hardware or regulatory limitation.

The UL MCS subfield indicates the MCS, from MCS0 to MCS3, to be used by the receiving STA for the HE trigger-based PPDU (see 26.5 (Parameters for HE-MCSs(#552))).

9.2.4.6.4.3 Operating Mode(#2209)

If the Control ID subfield is 1, the Control Information subfield contains(#1257) information related to the receive operating mode(#2209) of the STA transmitting the frame containing this information (see 25.8 (Receive operating mode)).

The format of the Control Information subfield is defined in Figure 9-15d (Control Information subfield format when Control ID subfield is 1).

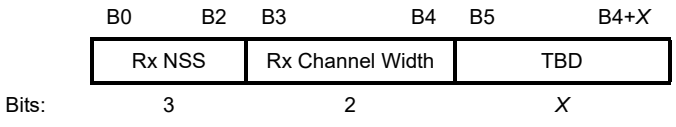


Figure 9-15d—Control Information subfield format when Control ID subfield is 1

The RX NSS subfield indicates the maximum number of spatial streams, N_{SS}, that the STA can receive(#1258) and is set to $N_{SS} - 1$.

The RX Channel Width subfield indicates the operating channel width supported by the STA in reception, and is set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 160 MHz.

9.2.4.6.4.4 HE link adaptation

If the Control ID subfield is 2, the Control Information subfield contains(#1257) information related to the HE link adaptation procedure (see 9.31.4 (Link adaptation using the HE variant HT Control field)).

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The format of the Control Information subfield is defined in Figure 9-15e (Control Information subfield format when Control ID subfield is 2).

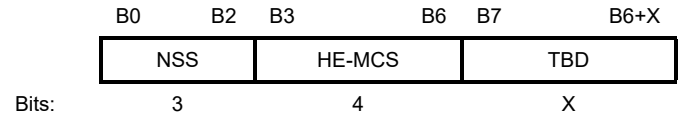


Figure 9-15e—Control Information subfield format when Control ID subfield is 2

The NSS subfield indicates the recommended number of spatial streams, N_{SS}, and is set to $N_{SS} - 1$.

The HE-MCS subfield indicates the recommended HE-MCS, and is set to the HE-MCS Index value (defined in 26.5 (Parameters for HE-MCSs(#552))).

9.2.4.6.5 Buffer Status Report (BSR)(#824)

The Control Information subfield, when the Control ID subfield is 3, contains buffer status information used for UL MU operation (see 25.5.2.5 (HE buffer status feedback operation for UL MU)).

The format of the Control Information subfield is defined in Figure 9-15f (Control Information subfield format when Control ID subfield is 3).

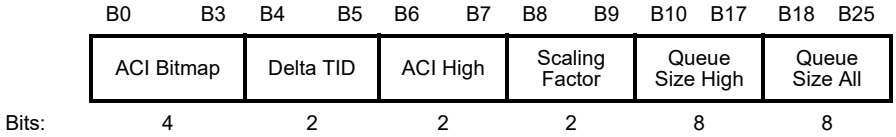


Figure 9-15f—Control Information subfield format when Control ID subfield is 3

The ACI Bitmap subfield indicates the access categories for which the buffer status is reported and its encoding is shown in Table 9-18b (ACI Bitmap subfield encoding). Each bit of the bitmap is set to 1 to indicate that the buffer status of the AC, which ACI is identified by the location of the bit in the ACI Bitmap subfield, is reported and set to 0 otherwise.

Table 9-18b—ACI Bitmap subfield encoding

B0	B1	B2	B3
AC_BE	AC_BK	AC_VI	AC_VO

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The Delta TID subfield, together with the values of the AC Bitmap subfield, indicate the number of TIDs for which the STA is reporting the buffer status. The encoding of the Delta TID subfield is defined in Table 9-18c (Delta TID subfield encoding).

Table 9-18c—Delta TID subfield encoding

Number of bits in the ACI Bitmap subfield that are set to 1	Mapping of Delta TID subfield value and number of TIDs, N_{TID}
0	Values 0 to 2 are not applicable; Value 3 indicates 8 TIDs (i.e., all ACs have traffic)
1	Value 0 indicates 1 TID; Value 1 indicates 2 TIDs; Values 2 to 3 are not applicable;
2	Value 0 indicates 2 TID; Value 1 indicates 3 TIDs; Value 2 indicates 4 TIDs; Value 3 is not applicable;
3	Value 0 indicates 3 TID; Value 1 indicates 4 TIDs; Value 2 indicates 5 TIDs; Value 3 indicates 6 TIDs;
4	Value 0 indicates 4 TID; Value 1 indicates 5 TIDs; Value 2 indicates 6 TIDs; Value 3 indicates 7 TIDs;
NOTE—The number of TIDs can be obtained as $N_{TID} = N_{ones} + F_{Val}$, where N_{ones} is the number of bits set to one in the AC Bitmap subfield, and F_{Val} is the value of the Delta TID subfield except when N_{ones} is equal to 0 for which there is the $N_{TID} = 8$ case.	

The ACI High subfield indicates the ACI of the AC for which the BSR is indicated in the Queue Size High subfield.

The Scaling Factor subfield indicates the unit *SF*, in octets, of the Queue Size subfields. *SF* is equal to:

16 if the Scaling Factor subfield is 0

128 if the Scaling Factor subfield is 1

2 048 if the Scaling Factor subfield is 2

16 384 if the Scaling Factor subfield is 3

The Queue Size High subfield indicates the amount of buffered traffic, in units of *SF* octets, for the AC identified by the ACI High subfield.

The Queue Size All subfield indicates the amount of buffered traffic, in units of *SF* octets, for all the ACs identified by the ACI Bitmap subfield.

The queue size values in the Queue Size High and Queue Size All subfields are the total sizes, rounded up to the nearest multiple of SF octets, of all MSDUs and A-MSDUs buffered at the STA (including the MSDUs or A-MSDUs contained in the present (A-)MPDU) in the delivery queues used for MSDUs and A-MSDUs with AC(s) that are specified in the ACI High and ACI Bitmap subfields, respectively. A queue size value of 254 is used for all sizes greater than $254 \times SF$ octets. A queue size value of 255 is used to indicate an unspecified or unknown size. If a QoS Data frame is fragmented and is not carried in an A-MPDU, the queue size value can remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted. If a QoS Data frame is fragmented and is carried in an A-MPDU, the queue size values are set according to the rules in 10.9 (HT operation).(#824)(#93)(#1067)(#2388)

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9.2.4.6.5.1 UL power headroom

The Control Information subfield, when the Control ID subfield is 4, contains the UL power headroom used for power pre-correction (see 26.3.13.2 (Power pre-correction).

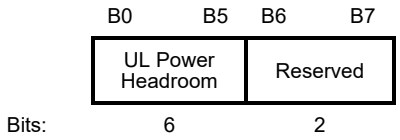


Figure 9-15g—Control Information subfield format when the Control ID subfield is 4

The 5 LSBs (B0-B4) of the UL Power Headroom subfield indicate the available power headroom in units of dB, for the current MCS. The resolution for the UL power headroom reported in UL Power Headroom subfield is 1 dB. The UL Power Headroom subfield carries a value 0 to 31 that maps to 0 dB to 31 dB. B5 of the UL Power Headroom subfield is set to 1 to indicate that the minimum transmit power for the current MCS is reached by the STA and set to 0 otherwise.(#340)

9.2.5 Duration/ID field (QoS STA)

9.2.5.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Change item a) of the 2nd paragraph as follows:

The Duration/ID field is determined as follows:

a) Single protection settings.

1) For an RTS frame that is not part of a dual clear-to-send (CTS) exchange and is not part of a BDT exchange(11ah), the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one Ack or BlockAck frame if required, plus any NDPs required, plus explicit feedback if required, plus applicable IFSs.

1a) In an MU-RTS frame, the Duration/ID field is set to the estimated time, in microseconds, required for the pending transmission.

Change item b) of the 2nd paragraph as follows:(#366)

b) Multiple protection settings. The Duration/ID field is set to a value D as follows:

4) Else $T_{END-NAV} - T_{PPDU} \le D \le T_{TXOP-REMAINING} - T_{PPDU}$

where

$T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 10.22.2.8 (TXOP limits) (for a TXOP limit of 0), including applicable IFS durations

$T_{PENDING}$ is the estimated time required for the transmission of

—Pending MPDUs of the same AC

—Any associated immediate response frames

—Any HT NDP, VHT NDP, or Beamforming Report Poll frame transmissions and explicit feedback response frames

—Applicable IFSs

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—Any RDG

—Any pending QoS Null frame exchanges by paged STAs(11ah)

—Any pending PS-Poll or NDP PS-Poll frame exchanges by paged STAs(11ah)

—Any DL MU PPDUs

—Any HE trigger-based PPDUs

—Any Trigger frames to solicit HE trigger-based PPDUs

T_{TXOP} is the duration given by dot11EDCATableTXOPLimit (dot11QAPEDCATableTXOPLimit for the AP) for that AC

$T_{TXOP-REMAINING}$ is T_{TXOP} less the time already used time within the TXOP

$T_{END-NAV}$ is the remaining duration of any NAV set by the TXOP holder, or 0 if no NAV has been established

T_{PPDU} is the time required for transmission of the current PPDU

9.2.5.7 Setting for control response frames

Insert a new paragraph after the 2nd paragraph of this subclause:

In a CTS frame that is transmitted in response to an MU-RTS frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the MU-RTS frame that elicited the CTS frame minus the time, in microseconds, between the end of the PPDU carrying the MU-RTS frame and the end of the PPDU carrying the CTS frame.

9.3 Format of individual frame types

9.3.1 Control frames

9.3.1.3 CTS frame format

Change the 2nd paragraph of this subclause as follows:

When the CTS frame is a response to an RTS frame, the value of the RA field of the CTS frame is set to the address from the TA field of the RTS frame with the Individual/Group bit forced to the value 0. When the CTS frame is a response to an MU-RTS frame, the value of the RA field of the CTS frame is set to the address from the TA field of the MU-RTS frame.(#2603)

9.3.1.8 BlockAckReq frame format

9.3.1.8.2 Basic BlockAckReq variant

Change Figure 9-28 as follows:

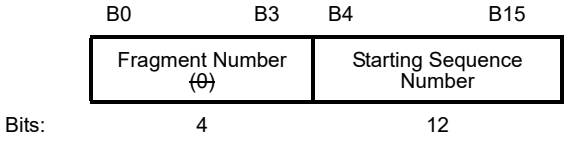


Figure 9-28—Block Ack Starting Sequence Control subfield(#515)

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9.3.1.9 BlockAck frame format

9.3.1.9.1 Overview

Change Figure 9-33 as follows:

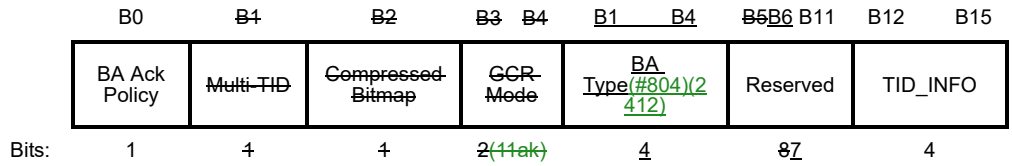


Figure 9-33—BA Control field

Change the 3rd paragraph of this subclause as follows:

The RA field of the BlockAck frame that is not a Multi-STA BlockAck variant(#Ed) is the address of the recipient STA that requested the Block Ack. An HE AP that transmits a Multi-STA BlockAck frame with different values of the AID subfield in Per STA Info subfields sets the RA field to the broadcast address. An HE AP that transmits a Multi-STA BlockAck frame with a single AID subfield or with the same values of the AID subfield in Per STA Info subfields sets the RA field to the address of the recipient STA that requested the Block Ack or to the broadcast address. An HE non-AP STA transmits a Multi-STA BlockAck frame with a single AID subfield or with the same values of the AID subfield in Per STA Info subfields and sets the RA field to the address of the recipient STA that requested the Block Ack frame.(#2212)

Change the 6th paragraph of this subclause as follows:

For BlockAck frames sent under Delayed and HT-delayed agreements, the BA Ack Policy subfield of the BA Control field has the meaning shown in Table 9-23 (BA Ack Policy subfield). For BlockAck frames sent under other types of agreement, the BA Ack Policy subfield is reserved. A Multi-STA BlockAck frame is not sent under Delayed and HT-delayed agreements.

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Change Table 9-24 as follows:

Table 9-24—BlockAck frame variant encoding(11ak)

~~Multi-TID subfield value~~	~~Compressed Bitmap subfield value~~	~~GCR subfield value~~	BA Type (B1 B2 B3 B4)	BlockAck frame variant
~~0~~	~~0~~	~~00~~	0000	Basic BlockAck
		~~01~~	0001	Reserved
		~~10~~	0010	Reserved
		~~11~~	0011	Reserved
~~0~~	~~1~~	~~00~~	0100	Compressed BlockAck
		~~01~~	0101	GLK-GCR BlockAck(#961)(#1137)(#212)
		~~10~~	0110	GCR BlockAck
		~~11~~	0111	Reserved
~~1~~	~~0~~	~~00~~	1000	Extended Compressed BlockAck
		~~01~~	1001	Reserved
		~~10~~	1010	Reserved
		~~11~~	1011	Reserved
~~1~~	~~1~~	~~00~~	1100	Multi-TID BlockAck
		~~01~~	1101	~~Reserved~~ Multi-STA BlockAck(#2413)
		~~10~~	1110	Reserved
		~~11~~	1111	Reserved

Change the 7th paragraph of this subclause as follows:

The ~~values of the Multi-TID, Compressed Bitmap, and GCR~~ BA Type subfield~~s~~ of the BA Control field determines which of the BlockAck frame variants is represented, as indicated in the Table 9-24 (BlockAck frame variant encoding(11ak)).

9.3.1.9.3 Compressed BlockAck variant

Change subclause 9.3.1.9.3 (including Figure 9-34) as follows:

The TID_INFO subfield of the BA Control field of the Compressed BlockAck frame contains the TID for which this BlockAck frame is sent.

The BA Information field of the Compressed BlockAck frame comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as shown in Figure 9-35 (BA Information field (Compressed BlockAck)). The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 10.24.7.5 (Generation and transmission of BlockAck

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frames by an HT STA or DMG STA). ~~The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.~~

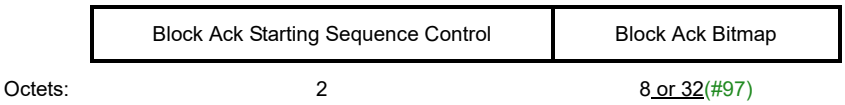


Figure 9-34—BA Information field (Compressed BlockAck)

(#97)The Fragment Number subfield is set as defined in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant)

Insert the following table:

Table 9-24a—Fragment Number subfield encoding for the Compressed BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/ OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2-B1	B0			
0	0	0	OFF	8 octets	64
0	1	0		Reserved	Reserved
0	2	0		32 octets	256
0	3	0		Reserved	Reserved
0	0	1	ON	8 octets	16
0	1	1		Reserved	Reserved
0	2	1		32 octets	64
0	3	1		Reserved	Reserved
1	Any	Any		Reserved	Reserved
NOTE—A Compressed BlockAck frame with B0 of the Fragment Number subfield set to 1 can only be sent to an HE STA whose HE Fragmentation Support subfield in the HE Capabilities element it transmits is 3 (see 25.3 (Fragmentation)).					

Change the remainder of 9.3.1.9.3 as follows:

(#97)When B0 of the Fragment Number subfield is 0, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is used to indicate the receive status of up to 64 or 256 MSDUs and A-MSDUs depending upon the value of B2-B1 in the Fragment Number subfield as shown in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant).~~The Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is 8 octets in length and is used to indicate the received status of up to 64 MSDUs and A-MSDUs.~~ Each bit that is equal to 1 in the compressed Block Ack Bitmap subfield(#1279) acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number, with the first bit of the Block Ack Bitmap subfield(#1280) corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

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When (#1806)B0 of the Fragment Number subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is used to indicate the receive status of up to 16 or 64 MSDUs and A-MSDUs depending upon the value B2-B1 in the Fragment Number subfield as shown in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant). If bit position *n* of the Block Ack Bitmap subfield(#1281) is 1, it acknowledges receipt of an MPDU with sequence number value *SN* and fragment number value *FN* with $n = 4 \times (SN - SSN) + FN$, where *SSN* is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position *n* of the Block Ack Bitmap subfield(#1282) is 0, it indicates that the MPDU has not been received.(#1138)

NOTE—When (#1808)the B0 of the Fragment Number subfield is equal to 1 then the (#1139)Block Ack Bitmap subfield(#1278) is split into (#1809)(Block Ack Bitmap subfield length)/4 subbitmaps, each of which indicates receive status for (#1270)up to 4 fragments of each of the MSDUs(#2300) as indicated in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant). (#1275)For an A-MSDU, only the first bit of the subbitmap is used, as fragmentation is not allowed in an A-MSDU.

Insert a new subclause after 9.3.1.9.6:

9.3.1.9.7 Multi-STA BlockAck variant

The format defined below is used for multi-STA multi-TID, and multi-STA single TID BlockAck variant. Multi-STA BlockAck(#Ed) frames shall be supported if either UL MU or multi-TID A-MPDU operation is supported.(#80)

The TID_INFO subfield of the BA Control field of the Multi-STA BlockAck frame is reserved.

The BA Information field of the Multi-STA BlockAck frame comprises one or more (#1271)Per STA Info subfields. The Per STA Info subfield is shown in Figure 9-38a (Per STA Info subfield format).

	Per AID TID Info	Block Ack Starting Sequence Control	Block Ack Bitmap
Octets: (#555)	2	0 or 2	0, 4, 8, 16 or 32

Figure 9-38a—Per STA Info subfield format

The Per AID TID Info subfield is shown in Figure 9-38b (Per AID TID Info subfield format).

	B0	B10	B11	B12	B15
	AID		Ack Type(#1408)	TID	
Bits:	11		1	4	

Figure 9-38b—Per AID TID Info subfield format

When Multi-STA BlockAck variant is intended for a non-AP STA, the AID subfield(#2581) carries the AID of the non-AP STA for which the Per STA Info subfield(#1272) is intended. When the Multi-STA BlockAck variant is intended for an AP, the AID subfield is set to 0.(#99)

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NOTE—One or more Per STA Info subfields with same value of the AID subfield and different values of the TID subfields can be present in the Multi-STA BlockAck frame.(#80)

The TID subfield(#2581) contains the TID for which the acknowledgment or block acknowledgment contained in the Per AID TID Info subfield applies.

NOTE—When a Multi-STA BlockAck frame is used to acknowledge a management frame, the TID value is set to 15.(#100)

If the Ack Type(#1408) subfield is (#2185)1 and the TID value of the Per AID TID Info subfield is less than 8 or equal to 15, then the Block Ack Starting Sequence Control and Block Ack Bitmap subfields(#1274) are not present and the Per STA Info subfield(#1141) acknowledges(#Ed) successful reception of a single MPDU indicated by the TID of the Per AID TID Info subfield. (#2414)(#2582)If the Ack Type subfield is 1 and the TID subfield of the Per AID TID Info field is 14, then the Block Ack Starting Sequence Control and Block Ack Bitmap are not present and the Per STA Info field acknowledges(#Ed) successful reception of all the MPDUs carried in the eliciting A-MPDU. (#2232)(#2458)The Ack Type field is not set to 1 when responding to a BlockAckReq frame or an MU-BAR frame. If the Ack Type(#1408) subfield is 0, then the Block Ack Starting Sequence Control and Block Ack Bitmap subfields(#1141) are present.

If the Ack Type field is 0, the Fragment Number subfield encoding is defined in Table 9-24b (Fragment Number subfield encoding for the Multi-STA BlockAck variant).

Table 9-24b—Fragment Number subfield encoding for the Multi-STA BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/ OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2-B1	B0			
0	0	0	OFF	8 octets	64
0	1	0		16 octets	128
0	2	0		32 octets	256
0	3	0		4 octets	32
0	0	1	ON	8 octets	16
0	1	1		16 octets	32
0	2	1		32 octets	64
0	3	1		4 octets	8
1	Any	Any		Reserved	Reserved
NOTE—A Multi-STA BlockAck frame with B0 of the Fragment Number subfield set to 1 can only be sent to an HE STA whose HE Fragmentation Support subfield in the HE Capabilities element it transmits is 3 (see 25.3 (Fragmentation)).					

When B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield(#1289) is 0(#515)(#1182), the Block Ack Starting Sequence Control subfield is as defined in Figure 9-28. The BA Information field of the Multi-STA BlockAck frame contains an 8-octet, 16-octet, 32-octet or 4-octet Block Ack Bitmap subfield depending on B2-B1 of(#Ed) the Fragment Number subfield as defined in the Table 9-24b (Fragment Number subfield encoding for the Multi-STA BlockAck variant). Each bit that is equal to 1 in the Block Ack Bitmap subfield acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number with the first bit of the Block Ack Bitmap subfield corresponding to the

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MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

When B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield(#1290) is 1, the Block Ack Bitmap subfield of the BA Information field of the Multi-STA Block Ack frame is used to indicate the receive status of up to 16, 32, 64 or 8 MSDUs and A-MSDUs depending on B2-B1 of(#Ed) the Fragment Number subfield as shown in the Table 9-24b (Fragment Number subfield encoding for the Multi-STA BlockAck variant). If bit position *n* of the Block Ack Bitmap subfield(#1281) is 1, it acknowledges receipt of an MPDU with sequence number value *SN* and fragment number value *FN* with $n = 4 \times (SN - SSN) + FN$, where *SSN* is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position *n* of the Block Ack Bitmap subfield(#1282) is 0, it indicates that the MPDU has not been received.(#1138)

NOTE—When B0 of the Fragment Number subfield is 1(#1142) then the Block Ack Bitmap(#1143) field is split into Block Ack Bitmap field length/4 subbitmaps, each of which indicates receive status for 4 fragments of each of the MSDUs(#2300) as indicated in Table 9-24b (Fragment Number subfield encoding for the Multi-STA BlockAck variant). (#1287)For an A-MSDU, only the first bit of the subbitmap is used, as fragmentation is not allowed in an A-MSDU.

Change the title of 9.3.1.20 as follows:

9.3.1.20 VHT/HE NDP Announcement frame format

Insert the following at the end of 9.3.1.20:

(#1222)The HE NDP Announcement uses the same Frame Control Type as the VHT NDP Announcement. The frame format of the HE NDP Announcement frame with multiple STA info field is shown in Figure 9-51a (HE NDP Announcement frame format).

	Frame Control	Duration	RA	TA	Sounding Dialog Token	STA Info 1	…	STA Info *n*	FCS
Octets:	2	2	6	6	1	4		4	4

Figure 9-51a—HE NDP Announcement frame format

Bit 1 of the Sounding Dialog Token is set to 1 to indicate an HE NDP Announcement frame.

The format of the STA Info subfield in an HE NDP Announcement Frame is defined in Figure 9-51b (STA Info subfield format in an HE NDP Announcement frame).(#Ed)

	B0 B10	B11 B24	B25 B26	B27	B28	B29 B31
	AID11	Partial BW Info	Feedback Type And Ng	Disambiguation (#Ed)	Codebook Size	Nc
Bits:	11	14	2	1	1	3

Figure 9-51b—STA Info subfield format in an HE NDP Announcement frame

The Partial BW Info subfield is defined in Figure 9-51c (Partial BW Info subfield).

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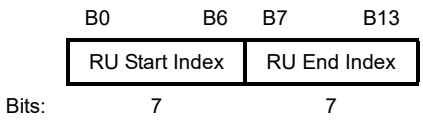


Figure 9-51c—Partial BW Info subfield

The RU Start Index subfield of the Partial BW subfield indicates the first 26-tone RU for which the HE beamformer is requesting feedback. The RU End Index subfield of the Partial BW subfield indicates the last 26-tone RU for which the HE beamformer is requesting feedback.

The Feedback Type And Ng and Codebook Size subfields are defined inTable 9-25a (Feedback Type And Ng subfield and Codebook Size subfield encoding)

Table 9-25a—Feedback Type And Ng subfield and Codebook Size subfield encoding

Feedback Type + Ng + codebook size	Description
000	SU, Ng4, quantization resolution = {2, 4}
001	SU, Ng4, quantization resolution = {4, 6}
010	SU, Ng16, quantization resolution = {2, 4}
011	SU, Ng16, quantization resolution = {4, 6}
100	MU+Ng4, quantization resolution = {5, 7}
101	MU+Ng4, quantization resolution = {7, 9}
110	CQI only feedback
111	MU+Ng16, quantization resolution = {7, 9}

The Disambiguation subfield is set to 1 to prevent a VHT STA from wrongly determining it's AID in the HE STA Info.

Insert a new subclause after 9.3.1.22:

9.3.1.23 Trigger frame format

The Trigger frame solicits and allocates resources for UL MU transmissions a SIFS(#2195) after the PPDU that carries the Trigger frame(#368). The Trigger frame also carries other information required by the responding STA to send an HE trigger-based PPDU(#718).

The frame format for the Trigger frame is as defined in Figure 9-52a (Trigger frame).

The Duration(#1297) field is set as defined in 9.2.5 (Duration/ID field (QoS STA)).

The RA field of the Trigger frame is the address of the recipient STA.(#262) If the Trigger Frame has one User Info field then the RA of the Trigger Frame is the STA's MAC Address. If the Trigger Frame has multiple User Info fields then the RA of the Trigger Frame is the broadcast address.(#102)

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	Frame Control	Duration	(RA)	TA	Common Info	User Info(#1520)	...	User Info(#1520)	Padding	FCS
Octets:	2	2	6	6	TBD	TBD		TBD	variable(#2890)	4

Figure 9-52a—Trigger frame

The TA field value is the address of the STA transmitting the Trigger frame.

The Common Info field is defined in Figure 9-52b (Common Info field(#2134)(#101)).

	B0 B3	B4 B15	B16	B17	B18 B19	B20 B21	B22	B23 B25	B26
	Trigger Type	Length	Cascade Indication	CS Required	BW	GI And LTF Type(#1420)(#1300)	MU-MIMO LTF Mode	Number Of HE-LTF Symbols	STBC
Bits:	4	12	1	1	2	2	1	3	1

	B27	B28 B33	B34 B36	B37 B52	B53	B54 B62	B63	
	LDPC Extra Symbol	AP TX Power	Packet Extension	Spatial Reuse	Doppler	HE-SIG-A Reserved	Reserved	Trigger Dependent Common Info
Bits:	1	6	3	16	1	9	1	variable

Figure 9-52b—Common Info field(#2134)(#101)

The Trigger Type subfield indicates the type of the Trigger frame. The Trigger frame can include an optional Trigger Dependent Common Info field(#613) and optional Trigger Dependent User Info field(#1520)(#613). The Trigger Type subfield encoding is defined in Table 9-ax2 (Trigger Type subfield encoding)(#376).

Table 9-ax2—Trigger Type subfield encoding

Trigger Type field value	Description
0	Basic Trigger
1	Beamforming Report Poll(#Ed)
2	MU-BAR
3	MU-RTS
4	Buffer Status Report Poll (BSRP)(#824)
5-15(#262)	Reserved

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The Length subfield of the Common Info field indicates the value of the L-SIG Length field of the HE trigger-based PPDU that is the response to the Trigger frame.

If the Cascade Indication subfield is 1, then a subsequent Trigger frame as defined in 25.7 (TWT operation) and in 25.14.2 (Power save with UL OFDMA-based random access) follows the current Trigger frame. Otherwise the Cascade Indication subfield is 0.(#372)

The CS Required subfield is set to 1 to indicate that the STAs identified in the User Info(#1520) fields are required to use ED to sense the medium and to consider the medium state and the NAV in determining whether or not to respond(#557). The CS Required(#2689) subfield is set to 0 to indicate that the STAs identified in the User Info(#1520) fields are not required to(#234) consider the medium state or the NAV in determining whether or not to respond.

The BW subfield indicates the bandwidth in the HE-SIG-A of the HE trigger-based PPDU and is defined in Table 9-ax3 (BW subfield encoding).(#101)

Table 9-ax3—BW subfield encoding

BW subfield value	Description
0	20 MHz
1	40 MHz
2	80 MHz
3	80+80 MHz or 160 MHz

The GI And LTF Type subfield(#1420)(#1300) of the Common Info field indicates the GI(#1420) and HE-LTF type of the HE trigger-based PPDU response. The GI And LTF Type subfield(#1420)(#1300) encoding is defined in Table 9-ax4 (GI And LTF Type subfield(#1420)(#1300) encoding).

Table 9-ax4—GI And LTF Type subfield(#1420)(#1300) encoding

GI(#1420) And LTF field value	Description
0	1x LTF + 1.6 μs GI(#101)
1	2x LTF + 0.8 μs GI(#1420)
2	2x LTF + 1.6 μs GI(#1420)
3	4x LTF + 3.2 μs GI(#1420,#1146)

The MU-MIMO LTF Mode subfield of the Common Info field indicates the LTF mode of the UL MU-MIMO HE trigger-based PPDU response. The AP shall set the MU-MIMO LTF Mode subfield to Single Stream pilot if the triggered UL PPDU contains partial or full UL OFDMA allocation.(#227) The MU-

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MIMO LTF Mode subfield encoding is defined in Table 9-ax5 (MU-MIMO LTF Mode subfield encoding).(#101)

Table 9-ax5—MU-MIMO LTF Mode subfield encoding

MU-MIMO LTF subfield value	Description
0	Single stream pilots
1	Mask LTF sequence of each spatial stream by a distinct orthogonal code

The Number of HE-LTFs subfield of the Common Info field indicates the number of HE-LTF symbols present in the HE trigger-based PPDU response. The number of HE-LTF symbols is a function of the total number of space-time streams. The number of HE-LTF subfield encoding is defined in Table 22-13.

The STBC subfield of the Common Info field indicates the status of STBC encoding of the HE trigger-based PPDU response. It is set to 1 if STBC encoding is used and set to 0 otherwise.

The LDPC Extra Symbol subfield of the Common Info field indicates the status of LDPC Extra Symbol. It is set to 1 when LDPC extra symbol is present and set to 0 otherwise.

The AP Tx Power subfield of the Common Info field indicates the combined average power per 20 MHz bandwidth of all transmit antennas used to transmit the trigger frame at the HE AP. The resolution for the transmit power reported in the Common Info field is 1 dB. The AP Tx Power subfield encoding is defined in Table 9-ax6 (AP Tx Power subfield encoding).(#101)

Table 9-ax6—AP Tx Power subfield encoding

AP Tx Power subfield value	Description
0-60	Values 0 to 61 maps to –20 dBm to 40 dBm
61-63	Reserved

(#101)The Packet Extension subfield of the Common Info field indicates the packet extension duration of the trigger-based PPDU response. The first two bits indicate the "a-factor" and the third bit indicates the PE-Disambiguity.

The Spatial Reuse subfield(#Ed) carries the value for the Spatial Reuse field in the HE-SIG-A field of the HE trigger-based PPDU transmitted as a response to the Trigger frame. For HE trigger-based PPDU, four SR fields are signaled:

- For 20 MHz one SR field corresponding to entire 20 MHz (other 3 fields indicate identical values)
- For 40 MHz two SR fields for each 20 MHz (other 2 fields indicate identical values)
- For 80 MHz four SR fields for each 20 MHz
- For 160 MHz four SR fields for each 40 MHz

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When operating 40 MHz in 2.4GHz band, two SR fields, SR field 1 and SR field 2, are set to same values. When operating 80+80 MHz, SR field 3 is set to same value as SR field 1, and SR field 4 is set to the same value as SR field 2.(SR Motion #11)

The exact location of each 20 MHz for 80 MHz BW is TBD.

The Doppler subfield indicates(#Ed) a high doppler mode of transmission.

Editor's Note: The edits in 16/780r1 change Figure 9-51c without change tracking. Presumably HE-SIG-A Info subfield is changed to HE-SIG-A Reserved subfield. However, no edits delete the next paragraph, and, in fact, a comment (#1299) modifying this paragraph is accepted in the same document.

The HE-SIG-A Info subfield of the Common Info field indicates the content of the HE-SIG-A field of the HE trigger-based PPDU response. The TBD bits in HE-SIG-A of the HE trigger-based PPDU that are(#1299) implicitly known by all responding STAs can be excluded.

The HE-SIG-A Reserved subfield indicate the values of the reserved bits in the HE-SIG-A of the HE trigger-based PPDU transmitted as a response to the Trigger frame. The number of reserved bits is 9.(#101)

The User Info(#1520) field is defined in Figure 9-52c (User Info(#1520) field(#262)(#663)).(#101)

	B0 B11	B12 B19	B20	B21 B24	B25	B26 B31	B32 B38	B39	
	AID12	RU Allocation	Coding Type	MCS	DCM	SS Allocation	Target RSSI	Reserved	Trigger Dependent User Info(#1520)
Bits:	12	8	1	4	1	6	7	1	variable

Figure 9-52c—User Info(#1520) field(#262)(#663)

The AID12 subfield of the User Info(#1520) field carries the least significant(#Ed) 12 bits of the AID of the STA for which the User Info field is intended(#511). An AID12 subfield that is 0 indicates that the User Info field identifies an RU for random access.(#558) User Info fields with AID = 0 shall be allocated only after User Info fields with AID not equals to 0, if any, and before the MAC padding field, if present.(MAC Motion #86)

The RU Allocation subfield of the User Info(#1520) field indicates the RU used by the HE trigger-based PPDU of the STA identified by the AID12(#Ed) subfield(#1302). The RU Allocation subfield is 8 bits in length. The first bit, B12, indicates the allocated RU is located in the primary or non-primary 80 MHz (zero

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for primary and one for non-primary). The mapping of the subsequent 7 bits, B19-B13, indices to the RU allocation is defined in Table 9-ax7 (The encoding of B19-B13 of the RU Allocation subfield(#Ed)).

Table 9-ax7—The encoding of B19-B13 of the RU Allocation subfield(#Ed)

B19-B13	Description(#Ed)	Number of entries
0000000 - 0100100	Possible 26-tone RU cases in 80 MHz	37
0100101 - 0110100	Possible 52-tone RU cases in 80 MHz	16
0110101 - 0111100	Possible 106-tone RU cases in 80 MHz	8
0111101 - 1000000	Possible 242-tone RU cases in 80 MHz	4
1000001 - 1000010	Possible 484-tone RU cases in 80 MHz	2
1000011	996-tone RU cases in 80 MHz	1
1000100	2×996-tone RU case	1
Total		69

(#864)B12 is set to 0 for a 20 MHz, 40 MHz and 80 MHz PPDU. For the 2×996-tone RU case, B12 is set to 1. The mapping of subsequent 7 bits indices B19-B13 to RU index in each row depends on the BW bits in Common Info field:

— For a 20 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU) in an increasing order. B19-B13 are 0000000 indicates 26-tone RU1 [–121: –96], 0001000 indicates 26-tone RU9 [96: 121], and 0001001-0100100 are not used. B19-B13 are 0100101 indicates 52-tone RU1 [–121: –70], 0101000 indicates 52-tone RU4 [70: 121], and 0101001-0110100 are not used. B19-B13 are 0110101 indicates 106-tone RU1 [–122: –17], 0110110 indicates 106-tone RU2 [17: 122], and 0110111-0111100 are not used. B19-B13 are 0111101 indicates 242-tone RU1 [–122: –2, 2:122], and 0111110-1000000 are not used.

— For a 40 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) in an increasing order. B19-B13 are 0000000 indicates 26-tone RU1 [–243: –218], 0010001 indicates 26-tone RU18 [218: 243], and 0010010-0100100 are not used. B19-B13 are 0100101 indicates 52-tone RU1 [–243: –192], 0101100 indicates 52-tone RU8 [192: 243], and 0101101-0110100 are not used. Similar ordering is followed for 106-tone RU, 242-tone RU and 484-tone RU.

— For an 80 MHz, 160 MHz and 80+80 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU) in an increasing order. B19-B13 are 0000000 indicates 26-tone RU1 [–499: –474], and 0100100 indicates 26-tone RU37 [474: 499]. B19-B13 are 0100101 indicates 52-tone RU1 [–499: –448], and 0110100 indicates 52-tone RU16 [448: 499]. Similar ordering is followed for 106-tone RU, 242-tone RU, 484-tone RU and 996-tone RU. For a 160 MHz and 80+80 MHz PPDU, B19-B13 are 1000100 indicates 2×996-tone RU.

The Coding Type subfield of the User Info(#1520) field indicates the code type of the HE trigger-based PPDU response of the STA identified by the AID12(#Ed) subfield(#1302). Set to 0 for BCC and set to 1 for LDPC.

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The MCS subfield of the User Info(#1520) field indicates the MCS of the HE trigger-based PPDU response of the STA identified by the AID12(#Ed) subfield(#1302). The encoding of the MCS field is as defined in Section XXX.

The DCM subfield of the User Info(#1520) field indicates dual carrier modulation of the HE trigger-based PPDU response of the STA identified by the AID12(#Ed) subfield(#1302). A value of 1 indicates that the HE trigger-based PPDU response shall use DCM as defined in section XXX. A value 0 indicates that DCM is not be used(#237).

The SS Allocation subfield of the User Info(#1520) field indicates the spatial streams of the HE trigger-based PPDU response of the STA identified by the AID12(#Ed) subfield(#1302). The format of the SS Allocation subfield is defined in Figure 9-52d (SS Allocation subfield format).(#663)

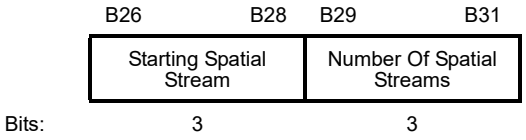


Figure 9-52d—SS Allocation subfield format

The Target RSSI subfield of the User Info field indicates the target received signal power of the HE trigger-based PPDU response. The resolution for the Target RSSI subfield in the User Info field is 1 dB. The Target RSSI subfield encoding is defined in Table 9-ax8 (Target RSSI subfield encoding).(#663)

Table 9-ax8—Target RSSI subfield encoding

Target RSSI subfield	Description
0-90	Values 0 to 90 map to −100 dBm to −20 dBm
91-127	Reserved

The Padding field extends the frame length to give the recipient STAs more time to prepare a response. (#2890)The Padding field of the Trigger frame, if present, is an integer number of octets ≥ 2: Padding field starts with special STAID[11:0] as 0xFFF and the rest bits of the Padding field are all set to one. 0xFFF is reserved as the special value to indicate the start of the MAC padding. The length of the Padding field is in units of octets and is set as defined in the following formulas.

For a non-HT PPDU, HT PPDU and VHT PPDU the length of the Padding field is given by Equation (9-ax1).

$$L_{PAD,MAC} = \left\lceil \frac{N_{DBPS} m_{PAD}}{8} \right\rceil \text{ octets} \qquad \text{(9-ax1)}$$

where

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$$m_{PAD} = \begin{cases} 0, \text{ max TF MAC Padding Duration among receiving STAs} = 0\ \mu s \\ 2, \text{ max TF MAC Padding Duration among receiving STAs} = 8\ \mu s \\ 4, \text{ max TF MAC Padding Duration among receiving STAs} = 16\ \mu s \end{cases}$$

For an HE PPDU, the length of the Padding field is given by Equation (9-ax2).

$$L_{PAD,MAC} = \left\lceil \frac{N_{DBPS,SHORT} m_{PAD}}{8} \right\rceil \text{ octets} \quad \text{(9-ax2)}$$

where

$$m_{PAD} = \begin{cases} 0, \text{ max TF MAC Padding Duration among receiving STAs} = 0\ \mu s \\ 2, \text{ max TF MAC Padding Duration among receiving STAs} = 8\ \mu s \\ 4, \text{ max TF MAC Padding Duration among receiving STAs} = 16\ \mu s \end{cases}$$

STBC is disallowed for Trigger Frame transmission.(#2890)

9.3.1.23.1 Basic Trigger variant(#2219)

If the Trigger frame is a Basic Trigger variant, the Trigger Dependent Common Info field is not present and the Trigger Dependent User Info field is defined in Figure 9-52e (Trigger Dependent User Info field for the Basic Trigger variant).(#Ed)

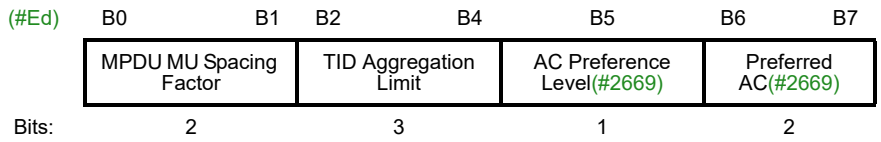


Figure 9-52e—Trigger Dependent User Info field for the Basic Trigger variant

The MPDU MU Spacing Factor subfield indicates the value by which the minimum MPDU start spacing defined in Table 8-159 is multiplied. The MPDU MU Spacing Factor subfield encoding is defined in Table 9-ax9 (MPDU MU Spacing Factor subfield encoding).

Table 9-ax9—MPDU MU Spacing Factor subfield encoding

Value	Description
0	Multiplier = 1
1	Multiplier = 2
2	Multiplier = 4
3	Multiplier = 8

The TID Aggregation Limit subfield indicates the maximum number of TIDs minus 1 that can be aggregated by a STA in a multi-TID A-MPDU carried in the responding HE trigger-based PPDU.

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The value in the TID Aggregation Limit subfield in Trigger frame is less than or equal to the value indicated in the Multi-TID Aggregation Support field in the HE Capabilities element (see 9.4.2.213 (HE Capabilities element)).(#2669)

The AC Preference Level subfield is set to 1 to indicate that MPDUs with TIDs that correspond to the AC indicated in the Preferred AC subfield are recommended with respect to TIDs from other ACs. The AC Preference Level subfield is set to 0 if the AP does not have a recommendation.(#Ed)(#2669)

The Preferred AC subfield indicates the AC that is recommended for aggregation of MPDUs of ACs belonging to the same AC as indicated or higher priority AC(s) within a multi-TID A-MPDU sent as a response to the Trigger frame (see 9.3.1.23 (Trigger frame format)). The encoding of the Preferred AC subfield is shown in Table 9-ax10 (Preferred AC subfield encoding).(#2669)

Table 9-ax10—Preferred AC subfield encoding

Value	Description
0	AC_VO
1	AC_VI
2	AC_BE
3	AC_BK

9.3.1.23.2 Beamforming Report Poll variant(#9)

If the Trigger frame is a Beamforming Report Poll variant, the Trigger Dependent Common Info field is not present and the Trigger Dependent User Info field is defined in Figure 9-52f (Trigger Dependent User Info field for the Beamforming Report Poll variant).

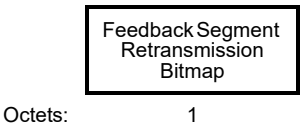


Figure 9-52f—Trigger Dependent User Info field for the Beamforming Report Poll variant

The Feedback Segment Retransmission Bitmap subfield indicates the requested feedback segments of an HE Compressed Beamforming report. If the bit in position n (n = 0 for LSB and n = 7 for MSB) is 1, then the feedback segment with the Remaining Feedback Segments subfield in the HE MIMO Control field equal to n is requested. If the bit in position n is 0, then the feedback segment with the Remaining Feedback Segments subfield in the HE MIMO Control field equal to n is not requested.

9.3.1.23.3 MU-BAR variant

If the Trigger frame is an MU-BAR variant, then the Trigger Dependent Common Info field is defined(#1307) in Figure 9-52g (Trigger Dependent Common Info field for the MU-BAR variant(#614)).

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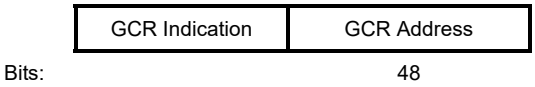


Figure 9-52g—Trigger Dependent Common Info field for the MU-BAR variant(#614)

If the Trigger frame is an MU-BAR variant, then the Trigger Dependent User Info(#1520) field is defined(#1307) in Figure 9-52h (Trigger Dependent User Info field for the MU-BAR variant(#2700))(#2698).

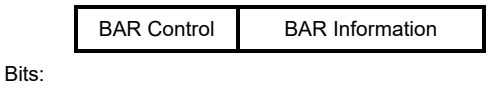


Figure 9-52h—Trigger Dependent User Info field for the MU-BAR variant(#2700)

The BAR Control subfield is defined in 9.3.1.8 (BlockAckReq frame format).

The BAR Information subfield is defined in 9.3.1.8 (BlockAckReq frame format).

9.3.1.23.4 MU-RTS variant

The MU-RTS frame format is a variant of Trigger frame format as shown in Figure 9-52a (Trigger frame).

The RA field of the MU-RTS frame is set to the broadcast address.(#2894)

NOTE—The TA field value is the address of the STA transmitting the MU-RTS frame.(#2603)

(#2222)The Common Info field is defined in Figure 9-52b (Common Info field(#2134)(#101)).

The Trigger Type subfield is set to 3 to indicate MU-RTS variant.

The BW subfield indicates the total PPDU bandwidth, and is defined in Table 9-ax3 (BW subfield encoding).

The Length, GI And LTF Type, MU MIMO LTF Mode, Number of LTFs, STBC, LDPC Extra Symbol, AP TX Power, Packet Extension, Spatial Reuse and HE-SIG-A Reserved fields are reserved.

NOTE—The Trigger Dependent Common Info field is not present in the MU-RTS frame.

The User Info field is defined in Figure 9-52c (User Info(#1520) field(#262)(#663)).

The Coding Type, DCM, SS Allocation and Target RSSI fields are reserved.

(#110)The RU Allocation subfield in the User Info(#1520) field addressed to the STA follows the same definition as described in 9.3.1.23 (Trigger frame format) and(#2222) indicates whether the CTS frame is transmitted on the primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel.(#1763)

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(#1311)(#2222)B12 of the RU Allocation subfield is set to 0 for indication of primary 20 MHz/40 MHz/80 MHz. For 160 MHz/80+80 MHz indication, B12 of the RU Allocation subfield is set to 1. The mapping of B19-B13 to RU Allocation subfield follows the RU index in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU) in an increasing order.

If the BW subfield indicates 20 MHz, then the 242-tone RU entry 0111101 for B19-B13 indicates primary 20 MHz channel.

If the BW subfield indicates 40 MHz, then the 242-tone RU entry for B19-B13 corresponding to the primary 20 MHz channel indicates primary 20 MHz; the 484-tone RU entry 1000001 for B19-B13 indicates the primary 40 MHz channel.

If the BW subfield indicates 80 MHz or 80+80 MHz or 160 MHz, then the 242-tone RU entry for B19-B13 corresponding to the primary 20 MHz indicates the primary 20 MHz channel, the 484-tone RU entry for B19-B13 corresponding to the primary 40 MHz indicates the primary 40 MHz channel and the 996-tone RU entry 1000011 for B19-B13 indicates the primary 80 MHz channel.

If the Bandwidth field indicates 80+80 MHz or 160 MHz, then the entry 1000100 for B19-B13 indicates primary and secondary 80 MHz.

NOTE—The Trigger Dependent User Info field is not present in the MU-RTS frame.(#2222)

9.3.1.23.5 BSRP variant(#824)

The BSRP variant Trigger frame format is as defined in Figure 9-52a (Trigger frame).

The Common Info field of the BSRP variant Trigger frame is defined in Figure 9-52b (Common Info field(#2134)(#101)) and the Trigger Dependent Common Info field is not present.

The User Info field of the BSRP variant Trigger frame is defined in Figure 9-52c (User Info(#1520) field(#262)(#663)) and the Trigger Dependent User Info field is not present.

9.3.2 Data frames

9.3.3 Management frames

9.3.3.1 Beacon frame format

Insert the following new rows (header row shown for convenience) into Table 9-27 (Beacon frame body):

Table 9-27—Beacon frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	TWT	The TWT element is optionally present when dot11TWTOptionActivated(#1313) is true; otherwise it is not present.

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9.3.3.5 Association Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-29 (Association Request frame body):

Table 9-29—Association Request frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

9.3.3.6 Association Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-30 (Association Response frame body):

Table 9-30—Association Response frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

9.3.3.7 Reassociation Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-31 (Reassociation Request frame body):

Table 9-31—Reassociation Request frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

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9.3.3.8 Reassociation Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-32 (Reassociation Response frame body):

Table 9-32—Reassociation Response frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

9.3.3.9 Probe Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-33 (Probe Request frame body):

Table 9-33—Probe Request frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

9.3.3.10 Probe Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-34 (Probe Response frame body):

Table 9-34—Probe Response frame body

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when dot11HEOptionImplemented(#1313) is true; otherwise it is not present.

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9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

9.4.1.11 Action field

Change Table 9-47 as follows (insert new row and updated reserved row):

Table 9-47—Category values

Code	Meaning	See subclause	Robust	Group addressed privacy
	...			
<ANA>	HE	9.6.24 (HE Action frame details)	No	No
~~21~~<ANA+1>–125	Reserved	—	—	—
	...			

Insert the following subclauses after 9.4.1.61:

9.4.1.62 HE MIMO Control field(#223)

The HE MIMO Control field is included in every HE Compressed Beamforming frame (see 9.4.1.63 (HE Compressed Beamforming Report field)). The HE MIMO Control field is defined in Figure 9-121a (HE MIMO Control field).

B0 B2	B3 B5	B6 B7	B8	B9	B10 B11	B12 B14	B15	B16 B22	B23 B29	B30 B35	B36 B39
Nc Index	Nr Index	BW	Grouping	Codebook Information	Feedback Type	Remaining Feedback Segments	First Feedback Segment	RU Start Index	RU End Index	Sounding Dialog Token Number	Reserved
Bits: 3	3	2	1	1	2	3	1	7	7	6	4

Figure 9-121a—HE MIMO Control field

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The subfields for the HE MIMO Control Fields are defined in Table 9-76a (HE MIMO Control field encoding).

Table 9-76a—HE MIMO Control field encoding

Subfield	Description
Nc Index	Indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix minus 1: Set to 0 for *Nc* = 1 Set to 1 for *Nc* = 2 … Set to 7 for *Nc* = 8
Nr Index	Indicates the number of rows, *Nr*, in the compressed beamforming feedback matrix minus 1: Set to 0 for *Nr* = 1 Set to 1 for *Nr* = 2 … Set to 7 for *Nr* = 8
BW	Indicates the channel width (#Ed)used to determine the starting and ending subcarrier indexes when interpreting the RU Start Index and RU End Index subfields. Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz
Grouping	Indicates the subcarrier grouping, *Ng*, used for the compressed beamforming feedback matrix: Set to 0 for *Ng* = 4 Set to 1 for *Ng* = 16
Codebook Information	Indicates the size of codebook entries: If Feedback Type is SU: Set to 0 for 2 bits for ψ, 4 bits for ϕ Set to 1 for 4 bits for ψ, 6 bits for ϕ If Feedback Type is MU: Set to 0 for 5 bits for ψ, 7 bits for ϕ Set to 1 for 7 bits for ψ, 9 bits for ϕ NOTE—The codebook size for MU Feedback with *Ng* = 16 is limited to {9, 7}
Feedback Type	Indicates the feedback type: Set to 0 for SU Set to 1 for MU Set to 2 for CQI feedback(#971)(#2713) 3 is reserved
Remaining Feedback Segments	Indicates the number of remaining feedback segments for the associated VHT Compressed Beamforming frame: Set to 0 for the last feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to a value between 1 and 6 for a feedback segment that is neither the first nor the last of a segmented report. Set to a value between 1 and 7 for a feedback segment that is not the last feedback segment of a segmented report. In a retransmitted feedback segment, the field is set to the same value associated with the feedback segment in the original transmission.

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Table 9-76a—HE MIMO Control field encoding *(continued)*

First Feedback Segment	Set to 1 for the first feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to 0 if not the first feedback segment or if the VHT Compressed Beamforming Report field and MU Exclusive Beamforming Report field are not present in the frame. In a retransmitted feedback segment, the field is set to the same value associated with the feedback segment in the original transmission.
RU Start Index	The starting RU index indicates the first 26-tone RU for which the HE beamformer is requesting feedback.
RU End Index	The ending RU index indicates the last 26-tone RU for which the HE beamformer is requesting feedback.
Sounding Dialog Token Number	The ending RU index indicates the last RU26 for which the HE beamformer is requesting feedback.[sic]

In an HE Compressed Beamforming frame not carrying all or part of a HE Compressed Beamforming report, the Nc Index, Nr Index, Channel Width, Grouping, Codebook Information, Feedback Type and Sounding Dialog Token Number subfields are reserved, the First Feedback Segment subfield is set to 0 and the Remaining Feedback Segments subfield is set to 7.

9.4.1.63 HE Compressed Beamforming Report field

(#112)The HE Compressed Beamforming Report field is used in the HE Compressed Beamforming And CQI frame (see 9.6.24.2 (HE Compressed Beamforming And CQI frame format)) to carry average SNR of each space-time stream and compressed beamforming feedback matrices V for use by a transmit beamformer to determine steering matrices Q, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming).

The size of the HE Compressed Beamforming Report field depends on the values in the HE MIMO Control field. The HE Compressed Beamforming Report field contains HE Compressed Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE Compressed Beamforming and CQI feedback (see 25.6 (HE sounding protocol)). HE Compressed Beamforming Report information is included in the HE Compressed Beamforming and CQI feedback if an SU feedback type or an MU feedback type is indicated in the Feedback Type field in the HE MIMO Control field.

The HE Compressed Beamforming Report information contains the channel matrix elements indexed, first, by matrix angles in order shown in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield), and second, by data and pilot subcarrier index from lowest frequency to highest frequency. The explanation on how these angles are generated from the beamforming feedback matrix V is given in 19.3.12.3.6 (Compressed beamforming feedback matrix) in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield), Nc is the number of columns in a compressed beamforming feedback matrix determined by the Nc Index field of the HE MIMO Control field, Nr is the number of rows in a compressed beamforming feedback matrix determined by the Nr Index field of the HE MIMO Control field.

The beamforming feedback matrix V is formed by the beamformee as follows. The beamformer transmits an NDP with $N_{STS,NDP}$ space-time streams, where $N_{STS,NDP}$ may take a value between 2 and 8. Based on this NDP, the beamformee estimates the $N_{RX,BFEE} \times N_{STS,NDP}$ channel, and based on that channel it determines a $Nr \times Nc$ orthogonal matrix V, where Nr and Nc satisfy Equation (8-1).

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Further restrictions on *Nc* are described in 26.2 (HE PHY service interface). The angles are quantized as defined in Table 9-68 (Quantization of angles).

The HE Compressed Beamforming Report information has the same structure and order as the VHT Compressed Beamforming Report information as defined in Table 9-69 (VHT Compressed Beamforming Report Information).

In Table 9-69 (VHT Compressed Beamforming Report Information), *Ns* is the number of subcarriers for which the Compressed Beamforming Feedback Matrix subfield is sent back to the beamformer. A beamformee may choose to reduce Ns by using a method referred to as grouping, in which only a single Compressed Beamforming Feedback Matrix is reported for each group of *Ng* adjacent subcarriers. For HE Compressed Beamforming Report, *Ns* is a function of the RU Start Index, RU End Index and Grouping subfields in the HE MIMO Control field (see 9.4.1.62 (HE MIMO Control field(#223))). Subcarriers *scidx(0)* and *scidx(Ns*–1*)* represent the S (Start)-tone corresponding to the RU Start Index and E (End)-tone corresponding to the RU End Index, respectively. For 40 MHz and 80 MHz, subcarrier $scidx(i) = scidx(i - 1) + Ng$, where $1 \le i \le Ns - 2$. The S-tone and E-tone corresponding to the possible RU indices are listed in Table 9-76b (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) for $Ng = 4$ and Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) for $Ng = 16$. For 160 MHz, to determine the S-tone and E-tone, RUs 37 to 73 occupying the higher 80 MHz use the same entries in Table 9-76b (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) and Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) as RUs 0 to 36 occupying the lower 80 MHz. For 20 MHz, $scidx(i)$, where $1 \le i \le Ns - 2$, includes all subcarrier indices between the S-tone and the E-tone subcarrier indices described in Table 9-76d (Feedback subcarrier indices for 20 MHz bandwidth for Ng = 4 and Ng = 16) for $Ng = 4$ and $Ng = 16$.

Table 9-76b—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 4

80 MHz 26-tone RU Index	80 MHz (S, E) FB tone	40 MHz 26-tone RU Index	40 MHz (S, E) FB tone	20 MHz 26-tone RU Index	20 MHz (S, E) FB tone
0	–500, –472	0	= (S, E) for 80 MHz + 256		
1	–476, –448	1			
2	–448, –420	2			
3	–420, –392	3			
4	–392, –364	4			
5	–368, –340	5			
6	–340, –312	6			
7	–312, –284	7			
8	–288, –260	8			
9	–260, –232				
10	–232, –204				

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Table 9-76b—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 4 *(continued)*

11	–204, –176				
12	–180, –152				
13	–152, –124				
14	–124, –96			0	–122, –96
15	–100, –72			1	= (S, E) for 80 MHz + 4
16	–72, –44			2	
17	–44, –16			3	= (S, E) for 80 MHz
18	–16, 16			4	
19	16, 44			5	
20	44, 72			6	= (S, E) for 80 MHz – 4
21	72, 100			7	
22	96, 124			8	
23	124, 152				
24	152, 180				
25	176, 204				
26	204, 232				
27	232, 260				
28	260, 288	9	= (S, E) for 80 MHz – 256		
29	284, 312	10			
30	312, 340	11			
31	340, 368	12			
32	364, 392	13			
33	392, 420	14			
34	420, 448	15			
35	448, 476	16			
36	472, 500	17			

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Table 9-76c—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 16

80 MHz 26-tone RU index	80 MHz (S, E) FB tone	40 MHz 26-tone RU index	40 MHz (S, E) FB tone	20 MHz 26-tone RU index	20 MHz (S, E) FB tone
0	–500, –468	0	= (S, E) for 80 MHz + 256		
1	–484, –436	1			
2	–452, –420	2			
3	–420, –388	3			
4	–404, –356	4			
5	–372, –340	5			
6	–340, –308	6			
7	–324, –276	7			
8	–292, –260	8			
9	–260, –228				
10	–244, –196				
11	–212, –164				
12	–180, –148				
13	–164, –116				
14	–132, –84			0	–122, –96
15	–100, –68			1	= (S, E) for 80 MHz + 4
16	–84, –36			2	
17	–52, –4			3	= (S, E) for 80 MHz
18	–20, 20			4	
19	4, 52			5	
20	36, 84			6	= (S, E) for 80 MHz – 4
21	68, 100			7	
22	84, 132			8	
23	116, 164				
24	148, 180				
25	164, 212				

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Table 9-76c—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 16 *(continued)*

26	196, 244				
27	228, 260				
28	260, 292	9	= (S, E) for 80 MHz – 256		
29	276, 324	10			
30	308, 340	11			
31	340, 372	12			
32	356, 404	13			
33	388, 420	14			
34	420, 452	15			
35	436, 484	16			
36	468, 500	17			

Table 9-76d—Feedback subcarrier indices for 20 MHz bandwidth for *Ng* = 4 and *Ng* = 16

Ng	Subcarrier indeces
4	–122, –120, –116, –112, –108, –104, –100, –96, –92, –88, –84, –80, –76, –72, –68, –64, –60, –56, –52, –48, –44, –40, –36, –32, –28, –24, –20, –16, –12, –8, –4, –2, 2, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72, 76, 80, 84, 88, 92, 96, 100, 104, 108, 112, 116, 120, 122
16	–122, –116, –100, –84, –68, –52, –36, –20, –4, –2, 2, 4, 20, 36, 52, 68, 84, 100, 116, 122

The Average SNR of space-time stream *i* subfield in the Table 8-53f is an 8-bit twos complement integer whose definition is shown in Table 8-53h (Average SNR of Space-Time Stream i subfield).

The $AvgSNR_i$ in Table 9-71 (Average SNR of Space-Time Stream i subfield) is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 9-76b (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) for *Ng* = 4 and Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) for *Ng* = 16, and then computing the arithmetic mean of those values. Each SNR value per subcarrier in stream *i* (before being averaged) corresponds to the SNR associated with the column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix *V*.

(PHY Motion 160)For HE beamformee, supporting *Ng* = 16 in the HE Compressed Beamforming Report field is optional for both SU and MU feedback types(#Ed). A beamformer shall not request *Ng* = 16 in an HE NDP Announcement frame(#Ed) if the beamformee does not indicate support for *Ng* = 16 in the HE Capabilities element it transmits (see 9.4.2.213 (HE Capabilities element)).

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For an HE beamformee, supporting the codebook size {4, 2} in the HE Compressed Beamforming Report field is optional for SU feedback type(#Ed). A beamformer shall not request codebook size {4, 2} in an HE NDP Announcement frame(#Ed) if the beamformee does not indicate support for the codebook size {4, 2} in the HE Capabilities element it transmits (see 9.4.2.213 (HE Capabilities element)).

For an HE beamformee, supporting codebook size {7, 5} in the HE Compressed Beamforming Report field is optional for MU feedback type(#Ed). A beamformer shall not request the codebook size {7, 5} in an HE NDP Announcement frame if the beamformee does not indicate support for the codebook size {7, 5} in the HE Capabilities element it transmits (see 9.4.2.213 (HE Capabilities element)).

9.4.1.64 HE MU Exclusive Beamforming Report field

(#112)The MU Exclusive Beamforming Report field is used by the HE Compressed Beamforming And CQI frame (see 9.6.24.2 (HE Compressed Beamforming And CQI frame format)) to carry explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 26.3.14.3 (DL MU-MIMO).

The size of the HE MU Exclusive Beamforming Report field depends on the values in the HE MIMO Control field. The HE MU Exclusive Beamforming Report field contains HE MU Exclusive Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE Compressed Beamforming and CQI feedback (see 25.6 (HE sounding protocol)). HE Compressed Beamforming Report information and HE MU Exclusive Beamforming Report information are included in the HE Compressed Beamforming and CQI feedback if the MU feedback type is indicated in the Feedback Type field in the HE MIMO Control field.

The HE MU Exclusive Beamforming Report information consists of Delta SNR subfields for each of the space-time stream (1 to *Nc*) of a subset of subcarriers typically spaced *Ng* apart, where *Ng* is signaled in the Grouping subfield of the HE MIMO Control field. Starting from the lowest frequency subcarrier and continuing to the highest frequency subcarrier. Specifically, the locations of the feedback subcarriers for delta SNR subfield shall be identical to the subcarrier locations of the compressed *V* matrices feedback.

No padding is present between $\Delta SNR_{k,i}$, in the HE MU Exclusive Beamforming Report field, even if they correspond to different subcarriers. The subset of subcarriers included is determined by the values of the RU Start Index, RU End Index, and Grouping subfield of the HE MIMO Control field. For each subcarrier included, the deviation in dB of the SNR of that subcarrier for each column of *V* relative to the average SNR of the corresponding space-time stream is computed using Equation (9-2).

The HE MU Exclusive Beamforming Report information has the same structure and order as the VHT MU Exclusive Beamforming Report information defined in Table 9-72 (MU Exclusive Beamforming Report information).

In Table 9-72 (MU Exclusive Beamforming Report information), Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Subcarriers $sscidx(0)$ and $sscidx(Ns' - 1)$ represent the S-tone corresponding to the RU Start Index and E-tone corresponding to the RU End Index, respectively. For 40 MHz and 80 MHz, subcarrier $sscidx(i) = sscidx(i - 1) + Ng$, where $1 \le i \le Ns' - 2$. The S-tone and E-tone corresponding to the possible RU indices are listed in Table 9-76b (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) for $Ng = 4$ and Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) for $Ng = 16$. For 160 MHz, to determine the S-tone and E-tone, RUs 37 to 73 occupying the higher 80 MHz use the same entries in Table 9-76b (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) and Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) as RUs 0 to 36 occupying the lower 80 MHz. For 20 MHz, $sscidx(i)$, where $1 \le i \le Ns' - 2$, includes all subcarrier indices between the S-tone and the E-tone subcarrier indices

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described in Table 9-76d (Feedback subcarrier indices for 20 MHz bandwidth for Ng = 4 and Ng = 16) for *Ng* = 4 and *Ng* = 16.

9.4.1.65 HE CQI-only Report field

(#112)The HE CQI-only Report field is used by the HE Compressed Beamforming And CQI frame (see 9.6.24.2 (HE Compressed Beamforming And CQI frame format)) to carry the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested.

The size of the HE Compressed Beamforming Report field depends on the values in the HE MIMO Control field. The HE Compressed Beamforming Report field contains HE CQI-only Report information or successive (possibly zero-length) portions thereof in the case of segmented HE Compressed Beamforming and CQI feedback (see 25.6 (HE sounding protocol)). HE CQI-only Report information is included in the HE Compressed Beamforming and CQI feedback if the CQI-only feedback type is indicated in the Feedback Type field of the HE MIMO Control field. The structure of the HE CQI-only Report field is shown in Table 9-76e (HE CQI-only Report information).

Table 9-76e—HE CQI-only Report information

Field	Size (bits)	Meaning
Average SNR for space-time stream 1 for RU index *k* = *ruidx*(0)	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index *k* = *ruidx*(0)	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).
Average SNR for space-time stream 1 for RU index *k* = *ruidx*(1)	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index *k* = *ruidx*(1)	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).
...		

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Table 9-76e—HE CQI-only Report information *(continued)*

Average SNR for space-time stream 1 for RU index $k = ruidx(Ncqi - 1)$	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index $k = ruidx(Ncqi - 1)$	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76f (Average SNR of RU index k for space-time stream i subfield).

Ncqi is the number of RU indices for which the CQI-only report is sent back to the beamformer. *Ncqi* is a function of the RU Start Index and RU End Index subfields in the HE MIMO Control field. The RU indices $ruidx(0)$ and $ruidx(Ncqi - 1)$ correspond to the RU Start Index and RU End Index subfields, respectively. The RU index $ruidx(i) = ruidx(i - 1) + 1$, where $1 \le i \le Ncqi - 2$.

The Average SNR of space-time stream *i* for the RU index *k* subfield in the Table 9-76e (HE CQI-only Report information) is an 6-bit twos complement integer whose definition is shown in Table 9-76f (Average SNR of RU index k for space-time stream i subfield).

Table 9-76f—Average SNR of RU index *k* for space-time stream *i* subfield

Average SNR of RU index *k* for space-time stream *i*	$AvgSNR_{k,i}$ (dB)
−32	≤ −10
−31	−9
−30	−8
...	
30	52
31	≥ 53

The $AvgSNR_{k,i}$ in Table 9-76f (Average SNR of RU index k for space-time stream i subfield) is found by computing the arithmetic mean of the SNR per subcarrier in decibels for space-time stream *i* over the subcarriers in RU index *k* for which the feedback is being requested.

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9.4.2 Elements

9.4.2.1 General

Insert the following new rows into Table 9-77 (Element IDs) (header row shown for convenience)::

Table 9-77—Element IDs

Element	Element ID	Element ID Extension	Extensible
HE Capabilities (see 9.4.2.213 (HE Capabilities element))	<ANA>	N/A	Yes
HE Operation (see 9.4.2.214 (HE Operation element))	<ANA>	N/A	Yes

9.4.2.196 TWT element

Change as Figure 9-586ax (Control field format) follows.

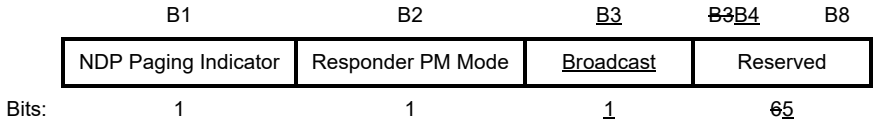


Figure 9-586ax—Control field format

Insert the following paragraph after Table 9-257l (TWT Setup Command field values):

The Broadcast field indicates if the TWT SP indicated by the TWT element is a broadcast TWT as defined in 10.44.3 (Broadcast TWT Operation)(#954). The Broadcast field is 1 to indicate that the TWT(s) defined by the TWT element are broadcast TWT(s). The Broadcast field is 0, otherwise.(#382)

Change Figure 9-586ay (Request Type field format) as follows (B4 from "Reserved" to "Trigger").

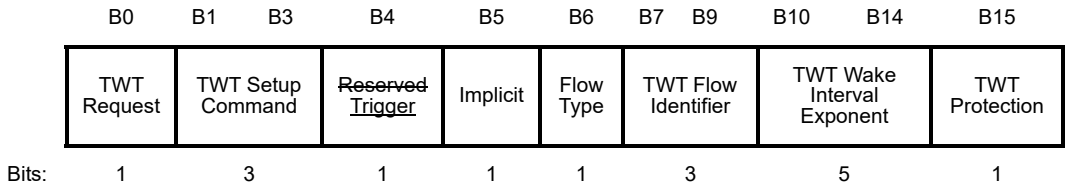


Figure 9-586ay—Request Type field format

Insert the following paragraph after Table 9-257l (TWT Setup Command field values):

The Trigger field indicates if the TWT SP indicated by the TWT element includes Trigger frames as defined in 10.44 (Target wake time (TWT)). The Trigger field is set to 1 to indicate that at least one Trigger frame is transmitted during the TWT SP. The Trigger field is set to 0 otherwise.

Change the text as shown in subclause 9.4.2.196 TWT element:

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For a TWT SP that is not a broadcast TWT SP, the ~~The~~ TWT Flow Identifier subfield contains a 3-bit value which identifies the specific information for this TWT request uniquely from other requests made between the same TWT requesting STA and TWT responding STA pair. For a TWT SP that is a broadcast TWT SP, the TWT Flow Identifier subfield contains a value that indicates recommendations on the types of frames that are transmitted during the broadcast TWT SP, encoded according to Table 9-257l1 (TWT Flow Identifier field for a broadcast TWT element).

Insert a new table as follows:

Table 9-257l1—TWT Flow Identifier field for a broadcast TWT element

TWT Flow Identifier field value	Description when transmitted in a broadcast TWT element
0	No constraints on the frames transmitted during a broadcast TWT SP.
1	Frames transmitted during a broadcast TWT SP are recommended to be limited to: PS-Poll, CQI, QoS Null with buffer status, Sounding Feedback, Management Action.(#383) Trigger frames transmitted by the AP during the broadcast TWT SP do not contain RUs for random access.
2	Frames transmitted during a broadcast TWT SP are recommended to be limited to: PS-Poll, CQI, QoS Null with buffer status, Sounding Feedback, Management Action, (Re)Association Request.(#383) Trigger frames transmitted by the AP during the broadcast TWT SP contain at least one RU for random access.
3-7	Reserved

Change the paragraph below as follows:

In a TWT element transmitted by a TWT requesting STA, the TWT wake interval is equal to the average time that the TWT requesting STA expects to elapse between successive TWT SPs. In a TWT element transmitted by a TWT responding STA, the TWT wake interval is equal to the average time that the TWT-responding STA expects to elapse between successive TWT SPs. In a TWT element contained in a TWT request/response that is sent to negotiate the wake intervals for beacon frames containing broadcast TWTs(#384), the TWT wake interval indicates the value of the listen interval (see 10.44.3.4 (Negotiation of TBTT and listen interval))(#616).

The TWT Wake Interval Exponent subfield is set to the value of the exponent of the TWT wake interval value in microseconds, base 2. The TWT wake interval of the requesting STA is equal to (TWT Wake Interval Mantissa) × $2^{(\text{TWT Wake Interval Exponent})}$(#1326).

Change the paragraph below as follows:

When transmitted by a TWT requesting STA or a TWT scheduled STA, the Target Wake Time field contains a positive integer which corresponds to a TSF time at which the STA requests to wake, or a value of zero when the TWT Setup Command subfield contains the value corresponding to the command "Request TWT".

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When a TWT responding STA or a TWT scheduling STA with dot11TWTGroupingSupport equal to 0 transmits a TWT element to the TWT requesting STA, the TWT element contains a value in the Target Wake Time field which corresponds to a TSF time at which the TWT responding STA requests the TWT requesting STA or TWT scheduled STA to wake and it does not contain the TWT Group Assignment field.

Change Table 9-257l (TWT Setup Command field values) by adding two new columns as shown:

Table 9-257l—TWT Setup Command field values

TWT Setup Command field value	Command name	Description when transmitted by a TWT requesting STA	Description when transmitted by a TWT responding STA	Description when transmitted by a TWT scheduled STA	Description when transmitted by a TWT scheduling STA
0	Request TWT	The Target Wake Time field of the TWT element contains 0s as the TWT responding STA specifies the target wake time value for this case, other TWT parameters* are suggested by the TWT requesting STA in the TWT request.	N/A	The Target Wake Time field of the TWT element contains 0s as the TWT scheduling STA specifies the target wake time value for this case, other TWT parameters (see NOTE)(#1328) are suggested by the TWT scheduled STA in the TWT request.	N/A
1	Suggest TWT	TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup might still be accepted.	N/A		N/A
2	Demand TWT	TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup will be rejected.	N/A		N/A

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Table 9-257l—TWT Setup Command field values *(continued)*

3	TWT Grouping	N/A	TWT responding STA suggests TWT group parameters that are different from the suggested or demanded TWT parameters of the TWT requesting STA	N/A	N/A
4	Accept TWT	N/A	TWT responding STA accepts the TWT request with the TWT parameters (See NOTE) indicated in the TWT element transmitted by the responding STA	N/A	TWT scheduling STA accepts the TWT request with the TWT parameters (see NOTE)(#1328) indicated in the TWT element transmtted by the TWT scheduled STA.
5	Alternate TWT	N/A	TWT responding STA suggests TWT parameters that are different from TWT requesting STA suggested or demanded TWT parameters	N/A	N/A
6	Dictate TWT	N/A	TWT responding STA demands TWT parameters that are different from TWT requesting STA TWT suggested or demanded parameters	N/A	
7	Reject TWT	N/A	TWT responding STA rejects TWT setup	N/A	TWT scheduling STA rejects TWT setup
NOTE—TWT Parameters are: TWT, Nominal Minimum Wake Duration, TWT Wake Interval and TWT Channel subfield values indicated in the element.					

Insert the following new subclauses after the last subclause in 9.4.2:

9.4.2.213 HE Capabilities element

An HE STA declares that it is an HE STA by transmitting the HE Capabilities element.

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The HE Capabilities element contains a number of fields that are used to advertise the HE capabilities of an HE STA. The HE Capabilities element is defined in Figure 9-ax1 (HE Capabilities element format)..

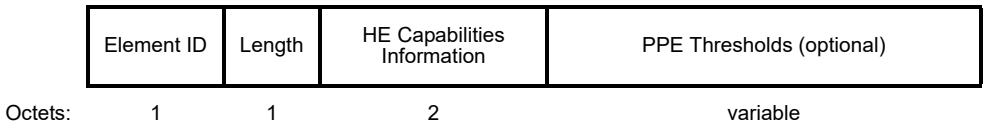


Figure 9-ax1—HE Capabilities element format

The Element ID and Length fields are defined in 9.4.2.1 (General).

The format of the HE Capabilities Information field is defined in Figure 9-ax2 (HE Capabilities Information field format)(#617).

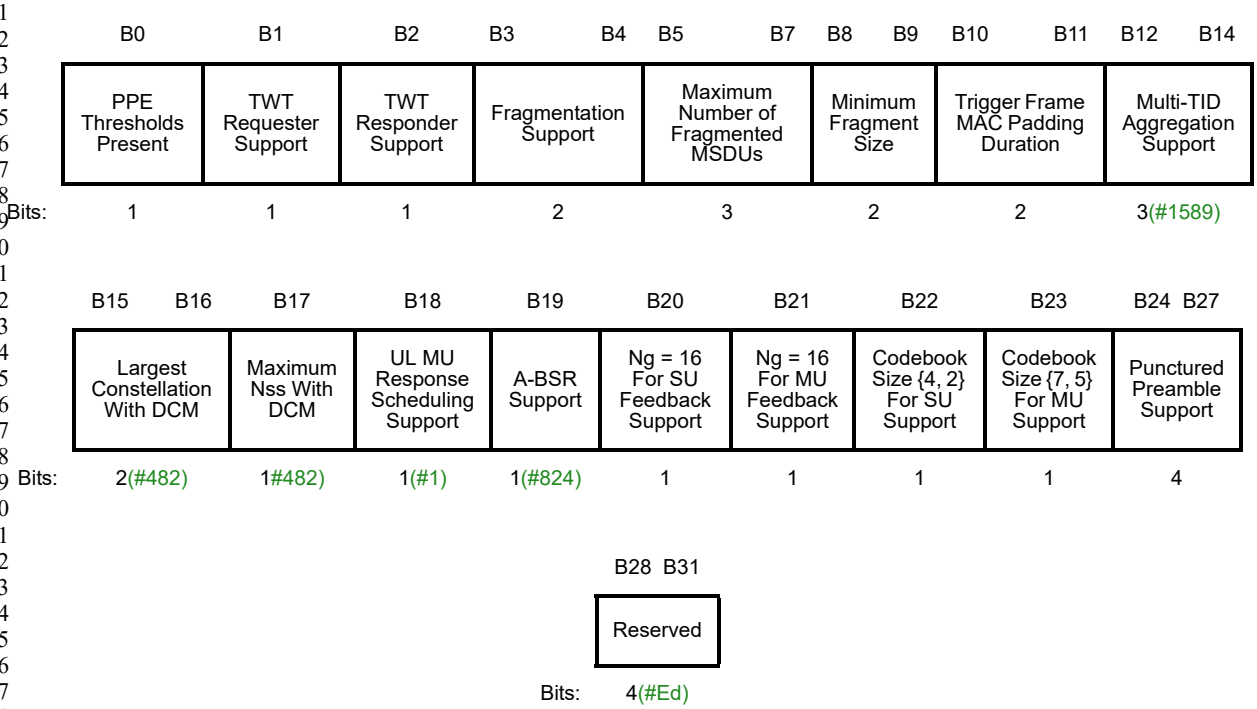


Figure 9-ax2—HE Capabilities Information field format

The PPE Thresholds Present field indicates if the PPE Thresholds field(#1330) is present or not. A value of 1 in this field means that the PPE Thresholds field is present. A value of 0 in this field means that the PPE Thresholds field(#1331) is not present because no packet extension is ever required for the STA transmitting this field.

The TWT Requester Support field indicates support by an HE STA for the role of TWT requesting STA as described in 10.44 (Target wake time (TWT)). The field is set to 1 if dot11TWTOptionActivated is true, the STA is an HE STA and the STA supports TWT requester STA functionality (see 10.44 (Target wake time (TWT))). Set to 0 otherwise.

The TWT Responder Support field indicates support by an HE STA for the role of TWT responder STA as described in 10.44 (Target wake time (TWT)). The field is set to 1 if dot11TWTOptionActivated is true, the

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STA is an HE STA and the STA supports TWT responder STA functionality (see 10.44 (Target wake time (TWT))). Set to 0 otherwise.

The Fragmentation Support field indicates the level of HE fragmentation that is supported by a STA. The encoding of this field is described in Table 9-ax13 (Fragmentation Support field encoding).

Table 9-ax13—Fragmentation Support field encoding

Fragmentation Support field value	Meaning
0	No support for HE fragmentation(#1336)
1	Support for fragments that are contained within a VHT single MPDU, no support for fragments within an A-MPDU
2	Support for up to one fragment for each MSDU and each MMPDU within a single A-MPDU or multi-TID A-MPDU
3	Support for multiple fragments for each MSDU within an A-MPDU or multi-TID A-MPDU and up to one fragment for each MMPDU in a multi-TID A-MPDU

The Maximum Number of Fragmented MSDUs subfield indicates the maximum number of fragmented MSDUs that can be concurrently received by a STA. The maximum number of fragmented MSDUs, N_{max}, defined by this field is $N_{max} = 2^{\text{Maximum Number Of F-MPDUs}}$, except for a value of the Maximum Number of Fragmented MSDUs equal to 7 which indicates that there is no restriction.

The Minimum Fragment Size field indicates the minimum payload size for the first fragment of an MSDU that is supported by a STA. The encoding of this field is described in Table 9-ax14 (Minimum Fragment Size field encoding).(#1482)(#167)(#165)(#1475)

Table 9-ax14—Minimum Fragment Size field encoding

Minimum Fragment Size field value	Minimum payload size (octets)
0	No restriction
1	128
2	256
3	512

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The format of the PPE Thresholds field is defined in Figure 9-ax3 (PPE Thresholds field format)(#2834).

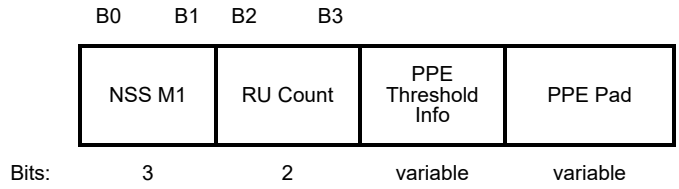


Figure 9-ax3—PPE Thresholds field format

The NSS M1 subfield contains an unsigned integer that is equal to the number of NSS values minus one for which PPE threshold information is included in the PPE Thresholds field.(#1334)

The RU Count subfield contains an unsigned integer that is equal to the number of RU allocation values for which HE PPE threshold information is included in the PPE Thresholds field. The value of zero for this field is reserved. The value of three for this field is reserved.

The PPE Threshold Info field is (NSS M1 + 1) × RU Count × 6 bits(#1337) in length. The format of the PPE Threshold Info field is defined in Figure 9-ax4 (PPE Thresholds Info field format)(#2835).

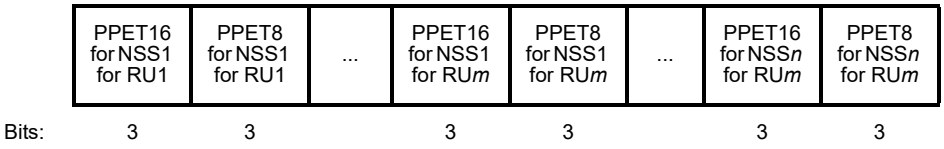


Figure 9-ax4—PPE Thresholds Info field format

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Each PPET8 for NSS*n* for RU*m* subfield and PPET16 for NSS*n* for RU*m* subfield contains a constellation index as defined in Table 9-ax15 (Constellation index).(#1349)(#619).

Table 9-ax15—Constellation index

Constellation Index	Corresponding Transmission Constellation
0	BPSK
1	QPSK
2	16-QAM
3	64-QAM
4	256-QAM
5	1024-QAM
6	Reserved
7	None

All the PPET8 for NSS*n* for RU*m* subfield and PPET16 for NSS*n* for RU*m* subfield values are combined to encode the minimum duration of the post-FEC padding and packet extension for HE PPDUs that are transmitted to the STA sending this field, for each value of NSS and RU specified by the field and implicitly, for values of NSS and RU not explicitly indicated in the field. The encoding is described in Table 9-ax16 (PPET8 and PPET16 encoding).

Table 9-ax16—PPET8 and PPET16 encoding

Result of comparison of the constellation index *x* of an HE PPDU with NSS value *n* and RU value m to the value in the PPET8 for NSS*n* for RU*m* subfield	Result of comparison of the constellation index of an HE PPDU with NSS value *n* and RU value m to the value in the PPET16 for NSS*n* for RU*m* subfield	Combined minimum total duration of the post-FEC padding and packet extension requirement for an HE PPDU transmitted to this STA using the constellation index = *x*, NSS = *n* and RU = *m*
x < PPET8 or PPET8 = None	*x* < PPET16 or PPET16 = None	0 µs
x > PPET8	*x* < PPET16 or PPET16 = None	8 µs
x > PPET8 or PPET8 = None	*x* > PPET16	16 µs
PPET8 = None(#1341)	PPET16 = None(#1338)	0
PPET8 not present	PPET16 not present	0

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The RU Allocation Index encoding is indicated in Table 9-ax17 (RU Allocation Index encoding).

Table 9-ax17—RU Allocation Index encoding

RU Allocation Index value	RU allocation value
0	2×996(#1337)
1	996
2	484
3	242

The PPE Pad field contains all zeros. The number of bits in the PPE Pad field is the number of bits required to round the length of the PPE Thresholds field up to the next integer number(#1895) of octets.

A STA that declares(#1165) support for HE trigger-based PPDUs(#1342) shall also declare whether they belong to class A or class B. Class A STAs (#575)are high capability devices and class(#1345) B STAs are low capability devices.

The Trigger Frame MAC Padding Duration subfield indicates the additional amount of time defined as *MinTrigProcTime*, in microseconds, needed for a non-AP STA to process a received Trigger frame. The Trigger Frame MAC Padding Duration subfield is set to 0 to indicate no additional processing time; 1 to indicate 8 μs; 2 to indicate 16 μs; remaining values are reserved.(#2890)

The Multi-TID Aggregation Support field indicates the number of TIDs minus 1 of QoS Data frames that an HE STA can aggregate in a multi-TID A-MPDU as described in 25.10.4 (A-MPDU with multiple TIDs). The Multi-TID Aggregation Support field is set to 0 when dot11AMPDUwithMultipleTIDOptionImplemented is false.(#1589)

A STA indicates DCM capability in the Largest Constellation With DCM subfield and the Maximum Nss With DCM subfield. The Largest Constellation With DCM subfield encoding is defined in Table 9-ax18 (Largest Constellation With DCM subfield encoding).(#482)

Table 9-ax18—Largest Constellation With DCM subfield encoding

Largest Constellation With DCM	Description
0	No DCM support
1	BPSK
2	QPSK
3	16-QAM

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The Maximum Nss With DCM subfield is set to 0 to indicate that DCM is only supported with a single spatial stream and set 1 to indicate that DCM is supported on up to two spatial streams.(#482)(#Ed)

The UL MU Response Scheduling Support subfield indicates support for receiving an MPDU that contains an UL MU Response Scheduling A-Control subfield. The UL MU Response Scheduling Support subfield is set to 1 if the STA supports reception of the UL MU Response Scheduling subfield and is set to 0 otherwise.(#1)

The A-BSR Support subfield indicates support by an AP for receiving an (A-)MPDU that contains a BSR in the A-Control subfield and support by a non-AP STA for generating an (A-)MPDU that contains a BSR in the A-Control subfield. The A-BSR Support subfield is set to 1 if the STA supports the BSR A-Control field functionality and set to 0 otherwise.(#824)(#93)(#1067)(#2388)

(PHY Motion #160)The Ng = 16 For SU Feedback Support subfield is set to 1 to indicate support for a tone grouping of 16 with the SU feedback type in the HE Compressed Beamforming Report field and set to 0 otherwise.(#Ed)

The Ng = 16 For MU Feedback Support subfield is set to 1 to indicate support for a tone grouping of 16 with the MU feedback type in the HE Compressed Beamforming Report field and set to 0 otherwise.(#Ed)

The Codebook Size {4, 2} For SU Support subfield is set to 1 to indicate support for the codebook size {4, 2} with the SU feedback type in the HE Compressed Beamforming Report field and set to 0 otherwise.(#Ed)

The Codebook Size {7, 5} For MU Support subfield is set to 1 to indicate support for the codebook size {7, 5} with the MU feedback type in the HE Compressed Beamforming Report field and set to 0 otherwise.(#Ed)

(PHY Motion #161)The Punctured Preamble Support subfield indicates whether an HE STA is capable of receiving a preamble-punctured HE MU PPDU with the Bandwidth field in HE-SIG-A field setting to values 4, 5, 6, or 7. This subfield contains 4 bits, indicating (from LSB to MSB) being capable of receiving HE MU PPDU with the Bandwidth field of HE-SIG-A setting to 4, 5, 6, 7 respectively. Set each of these 4 bits to 1 to indicate being capable of receiving, set to 0 otherwise.

9.4.2.214 HE Operation element

The operation of HE STAs in an HE BSS is controlled by the HT Operation element, the VHT Operation element and the HE Operation element. The format of the HE Operation element is defined in Figure 9-ax5 (HE Operation element format).

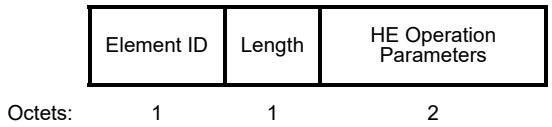


Figure 9-ax5—HE Operation element format

The Element ID and Length fields are defined in 9.4.2.1 (General).

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The format of the HE Operation Parameters field is defined in Figure 9-ax6 (HE Operation Parameters(#1350) field format).

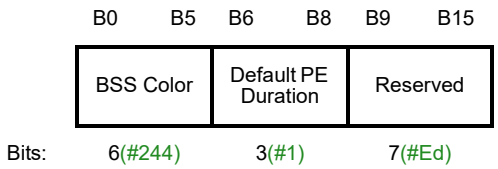


Figure 9-ax6—HE Operation Parameters(#1350) field format

The BSS Color field is an unsigned integer whose value is the BSS color(#1165) of the BSS corresponding to the AP which transmitted this element, except that a value of 0 in this field indicates that there is no BSS color(#1165) for this BSS.

The BSS Color field is an unsigned integer whose value is the BSS Color of the BSS corresponding to the AP, IBSS STA, mesh STA or TDLS STA that transmitted this element, except that a value of 0 in this field is used if one or more intended recipient STAs of an HE PPDU is not a member of a transmitting STA's BSS.(#73)

The Default PE Duration subfield indicates the PE duration in units of 4 μs, for an HE trigger-based PPDU that is solicited with UL MU Response Scheduling in the A-Control subfield. Values 5-7 of the Default PE Duration subfield are reserved.(#1)

9.6 Action frame format details

9.6.24 HE Action frame details

9.6.24.1 HE Action field

A HE Action field, in the octet immediately after the Category field, differentiates the HE Action frame formats. The HE Action field values associated with each frame format within the HE category are defined in Table 9-ax19 (HE Action field values).

Table 9-ax19—HE Action field values

Value	Meaning
0	HE Compressed Beamforming And CQI
1-255	Reserved

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9.6.24.2 HE Compressed Beamforming And CQI frame format

The HE Compressed Beamforming And CQI frame is an Action No Ack frame of category HE. The Action field of a HE Compressed Beamforming And CQI frame contains the information shown in Table 9-ax20 (HE Compressed Beamforming And CQI frame Action field format) .

Table 9-ax20—HE Compressed Beamforming And CQI frame Action field format

Order	Information
1	Category
2	HE Action
3	HE MIMO Control
4	HE Compressed Beamforming Report (see 9.4.1.63 (HE Compressed Beamforming Report field))
5	HE MU Exclusive Beamforming Report (see 9.4.1.64 (HE MU Exclusive Beamforming Report field))
6	HE CQI-only Report (see 9.4.1.65 (HE CQI-only Report field))

The Category field is defined in Table 9-47 (Category values).

The HE Action field is defined in Table 9-ax19 (HE Action field values).

The HE MIMO Control field is always present in the frame. The presence and contents of the HE Compressed Beamforming Report field, HE MU Exclusive Beamforming Report field and HE CQI-only Report field are dependent on the values of Feedback Type subfield of HE MIMO Control field.

No vendor-specific elements are present in HE Compressed Beamforming and CQI frame.

9.7 Aggregate MPDU (A-MPDU)

9.7.1 A-MPDU format

Change the 4th paragraph as follows:

The EOF Padding field is shown in Figure 9-739 (EOF Padding field format). This is present only in a VHT or HE PPDU.(#2481)

Change the 6th paragraph as follows:

In a VHT or HE PPDU(#2482), the following padding is present, as determined by the rules in 10.13.6 (A-MPDU padding for VHT PPDU):

- 0–3 octets in the Padding subfield of the final A-MPDU subframe (see Figure 9-740 (A-MPDU subframe format)) before any EOF padding subframes. The content of these octets is unspecified.
- Zero or more EOF padding subframes in the EOF Padding Subframes subfield.
- 0–3 octets in the EOF Padding Octets subfield. The content of these octets is unspecified.

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Change Table 9-422 as follows:

Table 9-422— MPDU delimiter fields (non-DMG)

Field	Size (bits)	Description
EOF	1	End of frame indication. Set to 1 in an A-MPDU subframe that has 0 in the MPDU Length field and that is used to pad the A-MPDU in a VHT or HE PPDU(#2483) as described in 10.13.6 (A-MPDU padding for VHT PPDU). Set to 1 in the MPDU delimiter of a VHT single MPDU as described in 10.13.7 (Setting the EOF field of the MPDU delimiter). Set to 0 otherwise.
Reserved	1	
MPDU Length	14	Length of the MPDU in octets. Set to 0 if no MPDU is present. An A-MPDU subframe with 0 in the MPDU Length field is used as defined in 10.13.3 (Minimum MPDU Start Spacing field) to meet the minimum MPDU start spacing requirement and also to pad the A-MPDU to fill the available octets in a VHT or HE PPDU(#2484) as defined in 10.13.6 (A-MPDU padding for VHT PPDU).
CRC	8	8-bit CRC of the preceding 16 bits.
Delimiter Signature	8	Pattern that may be used to detect an MPDU delimiter when scanning for an MPDU delimiter. The unique pattern is 0x4E (see NOTE below).
NOTE—The ASCII value of the character 'N' was chosen as the unique pattern for the value in the Delimiter Signature field.		

Change the 12th and 13th paragraph as follows:

The format of the MPDU Length field when transmitted by a non-DMG STA is shown in Figure 9-743. The MPDU Length Low subfield contains the 12 low order bits of the MPDU length. In a VHT or HE PPDU, the MPDU Length High subfield contains the two high order bits of the MPDU length. In an HT PPDU, the MPDU Length High subfield is reserved.

The MPDU length value is derived from the MPDU Length field subfields as follows:

$$L_{MPDU} = \begin{cases} L_{low} + L_{high} \times 4096, & \text{VHT PPDU} \\ L_{low}, & \text{HT PPDU} \\ L, & \text{DMG PPDU} \end{cases} \quad (9\text{-}5)$$

where

L_{low} is the value of the MPDU Length Low subfield

L_{high} is the value of the MPDU Length High subfield

L is the value of the MPDU Length field

NOTE—The format of the MPDU Length field maintains a common encoding structure for ~~both~~ HE, VHT and HT PPDUs. For HT PPDUs, only the MPDU Length Low subfield is used, while for VHT PPDUs, both subfields are used.

9.7.3 A-MPDU contents

Change the 1st paragraph of this subclause as follows:

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In a non-DMG PPDU, an A-MPDU is a sequence of A-MPDU subframes carried in a single PPDU with one of the following combinations of RXVECTOR or TXVECTOR parameter values:

- The FORMAT parameter set to VHT
- The FORMAT parameter set to HT_MF or HT_GF and the AGGREGATION parameter set to 1
- The FORMAT parameter set to S1G, S1G_DUP_1M, or S1G_DUP_2M and the AGGREGATION parameter set to 1(11ah)
- The FORMAT parameter set to HE_SU, HE_MU, HE_TRIG or HE_EXT

Insert the following paragraph:

An A-MPDU carried in an(#2829) HE MU PPDU may include MPDUs with different values of the TID field. Additional rules are TBD.

(#2429)Change the 5th paragraph as follows:

The Duration/ID fields in the MAC headers of all MPDUs in an A-MPDU carry the same value. The Duration/ID fields in the MAC headers of MPDUs in A-MPDUs carried in the same VHT MU PPDU, the same HE MU PPDU or all HE trigger-based PPDUs addressed to the same AP ~~all~~ carry the same value.

NOTE 1—The reference point for the Duration/ID field is the end of the PPDU carrying the MPDU. Setting the Duration/ID field to the same value in the case of A-MPDU aggregation means that each MPDU consistently specifies the same NAV setting.

(#2430)Change the 8th paragraph as follows:

A VHT MU PPDU does not carry more than one A-MPDU that contains one or more MPDUs soliciting an immediate response. An HE MU PPDU does not carry more than one A-MPDU that contains one or more MPDUs soliciting an immediate response that is not carried in an HE trigger-based PPDU.

NOTE 2—The TIDs present in a data enabled A-MPDU context are also constrained by the channel access rules (for a TXOP holder; see 10.22.2 (HCF contention based channel access (EDCA)) and 10.22.3 (HCF controlled channel access (HCCA))) and the RD response rules (for an RD responder, see 10.28.4 (Rules for RD responder)). This is not shown in these tables.

NOTE 3—If a STA supports A-MSDUs of 7935 octets (indicated by the Maximum A-MSDU Length field in the HT Capabilities element), A-MSDUs transmitted by that STA within an A-MPDU carried in a PPDU with FORMAT HT_MF or HT_GF are constrained so that the length of the QoS Data frame carrying the A-MSDU is no more than 4095 octets. The 4095-octet MPDU length limit does not apply to A-MPDUs carried in VHT or DMG PPDUs. The use of A-MSDU within A-MPDU might be further constrained as described in 9.4.1.14 (Block Ack Parameter Set field) through the operation of the A-MSDU Supported field.

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Insert the following three rows in 9-424 (A-MPDU Contexts):

Table 9-424—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
Data Enabled Immediate Response with Multiple TID Support	The multiple TID A-MPDU is transmitted outside a PSMP sequence by a TXOP holder in DL/UL MU frame exchange or a STA in UL MU frame exchange sequence including potential immediate responses.	Table 9-429a (Multiple TID A-MPDU contents in the data enabled immediate response context)
Data Enabled No Immediate Response with Multiple TID Support	The multiple TID A-MPDU is transmitted outside a PSMP sequence by a TXOP holder in DL/UL MU frame exchange or a STA in UL MU frame exchange sequence that does not solicit immediate responses.	Table 9-429b (Multiple TID A-MPDU contents in the data enabled no immediate response context)
UL MU(#1355)	The A-MPDU is transmitted to a STA that is UL MU capable.(#1361)	Table 9-429c (A-MPDU content in the UL MU context)

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Insert the following three tables at the end of the subclause:

Table 9-429a—Multiple TID A-MPDU contents in the data enabled immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedules(#1167) resource for following UL MU transmission and the HE A-Control fields of the Data frames and Management(#1364) frames do not include trigger information.(#578)	
Ack frame	If the preceding PPDU contains an MPDU that requires an Ack frame response.	At most one of the MPDUs is present.
BlockAck frame	If the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, at most one BlockAck frame for this TID.	
Multi-STA BlockAck frame	If the preceding PPDU contains an(#1370) implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BlockAck(#1293) frame.	
Action No Ack	Action No Ack frames.	
Data frames sent under an HT-immediate(#1382) block ack agreement	QoS Data frames with different TIDs, where each TID corresponds to an HT-immediate block ack agreement.	
QoS Null MPDUs with Ack Policy field(#1168) set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy field(#1168) set to No Acknowledgment.	
Action frame	At most one Action frame.	
Data frame with TID that has no block ack agreement and with Ack Policy field(#1168) set to Normal Ack	At most one Data(#1363) frame of the TID.	
Immediate BlockAckReq frames	At most one Data(#1363) frame for one TID that there is no Data(#1363) frames sent under	

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Table 9-429b—Multiple TID A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedules(#579) resource for following UL MU transmission and the HE A-Control fields of the Data frames and Management frames do not include trigger information.(#580)	
Ack frame	If the preceding PPDU contains an MPDU that requires an Ack frame response.	At most one of the MPDUs is present.
BlockAck frame	If the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, at most one BlockAck frame for this TID.	
Multi-STA BlockAck frame	If the preceding PPDU contains an(#1370) implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BlockAck(#1293) frame.	
Action No Ack	Action No Ack frames.	
Data frames without an HT-immediate(#1382) block ack agreement and with Ack Policy field(#1168) set to No Ack	QoS Data frames with TIDs that does not correspond to a block ack agreement. These have the Ack Policy field equal to No Ack.	
QoS Null MPDUs with Ack Policy field(#1168) set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy field set to No Ack(#1168).	

Table 9-429c—A-MPDU content in the UL MU context

MPDU Description	Conditions
Trigger frame(#1387)	One or more Trigger frames can be included
MPDU with trigger information in the MAC header	One or more MPDUs with trigger information in the MAC header can(#395) be included

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10. MAC sublayer functional description

10.3 DCF

10.3.1 General

Change as follows:

The virtual CS mechanism is achieved by distributing reservation information announcing the impending use of the medium. The exchange of RTS and CTS frames prior to the actual Data frame is one means of distribution of this medium reservation information. The RTS and CTS frames contain a Duration field that defines the period of time that the medium is to be reserved to transmit the actual Data frame and the returning Ack frame. A STA receiving either the RTS frame (sent by the originating STA) or the CTS frame (sent by the destination STA) shall process the medium reservation. Thus, a STA might be unable to receive from the originating STA and yet still know about the impending use of the medium to transmit a Data frame. The exchange of MU-RTS and simultaneous CTS responses by HE STAs prior to the actual Data frames (#1389)is another(#396) means of distribution of this medium reservation information.

10.3.2 Procedures common to the DCF and EDCAF

10.3.2.1 CS mechanism

Change the 3rd paragraph of the subclause as follows:

A first(11ah) virtual CS mechanism shall be provided by all MAC entities, and an additional second virtual CS mechanism shall be provided by an S1G MAC entity(11ah). The first mechanism is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames by non-DMG STAs, MU-RTS/CTS by HE STAs as defined in 10.3.2.8a, and RTS/DMG CTS frames by DMG STAs prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP other than PV1 MAC frames and PS-Poll frames and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The duration information may also be available in the RXVECTOR parameter TXOP_DURATION when an HE PPDU is received(#Ed).(#2596)

10.3.2.3 IFS

10.3.2.3.7 EIFS

Change the 2nd paragraph of 10.3.2.3.7 as follows:

EIFS shall not be invoked if the NAV is updated by the frame that would have caused an EIFS. EIFS shall not be invoked for an A-MPDU if one or more of its frames are received correctly. EIFS shall not be invoked if a valid TXOP_DURATION parameter is present in the RXVECTOR of a received HE PPDU.(#162)

10.3.2.4 Setting and resetting the NAV

Insert the following at the end of 10.3.2.4:

An HE AP may use a TBD mechanism to configure the use of RTS/CTS initiated by non-AP STA.

Insert a new subclause following 10.3.2.8:

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10.3.2.8a MU-RTS/CTS procedure(#1432)

10.3.2.8a.1 General

The MU-RTS/CTS procedure allows an AP to protect an MU transmission(#397). An HE AP may transmit an MU-RTS frame to solicit simultaneous CTS responses from one or more HE STAs.

Figure 10-ax1 (Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting(#2224)) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect DL MU PPDU and acknowledgement responses..

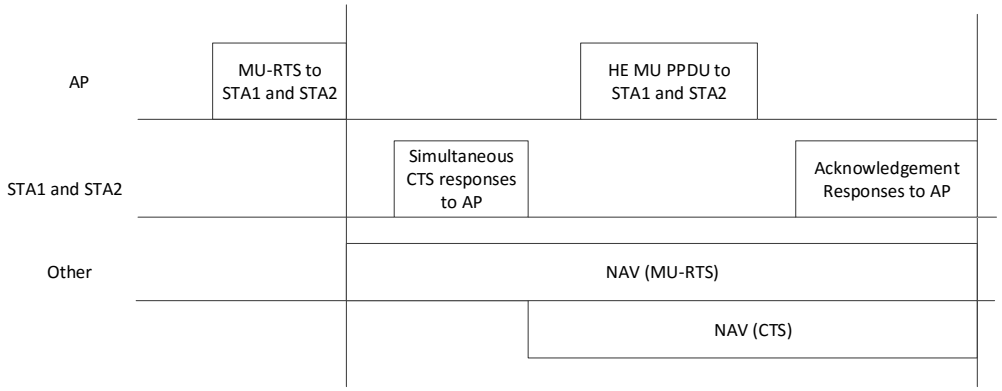


Figure 10-ax1—Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting(#2224)

Figure 10-ax2 (Example of MU-RTS/CTS/Trigger/HE trigger-based PPDU/Multi-STA BlockAck and NAV setting(#2224)) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the scheduled HE trigger-based PPDU and Multi-STA BlockAck frame.

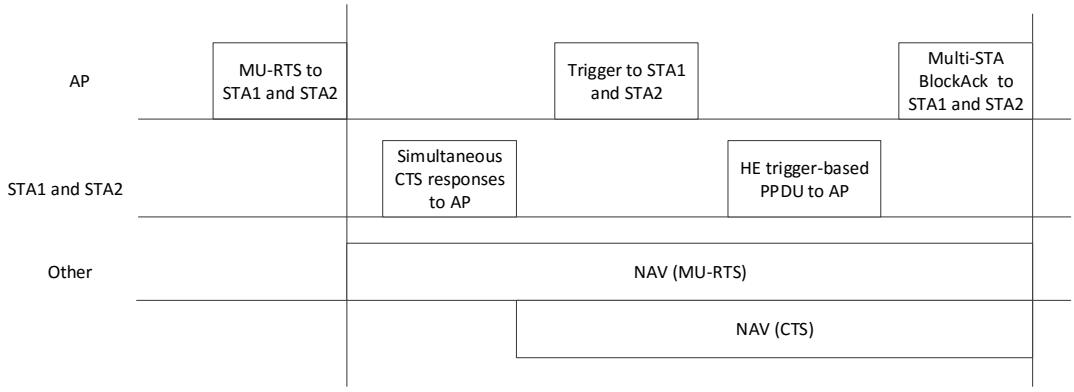


Figure 10-ax2—Example of MU-RTS/CTS/Trigger/HE trigger-based PPDU/Multi-STA BlockAck and NAV setting(#2224)

10.3.2.8a.2 MU-RTS procedure

The transmitter of an MU-RTS frame shall not request a STA to send a CTS frame response in a 20 MHz channel that is not occupied by the PPDU that contains the MU-RTS frame. In each 20 MHz channel occu-

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pied by the PPDU that contains an MU-RTS frame, the transmitter of the MU-RTS frame shall request at least one STA to send a CTS frame response that occupies the 20 MHz channel.(#1644)(#Ed)

(#2428)After transmitting an MU-RTS frame, the STA shall wait for a CTSTimeout interval with a value of aSIFSTime + aSlotTime + aRxPHYStartDelay. This interval begins when the MAC receives a PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the CTSTimeout interval, the STA shall conclude that the transmission of the MU-RTS frame has failed, and this STA shall invoke its backoff procedure upon expiration of the CTSTimeout interval. If a PHY-RXSTART.indication primitive does occur during the CTSTimeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to determine whether the MU-RTS frame transmission was successful. The recognition of a valid CTS frame sent by the recipient of the MU-RTS frame, corresponding to this PHY-RXEND.indication primitive, shall be interpreted as successful response, permitting the frame exchange sequence to continue. The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MU-RTS frame transmission.(#160)

10.3.2.8a.3 CTS Response(#996) to MU-RTS

If an(#2829) HE STA receives an MU-RTS frame, the HE STA shall commence the transmission of a CTS frame(#1396) response at the SIFS time boundary after the end of a received PPDU when all the following conditions are met:

— The MU-RTS frame has one of the User Info(#1520) fields addressed to the STA.

— The UL MU CS condition described in 25.5.2.4 (UL MU CS mechanism) indicates the medium is idle. The ED-based CCA during the SIFS after receiving an MU-RTS frame and virtual CS functions are used to determine the state of the medium to respond to an MU-RTS frame.(#2650)

— The RU Allocation subfield in the User Info field addressed to the STA indicates either the primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel.(#2428)

— The MU RTS frame is sent by the AP with which the STA is associated and the value of the regular NAV is 0.(#125)

The CTS frame sent in response to an MU-RTS frame shall be carried in a non-HT or non-HT duplicate PPDU.(#13)

An HE non-AP STA transmitting a CTS frame in response to an MU-RTS frame shall set the TXVECTOR parameter SCRAMBLER_INITIAL_STATE to the same value as the RXVECTOR parameter SCRAMBLER_INITIAL_STATE of the received MU-RTS frame.(#127) The rate selection rule for the CTS frame(#1396) is defined in 10.7.6 (Rate selection for Control frames).

(#963)A CTS frame sent in response to an MU-RTS frame(#1396) shall be transmitted on the 20 MHz channels indicated(#Ed) in the RU Allocation subfield of the User Info field of the MU-RTS frame(#1520)(#1727) when the indicated 20 MHz channels are all idle. If any 20 MHz channel indicated in the RU Allocation subfield of the User Info field is busy, the CTS frame response shall not be transmitted.(#1070)(#2651)

Figure 10-ax3 (An example of an MU-RTS frame soliciting CTS frame(#Ed)(#1396) responses on the primary 40 MHz channel(#2224)) shows an example of the exchange of MU-RTS and simultaneous CTS frame(#1396) responses on the(#1397) primary 40 MHz channel. In this example, MU-RTS is transmitted in a 40 MHz non-HT duplicate PPDU on the(#1397) primary 40 MHz channel. Further, the MU-RTS frame(Ed) requests STA1 to transmit a CTS frame(#1396) response in a non-HT PPDU on the(#1397) pri-

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mary 20 MHz channel and STA2 to transmit a CTS frame(#1396) response in a 40 MHz non-HT duplicate PPDU on the(#1397) primary 40 MHz channel.

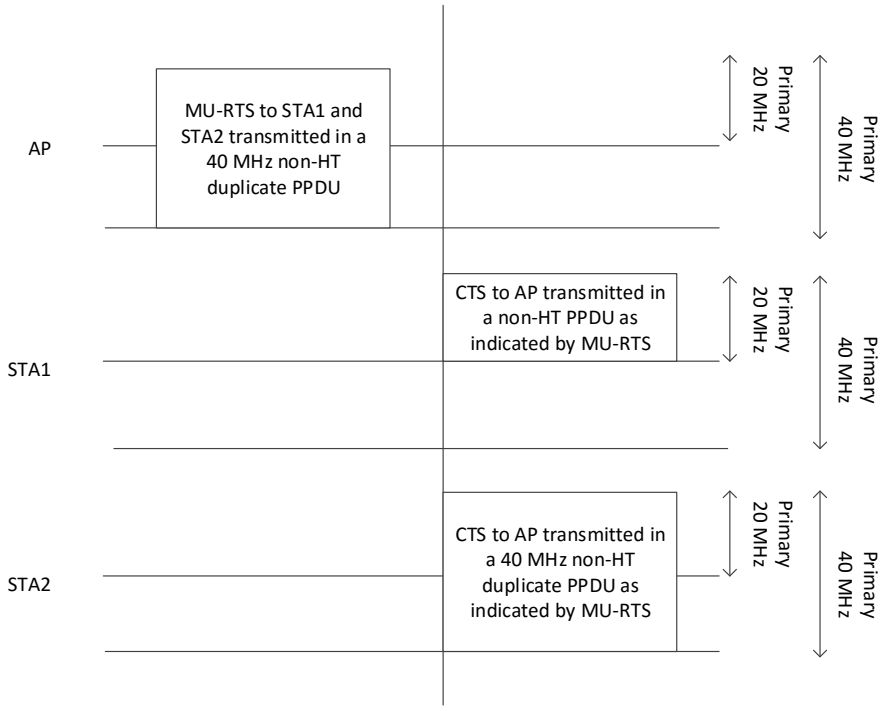


Figure 10-ax3—An example of an MU-RTS frame soliciting CTS frame(#Ed)(#1396) responses on the primary 40 MHz channel(#2224)

10.3.2.11 MU acknowledgement procedure

Insert a new subclause heading before the first paragraph as follows:

10.3.2.11.1 Acknowledgement procedure for DL MU PPDU in SU format

Change the subclause as follows:

The acknowledgment procedure performed by a STA that receives MPDUs that were transmitted within a VHT MU PPDU or an HE MU PPDU is the same as the acknowledgment procedure for MPDUs that were not transmitted within a VHT MU PPDU or an HE MU PPDU.

NOTE—All MPDUs transmitted within a VHT MU PPDU or an HE MU PPDU are contained within A-MPDUs, and the rules specified in 9.7.3 (A-MPDU contents) prevent an immediate response carried in SU format to more than one of the A-MPDUs.

Responses to A-MPDUs within a VHT MU PPDU or an HE MU PPDU that are not immediate responses to the VHT MU PPDU or the HE MU PPDU are transmitted in response to explicit BlockAckReq frames by the AP. Examples of VHT MU PPDU frame exchange sequences are shown in Figure 10-11 (An example of a TXOP containing a VHT MU PPDU transmission with an immediate acknowledgment to the VHT MU PPDU) and Figure 10-12 (An example of a TXOP containing a VHT MU PPDU transmission with no immediate acknowledgment to the VHT MU PPDU).

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Recovery within the TXOP that contains a VHT MU PPDU or an HE MU PPDU can be performed according to the rules of 10.22.2.7 (Multiple frame transmission in an EDCA TXOP). BlockAckRequest frames related to A-MPDUs within a VHT MU PPDU or an HE MU PPDU can be transmitted in a TXOP separate from the one that contained the VHT MU PPDU or the HE MU PPDU.

NOTE 1—A BlockAck frame or an Ack frame is sent in immediate response to the BlockAckReq frame for HT-immediate or HT-delayed Block Ack, respectively. An Ack frame might be sent in immediate response to a VHT single MPDU in the VHT MU PPDU.

NOTE 2—A BlockAckRequest frame would typically not be sent to a STA in the case where the A-MPDU to the STA contained no MPDUs requiring acknowledgment. It could be sent if MPDUs in a previous A-MPDU remain unacknowledged.

Insert a new subclauses 10.3.2.11.2 and 10.3.2.11.3 as follows:

10.3.2.11.2 Acknowledgement procedure for HE MU PPDU in MU format

A non-AP STA that is the recipient, within an(#2829) HE MU PPDU, of a QoS Data frame or QoS Null frame(#2606) that solicits an immediate response with Ack Policy equal to MU Ack in QoS Control field, shall send the immediate response according to the scheduling information defined by the UL trigger information that is carried either in the Trigger frame(s) or in the(#1402) MAC header. If no valid Trigger frame(s) or MAC header containing UL trigger information is received, then the STA shall not respond. An example of UL OFDMA acknowledgement to an HE MU PPDU is shown in Figure 10-ax4 (An example of a TXOP containing an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement).

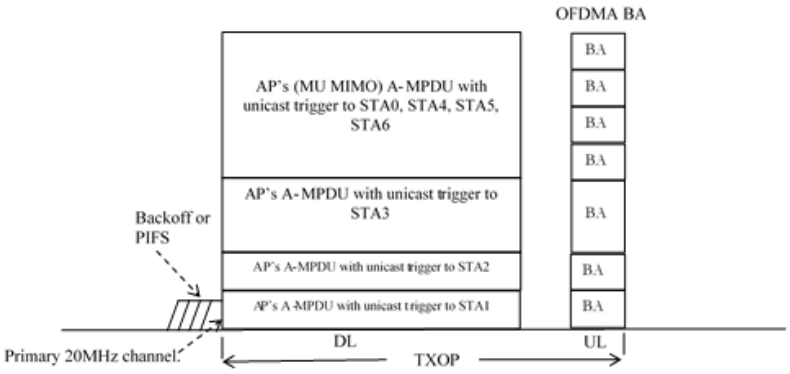


Figure 10-ax4—An example of a TXOP containing an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement

(#2607)

10.3.2.11.3 MU acknowledgement procedure for an UL MU transmission

When receiving frames(#409) from more than one STA that are part of an UL MU transmission (see(#1406) 9.42.2) and that require an immediate acknowledgement, an AP may send either multiple BlockAck frames (or Ack(#1408) frames) in an HE MU PPDU, or a Multi-STA BlockAck frame(#1407)(#1424) (see 25.4 (Block acknowledgement)). After a successful reception of an UL frame requiring acknowledgment, transmission of the DL acknowledgement shall commence after a SIFS, without regard to the busy/idle state of the medium.(#2608)

The example of a DL OFDMA BA is(#410) shown in Figure 10-ax5 (An example of a TXOP containing an UL MU transmission with an immediate DL MU transmission containing individually addressed(#1512)

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BlockAck frames acknowledging the frames received from the respective STAs), and examples for Multi-STA BlockAck frame acknowledgement to a UL MU PPDU are(#2816) given in Figure 10-ax6 (An example of a TXOP containing UL MU transmissions with an immediate Multi-STA BlockAck frame(#1407) acknowledging the MPDUs that were correctly received from each STA. The UL MU transmission may be OFDMA or MU-MIMO), Figure 10-ax7 (An example of a TXOP containing UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame. The UL MU transmissions may be OFDMA or MU-MIMO) and Figure 10-ax8 (An example of a TXOP containing UL MU transmissions with an immediate OFDMA HE MU PPDU containing Multi-STA BlockAck frames. The UL MU transmissions may be OFDMA or MU-MIMO).

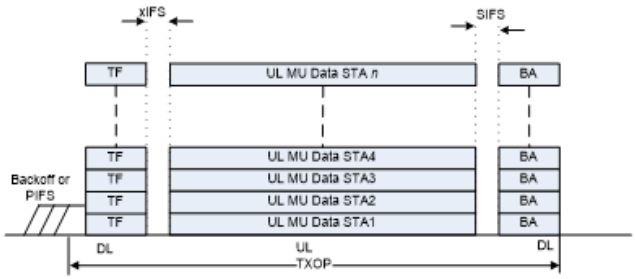


Figure 10-ax5—An example of a TXOP containing an UL MU transmission with an immediate DL MU transmission containing individually addressed(#1512) BlockAck frames acknowledging the frames received from the respective STAs

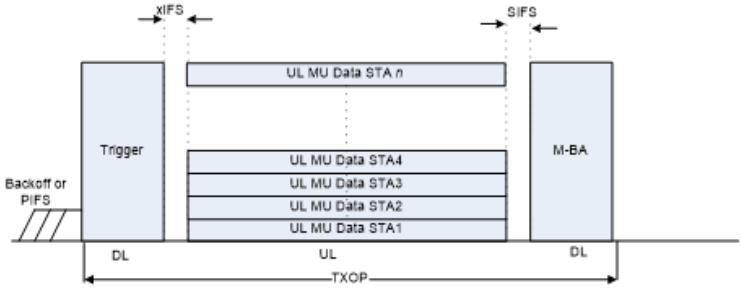


Figure 10-ax6—An example of a TXOP containing UL MU transmissions with an immediate Multi-STA BlockAck frame(#1407) acknowledging the MPDUs that were correctly received from each STA. The UL MU transmission may be OFDMA or MU-MIMO

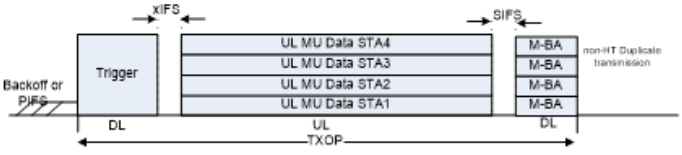


Figure 10-ax7—An example of a TXOP containing UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame. The UL MU transmissions may be OFDMA or MU-MIMO

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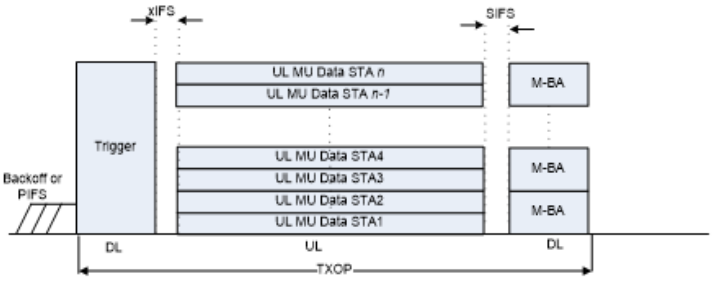


Figure 10-ax8—An example of a TXOP containing UL MU transmissions with an immediate OFDMA HE MU PPDU containing Multi-STA BlockAck frames. The UL MU transmissions may be OFDMA or MU-MIMO

10.5 Fragmentation

Change the 2nd paragraph as follows:

With static fragmentation, t~~T~~he length of each fragment shall be an equal number of octets for all fragments except the last, which may be smaller. The length of each fragment shall be an even number of octets, except for the last fragment of an MSDU or MMPDU, which may be either an even or an odd number of octets. The length of a static fragment shall never be larger than dot11FragmentationThreshold unless security encapsulation is invoked for the MPDU. If security encapsulation is active for the MPDU, then the MPDU shall be expanded by the encapsulation overhead and this may result in a fragment larger than dot11FragmentationThreshold. Unless the conditions described in 25.3.2 (Support and requirements for dynamic fragmentation) are met, static fragmentation is used.(#1484)

10.7 Multirate support

10.7.6 Rate selection for Control frames

10.7.6.5 Rate selection for control response frames

10.7.6.5.2 Selection of a rate or MCS

Insert the following at the end of the subclause:

Within an MU-RTS/CTS(#1431)(#2817) exchange, the simultaneous CTS shall be transmitted with the primary rate(#2379). The primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 10.7.10 (Non-HT basic rate calculation)) of the previous MU-RTS frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 10.7.10 (Non-HT basic rate calculation)) of the previous frame.

If a Multi-STA BlockAck frame or DL OFDMA acknowledgement frame is sent as an immediate response to an HE trigger-based PPDU(#1767), the AP may ignore the <HE-MCS, NSS> tuples that are used for MPDUs in HE trigger-based PPDU(#1767) from non-AP STAs that elicits the DL acknowledgement.

An AP that transmits a Multi-STA BlockAck frame in a non-HT PPDU, HT PPDU, VHT PPDU or HE PPDU shall use a rate, HT-MCS, <VHT-MCS, NSS> tuple or <HE-MCS, NSS> tuple, respectively, that is supported by all the recipients(#623).

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10.9 HT Control field operation

Change 10.9 as follows:

If the value of dot11HTControlFieldSupported is true, a STA shall set the +HTC Support subfield of the HT Extended Capabilities field of the HT Capabilities element to 1 in HT Capabilities elements that it transmits. If the value of dot11VHTControlFieldOptionImplemented is true, a STA shall set the +HTC-VHT Support subfield of the VHT Capabilities Information field of the VHT Capabilities element to 1 in VHT Capabilities elements that it transmits. If (#1433)dot11HEControlFieldOptionImplemented(#1313) is true, a STA shall set the +HTC-HE Support subfield of the HE Capabilities(#2397) Information field of the HE Capabilities element to 1 in HE Capabilities elements that it transmits.

A STA that has a value of true for at least one of dot11RDResponderOptionImplemented, dot11MCSFeedbackOptionImplemented, and dot11AlternateEDCAActivated shall set dot11HTControlFieldSupported or dot11VHTControlFieldOptionImplemented or both to true. A STA for which at least one of dot11HEULMUResponseSchedulingOptionImplemented(#1515)(#1), dot11MCSFeedbackOptionImplemented or dot11ROMIOptionImplemented is true shall set dot11HEControlFieldOptionImplemented(#1313) to true.

An HT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HT in the HT Extended Capabilities field of its HT Capabilities element (see 9.2.4.6 (HT Control field)).

A VHT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-VHT in the VHT Capabilities Information field of its VHT Capabilities element.

NOTE–An HT STA that does not support +HTC (HT or VHT variant) that receives a +HTC frame addressed to another STA still performs the CRC on the actual length of the MPDU and uses the Duration/ID field to update the NAV, as described in <reference>.

An HE variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HE in the HE Capabilities Information field of its HE Capabilities element. The HE variant HT Control field carried in the frame may contain a Control(#2495) subfield supported by the intended receiver that has:

- A value of 0 in the Control ID subfield when the transmitting STA expects an HE trigger-based PPDU(#Ed) that carries an immediate acknowledgement, as described in 25.5.2 (UL MU operation)(#2315).
- A value of 1 in the Control ID subfield when the transmitting STA changes the receive operating mode(#2209), as described in 25.8 (Receive operating mode)(#2228).
- A value of 2 in the Control ID subfield when the transmitting STA follows the HE link adaptation procedure, as described in 10.31.4 (Link adaptation using the HE variant HT Control field).
- A value of 3 in the Control ID subfield when the transmitting STA follows the corresponding buffer status report procedure, as described in 25.5.2.5 (HE buffer status feedback operation for UL MU)(#824)
- A value of 4 in the Control ID subfield when the transmitting STA follows the UL MU operation procedure, as described in 26.3.13.2 (Power pre-correction).

If the HT Control field is present in an MPDU aggregated in an A-MPDU(#1436), then all MPDUs of the same frame type (i.e., having the same value for the Type subfield of the Frame Control field) aggregated in the same A-MPDU(#1436) shall contain an HT Control field. The HT Control field of all MPDUs containing the HT Control field aggregated in the same A-MPDU(#1436) shall be set to the same value.

If an A-Control field is present in a frame then it shall contain at least one Control subfield, and the Control subfield shall be present in the A-Control field only if it is supported by the receiving STA; otherwise it shall

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not be present. At most one Control subfield with a given Control ID value shall be present in the A-Control field of QoS Data or Management frames carried in an (A-)MPDU.(#1253)(#134)

NOTE—An A-Control field that is present in a frame cannot contain only the Padding subfield.

An HE STA that receives an A-Control field shall ignore the remainder of the A-Control field that follows a Control ID subfield whose value is not recognized or is not supported by the STA.(#362)(#2206)

10.13 A-MPDU operation

10.13.1 A-MPDU contents

Change the 2nd paragraph as follows:

When an A-MPDU contains multiple QoS Control fields, bits 4 shall be identical across all MPDUs that contain the QoS Control fields and bits 8–15 of these QoS Control fields shall be identical across all MPDUs with equal value of the TID subfield.(#147)

10.22 HCF

10.22.2 HCF contention based channel access (EDCA)

10.22.2.2 EDCA backoff procedure

Insert the following at the end of subclause 10.22.2.2:

(MU Motion #57)When an HE STA successfully receives the corresponding acknowledgement frame in response to the MPDU sent in HE trigger based PPDU, the backoff for the associated EDCAF resumes the backoff counter countdown.

When an HE STA does not receive the corresponding acknowledgement frame in response to the MPDU sent in HE trigger based PPDU, the backoff for the associated EDCAF resumes the backoff counter countdown.

If an HE STA does not successfully receive the corresponding acknowledgement frame in response to the MPDU sent in an HE trigger based PPDU, the short retry counters and long retry counters for the associated EDCAF are not changed.

10.22.2.9 Truncation of TXOP

Insert the following at the end of subclause 10.22.2.9:

An HE STA that receives a CF-End frame should not reset its NAV if:

— The CF-End did not originate from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to and the most recent NAV update was due to a PPDU originating from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to.

— The CF-End originated from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to and the most recent NAV update was not due to a PPDU originating from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to.

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10.24 Block acknowledgement (block ack)

10.24.10 GCR block ack

10.24.10.3 GCR block ack BlockAckReq and BlockAck frame exchanges

Change the following 2nd and 3rd paragraphs as follows:

When the retransmission policy for a group address is GCR Block Ack, an originator shall not transmit more than the GCR buffer size number of A-MSDUs with RA set to the GCR concealment address and the DA field of the A-MSDU subframe set to the GCR group address before sending a BlockAckReq frame to one of the STAs that has a GCR block ack agreement for this group address. The RA field of the BlockAckReq frame shall be set to the MAC address of the destination STA. Upon reception of the BlockAck frame, an originator may send a BlockAckReq frame to another STA that has a block ack agreement for this group address, and this process may be repeated multiple times. If the originator has a GCR block ack agreement with one or more of the HE STAs for this group address, the originator may send an(#2817) MU-BAR frame (MU-BAR variant Trigger frame(#1532)) to one or more of the HE STAs(#1213). Upon reception of the BlockAck frame from one or more HE STAs, the(#2818) originator may send an(#2817) MU-BAR frame to one or more other(#413) HE STAs that have a GCR block ack agreement(#21), and this process may be repeated multiple times.(#136)

NOTE 1—If the originator sends a BlockAckReq frame to a STA with a MAC address that matches the SA in any of the A-MSDUs transmitted during the GCR TXOP, the Block Ack Bitmap subfield does not indicate the MSDUs sourced from this STA. This is because the STA will have discarded all group addressed MPDUs transmitted by the AP that have the source address equal to their MAC address (see 10.3.6 (Group addressed MPDU transfer procedure)).

When a recipient receives a BlockAckReq frame with the GCR Group Address subfield equal to a GCR group address, the recipient shall transmit a BlockAck frame at a delay of SIFS after the BlockAckReq frame. The BlockAck frame acknowledges the STA's reception status of the block of group addressed frames requested by the BlockAckReq frame. When an(#2819) HE STA receives an(#2817) MU-BAR frame with User Identifier subfield(#1444)(#2843) set to the AID of the HE STA, the HE STA shall transmit BlockAck frame in the indicated resource unit SIFS after the Trigger frame. The BlockAck frames report(#414) the HE STA's reception status of the block of group addressed frames requested by the MU-BAR frame.

Figure 10-36 (Example of a frame exchange with GCR block ack retransmission policy) shows an example of a frame exchange when the GCR block ack retransmission policy is used. The AP sends several A-MSDUs using the GCR block ack retransmission policy. The AP then sends a BlockAckReq frame to group member 1 of the GCR group, waits for the BlockAck frame, and then sends a BlockAckReq frame to group member 2. After receiving the BlockAck frame from GCR group member 2, the AP determines whether any A-MSDUs need to be retransmitted and sends additional A-MSDUs (some of which might be retransmissions of previous A-MSDUs) using the GCR block ack retransmission policy.

Insert the following paragraph and associated figure:

Figure 10-36a (Example of a frame exchange with GCR block ack retransmission policy(#22)(#415)(#1442)) shows another example of a frame exchange when the GCR block ack retransmission policy is used. The HE AP sends several A-MSDUs using the GCR block ack retransmission policy. The HE AP then sends an(#2817) MU-BAR to group members 1 and 2 of the GCR group, waits for the BlockAck frames, and then sends an(#2817) MU-BAR to group members 3 and 4 and then waits for the BlockAck frame. The HE AP then sends a BAR frame to group member 5, which is a non-HE STA, and waits for the BlockAck frame(#22)(#1442). After receiving the BlockAck frames(#22)(#1442), the HE AP

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determines whether any A-MSDUs need to be retransmitted and sends additional A-MSDUs (some of which might be retransmissions of previous A-MSDUs) using the GCR block ack retransmission policy.

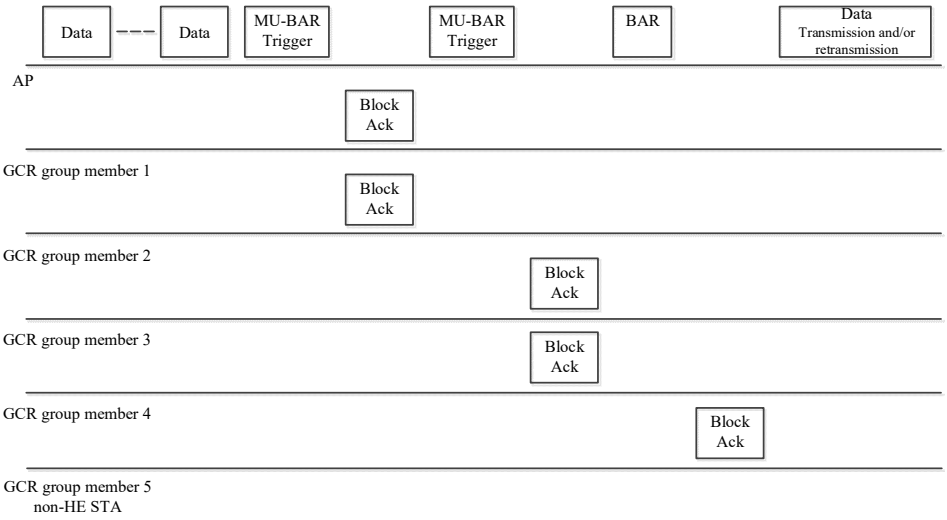


Figure 10-36a—Example of a frame exchange with GCR block ack retransmission policy(#22)(#415)(#1442)

Change the 6th,7th and 8th paragraph as follows:

After completing the BlockAckReq or MU-BAR and BlockAck frame exchanges(#23), the originator determines from the information provided in the BlockAck bitmap and from the missing BlockAck frames which, if any, A-MSDUs need to be retransmitted.

An originator adopting the GCR block ack retransmission policy for a GCR group address chooses a lifetime limit for the group address. The originator may vary the lifetime limit for the group address at any time and may use different lifetime limits for different GCR group addresses. The originator transmits and retries each A-MSDU until the appropriate lifetime limit is reached or until each one has been received by all group members to which a BlockAckReq frame or an MU-BAR frame has been sent, whichever occurs first.

For GCR streams with retransmission policy equal to GCR Block Ack, an originator may regularly send a BlockAckReq frame with the GCR Group Address subfield in the BAR Information field set to the GCR group address and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group. An originator may also (#1443)send an MU-BAR frame with AID12 fields(#1444) set to AIDs of HE STAs that transmit the BlockAck frames and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group.

NOTE 2—This is because an originator might transmit Management frames, QoS Data frames with a group address in the Address 1 field (including different GCR streams), and non-QoS Data frames intermingled. Since these are transmitted using a single sequence counter, missing frames or frames sent to group addresses absent from a receiving STA's dot11GroupAddresses table complicate receiver processing for GCR streams with a GCR block ack retransmission policy since the cause of a hole in a receiver's block ack bitmap is ambiguous: it is due either to an MPDU being lost from the GCR stream or to transmissions of MPDUs not related to the GCR service using the same sequence number counter.

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Change the last paragraph as follows:

If the beginning of such reception does not occur during the first slot time following a SIFS(#24)(#587)(#694)(#1756)(#1769)(#2615)(#2231), then the originator may perform error recovery by retransmitting a BlockAckReq frame or an MU-BAR frame(Ed) PIFS after the previous BlockAckReq frame or an MU-BAR frame when both of the following conditions are met:

— The carrier sense mechanism (see 10.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (defined in 10.3.7 (DCF timing relations)) after the expected start of a Block-Ack frame, and

— The remaining duration of the GCR TXOP is longer than the total time required to retransmit the GCR BlockAckReq frame or an MU-BAR frame plus one slot time.

NOTE 3—If an originator fails to receive a BlockAck frame in response to a BlockAckReq frame and there is insufficient time to transmit a recovery frame, the AP retransmits the BlockAckReq frame in a new TXOP.

10.44 Target wake time (TWT)

10.44.1 TWT overview

Change the 2nd paragraph of 9.44.1 as follows:

A TWT requesting STA communicates wake scheduling information to its TWT responding STA and the TWT responding STA devises a schedule and delivers TWT values to the TWT requesting STA when a TWT agreement has been established between them as described in 10.44.2 (Individual TWT agreements). When explicit TWT is employed, a TWT requesting STA wakes and performs a frame exchange and receives the next TWT information in a response from the TWT responding STA as described in 10.44.2.2 (Explicit TWT operation). When implicit TWT is used, the TWT requesting STA calculates the Next TWT by adding a fixed value to the current TWT value as described in 10.44.3 (Implicit TWT operation). An HE AP can additionally devise schedules and deliver TWT values to HE non-AP STAs without requiring that an individual TWT agreement has been established between them, as described in 10.44.4 (Broadcast TWT operation).

Insert a subclause heading after the 2nd paragraph of 10.44.1 (rest of dependent subclauses become dependent of this new subclause):

10.44.2 Individual TWT agreements

Change the 2 paragraphs (4th, 5th) of 9.44.1 as follows:

A STA with dot11TWTOptionActivated equal to true and that operates in the role of TWT requesting STA shall set the TWT Requester Support subfield to 1 in all S1G Capabilities or HE Capabilities elements that it transmits. A STA with dot11TWTOptionActivated equal to true and that operates in the role of TWT responding STA shall set the TWT Responder Support subfield to 1 in all S1G Capabilities or HE Capabilities elements that it transmits.

If the TWT Responder Support subfield of the S1G Capabilities or of the HE Capabilities element received from its associated AP is equal to 1, a non-AP STA with dot11TWTOptionActivated equal to true may transmit a TWT element to the AP with a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and with the TWT Request field equal to 1.

Insert a new paragraph after the 9th paragraph as follows:

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A STA that transmits a frame carrying a TWT element to an HE STA may set the Trigger subfield of the TWT element(#739) to 1. Otherwise, the STA shall set the Trigger subfield to 0. In a TWT response, a Trigger field equal to 1 indicates a trigger-enabled TWT. The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission a Trigger frame to the TWT requesting STA, as described in 25.5.2 (UL MU operation)(#684), within each TWT SP for that TWT agreement. The TWT responding STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. Otherwise, the TWT responding STA(#417) shall set the Cascade Indication field to 0.

Insert a sentence at the end of the 10th paragraph of 10.44.1 as follows:

An HE STA that transmits a TWT element to another HE STA shall set the Implicit subfield of the element to 1 and the NDP Paging Indicator subfield of the element to 0.

Insert a sentence at the end of the 12th paragraph of 10.44.1 as follows:

A TWT requesting STA transmits a frame during a trigger-enabled TWT SP in response to a Trigger frame (see 25.5.2 (UL MU operation)).

Change the last 2 paragraphs of 10.44.1 as follows:

The Flow Type field in the TWT response that successfully set up a TWT agreement indicates the type of interaction between the TWT requesting STA and the TWT responding STA within each TWT SP for that TWT agreement. Flow Type field equal to 0 indicates an announced TWT. The TWT responding STA of an announced TWT agreement shall not transmit a frame, except for a Trigger frame within a trigger-enabled TWT SP, to the TWT requesting STA within a TWT SP until it has successfully received a PS-Poll frame or APSD Trigger frame(#1535) (see 10.2.2.5 (Power management with APSD)) from the TWT requesting STA. Flow Type field equal to 1 indicates an unannounced TWT. The TWT responding STA of an unannounced TWT agreement may transmit a frame to the TWT requesting STA within a TWT SP before it has successfully received a frame from the TWT requesting STA.

An S1G TWT requesting STA indicates which single channel it desires to use as a temporary primary channel during a TWT SP by setting a single bit to 1 within the TWT Channel field of the TWT element, according to the mapping described for that field. An S1G TWT responding STA indicates which single channel the TWT requesting STA is permitted to use as a temporary primary channel during a TWT SP by setting a single bit to 1 within the TWT Channel field of the TWT element, according to the mapping described for that field. During a TWT SP, access to a channel which is not the primary channel of the BSS shall be performed according to the procedure described in 9.49 (Subchannel Selective Transmission (SST)). An HE STA indicates TBD.

10.44.3 Implicit TWT operation

Change the 3rd paragraph of 9.44.4 of as follows:

A TWT requesting STA awake for an implicit TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA. A TWT requesting STA awake for a trigger-enabled TWT SP may transition to the doze state if it receives from the TWT responding STA a Trigger frame that has a Cascade Indication(#1448) field equal to 0 and that is not addressed to(#1447) the TWT requesting STA(#417).

Insert a sentence at the end of the 4rd paragraph of 10.44.4 as follows:

An HE STA shall not generate BAT, TACK, or STACK frames.

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Insert a new subclause, and dependent subclauses, at the end of 10.44 as follows:

10.44.4 Broadcast TWT operation

10.44.4.1 General

A TWT scheduling STA is an HE AP with dot11TWTOptionActivated equal to true that includes a TWT element in the Beacon frame, and follows the rules described in 10.44.4.2 (Rules for TWT scheduling STA)(#956).

A TWT scheduled STA is an HE non-AP STA that:

— TBD: Declares support of being a TWT scheduled STA

— Receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling STA and,

— Has not negotiated any implicit TWT agreement with the HE AP as described in 10.44.2 (Individual TWT agreements).

A TWT scheduled STA follows the schedule provided by the TWT scheduling STA as described in Error! Reference source not found. (Rules for TWT scheduled STA). A TWT scheduled STA can negotiate the TBTT and listen interval for Beacon frames it intends to receive as described in 10.44.4.3 (Negotiation of TBTT and listen interval).

An example of broadcast TWT operation is shown in Figure 10-ax2 (Example of broadcast TWT operation), where the AP is the TWT scheduling STA and STA 1 and STA 2 are the TWT scheduled STAs.

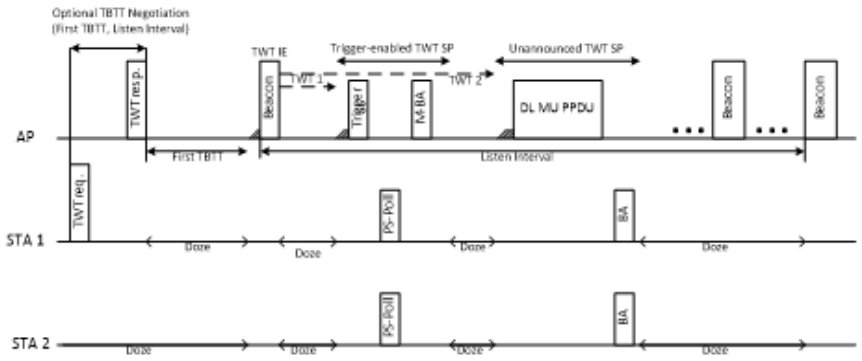


Figure 10-ax2—Example of broadcast TWT operation

10.44.4.2 Rules for TWT scheduling STA

A TWT scheduling STA may include a TWT element in a Beacon frame scheduled at a TBTT (see 10.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling STA shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. Each TWT parameter set specifies the TWT parameters of a broadcast TWT that are valid within a broadcast TWT SP.

The TWT scheduling STA sets the TWT parameters of each set as described below:

— The TWT scheduling STA shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0. The TWT scheduling STA shall schedule for transmission a Trigger frame addressed to(#2620) one or more TWT scheduled STAs during a trigger-enabled TWT SP. The TWT scheduling STA that intends to transmit additional Trigger frames during a trig-

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ger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. Otherwise, it shall set the Cascade Indication(#1448) field to 0.

— The TWT scheduling STA shall set the TWT Flow Identifier field according to Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element). The TWT scheduling STA should only send frames that satisfy the TWT flow identifier recommendations listed in Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element) during the TWT SP(s).

— The TWT scheduling STA shall set the TWT field to the TSF[TBD X: TBD Y] time at which the first TWT is scheduled.

— The TWT scheduling STA shall include the value of the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT. The TWT parameters are valid for each successive TWT of the periodic TWT.

— TBD

10.44.4.3 Negotiation of TBTT and listen interval

A TWT scheduled STA that intends to operate in power save mode (see 10.2.2.2 (STA Power Management modes)) may transmit a TWT request frame to the TWT scheduling STA that identifies the TBTT of the next Beacon frame the STA intends to receive and the interval between subsequent Beacon frames it intends to receive. The TWT request frame shall contain:

— The value of the requested first TBTT in the Target Wake Time field when the TWT Command field is Suggest TWT or Demand TWT.

— The value of the listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

A TWT scheduling STA that receives a TWT request frame from a STA whose value of the TWT wake interval is equal to the STA's listen interval shall respond with a TWT response frame that contains either Accept TWT or Reject TWT in the TWT Command field and, in the case of an Accept TWT, it shall also contain:

— The value of the allocated first TBTT in the Target Wake Time field, and

— The value of the listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

After successfully completing the negotiation, the TWT scheduled STA may go to doze state until its TSF matches the next negotiated TBTT provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TWT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated TBTTs and shall operate as described in in Error! Reference source not found. (Rules for TWT scheduled STA).

Either STA can tear down an established negotiation following the tear down procedure described in 10.44.8 (TWT Teardown).

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Insert new Clauses 25 and 26 following Clause 24 as follows:

25. High Efficiency (HE) MAC specification

25.1 Introduction

The use of HCCA and TSPEC are banned at HE STAs.(#2414)

25.2 Channel Access

25.2.1 Intra-BSS and inter-BSS frame detection

An HE STA(#2331) determines whether a received(#1577) frame is an inter-BSS or an intra-BSS frame by using the RXVECTOR parameters (e.g., BSS_COLOR in HE PPDUs or GROUP_ID and PARTIAL_AID in VHT PPDUs)(#186)(#2434) or MAC address(#1575).

A frame received(#1577) by the STA is an intra-BSS frame if one of the following conditions is true:

- The RXVECTOR parameter BSS_COLOR(#2435) in the received PPDU carrying the frame(#1577) is the same as the BSS color announced by the AP to which the STA is associated
- The RA field, TA field or BSSID field(#2438)(#2662) of the received(#1577) frame with the Individual/Group bit forced to the value 0(#447) is the same as the BSSID of AP to which the STA is associated(#608)
- The AP to which the STA is associated is a member of a Multiple BSSID Set with two or more members(#703)(#257)(#2332) and the RA field, TA field or BSSID field(#2438, #2662) of the received(#1577) frame with the Individual/Group bit forced to the value 0(#447) is same as the BSSID of any member of the Multiple BSSID Set
- The RXVECTOR parameter PARTIAL_AID in the received VHT PPDU with the RXVECTOR parameter GROUP_ID equal to 0 is the same as the BSSID[39:47] of the AP to which the STA is associated(#2437)
- The value of RXVECTOR parameter PARTIAL_AID [8-N+1:8] in the received VHT PPDU with the RXVECTOR parameter GROUP_ID equal to 63 is the same as the Partial BSS Color announced by the AP to which the STA is associated when the value (N) of the Partial BSS Color Length field in the most recently received HE Operation element is not equal to 0.(#705)(#2436)

A frame received by the STA is an inter-BSS frame if one of the following conditions is true(#62)(#2718):

- The RXVECTOR parameter BSS_COLOR of the PPDU carrying the frame is not 0 and does not match the BSS color announced by the AP to which the STA is associated
- When the RXVECTOR parameter BSS_COLOR of the PPDU carrying the frame is not present:
  - The BSSID field of the received frame with Individual/Group bit forced to the value 0, if available, does not match the BSSID of AP to which the STA is associated
  - If the BSSID field is not available, both the RA and TA fields exist, and none of the address fields of the received frame with Individual/Group bit forced to the value 0 match the BSSID of AP to which the STA is associated(#Ed)
- The AP to which the STA is associated is a member of a Multiple BSSID Set with two or more members and the BSSID field of the received frame with Individual/Group bit forced to the value 0, if available, does not match the BSSID of any member of the Multiple BSSID Set
- If the AP to which the STA is associated is a member of a Multiple BSSID Set with two or more members, the BSSID field is not available, both the RA and TA fields exist, and none of the address

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fields of the received frame with the Individual/Group bit forced to the value 0 match the BSSID of any member of the Multiple BSSID Set(#Ed)

— The RXVECTOR parameter PARTIAL_AID of the received VHT PPDU frame with the RXVECTOR parameter GROUP_ID equal to 0 is different from the BSSID[39:47] of the AP to which the STA is associated(#2439)

— The value of RXVECTOR parameter PARTIAL_AID [8-N+1:8] in the received VHT PPDU with the RXVECTOR parameter GROUP_ID equal to 63 is different from the Partial BSS Color announced by the AP to which the STA is associated when the value (N) of the Partial BSS Color Length field in the most recently received HE Operation element is not equal to 0.(#705)(#2439)

— An HE AP receives either a VHT MU PPDU or an HE MU PPDU.(#2440)

If the received frame satisfies both intra-BSS and inter-BSS conditions, the decision made by using the MAC address takes precedence over the decision made by using the RXVECTOR parameter BSS_COLOR (#640)(#2661)(#776).

If the received frame does not satisfy any of the intra-BSS and inter-BSS conditions, then the frame cannot be determined as intra-BSS or inter-BSS frame(#62).

25.2.2 Updating two NAVs

Mandatory or optional support of two NAVs is TBD.

For the two NAVs maintained by an(#2829) HE STA, one is identified as intra-BSS(#1465) NAV, and the second one is identified as regular NAV.

A STA that receives at least one valid frame in a PSDU and identifies the frame as intra-BSS(#1465) can update its intra-BSS(#1465) NAV with the information from any valid Duration field in the PSDU.

A STA that receives at least one valid frame in a PSDU and identifies the frame as inter-BSS(#1465) can update its regular NAV with the information from any valid Duration field in the PSDU.

A STA that receives at least one valid frame in a PSDU and cannot identify the frame as intra-BSS(#1465) or inter-BSS(#1465) can update its regular NAV with the information from any valid Duration field in the PSDU.

A STA that receives a valid HE-SIG-A in an(#2829) HE PPDU and identifies the HE-SIG-A as intra-BSS(#1465) can update its intra-BSS(#1465) NAV with the information from the TXOP Duration field in the HE-SIG-A.

A STA that receives a valid HE-SIG-A in an(#2829) HE PPDU and identifies the HE-SIG-A as inter-BSS(#1465) can update its regular NAV with the information from the TXOP Duration field in the HE-SIG-A.

When the received frame's RA is equal to the STA's own MAC address, the STA shall not update its intra-BSS(#1465) NAV or regular NAV with the information from the Duration field.

When a STA receives both a valid HE-SIG-A in an(#2829) HE PPDU and a valid frame in the PSDU of the HE PPDU, the STA shall not update its intra-BSS(#1465) NAV or regular NAV with the information from the TXOP Duration field in the HE-SIG-A.

For all other received frames that are identified by the STA as intra-BSS(#1465), the STA shall update its intra-BSS(#1465) NAV when the received value of the Duration field is greater than the STA's current intra-BSS(#1465) NAV value.

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For all other received frames that are identified by the STA as inter-BSS(#1465) or cannot be identified as intra-BSS(#1465) or inter-BSS(#1465), the STA shall update its regular NAV when the received value of the Duration field is greater than the STA's current regular NAV value.

For all other received HE-SIG-As that are identified by the STA as intra-BSS(#1465), the STA shall update its intra-BSS(#1465) NAV when the received value of the TXOP Duration field is greater than the STA's current intra-BSS(#1465) NAV value.

For all other received HE-SIG-As that are identified by the STA as inter-BSS(#1465), the STA shall update its inter-BSS(#1465) NAV when the received value of the TXOP Duration field is greater than the STA's current regular NAV value.

25.3 Fragmentation

25.3.1 General

An HE STA supports the static fragmentation procedure defined in 10.2.7 (Fragmentation/defragmentation overview), 10.5 (Fragmentation), and 10.6 (Defragmentation). In addition, an HE STA can support the dynamic fragmentation procedure defined in this subclause.(#1484)

An HE STA can dynamically fragment individually addressed MSDUs or MMPDUs and defragment received MPDUs as defined in this subclause, and using the fragmentation/defragmentation processes defined in 10.2.7 (Fragmentation/defragmentation overview) without being subject to the rules defined in that subclause. Dynamic fragmentation provides further flexibility in aggregating the data so that padding can be minimized (see 25.5 (MU operation))(#30).

25.3.2 Support and requirements for dynamic fragmentation

A dynamic fragment is an MPDU, the payload of which carries a portion of an MSDU or MMPDU. The generation of dynamic fragments follows the rules defined in 10.2.7 (Fragmentation/defragmentation overview) and 10.5 (Fragmentation), except for:

— Generation of dynamic fragments and their transmission within an MPDU or A-MPDU under HT-immediate block ack agreements is allowed for an HE STA under the conditions defined in 25.3.4 (Procedure at the recipient).(#2627)(#2626)

— Reception of dynamic fragments is not mandatory. An HE STA declares its dynamic fragments reception capability in the HE Fragmentation Support field of the HE Capabilities element(#1471).

— The length of each fragment is not required to be equal for all fragments of the MSDU or MMPDU. The length of each fragment may be of any nonzero value, except that the length of the first fragment of an MSDU shall be greater than or equal to the minimum fragment size specified by the receiver STA in the Minimum Fragment Size subfield of the HE Capabilities element it transmits. An MSDU with a size that is less than the minimum fragment size shall not be fragmented.(#30)(#697)(#696)(#1470)(#165)

25.3.3 Procedure at the originator(#1484)

25.3.3.1 General(#Ed)

An originator STA transmitting an MPDU or A-MPDU that contains one or more dynamic fragments shall solicit an immediate response from the recipient STA for each of the fragments contained in the MPDU or A-MPDU, except when the fragments are sent under level 3 dynamic fragmentation (see 25.3.3.3 (Level 3 dynamic fragmentation)).(#2629)(#1794).

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NOTE—The originator STA sends the fragments in order as defined in 10.5 (Fragmentation), except for level 3 dynamic fragmentation.

If the originator STA received explicit indications in response frames that none of the transmissions of previously transmitted fragment(s) of an MSDU or MMPDU have been successfully received then the STA may retransmit the full MSDU or MMPDU instead of retransmitting all the failed fragments. Otherwise, the originator STA may retransmit the failed fragment, in which case the frame body length and contents of the retransmitted fragment shall be the same as the first transmitted fragment and shall remain fixed for the lifetime of the MSDU or MMPDU at that STA.(#1225)

NOTE—An explicit indication is the absence of a valid Ack frame, BlockAck frame or Multi-STA BlockAck frame that is expected to be present in the first MPDU of the immediately received A-MPDU, or the absence of a BA Information field in the immediately received Multi-STA BlockAck frame for the TID of the transmitted fragment(s).(#1225)

An originator STA shall not transmit to a recipient STA an MPDU or A-MPDU containing dynamic fragments that do not satisfy the conditions in the subclauses below.(#1480)(#1479)(#1478)(#750)

25.3.3.2 Level 1 dynamic fragmentation(#1484)

An originator STA may transmit to a recipient STA an MPDU(#1472) or VHT single MPDU(#1473) that contains one dynamic fragment of an MSDU or MMPDU if the recipient STA has indicated a value 1 in the HE Fragmentation Support field of its HE Capabilities element. The originator STA shall follow the rules defined in 10.13.8 (Transport of VHT single MPDUs) for generating the VHT single MPDU.(#Ed)

25.3.3.3 Level 2 dynamic fragmentation(#1484)

An originator STA may transmit to a recipient STA, which has indicated a value 2 in the HE Fragmentation Support field of its HE Capabilities element, an MPDU, VHT single MPDU, or A-MPDU(#1473) that contains:

— One dynamic fragment of an MSDU or MMPDU in an MPDU or VHT single MPDU(#1474)
  - The originator STA shall follow the rules defined in 10.13.8 (Transport of VHT single MPDUs) for generating the VHT single MPDU

— Up to one dynamic fragment of an MSDU or MMPDU for each MSDU and for the MMPDU in an A-MPDU format(#1474)(#2464)
  - The originator STA shall follow the rules defined in 10.24.7.7 (Originator's behavior) for generating the A-MPDU and the rules defined in 25.10.4 (A-MPDU with multiple TIDs) for generating the multi-TID A-MPDU (that can contain the fragment of the MMPDU)(#1476)

25.3.3.4 Level 3 dynamic fragmentation(#1484)

An originator STA may transmit to a recipient STA, which has indicated a value 3 in the HE Fragmentation Support field of its HE Capabilities element, an MPDU, VHT single MPDU, or A-MPDU(#1473) that contains:

— One dynamic fragment of an MSDU or MMPDU in an MPDU or VHT single MPDU(#1474)
  - The originator STA shall follow the rules defined in 10.13.8 (Transport of VHT single MPDUs) for generating the VHT single MPDU

— Up to four dynamic fragments of an MSDU(#1475) for each MSDU and up to one dynamic fragment of an MMPDU(#1476)(#1475)(#2465) in an A-MPDU
  - The originator STA shall set the Fragment Number subfield of each MPDU to a value less than 4
  - The originator STA shall follow the rules defined in 10.24.7.7 (Originator's behavior) for generating the A-MPDU with the exception that the A-MPDU should contain MPDUs whose range of the Sequence Number subfields does not exceed 16.(#697)(#Ed)

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25.3.4 Procedure at the recipient

25.3.4.1 General(#Ed)

An HE STA shall set the HE Fragmentation Support subfield of the HE Capabilities element it transmits to 0 if its dot11HEDynamicFragmentationImplemented is false. Otherwise the HE STA shall set the HE Fragmentation Support subfield as follows:

— Set to 1 if the STA supports reception of dynamic fragments following the procedure defined in 25.3.3.2 (Level 1 dynamic fragmentation(#1484))

— Set to 2 if the STA supports reception of dynamic fragments following the procedure defined in 25.3.3.3 (Level 2 dynamic fragmentation(#1484))

— Set to 3 if the STA supports reception of dynamic fragments following the procedure defined in 225.3.3.4 (Level 3 dynamic fragmentation(#1484))

(#1481)(#424)Defragmentation of dynamic fragments shall follow the rules defined in 10.6 (Defragmentation) with the following exceptions:(#Ed)

— The recipient STA shall support the concurrent reception of dynamic fragments of a number of *outstanding* MSDUs or MMPDUs from a transmitting STA that is equal to N_{max}, where N_{max} for MSDUs is indicated in the Maximum Number of Fragmented MSDUs subfield of the HE Capabilities element transmitted by the STA, and N_{max} is equal to 1 for MMPDUs. The term *outstanding* refers to an MPDU containing all or part of an MSDU or MMPDU for which transmission has been started, and for which delivery of the MSDU or MMPDU has not yet been completed (i.e., an acknowledgment of the final fragment has not been received and the MSDU or MMPDU has not been discarded due to retries, lifetime, or for some other reason). (#1482)(#697)(#167)(#1484)

— The recipient STA is not subject to the receive timer rules(#1483) for each of the MSDUs/MMPDUs defined in 10.6 (Defragmentation)(#2318).

25.3.4.2 Level 1 dynamic defragmentation

Upon reception of an MPDU or VHT single MPDU that carries one or more dynamic fragments, the recipient STA responds with an Ack frame when the received fragment is contained in an MPDU or VHT single MPDU that solicits the immediate response. The receiver STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame and the rules defined in 25.4 (Block acknowledgement) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting VHT single MPDU carried in a Trigger-based PPDU(#1793)(#2628).

25.3.4.3 Level 2 dynamic fragmentation(#1484)

Upon reception of an MPDU or A-MPDU that carries one or more dynamic fragments, the recipient STA responds with one of the following frames:

— An Ack frame when the received fragment is contained in an MPDU or VHT single MPDU that solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame and the rules defined in 25.4 (Block acknowledgement) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting VHT single MPDU carried in a HE trigger-based PPDU(#1793)(#2628).

— A BlockAck frame when the received fragments, up to one fragment for each MSDU, are contained in an A-MPDU that solicits an immediate response(#1820)(#1485). The recipient STA shall follow the rules defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame and the rules in 25.4 (Block acknowledgement) for generating the Multi-STA BlockAck frame(#1793), except that the STA shall:

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- Set to 0 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame or Multi-STA BlockAck(#Ed) frame that corresponds to a TID of a received fragment(#967)
- Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield and TID subfield of a successfully received fragment contained in the soliciting A-MPDU or multi-TID A-MPDU
- Update the corresponding block ack record(#1486)(#Ed) only when an MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)) otherwise it shall not update the block ack record(#Ed) for that MSDU.(#1793)(#1217)

A recipient STA shall discard any fragments that have been received during an HT-immediate BA session for a TID if it receives a BlockAckReq(#Ed) frame from the originator STA for that TID when the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq(#Ed) frame (where the comparison of the two values is performed modulo 4096)(#1662)(#2197)(#1217).

25.3.4.4 Level 3 dynamic fragmentation(#1484)

Upon reception of an MPDU or A-MPDU that carries one or more dynamic fragments, the recipient STA responds with one of the following frames:

— An Ack frame when the received fragment is contained in an MPDU or VHT single MPDU that solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame and the rules defined in 25.4 (Block acknowledgement) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting VHT single MPDU carried in a Trigger-based PPDU(#1793)(#2628).

— A BlockAck frame when the received fragments, one or more fragments for each MSDU, are contained in an A-MPDU that solicits the immediate response. The recipient STA shall follow the rules in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, except that the STA shall:

- Set to 1 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment
- Set to 1 each bit in location *B*(#633) of the Block Ack Bitmap field that corresponds to a successfully received fragment and shall set it to 0 otherwise, with *B*(#633) calculated as:
  $B = SC - SSN$, where *SC* and *SSN* are treated as 14-bit unsigned integers
  SC is the value of the Sequence Control subfield of an MPDU containing the fragment for which the receive status is indicated
  SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame
- Update the corresponding block ack record(#1486) only when an MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)). Otherwise it shall not update the block ack record for that MSDU.(#1793)(#1217)

The(#Ed) recipient STA shall discard any fragments that have been received during an HT-immediate BA session for a TID if it receives a BlockAckReq(#Ed) frame from the originator STA for that TID when the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq(#Ed) frame (where the comparison of the two values is performed modulo 4096)(#1662)(#2197)(#1217).

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25.4 Block acknowledgement

25.4.1 Selection of BlockAck and BlockAckReq variants

An HE STA may send a Multi-STA BlockAck frame in response to an HE trigger-based PPDU. A Multi-STA BlockAck frame contains one or more BA Information fields with one or more AIDs and one or more different TIDs. An HE AP that transmits a Multi-STA BlockAck frame with different AID subfield values shall set the RA field to the broadcast address. An HE AP that transmits a Multi-STA BlockAck frame with a single AID subfield or with the same values of the AID subfield in Per STA Info subfields shall set the RA field to the address of the recipient STA that requested the Block Ack or to the broadcast address. An HE non-AP STA shall transmit a Multi-STA BlockAck frame with a single AID subfield or with the same values of the AID subfield in Per STA Info subfields and shall set the RA field to the address of the recipient STA that requested the Block Ack frame.(#1493)(#2212)

An HE STA that supports Multi-STA BA shall examine each received Multi-STA sent by an STA with which it has a BA agreement. On receiving such a Multi-STA BlockAck frame a STA performs the following for each BA Information field with its AID:

— If the Ack Type(#1408) field is 0 then the Block Ack Starting Sequence Control(#1490), TID and Block Ack Bitmap fields(#Ed) of the STA Info field are processed according to 10.24.7 (HT-immediate block ack extensions) and 25.3 (Fragmentation).(MAC Motion #87)

— If the Ack Type(#1408) field is 1, then the STA Info field indicates either the acknowledgement of a single MPDU identified by the value of the TID or of all MPDUs carried in the eliciting PPDU, when the TID field is set to 14.(MAC Motion #87)

25.5 MU operation

25.5.1 HE DL MU operation

25.5.1.1 General

HE DL MU operation allows an AP to transmit simultaneously to one or more non-AP STAs in DL OFDMA, DL MU-MIMO or both.

An AP shall not transmit to a STA an HE MU PPDU with the HE-SIG-B allocating more than one RU(#1501) (see 26.3.10.8.3 (Time domain encoding)), unless the STA set the DL OFDMA Capable subfield of the HE Capabilities element to 1.

An AP shall not transmit to a STA an(#2829) HE MU PPDU with the HE-SIG-B allocating spatial streams to more than one recipient STA, unless the STA set the DL MU-MIMO(#1507) Capable subfield of the HE Capabilities element to 1.

The transmission for all the STAs in an HE MU PPDU in either DL OFDMA or DL MU-MIMO(#1507) shall end at the same time, indicated by the L-SIG field as described in 26.3.10.5 (L-SIG).

The padding procedure for each A-MPDU in an HE MU PPDU is the same as for an A-MPDU in a VHT PPDU and defined in 10.13.6 (A-MPDU padding for VHT PPDU).

25.5.1.2 HE MU PPDU payload

The content of each A-MPDU(#1537) in an HE MU PPDU is based on the rules specified in 10.13.1 (A-MPDU contents).

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The frame type and address type (individually addressed or group addressed(#1509)) of MPDUs may be different across A-MPDUs within a same HE MU PPDU(#598).

A group addressed(#1510) frame in a groupcast RU of an HE MU PPDU shall not include information intended for a STA that is identified as the recipient of another RU in the same HE MU PPDU.

25.5.2 UL MU operation

25.5.2.1 General

The UL MU operation allows an AP to solicit simultaneous immediate response frames(#1513) from one or more non-AP STAs. Non-AP STAs transmit their response frames using(#1514) HE trigger-based PPDU format, in either UL OFDMA(#1515),(#431) UL MU-MIMO, or both.

An HE STA with dot11ULOFDMAOptionImplemented(#1515) set to true shall set the UL OFDMA Capable(#1515) subfield of the HE Capabilities element it transmits to 1. Otherwise, the HE STA shall set the UL OFDMA Capable subfield of the HE Capabilities element it transmits to 0(#417).

An HE STA with dot11ULMUMIMOOptionImplemented set to true shall set the UL MU-MIMO(#1507) Capable subfield of the HE Capabilities element it transmits to 1. Otherwise, the HE STA shall set UL MU-MIMO Capable subfield of the HE Capabilities element it transmits to 0(#417).

A non-AP STA with dot11ULOFDMAOptionImplemented(#1515) or dot11ULMUMIMOOptionImplemented equal to true is referred to as an UL MU capable STA.

An HE STA shall set the UL MU Response Scheduling Support subfield of the HE Capabilities element it transmits to 1 if its dot11HEULMUResponseSchedulingOptionImplemented is true; otherwise the STA shall set it to 0.(#1)

25.5.2.2 Rules for soliciting UL MU frames

25.5.2.2.1 General

An AP shall not send to a STA a frame soliciting an HE trigger-based PPDU response unless the STA is UL MU capable(#1516)(#1518).

An AP shall not send to a STA an MPDU that contains an UL MU Response Scheduling A-Control subfield, unless the STA has set the UL MU Response Scheduling Support subfield to 1 in the HE Capabilities element it transmits.(#1)

An AP may transmit a PPDU that elicits an HE trigger-based PPDU from one or more UL MU capable STAs by including in the PPDU at least one of:

— A Trigger frame that includes one or more User Info fields(#1520) addressed to the recipient STAs(#Ed).
  - For recipient STAs that are associated with the AP, the User Info field(#1520) is addressed to a recipient STA if the value of the AID12(#Ed) subfield(#2683) of the User Info(#1520) field is equal to the AID of the STA.
  - For recipient STAs that are not associated with the AP, TBD

— An UL MU Response Scheduling A-Control subfield of individually addressed MPDUs contained in the HE MU PPDU that:(#1)
  - Are carried in a VHT single MPDU format that solicits an immediate Ack frame (see 10.13.8 (Transport of VHT single MPDUs))

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- Are carried in an A-MPDU format that solicits an immediate BlockAck frame (see 10.24.7.7 (Originator's behavior))
- Are carried in a multi-TID A-MPDU format that solicits an immediate Multi-STA BA frame (see 25.10.4 (A-MPDU with multiple TIDs))

NOTE—The AP additionally follows the rules defined in 25.3.3 (Procedure at the originator(#1484)) when fragments are present in the generated MPDU(s).

The following two frames shall not be present at the same time in an A-MPDU:(#595)

— A Trigger frame with a User Info field(#1520) addressed to a STA

— An(#1525) MPDU addressed to a STA that includes “contains an UL MU Response Scheduling A-Control subfield(#1)

If a Trigger frame is aggregated with other frames in an A-MPDU, the Trigger frame shall be the first frame in the A-MPDU.

(#1634)A transmitted Trigger frame that contains a User Info field with the AID of a non-AP STA may contain a Padding field, whose length shall ensure that at least *MinTrigProcTime*, in microseconds, passes from the end of the User Info field that contains that AID and the end of the PPDU that contains the Trigger frame, where the *MinTrigProcTime* is equal to the value specified by the non-AP STA in the Trigger Frame MAC Padding subfield of the HE Capabilities element it transmits. AP shall apply the Trigger Frame MAC Padding field with duration corresponding to the longest value among all STAs that have requested extra *MinTrigProcTime* through Trigger Frame MAC Padding Duration capability.

The AP shall ensure that the duration of the symbols that follow the symbol in the Trigger Frame that contains the last bit of the STA’s User info field is larger than or equal to the *MinTrigProcTime* value specified by the STA.

NOTE 1—The start of the Padding subfield is identified by a User Info field that has a value of the AID equal to 2047, and the remaining subfields of the Padding field are set to 1.

NOTE 2—This rule applies to all variants of the Trigger frame (Basic, MU BAR, MU RTS, etc).

25.5.2.2.2 Allowed settings of the Trigger frame fields

If dot11MultiBSSIDActivated is true and at least two of the Trigger frame recipient STAs are associated with two different BSSIDs, then the TA shall be set to a common address TBD; in all other cases the TA shall be set to the BSSID of the AP to which all recipient STAs are associated.

An AP shall not set any subfields of the Common Info field(#1529) to a value that is not supported by all the recipient STAs of the Trigger frame.

An AP shall not set any subfields of a User Info field to a value that is not supported by the recipient STAs of the User Info field.

If a Trigger frame is transmitted in a broadcast RU of an(#2829) HE MU PPDU, then the Trigger frame shall not include any User Info fields addressed to a STA that is identified as recipient of another RU or spatial stream of the same HE MU PPDU.

The responding STA shall not aggregate QoS Data frames in the multi-TID A-MPDU with a number of TIDs that exceeds the value indicated by the TID Aggregation Limit subfield in the Trigger Dependent User Info field of a Basic Trigger variant Trigger frame (see 9.3.1.23.1 (Basic Trigger variant(#2219))) intended to it.(#2219)

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The AP shall set the value in the TID Aggregation Limit subfield in the Type dependent Per User Information field to 0 for an HE STA with STA that has indicated a zero value in the Multi-TID Support field of the HE Capabilities element it transmits and is identified by the AID12 subfield of the User Info field of a Basic Trigger variant Trigger frame (see 9.3.1.23 (Trigger frame format)).(#2669)

The AP may assign any value between 0 and 7 in the TID Aggregation Limit subfield in the Trigger Dependent User Info field to 1 for an HE STA with STA that has indicated a nonzero value in the Multi-TID Support field of the HE Capabilities element it transmits and is identified by the AID12 subfield of the User Info field of a Basic Trigger variant Trigger frame.(#Ed)(#2669)

The AP may assign any value in the AC Preference Level subfield in the Trigger Dependent User Info field for an HE STA identified by the AID12 subfield of the User Info field of a Basic Trigger variant Trigger frame.(#2669)

The AP may assign any value defined in Table 9-ax10 (Preferred AC subfield encoding) in the AC Preference Level subfield in the Trigger Dependent User Info field to 1 for an HE STA and identified by the AID12 subfield of the User Info field of a Basic Trigger variant Trigger frame.(#2669)

NOTE—A STA follows the rules in 25.10.4 (A-MPDU with multiple TIDs) for aggregating the QoS Data frames with multiple TIDs in HE trigger-based PPDUs.(#2669)

25.5.2.2.3 AP access procedures for UL MU operation

An UL OFDMA MPDU/A-MPDU is the acknowledgement of the Trigger frame. When the AP receives MPDU correctly from at least one STA indicated by Trigger frame(#1535), the frame exchange initiated by the Trigger frame(#1535) is successful.

25.5.2.3 STA behavior

A STA shall not transmit an HE trigger-based PPDU unless it is(#2824) explicitly enabled by an AP in one of the operation modes described in this subclause(#1304).

The inter frame space between a PPDU that contains a Trigger frame and the triggered HE trigger-based PPDU is SIFS.

A STA shall commence the transmission of an HE trigger-based PPDU at the SIFS time boundary after the end of a received PPDU, when all the following conditions are met

— The received PPDU contains either a Trigger frame(#1532) with a User Info(#1520) field addressed to the STA, or an MPDU addressed to the STA that contains an UL MU Response Scheduling A-Control subfield, but not both(#1). The User Info(#1520) field is addressed to a STA if the AID12(#Ed) subfield(#2685) is equal to the AID of the STA and(#766) the STA is associated with the AP. If the STA is not associated with the AP, TBD.

— The UL MU CS Condition described in 25.5.2.4 (UL MU CS mechanism) indicates the medium is idle, or the CS Required subfield in a Trigger frame is 0.

A STA transmitting an HE trigger-based PPDU in response to a Trigger frame, shall set the TXVECTOR parameter as follows:

— The L_LENGTH parameter shall be set to the value indicated by the Length subfield(#253) of the eliciting Trigger frame(#1).

— The GI_LTF_TYPE(#1420) parameter shall be set to the value indicated by the CP-LTF subfield of the Common Info field of the eliciting Trigger frame

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- The SIG-A_CONT parameter shall be set to the value indicated by the SIG-A subfield of the Common Info field of the eliciting Trigger frame [TBD, depending on how the TXVECTOR is defined we may spell out all the subfields of SIG-A]
- The DCM parameter shall be set to the value indicated by the DCM subfield of the User Info field(#1520) of the eliciting Trigger frame
- The CODING_TYPE parameter shall be set to the value indicated by the Coding Type subfield of the User Info(#1520) field of the eliciting Trigger frame
- The RU parameter shall be set to the value indicated by the RU Allocation field of the Trigger frame(#1535)
- The NSTS parameter shall be set to TBD

(#1)A STA transmitting an HE trigger-based PPDU in response to soliciting MPDU(s), containing an UL MU Response Scheduling A-Control subfield, shall set the TXVECTOR parameters as follows:

- N_{SYM} shall be set to the F_{VAL} + 1, where F_{VAL} is the value of the UL PPDU Length subfield of the UL MU Response Scheduling subfield
- UL_TARGET_RSSI, DL_TX_POWER, RU_ALLOCATION, and MCS parameters shall be set to the values of UL Target RSSI, DL TX Power, RU Allocation, and UL MCS subfields of the UL MU Response Scheduling subfield, respectively.
- BW shall be equal to the bandwidth of the soliciting DL MU PPDU
- BSS_COLOR, and DCM shall be set to the values of the RXVECTOR parameters BSS_COLOR, and DCM of the soliciting DL MU PPDU, respectively
- MU_MIMO_LTF_MODE, LDPC_EXTRA, NSTS, STBC, CODING TYPE, SS_ALLOCATION shall all be set to 0
- SPATIAL_REUSE shall be set to the value indicating SR_Disallowed
- PE_DURATION shall be set to the default PE duration value for UL MU response scheduling, which is indicated by the AP in the Default_PE Duration subfield of the HE Operation element it transmits, and the a-factor shall be set to 4 (see 26.3.12 (Packet extension(#1781)))
- TXOP_DURATION parameter shall be set according the rules defined in 25.2.1 (Updating two NAVs)
- CP_LTF_TYPE parameter shall be set to indicate 4x LTF + 3.2 μs CP if the RXVECTOR parameter CP_LTF_TYPE is 4x LTF + 3.2 μs CP or 2x LTF + 1.6 μs CP ; otherwise shall be set to indicate 2x LTF + 1.6 μs CP

NOTE 1—The HE trigger-based PPDU in this case is only sent in UL OFDMA format and CS is not required prior to its transmission (see 25.5.2.4 (UL MU CS mechanism)).

NOTE 2—The use of BCC limits the available RU sizes as defined in 26.3.11.7 (BCC interleavers).

The STA that responds to a DL MU PPDU containing MPDU(s) addressed to it that include UL MU Response Scheduling A-Control subfield(s) follows the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame, the rules defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, and the rules defined in 25.4 (Block acknowledgement) for generating the Multi-STA BlockAck frame.

NOTE—The STA additionally follows the rules defined in 25.3.3 (Procedure at the originator(#1484)) when fragments are present in the soliciting (A-)MPDU(s).

The MAC padding procedure is described in 10.42.2.1.2.(#1536)

The content of each A-MPDU(#1537) in an HE MU PPDU is based on the rules specified in 9.7.3 (A-MPDU contents)(#2172) and the additional rules described in this subclause.

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If the Trigger Type field(#1539) of a Trigger frame is not equal to 0, the STA shall include in the response A-MPDU at least one MPDU of the required type. If the STA does not have a frame of the required type, the STA should transmit QoS Null frame.

NOTE—The frame type of MPDUs may be different across A-MPDUs within a same HE trigger-based PPDU(#598).

25.5.2.4 UL MU CS mechanism

The ED-based CCA and virtual CS functions are used to determine the state of the medium if CS is required before responding to a received Trigger frame. ED-based CCA for UL MU CS follows the same procedure as defined in VHT receiver specification(#978)(#2647). ED-based CCA is described in 21.3.18.5.2 (CCA sensitivity for operating classes requiring CCA-ED)(#978)(#2647) and virtual CS is defined in 10.3.2.1 (CS mechanism).

When two NAVs are supported by a STA, if one or both of the NAVs are considered and the considered NAV's counter is nonzero, then the virtual CS indicates busy. Otherwise, the virtual CS is idle.

When only one NAV is supported by a STA, if the NAV is considered and the NAV counter is nonzero, then virtual CS is busy. Otherwise, the virtual CS is idle.

Editor's Note: The previous sentence is only needed if support for two NAVs is optional. Mandatory or optional support for two NAVs is still TBD.

A NAV is considered in virtual CS for a STA that is polled from a Trigger frame for UL MU transmission unless one of the following conditions is met:

- The NAV was set by a frame originating from the AP sending the Trigger frame
- The response generated by the STA contains an Ack frame or a BlockAck frame and the duration of the HE trigger-based PPDU is less than a TBD value
- The NAV was set by a frame originating from an intra-BSS STA
- The CS Required subfield in the Trigger frame is 0
- Other condition TBD

If the CS Required subfield in a Trigger frame is set to 1, the STA shall consider the status of the CCA (using Energy Detect defined in 21.3.18.5.2 CCA sensitivity for operating classes requiring CCA-ED(#768)) and the virtual carrier sense (NAV) before UL MU transmission in response to the Trigger frame(#1532). In this case, the STA shall sense the medium using energy-detect (ED) after receiving the PPDU that contains the Trigger frame (i.e. during the SIFS time), and it shall perform the energy-detect (ED) at least in the subchannel that contains the STA's UL allocation, where the sensed subchannel consists of either a single 20 MHz channel or multiple of 20 MHz channels. The STA may transmit an HE trigger-based PPDU when the 20 MHz channels containing the allocated RUs(#1295) in the Trigger frame are considered idle; if the STA detects that the 20 MHz channels containing the allocated RUs(#1295) are not all idle, then the STA shall not transmit anything in the allocated RUs(#1295).

If the CS Required subfield in a Trigger frame is set to 0 or an UL MU response scheduling A-Control field is included in the received (A-)MPDU that solicits a response, the STA may respond with an HE trigger-based PPDU without regard to the busy/idle state of the medium.(#979)

The CS Required subfield in the MU-RTS variant of the Trigger frame shall be set to 1.(#2226)

The AP shall set the CS Required subfield to 1 except under the following conditions:

- All solicited HE trigger-based PPDU(s) containing an Ack or BlockAck frame(#1547)(#1546) and the length of the HE trigger-based PPDU is below a TBD threshold.
- Other conditions are TBD.

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25.5.2.5 HE buffer status feedback operation for UL MU

(#1550)(#254)(#769)(#2711)(#1062)(#45)(#770)(#438)(#1065)A non-AP STA delivers buffer status reports (BSRs) to assist its AP in allocating UL MU resources in an efficient way. The non-AP STA can either implicitly deliver BSRs in the QoS Control field or BSR A-Control field of any frame transmitted to the AP (unsolicited BSR) or explicitly deliver BSRs in any frame sent to the AP in response to a BSRP variant Trigger frame (solicited BSR).(#178)(#2189)

A non-AP STA reports its buffer status (unsolicited BSR) to the AP to which it is associated using either the QoS Control field or the BSR A-Control field of frames it transmits as defined below:

— The HE STA shall report the buffer status for a given TID in the Queue Size subfield of the QoS Control field in QoS Data or QoS Null frames it transmits; except that the STA may set the Queue Size subfield to 255 to indicate an unknown/unspecified BSR for that TID.

  • The HE STA may aggregate multiple QoS Data frames or QoS Null frames in an A-MPDU to report the buffer status for different TIDs. The HE STA shall follow the A-MPDU aggregation rules defined in 25.10.4 (A-MPDU with multiple TIDs) for aggregating QoS Data frames with multiple TIDs. The HE STA does not follow the rules defined in 25.10.3 (A-MPDU with multiple TIDs) for QoS Null frames whose Ack Policy subfield is No Ack.(#771)(#1066)(#2190)(#2191)

— The HE STA may report the buffer status in the BSR A-Control subfield of frames it transmits if the AP has indicated its support in the A-BSR Support subfield of its HE Capabilities element; otherwise the STA shall not report the buffer status in the BSR A-Control subfield.

  • The HE STA shall report the buffer status for its preferred AC, indicated by the ACI High subfield, in the Queue Size High subfield of the BSR A-Control field; except that the STA may set the Queue Size High subfield to 255 to indicate an unknown/unspecified BSR for that AC
  • The HE STA shall report the buffer status for all ACs, indicated by the ACI Bitmap subfield, in the Queue Size All subfield of the BSR A-Control field; except that the STA may set the Queue Size All subfield to 255 to indicate an unknown/unspecified BSR for those ACs(#2190, 2191)
  • The HE STA shall set the Delta TID subfield according to Table 9-XX (Delta TID subfield encoding), and the Scaling Factor subfield as defined in 9.2.4.6.4.5 (Buffer Status Report (BSR)).(#45)(#178)(#770)(#817)(#1066)

NOTE 1—The STA can send an unsolicited BSR in response to Basic variant Trigger frames (with or without random RUs, as defined in 25.5.2.3 (STA behavior) and in 25.5.2.6 (UL OFDMA-based random access)) or it can send the unsolicited BSR after accessing the WM using EDCA.(#254)(#769)(#2189)

NOTE 2—The STA can include both the QoS Control and the BSR A-Control field in the same frame and it can set the Queue Size subfield of either of them to a value of 255.

An AP can also solicit one or more non-AP STAs for their BSR(s) by sending a BSRP variant Trigger frame (see 9.3.1.23 (Trigger frame format)).(#1062) The non-AP STA responds (solicited BSR) as defined below:

— The STA that receives a BSRP variant Trigger frame shall follow the rules defined in 25.5.2.3 (STA behavior) to generate the trigger-based PPDU when the Trigger frame contains the STA's AID in any of the Per User Info fields; otherwise the STA shall follow the rules defined in 25.5.2.6 (UL OFDMA-based random access) to gain access to a random RU and generate the Trigger-based PPDU when the Trigger frame contains one or more random RU(s).(#254)(#769)(#1065)

— The STA shall include in the HE trigger-based PPDU one or more QoS Null or QoS Data frames containing one of the following:

  • The QoS Control field(s) with Queue Size subfields for each of the TIDs for which the STA has buffer status to report to the AP.(#771)(#1066)(#2190)(#2191)
  • The BSR A-Control field with the Queue Size All subfield indicating the queue size for all the ACs, indicated by the ACI Bitmap subfield, for which the STA has buffer status to report to the AP when the AP has indicated its support in the A-BSR Support subfield of its HE Capabilities

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element. The STA shall set Delta TID, SF, ACI High and Queue Size High subfields of the BSR A-Control field as defined in 9.2.4.6.5 (Buffer Status Report (BSR)(#824))).(#45)(#770)(#817)(#1066)(#2190)(#2191)

— The HE STA shall not solicit an immediate response for the frames carried in the trigger-based PPDU (e.g., by setting the Ack Policy subfield of the frame to Normal Ack or Implicit BAR).(#438)

NOTE—Similar to unsolicited BSR, the STA can set Queue Sizes in either QoS Control or BSR A-Control field to 255 to indicate unknown/unspecified BSR for a TID, AC or all AC.

25.5.2.6 UL OFDMA-based random access

UL OFDMA-based random access is a mechanism for HE STAs to randomly select resource units (RUs) assigned by an AP in a soliciting Trigger frame that contains random RUs.(#2383) The HE AP indicates a TBD parameter in the Trigger frame for HE STAs to initiate random access following the Trigger frame transmission.

25.5.2.6.1 Random access procedure

In this subclause(#1304), the random access procedure is described with respect to UL OFDMA contention parameters. The procedure is also illustrated in Figure 25-1 (Illustration of the UL OFDMA-based random access procedure). An HE STA that uses the random access procedure maintains an internal OFDMA backoff (OBO) counter(#2712). The OFDMA contention window (OCW) is an integer with an initial value of OCWmin. Other parameters for random access are TBD.

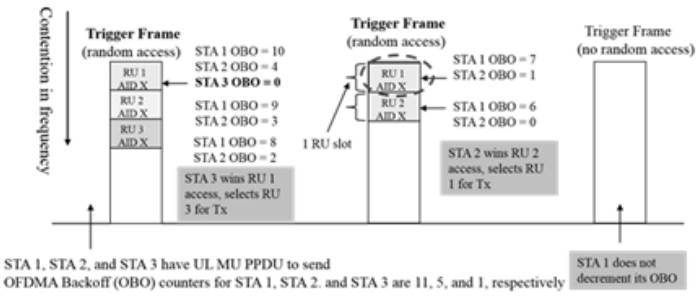


Figure 25-1—Illustration of the UL OFDMA-based random access procedure

An HE AP indicates the value of OCWmin for the random access operation. The method of indication of the OCWmin value is TBD.

The random access procedure initiates with an HE STA receiving a Trigger frame for random access.

For an initial UL PPDU transmission, when an HE STA obtains the value of OCWmin from the HE AP, it shall set the value of OCW to the OCWmin and shall initialize its OBO counter to a random value in the range of 0 and OCWmin.

If the OBO counter for an HE STA is smaller than the number of RUs assigned to AID value TBD in a Trigger frame, then the HE STA shall decrement its OBO counter to zero. Otherwise, the HE STA decrements its OBO counter by a value equal to the number of RUs assigned to AID value TBD in a Trigger frame. For instance, as shown in Figure 25-1 (Illustration of the UL OFDMA-based random access procedure), HE STA 1 and HE STA 2 decrement their non-zero OBO counters by 1 in every RU assigned to AID value TBD for random access within the Trigger frame.

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If the OBO counter for an HE STA is zero or if the OBO counter decrements to 0, the STA(#1551) randomly selects any one of the assigned RUs for random access and transmits its UL PPDU in the selected RU. Otherwise, the STA resumes with its OBO counter in the next Trigger frame for random access.

25.5.3 HE MU cascading operation

A TXOP can include both DL MU and UL MU transmissions.

An(#603) HE AP can initiate a cascading sequence of MU PPDUs in a TXOP, allowing alternating HE MU PPDUs and HE trigger-based PPDUs starting with a DL MU PPDU in the same TXOP, as illustrated in Figure 25-2 (An example of cascading sequence of MU PPDUs).

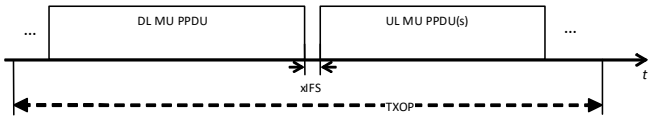


Figure 25-2—An example of cascading sequence of MU PPDUs

The cascading sequence has only one DL transmitter. The cascading sequence may have different UL transmitters within each HE trigger-based PPDU(#1556). The cascading sequence may have a different set of transmitters in HE trigger-based PPDUs as compared to the DL HE MU PPDU that follows the HE trigger-based PPDUs within the same TXOP.

25.6 HE sounding protocol

Editor's Note: Editing instructions in 16/773r2 do not mention the existing text in this subclause. I'll leave it here until the group decides what they want to do with it (delete, modify, move).

The HE sounding protocol is initiated by an AP sending an NDP Announcement frame (TBD) followed by an HE NDP transmitted a SIFS after the end of the PPDU carrying the NDP Announcement (TBD).

An HE AP may use the Trigger frame to solicit HE beamforming feedback from a STA provided that the UL MU Capable field of the most recently received HE Capabilities element from that STA is 1 (see 25.5.2 (UL MU operation)).

An HE AP may solicit beamforming feedback from multiple STAs sequentially through SU transmission.

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An example of the HE sounding protocol using MU operation to solicit feedback is shown in Figure 25-3 (An example of the HE sounding protocol using MU operation).

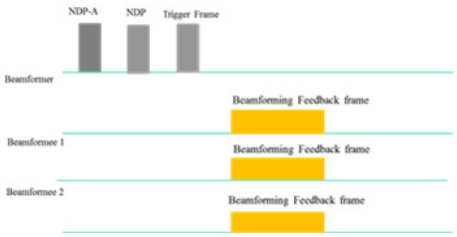


Figure 25-3—An example of the HE sounding protocol using MU operation

(#802)(#2234)(#55)(#1221)(#1915)(#1695)(#1000)

25.6.1 General

Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use HE sounding protocol to determine the channel state information. Similar to VHT, HE uses explicit feedback mechanism where the HE beamformee measures the channel from the training signal transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.

25.6.2 Rules for HE sounding protocol sequences

The HE beamformer shall initiate a sounding sequence by transmitting a HE NDP Announcement frame followed by a HE NDP after SIFS.

If the HE NDP Announcement frame includes more than one STA Info field, the RA of the HE NDP Announcement frame shall be set to a broadcast address, else it shall be set to the MAC address of the STA whose AID is included in the STA Info field. The HE NDP Announcement frame shall indicate the *Ng*, codebook and *Nc* to be used by the intended receiver STAs for the generation of CBF except when the HE NDP Announcement frame contains only one STA Info element with the Feedback Type subfield in the STA Info field is equal to SU. When the HE NDP Announcement frame contains only one STA Info element with the Feedback Type subfield in the STA Info field set to SU, then the *Ng*, codebook and *Nc* to be used for the generation of the Compressed Beamforming Report(#Ed) shall be determined by the recipient of the NDP Announcement frame.

A HE beamformer that transmits a HE NDP Announcement frame with more than one STA info field should transmit a Beamforming Report Poll Trigger frame SIFS after the HE NDP to retrieve HE Compressed Beamforming feedback from the intended HE beamformees in the same TXOP. The HE beamformer may subsequently send additional Beamforming Report Poll Trigger frames SIFS after receiving the HE Compressed Beamforming feedback to retrieve subsequent feedbacks in the same TXOP.

A HE beamformer that sets the Feedback Type subfield of a STA Info field to MU shall set the Nc Index field(#Ed) to a value less than or equal to the minimum of:

— The maximum number of supported spatial streams according to the corresponding HE beamformee's Rx HE-MCS Map subfield in the supported HE-MCS and NSS set field

— The maximum number of supported spatial streams according to the Rx NSS subfield value in the operating mode field of the most recently received Operating Mode Notification frame or the

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Operating Mode Notification element with the Rx NSS Type subfield equal to 0 for the corresponding HE beamformee

— The maximum number of supported spatial streams according to the Rx NSS subfield value in the most recently received frame that carried a Received Operating Mode Indication subfield (see 25.8 (Receive operating mode)).

The HE beamformee shall indicate the maximum number of space-time streams it can receive in a HE NDP as well as the total number of space-time streams (summed across all users) it can receive in a DL MU-MIMO packet through the Beamformee STS Capability field. For an HE beamformee, the value of this capability field shall be greater than or equal to 4.

A HE beamformer that sets the Feedback Type subfield of the STA Info field to MU shall set the Ng field(#Ed) value in the STA Info field of the HE NDP Announcement frame to either 0 (for $Ng = 4$) or 1 (for $Ng = 16$).

A HE beamformer shall set the RU Start Index and RU End Index in the STA Info field to indicate the starting 26-tone RU(#Ed) and the ending 26-tone RU(#Ed) of the requested HE compressed beamforming report. The RU Start Index is 7 bits and indicates the lowest 26-tone RU(#Ed) for which the HE beamformer is requesting feedback. The RU End Index is 7 bits and indicates the highest 26-tone RU(#Ed) for which the HE beamformer is requesting feedback. The 26-tone RU(#Ed) location is based on the RXVECTOR parameter(#Ed) CH_BANDWIDTH of the HE NDP Announcement when received in a HE PPDU or the RXVECTOR parameter(#Ed) CH_BANDWIDTH_IN_NON_HT when the HE NDP Announcement is received in a non-HT PPDU.

The HE beamformer shall set the starting RU index to a value equal to the maximum of:

— The minimum 26-tone RU(#Ed) located within the channel width in the VHT Operation Information field

— The minimum 26-tone RU(#Ed) located within the channel width in the Receive Operating Mode Notification Indication (see 25.8 (Receive operating mode))

The HE beamformer shall set the ending RU index to a value equal to the minimum of:

— The maximum 26-tone RU(#Ed) located within the channel width in the VHT Operation Information field

— The maximum 26-tone RU(#Ed) located within the channel width in the Receive Operating Mode Notification Indication

A HE beamformer that transmits a HE NDP Announcement frame that has only one STA Info field with the Feedback Type subfield equal to SU shall set the Nc Index field to 0 and the Ng field to 0.

An example of HE sounding protocol with a single HE beamformee is shown in Figure 25-4 (An example of the sounding protocol with a single HE beamformee).

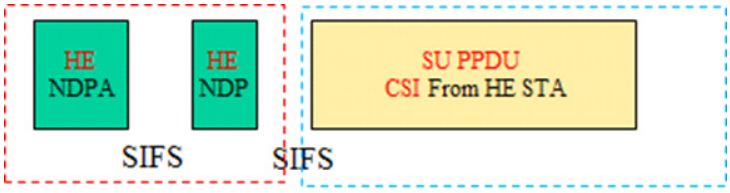


Figure 25-4—An example of the sounding protocol with a single HE beamformee

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A non-AP HE beamformee that receives a HE NDP Announcement frame for a HE beamformer with which it is associated and that contains the HE beamformee's AID in the AID subfield of STA Info field, and there is only one STA Info field, shall transmit its HE Compressed beamforming feedback SIFS after receiving the HE NDP. The TXVECTOR parameter CH_BANDWIDTH for(#Ed) the PPDU containing the HE compressed beamforming feedback shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter(#Ed) CH_BANDWIDTH of the HE NDP Frame.

An example of HE sounding protocol with more than one HE beamformee is shown in Figure 25-5 (An example of the sounding protocol with a single HE beamformee).

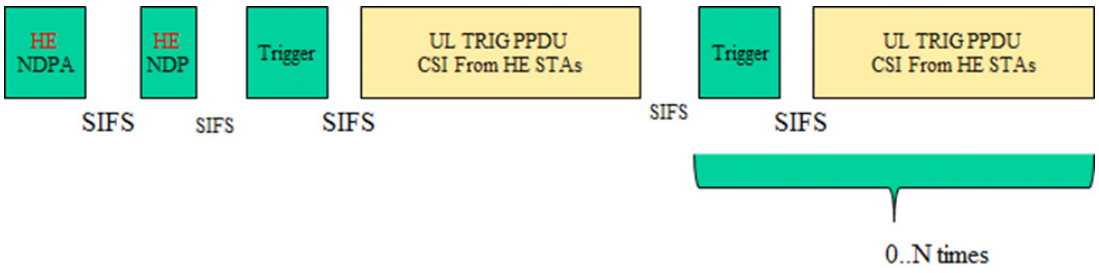


Figure 25-5—An example of the sounding protocol with a single HE beamformee

A non-AP HE beamformee that receives a HE NDP Announcement frame from a HE beamformer with which it is associated and that contains the HE beamformee's AID in any of the STA Info field, and there are multiple STA Info fields in the HE NDP Announcement, shall compute the HE Compressed beamforming feedback after receiving the HE NDP. The STA shall transmit the HE compressed beamforming feedback as a response to a Beamforming Report Poll(#Ed) variant Trigger frame that contains the AID of the STA in any of the User Info(#Ed) fields following the rules defined in 25.5.2.3 (STA behavior).

The value of the Sounding Dialog Token Number in the HE MIMO Control field shall be set to the same value as the Sounding Dialog Token Number field in the corresponding HE NDP Announcement frame.

The HE Compressed Beamforming feedback is comprised of the HE Compressed Beamforming Report information and the MU Exclusive Beamforming Report information.

25.6.3 Rules for segmented feedback in HE sounding protocol sequences(#1222)

HE Compressed beamforming feedback shall be transmitted in a single PPDU unless the size of the feedback is greater than 11 454 octets. The HE beamformer shall support maximum MPDU length for HE Compressed beamforming feedback of size which is the minimum of:

- 11 454 octets
- The size of the HE compressed beamforming feedback requested

25.7 TWT operation

25.8 Receive operating mode

25.8.1 General

An HE STA can change its operating mode setting either using the procedure described in 11.42 (Notification of operating mode changes)(#2327), or the procedure described(#1561) in this subclause.

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Receive operating mode (ROM) indication is a procedure for a first HE STA to indicate the maximum operating channel width and the maximum number of spatial streams it can receive from(#605) a second HE STA.

When the first HE STA chooses to indicate its ROM setting, this can be signaled using the ROM subfield in the HE variant HT Control field sent in a Data frame(#1563). The ROM subfield is set to indicate that the first HE STA supports receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield (see 9.2.4.6.4 (A-Control)(#1564)). The dot11ROMIOptionImplemented defines whether the HE AP implements the reception of the ROM setting and the AP transmits according to the ROM setting to the transmitter of the ROM setting. An HE AP shall set dot11ROMIOptionImplemented to true.

ROM indication allows an HE STA to adapt the maximum operating channel width or the maximum number of spatial streams it can receive. In doing so, an HE STA may save power by changing to a ROM setting that consumes less power, or by changing to a ROM setting that supports higher throughput operation. Unlike 11.42 (Notification of operating mode changes)(#2327), ROM indication can be signaled in the MAC header of a Data frame as opposed to a management frame exchange. Hence, there is minimal impact on channel efficiency.

25.8.2 Rules for ROM indication

An HE STA may transmit an individually addressed Data frame(#1563) that contains the ROM subfield to indicate that the transmitting HE STA supports receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield of the ROM subfield.

The transmitting HE STA shall support (#444)receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield of the ROM subfield indicated in the eliciting frame immediately after receiving a successful acknowledgement from the responding HE STA.

If there is a change to the current maximum operating channel width or the maximum number of spatial streams, the transmitting HE STA(#639) shall adjust to the most recently sent ROM settings within a time TBD [Outage Time] following the receipt of an immediate acknowledgement response. The transmitting HE STA shall support receiving frames with a bandwidth up to and including the most recent value indicated by the Channel Width subfield and with a number of spatial streams up to and including the most recent value indicated by the Rx NSS subfield of the ROM subfield.

NOTE—In the event of transmission failure(#1570), the transmitting HE STA can attempt the recovery procedure defined in 10.22.2.7 (Multiple frame transmission in an EDCA TXOP)(#1571) and can defer from changing to the new ROM settings indicated in the eliciting frame until a successful acknowledgement from the responding STA is received.

The responding HE STA shall use the value indicated by the Channel Width subfield most recently received from the transmitting HE STA as the current maximum operating channel width that the transmitting HE STA indicated as supported for receiving frames.

The responding HE STA shall use the value indicated by the Rx NSS subfield most recently received from the transmitting HE STA as the current maximum number of spatial streams that the transmitting HE STA indicated as supported for receiving frames.

The responding HE STA shall not transmit a subsequent PPDU to the transmitting HE STA that uses a bandwidth or a number of spatial stream not indicated as currently supported by the transmitting HE STA.

If there is a change to the current maximum operating channel width or the maximum number of spatial stream that the transmitting STA is capable of receiving, the responding HE STA shall not sent any PPDU to

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the transmitting HE STA within a time TBD [Outage Time] following the transmission of an immediate acknowledgement response.

25.9 Spatial reuse operation

25.9.1 General

The objective of the HE spatial reuse operation is to improve the system level performance, the utilization of medium resources and power saving(#2714) in dense deployment scenarios by early identification of signals from overlapping basic service sets (OBSSs) and interference management.

25.9.2 Color code based CCA rules

(#62)If the detected frame is inter-BSS(#1575), under TBD condition, uses TBD OBSS PD level that is greater than the minimum receiver(#2334) sensitivity level.

An HE STA(#2331) should regard an inter-BSS PPDU with a valid PHY header and that has receiving power/RSSI below the OBSS PD level used by the receiving STA and that meets additional TBD conditions, as not having been received at all (e.g., should not update its NAV), except that the medium condition shall indicate BUSY during the period of time that is taken by the receiving STA to validate that the PPDU is inter-BSS(#1580), but not longer than the time indicated as the length of the PPDU payload.

An HE STA(#2331) should revise the NAV depending on TBD conditions at the recipient of the ongoing inter-BSS frame(#2720).

25.9.3 Adaptive CCA and transmit power control

When the color code based CCA rule is used, as described in 25.9.2 (Color code based CCA rules)(#2721), an HE STA is allowed to adjust the OBSS PD(#2333) threshold in conjunction with transmit power control to improve the system level performance and the utilization of the spectrum resources.

To further improve the possibilities of spatial reuse, an HE STA(#2331) is allowed to adjust the setting of one or more following parameters:(#1583) CCA ED level, 802.11 signal detect CCA or TXPWR threshold values. The constraints on selecting threshold values are TBD.

25.10 A-MPDU operation

25.10.1 General

A-MPDU operation for an HE PPDU follows the procedures defined in 10.13 (A-MPDU operation) and, additionally, the procedures defined in this subclause.(#681)

25.10.2 A-MPDU padding for an HE MU PPDU

An HE STA that transmits an HE MU PPDU that contains one or more PSDUs, each of which carries an A-MPDU, shall construct the A-MPDU(s) as described in 10.13.6 (A-MPDU padding for VHT PPDU).(#1585)

25.10.3 A-MPDU padding for an HE trigger-based PPDU(#1585)

A non-AP STA that transmits an HE trigger-based PPDU shall construct the PSDU carried in the HE trigger-based PPDU as described in this subclause(#1585).

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The STA computes the PSDU_LENGTH based on the TXVECTOR parameters.

The STA may add A-MPDU subframes to the A-MPDU contained in the PSDU provided that the following constraints are fulfilled:

— The A-MPDU content constraints (see 10.13.1 (A-MPDU contents)) for the intended recipient

— The Length limit constraints (see 9.7.1 (A-MPDU format) and 10.13.2 (A-MPDU length limit rules)) for the intended recipient

— The MPDU start spacing constraints (see 10.13.3 (Minimum MPDU Start Spacing field)) for the intended recipient

provided that the following conditions are met:(#1586)

— The A-MPDU subframes have a value greater than 0 in the MPDU Length field, or have a value 0 in the MPDU Length field and a value 0 in the EOF field.

— After incrementing the A-MPDU_Length with the length of each such added A-MPDU subframe, the relationship A-MPDU_Length ≤ PSDU_LENGTH is true.

Padding is then(#1586) added such that the resulting A-MPDU contains exactly PSDU_LENGTH octets as follows:

— First, while A-MPDU_Length < PSDU_LENGTH and A-MPDU_Length mod 4 ≠ 0(#1587), add an octet to the final A-MPDU subframe's Padding subfield and increment A-MPDU_Length by 1.

— Then, while A-MPDU_Length + 4 < PSDU_LENGTH, add an EOF padding subframe to the EOF Padding Subframes field and increment A-MPDU_Length by 4.

— Finally, while A-MPDU_Length < PSDU_LENGTH, add an octet to the EOF Padding Octets subfield and increment A-MPDU_Length by 1.

The STA shall not add an A-MPDU subframe with EOF equal to 0 after any A-MPDU subframe with EOF set to 1. The STA shall not add an(#1774) A-MPDU subframe with EOF equal to 1 and with MPDU Length field equal to 0 before an A-MPDU subframe that contains a VHT single MPDU (see 10.13.7 (Setting the EOF field of the MPDU delimiter)).

25.10.4 A-MPDU with multiple TIDs

(#71)(#190)A multi-TID A-MPDU is an A-MPDU that contains QoS Data frames with two or more different TID values.

An HE STA with dot11MultiTIDAMPDUImplemented set to true shall set the Multi-TID Aggregation Support subfield of the HE Capabilities element it transmits to a nonzero value. Otherwise, the HE STA shall set it to 0.

An HE STA shall not send a multi-TID A-MPDU to an HE STA that has the Multi-TID Aggregation Support subfield in the HE Capabilities element equal to 0.

An HE STA may aggregate in a multi-TID A-MPDU QoS Data frames with multiple TIDs as defined in Table 9-429a (Multiple TID A-MPDU contents in the data enabled immediate response context) or Table 9-429b (Multiple TID A-MPDU contents in the data enabled no immediate response context).

If the multi-TID A-MPDU is transmitted in a PPDU that is not an HE trigger-based PPDU, then the number of different TID values in the multi-TID A-MPDU shall not exceed the number specified by the intended recipient in the Multi-TID Aggregation Support field of the HE Capabilities element.

If the multi-TID A-MPDU is transmitted in an HE trigger-based PPDU, then the number of different TID values in the multi-TID A-MPDU shall not exceed the value specified in the Multi-TID Aggregation Limit

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subfield in the Trigger Dependent User Info subfield of the User Info field in the Basic Trigger variant Trigger frame that allocated resources for the HE trigger-based PPDU.

A multi-TID A-MPDU shall not be transmitted in an HE SU PPDU or HE extended range SU PPDU except when TXOP limit is not zero for the AC that is used to gain access to the medium. This AC is defined as the primary AC. When TXOP limit is not zero then the STA may aggregate QoS Data frames from one or more TIDs in the A-MPDU under the following conditions:

— The A-MPDU shall be carried in an HE SU PPDU or an HE ER SU PPDU transmitted within the obtained TXOP

— The A-MPDU shall contain one or more MPDUs with any of the TIDs that correspond to the primary AC

— When any of the buffers is empty or when no more MPDUs can be aggregated in the A-MPDU from any of the TIDs that correspond to the primary AC then the A-MPDU may additionally contain one or more MPDUs with TIDs that do not correspond to the primary AC if the TIDs correspond to any AC that has a higher priority with respect to the primary AC and the addition of these MPDUs does not cause the STA to exceed the current TXOP duration

The Multi-STA BlockAck frame shall be used to acknowledge the MPDUs in a multiple TID A-MPDU. The value of the TID field in the Multi-STA BlockAck frame is TBD.(#1292)

(#2669)The responding HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true shall not aggregate QoS Data frames in the multi-TID A-MPDU with a number of TIDs that exceeds the value indicated in the TID Aggregation Limit subfield in the Trigger Dependent User Info field(#Ed) of a Basic Trigger variant Trigger frame (9.3.1.23.1 Basic Trigger) intended for it.

For an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true and having a single A-MPDU containing MPDUs with different value of TIDs, the MPDUs with the same TID value may be aggregated in non-contiguous A-MPDU subframes.

When the AP specifies a value defined in Table 9-ax10 (Preferred AC subfield encoding) in the Preferred AC subfield and a value of 1 in the AC Preference Level subfield in the Trigger Dependent User Info field(#Ed) of a Basic Trigger variant Trigger frame, then an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true and with buffered traffic in the indicated preferred AC should aggregate MPDUs from any one of the TIDs from the same AC or higher AC as indicated in the Preferred AC subfield of the Trigger Dependent User Info field(#Ed) in the Trigger frame.

When the AP specifies a value defined in Table 9-ax10 (Preferred AC subfield encoding) in the Preferred AC subfield and a value of 1 in the AC Preference Level subfield in the Trigger Dependent User Info(#Ed) field of a Basic Trigger variant Trigger frame, then an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true may aggregate MPDUs from any other TID.

The STA may aggregate MPDUs from TIDs in other ACs within the remaining time to the UL PPDU duration value indicated in the Length subfield in the Common Info field of the Trigger frame.

The total number of TIDs from which QoS Data MPDUs are aggregated by the STA shall not exceed the limit indicated in the TID Aggregation Limit subfield of its User Info(#Ed) field in the Trigger frame.

When the AP specifies a value of 0 in the AC Preference Level subfield in the Trigger Dependent User Info(#Ed) field of a Basic Trigger(#Ed) variant Trigger frame, then an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true may aggregate MPDUs from any AC/TID or combination of TIDs, up to the limit indicated in the TID Aggregation Limit subfield in Trigger Dependent User Info(#Ed) field of the Trigger frame.

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An HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to false should select any one of the TID value within the AC value indicated in the Preferred AC subfield and AC Preference Level subfield is 1 in the Trigger Dependent User Info(#Ed) field of a Basic Trigger variant Trigger frame.

An HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to false may select a TID from any AC when the AC Preference Level subfield is 0 in the Trigger Dependent User Info(#Ed) field of a Basic Trigger variant Trigger frame.

NOTE—A multi-TID A-MPDU allows the aggregation of an Action Ack frame as well.

25.11 TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG, BEAM_CHANGE and BSS_COLOR for an HE PPDU(#2517)

Each element of the TXVECTOR parameter STA_ID_LIST identifies the STA or group of STAs that is the recipient of an RU in the HE MU PPDU. If an RU is intended for a single STA, then the STA_ID_LIST element for that RU is set to the AID of the STA receiving the PSDU contained in that RU. If an RU is intended for an AP, then the STA_ID_LIST contains only one element that is set to the AID of the non-AP STA transmitting the PPDU. If an RU is intended for a group of STAs then the STA_ID_LIST element is set as follows:

- For an AP with dot11MultiBSSIDActivated equal to false, if the RU is intended for all STAs in the BSS, the STA_ID_LIST element is set to 0
- For an AP with dot11MultiBSSIDActivated equal to true, if the RU is intended for all STAs in any of its BSSs, the STA_ID_LIST element is set to partial virtual bitmap value assigned for the group addressed frame (see 9.4.2.6 (TIM element))
- For an AP with dot11MultiBSSIDActivated equal to true, if the RU is intended for all STAs on all its BSSs, the STA_ID_LIST element is set to 2047

The Uplink Flag is carried in the TXVECTOR parameter UPLINK_FLAG of an HE SU PPDU, HE extended range SU PPDU, and HE MU PPDU and is set as follows:

- A STA transmitting an HE PPDU that is addressed to an AP shall set the TXVECTOR parameter UPLINK_FLAG to 1
- An AP transmitting an HE PPDU that is addressed to a non-AP STA shall set the TXVECTOR parameter UPLINK_FLAG to 0
- A STA transmitting an HE PPDU in a direct path to a (T)DLS peer STA, or to a member of an IBSS, or to a mesh STA, shall set the TXVECTOR parameter UPLINK_FLAG to 0

NOTE—A (T)DLS(#1592) peer STA or the member of an IBSS can identify that the HE PPDU is sent in a direct path from the To DS and From DS fields of the MAC header of its MPDU(s)

The TXVECTOR parameter UPLINK_FLAG is not present for HE trigger-based PPDUs.

The TXVECTOR parameter BEAM_CHANGE of an HE SU PPDU, HE extended range SU PPDU shall be set to 1 if the number of spatial streams is greater(#Ed) than 2 or the PPDU is the first PPDU in a TXOP.(#2517)

The BSS Color is an identifier of the BSS and is used to assist a receiving STA in identifying the BSS from which a PPDU originates so that the STA can use the channel access rules as described in 25.9 (Spatial reuse operation)(#2338) or reduce power consumption as described in 25.14.1 (Intra-PPDU power save for HE non-AP STAs).

An HE STA transmitting an HE Operation element shall select a value in the range 1 to 63 to include in the BSS Color subfield of the HE Operation element that it transmits and shall maintain that single value of the BSS Color subfield for the lifetime(#1594) of the BSS. An HE STA that transmitted an HE Operation

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element shall set the TXVECTOR parameter BSS_COLOR of an HE PPDU to the value indicated in the BSS Color subfield of its HE Operation element.

An HE STA receiving an HE Operation element shall set the TXVECTOR parameter BSS_COLOR of an HE PPDU to the value indicated in the BSS Color subfield of the HE Operation element received from the HE STA with which it is associated or intends to transmit.(#643)(#2259)(#2260)

An HE STA that received an HE PPDU with RXVECTOR parameter BSS_COLOR with(#Ed) a value between 1 and 63 may ignore the HE PPDU subject to the rules as described in 25.9 (Spatial reuse operation).

An HE STA transmitting an HE SU PPDU or an HE extended range SU PPDU for which one or more intended recipient STAs is not a member of a transmitting STA's BSS shall set the TXVECTOR parameter BSS_COLOR of the HE PPDU to 0.

An HE STA that received an HE SU PPDU or an HE extended range SU PPDU with RXVECTOR parameter BSS_COLOR equal to 0 shall not discard the HE PPDU.

A HE STA associated with an HE AP that is transmitting an HE PPDU in a direct path to a DLS or TDLS peer STA shall set the TXVECTOR parameter BSS_COLOR to the value of the value indicated in the BSS Color subfield of the HE Operation element received from the HE AP.

All APs that are members of a Multiple BSSID Set element shall use the same BSS Color.(#73)(#210)

25.12 TXVECTOR parameter TXOP_DURATION for an HE PPDU(#2596)

TXOP Duration field is carried in the TXVECTOR parameter TXOP_DURATION of an HE PPDU and indicates duration information for NAV setting and protection of TXOP.

A STA that transmits an HE SU PPDU, HE extended range SU PPDU, or HE MU PPDU may indicate no duration information for NAV setting by setting the TXVECTOR parameter TXOP_DURATION to all 1s.

If a STA transmits an HE SU PPDU, HE extended range PPDU, or HE MU PPDU that carries a PS-Poll frame, the STA shall set the TXVECTOR parameter TXOP_DURATION to all 1s.

A TXOP responder that transmits an HE trigger-based PPDU shall set the TXVECTOR parameter TXOP_DURATION to all 1s if the RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is set to all 1s.

A TXOP responder that transmits an HE trigger-based PPDU shall not set the TXVECTOR parameter TXOP_DURATION to all 1s if any one of the following condition is met:

— The RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is not set to all 1s
— The RXVECTOR parameter FORMAT of the soliciting PPDU is not equal to HE_SU, HE_MU, or HE_EXT_SU

If the TXVECTOR parameter TXOP_DURATION of an HE PPDU is not set to all 1s, and there exists Duration field in the MAC header of the HE PPDU, the duration information indicated by the TXVECTOR parameter TXOP_DURATION is determined based on the duration information indicated by the Duration field in the MAC header and shall indicate the largest feasible duration information that is smaller than or equal to the duration information indicated by the Duration field.

NOTE 1—Except for a PS-Poll frame, the Duration/ID field in a data frame, management frame and control frame indicates duration information.

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NOTE 2—For a TXOP responder, the Duration field in the MAC header of the response PPDU is set based on the Duration field in the MAC header of the soliciting PPDU as described in 9.2.5.7 (Setting for control response frames) or 9.2.5.8 (Setting for other response frames).

For a TXOP responder that transmits an HE trigger-based PPDU carrying a PS-Poll frame, if the TXOP responder does not set the TXVECTOR parameter TXOP_DURATION of the HE trigger-based PPDU to all 1s, the TXOP responder first calculates potential duration information equal to the duration information indicated by the Duration field of the frame that solicits the response minus the time, in microseconds, between the end of the PPDU carrying the frame that soliciting the HE trigger-based PPDU and the end of the HE trigger-based PPDU. If the calculated potential duration information includes a fractional microsecond, the potential duration information is rounded up to the next higher integer. Then the duration information indicated by the TXVECTOR parameter TXOP_DURATION is determined based on the calculated potential duration information and shall indicate the largest feasible duration information that is smaller than or equal to the calculated potential duration information.

The encoding of TXVECTOR/RXVECTOR parameter TXOP_DURATION for indicating duration information is defined in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).

25.13 HE PPDU post FEC padding and packet extension

An HE STA with dot11PPEThresholdsRequired set to false may set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 0.

An HE STA with dot11PPEThresholdsRequired set to true shall set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1.

A STA that sets the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1 shall indicate its minimum post-FEC padding and packet extension duration value per constellation, NSS and RU allocation by setting the subfields of the PPE Thresholds field according to 9.4.2.213 (HE Capabilities element) and using the corresponding values from dot11PPEThresholdsMappingTable.

A STA transmitting an HE PPDU to a receiving STA shall include a minimum post-FEC padding as determined(#1597) by the post-FEC padding a-factor (see 26.3.11 (Data field) and after including the post-FEC padding, the transmitting STA shall include a packet extension that yields a total post-FEC padding plus packet extension that corresponds to at least the value indicated in the HE Capabilities element received from the receiving STA.

25.14 Power management

25.14.1 Intra-PPDU power save for HE non-AP STAs

An HE non-AP STA (#1598)has dot11IntraPPDUPowerSaveOptionActivated equal to true operates in intra-PPDU power save mode.

An HE non-AP STA that is in intra-PPDU power save mode may enter the doze state until the end of a PPDU currently being received(#2848) when one of the following conditions is met:

— The PPDU is an HE MU PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated, the RXVECTOR parameter UL_FLAG is 0 and the RXVECTOR parameter STA_ID_LIST does not include the identifier of the STA or the broadcast identifier(s) intended for the STA.(#Ed)

— The PPDU is an HE MU PPDU, HE SU PPDU or HE extended range SU PPDU and one of the following conditions are true:(#Ed)

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- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated and the RXVECTOR parameter UL_FLAG is 1
- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated, the RXVECTOR parameter UL_FLAG is 0 and a PHY-RXEND.indication(UnsupportedRate) primitive was received(#194)

— The PPDU is an HE trigger-based PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated(#1599)

— The PPDU is a VHT PPDU where(#782) the RXVECTOR parameter PARTIAL_AID is the BSSID[39:47] of the BSS with which the STA is associated and the RXVECTOR parameter GROUP_ID is 0.(#Ed)

— The PPDU is a PPDU with(#782):

- An A-MPDU including TA or RA equal to the BSSID of the BSS with which the STA is associated and,
- The RA is not the(#Ed) MAC address of the STA

An HE STA that is in intra-PPDU power save mode and has entered doze state shall continue to operate its NAV timers(#2850) and consider the medium busy during doze state and shall transition into awake state at the end of the PPDU.

NOTE—The STA can contend for access to the medium immediately on the expiry of the NAV timers(#2851).(#1600)

25.14.2 Power save with UL OFDMA-based random access

This subclause(#1304) illustrates the power save mechanisms for HE STAs using the(#1601) random access procedure (see 25.5.2.6.1 (Random access procedure)).

An HE AP may indicate values of one or multiple Trigger frame start time(s) for random access in the Beacon. The power save operation with the indication of one value of Trigger frame start time in a Beacon for random access is shown in Figure 25-6 (Trigger frame (TF) start time in the Beacon frame for power save operation with random access operation(#2852)).

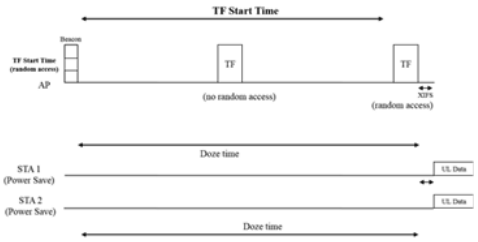


Figure 25-6—Trigger frame (TF) start time in the Beacon frame for power save operation with random access operation(#2852)

When an HE STA receives a Beacon with the value of Trigger frame start time for random access, it may enter the doze state until(#1602) the expiration of the value indicated in the Beacon.

If random access(#646) is enabled by a sequence of Trigger frames, then all the Trigger frames in the sequence shall have the Cascade Indication field set to 1, except for the last Trigger frame in the sequence, which(#1603) shall have the Cascade Indication field set to 0.

An HE STA may use the value indicated in the Cascade Indication field in a Trigger frame to enter the doze state. If the OBO counter decrements to a non-zero value with the random access procedure in a Trigger frame with Cascade Indication field set to 0, it may enter the doze state immediately. If the OBO counter

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decrements to a non-zero value with the random access procedure in a Trigger frame with Cascade Indication field set to 1, it may remain awake for random access in the cascaded Trigger frame.

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26. High Efficiency (HE) PHY specification

26.1 Introduction

26.1.1 Introduction to the HE PHY

Clause 26 specifies the PHY entity for a high efficiency (HE) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 26, an HE STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory requirements of the following PHY specifications:(#348)

— Clause 19 (High Throughput (HT) PHY specification) and Clause 21 (Very High Throughput (VHT) PHY specification)(#1021) when the HE STA with greater than or equal to 80 MHz capability is operating in the 5 GHz band(PHY Motion #163)

— Clause 19 (High Throughput (HT) PHY specification) when the 20 MHz only non-AP HE STA is operating in the 5 GHz band(PHY Motion #163)

— Clause 19 (High Throughput (HT) PHY specification) when the HE STA is operating in the 2.4 GHz band

The HE PHY with greater than or equal to 80 MHz capability is based on the VHT PHY defined in Clause 21 (Very High Throughput (VHT) PHY specification)(#1021), which in turn is based on the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification)(#1021), which in turn is further based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification)(#1021). The HE PHY with 20 MHz only capability (see 26.3.8 (20 MHz only HE STAs)) is based on the HT PHY defined in Clause 19, which in turn is based on the OFDM PHY defined in Clause 17.(PHY Motion #163) The HE PHY extends the maximum number of users supported for downlink multi-user MIMO (MU-MIMO) transmissions to eight and provides support for downlink and uplink orthogonal frequency division(#1185) multiple access (OFDMA) as well as for uplink MU-MIMO. Both downlink and uplink MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones) and in an MU-MIMO resource unit, there is support for up to eight users with up to four space-time streams per user with the total number of space-time streams not exceeding eight.

The HE PHY provides support for 20 MHz, 40 MHz, 80 MHz and 160 MHz contiguous channel widths and support for 80+80 MHz non-contiguous channel width, depending on the frequency band and capability(PHY Motion #163). For channel widths greater than or equal to 80 MHz, the HE PHY supports channel puncturing(PHY Motion #161) transmissions where one or more of the non-primary 20 MHz channels in an HE MU PPDU with more than one RU is zeroed out.(#879)

The HE PHY provides support for 0.8 μs, 1.6 μs and 3.2 μs(#1922) guard interval durations.

The HE PHY provides support for 3.2 μs (1x LTF), 6.4 μs (2x LTF), and 12.8 μs (4x LTF) LTF symbol durations (symbol duration not including the guard interval). The HE PHY supports a single Data field OFDM symbol duration of 12.8 μs (excluding guard interval).(#269)

The HE PHY data subcarrier frequency spacing is a quarter of VHT PHY and HT PHY subcarrier frequency spacing defined in Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 19 (High Throughput (HT) PHY specification), respectively.(#1605) The HE PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), 64-QAM, 256-QAM and 1024-QAM. Forward error correction (FEC) coding (convolutional or LDPC coding) is used with coding rates of 1/2, 2/3, 3/4 and 5/6.

An HE STA shall support the following Clause 26 features:(#351)

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- Binary convolutional coding for 26-, 52-, 106- and 242-tone RUs (transmit and receive) when the number of spatial streams is less than or equal to 4
- Binary convolution coding for a 20 MHz HE SU PPDU (transmit and receive) when the number of spatial streams is less than or equal to 4
- LDPC as the only coding scheme for 484-, 996- and 2×996-tone RUs (transmit and receive)
- LDPC coding for 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE SU PPDUs
- LDPC when declaring support for more than 4 spatial streams
- LDPC when declaring support for MCS10 and MCS11(PHY Motion #158)
- A combination of 2x LTF with 0.8 μs GI duration on both LTF and data
- A combination of 2x LTF with 1.6 μs GI duration on both LTF and data
- A combination of 4x LTF with 3.2 μs GI duration on both LTF and data

An HE STA may support the following Clause 26 features:(#351)

- Other combinations of LTF durations and GI durations
- LDPC coding for 26-, 52-, 106- and 242-tone RUs (transmit and receive) when the number of spatial streams is less than or equal to 4
- LDPC coding for a 20 MHz HE SU PPDU (transmit and receive) when the number of spatial streams is less than or equal to 4
- LDPC (transmit and receive) when declaring support for less than or equal to 4 spatial streams and when declaring not supporting MCS10 and MCS11(PHY Motion #158)
- Dual carrier modulation (transmit and receive)

Editor's Note: Once mandatory and optional TBDs are decided, the above text will be revised.(#1461)(#2352)

26.1.2 Scope

The services provided to the MAC by the HE PHY consist of the following protocol functions:

a) A function that maps the PSDU received from the MAC into a PPDU for transmission to one or more receiving STAs.(#2354)

b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of HE, Clause 21 (Very High Throughput (VHT) PHY specification), Clause 19 (High Throughput (HT) PHY specification) and Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PHYs.(#1021) A non-AP STA with 20 MHz only capability supports a mixture of HE, Clause 19 and Clause 17 PHYs.(PHY Motion #163)

26.1.3 HE PHY functions

26.1.3.1 General

The HE PHY contains two functional entities: the PHY function, and the physical layer management function (i.e., the PLME). Both of these functions are described in detail in 26.3 (HE PHY) and 26.4 (HE PLME). The HE PHY service is provided to the MAC through the PHY service primitives defined in Clause 7 (PHY service specification). The HE PHY service interface is described in 26.2 (HE PHY service interface).

26.1.3.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

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26.1.3.3 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the HE-PHY-compliant developer.

The service of a layer is the set of capabilities that it offers to a user in the next higher layer. Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

26.1.4 PPDU formats

The structure of the PPDU transmitted by an HE STA is determined by the TXVECTOR parameters as defined in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).

The FORMAT parameter determines the overall structure of the PPDU and can take on one of the following values:

- Non-HT format (NON_HT), based on Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) and including non-HT duplicate format.
- HT-mixed format (HT_MF) as specified in Clause 19 (High Throughput (HT) PHY specification).
- HT-greenfield format (HT_GF) as specified in Clause 19 (High Throughput (HT) PHY specification).
- VHT format (VHT) as defined in Clause 21 (Very High Throughput (VHT) PHY specification).(#468)
- HE SU PPDU format (HE_SU) carries a single PSDU. With this format the HE-SIG-A field is not repeated. Support for the HE SU PPDU format is mandatory.
- HE extended range SU PPDU format (HE_EXT_SU) carries a single PSDU. It is similar to the SU format, except that the HE-SIG-A field is repeated. Support for the HE extended range SU PPDU format is TBD (mandatory or optional).
- HE MU PPDU format (HE_MU) carries one or more PSDUs to one or more users. Support for the HE MU PPDU format is mandatory.
- HE trigger-based PPDU format (HE_TRIG) carries a single PSDU and is sent in response to a PPDU that carries a Trigger frame. The preamble format prior to the HE-STF field is identical to the HE SU PPDU. Support for the HE trigger-based PPDU format is TBD (mandatory or optional).

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26.2 HE PHY service interface

26.2.1 Introduction

26.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)) are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication primitive.

Table 26-1—TXVECTOR and RXVECTOR parameters(#1780)

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or non-HT duplicate PPDU format. In this case, the modulation is determined by the NON_HT_MODULATION parameter. HT_MF indicates HT-mixed format. HT_GF indicates HT-greenfield format. VHT indicates VHT format. HE_SU indicates HE SU PPDU format. HE_MU indicates HE MU PPDU format. HE_EXT_SU indicates HE extended range SU PPDU format. HE_TRIG indicates HE trigger-based PPDU format(#1029).	Y	Y
NON_HT_MODULATION	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
L_LENGTH	FORMAT is HE_SU or HE_MU or HE_EXT_SU	Not present. NOTE—The Length field of the L-SIG for HE PPDU is defined in Equation (26-14) using the TXTIME value defined in 26.4.3 (TXTIME and PSDU_LENGTH calculation), which in turn depend on other parameters including the TXVECTOR parameter APEP_LENGTH.	N	N
	FORMAT is HE_TRIG	Indicates the value in the Length field of the L-SIG in the range of 1 to 4095. The value comes from the trigger frame which triggers the HE trigger-based PPDU.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

L_DATARATE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present NOTE—The RATE field in the L-SIG field in HE PPDU is set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field).	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LSIGVALID	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
SERVICE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
SMOOTHING	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
AGGREGATION	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
NUM_EXTEN_SS	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
ANTENNA_SET	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
N_TX	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

EXPANSION_MAT_TYPE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Set to COMPRESSED_SV.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
EXPANSION_MAT	FORMAT is HE_SU or HE_EXT_SU or HE_TRIG	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 26.3.16.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE NDP PPDUs or VHT NDP PPDUs.	Y	N
	FORMAT is HE_MU	For each user, contains a vector in the number of all the subcarriers within the RU which is assigned to this user. The vector for each subcarrier contains feedback matrices as defined in in 26.3.16.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE NDP PPDUs or VHT NDP PPDUs.	M U	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CHAN_MAT_TYPE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Set to COMPRESSED_SV.	N	Y
	FORMAT is HE_MU or HE_EXT_SU or HE_TRIG or (FORMAT is HE_SU and PSDU_LENGTH is greater than 0)	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CHAN_MAT	FORMAT is HE_SU and PSDU_LENGTH equals 0	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 26.3.12.3.2 (Beamforming Feedback) based on the channel measured during the training symbols of previous HE NDP PPDU.	N	Y
	FORMAT is HE_MU or HE_EXT_SU or HE_TRIG or (FORMAT is HE_SU and PSDU_LENGTH is greater than 0)	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

DELTA_SNR	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Contains an array of delta SNR values as defined in 9.4.1.64 (HE MU Exclusive Beamforming Report field) based on the channel measured during the training symbols of the received VHT NDP PPDU or HE NDP PPDU. NOTE—In the RXVECTOR this parameter is present only for HE NDP PPDUs for MU sounding.	M U	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RCPI	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
SNR	FORMAT is HE_SU or or HE_EXT_SU	Contains an array of received SNR measurements for each spatial stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 9.4.1.63 (HE Compressed Beamforming Report field)	N	Y
	FORMAT is HE_MU	Contains an array of received SNR measurements for each spatial stream of the receiver. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones which are assigned to the receiver in each stream as described in 9.4.1.63 (HE Compressed Beamforming Report field)	N	Y
	FORMAT is HE_TRIG	Contains an array of received SNR measurements for each spatial stream per user. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones which are assigned to the user in each stream as described in 9.4.1.63 (HE Compressed Beamforming Report field)	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CQI	FORMAT is HE_SU and PSDU_LENGTH equals 0	Contains an array of received SNR measurements for each spatial stream per 26-tone RU. Each SNR is an absolute number represented by 6 bits, with 1 dB granularity and a range of -10 dB to 53 dB	N	Y
	FORMAT is HE_MU or HE_EXT_SU or HE_TRIG or (FORMAT is HE_SU and PSDU_LENGTH is greater than 0)	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
NO_SIG_EXTN	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

FEC_CODING	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
STBC	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates if STBC is used. In an HE MU PPDU where each RU includes no more than 1 user: Set to 1 to indicate all RUs are STBC encoded in the payload Set to 0 to indicate all RUs are not STBC encoded in the payload In HE SU PPDU, HE extended range SU PPDU or HE trigger-based PPDU: Set to 1 to that indicate STBC is used in the payload Set to 0 to indicate that STBC is not used in the payload STBC is not applied in MU-MIMO RUs, in case of HE MU PPDU if any RU is assigned to more than 1 user, STBC is set to 0 to indicate all RUs are not STBC encoded in the payload.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
GI_TYPE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates the length of the GI for the HE-LTF and HE-Data fields. Enumerated type: 0.8 µs 1.6 µs 3.2 µs NOTE—the length of GI for pre-HE modulated fields is 0.8 µs.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TXPWR_LEVEL_INDEX	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	The allowed values for the TXPWR_LEVEL_INDEX parameter are in the range from 1 to numberOfOctets (dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

RSSI	FORMAT is HE_SU or or HE_EXT_SU	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the HE-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	FORMAT is HE_MU	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of PHY legacy preamble. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	FORMAT is HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
MCS	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates the modulation and coding scheme used in the transmission of the PPDU. Integer: range 0 to 11	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DCM	FORMAT is HE_SU or HE_MU or or HE_EXT_SU or HE_TRIG	Set to 1 to indicate that dual carrier modulation is used for the HE-Data field. Set to 0 to indicate that dual carrier modulation is not used for the HE-Data field. NOTE—DCM is only applied to MCS0, MCS1, MCS3 and MCS4. DCM is only applied to 1 and 2 spatial streams. DCM is only applied to HE SU PPDU, HE extend range SU PPDU, and SU RUs in HE MU PPDU. DCM is not applied to MU-MIMO. DCM is not applied to STBC.	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
MCS_SIG_B	FORMAT is HE_MU	Indicates the modulation and coding scheme used for HE-SIG-B field. Integer in the range 0 to 5	Y	Y
	Otherwise	Not present.	N	N
DCM_SIG_B	FORMAT is HE_ MU	Set to 1 to indicate that dual carrier modulation is used for the HE-SIG-B field. Set to 0 to indicate that dual carrier modulation is not used for the HE-SIG-B field.	Y	Y
	Otherwise	Not present.	N	N

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

SIG_B_COMPRESSION_MODE	FORMAT is HE_MU	Used to differentiate full bandwidth MU-MIMO from OFDMA MU PPDU. In case of full bandwidth MU-MIMO set to 1, otherwise set to 0.	Y	N
	Otherwise	Not present.	N	N
REC_MCS	FORMAT is HE_SU or HE_MU or HE_EXT_SU	Indicates the MCS that the receiver recommends	N	O
	FORMAT is HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CH_BANDWIDTH	FORMAT is HE_SU or HE_EXT_SU or HE_TRIG	Indicates the channel width of the transmitted PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz	Y	Y
	FORMAT is HE_MU	Indicates the channel occupied by the transmitted PPDU, supporting channel bonding. See the field of Bandwidth in Table 26-16 (Fields in the HE-SIG-A for an HE MU PPDU)	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DYN_BANDWIDTH_IN_NON_HT	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CH_BANDWIDTH_IN_NON_HT	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

LENGTH	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
APEP_LENGTH	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	If equal to 0, indicates an HE NDP PPDU. If greater than 0, indicates the number of octets in the range 1 to 1048575 in the A-MPDU pre-EOF padding (see 10.13.2 (A-MPDU length limit rules)) carried in the PSDU.	M U	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
PSDU_LENGTH	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates the number of octets in the HE PSDU in the range of 0 to aPSDUMaxLength octets (see Table 26-39 (HE PHY characteristics)). A value of 0 indicates an HE NDP PPDU.	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
USER_POSITION	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).(#1780)		
NUM_STS	FORMAT is HE_SU	Indicates the number of space-time streams. Integer in the range 1-8.	Y	Y
	FORMAT is HE_EXT_SU	Indicates the number of space-time streams. Integer in the range 1-2.	Y	Y
	FORMAT is HE_MU	Indicates the number of space-time streams. Integer in the range: 1-4 in the TXVECTOR per user 0-4 in the RXVECTOR per MU-MIMO RU 1-8 per non MU-MIMO RU in the TXVECTOR 0-8 per non MU-MIMO RU in the RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	M U	M U
	FORMAT is HE_TRIG	Indicates the number of space-time streams. Integer in the range: 1-4 in the TXVECTOR for MU-MIMO RU 0-4 per user in the RXVECTOR per MU-MIMO RU 1-8 in the TXVECTOR for non MU-MIMO RU 0-8 per non MU-MIMO RU in the RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

GROUP_ID	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
PARTIAL_AID	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TXOP_DURATION	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates a duration of time that is used to update the NAV for this TXOP (see 25.2.2 (Updating two NAVs)), except for a value of 127 (i.e., all 1s) which indicates an invalid value of TXOP duration in the HE-SIG-A field (see 25.11a (TXVECTOR parameters TXOP_DURATION for an HE PPDU)). B0 indicates whether the granularity is 8 µs or 128 µs. When B0 is 0, then B1 to B6 indicate a duration, in units of 8 µs, starting from 0 to 504 us (i.e, duration = (8 µs × value of (B1-B6)) µs). When B0 is 1, then B1 to B6 indicate a duration, in units of 128 µs, starting from 512 µs until 8448 µs (i.e, duration = (512 + 128 × value of (B1-B6)) µs). See 25.11a (TXVECTOR parameters TXOP_DURATION for an HE PPDU) for more details.(#783)	Y	Y
	Otherwise	Not present.	N	N
SPATIAL_REUSE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates the spatial reuse parameter. There is only one value for an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU. There might be one to four values for an HE trigger-based PPDU depending on the bandwidth of the PPDU. See the Spatial Reuse field definition in 26.3.10.7.2 (Content)	Y	Y
	Otherwise	Not present	N	N
DOPPLER	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates whether the doppler effect should be considered for the PPDU. The value is 0 or 1	Y	N
	Otherwise	Not present	N	N
NUM_USERS	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present. NOTE—number of users for an HE SU PPDU, HE extended range SU PPDU and HE trigger-based PPDU is always 1. The number of users for an HE MU PPDU is determined by RU_ALLOCATION.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

RU_ALLOCATION	FORMAT is HE_MU	Each 8 bit per 20 MHz PPDU BW for signaling: The RU arrangement in frequency domain Number of MU-MIMO allocations See 26.3.10.8.4 (HE-SIG-B common content) for details.	Y	Y
	FORMAT is HE_TRIG	8 bit for RU allocation in the whole bandwidth. See 9.3.1.23 (Trigger frame format) for details	Y	Y
	Otherwise	Not present	N	N
BEAMFORMED	FORMAT is HE_SU or HE_EXT_SU	Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise.	Y	Y
	FORMAT is HE_MU or HE_TRIG	For a single user allocation in an RU, set to 1 if a beamforming steering matrix is applied, and set to 0 otherwise. For each user in a multi-user allocation in an RU, always set to 0.	M U	O
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
HE_LTF_TYPE	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Indicates the type of HE-LTF. Enumerated type: 1x HE-LTF 2x HE-LTF 4x HE-LTF See 26.3.10.10 (HE-LTF) for details.	Y	Y
	Otherwise	Not present.	N	N
HE_LTF_MODE	FORMAT is HE_TRIG	Indicates whether the UL MU MIMO transmission uses single stream pilots or a mask on each spatial stream of the LTF sequence by a distinct orthogonal code. It is only present for full bandwidth MU-MIMO.	Y	N
	Otherwise	Not present.	N	N
STARTING_STS_NUM	FORMAT is HE_TRIG	Indicates the starting STS number in the global space-time streams for the UL MU MIMO.	Y	N
	Otherwise	Not present.	N	N

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

TXOP_PS_NOT_ALLOWED	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TIME_OF_DEPARTURE_REQUE	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
RX_START_OF_FRAME_OFFSET	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
PREAMBLE_TYPE	FORMAT is NON_HT and NON_HT_MODULATION is one of ERP-DSSS ERP-CCK	Enumerated type: SHORTPREAMBLE LONGPREAMBLE	Y	Y
	Otherwise	Not present	N	N
PE_DURATION	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG.	Determines the duration of PE field in an HE PPDU. Possible values are 0 µs, 4 µs, 8 µs, 12 µs and 16 µs.	Y	Y
BEAM_CHANGE	FORMAT is HE_SU or HE_EXT_SU(#2675)	Indicates if beam changes or not between pre-HE and HE modulated fields. Refer to subclause 26.3.9 (Mathematical description of signals) for the definition of pre-HE and HE modulated fields. 1 indicates that the beam is changed between the two portions. 0 indicates that the beam does not change between the two portions.(#1925)	Y (#2153)	Y (#2153)
	Otherwise	Not present(#2675)		

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Table 26-1—TXVECTOR and RXVECTOR parameters(#1780) *(continued)*

BSS_COLOR	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG	Set to a value of the AP's choosing within the range 0 to 63(#835) (see 25.11 (TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG, BEAM_CHANGE and BSS_COLOR for an HE PPDU(#2517))).	Y	Y
	Otherwise	Not present	N	N
UPLINK_FLAG	FORMAT is HE_SU or HE_MU or HE_EXT_SU	Set to 1 if the HE PPDU is addressed to an AP.(#1611) Set to 0 otherwise (see 25.11 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	Y	Y
	Otherwise	Not present	N	N
STA_ID_LIST	FORMAT is HE_MU	Indicates the list of STA IDs for an HE MU PPDU (see 25.11 (TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG, BEAM_CHANGE and BSS_COLOR for an HE PPDU(#2517))).	MU	Y
	Otherwise	Not present	N	N
SCRAMBLER_INTIAL_STATE	FORMAT is NON_HT	In TXVECTOR, if present, indicates the initial state of the scrambler of the transmitted PPDU. In RXVECTOR, indicates the Scrambler Initialization value in the Service field, prior to descrambling.(#127)	O	Y
	FORMAT is HE_MU or HE_TRIG	Not present.	N	N
	Otherwise	Indicates the Scrambler Initialization value in the Service field, prior to descrambling.	N	Y

NOTE—In the "TXVECTOR" and "RXVECTOR" columns, the following apply:
Y = Present;
N = Not present;
O = Optional;
MU indicates that the parameter is present once for an HE SU PPDU and HE extended range SU PPDU and present per user for an HE MU PPDU. For an HE trigger-based PPDU, MU in the TXVECTOR column indicates that the parameter is present once and MU in the RXVECTOR column indicates the parameter is present per user.(#2676) Parameters specified to be present per user are conceptually supplied as an array of values indexed by *u*, where *u*(#2356) takes values 0 to NUM_USERS–1.

26.3 HE PHY

26.3.1 Introduction

26.3.2 HE PPDU formats

Four HE PPDU formats are defined: HE SU PPDU, HE MU PPDU, HE extended range SU PPDU and HE trigger-based PPDU.

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The format of the HE SU PPDU is defined as in Figure 26-1 (HE SU PPDU format). This PPDU format is used for SU transmission and, in this format, the HE-SIG-A field is not repeated(#1838).

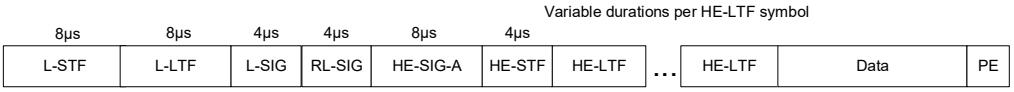


Figure 26-1—HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 26-2 (HE MU PPDU format). This format is used for transmission to one or more users that is not a response of a Trigger frame.(#271) The HE-SIG-B field is present in this format.(#1839)

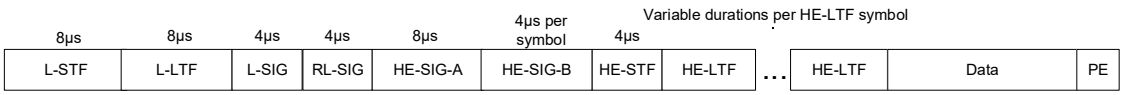


Figure 26-2—HE MU PPDU format

The format of the HE extended range SU PPDU is defined as in Figure 26-3 (HE extended range SU PPDU format). This format is used for SU transmission and, in this format,(#1840) the HE-SIG-A field is repeated.

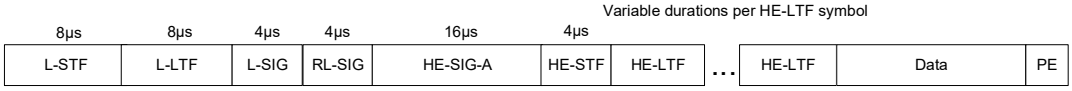


Figure 26-3—HE extended range SU PPDU format

The format of the HE trigger-based PPDU is defined as in Figure 26-4 (HE trigger-based PPDU format). This format is used for a transmission that is a response to a Trigger frame.(#1032) The HE trigger-based PPDU format is identical to the HE SU PPDU format for the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A fields. The duration of the HE-STF field is 8 μs.(#881)

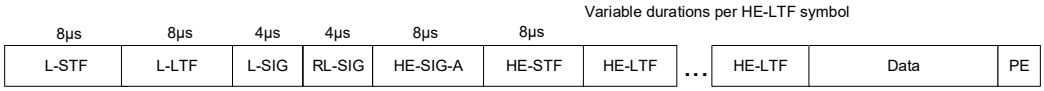


Figure 26-4—HE trigger-based PPDU format

The fields of the HE PPDU formats are summarized in Figure 26-2 (HE PPDU fields(#2343)).

Table 26-2—HE PPDU fields(#2343)

Field	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field

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Table 26-2—HE PPDU fields(#2343) *(continued)*

L-SIG	Non-HT SIGNAL field
RL-SIG	Repeated Non-HT SIGNAL field
HE-SIG-A	HE Signal A field
HE-SIG-B	HE Signal B field
HE-STF	HE Short Training field
HE-LTF	HE Long Training field
Data	The Data field carrying the PSDU(s)
PE	Packet Extension field

The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, HE-LTF, and PE fields exist only in HE PPDUs. (#1612)The HE-SIG-B field is present only in the HE MU PPDU. The duration of the PE field is determined by the TXVECTOR parameter PE_DURATION.

(#1843)The HE NDP PPDU is an HE SU PPDU where the Data field contains zero OFDM symbols and the PE field has a 4 μs duration.(#2756)(#1929)

NOTE—The number of HE-LTF OFDM symbols, $N_{HE\text{-}LTF}$, (#1612)is a function of the total number of space-time streams N_{STS} as shown in Table 26-6 (Frequently used parameters(#282)).

(#883)The L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, HE-SIG-A-R, and HE-SIG-B fields are referred to as the Pre-HE modulated fields, while the HE-STF, HE-LTF and Data fields are referred to as the HE modulated fields.(#472)

26.3.3 Transmitter block diagram

The generation of each field in an(#2829) HE PPDU uses many of the following blocks:

a) pre-FEC PHY padding
b) Scrambler
c) FEC (BCC or LDPC) encoders
d) post-FEC PHY padding
e) Stream parser
f) Segment parser (for contiguous 160 MHz and noncontiguous 80+80 MHz transmissions)
g) BCC interleaver
h) Constellation mapper
i) DCM tone mapper
j) Pilot insertion
k) Replicate over multiple 20 MHz (if BW > 20 MHz)
l) Multiply by 1st column of $P_{HE\text{-}LTF}$(#1090)
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder
p) Cyclic shift diversity (CSD) per STS insertion

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q) Spatial mapper
r) Inverse discrete Fourier transform (IDFT)
s) Cyclic shift diversity (CSD) per chain insertion
t) Guard interval (GI) insertion
u) Windowing

Figure 26-5 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE extended range SU PPDU when the Beam Change field is 1 and the HE MU PPDU(#1659)) to Figure 26-13 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) show example transmitter block diagrams. The actual structure of the transmitter is implementation dependent.

In particular, Figure 26-5 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE extended range SU PPDU when the Beam Change field is 1 and the HE MU PPDU(#1659)) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an(#2829) HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 1. These transmit blocks are also used to generate the L-STF and L-LTF fields(#470) of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 1, with the following exceptions(#Ed):

— The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.
— The BCC interleaver is not applied in the repeated HE-SIG-A symbols (i.e. the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE extended range SU PPDU.

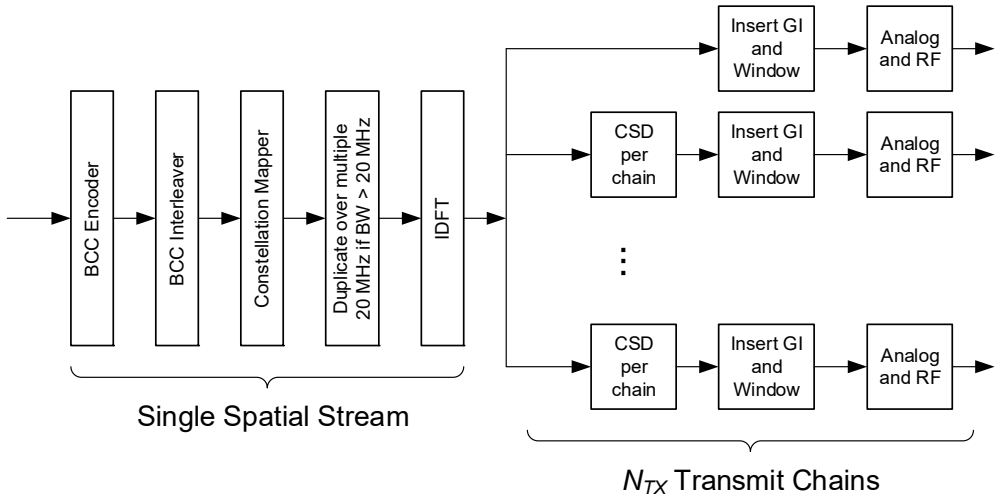


Figure 26-5—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE extended range SU PPDU when the Beam Change field is 1 and the HE MU PPDU(#1659)

Figure 26-6 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE extended range SU PPDU when the Beam Change field is 0(#2360)(#1659)) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an(#2829) HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 0. These transmit blocks are also used to generate the L-STF and L-LTF fields(#471) of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 0, with the following exceptions:

— The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.

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— The BCC interleaver is not applied in the repeated HE-SIG-A field OFDM symbols (i.e., the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE extended range SU PPDU.

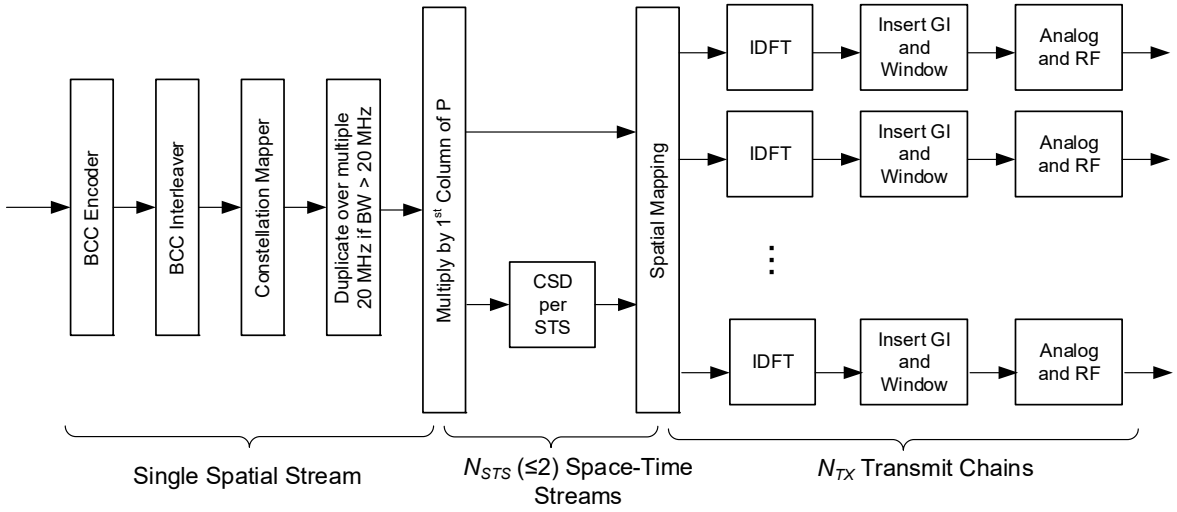


Figure 26-6—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE extended range SU PPDU when the Beam Change field is 0(#2360)(#1659)

Figure 26-7 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE trigger-based PPDU(#1659)) shows the transmit process for the L-SIG, RL-SIG and HE-SIG-A fields of an HE trigger-based PPDU using one frequency segment. In the HE trigger-based PPDU, the pre-HE-STF preamble, which includes legacy preamble, RL-SIG and HE-SIG-A fields, is sent only on the 20 MHz channels where the HE modulated fields are located. When the HE modulated fields are located in more than one 20 MHz channel, the pre-HE-STF preamble is duplicated over the multiple 20 MHz channels. The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.(#1659)

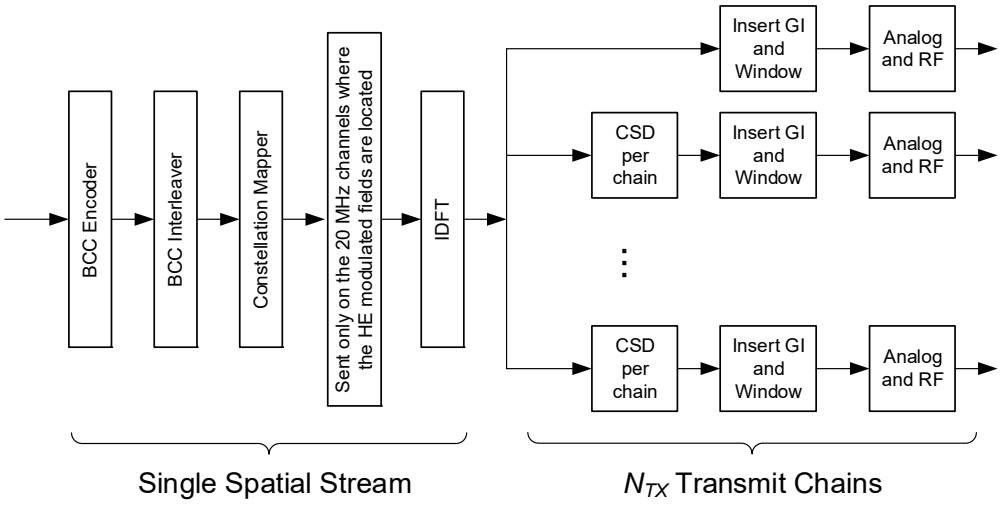


Figure 26-7—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE trigger-based PPDU(#1659)

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Figure 26-8 (Transmitter block diagram for the HE-SIG-B field) shows the transmit process for the HE-SIG-B field of an HE MU PPDU using one frequency segment. This block diagram is for transmitting HE-SIG-B in one 20 MHz subchannel. Refer to 26.3.10.8.1 (Encoding and modulation) for the methods of transmitting HE-SIG-B in 40 MHz, 80 MHz and 160 MHz. The DCM tone mapper is applied only if the DCM indication in HE-SIG-A field is set to 1.(#519)

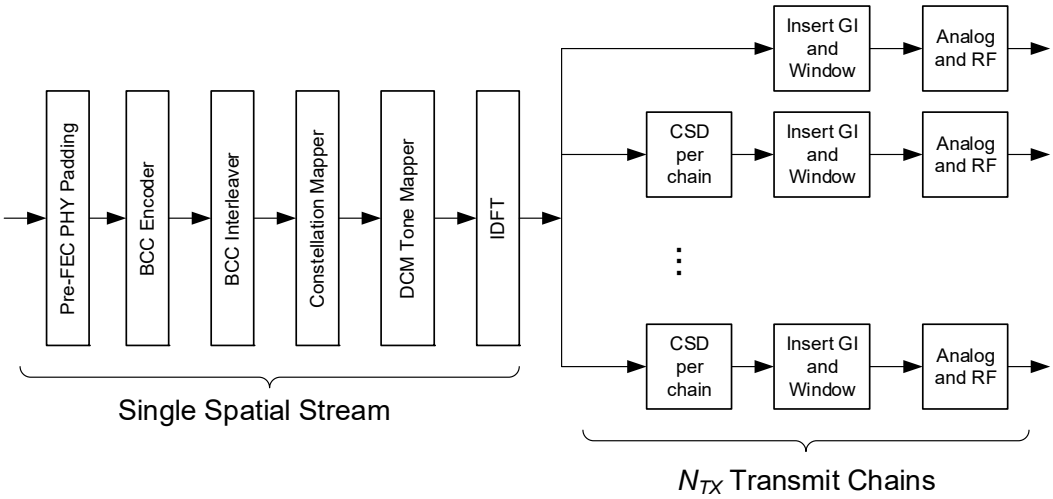


Figure 26-8—Transmitter block diagram for the HE-SIG-B field

Figure 26-9 (Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU(#838) with BCC encoding) shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, or 242-tone RU(#838) with BCC encoding for a single frequency segment when the number of spatial stream is less than or equal to 4. This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block may be applied only for single spatial stream and only when DCM is not applied. The DCM tone mapper is applied only when the DCM indication for the RU is set to 1. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HE-LTF fields. This is illustrated in Figure 26-26 (Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots). A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial and frequency mapping block of Figure 26-9 (Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU(#838) with BCC encoding)(#1117), are also used to generate the HE-STF

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field. (#520)This figure also applies to the data field with BCC encoding in an(#2829) HE trigger-based PPDU.

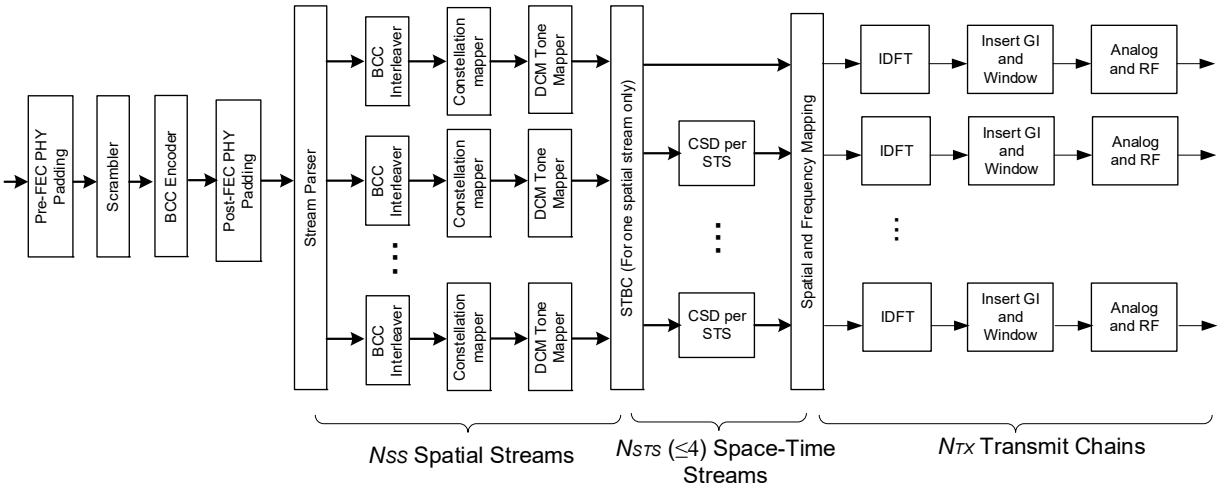


Figure 26-9—Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU(#838) with BCC encoding

Figure 26-10 (Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-tone(#838) RU with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, 242-, 484-, or 996-tone(#838) RU with LDPC encoding for a single frequency segment. This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block may be applied only for single spatial stream and only when DCM is not applied. The DCM tone Mapper is applied only when the DCM indication for the RU is set to 1. (#519)This figure also applies to the data field with LDPC encoding in an(#2829) HE trigger-based PPDU.

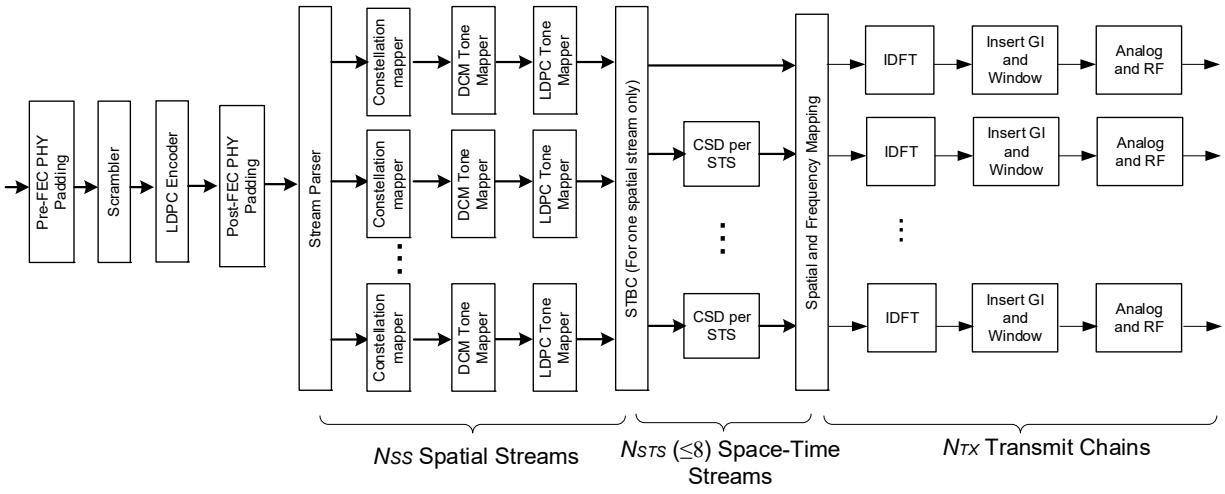


Figure 26-10—Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-tone(#838) RU with LDPC encoding

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Figure 26-11 (Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-tone(#838) RU with LDPC encoding(#277)) shows the transmitter blocks used to generate the Data field of an(#2829) HE downlink MU-MIMO transmission within a 106-, 242-, 484-, or 996-tone(#838) RU with LDPC encoding. This also includes the downlink MU-MIMO transmission in an RU that is part of a downlink (#276)OFDMA PPDU.

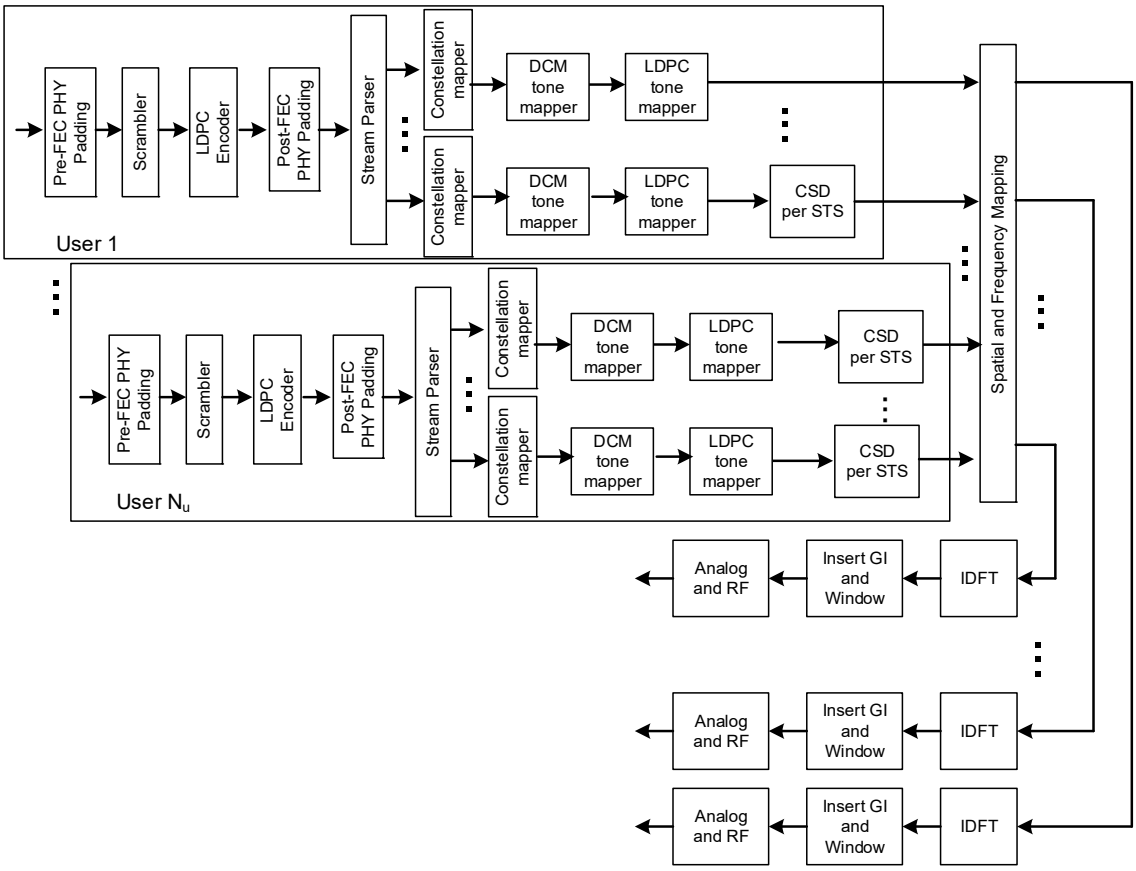


Figure 26-11—Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-tone(#838) RU with LDPC encoding(#277)

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Figure 26-12 (Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 160 MHz with LDPC encoding.

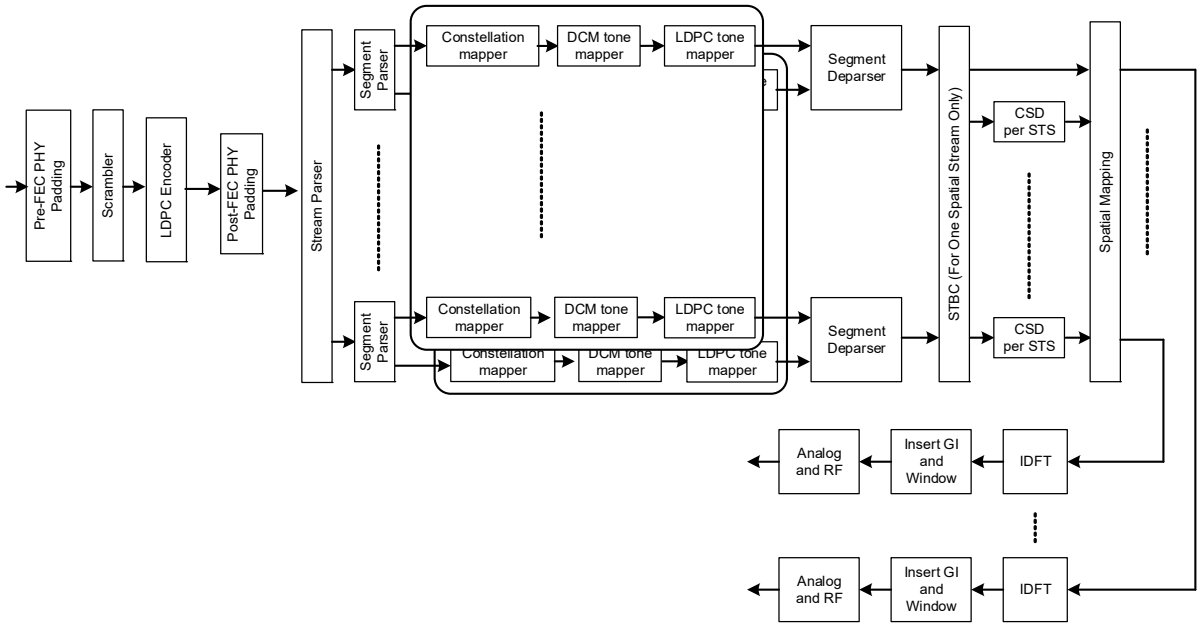


Figure 26-12—Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding

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Figure 26-13 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 80+80 MHz with LDPC encoding.

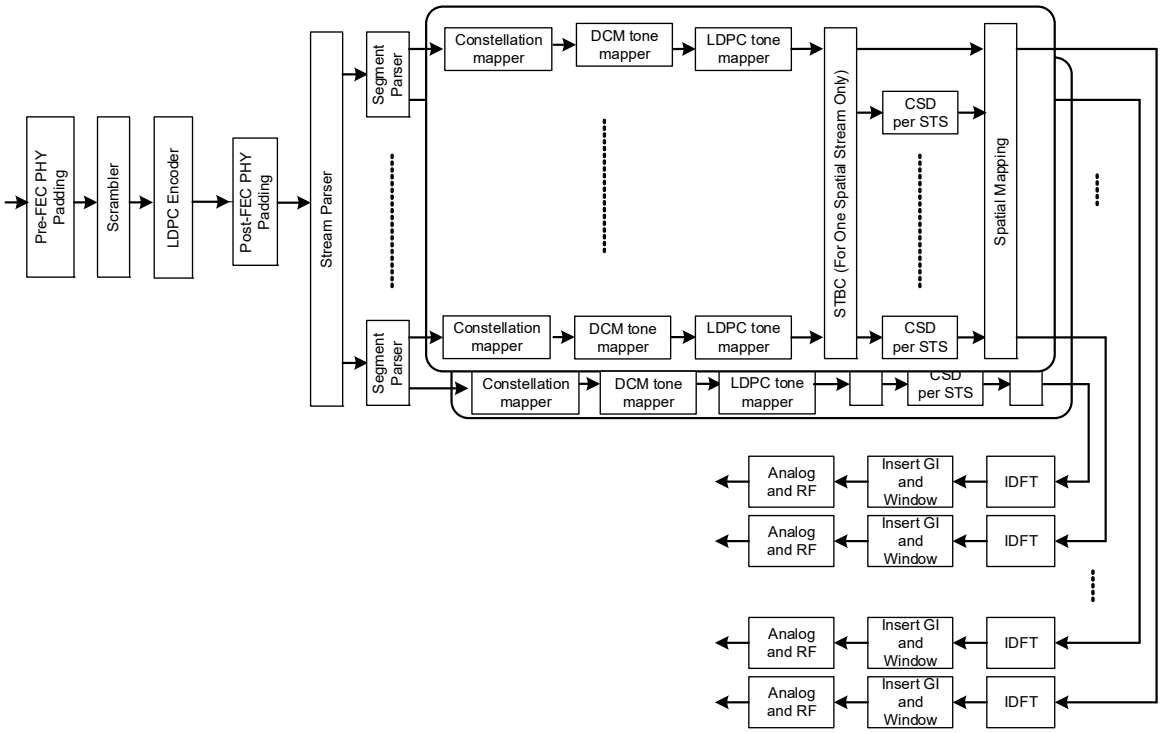


Figure 26-13—Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding

26.3.4 Overview of the PPDU encoding process

26.3.5 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a compact representation of the modulation and coding used in the Data field of the PPDU. For an HE SU PPDU and an HE extended range SU PPDU it is carried in the HE-SIG-A field. For an HE MU PPDU it is carried in the HE-SIG-B field. For an HE trigger-based PPDU, it is carried in the User Info fields(#Ed) of the Trigger frame.

The HE-SIG-B-MCS is a compact representation of the modulation and coding used in the HE-SIG-B field of the PPDU. For an HE MU PPDU, it is carried in the HE-SIG-A field. HE-SIG-B-MCS consists of indices 0 to 5 and each HE-SIG-B-MCS represents the same modulation and coding as the HE-MCS with the same index.(#2518)

Rate-dependent parameters for the full set of HE-MCSs are shown in Table 26-40 (HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1) to Table 26-95 (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) (in 26.5 (Parameters for HE-MCSs(#552))). These tables give rate-dependent parameters for HE-MCSs with indices 0 to 11, with number of spatial streams from 1 to 8, RU options of 26-tone, 52-tone, 106-tone, 242-tone, 484-tone and 996-tone, and bandwidth options of 20 MHz, 40 MHz, 80 MHz, and either 160 MHz or 80+80 MHz. HE-MCSs with indices 10 and 11 (1024-QAM) are optionally applied to the Data field of an HE PPDU with RUs equal to or larger than 242-tone. The HE extended range

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SU PPDU is 20 MHz and can only be transmitted with the <HE-MCS, NSS> tuples <MCS 0, 1>, <MCS 1, 1> and <MCS 2, 1>(#1616)(#278).

DCM is an optional modulation scheme used for the HE-SIG-B field and the Data field in an HE PPDU. It is indicated in the HE-SIG-A field for the HE-SIG-B field in an HE MU PPDU and for the Data field in HE SU PPDU, HE trigger-based PPDU and HE extended range SU PPDU and indicated in the HE-SIG-B field for the Data field in an HE MU PPDU. It is only applied for the HE-MCSs with indices 0, 1, 3 and 4.

26.3.6 Timing-related parameters

Refer to Table 19-6 (Timing-related constants) and Table 21-5 (Timing-related constants) for timing-related parameters for non-HE PPDU formats.

Table 26-3 (Timing-related constants) defines the timing-related parameters for HE PPDU formats..

Table 26-3— Timing-related constants

Parameter	Values	Description
$\Delta_{F,\text{Pre-HE}}$	312.5 kHz	Subcarrier frequency spacing for the pre-HE modulated fields(#279).
$\Delta_{F,\text{HE}}$	78.125 kHz	Subcarrier frequency spacing for the HE modulated fields(#279).
$T_{DFT,\text{Pre-HE}}$	3.2 µs	IDFT/DFT period for the pre-HE modulated fields(#279).
$T_{DFT,\text{HE}}$	12.8 µs	IDFT/DFT period for the HE Data field(#279)(#Ed).
$T_{GI,\text{Pre-HE}}$	0.8 µs	Guard interval duration for the legacy preamble, RL-SIG, HE-SIG-A and HE-SIG-B
$T_{GI,\text{HE-LTF}}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-LTF field, same as $T_{GI,Data}$
$T_{GI,Data}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-Data field
$T_{GI1,Data}$	0.8 µs	Base guard interval duration for the HE-Data field.
$T_{GI2,Data}$	1.6 µs	Double guard interval duration for the HE-Data field.
$T_{GI4,Data}$	3.2 µs	Quadruple guard interval duration for the HE-Data field.
T_{SYM1}	13.6 µs = $T_{DFT,\text{HE}} + T_{GI1,Data} = 1.0625 \times T_{DFT,HE}$	OFDM symbol duration with base GI(#1108)(#279)
T_{SYM2}	14.4 µs = $T_{DFT,\text{HE}} + T_{GI2,Data} = 1.125 \times T_{DFT,HE}$	OFDM symbol duration with double GI(#1109)
T_{SYM4}	16 µs = $T_{DFT,\text{HE}} + T_{GI4,Data} = 1.25 \times T_{DFT,\text{HE}}$	OFDM symbol duration with quadruple GI(#1110)
T_{SYM}	T_{SYM1}, T_{SYM2}, or T_{SYM4} depending on the GI used (see Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#2757))	Symbol interval

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Table 26-3— Timing-related constants *(continued)*

$T_{\text{L-STF}}$	8 μs = 10 × $T_{DFT,\text{Pre-HE}}$ /4	Non-HT Short Training field duration
$T_{\text{L-LTF}}$(#1040)	8 μs = 2 × $T_{DFT,\text{Pre-HE}}$ + $T_{GI2,Data}$	Non-HT Long Training field duration
$T_{\text{L-SIG}}$	4 μs	Non-HT SIGNAL field duration
$T_{\text{RL-SIG}}$	4 μs	Repeated non-HT SIGNAL field duration
$T_{\text{HE-SIG-A}}$	8 μs = 2 × 4 μs	HE-SIG-A field duration in an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU
$T_{\text{HE-SIG-A-R}}$	16 μs = 4 × 4 μs(#279)	HE-SIG-A field duration in an HE extended range SU PPDU
$T_{\text{HE-STF-T}}$	8 μs = 5 × 1.6 μs	HE-STF field duration for an HE trigger-based PPDU
$T_{\text{HE-STF-NT}}$	4 μs = 5 × 0.8 μs	HE-STF field duration for an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU
$T_{\text{HE-LTF-1X}}$	3.2 μs	Duration of each 1x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-2X}}$	6.4 μs	Duration of each 2x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-4X}}$	12.8 μs	Duration of each 4x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF}}$	$T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$ or $T_{\text{HE-LTF-4X}}$ depending upon the LTF duration used	Duration of each OFDM symbol without GI in the HE-LTF field (#279)
$T_{\text{HE-LTF-SYM}}$	sum of $T_{\text{HE-LTF}}$ and $T_{GI,\text{HE-LTF}}$	Duration of each OFDM symbol including GI in the HE-LTF field
$T_{\text{HE-SIG-B}}$	4 μs = $T_{DFT,\text{Pre-HE}}$ + $T_{GI,\text{Pre-HE}}$	Duration of each OFDM symbol in the HE-SIG-B field(#Ed)
$N_{service}$	16	Number of bits in the SERVICE field
N_{tail}	6	Number of tail bits per BCC encoder
T_{SYML}	4 μs	Symbol duration including GI prior to the HE-STF field
T_{PE}	0, 4 μs, 8 μs, 12 μs or 16 μs depending on the actual extension duration used	Duration of the Packet Extension field(#279)

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Table 26-4 (Tone allocation related constants for Data field in a non-OFDMA HE PPDU) defines tone allocation related parameters for a non-OFDMA HE PPDU.

Table 26-4—Tone allocation related constants for Data field in a non-OFDMA HE PPDU

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description
N_{SD}	234	468	980	980	1960	Number of complex data numbers per frequency segment
N_{SP}	8	16	16	16	32	Number of pilot values per frequency segment
N_{ST}	242	484	996	996	1992	Total number of subcarriers per frequency segment
N_{SR}	122	244	500	500	1012	Highest data subcarrier index per frequency segment
N_{Seg}	1	1	1	2	1	Number of frequency segments
N_{DC}	3	5	5	5	23	Number of null tones at DC per segment
$N_{Guard,Left}$	6	12	12	12	12	Number of guard tones at the lower side of the spectrum
$N_{Guard,Right}$	5	11	11	11	11	Number of guard tones at the higher end of the spectrum
NOTE: $N_{ST} = N_{SD} + N_{SP}$						

Table 26-5 (Tone allocation related constants for RUs in an OFDMA HE PPDU)(#281) defines tone allocation related parameters for a OFDMA HE PPDU.

Table 26-5—Tone allocation related constants for RUs in an OFDMA HE PPDU

Parameter	RU Size (tones)						Description
	26	52	106	242	484	996	
N_{SD}	24	48	102	234	468	980	Number of complex data numbers per RU
N_{SP}	2	4	4	8	16	16	Number of pilot values per RU
N_{ST}	26	52	106	242	484	996	Total number of subcarriers per RU
NOTE: $N_{ST} = N_{SD} + N_{SP}$							

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Table 26-6 (Frequently used parameters(#282)) defines parameters used frequently in Clause 26.

Table 26-6—Frequently used parameters(#282)

Symbol	Explanation
N_{CBPS}, $N_{CBPS,r,u}$	Number of coded bits per symbol at r-th RU for user u, $r = 0, \ldots, N_{RU} - 1$, $u = 0, ..., N_{user,r} - 1$. For an HE SU PPDU, $N_{CBPS} = N_{CBPS,0,0}$(#1042) For an HE MU PPDU, N_{CBPS} is undefined
N_{CBPSS}, $N_{CBPSS,r,u}$	Number of coded bits per symbol per spatial stream. For the Data field, $N_{CBPSS,r,u}$ equals the number of coded bits per symbol per spatial stream at r-th RU for user u, $r = 0, \ldots, N_{RU} - 1$, $u = 0, ..., N_{user,r} - 1$. For the Data field of an HE SU PPDU, $N_{CBPSS} = N_{CBPSS,0,0}$ For the Data field of an HE MU PPDU, N_{CBPSS} is undefined
N_{DBPS}, $N_{DBPS,r,u}$	Number of data bits per symbol at r-th RU for user u, $r = 0, \ldots, N_{RU} - 1$, $u = 0, ..., N_{user,r} - 1$. For an HE SU PPDU, $N_{DBPS} = N_{DBPS,0,0}$ For an HE MU PPDU, N_{DBPS} is undefined
N_{BPSCS}, $N_{BPSCS,u}$	Number of coded bits per subcarrier per spatial stream at r-th RU for user u, $r = 0, \ldots, N_{RU} - 1$, $u = 0, ..., N_{user,r} - 1$. For an HE SU PPDU, $N_{BPSCS} = N_{BPSCS,0,0}$ For an HE MU PPDU, N_{BPSCS} is undefined
N_{RX}	Number of receive chains
N_{RU}	For pre-HE modulated fields, $N_{RU} = 1$. For HE modulated fields, N_{RU} represents the number of RUs in the transmission (equal to the TXVECTOR parameter NUM_RUS).
$N_{user,r}$(#1043)	For pre-HE modulated fields, $N_{uset,r} = 1$. For HE modulated fields, $N_{uset,r}$ represents the number of users at r-th RU in the transmission (summing over all RUs equals to the TXVECTOR parameter NUM_USERS_TOTAL).
N_{STS}, $N_{STS,r,u}$	For pre-HE modulated fields, $N_{STS,r,u} = 1$ (see NOTE). For HE modulated fields, $N_{STS,r,u}$ represents(#1044) the number of space-time streams at r-th RU for user u, $u = 0, ..., N_{user,r} - 1$. In case of STBC, $N_{STS,r,u} = 2$ For an HE SU PPDU, $N_{STS} = N_{STS,0,0}$ For an HE MU PPDU, $N_{STS} = max_{r=0}^{N_{RU}-1} N_{STS,r,total}$
$N_{STS,r,total}$	For HE modulated fields, $N_{STS,r,total}$(#522) is the total number of space-time streams at the r-th RU in a PPDU. $N_{STS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{STS,r,u}$ For pre-HE modulated fields, $N_{STS,r,total}$ is undefined. Note that $N_{STS,r,total} = N_{STS}$ for an HE SU PPDU.

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Table 26-6—Frequently used parameters(#282) *(continued)*

N_{SS}, $N_{SS,r,u}$	Number of spatial streams. For the Data field, $N_{SS,r,u}$ is the number of spatial streams at r-th RU for user u, $u = 0, ..., N_{user,r} - 1$ For the Data field of an HE SU PPDU, $N_{SS} = N_{SS,0,0}$ For the Data field of an HE MU PPDU, $N_{SS} = max_{r=0}^{N_{RU}-1} N_{SS,r,total}$
$N_{SS,r,total}$	For HE modulated fields, $N_{SS,r,total}$ is the total number of spatial streams at r-th RU in a PPDU. $N_{SS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{SS,r,u}$ For pre-HE modulated fields, $N_{SS,r,total}$ is undefined. Note that $N_{SS,r,total} = N_{SS}$ for an HE SU PPDU.
N_{TX}	Number of transmit chains
$N_{HE\text{-}LTF}$	The number of OFDM symbols in the HE-LTF field (see 26.3.9.10 (HE-LTF))
$N_{HE\text{-}SIG\text{-}B}$	The number of OFDM symbols in the HE-SIG-B field
K_r	Set of subcarrier indices in the r-th RU
R, $R_{r,u}$	$R_{r,u}$ is the coding rate at r-th RU for user u, $u = 0, ..., N_{user,r} - 1$. For an HE SU PPDU, $R = R_{0,0}$ For an HE MU PPDU, R is undefined
$M_{r,u}$	For pre-HE modulated fields, $M_{r,u} = 0$. For HE modulated fields, $M_{r,0} = 0$ for $u = 0$ and $M_{r,u} = \sum_{u'=0}^{u-1} N_{STS,r,u'}$ for u, $u = 1, ..., N_{user,r} - 1$.
(#472)NOTE—For pre-HE modulated fields, u and r are zeros only since $N_{user,r} = 1$ and $N_{RU} = 1$.	

26.3.7 OFDMA and SU tone allocation

Orthogonal Frequency Division Multiple Access (OFDMA) is the multi-user variant of the OFDM scheme where multiple-access is achieved by assigning subsets of subcarriers to different users, allowing simultaneous data transmission by several users. In OFDMA, the resources are allocated in two dimensional regions over time and frequency. In HE, the time region covers the entire data portion of an HE PPDU, and the frequency region includes a number of contiguous subcarriers with the exception of the RUs which straddle DC where nulls are placed in the middle of the band. The difference between OFDM and OFDMA is illustrated in Figure 26 14. Similar to OFDM, OFDMA employs multiple subcarriers, but the subcarriers are divided into several groups of subcarriers where each group is denoted as a resource unit (RU). The grouping of subcarriers into groups of resource units is referred to as subchannelization. In HE, the

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subcarriers that form an RU(#1948) are physically adjacent (contiguous except at the middle of the band where nulls are placed at DC).

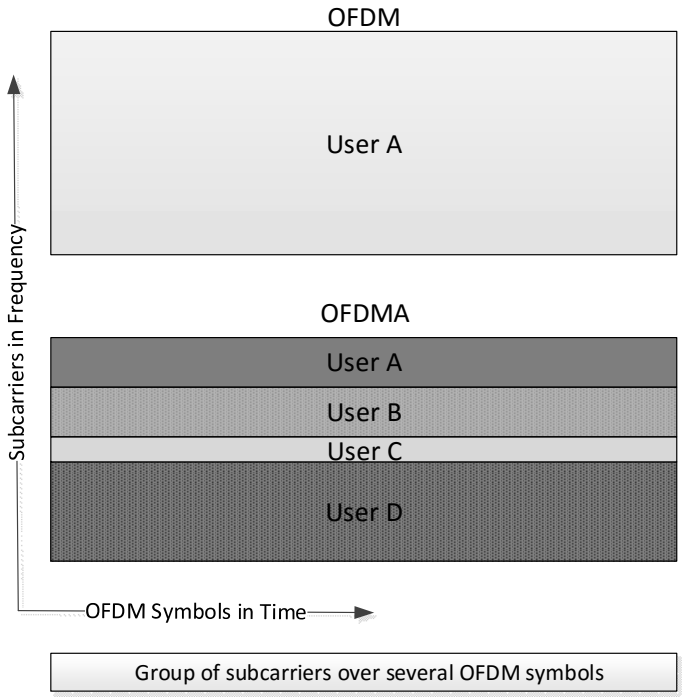


Figure 26-14—Illustration of OFDM and OFDMA concepts

Subchannelization defines subchannels that can be allocated to stations depending on their channel conditions and service requirements. Using subchannelization, an OFDMA system can potentially allocate different transmit powers to different allocations.

OFDMA is a method to add multiple access in OFDM systems and has been adopted by other wireless standards, and the HE amendment introduces OFDMA into 802.11 WLAN networks. The OFDMA parameters in HE satisfy general design criteria for OFDM systems as follows:

$$\begin{aligned} &T_{CP} \geq \tau_{RMS} \quad \text{(to prevent ISI due to delay spread)} \\ &T_{CP}\Delta f \ll 1 \quad \text{(for spectral efficiency improvement)} \end{aligned} \tag{26-1}$$

In OFDMA, an OFDM symbol is constructed of subcarriers, the number of which is a function of the FFT size. There are several subcarrier types: 1) Data subcarriers which are used for data transmission; defined in 26.3.7.1 (Resource unit, guard and DC subcarriers(#1951)), 2) Pilot subcarriers which are utilized for phase information and parameter tracking; defined in 26.3.7.3 (Pilot tones), and 3) unused subcarriers which are not used for data/pilot transmission. The unused subcarriers are the DC subcarrier (defined in 26.3.7.1 (Resource unit, guard and DC subcarriers(#1951))), the Guard band subcarriers at the band edges (defined in 26.3.7.1 (Resource unit, guard and DC subcarriers(#1951))), and the Null subcarriers (defined in 26.3.7.2 (Null subcarriers)).

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26.3.7.1 Resource unit, guard and DC subcarriers(#1951)

The following resource units (RUs) are defined for DL and UL transmission: a 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU, 484-tone RU and 996-tone RU and 2×996-tone RU(#838)(#1337)(#353).

The 26-tone RU and 52-tone RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission. The 484-tone RU(#838) is used in the 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission. The 996-tone RU(#838) is used in the 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission. The 2×996-tone RU is used in the 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission.(#888)

The 242-tone and larger RUs are used in the HE SU PPDU formats. The 242-tone RU(#838) is used in the 20 MHz HE SU PPDU format. The 484-tone RU(#838) is used in the 40 MHz HE SU PPDU format. The 996-tone RU(#838) is used in the 80 MHz HE SU PPDU format. The 2×996-tone RU(#838)(#1337) is used in the 160 MHz and 80+80 MHz HE SU PPDU formats.(#888)

The maximum number(#Ed) of RUs in the 20 MHz, 40 MHz, 80 MHz, 160 MHZ and 80+80 MHz HE PPDU formats are defined in Table 26-7 (Maximum number of RUs for each channel width(#1850)).(#285).

Table 26-7—Maximum number of RUs for each channel width(#1850)

RU type	CBW20	CBW40	CBW80	CBW80+80 and CBW160
26-tone RU(#838)	9	18	37	74
52-tone RU	4	8	16	32
106-tone RU	2	4	8	16
242-tone RU	1-SU/MU-MIMO	2	4	8
484-tone RU	N/A	1-SU/MU-MIMO	2	4
996-tone RU	N/A	N/A	1-SU/MU-MIMO	2
2×996 tone RU(#1337)	N/A	N/A	N/A	1-SU/MU-MIMO

An HE MU PPDU using OFDMA transmission can carry a mixture of 26-, 52- and 106-tone RUs within any of the 242-tone RU(#838) boundaries(#888).

Table 26-8—Subcarrier indices for RUs in a 20 MHz HE PPDU

RU type					
26-tone RU(#838)	RU 1 [−121: −96](#1111)	RU 2 [−95: −70]	RU 3 [−68: −43]	RU 4 [−42: −17]	RU 5 [−16: −4, 4: 16](#1111)
	RU 6 [17: 42]	RU 7 [43: 68]	RU 8 [70: 95]	RU 9 [96: 121]	

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Table 26-8—Subcarrier indices for RUs in a 20 MHz HE PPDU

52-tone RU	RU 1 [−121: −70]	RU 2 [−68: −17]	RU 3 [17: 68]	RU 4 [70: 121]	
106-tone RU	RU 1 [−122: −17]		RU 2 [17: 122]		
242-tone RU	RU 1 [−122: −2, 2:122]				

Table 26-9—Subcarrier indices for RUs in a 40 MHz HE PPDU

RU type					
26-tone RU(#838)	RU 1 [−243: −218]	RU 2 [−217: −192]	RU 3 [−189: −164]	RU 4 [−163: −138]	RU 5 [−136: −111]
	RU 6 [−109: −84]	RU 7 [−83: −58]	RU 8 [−55: −30]	RU 9 [−29: −4]	
	RU 10 [4: 29]	RU 11 [30: 55]	RU 12 [58: 83]	RU 13 [84: 109]	RU 14 [111: 136]
	RU 15 [138: 163]	RU 16 [164: 189]	RU 17 [192: 217]	RU 18 [218: 243]	
52-tone RU	RU 1 [−243: −192]	RU 2 [−189: −138]	RU 3 [−109: −58]	RU 4 [−55: −4]	
	RU 5 [4: 55]	RU 6 [58: 109]	RU 7 [138: 189]	RU 8 [192: 243]	
106-tone RU	RU 1 [−243: −138]	RU 2 [−109: −4]	RU 3 [4: 109]	RU 4 [138: 243]	
242-tone RU	RU 1 [−244: −3]		RU2 [3: 244]		
484-tone RU	RU 1 [−244: −3, 3: 244]				

Table 26-10—Subcarrier indices for RUs in an 80 MHz HE PPDU

RU type	

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Table 26-10—Subcarrier indices for RUs in an 80 MHz HE PPDU

26-tone RU	RU 1 [−499: −474]	RU 2 [−473: −448]	RU 3 [−445: −420]	RU 4 [−419: −394]	RU 5 [−392: −367]
	RU 6 [−365: −340]	RU 7 [−339: −314]	RU 8 [−311: −286]	RU 9 [−285: −260]	
	RU 10 [−257: −232]	RU 11 [−231: −206]	RU 12 [−203: −178]	RU 13 [−177: −152]	RU 14 [−150: −125]
	RU 15 [−123: −98]	RU 16 [−97: −72]	RU 17 [−69: −44]	RU 18 [−43: −18]	RU 19 [−16: −4, 4: 16]
	RU 20 [18: 43]	RU 21 [44: 69]	RU 22 [72: 97]	RU 23 [98: 123]	RU 24 [125: 150]
	RU 25 [152: 177]	RU 26 [178: 203]	RU 27 [206: 231]	RU28 [232: 257]	
	RU 29 [260: 285]	RU 30 [286: 311]	RU 31 [314: 339]	RU 32 [340: 365]	RU 33 [367: 392]
	RU 34 [394: 419]	RU 35 [420: 445]	RU 36 [448: 473]	RU37 [474: 499]	
52-tone RU	RU 1 [−499: −448]	RU 2 [−445: −394]	RU 3 [−365: −314]	RU 4 [−311: −260]	
	RU 5 [−257: −206]	RU 6 [−203: −152]	RU 7 [−123: −72]	RU 8 [−69: −18]	
	RU 9 [18: 69]	RU 10 [72: 123]	RU 11 [152: 203]	RU 12 [206: 257]	
	RU 13 [260: 311]	RU 14 [314: 365]	RU 15 [394: 445]	RU 16 [448: 499]	
106-tone RU	RU 1 [−499: −394]	RU 2 [−365: −260]	RU 3 [−257: −152]	RU 4 [−123: −18]	
	RU 5 [18: 123]	RU 6 [152: 257]	RU 7 [260: 365]	RU 8 [394: 499]	
242-tone RU	RU 1 [−500: −259]	RU 2 [−258: −17]	RU 3 [17: 258]	RU 4 [259: 500]	
484-tone RU	RU 1 [−500: −17]		RU 2 [17: 500](#2758)		
996-tone RU	RU 1 [−500: −3, 3: 500]				

A 26-tone RU(#838) consists of 24 data subcarriers and 2 pilot subcarriers. The positions of the pilots for the 26-tone RU(#838) are(#1957) defined in 26.3.7.3 (Pilot tones). The location of the 26-tone RUs(#838) are fixed as defined in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU), Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU)(#1958) and shown in Figure 26-15 (RU locations in a 20 MHz HE PPDU), Figure 26-16 (RU locations in a 40 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU)(#2759) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission, respectively. The same structure as used for the 80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU or HE trigger-based PPDU formats using OFDMA transmission.

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The center 26-tone RU(#838) in the 20 MHz and 80 MHz HE MU PPDU or HE trigger-based PPDU formats using OFDMA transmission (Figure 26-15 (RU locations in a 20 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU)) is located on subcarriers [–16: –4, 4: 16].(#888)

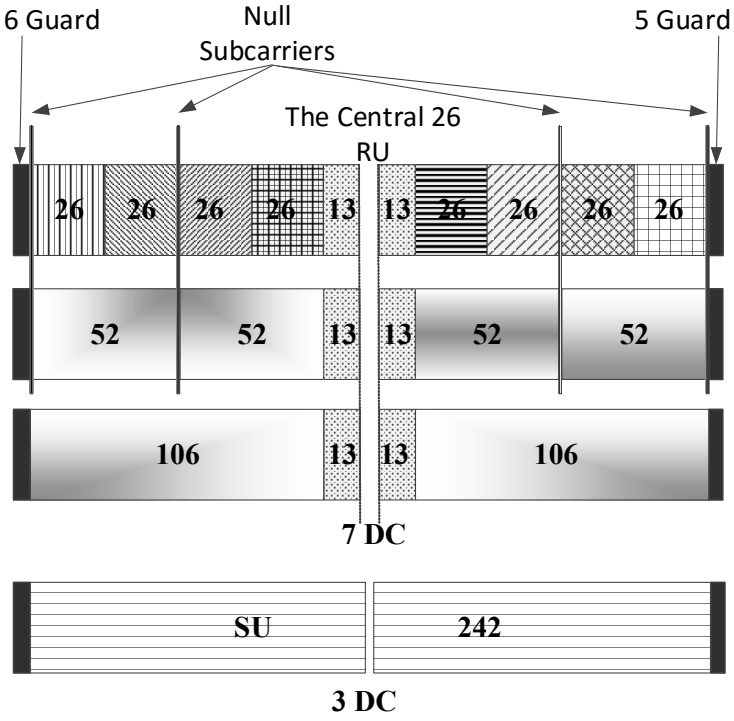


Figure 26-15—RU locations in a 20 MHz HE PPDU

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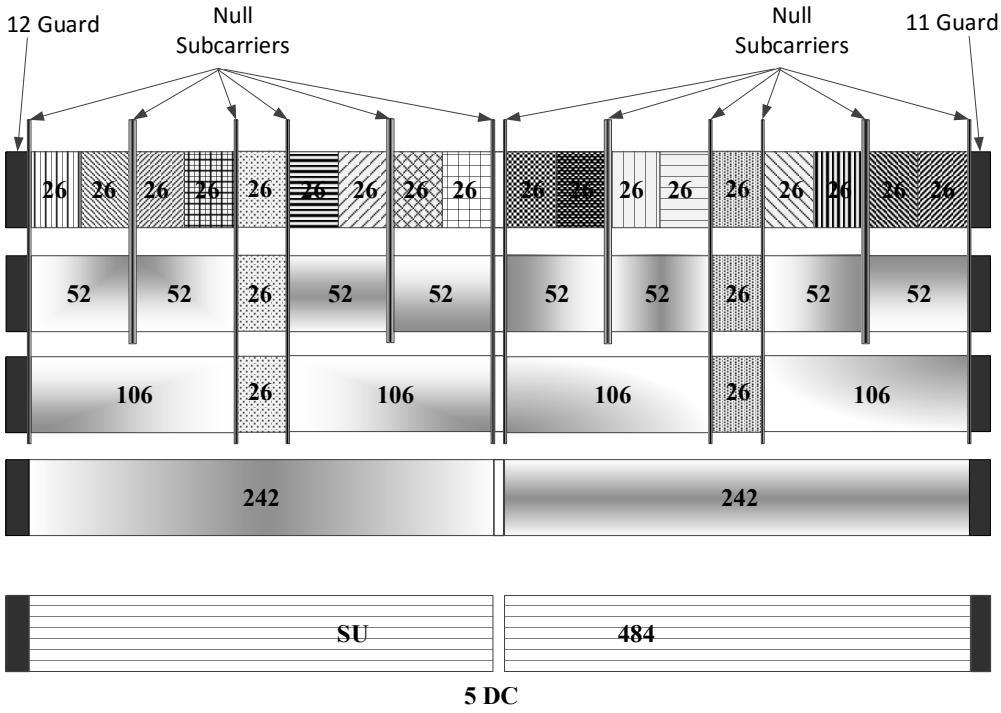


Figure 26-16—RU locations in a 40 MHz HE PPDU

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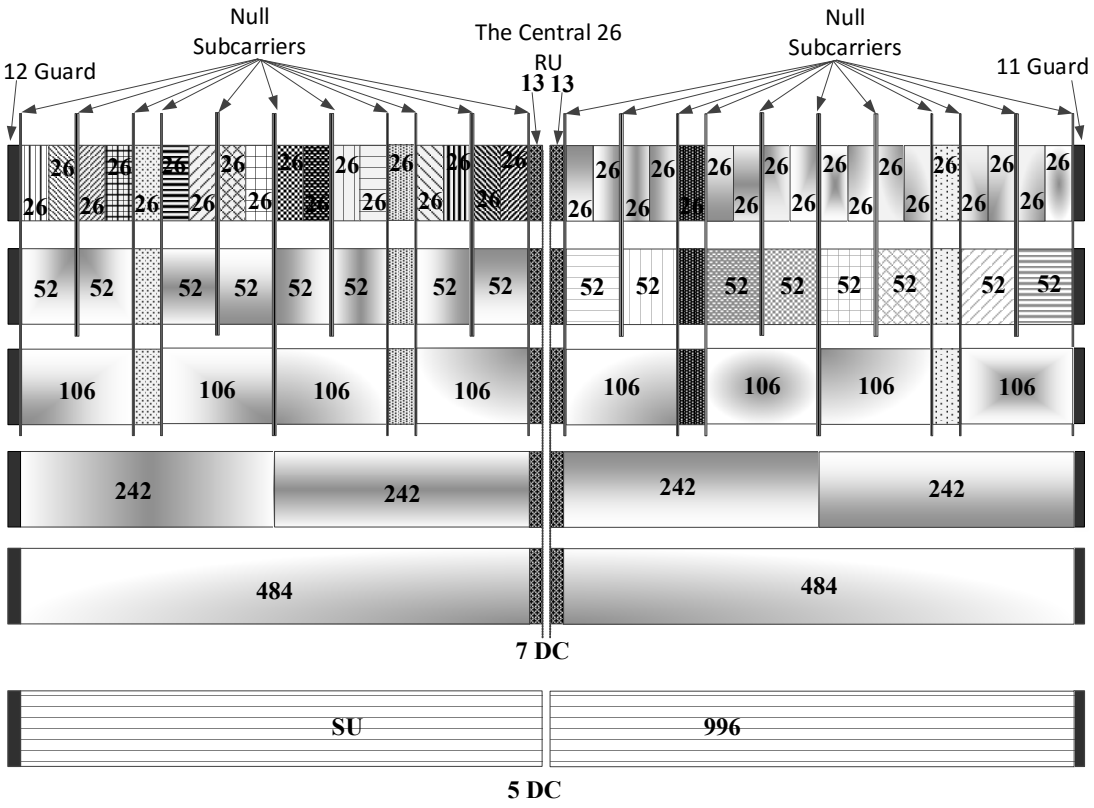


Figure 26-17—RU locations in an 80 MHz HE PPDU

A 52-tone RU(#838) consists of 48 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 52-tone RU(#838) are(#1960) defined in 26.3.7.3 (Pilot tones). The locations of the 52-tone RUs(#838) are fixed as defined in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU), Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 26-15 (RU locations in a 20 MHz HE PPDU), Figure 26-16 (RU locations in a 40 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU format or HE trigger-based PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission.(#888)

A 106-tone RU(#838) consists of 102 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 106-tone RU(#838) are(#1961) defined in 26.3.7.3 (Pilot tones). The locations of the 106-tone RUs(#838) are fixed as defined in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU), Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 26-15 (RU locations in a 20 MHz HE PPDU), Figure 26-16 (RU locations in a 40 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU formats or HE trigger-based PPDU formats using OFDMA transmission.

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A 242-tone RU(#838) consists of 234 data subcarriers and 8 pilot subcarriers. The positions of pilots for the 242-tone RU(#838) are(#1962) defined in 26.3.7.3 (Pilot tones). The locations of the 242-tone RUs(#838) are fixed as defined in Table 26-8 (Subcarrier indices for RUs in a 20 MHz HE PPDU),(#1669) Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 26-15 (RU locations in a 20 MHz HE PPDU), Figure 26-16 (RU locations in a 40 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE PPDU formats, respectively. The same structure as used in the 80 MHz HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU formats.(#888)

A 484-tone RU(#838) consists of 468 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 484-tone RU(#838) is defined in 26.3.7.3 (Pilot tones). The locations of the 484-tone RUs(#838) are fixed as defined in Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 26-16 (RU locations in a 40 MHz HE PPDU) and Figure 26-17 (RU locations in an 80 MHz HE PPDU) for the 40 MHz and 80 MHz HE PPDU formats. The same structure as used for the 80 MHz HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU formats.(#888)

A 996-tone RU(#838) consists of 980 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 996-tone RU(#838) is defined in 26.3.7.3 (Pilot tones). The locations of the 996-tone RUs(#838) are fixed and located on subcarrier [−1012: −515, −509: −12] and [12: 509, 515: 1012] for each half of the BW, respectively, for 160 MHz and 80+80 MHz(#Ed) HE PPDU formats.(#888)

The 20 MHz HE MU PPDU and HE trigger-based PPDU with more than one RU has 7 DC subcarriers located at [−3: 3]. The 20 MHz HE SU PPDU with a 242-tone RU(#838) has 3 DC subcarriers located at [−1: 1]. The 40 MHz HE PPDU with a 484-tone RU has 5 DC subcarriers located at [−2: 2]. An 80 MHz HE MU PPDU and HE trigger-based PPDU with more than one RU has 7 DC subcarriers located at [−3: 3]. The 80 MHz HE SU PPDU with a 996-tone RU has 5 DC subcarriers located at [−2: 2]. The same structure as used in the 80 MHz HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU. The DC tones are located on subcarriers [−11: 11].(#1963)(#888)

The 20 MHz HE PPDU format has 11 guard subcarriers (6, 5) located at [−128: −123] and [123: 127] as shown in Figure 26-15 (RU locations in a 20 MHz HE PPDU). The 40 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [−256: −245] and [245: 255] as shown in Figure 26-16 (RU locations in a 40 MHz HE PPDU). The 80 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [−512: −501] and [501: 511] as shown in Figure 26-17 (RU locations in an 80 MHz HE PPDU). For 160 MHz and 80+80 MHz HE PPDUs, the same number of leftmost and rightmost guard subcarriers as 80 MHz are defined at each edge of the 160 MHz.

(PHY Motion #165)In an HE MU PPDU, at least *N*x4x26 subcarriers (contiguous or non-contiguous), where *N* is the number of 20 MHz channels' legacy preambles present, shall be occupied throughout the signaled BW.

26.3.7.2 Null subcarriers

There are null subcarriers between the 26-, 52- and 106-tone RU(#838) locations as illustrated in Figure 26-15 (RU locations in a 20 MHz HE PPDU), Figure 26-16 (RU locations in a 40 MHz HE PPDU) and

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Figure 26-17 (RU locations in an 80 MHz HE PPDU). The null subcarriers have zero energy. The indices of the null subcarrier are enumerated in Table 26-11 (Null subcarrier indices).

Table 26-11— Null subcarrier indices

Channel Width	RU Size	Null Subcarrier Indices
20 MHz	26, 52	±69, ±122
	106	none
	242	none
40 MHz	26, 52	±3, ±56, ±57, ±110, ±137, ±190, ±191, ±244
	106	±3, ±110, ±137, ±244
	242, 484	none
80 MHz	26, 52	±17, ±70, ±71, ±124, ±151, ±204, ±205, ±258, ±259, ±312, ±313, ±366, ±393, ±446, ±447, ±500
	106	±17, ±124, ±151, ±258, ±259, ±366, ±393, ±500
	242, 484	none
	996	none

26.3.7.3 Pilot tones

If pilot tones are present in the HE-LTF field, the pilot tone locations in the HE-LTF field and Data field shall be the same. All pilot tones are at the even indices enumerated in Table 26-12 (Pilot tone indices).(#1789)

Table 26-12— Pilot tone indices

Channel Width	RU Size	Pilot Tone Indices
20 MHz	26, 52	±10, ±22, ±36, ±48, ±62, ±76, ±90, ±102, ±116
	106, 242	±22, ±48, ±90, ±116
40 MHz	26, 52	±10, ±24, ±36, ±50, ±64, ±78, ±90, ±104, ±116, ±130, ±144, ±158, ±170, ±184, ±198, ±212, ±224, ±238
	106, 242, 484	±10, ±36, ±78, ±104, ±144, ±170, ±212, ±238
80 MHz	26, 52	±10, ±24, ±38, ±50, ±64, ±78, ±92, ±104, ±118, ±130, ±144, ±158, ±172, ±184, ±198, ±212, ±226, ±238, ±252, ±266, ±280, ±292, ±306, ±320, ±334, ±346, ±360, ±372, ±386, ±400, ±414, ±426, ±440, ±454, ±468, ±480, ±494
	106, 242, 484	±24, ±50, ±92, ±118, ±158, ±184, ±226, ±252, ±266, ±292, ±334, ±360, ±400, ±426, ±468, ±494
	996	±24, ±92, ±158, ±226, ±266, ±334, ±400, ±468

The pilot tones locations for 160 MHz or 80+80 MHz shall use the same 80 MHz locations for both 80 MHz.

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26.3.7.4 RU restriction rules when operating 20 MHz(#854)

A non-AP STA can operate with 20 MHz, because either it is a 20 MHz-only HE device (see 26.3.9 (Mathematical description of signals)), or it reduces operating channel width to 20 MHz by ROM (see 25.8 (Receive operating mode)). When a 20 MHz operating non-AP STA is either a recipient of 40, 80, 80+80 or 160 MHz DL-OFDMA, or one of transmitters of 40, 80, 80+80 or 160 MHz UL-OFDMA, RU tone mapping in 20MHz is not aligned with 40, 80, 80+80 or 160 MHz RU tone mapping (see 26.3.7.1 (Resource unit, guard and DC subcarriers(#1951))). Due to misalignment of these RU locations, some of these RUs may cause significant performance penalty or interference to neighbor RUs. To improve the throughput and interoperability, some RUs in 20 MHz operating STAs are restricted to be used in 40, 80, 80+80 or 160 MHz OFDMA operation

An AP shall not assign the following RUs to 20 MHz operating STAs

— For 26-tone RUs, [Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU)]
  - RU 5 and 14 in 40 MHz DL/UL OFDMA (2 26-tone RUs are restricted)
  - RU 5, 10, 14, 19, 24, 28, 33 in 80 MHz DL/UL OFDMA (7 26-tone RUs are restricted)
  - RU 5, 10, 14, 19, 24, 28, 33 in lower 80 MHz and upper 80 MHz, in 80+80 or 160 MHz DL/UL OFDMA (14 26-tone RUs are restricted)

— For 52-tone RUs, [Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU)]
  - RU 5, 12 in 80 MHz DL/UL OFDMA (2 of 52-tone RUs are restricted)
  - RU 5, 12 in lower 80 MHz and upper 80 MHz, in 80+80 or 160 MHz DL/UL OFDMA (4 of 52-tone RUs are restricted)

— For 106-tone RUs, [Table 26-9 (Subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 26-10 (Subcarrier indices for RUs in an 80 MHz HE PPDU)]
  - RU 3, 6 in 80MHz DL/UL OFDMA (2 of 106-tone RUs are restricted)
  - RU 3, 6 in lower 80 MHz and upper 80 MHz, in 80+80 or 160 MHz DL/UL OFDMA (4 of 106-tone RUs are restricted)

Center 26-tone RU in primary 20 channel shall not be assigned to any STAs where 20 MHz operating STAs are recipients of 40/80/160/80+80 OFDMA.

It is optional whether all 242-tone RUs of 20 MHz operating STAs to be supported in 40/80/160/80+80 MHz DL-OFDMA. If supported, there is no restriction on 242-tone RUs. 242-tone RU shall not be allocated to 20 MHz operating STAs in 40/80/160/80+80 for UL-OFDMA.

26.3.8 20 MHz only HE STAs

(PHY Motion #163)A 20 MHz only HE STA operates with 20 MHz channel width only, in frequency bands between 1 GHz and 6 GHz. A 20 MHz only HE STA operates in the primary 20 MHz channel as a mandatory mode. It is indicated in the capability field, whether an HE STA is 20 MHz only, 80 MHz, 160 MHz or 80+80MHz capable. Only a non-AP HE STA can be a 20 MHz-only STA.

An HE AP in 5 GHz shall be 80 MHz capable and operate for both 80 MHz capable non-AP HE STAs and 20 MHz only non-AP HE STAs.

A 20 MHz only non-AP HE STA supports tone mapping of 26-tone RU, 52-tone RU, 106-tone RU and 242-tone RU, for 20 MHz and 40 MHz OFDMA in 2.4 GHz and 5 GHz frequency band, and for 80 MHz, 80+80 MHz and 160 MHz OFDMA in 5 GHz frequency band, where some of RUs are restricted to operate (see 26.3.7.4 (RU restriction rules when operating 20 MHz(#854))).

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26.3.9 Mathematical description of signals

For a description of the conventions used for the mathematical description of the signals, see 17.3.2.5 (Mathematical conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 26:

$[Q]_{m,n}$ indicates the element in row m and column n of matrix, where $1 \le m \le N_{row}$ and $1 \le n \le N_{col}$(#2369)

N_{row} and N_{col} are the number of rows and columns, respectively, of the matrix Q.

$[Q]_{m:n}$ indicates a matrix consisting of columns m to n(#1966) of matrix Q.

For a description on subcarrier indices over which the signal is transmitted for non-HT, HT and VHT PPDUs, see 22.3.7 (Mathematical description of signals).

For a 20 MHz non-OFDMA HE PPDU(#Ed) transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on subcarriers –122 to –2 and 2 to 122, with 0 being the center (DC) subcarrier.

For a 20 MHz OFDMA HE PPDU(#Ed) transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on subcarriers –122 to –4 and 4 to 122, with 0 being the center (DC) subcarrier.

For a 40 MHz non-OFDMA and OFDMA HE PPDU(#Ed) transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on subcarriers –244 to –3 and 3 to 244.

For an 80 MHz non-OFDMA HE PPDU(#Ed) transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –3 and 3 to 500.

For an 80 MHz OFDMA HE PPDU(#Ed) transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –4 and 4 to 500.

For a 160 MHz HE PPDU transmission or a noncontiguous 80+80 MHz transmission, and each half 80 MHz bandwidth is divided into 1024 subcarriers, and the subcarriers on which the signal is transmitted in each 80 MHz bandwidth is identical to an 80 MHz HE PPDU transmission, depending on non-OFDMA or OFDMA transmission within the corresponding(#898) 80 MHz.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (26-2).

$$r_{RF}^{(i_{Seg}, i_{TX})}(t) = \mathrm{Re}\left\{ \frac{1}{\sqrt{N_{Seg}}} r_{PPDU}^{(i_{Seg}, i_{TX})}(t) \exp\left(j2\pi f_c^{(i_{Seg})} t\right) \right\}, \quad i_{Seg} = 0, \ldots, N_{Seg} - 1; \; i_{TX} = 1, \ldots, N_{TX} \quad (26\text{-}2)$$

where

N_{Seg} represents the number of frequency segments in the transmit signal as defined in Table 26-4 (Tone allocation related constants for Data field in a non-OFDMA HE PPDU)(#1671)

$r_{PPDU}^{(i_{Seg}, i_{TX})}$ represents the complex baseband signal of frequency segment i_{Seg} and transmit chain i_{TX}

$f_c^{(i_{Seg})}$ represents the center frequency of the portion of the PPDU transmitted in frequency segment i_{Seg}

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 26-18 (Timing boundaries for HE PPDU fields(#899)), where $N_{\text{HE-LTF}}$ is the number of HE-LTF symbols and is defined in Table 26-6

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(Frequently used parameters(#282)), $N_{\text{HE-SIG-B}}$ is the number of symbols in the HE-SIG-B field, and N_{SYM} is the number of symbols in the Data field.

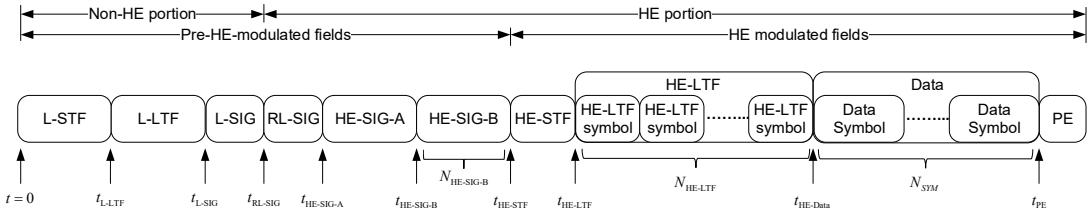


Figure 26-18—Timing boundaries for HE PPDU fields(#899)

The time offset, t_{Field}, determines the starting time of the corresponding field relative to the start of L-STF ($t = 0$).

The signal transmitted on frequency segment i_{Seg} of transmit chain i_{TX} shall be as shown in Equation (26-3).

$$\begin{aligned} r_{PPDU}^{(i_{Seg}, i_{TX})}(t) = {} & r_{\text{L-STF}}^{(i_{Seg}, i_{TX})}(t) + r_{\text{L-LTF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{L-LTF}}) \\ & + r_{\text{L-SIG}}^{(i_{Seg}, i_{TX})}(t - t_{\text{L-SIG}}) + r_{\text{RL-SIG}}^{(i_{Seg}, i_{TX})}(t - t_{\text{RL-SIG}}) + r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-SIG-A}}) + r_{\text{HE-SIG-B}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-SIG-B}}) \\ & + r_{\text{HE-STF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-STF}}) + r_{\text{HE-LTF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-LTF}}) + r_{\text{HE-Data}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-Data}}) + r_{\text{HE-PE}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-PE}}) \end{aligned} \tag{26-3}$$

where

$0 \le i_{Seg} \le N_{Seg} - 1$

$1 \le i_{TX} \le N_{TX}$

$t_{\text{L-LTF}} = T_{\text{L-STF}}$

$t_{\text{L-SIG}} = t_{\text{L-LTF}} + T_{\text{L-LTF}}$

$t_{\text{RL-SIG}} = t_{\text{L-SIG}} + T_{\text{L-SIG}}$

$t_{\text{HE-SIG-A}} = t_{\text{RL-SIG}} + T_{\text{RL-SIG}}$

$$t_{\text{HE-SIG-B}} = \begin{cases} t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A}}, & \text{for an HE MU PPDU} \\ undefined, & \text{otherwise} \end{cases}$$

$$t_{\text{HE-STF}} = \begin{cases} t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A}}, & \text{for an HE SU PPDU and HE trigger-based PPDU} \\ t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A-R}}, & \text{for an HE extended range SU PPDU} \\ t_{\text{HE-SIG-B}} + N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}}, & \text{for an HE MU PPDU} \end{cases}$$

where $N_{HE\text{-}SIG\text{-}B}$ is the number of OFDM symbols in the HE-SIG-B field

$$t_{\text{HE-LTF}} = \begin{cases} t_{\text{HE-STF}} + T_{\text{HE-STF-T}}, & \text{for an HE trigger-based PPDU} \\ t_{\text{HE-STF}} + T_{\text{HE-STF-NT}}, & \text{otherwise} \end{cases}$$

$$t_{\text{HE-Data}} = \begin{cases} t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-1X}} + T_{\text{GI,HE-LTF}}), & \text{for 1x HE-LTF} \\ t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-2X}} + T_{\text{GI,HE-LTF}}), & \text{for 2x HE-LTF} \\ t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-4X}} + T_{\text{GI,HE-LTF}}), & \text{for 4x HE-LTF} \end{cases}$$

$t_{\text{HE-PE}} = t_{\text{HE-Data}} + N_{SYM} T_{SYM}$

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In an HE SU PPDU, HE MU PPDU and HE extended range SU PPDU, each field, $r_{Field}^{(i_{Seg}, i_{TX})}(t)$, is defined as the summation of one or more subfields, where each subfield is defined to be an inverse discrete Fourier transform as specified in Equation (26-4)(#2158).(#526)

$$r_{Field}^{(i_{Seg}, i_{TX})}(t) = w_{T_{Field}}(t) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{Norm,r}}} \sum_{k \in K_r} \eta_{Field,r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}-1} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} \Upsilon_{k,BW} \quad (26\text{-}4)$$
$$X_{k,r,u}^{i_{Seg},m} \exp(j2\pi k \Delta_{F,Field}(t - T_{GI,Field} - T_{CS,\mathrm{HE}}(M_{r,u}+m)))$$

In an HE trigger-based PPDU, transmitted by user-*u* in the *r*-th RU, each field, $r_{Field}^{(i_{Seg}, i_{TX})}(t)$, is defined in Equation (26-5).(#526)

$$r_{Field}^{(i_{Seg}, i_{TX})}(t) = \frac{\alpha_r \beta_r}{\sqrt{N_{Norm,r}}} w_{T_{Field}}(t) \sum_{k \in K_r} \eta_{Field} \sum_{m=1}^{N_{STS,r,u}-1} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} \Upsilon_{k,BW} \quad (26\text{-}5)$$
$$X_{k,r,u}^{(i_{Seg},m)} \exp(j2\pi k \Delta_{F,Field}(t - T_{GI,Field} - T_{CS,\mathrm{HE}}(M_{r,u}+m)))$$

In the remainder of this subclause, pre-HE modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, and HE-SIG-B fields, while HE modulated fields refer to the HE-STF, HE-LTF, Data, and PE fields, as shown in Figure 26-18 (Timing boundaries for HE PPDU fields(#899)). The total power of the time domain HE modulated field signals summed over all transmit chains should not exceed the total power of the time domain pre-HE modulated field signals summed over all transmit chains. For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (26-4) the following notations(#1975) are used:

$N_{Field}^{\mathrm{Tone}}$ Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields) summarizes the various values of $N_{Field}^{\mathrm{Tone}}$ as a function of bandwidth per frequency segment. In the case of an HE OFDMA PPDU, the $N_{Field}^{\mathrm{Tone}}$ value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.

Table 26-13—Tone scaling factor and guard interval duration values for HE PPDU fields

Field	N_{Field}^{Tone} as a function of bandwidth, and RU size per frequency segment				Guard interval duration
	20 MHz	40 MHz	80 MHz	160 MHz	
L-STF	12	24	48	96	-
L-LTF	52	104	208	416	$T_{GI2,Data}$

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Table 26-13—Tone scaling factor and guard interval duration values for HE PPDU fields

L-SIG in an HE PPDU	56	112	224	448	$T_{GI,\text{LegacyPreamble}}$
L-SIG in a non-HT duplicate PPDU(#1988)	-	104	208	416	
RL-SIG	56	112	224	448	$T_{GI,\text{LegacyPreamble}}$
HE-SIG-A	56	112	224	448	$T_{GI,\text{LegacyPreamble}}$
HE-SIG-B	56	112	224	448	$T_{GI,\text{LegacyPreamble}}$
HE-STF not in an HE trigger-based PPDU	14	30	62	126	-
HE-STF in an HE trigger-based PPDU	30	60	124	248	-
HE-LTF 1x Duration	60	122	250	500	$T_{GI,\text{HE-LTF1}}$
HE-LTF 2x Duration	122	242	498	996	$T_{GI,\text{HE-LTF2}}$
HE-LTF 4x Duration	242	484	996	1992	$T_{GI,\text{HE-LTF4}}$
HE-Data	242	484	996	1992	$T_{GI1,Data}$(#2502), $T_{GI2,Data}$ or $T_{GI4,Data}$
NON_HT_DUP_OFDM-Data(#1988)	-	104	208	416	$T_{GI,\text{LegacyPreamble}}$

NOTE—in the case of an HE OFDMA PPDU, the N_{Field}^{Tone} value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.

$N_{Norm,r}$ If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields, $N_{Norm,r} = N_{TX}$. If the TXVECTOR parameter BEAM_CHANGE is 0, then for pre-HE modulated fields $N_{Norm,r} = N_{STS,r,total}$, where $N_{STS,r,total}$ is given in Table 26-6 (Frequently used parameters(#282)). For HE modulated fields $N_{Norm,r} = N_{STS,r,total}$.

$w_{T_{Field}}(t)$ is a windowing function. An example function, $w_{T_{Field}}(t)$, is given in 18.3.2.5 (Mathematical conventions in the signal descriptions).

K_r For pre-HE modulated fields, K_r(#2760) is the set of subcarriers indices from $-N_{SR}$ to N_{SR}. For HE modulated fields in a non-OFDMA HE PPDU, Kr is the set of subcarriers indices from $-N_{SR}$ to N_{SR}. For HE modulated fields in an OFDMA HE PPDU, K_r is the set of subcarrier indices for the tones in the r-th RU.

$\eta_{Field,k}$ is the power boost factor per OFDM symbol, which is $\sqrt{2}$ for the L-STF, L-LTF, HE-STF and HE-LTF fields in the HE extended range SU PPDU, and 1 otherwise.(#526)

$$\eta_{\text{L-SIG},k} = \begin{cases} \sqrt{2}, k = -28, -27, 27, 28 \text{ for an HE extended range SU PPDU} \\ 1, \text{ otherwise} \end{cases} \text{(#526)} \quad \text{(26-6)}$$

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

β_r is the per-RU power normalization factor and is defined in Equation (26-7)

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$$\beta_r = \begin{cases} \dfrac{\varepsilon_{Field}}{\sqrt{N_{Field}^{\text{Tone}}}}, & \text{Pre-HE modulated fields when BEAM\_CHANGE = 1} \\ \varepsilon_{Field}\sqrt{\dfrac{|K_r|}{|K_r^{Field}|}} \Big/ \sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}, & \text{otherwise} \end{cases} \quad \text{(\#526)} \quad \text{(26-7)}$$

$$\varepsilon_{Field} = \begin{cases} \sqrt{\dfrac{N_{\text{L-LTF}}^{\text{Tone}}}{N_{\text{L-SIG}}^{\text{Tone}}}}, & \text{For the L-STF and L-LTF fields} \\ 1, & \text{otherwise} \end{cases} \quad \text{(\#526)}$$

$|K_r|$ is the cardinality of the set of subcarriers K_r

K_r^{Field} is the set of subcarriers that have non-zero values within K_r in the HE-STF and Data fields, and defined in Equation (26-8) for the HE-LTF field.

$$K_r^{\text{HE-LTF}} = \begin{cases} |K_r|/4, & \text{for 1x HE-LTF} \\ |K_r|/2, & \text{for 2x HE-LTF} \\ |K_r|, & \text{for 4x HE-LTF} \end{cases} \quad \text{(26-8)}$$

$Q_k^{(i_{Seg})}$ is the spatial mapping matrix for the subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_k^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,total}$ columns. If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields $Q_k^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{Pre-HE}} T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are TBD; otherwise it is identical to the spatial mapping $Q_k^{(i_{Seg})}$ for HE modulated fields(#1848).

$\Delta_{F,Field}$ is the subcarrier frequency spacing. For pre-HE modulated fields, $\Delta_{F,Field} = \Delta_{F,\text{Pre-HE}}$ given in Table 26 3. For HE modulated fields, $\Delta_{F,Field} = \Delta_{F,\text{HE}}$ given in Table 26-3 (Timing-related constants).

$X_{k,r,u}^{(i_{Seg},m)}$ is the frequency-domain symbol in subcarrier k of user u in the r-th RU for frequency segment i_{Seg} of space-time stream m. Some of the $X_{k,r,u}^{(i_{Seg},m)}$ within $-N_{SR} \le k \le N_{SR}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the null subcarriers(#902) in an HE OFDMA PPDU, as well as the unmodulated tones of L-STF, HE-STF, and HE-LTF fields. Note that the multiplication matrices $A_{\text{HE-LTF}}^k$ are included in the calculation of $X_{k,r,u}^{(i_{Seg},m)}$ for the HE-STF and HE-LTF fields. When the TXVECTOR parameter BEAM_CHANGE is 0, the first column of the multiplication matrices $A_{\text{HE-LTF}}^k$ are included in the calculation of $X_{k,r,u}^{(i_{Seg},m)}$ for the pre-HE modulated fields.

$T_{GI,Field}$ is the guard interval duration used for each OFDM symbol in the field. The value for each field is as defined in Table 26-3 (Timing-related constants)(#1674).

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$T_{CS,\,\mathrm{HE}}(l)$ For pre-HE modulated fields, $T_{CS,\,\mathrm{HE}}(l) = 0$. For HE modulated fields, $T_{CS,\,\mathrm{HE}}(l)$ represents the cyclic shift per space-time stream, whose value is defined in Table 25-xx (Cyclic shift values for the HE modulated fields of a PPDU).

$\Upsilon_{k,\,BW}$ is used to represent tone rotation. BW in $\Upsilon_{k,\,BW}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 26-14 (CH_BANDWIDTH and for pre-HE modulated fields). In HE modulated fields, $\Upsilon_{k,\,BW} = 1$ in all the subcarriers. In pre-HE modulated fields, $\Upsilon_{k,\,BW}$ is defined as in 21.3.7.5 (Definition of tone rotation) when TXVECTOR parameter BEAM_CHANGE is set to 1 and $\Upsilon_{k,\,BW} = 1$ for all the tones when TXVECTOR parameter BEAM_CHANGE is set to 0. When the TXVECTOR parameter BEAM_CHANGE is not present (such as in an HE MU PPDU and HE trigger-based PPDU), BEAM_CHANGE is assumed to be set to 1.(#2761)(#293)

Table 26-14—CH_BANDWIDTH and $\Upsilon_{k,\,BW}$ for pre-HE modulated fields

CH_BANDWIDTH	$\Upsilon_{k,\mathrm{BW}}$
CBW20	$\Upsilon_{k,\,20}$
CBW40	$\Upsilon_{k,\,40}$
CBW80	$\Upsilon_{k,\,80}$
CBW160	$\Upsilon_{k,\,160}$
CBW80+80	$\Upsilon_{k,\,80}$ per frequency segment

26.3.10 HE preamble

26.3.10.1 Introduction

The HE portion of HE format preamble consists of pre-HE modulated fields and HE modulated fields. The HE modulated fields consist of HE-STF, HE-LTF and Data fields(#2762). The pre-HE modulated fields for the various HE PPDU formats are the following(#291):

- RL-SIG and HE-SIG-A fields of an HE SU PPDU
- RL-SIG, HE-SIG-A and HE-SIG-B fields of an HE MU PPDU
- RL-SIG, HE-SIG-A and repeated HE-SIG-A fields of an HE extended range SU PPDU
- RL-SIG and HE-SIG-A fields of an HE trigger-based PPDU

26.3.10.2 Cyclic shift(#1052)

26.3.10.2.1 Cyclic shift for pre-HE modulated fields

When the TXVECTOR parameter BEAM_CHANGE is 1(#Ed), the cyclic shift value $T_{CS}^{i_{TX}}$ for the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A and HE-SIG-B fields of the PPDU for transmit chain i_{TX} out of a total of

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N_{TX} are defined in Table 22-10 (Cyclic shift values for L-STF, L-LTF, L-SIG, and VHT-SIG-A fields of the PPDU). In UL MU transmission the cyclic shift value $T_{CS}^{i_{TX}}$ is based on the transmit chain index of each STA.

When the TXVECTOR parameter BEAM_CHANGE is 0(#Ed), the cyclic shift value $T_{CS}^{i_{TX}}$ for the L-STF, L-LTF, L-SIG, RL-SIG, and HE-SIG-A fields is not specified.

26.3.10.2.2 Cyclic shift for HE modulated fields

The cyclic shift values defined in this subclause apply to the HE-STF, HE-LTF and Data fields of the HE PPDU when the TXVECTOR parameter BEAM_CHANGE is 1(#Ed), and apply to the entire PPDU when the TXVECTOR parameter BEAM_CHANGE is 0(#Ed).

Throughout the HE modulated fields of the preamble, cyclic shifts are applied to prevent unintended beamforming when correlated signals are transmitted in multiple space-time streams. The same cyclic shift is also applied to these streams during the transmission of the Data field of the HE PPDU. The cyclic shift value $T_{CS,\,\mathrm{HE}}(n)$ for the HE modulated fields for space-time stream n out of $N_{STS,total}$ total space-time streams is shown in Table 22-11 (Cyclic shift values for the VHT modulated fields of a PPDU).

26.3.10.3 L-STF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-STF field shall be as specified in Equation (26-9). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg}i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX}\cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}\in\Omega_{20\text{MHz}}}\sum_{k=-26}^{26} \eta_{\text{L-STF},\,k}\left(\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\,\text{BW}} S_{k,\,20} \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t-T_{CS}^{i_{TX}}))\right) \quad (26\text{-}9)$$

(#525)where

ε is a power scaling factor with the value $\varepsilon = \sqrt{\frac{N_{\text{Tone}}^{\text{L-LTF}}}{N_{\text{Tone}}^{\text{L-SIG}}}}$

$\eta_{\text{L-STF},\,k}$ is a PPDU format dependent scaling factor for the L-STF field on tone index k with the following value

$$\eta_{\text{L-STF},\,k} = \begin{cases}\sqrt{2}, & \text{for an HE extended range SU PPDU}\\ 1, & \text{otherwise}\end{cases} \text{ (#1986)} \quad (26\text{-}10)$$

$N_{20\text{MHz}}$ is defined in 22.3.8.3.4 (L-SIG definition)

$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i)\cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 26.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

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$N_{\text{L-STF}}^{\text{Tone}}$ has the value given in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#1988).

$\Omega_{20\text{MHz}}$ is a set of 20 MHz channels that contains the channels where pre-HE modulated fields are located and the channel indices are within 0 to $N_{20\text{MHz}} - 1$ in an HE trigger-based PPDU or HE MU PPDU with preamble puncturing, or equal to {0, 1, …, $N_{20\text{MHz}} - 1$} otherwise.

$S_{k,20}$ is defined as $S_{-26,26}$ in Equation (18-6).(#1985)(#1989)

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-STF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (26-11). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg} i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS,\,total} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS,\,total}} \eta_{\text{L-STF},k} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} S_{k,\,20} \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{CS,\,\text{HE}}(m))) \right) \quad (26\text{-}11)$$

(#1050)(#525)where

$T_{CS,\,\text{HE}}(m)$ represents the cyclic shift for space time stream m as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is the spatial mapping/steering matrix for subcarrier k, in frequency segment i_{Seg} on the data symbols over tone spacing $\Delta_{F,\,\text{HE}}$ as defined in Table 26-3 (Timing-related constants). Refer to the descriptions in 22.3.10.11.1 (Transmission in VHT format) for examples of $Q_k^{(i_{Seg})}$.(#1991)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (26-58)

26.3.10.4 L-LTF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-LTF field shall be as specified in Equation (26-12). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg} i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-26}^{26} \eta_{\text{L-LTF},k} \left(\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\,\text{BW}} L_{k,\,20} \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{LegacyPreamble}} - T_{CS}^{i_{TX}})) \right) \quad (26\text{-}12)$$

$\eta_{\text{L-LTF},k}$ is a PPDU format dependent scaling factor for the L-LTF field on tone index k with the same value as $\eta_{\text{L-STF},k}$.(#525)

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

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$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 26.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

$N_{\text{L-LTF}}^{\text{Tone}}$ has the value given in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#1988).

$L_{k,20}$ is defined as $L_{-26,26}$ in Equation (18-8).(#1992)

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-LTF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (26-13). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg} i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS,\,total} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS,\,total}} \eta_{\text{L-LTF},\,k} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} L_{k,\,20} \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{LegacyPreamble}} - T_{CS,\,\text{HE}}(m))) \right) \quad (26\text{-}13)$$

(#1050)where

$T_{CS,\,\text{HE}}(m)$ represents the cyclic shift for space time stream m as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is defined in 26.3.9 (Mathematical description of signals)(#1094)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (26-58)

26.3.10.5 L-SIG

The L-SIG field is used to communicate rate and length information. The structure of the L-SIG field is defined in Figure 17-5 (SIGNAL field bit assignment)(#1835).

In an(#2829) HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field)(#1835). In a non-HT duplicate PPDU, the RATE field is defined in 17.3.4.2 (RATE field)(#1835) using the L_DATARATE parameter in the TXVECTOR.

The LENGTH field shall be set to the value given by Equation (26-14).

$$\text{Length} = \left\lceil \frac{\text{TXTIME} - 20}{4} \right\rceil \times 3 - 3 - m \text{ (\#1683)} \quad (26\text{-}14)$$

where

TXTIME (in μs) is defined in 26.4.3 (TXTIME and PSDU_LENGTH calculation).

m is 1 for an HE MU PPDU and HE extended range SU PPDU, and 2 otherwise.

The LSB of the binary expression of the Length value shall be mapped to B5. In a non-HT duplicate PPDU, the LENGTH field is defined in 17.3.4.3 (LENGTH field)(#2859) using the L_LENGTH parameter in the TXVECTOR.

The Reserved (R) field shall be set to 0.

The Parity (P) field has the even parity of bits 0-16.

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The SIGNAL TAIL field shall be set to 0.

The L-SIG field shall be encoded, interleaved, and mapped following the steps described in 17.3.5.6 (Convolutional encoder), 17.3.5.7 (Data interleaving), and 17.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by $d_k, k = 0, \ldots, 47$. Pilots shall be inserted as described in 17.3.5.9 (Pilot subcarriers). Extra 4 BPSK modulated tones are added, two at each edge of the subcarriers used by data and pilot tones. The 4 extra tones [–28, –27, 27, 28] of L-SIG in 20 MHz HE PPDU is [–1, –1, –1, 1].(#1835)

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform of the L-SIG field shall be as given by Equation (26-15).

$$r_{\text{L-SIG}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\, \text{BW}} \eta_{\text{L-SIG},\, k} (D_{k,\,20} + p_0 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{LegacyPreamble}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (26\text{-}15)$$

where

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k,\,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ -1, k = -28, -27, 27 \\ 1, k = 28 \\ d_{M_{20}^r(k)}, \text{otherwise} \end{cases} \quad (\#1684)$$

$$M_{20}^r(k) = \begin{cases} k + 26, -26 \le k \le -22 \\ k + 25, -20 \le k \le -8 \\ k + 24, -6 \le k \le -1 \\ k + 23, 1 \le k \le 6 \\ k + 22, 8 \le k \le 20 \\ k + 21, 22 \le k \le 26 \end{cases}$$

P_k is defined in 17.3.5.10 (OFDM modulation)(#1835)

P_0 is the first pilot value in the sequence defined in 17.3.5.10 (OFDM modulation)

$N_{\text{L-SIG}}^{\text{Tone}}$ is defined in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#476)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 26.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

NOTE—$M_{20}^r(k)$ is a "reverse" function of the function $M(k)$ defined in 17.3.5.10 (OFDM modulation)(#1835).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the L-SIG field shall be as given by Equation (26-16).

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$$r_{\text{L-SIG}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{STS,\,total} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \quad (26\text{-}16)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS,\,total}} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} \eta_{\text{L-SIG},\,k} (D_{k,\,20} + p_0 P_k) \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{LegacyPreamble}} - T_{CS,\,\text{HE}}(m))) \right)$$

(#1050)(#525)where

$\eta_{\text{L-SIG},\,k}$ is a PPDU dependent scaling factor for the L-SIG field on the tone index k with the following value:

$$\eta_{\text{L-SIG},\,k} = \begin{cases} \sqrt{2}, & k = \pm 28, \pm 27 \text{ for an HE extended range SUPPDU} \\ 1, & \text{otherwise} \end{cases} \quad (\#525)$$

$T_{CS,\,\text{HE}}(m)$ represents the cyclic shift for space time stream m as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is defined in 26.3.9 (Mathematical description of signals)(#1094)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (26-58)

26.3.10.6 RL-SIG

The RL-SIG field is used to identify an(#2829) HE PPDU.

The time domain waveform of the RL-SIG field is generated by repeating the time domain waveform of the L-SIG field, as defined in Equation (26-17).

$$r_{\text{RL-SIG}}^{(i_{Seg},\,i_{TX})}(t) = r_{\text{L-SIG}}^{(i_{Seg},\,i_{TX})}(t) \quad (26\text{-}17)$$

26.3.10.7 HE-SIG-A

26.3.10.7.1 General

The HE-SIG-A field carries information required to interpret HE PPDUs.(#1846)

26.3.10.7.2 Content

The HE-SIG-A field for an HE SU PPDU or an HE extended range SU PPDU contains the fields listed in Table 26-15 (HE-SIG-A field of an HE SU PPDU and HE extended range SU PPDU(#Ed)).

Table 26-15—HE-SIG-A field of an HE SU PPDU and HE extended range SU PPDU(#Ed)

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description

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Table 26-15—HE-SIG-A field of an HE SU PPDU and HE extended range SU PPDU(#Ed)

HE-SIG-A1	B0	Format	1	Differentiate an HE SU PPDU from an HE trigger-based PPDU:(#1685) Set to 0 for HE trigger-based PPDU Set to 1 for HE SU PPDU This field is reserved and set to 1 for an HE extended range SU PPDU.(#1196)
	B1	Beam Change	1	Set to 1 indicates that the pre-HE-STF portion of the SU PPDU is spatially mapped differently from HE-LTF1. Set to 0 indicates that the pre-HE-STF portion of the SU PPDU is spatially mapped the same way as HE-LTF1 on each tone.
	B2	UL/DL	1	Indicates whether the PPDU is sent UL or DL: Set to 0 for DL Set to 1 for UL(#2002) This field indicates DL for TDLS. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.
	B3-B6	MCS	4	For an HE SU PPDU: Set to *n* for MCS*n*, where *n* = 0, 1, 2, …., 11 Values 12-15 are reserved For HE extended range SU PPDU with Bandwidth field set to 0 (242-tone RU): Set to *n* for MCS*n*, where *n* = 0, 1, 2 Values 3-15 are reserved For HE extended range SU PPDU with Bandwidth field set to 1 (right 106-tone RU in P20): Set to 0 for MCS 0 Values 1-15 are reserved
	B7	DCM	1	Indicates whether or not DCM is applied to the Data field for the MCS indicated. Set to 1 to indicate that DCM is applied to the Data field Set to 0 to indicate that DCM is not applied to the Data field. DCM is only applied for MCS0, MCS1, MCS3 and MCS4. DCM is only applied for 1 and 2 spatial streams. DCM is not applied when STBC is used.(#2007)
	B8-B13	BSS Color	6	The BSS Color field is an identifier of the BSS
	B14	Reserved	1	Reserved and set to 1(PHY Motion #162)
	B15-B18	Spatial Reuse	4	"SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD. Other details are TBD. Notes: this part needs further development.(#2169)

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Table 26-15—HE-SIG-A field of an HE SU PPDU and HE extended range SU PPDU(#Ed)

	B19-B20	Bandwidth	2	For an HE SU PPDU: Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz(#Ed) For an HE extended range SU PPDU: Set to 0 for 242-tone RU Set to 1 for right 106-tone RU within the primary 20 MHz
	B21-B22	GI+LTF Size(#1420)	3	Indicates the GI duration(#1420) and HE-LTF size. Set to 0 to indicate a 1x HE-LTF and 0.8 µs GI Set to 1 to indicate a 2x HE-LTF and 0.8 µs GI Set to 2 to indicate a 2x HE-LTF and 1.6 µs GI Set to 3 to indicate a 4x HE-LTF and 3.2 µs GI(#2005)
	B23-B25	Nsts	3	Indicates the number of space time streams.(#1457) For an HE SU PPDU: Set to the number of space time streams minus 1 For an HE extended range SU PPDU: Set to 0 for 1 space time stream Value 1 is TBD Values 2-7 are reserved
HE-SIG-A2	B0-B6	TXOP Duration	7	Set to 127 to indicate no duration information. Set to value other than 127 to indicate duration information for NAV setting and protection of the TXOP. NOTE—The encoding of TXOP Duration field is the same as the TXOP_DURATION parameter(#Ed) in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).(#783)
	B7	Coding	1	Indicates whether BCC or LDPC is used: Set to 0 to indicate BCC Set to 1 to indicate LDPC(#1197)
	B8	LDPC Extra Symbol	1	Indicates the presence of the extra OFDM symbol for LDPC.(#1197) Set to 1 if an extra OFDM symbol for LDPC is present Set to 0 if an extra OFDM symbol for LDPC is present Reserved and set to 1 when the Coding field is 0.
	B9	STBC	1	Set to 1 if space time block coding is used Set to 0 otherwise
	B10	TxBF	1	Set to 1 if a Beamforming steering matrix is applied to the waveform in an SU transmission Set to 0 otherwise
	B11-B12	A-factor	2	Indicate the "a-factor" value as defined in Table 26-37 (a-factor subfield encoding).(#2534)
	B13	PE Disambiguity	1	Indicate PE Disambiguity as defined in 26.3.12 (Packet extension(#1781)).(#2534)

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Table 26-15—HE-SIG-A field of an HE SU PPDU and HE extended range SU PPDU(#Ed)

	B14	Reserved	1	Reserved and set to 1
	B15	Doppler	1	Set to 0 if Doppler mode is not used Set to 1 if Doppler mode is used(#2167)
	B16-B19	CRC	4	CRC for bits 0-41 of the HE-SIG-A field (see 26.3.10.7.3 (CRC computation)). The first bit to be transmitted is bit *c7* as explained in 26.3.10.7.3 (CRC computation)).(#2535)
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.				

(#475)The HE-SIG-A field of an HE MU PPDU contains the fields listed in Table 26-16 (HE-SIG-A field of an HE MU PPDU(#Ed)).

Table 26-16—HE-SIG-A field of an HE MU PPDU(#Ed)

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	UL/DL	1	Indicates whether the PPDU is sent UL or DL: Set to 0 for DL Set to 1 for UL(#2002) This field indicates DL for TDLS. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.
	B1-B3	SIGB MCS	3	Indicates the MCS of the HE-SIG-B field: Set to 0 for MCS 0 Set to 1 for MCS 1 Set to 2 for MCS 2 Set to 3 for MCS 3 Set to 4 for MCS 4 Set to 5 for MCS 5(#1616) The values 6 and 7 are reserved(#847)
	B4	SIGB DCM	1	Set to 1 indicates that the HE-SIG-B is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the HE-SIB-B is not modulated with dual sub-carrier modulation for the MCS. DCM is only applicable to MCS0, MCS1, MCS3, and MCS4.
	B5-B10	BSS Color	6	The BSS Color field is an identifier of the BSS

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Table 26-16—HE-SIG-A field of an HE MU PPDU(#Ed) *(continued)*

	B11-B14	Spatial Reuse	4	"SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD. Other details are TBD. Notes: this part needs further development.(#2169)
	B15-B17	Bandwidth	3(#846)	Set to 0 for full 20 MHz Set to 1 for full 40 MHz Set to 2 for full 80 MHz Set to 3 for full 160 MHz and 80+80 MHz(#Ed) Set to 4 for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured Set to 5 for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz sub-channels in secondary 40 MHz is punctured Set to 6 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured Set to 7 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present.(PHY Motion #161)
	B18-B21	Number Of HE-SIG-B Symbols Or MU-MIMO Users	4	If the SIGB Compression field is 0, indicates the number of OFDM symbols in the HE-SIG-B field minus 1.(#821) If the SIGB Compression field is 1, indicates the number of MU-MIMO users minus 1.(#296)
	B22	SIGB Compression	1	Set to 1 for full BW MU-MIMO. Set to 0 otherwise.
	B23-B24	GI+LTF Size(#1420)	3	Indicates the GI duration(#1420) and HE-LTF size. Set to 0 to indicate a 1x HE-LTF and 0.8 μs GI Set to 1 to indicate a 2x HE-LTF and 0.8 μs GI Set to 2 to indicate a 2x HE-LTF and 1.6 μs GI Set to 3 to indicate a 4x HE-LTF and 3.2 μs GI(#2005)
	B25	Doppler	1	Set to 0 if Doppler mode is not used Set to 1 if Doppler mode is used(#2167)
HE-SIG-A2	B0-B6	TXOP Duration	7	Set to 127 to indicate no duration information. Set to value other than 127 to indicate duration information for NAV setting and protection of the TXOP. NOTE—The encoding of TXOP Duration field is the same as the TXOP_DURATION parameter(#Ed) in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).(#783)
	B7	Reserved	1	Reserved and set to 1

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Table 26-16—HE-SIG-A field of an HE MU PPDU(#Ed) *(continued)*

B8-B10	Number of HE-LTF Symbols	3	Indicates the number of HE-LTF symbols: Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols Other values are reserved.(#2127)
B11	LPDC Extra Symbol	1	Indication of the presence of the extra OFDM symbol for LDPC.
B12	STBC	1	In an HE MU PPDU where each RU includes no more than 1 user, set to 1 to indicate all RUs are STBC encoded in the payload, set to 0 to indicate all RUs are not STBC encoded in the payload. STBC is not applied in MU-MIMO RUs. STBC doesn't apply to HE-SIG-B.(#540)
B13-B14	A-factor	2	Indicate the "a-factor" value as defined in Table 26-37 (a-factor subfield encoding).(#2534)
B15	PE Disambi-guity	1	Indicate PE Disambiguity as defined in 26.3.12 (Packet extension(#1781)).(#2534)
B16-B19	CRC	4	CRC for bits 0-41 of the HE-SIG-A field (see 26.3.10.7.3 (CRC computation)). The first bit to be transmitted is bit *c7* as explained in 26.3.10.7.3 (CRC computation)).(#2535)
B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

When the Bandwidth field is set to 5 or 7, the HE-SIG-B field may indicate which 20 MHz sub-channel(s) in the preamble of secondary 40 MHz channel are punctured by its RU allocation signaling; when the Bandwidth field is set to 6 or 7, the HE-SIG-B field may indicate which 20 MHz sub-channel(s) in the preamble of secondary 80 MHz channel are punctured by its RU allocation signaling. See 26.3.10.8 (HE-SIG-B) for the RU allocation signaling.

It is optional for an HE STA to receive a preamble-punctured HE MU PPDU with the Bandwidth field in HE-SIG-A setting to a values 4 to 7. Whether or not an HE STA is capable of receiving preamble-punctured HE MU PPDU with the Bandwidth field of HE-SIG-A field setting to 4, 5, 6, 7 are indicated by the Preamble Puncturing Receive Capable subfield in the HE Capabilities field (see 9.4.2.213 (HE Capabilities element)).

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The HE-SIG-A field for an HE trigger-based PPDU contains the fields listed in Table 26-17 (HE-SIG-A field of an HE trigger-based PPDU(#Ed)).

Table 26-17—HE-SIG-A field of an HE trigger-based PPDU(#Ed)

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	Format	1	Set to 0 for an HE SU PPDU Set to 1 for an HE trigger-based PPDU
	B1-B6	BSS Color	6	The BSS Color field is an identifier of the BSS
	B7-B10	Spatial Reuse 1(SR Motion #11)	4	If the Bandwidth field indicates 20 MHz, 40 MHz, or 80 MHz: Spatial Reuse field for the first 20 MHz subband (see NOTE 1) If the Bandwidth field indicates 160/80+80 MHz: Spatial Reuse field for first 40 MHz subband of the 160 MHz operating band. (see NOTE 1) "SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD.
	B11-B14	Spatial Reuse 2	4	If the Bandwidth field indicates 20 MHz, 40 MHz, or 80 MHz: Spatial Reuse field for the second 20 MHz subband (see NOTE 1) When operating 20 MHz, this field is set to same value as Spatial Reuse 1 field. When operating 40 MHz in 2.4 GHz band, this field is set to same value as Spatial Reuse 1 field If the Bandwidth field indicates 160/80+80 MHz: Spatial Reuse field for second 40 MHz subband of the 160 MHz operating band. (see NOTE 1) "SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD.
	B15-B18	Spatial Reuse 3	4	If the Bandwidth field indicates 20 MHz, 40 MHz or 80 MHz: Spatial Reuse field for the third 20 MHz subband (see NOTE 1) When operating in 20 MHz or 40 MHz, this field is set to same value as Spatial Reuse 1 field. If the Bandwidth field indicates 160/80+80 MHz: Spatial Reuse field for third 40 MHz subband of the 160 MHz operating band. (see NOTE 1) When operating in 80+80 MHz, this field is set to same value as Spatial Reuse 1 field. "SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD.

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Table 26-17—HE-SIG-A field of an HE trigger-based PPDU(#Ed) *(continued)*

	B19-B22	Spatial Reuse 4	4	If the Bandwidth field indicates 20 MHz, 40 MHz or 80 MHz: Spatial Reuse field for the fourth 20 MHz subband (see NOTE 1) When operating in 20 MHz, this field is set to same value as Spatial Reuse 1 field. When operating in 40 MHz, this field is set to same value as Spatial Reuse 2 field. If the Bandwidth field indicates 160/80+80 MHz: Spatial Reuse field for fourth 40 MHz subband of the 160 MHz operating band. (see NOTE 1) When operating in 80+80 MHz, this field is set to same value as Spatial Reuse 2 field "SR_allowed" signaling indicates whether SR operation is allowed or not. Set to 0 to indicate SR is disallowed. The conditions to disallow SR are TBD.
	B23	Reserved	1	Reserved and set to value indicated in the Trigger frame
	B24-B25	Bandwidth	2	TBD
HE-SIG-A2	B0-B6	TXOP Duration	7	Set to 127 to indicate no duration information. Set to value other than 127 to indicate duration information for NAV setting and protection of the TXOP. NOTE—The encoding of TXOP Duration field is the same as the TXOP_DURATION parameter(#Ed) in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).(#783)
	B7-B15	Reserved	9	Reserved and set to value indicated in the Trigger frame
	B16-B19	CRC	4	CRC of bits 0-41 of the HE-SIG-A field. See 26.3.10.7.3 (CRC computation). The first bit to be transmitted is bit C3 as explained in 26.3.10.7.3 (CRC computation)).(#2535)
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

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Table 26-17—HE-SIG-A field of an HE trigger-based PPDU(#Ed) *(continued)*

NOTE 1—The four Spatial Reuse fields, 1, 2, 3, and 4, are arranged in increasing order of frequency and correspond to:

— For 20 MHz one Spatial Reuse field corresponding to the entire 20 MHz (other 3 fields indicate identical values)

— For 40 MHz two Spatial Reuse fields for each 20 MHz sub-band (other 2 fields indicate identical values)

— For 80 MHz four Spatial Reuse fields for each 20 MHz sub-band

- For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 20 MHz sub-band is also applicable to the 242-tone RU which is most closely aligned in frequency (in the tone-plan of that BW) with the aforementioned 20 MHz sub-band. The correspondence from an Spatial Reuse field to a 242-tone RU also holds for any RU within the 242-tone RU. The above also implies that a 20 MHz OBSS STA uses the Spatial Reuse field corresponding to its 20 MHz channel, a 40 MHz OBSS STA located on the lower frequency half of the 80 MHz BSS uses Spatial Reuse 1 field, Spatial Reuse 2 field values and a 40 MHz OBSS STA located on the upper frequency half of the 80 MHz BSS uses Spatial Reuse 3 field , Spatial Reuse 4 field values

— For 160 MHz and 80+80 MHz four Spatial Reuse fields for each 40 MHz sub-band

- For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 40 MHz sub-band is also applicable to the 484-tone RU which is most closely aligned in frequency (in the tone-plan of that BW) with the aforementioned 40 MHz sub-band. The correspondence from an Spatial Reuse field to a 484-tone RU also holds for any RU within the 484-tone RU.

NOTE 2—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

26.3.10.7.3 CRC computation

The CRC computation defined in this subclause applies to HE-SIG-A, the Common field of HE-SIG-B and the User Specific field of HE-SIG-B.

The CRC is calculated over(#2015) bits 0 to L of the HE-SIG (L = 41 for HE-SIG-A, or L = x for each HE-SIG-B common block fields, or L = x for HE-SIG-B user specific fields). The value of the CRC field shall be the 1s complement of

$$crc(D) = (M(D) + I(D))D^{8} mod\ G(D)$$

where

$$M(D) = \sum_{i=0}^{L} m_{L-i} D^{i}$$

where

$$I(D) = \sum_{i=L-7}^{L} D^{i}$$

$G(D)$ is defined in Equation (19-18)(#2018)

The CRC field is transmitted from *c4* to *c7* with *c7* first.(#2286)

Figure 19-8 (HT-SIG CRC calculation) shows the operation of the CRC, where the serial input are from m_L to m_0, and the output is stopped at *c4*.

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26.3.10.7.4 Encoding and modulation

For an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU, the HE-SIG-A field is composed of two parts, HE-SIG-A1 and HE-SIG-A2, each containing 26 data bits. HE-SIG-A1 is transmitted before HE-SIG-A2. The HE-SIG-A symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 17.3.5.6 (Convolutional encoder), 26.3.11.7 (BCC interleavers)(#2183), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers)(#2771), respectively. The constellation mappings of HE-SIG-A in HE SU PPDU, HE MU PPDU and HE trigger-based PPDU are shown in Figure 26-19 (Data tone constellation of HE-SIG-A symbols)(#2772). The first and second half of the stream of 104 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 52 complex numbers, where respectively, the first 52 complex numbers form the first symbol of HE-SIG-A and the second 52 complex numbers form the second symbol of HE-SIG-A. If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field of an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU shall be as specified in Equation (26-18).(#2287)(#525)

$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}}(D_{k,n,20} + p_{n+2} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{LegacyPreamble}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (26\text{-}18)$$

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k,n,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^{r}(k),n}, \text{otherwise} \end{cases}$$

$$M_{20}^{r}(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 27, -20 \le k \le -8 \\ k + 26, -6 \le k \le -1 \\ k + 25, 1 \le k \le 6 \\ k + 24, 8 \le k \le 20 \\ k + 23, 22 \le k \le 28 \end{cases} \quad (\#525)$$

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)

$N_{\text{HE-SIG-A}}^{\text{Tone}}$ is defined in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#476)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 26.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the HE-SIG-A field shall be as given by Equation (26-19).

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$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW}=0}^{N_{20\text{MHz}}} \sum_{k=-N_{SR}}^{N_{SR}} \left(\begin{array}{l} (D_{k,n,i_{BW}}^{i_{Seg}} + p_{n+4} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{ Pre-HE}}(t - nT_{SYML} - T_{GI,\text{ LegacyPreamble}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (26\text{-}19)$$

(#2288)(#1050)(#525)where

$T_{CS,\text{ HE}}(m)$ represents the cyclic shift for space time stream m as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is defined in 26.3.9 (Mathematical description of signals)(#1094)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (26-58)

For an HE extended range SU PPDU, the HE-SIG-A field is composed of four parts, i.e. HE-SIG-A1, HE-SIG-A2, HE-SIG-A3 and HE-SIG-A4, each part containing 26 data bits. These four parts are transmitted sequentially from HE-SIG-A1 to HE-SIG-A4. HE-SIG-A1 and HE-SIG-A2 have the same data bits. HE-SIG-A3 and HE-SIG-A4 have same data bits. The data bits of HE-SIG-A1 and HE-SIG-A3 shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted. HE-SIG-A2 shall be BCC encoded at rate, R = 1/2, mapped to a QBPSK constellation without interleaving(#912) and have pilots inserted. The constellation mappings of the HE-SIG-A field in an HE extended range SU PPDU is shown in Figure 26-19 (Data tone constellation of HE-SIG-A symbols). The QBPSK constellation on HE-SIG-A2 is used to differentiate between an HE extended range SU PPDU and an HE MU PPDU when m = 1 in Equation (26-14), which indicates HE MU PPDU or HE extended range SU PPDU(#1687). HE-SIG-A4 shall be BCC encoded at rate, R = 1/2, mapped to a BPSK constellation without interleaving(#913) and have pilots inserted. BCC encoding, Data interleaving, constellation mapping and pilot insertion follow the steps described in 17.3.5.6 (Convolutional encoder), 26.3.11.7 (BCC interleavers)(#2183), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers)(#2774), respectively.

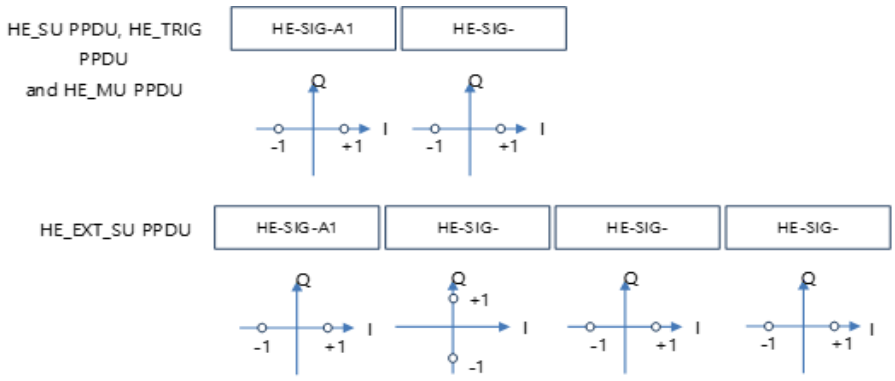


Figure 26-19—Data tone constellation of HE-SIG-A symbols

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field in an HE extended range SU PPDU, shall be as specified in Equation (26-20).

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$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{3} w_{T_{\text{SYML}}}(t - nT_{SYML}) \quad (26\text{-}20)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \left(\Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}} (R_n D_{k,\,n,\,20} + p_{n+2} P_k) \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{LegacyPreamble}} - T_{CS}^{i_{TX}})) \right)$$

(#2289)where

R_n is a phase rotation vector defined as [1, j, 1, 1](#2372)

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform for the HE-SIG-A field in an HE extended range SU PPDU, shall be as specified in Equation (26-21).(#2290)

$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{STS,\,total} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{3} w_{T_{\text{SYML}}}(t - nT_{SYML}) \quad (26\text{-}21)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}} \sum_{k=-28}^{28} \sum_{m=0}^{N_{STS,\,total}-1} \left(\left[Q_{4(k - K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k - K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} (R_n D_{k,\,n,\,20} + p_{n+2} P_k) \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{\text{GI, LegacyPreamble}} - T_{CS,\,HE}(m))) \right)$$

26.3.10.8 HE-SIG-B

26.3.10.8.1 Encoding and modulation

The HE-SIG-B field is separately encoded on each 20 MHz band. The encoding structure in one such 20 MHz band is shown in Figure 26-20 (HE-SIG-B field encoding structure in each 20 MHz). It consists of a Common Block field followed by a User Specific field which together are referred to as the HE-SIG-B content channel(#2020).

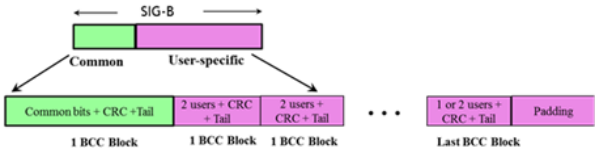


Figure 26-20—HE-SIG-B field encoding structure in each 20 MHz

The Common Block field of a HE-SIG-B content channel(#2020) contains information regarding the resource unit allocation such as the RU arrangement in frequency domain, the RUs allocated for MU-MIMO and the number of users in MU-MIMO allocations. The Common Block field is described in detail in 26.3.10.8.4 (HE-SIG-B common content).

The User Specific field of a HE-SIG-B content channel(#2020) consists of one or more(#2022) User Block fields. Each User Block field is made up of two user fields that contain(#2020) information for two STAs to decode their payloads. The last User Block field may contain information for one or two STAs depending on whether the number of users indicated by the RU allocation signaling is odd and depending on the signaling of the center 26-tone RU(#302). See 26.3.10.8.5 (HE-SIG-B per-user content) for a description of the contents of the User Block field.

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When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission), the Common Block field is not present and the content channel consists of only the User Specific field.(#2543)

26.3.10.8.2 Frequency domain mapping

The 20 MHz PPDU contains one content channel in which the Common Block field and User Specific field are carried as shown in Figure 26-21 (HE-SIG-B content channel for a 20 MHz PPDU). The Common Block field contains the RU allocation signaling for RUs that occur within the 242-tone RU boundary.



Figure 26-21—HE-SIG-B content channel for a 20 MHz PPDU

The 40 MHz PPDU contains two content channels, each occupying a 20 MHz segment. Each content channel contains a Common Block field followed by User Specific field as shown in Figure 26-22 (HE-SIG-B content channel for a 40 MHz PPDU). The content channels are ordered in increasing order of the absolute frequency i.e., the first content channel carries Common Block field and User Specific field corresponding to RUs whose subcarrier indices fall between [−244: −3] and the second content channel carries Common Block field and User Specific field corresponding to RUs whose subcarrier indices fall between [3:244].(#2544) If a 484-tone RU is signaled, both content channels will carry Common Block field and User Specific field corresponding to the 484-subcarrier RU.

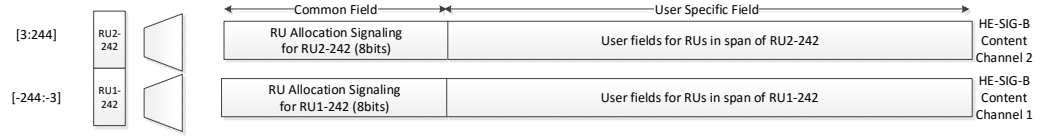


Figure 26-22—HE-SIG-B content channel for a 40 MHz PPDU

The 80 MHz PPDU contains two content channels each of which are duplicated once as shown in Figure 26-23 (Default mapping of the two HE-SIG-B channels and their duplication in an 80 MHz PPDU). The arrangement of the content channels are in increasing order of the absolute frequency where HE-SIG-B content channel 1 occupies the tones in the 20 MHz segment with the lowest subcarrier indices followed by the HE-SIG-B content channel 2 in the adjacent 20 MHz segment. This structure of the first content channel occupying the lower subcarrier index followed by the second content channel is repeated with content duplication in the remaining two 20 MHz segments, respectively. The first content channel appearing in the 20 MHz segments carries a Common Block field and User Specific field corresponding to RUs whose subcarriers indices overlap those segments.(#2544) The Common Block field of content channel 1 contains the following: an RU allocation signaling field for RUs with subcarrier indices in the range [−500:−259], followed by a second RU allocation signaling field for RUs with subcarrier indices between [17:258] and 1 bit to indicate the presence of the user field corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16].(#1692) The second content channel carries a Common Block field and User Specific field corresponding to RUs whose subcarrier indices fall in those segments. The Common Block field of content channel 2 contains the following: an RU allocation signaling field for RUs whose subcarrier indices fall in the range [−258:−17], followed by a second RU allocation signaling field for RUs with subcarrier indices between [259:500] and 1 bit to indicate presence of the user field corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16]. The same value for the bit signaling presence of the center 26-tone RU is carried in both content channels.(#1692) The user fields in the User Specific field that follow the common field are arranged in the same order as the RU allocation signaling. When assigned, the user field

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corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16] is carried as the last user field in the HE-SIG-B content channel 1.(#1692)(#2023) When RUs greater than 242 subcarriers are signaled in the RU allocation signaling in a portion of the bandwidth, the signaling is carried in both content channels placed in the order of the absolute subcarrier index.

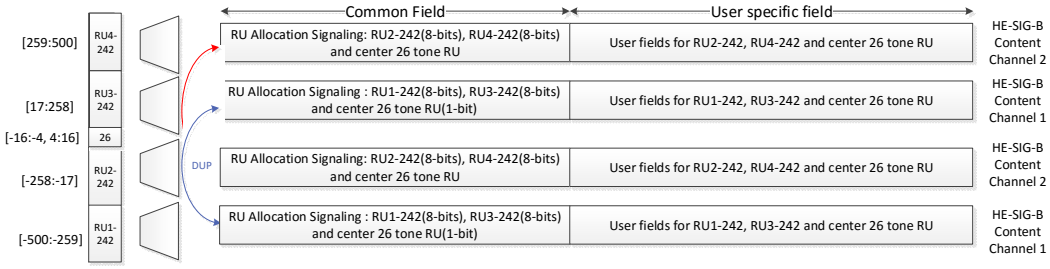


Figure 26-23—Default mapping of the two HE-SIG-B channels and their duplication in an 80 MHz PPDU

The 160 MHz PPDU contains two content channels each of which are duplicated four times as shown in Figure 26-24 (Default mapping of the two HE-SIG-B channels and their duplication in a 160 MHz PPDU). The arrangement of the content channels are in increasing order of the absolute frequency.(#2023) The first content channel occupies the tones in the 20 MHz segment with the lowest subcarrier indices and the second content channel in the adjacent 20 MHz segment. This pattern of arranging HE-SIG-B content channel 1 and HE-SIG-B content channel 2 is duplicated over the other segments. The HE-SIG-B content channel 1 and HE-SIG-B content channel 2 carries RU allocation signaling at 242-tone RU granularity that overlap with the 20 MHz segments in which the content channels are carried (including duplication). The signaling for the presence of the user field corresponding to a center 26-tone RU in the 80 MHz segment with the lower sub-carrier index is carried in HE-SIG-B content channel 1 as a 1-bit sub-field placed at the end of the Common field. Similarly, signaling for the center 26-tone RU in the 80 MHz segment with the higher subcarrier index is carried in HE-SIG-B content channel 2 as 1-bit sub-field placed at the end of the common field. When assigned, the user field corresponding to the center 26-tone RU in the 80 MHz segments is carried as the last user field in their respective content channels.(#1692) When RUs greater than 242

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subcarriers are signaled in the RU allocation signaling in a portion of the bandwidth, the signaling is carried in both content channels placed in the order of the absolute sub-carrier index.

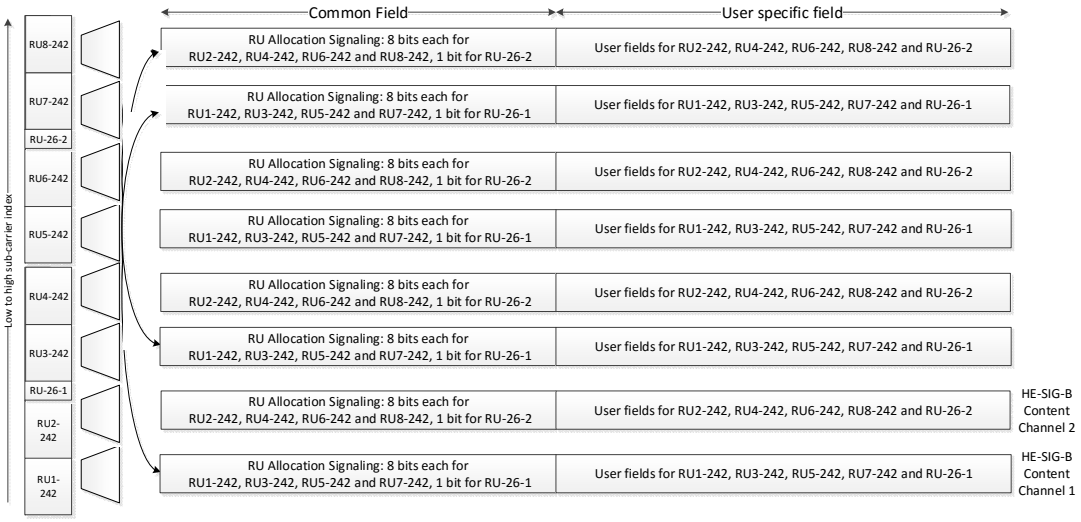


Figure 26-24—Default mapping of the two HE-SIG-B channels and their duplication in a 160 MHz PPDU

For an MU-MIMO allocation of RU size greater than 242 subcarriers(#2546), the User Block subfields are dynamically split between the two HE-SIG-B content channels (1/2) and the split is decided by the AP (on a per case basis). See 26.3.10.8.4 (HE-SIG-B common content) and 26.3.10.8.5 (HE-SIG-B per-user content)(#1006) for more details.

(PHY Motion #161)When preamble puncturing is present as indicated by values 4 to 7 in the Bandwidth field of HE-SIG-A field of an HE MU PPDU (see Table 26-16 (HE-SIG-A field of an HE MU PPDU(#Ed))), the frequency domain structure of HE-SIG-B is the same as defined for the full bandwidth, i.e. the HE-SIG-B field frequency domain structure is solely dependent on the total bandwidth.

26.3.10.8.3 Time domain encoding

In each 20 MHz band, the bits in the Common Block field shall have CRC and tail bits added and then be BCC encoded at rate R = ½. The CRC bits are computed as described in 26.3.10.7.3 (CRC computation).(#2025) Padding bits are not added after the common block.

In the User Specific field, in any 20 MHz band, the bits corresponding to two STAs (i.e. two User fields) are encoded together. Specifically, the STAs scheduled in the HE MU PPDU(#Ed) are split into groups of two. Each group of two User fields shall have CRC and tail bits added and then BCC encoded at rate R = ½ using the encoder described in 17.3.5.6 (Convolutional encoder)(#307). If the number of users in the content channel is odd, the User Block field corresponding to the last user, who is not grouped, is encoded after adding tail and CRC bits. After encoding, padding bits are added to each content channel to round up the number of symbols the content channel occupies to the nearest integer value. Further padding is added to each content channel until the number of OFDM symbols in the content channel equals the Number of HE-SIG-B symbols signaled by a 4-bit field in the HE-SIG-A field for an HE MU PPDU. Thus, padding ensures that the content channels in different 20 MHz bands end at the same OFDM symbol.(#306) (#2027)For both the Common Block and User Specific fields, when the code rate is not equal to ½, the convolutional encoder output bits for each field (including padding bits) are concatenated, then the concatenated bit streams are punctured as described in 17.3.5.6 (Convolutional encoder)(#307)(#2028).

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The coded bits are interleaved as in 26.3.11.7 (BCC interleavers). The interleaved bits are mapped to constellation points from the MCS specified in HE-SIG-A and have pilots inserted following the steps described in 17.3.5.8 (Subcarrier modulation mapping) and 17.3.5.9 (Pilot subcarriers)(#307), respectively.(#2183)

The guard interval(#915) used for HE-SIG-B shall be 0.8 μs.(#2030)

The number of OFDM symbols in the HE-SIG-B field, denoted by $N_{SYM,\text{HE-SIG-B}}$, shall be signaled by a 4-bit field in the HE-SIG-A field of a HE MU PPDU(#477) (see (#1304)26.3.10.7.2 (Content)(#2781)).

(#2031)For the c-th content channel (c = 1 or 2), denote the sample on the k-th data(#525) subcarrier of the n-th symbol by $d_{k,n,c}$. The time domain waveform for the HE-SIG-B follows Equation (26-22).

$$r_{\text{HE-SIG-B}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-B}}^{\text{Tone}}}} \sum_{n=0}^{N_{SYM,\text{HE-SIG\_B}}} w_{T_{\text{HE-SIG-B}}}(t - nT_{SYML}) \quad (26\text{-}22)$$

$$\sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-N_{SR}}^{N_{SR}} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}} \Gamma_{M_{20}^r(k)} (D_{k,n,i_{BW}}^{i_{Seg}} + p_{n+4} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}})) \Delta_{F,\,\text{Pre-HE}} (t - nT_{SYML} - T_{GI,\,\text{LegacyPreamble}} - T_{CS}^{i_{TX}})) \end{array} \right)$$

(#525)where

$\Gamma_{M_{20}^r(k)}$ is the phase rotation value for HE-SIG-B field PAPR reduction. When the HE-SIG-B field is modulated with MCS=0 and DCM=1, $\Gamma_{M_{20}^r(k)} = 1$. For all other modulation schemes of HE-SIG-B field,

$$\Gamma_{M_{20}^r(k)} = \begin{cases} 1 & 0 \le M_{20}^r(k) < 26 \\ (-1)^{M_{20}^r(k)} & 26 \le M_{20}^r(k) < 52 \end{cases} \quad (\#525)$$

$N_{20\text{MHz}}$ and $K_{\text{Shift}}(i)$ are defined in 21.3.8.2.4 (L-SIG definition)(#2782)

$$D_{k,n,i_{BW}}^{i_{Seg}} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^r(k),\,n,\,(i_{BW} mod\ 2)+1}, \text{otherwise} \end{cases}$$

$$M_{20}^r(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 27, -20 \le k \le -8 \\ k + 26, -6 \le k \le -1 \\ k + 25, 1 \le k \le 6 \\ k + 24, 8 \le k \le 20 \\ k + 23, 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)(#307)

$N_{SYM,\text{HE-SIG-B}}$ his the number of OFDM symbols in the HE-SIG-B field

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26.3.10.8.4 HE-SIG-B common content

The Common Block field in the HE-SIG-B field carries the RU allocation subfields. Depending on the PPDU bandwidth, the Common Block field can contain multiple RU Allocation subfields. The format of the Common Block field is defined in Table 26-18 (Common Block field(#2024)).

Table 26-18—Common Block field(#2024)

Subfield	Number of bits	Description
RU Allocation	*N* x 8	Indicates the RU arrangement in the frequency domain. It also indicates the number of user fields in each RU. For RUs of size greater than or equal to 106-tones that support MU-MIMO, it indicates the number of users multiplexed using MU-MIMO. *N* = 1 for a 20 MHz and a 40 MHz HE MU PPDU *N* = 2 for an 80 MHz HE MU PPDU *N* = 4 for a 160 MHz or 80+80 MHz HE MU PPDU
Center 26-tone RU	1	This field is present only for full bandwidth 80 MHz, 160 MHz and 80+80 MHz. For full bandwidth 80 MHz: Set to 1 to indicate that the center 26-tone RU is allocated in the Common Block fields of both HE-SIG-B content channels with the same value. Set to 0, otherwise. For full bandwidth 160 MHz or 80+80 MHz: Set to 1 to indicate that the center 26-tone RU is allocated for one individual 80 MHz in the Common Block fields of both HE-SIG-B content channels. Set to 0, otherwise.
CRC	4	See 26.3.10.7.3 (CRC computation)
Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.(#1010)		

An RU Allocation subfield in the Common Block field of HE-SIG-B consists of 8 bits that indicates the following for a 20 MHz PPDU BW:

— The RU arrangement in the frequency domain: indexes the size of the RUs and their placement in the frequency domain.

— Number of user fields in each RU in the HE-SIG-B content channel: the number of users multiplexed in the RUs indicated by the arrangement; for RUs of size greater than or equal to 106 tones that support MU-MIMO, it indicates the number of users multiplexed using MU-MIMO.

The mapping of the 8-bit RU Allocation subfield to the RU arrangement and the number of user fields per RU is defined in the Table 26-19 (RU allocation signaling: arrangement and number of MU-MIMO allocations(#2032)). In the table, the number of entries column refers to the number of 8-bit indices that refer to the same RU arrangement in the frequency domain but differ in the number of users fields per RU. The RU arrangement and the number of user fields per RU together indicate the number of user-fields in the User specific field of HE-SIG-B. Signaling for the center 26-tone RU in BW ≥ 80 MHz follows the RU

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Allocation subfields. For full BW 80 MHz, 1 bit is added to indicate if center 26-tone RU is allocated in the Common Block fields of both HE-SIG-B content channels with same value. For full BW 160 MHz, 1 bit is added to indicate if center 26-tone RU is allocated for one individual 80 MHz in common block fields of both HE-SIG-B content channels(#1001).

Table 26-19—RU allocation signaling: arrangement and number of MU-MIMO allocations(#2032)

8 bits indices (b7 b6 b5 b4 b3 b2 b1 b0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
00000000	26	26	26	26	26	26	26	26	26	1
00000001	26	26	26	26	26	26	26	52		1
00000010	26	26	26	26	26	52		26	26	1
00000011	26	26	26	26	26	52		52		1
00000100	26	26	52		26	26	26	26	26	1
00000101	26	26	52		26	26	26	52		1
00000110	26	26	52		26	52		26	26	1
00000111	26	26	52		26(#1060)	52		52		1
00001000	52		26	26	26	26	26	26	26	1
00001001	52		26	26	26	26	26	52		1
00001010	52		26	26	26	52		26	26	1
00001011	52		26	26	26	52		52		1
00001100	52		52		26	26	26	26	26	1
00001101	52		52		26	26	26	52		1
00001110	52		52		26	52		26	26	1
00001111	52		52		26(#1060)	52		52		1
$00010y_2y_1y_0$	52		52		-	106				8
$00011y_2y_1y_0$	106				-	52		52		8
$00100y_2y_1y_0$	26	26	26	26	26	106				8
$00101y_2y_1y_0$	26	26	52		26(#1060)	106				8

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Table 26-19—RU allocation signaling: arrangement and number of MU-MIMO allocations(#2032) *(continued)*

$00110y_2y_1y_0$	52	26	26	26	106				8
$00111y_2y_1y_0$	52	52		26	106				8
$01000y_2y_1y_0$	106			26	26	26	26	26	8
$01001y_2y_1y_0$	106			26	26	26	52		8
$01010y_2y_1y_0$	106			26	52		26	26	8
$01011y_2y_1y_0$	106			26	52		52		8
$0110y_1y_0z_1z_0$	106			-	106				16
01110000	52	52		-	52		52		1
01110001	242-tone RU empty								1
01110010	484-tone RU with zero HE-SIG-B User Specific field in the corresponding HE-SIG-B Content Channel								1
01110011	996-tone RU with zero HE-SIG-B User Specific field in the corresponding HE-SIG-B Content Channel								1
$011101x_1x_0$	Definition TBD								4
$011111x_1x_0$	Definition TBD								8
$10y_2y_1y_0z_2z_1z_0$	106			26	106				64
$11000y_2y_1y_0$	242								8
$11001y_2y_1y_0$	484								8
$11010y_2y_1y_0$	996								8
$11011y_2y_1y_0$	2×996								8
$111x_4x_3x_2x_1x_0$	Definition TBD								32

$y_2y_1y_0$ = 000-111 indicates number of STAs multiplexed in an RU. The binary vector $y_2y_1y_0$ is indexed as [y[3]y[2]y[1]] indicates $2^2 \times y[3] + 2^1 \times y[2] + y[1] + 1$ STAs multiplexed in the RU.

$z_2z_1z_0$ = 000-111 indicates number of STAs multiplexed in another RU. The binary vector $z_2z_1z_0$ is indexed as [z[3]z[2]z[1]] indicates $2^2 \times z[3] + 2^1 \times z[2] + z[1] + 1$ STAs multiplexed in the RU.

Similarly, y_1y_0 = 00-11 indicates number of STAs multiplexed in an RU. The binary vector y_1y_0 is indexed as [y[2]y[1]] indicates $2^1 \times y[2] + y[1] + 1$ STAs multiplexed in the RU.

Similarly, z_1z_0 = 00-11 indicates the number of STAs multiplexed in another RU. The binary vector z_1z_0 is indexed as [z[2]z[1]] indicates $2^1 \times z[2] + z[1] + 1$ STAs multiplexed in the RU.

The definition for entries with 'x' bits is TBD.

'-' means no STA in that RU.

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The number of RU Allocation subfields in the Common Block field depends on the PPDU bandwidth

— In the default mode, for a 20 MHz and a 40 MHz PPDU, each HE-SIG-B content channel contains one RU Allocation subfield followed by multiple user fields. The position of the user-field in the user-specific field together with the 8-bit RU Allocation subfield indicates the RU assignment to the user.

— In the default mode for an 80 MHz PPDU, each HE-SIG-B content channel contains two RU Allocation subfields for a total of 16 bits of RU allocation signaling, one each for the RUs in the two 20 MHz segments of the HE-SIG-B content channel. The user fields corresponding to the first RU allocation signaling field are followed by the user fields indicated by the second RU allocation signaling field in the user specific field.

— In the default mode for a 160 MHz PPDU, each HE-SIG-B content channel contains four RU Allocation subfields for a total of 32 bits of RU allocation signaling, one each for the RUs in the four 20 MHz segments of the HE-SIG-B content channel. The user fields for each of the 20 MHz segments in the content channel are arranged by the order in which their RU allocation signaling fields appear in the common field.(#2784)

26.3.10.8.5 HE-SIG-B per-user content

The user-specific field consists of multiple user fields. The user fields follow the common block field of HE-SIG-B. The RU allocation subfield in the Common block field and the position of the user field in the HE-SIG-B user specific field together identify the RU used to transmit a STA's data. Multiple RU allocations addressed to a single STA shall not be allowed in 802.11ax. Therefore, the signaling that enables STAs to decode its data is carried in only one user field.(#1010) An example for the mapping of the 8-bit RU allocation subfield and the position of the user field to an STA's data is illustrated in Figure 26-25 (Illustration for the mapping of the 8-bit RU allocation subfield and the position of the user-field to the STA's assignment). The RU arrangement signaling indicates an arrangement of 106-tone RU followed by five 26-tone RUs and that the 106-tone RU contains three user-fields, i.e., the 106-tone RU supports multiplexing of three users using MU-MIMO. The eight user fields in the HE-SIG-B user-specific field thus map to the 6 RUs, with the first three user fields indicating MU-MIMO allocations in the first 106-tone RU followed by user fields corresponding to the each of the five 26-tone RUs.

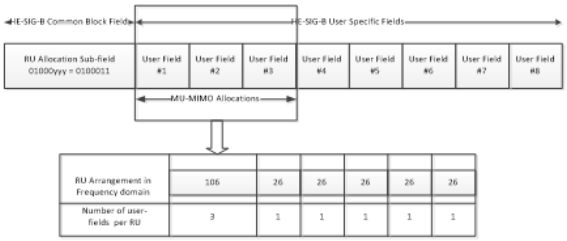


Figure 26-25—Illustration for the mapping of the 8-bit RU allocation subfield and the position of the user-field to the STA's assignment

The contents of the user field differ based on whether the field addresses a single-STA in an RU or a STA in an(#2817) MU-MIMO allocation in an RU. Irrespective of whether the allocation is for a STA in an(#196) SU or an MU-MIMO allocation, the size of the user field is the same.

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The HE-SIG-B user field for an(#916) SU allocation contain the subfields shown in Table 26-20 (Fields of the HE-SIG-B user field for an(#916) non-MU-MIMO(#1101) allocation(#2037)).

Table 26-20—Fields of the HE-SIG-B user field for an(#916) non-MU-MIMO(#1101) allocation(#2037)

Bit	Field	Number of bits	Description
B0-B10	STA-ID	11	The STA-ID refers to the AID described in 9.4.1.8 (AID field). The 11 LSBs of the AID field are used to address the STAs in this field.(#1002) For RUs that carry a broadcast allocation: — For single BSS AP, the STAID for broadcast will be 0 — For Multiple BSS AP, the STAID for broadcast to a specific BSS will follow the group addressed AID assignment in the TIM according to the existing Multi-BSSID TIM operation — For multiple BSS AP, the STAID for broadcast to all BSS of the AP is set to 2047(#2681) — STAID value 2046 is used to indicate that the RU carries no data — When a STA transmits on the uplink using the HE MU PPDU format, the STA-ID field is populated by the AID of the transmitter assigned by the AP
B11-B13	NSTS	3	Number of spatial streams. Set to the number of space time streams minus 1.(#Ed)
B14	Tx Beam-forming	1	Use of transmit beamforming. Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise.
B15-B18	MCS	4	Modulation and coding scheme Set to *n* for MCS*n*, where *n* = 0, 1 ,2 …., 11 Values 12 to 15 are reserved

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Table 26-20—Fields of the HE-SIG-B user field for an(#916) non-MU-MIMO(#1101) allocation(#2037) *(continued)*

B19	DCM	1	Indicates whether or not dual carrier modulation is used. Set to 1 to indicate that the payload of the HE MU PPDU is modulated with dual carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual carrier modulation for the MCS.
B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.(#1010)			

The HE-SIG-B user field for an STA in MU-MIMO allocation contain the subfields shown in Table 26-21 (Fields of the HE-SIG-B user field for an(#2817) MU-MIMO allocation(#2037)).

Table 26-21—Fields of the HE-SIG-B user field for an(#2817) MU-MIMO allocation(#2037)

Bit	Field	Number of bits	Description
B0-B10	STA-ID	11	The STA-ID refers to the AID described in 9.4.1.8 (AID field). The 11 LSBs of the AID field are used to address STAs in this field.(#1003)
B11-B14	Spatial Configuration	4	Indication for the number of spatial streams for a STA in an(#2817) MU-MIMO allocation. See Table 26-22 (Spatial Configuration subfield encoding).
B15-B18	MCS	4	Modulation and coding scheme. Set to n for MCSn, where n = 0, 1, 2,…..11 Values 12 to 15 are reserved
B19	DCM	1	Indicates whether or not dual carrier modulation is used. Set to 1 to indicate that the payload of the HE MU PPDU is modulated with dual carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual carrier modulation for the MCS.
B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.(#1010)			

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A user field for an MU-MIMO allocation includes a Spatial Configuration subfield consisting of 4 bits that indicates the number of spatial streams for each STA and the total number of spatial streams in the MU-MIMO allocation. The subfield shown in Table 26-22 (Spatial Configuration subfield encoding) is constructed by using the entries corresponding to the value of number of users (N_{user}) multiplexed using MU-MIMO in an RU. When MU-MIMO is used in an RU of size less than or equal to 242 subcarriers(#310), the number of users (N_{user}) in an MU-MIMO allocation is equal to the number of user fields per RU signaled for the RU in the RU allocation subfield of an HE-SIG-B Common block field. When MU-MIMO is used in RUs of size greater than 242 subcarriers(#310), the number of users (N_{user}) in an MU-MIMO allocation is computed as the sum of the number of user-fields per RU indicated for the RU by the 8-bit RU allocation subfield in each HE-SIG-B content channel. For a given value of N_{user}(#2786), the four bits of the spatial configuration subfield are used as follows: A STA with a STA-ID that matches the 11-bit ID signaled in the user field for an MU-MIMO allocation derives the number of spatial streams allocated to it using the row corresponding to the signaled 4-bit spatial configuration subfield and the column corresponding to the position of the user field in the user-specific field. The starting stream index for the STA is computed by summing the Nsts in the columns prior to the column indicated by the STA's user-field position. In the case of load balancing for RUs of size greater than 242 subcarriers(#310) where user fields corresponding to the same MU-MIMO allocations are split into two HE-SIG-B content channels, the user-field positions are logically continuous with the first user field corresponding to the same RU(#310) in the second HE-SIG-B content channel updating its position (and therefore, column index) from that of the last user field in the first HE-SIG-B content channel.

Table 26-22—Spatial Configuration subfield encoding

N_{user}	B0...B3	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of entries
2	0000-0011	1-4	1							2-5	10
	0100-0110	2-4	2							4-6	
	0111-1000	3-4	3							6-7	
	1001	4	4							8	
3	0000-0011	1-4	1	1						3-6	13
	0100-0110	2-4	2	1						5-7	
	0111-1000	3-4	3	1						7-8	
	1001-1011	2-4	2	2						6-8	
	1100	3	3	2						8	
4	0000-0011	1-4	1	1	1					4-7	11
	0100-0110	2-4	2	1	1					6-8	
	0111	3	3	1	1					8	
	1000-1001	2-3	2	2	1					7-8	
	1010	2	2	2	2					8	

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Table 26-22—Spatial Configuration subfield encoding *(continued)*

5	0000-0011	1-4	1	1	1	1				5-8	6
	0100-0101	2-3	2	1	1	1				7-8	
6	0000-0010	1-3	1	1	1	1	1			6-8	4
	0011	2	2	1	1	1	1			8	
7	0000-0001	1-2	1	1	1	1	1	1		7-8	2
8	0000	1	1	1	1	1	1	1	1	8	1

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission), the number of STAs in the MU-MIMO group is indicated in the 'SIGB Number of Symbols/Number of MU-MIMO users field' in the HE-SIG-A field. For bandwidths larger than 20 MHz, the User block fields are split equitably between two HE-SIG-B content channels, i.e., for a k user MU-MIMO PPDU, 1, …, $\lceil k/2 \rceil$ User block fields are carried in HE-SIG-B content channel 1 and $\lceil k/2 \rceil + 1$, …, k User block fields in HE-SIG-B content channel 2.(#2543)

The total number of spatial streams (total N_{STS}) is computed by summing all columns for the row signaled by the spatial configuration subfield and is indicated in Table 26-22 (Spatial Configuration subfield encoding) under the column Total Nsts(#311).

26.3.10.9 HE-STF

The main purpose of the HE-STF field is to improve automatic gain control estimation in a MIMO transmission. The duration of the HE-STF field for HE PPDUs except HE trigger-based PPDUs is $T_{\text{HE-STF-NT}}$(#312) (periodicity of 0.8 μs with 5 periods) and the duration of the HE-STF field for an HE trigger-based PPDU is $T_{\text{HE-STF-T}}$(#312) (periodicity of 1.6 μs with 5 periods). The tone indices for HE-STF field for HE PPDUs except HE trigger-based PPDUs is defined in Equation (26-23).

$$i_{STF} \bmod 16 = 0, \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR}$$
$$i_{STF} : \text{HE-STF tone index} \qquad (26\text{-}23)$$

The tone indices for HE-STF fields for an HE trigger-based PPDU are defined in Equation (26-24).

$$i_{STF} \bmod 8 = 0, \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR}$$
$$i_{STF} : \text{HE-STF tone index} \qquad (26\text{-}24)$$

For the HE-STF field, the M sequence is defined by Equation (26-25).

$$M = \{-1, -1, -1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, -1, 1\} \qquad (26\text{-}25)$$

The HE-STF field is constructed from the M sequence(s) multiplied by $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ and extra coefficients selected out of $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ at tone indices which are null but shall have the HE-STF coefficients after mapping M sequences to each 20 MHz subchannel.(#313)

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For a 20 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-26).

$$HES_{-112:16:112} = \{M\} \cdot (1+j)/\sqrt{2}$$
$$HES_{0} = 0 \quad (26\text{-}26)$$

where $HES_{a:b:c}$ means coefficients of the HE-STF on every b tone indices from a to c tone indices and coefficients on other tone indices are set to zero.

For a 40 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-27).

$$HES_{-240:16:240} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \quad (26\text{-}27)$$

For an 80 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-28).

$$HES_{-496:16:496} = \{M, 1, -M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (26\text{-}28)$$

For a 160 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-29).(#529)

$$HES_{-1008:16:1008} = \{M, 1, -M, 0, -M, 1, -M, 0, -M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (26\text{-}29)$$

For an 80+80 MHz transmission, the primary 80 MHz segment for HE PPDUs except HE trigger-based PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (26-28).

For an 80+80 MHz transmission, the frequency domain sequence of the secondary 80 MHz segment for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-30).(#529)

$$HES_{-496:16:496} = \{-M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (26\text{-}30)$$

For a 20 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-31).

$$HES_{-120:8:120} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \quad (26\text{-}31)$$

For a 40 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-32).

$$HES_{-248:8:248} = \{M, -1, -M, 0, M, -1, M\} \cdot (1+j)/\sqrt{2}$$
$$HES_{\pm 248} = 0 \quad (26\text{-}32)$$

For an 80 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-33).

$$HES_{-504:8:504} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2}$$
$$HES_{\pm 504} = 0 \quad (26\text{-}33)$$

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For a 160 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-34).(#530)

$$\begin{aligned} HES_{-1016:8:1016} = \{&M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M, 0 \\ &-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \\ HES_{\pm 8} = 0,\ HES_{\pm 1016} = 0 \end{aligned} \quad (26\text{-}34)$$

For an 80+80 MHz transmission, the primary 80 MHz segment for HE trigger-based PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (26-33).(#530)

For an 80+80 MHz transmission, the frequency domain sequence of the secondary 80 MHz segment for HE trigger-based PPDUs is given by Equation (26-35).(#530)

$$\begin{aligned} HES_{-504:8:504} &= \{-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \\ HES_{\pm 504} &= 0 \end{aligned} \quad (26\text{-}35)$$

For an OFDMA transmission, the coefficients in Equation (26-26) to Equation (26-33) are set to zero if those values are corresponding to tone indices for which no RUs are defined (see 26.3.7 (OFDMA and SU tone allocation))(#917).

The time domain representation of the signal for HE PPDUs except HE trigger-based PPDUs on frequency segment i_{Seg} of transmit chain i_{TX} shall be as specified in Equation (26-36).

$$r_{\text{HE-STF}}^{(i_{Seg} i_{TX})}(t) = w_{T_{\text{HE-STF-NT}}}(t) \cdot \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}} \sum_{k \in K} \sum_{u=0}^{N_{user,r}-1} \sum_{m=0}^{N_{STS,r,u}-1} \left(\eta_{\text{HE-STF},k} \left[Q_k^{(i_{Seg})} \right]_{i_{TX}, M_{r,u}+m} HES_k \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - T_{CS,HE}(M_{r,u}+m))) \right) \quad (26\text{-}36)$$

where

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

$\eta_{\text{HE-STF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-STF},k} = \begin{cases} \sqrt{2}, & \text{for an HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$ (#2045)(#526)

β_r is the per-RU power normalization factor and defined by

$$\beta_r = \left(\sqrt{\frac{|K_r|}{|K_r^{\text{HE-STF}}|}} \right) \Big/ \left(\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|} \right)$$ (#315)

$|K_r|$ is the cardinality of the set of subcarriers K_r

$K_r^{\text{HE-STF}}$ is the set of subcarriers that have non-zero values within K_r in the HE-STF field(#2046)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space time stream $M_{r,u}+m$ as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is defined in 26.3.9 (Mathematical description of signals)(#1094)

$w_{T_{\text{HE-STF-NT}}}$ is the windowing function for HE-STF field in the non-HE trigger-based PPDU

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The time domain representation of the signal for HE trigger-based PPDUs on frequency segment i_{Seg} of transmit chain i_{TX} shall be as specified in Equation (26-37).

$$r_{\text{HE-STF}}^{(i_{Seg}i_{TX})}(t) = \frac{1}{\sqrt{\left|K_r^{\text{HE-STF}}\right| N_{STS,\,r,\,total}}} w_{T_{\text{HE-STF-T}}}(t) \sum_{k \in K} \sum_{m=1}^{N_{STS,\,r,\,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX},\,(M_{r,\,u}+m)} HES_k \cdot \exp(j2\pi k \Delta_{F,\,\text{HE}}(t - T_{CS,\,HE}(M_{r,\,u}+m))) \right) \quad \text{(\#316)} \qquad (26\text{-}37)$$

where

$w_{T_{\text{HE-STF-T}}}$ is the windowing function for HE-STF field in the HE trigger-based PPDU

26.3.10.10 HE-LTF

The HE-LTF field(#918) provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams (spatial mapper inputs) used for the transmission of the PSDU(s) in the r-th RU. In an HE trigger-based PPDU, the transmitter of user-u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. A HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot tones of each HE-LTF symbol are multiplied by the entries of a matrix $R_{\text{HE-LTF}}$ defined in the following text. The multiplication of the pilot tones in the HE-LTF symbol by the $R_{\text{HE-LTF}}$ matrix instead of the $P_{\text{HE-LTF}}$ matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the HE-LTF. In an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU with a single RU (the RU having an MU-MIMO allocation or an SU allocation)(PHY Motion #159), the number of HE-LTF symbols, $N_{\text{HE-LTF}}$, is a function of the total number of space-time streams N_{STS} as shown in Table 26-6 (Frequently used parameters(#282))(#2792). In an HE trigger-based PPDU, $N_{\text{HE-LTF}}$(#922) is indicated in the Trigger frame that triggers the transmission of the PPDU. In an HE MU PPDU, $N_{\text{HE-LTF}}$(#922) is indicated in the HE-SIG-A field. In an HE MU PPDU with more than one RU and an HE trigger-based PPDU, $N_{\text{HE-LTF}}$(#922) may take any value among one, two, four, six or eight, which is greater than or equal to the maximum value of the function in Table 26-6 (Frequently used parameters(#282)) when it is calculated for each $N_{STS,r,total}$ separately.(PHY Motion #159)

An HE PPDU supports 3 HE-LTF modes, which are 1x HE-LTF, 2x HE-LTF and 4x HE-LTF. It is optional to support the 1x HE-LTF mode in an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU. It is mandatory to support transmission of 1x HE-LTF in an UL MU-MIMO PPDU over the full bandwidth, for a STA declaring support for UL MU-MIMO. The 1x HE-LTF mode is disallowed in an HE MU PPDU and in an HE trigger-based PPDU with more than one RUs, and is also disallowed in an HE MU PPDU with one RU whenever the RU has an MU-MIMO allocation.(PHY Motion #159) In an HE SU PPDU, HE MU PPDU and HE extended range SU PPDU, the combination of HE-LTF modes and GI duration is indicated in HE-SIG-A field. In an HE trigger-based PPDU, the combination of HE-LTF modes and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. The mandatory combinations of HE-LTF modes and GI duration are:

— 2x HE-LTF, $T_{GI1,Data}$(#2498)

— 2x HE-LTF, $T_{GI2,Data}$(#2496)

— 4x HE-LTF, $T_{GI4,Data}$(#2497)

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The optional combinations of HE-LTF mode and GI duration are:

— 1x HE-LTF, $T_{GI1,Data}$(#2499) in an(#2829) HE SU PPDU or HE extended SU PPDU

— 1x HE-LTF, $T_{GI1,Data}$(#2500) in a non-OFDMA, MU-MIMO HE MU PPDU

— 1x HE-LTF, $T_{GI2,Data}$(#2501) in a non-OFDMA, MU-MIMO HE trigger-based PPDU

The duration of each HE-LTF symbol is $T_{\text{HE-LTF}}$(#2875) is defined in Equation (26-38). In an HE SU PPDU, HE MU PPDU or HE extended range SU PPDU, the HE-LTF symbol duration is indicated in HE-SIG-A field. In an HE trigger-based PPDU, the HE-LTF symbol duration is indicated in the Trigger frame that triggers the transmission of the PPDU.

$$T_{\text{HE-LTF}} = \begin{cases} T_{\text{HE-LTF-1X}}, \text{ if 1x HE-LTF} \\ T_{\text{HE-LTF-2X}}, \text{ if 2x HE-LTF} \\ T_{\text{HE-LTF-4X}}, \text{ if 4x HE-LTF} \end{cases} \quad (26\text{-}38)$$

where $T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$, $T_{\text{HE-LTF-4X}}$ are defined in Table 26-3 (Timing-related constants).

In a 20 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-39).

$$\begin{aligned} HELTF_{-122,122} = \\ &\{0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, \\ &0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\ &1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\ &-1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, \\ &-1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\ &0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, \\ &0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, \\ &0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0\} \end{aligned} \quad (26\text{-}39)$$

In a 20 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-40).

$$\begin{aligned} HELTF_{-122,122} = \\ &\{-1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, \\ &0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, \\ &0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, \\ &0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\ &0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, 0, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, \\ &0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, \\ &0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, \\ &0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, \\ &0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1\} \end{aligned} \quad (26\text{-}40)$$

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In a 20 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-41).

$$HELTF_{-122,122} =$$
$$\{-1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1,$$
$$+1, -1, -1, -1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1,$$
$$+1, +1, -1, -1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1,$$
$$+1, -1, +1, -1, -1, -1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -$$
$$1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1,$$
$$-1, -1, -1, +1, -1, +1, +1, +1, 0, 0, 0, -1, +1, -1, +1, -1, +1, +1, -1, +1, +1, +1, -1, -1,$$
$$+1, -1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, -1, -1, -1, -1, +1,$$
$$+1, -1, -1, -1, -1, -1, -1, +1, -1, +1, -1, -1, -1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -$$
$$1, -1, -1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1,$$
$$+1, +1, -1, +1, -1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1,$$
$$+1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1\}$$

(26-41)

In a 40 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-42).

$$HELTF_{-244,244} =$$
$$\{+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0,$$
$$0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0,$$
$$0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1,$$
$$0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -$$
$$1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0,$$
$$-1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,$$
$$0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0,$$
$$0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, +1, 0,$$
$$0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1,$$
$$0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -$$
$$1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,$$
$$-1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0,$$
$$0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0,$$
$$0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1,$$
$$0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,$$
$$+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1\}$$

(26-42)

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In a 40 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-43).

$HELTF_{-244,244}$ =

{+1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1,
0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1,
0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1,
0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1,
0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1,
0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1,
0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1,
0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1,
0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, 0, 0, 0, 0, 0, 0, −1, 0, −1, 0, − (26-43)
1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
−1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0,
−1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0,
+1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1}

In a 40 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-44).

$HELTF_{-244,244}$ =

{+1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1,
+1, +1, +1, −1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, −1,
+1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1,
+1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, +1, +1, +1, −1, +1,
+1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, −1,
−1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1,
−1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1,
−1, +1, +1, +1, −1, −1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1,
+1, −1, −1, −1, +1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1,
+1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, +1, 0, 0, 0, 0, 0, −1, +1, +1, +1, +1, −1, +1, (26-44)
+1, −1, −1, +1, −1, +1, −1, +1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, +1,
+1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1,
−1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1,
+1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1,
+1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, −1,
+1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, −1, +1, −1, −1,
−1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1,
−1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1,
+1, −1, −1, −1, −1}

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In an 80 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-45).

$$
\begin{aligned}
HELTF_{-500,500} = \\
&\{-1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, - \\
&1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, \\
&0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, \\
&0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\
&1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, \\
&0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, \\
&0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, - \\
&1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, \\
&-1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, \\
&0, 0, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, \\
&0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, \\
&0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, \\
&0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, +1\}
\end{aligned}
\tag{26-45}
$$

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In an 80 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-46).

$HELTF_{-500,500}$ =

{+1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1,
0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1,
0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1,
0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1,
0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1,
0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1,
0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1,
0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1,
0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1,
0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1,
0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1,
0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1,
0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1,
0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1,
0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1,
0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1,
0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1,
0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, (26-46)
+1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
−1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0,
+1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0,
+1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0,
−1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0,
+1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0,
+1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0,
−1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0,
−1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0,
−1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0,
−1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0,
+1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1}

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In an 80 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-47).

$$
\begin{aligned}
HELTF_{-500,500} = \\
&\{+1, +1, -1, +1, -1, +1, -1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -\\
&1, +1, +1, +1, +1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1,\\
&-1, +1, +1, +1, -1, -1, -1, -1, -1, -1, +1, +1, +1, +1, +1, +1, -1, +1, +1, +1, -1, +1, +1,\\
&-1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1,\\
&-1, +1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, +1, +1, +1, +1, -1, -1,\\
&+1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1,\\
&-1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1,\\
&-1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1,\\
&+1, +1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1,\\
&-1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1,\\
&-1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1,\\
&+1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1,\\
&-1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, -1, +1, -1, -1,\\
&-1, -1, -1, -1, -1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, +1, +1, -1, -1, +1,\\
&-1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, +1,\\
&-1, -1, +1, -1, +1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1,\\
&+1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1,\\
&-1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1,\\
&-1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1,\\
&+1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1,\\
&+1, +1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1,\\
&-1, -1, -1, +1, -1, +1, -1, -1, -1, -1, +1, +1, +1, -1, -1, +1, 0, 0, 0, 0, 0, +1, -1, -1, -\\
&1, -1, -1, -1, +1, -1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1,\\
&-1, -1, +1, +1, -1, +1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1,\\
&+1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, -1, -1,\\
&-1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1,\\
&-1, -1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1,\\
&-1, +1, -1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1,\\
&-1, +1, -1, -1, +1, -1, +1, +1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1,\\
&+1, -1, -1, -1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1,\\
&-1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, -1, +1, +1, -1,\\
&-1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1,\\
&+1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1,\\
&+1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1,\\
&-1, -1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1,\\
&-1, -1, +1, +1, +1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1,\\
&-1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1,\\
&-1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1,\\
&-1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1, +1, -1, +1, -1, +1, -1, +1,\\
&-1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1, -1,\\
&-1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1,\\
&+1, +1, +1, -1, +1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1,\\
&+1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1,\\
&+1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1\}
\end{aligned}
\tag{26-47}
$$

In a 160 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-48).

$$HELTF_{-1012,\,1012} = \{1\text{x LTF}_{\text{80MHz\_primary}}, \text{zeros}(1, 23), 1\text{x LTF}_{\text{80MHz\_secondary}}\} \tag{26-48}$$

where

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$1x\ LTF_{80MHz\_primary} = \{L\text{-}LTF_{80MHz\_1x}, 0, R\text{-}LTF_{80MHz\_1x}\}$
$1x\ LTF_{80MHz\_secondary} = \{L\text{-}LTF_{80MHz\_1x}, 0, (-1)*R\text{-}LTF_{80MHz\_1x}\}$

In a 160 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-49).

$$HELTF_{-1012,1012} = \{2x\ LTF_{80MHz\_primary}, zeros(1, 23), 2x\ LTF_{80MHz\_secondary}\} \quad (26\text{-}49)$$

where

$2x\ LTF_{80MHz\_primary} =$
$\{\{1^{st}\ 242\text{-RU}\}, \{2^{nd}\ 242\text{-RU}\}, \{central\ 26\text{-RU}\}, \{3^{rd}\ 242\text{-RU}\}, \{4^{th}\ 242\text{-RU}\}\}$ (26-50)
$2x\ LTF_{80MHz\_secondary} =$
$\{\{1^{st}\ 242\text{-RU}\}, (-1)*\{2^{nd}\ 242\text{-RU}\}, \{central\ 26\text{-RU}\}, \{3^{rd}\ 242\text{-RU}\}, (-1)*\{4^{th}\ 242\text{-RU}\}\}$ (26-51)

In a 160 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-52).

$$HELTF_{-1012,1012} = \{4x\ LTF_{80MHz\_primary}, zeros(1, 23), 4x\ LTF_{80MHz\_secondary}\} \quad (26\text{-}52)$$

where

$$4x\ LTF_{80MHz\_primary} = \{L\text{-}LTF_{80MHz\_4x}, 0, R\text{-}LTF_{80MHz\_4x}\} \quad (26\text{-}53)$$

$$4x\ LTF_{80MHz\_secondary} = \{L\text{-}LTF_{80MHz\_4x}, 0, (-1)*R\text{-}LTF_{80MHz\_4x}\} \quad (26\text{-}54)$$

For a noncontiguous 80+80 MHz transmission, the 1x HE-LTF sequence is given by Equation (26-55).

$$HELTF_{80+80MHz} = \{1x\ LTF_{80MHz\_primary}, zeros(1, 23), 1x\ LTF_{80MHz\_secondary}\} \quad (26\text{-}55)$$

For a noncontiguous 80+80 MHz transmission, the 2x HE-LTF sequence is given by Equation (26-56).

$$HELTF_{80+80MHz} = \{2x\ LTF_{80MHz\_primary}, zeros(1, 23), 2x\ LTF_{80MHz\_secondary}\} \quad (26\text{-}56)$$

For a noncontiguous 80+80 MHz transmission, the 4x HE-LTF sequence is given by Equation (26-57).

$$HELTF_{80+80MHz} = \{4x\ LTF_{80MHz\_primary}, zeros(1, 23), 4x\ LTF_{80MHz\_secondary}\} \quad (26\text{-}57)$$

The generation of the time domain HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, HE trigger-based PPDU using single stream pilots is shown in Figure 26-26 (Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU,

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HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots) where $A^{k}_{\text{HE-LTF}}$ is given by Equation (26-58).

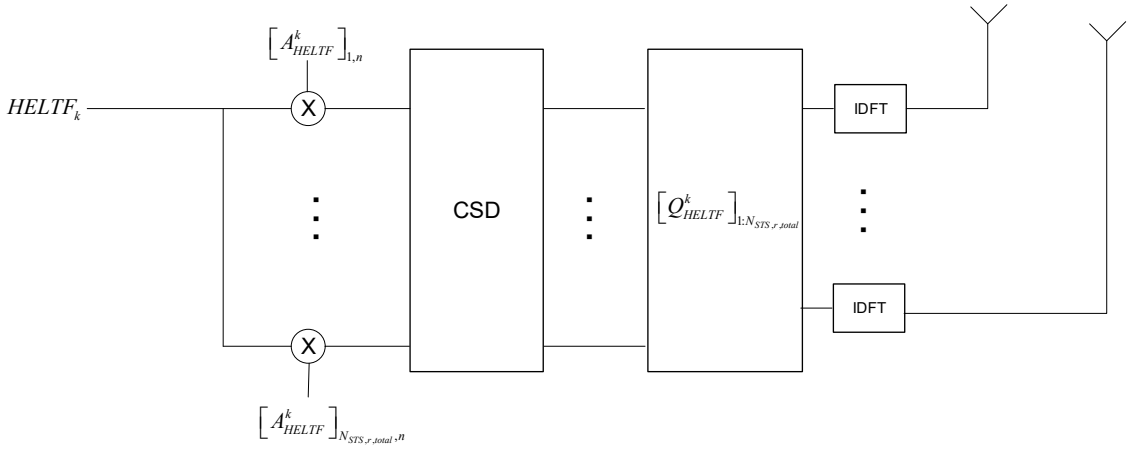


Figure 26-26—Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots

The generation of time domain symbol of 1x HE-LTF is equivalent to modulating every 4 tones in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first ¼ of the OFDM symbol in the time domain, as shown in Figure 26-27 (Generation of 1x HE-LTF symbols per frequency segment).

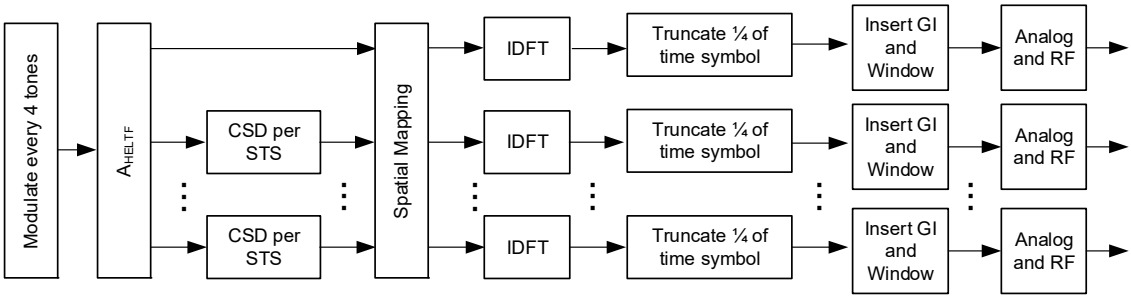


Figure 26-27—Generation of 1x HE-LTF symbols per frequency segment

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The generation of time domain symbol of 2x HE-LTF is equivalent to modulating every other tone in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first half of the OFDM symbol in time domain, as shown in Figure 26-28 (Generation of 2x HE-LTF symbols per frequency segment).

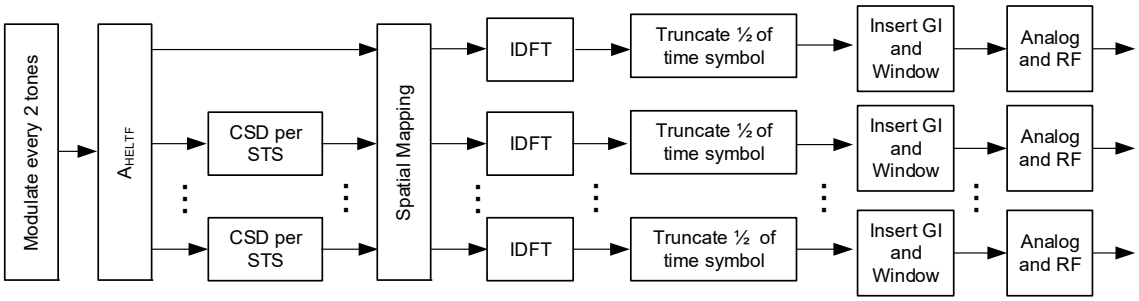


Figure 26-28—Generation of 2x HE-LTF symbols per frequency segment

$A^{k}_{\text{HE-LTF}}$ is given by Equation (26-58).

$$A^{k}_{\text{HE-LTF}} = \begin{cases} R_{\text{HE-LTF}}, \text{ if } k \in K_{\text{Pilot}} \\ P_{\text{HE-LTF}}, \text{ otherwise} \end{cases} \quad (26\text{-}58)$$

where

K_{Pilot} is the set of subcarrier indices for the pilot tones as defined in 26.3.7.3 (Pilot tones)(#2794).

$R_{\text{HE-LTF}}$ is a $N_{\text{HE-LTF}} \times N_{\text{HE-LTF}}$ matrix whose elements are defined in Equation (26-59)(#2877).

$$\left[R_{\text{HE-LTF}}\right]_{m,n} = \left[P_{\text{HE-LTF}}\right]_{1,n}, 1 \le m, n \le N_{\text{HE-LTF}} \quad (26\text{-}59)$$

$P_{\text{HE-LTF}}$ is defined in Equation (26-60).

$$P_{\text{HE-LTF}} = \begin{cases} P_{4\times 4}, N_{\text{HE-LTF}} \le 4 \\ P_{6\times 6}, N_{\text{HE-LTF}} = 6 \\ P_{8\times 8}, N_{\text{HE-LTF}} = 8 \end{cases} \quad (26\text{-}60)$$

where $P_{4\times 4}$ is defined in Equation (19-27), $P_{6\times 6}$ is defined in Equation (21-45), and $P_{8\times 8}$ is defined in Equation (22-46)(#2878).

In an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU and HE trigger-based PPDU using single stream pilots, the time domain representation of the waveform transmitted on frequency segment i_{Seg} of transmit chain i_{TX} shall be as described by Equation (26-61)(#2798).

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$$r_{\text{HE-LTF}}^{(i_{Seg} i_{TX})}(t) = \frac{\eta_{\text{HE-LTF-Mode}}}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{\text{HE-LTF}}-1} w_{T_{\text{HE-LTF}}}(t - nT_{\text{HE-LTF}}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \eta_{\text{HE-LTF},k} \quad (26\text{-}61)$$

$$\sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX}, (M_{r,u}+m)} \left[A_{\text{HE-LTF}}^k \right]_{(M_{r,u}+m),(n+1)} HELTF_k \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{\text{HE-LTF}} - T_{GI} - T_{CS,\text{HE}}(M_{r,u}+m)) \right)$$

(#1050)where

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

$\eta_{\text{HE-LTF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-LTF},k} = \begin{cases} \sqrt{2}, & \text{for an HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases} \quad (\#526)$$

$N_{\text{HE-LTF}}^{\text{Tone}}$ is defined in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#476)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space time stream $M_{r,u}+m$ as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$Q_k^{(i_{Seg})}$ is defined in 26.3.9 (Mathematical description of signals)(#1094)

$A_{\text{HE-LTF}}^k$ is defined in Equation (26-58)

K_r is the set of subcarrier indices for the tones in the r-th RU as defined in 26.3.9 (Mathematical description of signals)(#2144)

$\eta_{\text{HE-LTF-Mode}}$ is the power scaling factor defined by(#2144)(#526)

$$\eta_{\text{HE-LTF-Mode}} = \begin{cases} 2 & \text{for 1x HE-LTF} \\ \sqrt{2} & \text{for 2x HE-LTF} \\ 1 & \text{for 4x HE-LTF} \end{cases} \quad (\#526)$$

26.3.11 Data field

26.3.11.1 General

The number of OFDM symbols in the Data field is determined by the Length field in L-SIG (see Equation (26-14)(#1625)), the preamble duration and the setting of the GI+LTF Size(#1420) field in HE-SIG-A (see 26.3.10.7 (HE-SIG-A)). Data symbols in an HE PPDU shall use a DFT period of 12.8 µs and subcarrier spacing of 78.125 kHz. Data symbols in an HE PPDU shall support guard interval durations of 0.8 µs, 1.6 µs and 3.2 µs. HE PPDUs shall have single stream pilots in the Data field. In UL MU-MIMO transmissions, all streams use the same pilot sequence. The Data field in UL MU transmissions shall immediately follow the HE-LTF field(#1304).

When BCC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the tail bits, the post-FEC padding bits and the packet extension (bits for SU and bits for each user u in MU). When LDPC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the post-FEC padding bits and the packet extension. No tail bits are present when LDPC encoding is used.

The Data field of the HE PPDU contains data for one or more users.

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26.3.11.2 Pre-FEC encoding process

A two-step padding process is applied on all HE PPDUs. A pre-FEC padding with both MAC and PHY padding is applied before conducting FEC coding, and a post-FEC PHY padding is applied on the FEC encoded bits.

The pre-FEC padding may pad toward 4 possible boundaries in the last one (in the case of non STBC), or two (in the case of STBC) OFDM symbols of an(#2829) HE PPDU, the 4 possible boundaries partition(#1837) the FEC output bit stream of the last OFDM symbol(s) into 4 symbol segments. The 4 possible boundaries are represented by a parameter *a-factor*(#326).

Figure 26-29 (HE PPDU padding process in the last OFDM symbol (non STBC) when a = 1) illustrates these 4 possible symbol segments in the last OFDM symbol of a non STBC case, and the general padding process assuming the desired pre-FEC padding boundary, *a-factor*, is 1. In the case of STBC, the FEC output bits and post-FEC padding bits as shown in Figure 26-30 (HE PPDU padding process in the last OFDM symbol (STBC) when a = 1), are modulated into the last two OFDM symbols by STBC encoding, each with the same number of effective symbol segments, *a-factor*, being 1.

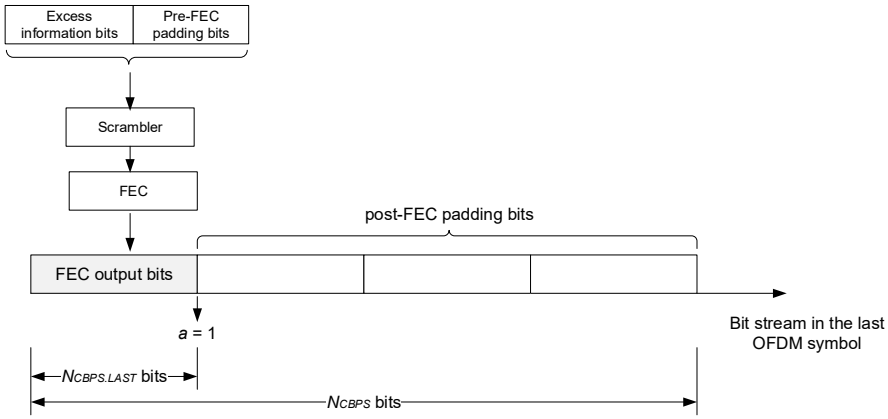


Figure 26-29—HE PPDU padding process in the last OFDM symbol (non STBC) when *a* = 1

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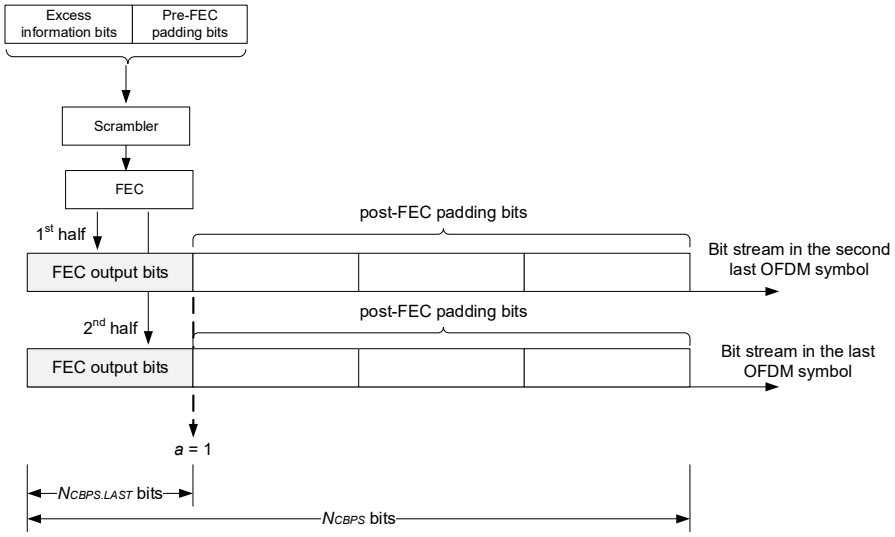


Figure 26-30—HE PPDU padding process in the last OFDM symbol (STBC) when *a* = 1

The pre-FEC padding process is described in this subclause, and the encoding and post-FEC padding process are described in 26.3.11.4 (Coding)(#1113). While this subclause describes the pre-FEC padding processing of an SU transmission, its extension to MU transmission is described in 25.3.10.3.4 (Encoding Process for HE MU PPDUs).

In an HE SU PPDU transmission, the transmitter first computes the number of excess bits in the last OFDM symbol(s). Specifically, for HE SU PPDU with BCC encoding, the number of excess bits is calculated based on Equation (26-62).

$$N_{Excess} = mod(8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}, m_{STBC} \cdot N_{DBPS}) \quad (26\text{-}62)$$

where

m_{STBC} is 2 when STBC is used, and 1 otherwise

APEP_LENGTH is the TXVECTOR parameter APEP_LENGTH

For an(#2829) HE SU PPDU with LDPC encoding, the number of excess bits is calculated based on Equation (26-63):

$$N_{Excess} = mod(8 \cdot \text{APEP\_LENGTH} + N_{service}, m_{STBC} \cdot N_{DBPS}) \quad (26\text{-}63)$$

Based(#2060) on N_{Excess}, compute the initial number of symbol segments in the last OFDM symbol(s), a-factor value or a_{init}, as shown in Equation (26-64).

$$a_{init} = \begin{cases} 4, & \text{if } N_{Excess} = 0 \\ \left\lceil \dfrac{N_{Excess}}{m_{STBC} \cdot N_{DBPS,SHORT}} \right\rceil, & \text{otherwise} \end{cases} \quad (26\text{-}64)$$

where

$N_{DBPS,SHORT} = N_{CBPS,SHORT} \cdot R$, in which R is the coding rate, and

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$$N_{CBPS,SHORT} = N_{SD,SHORT} \cdot N_{SS} \cdot N_{BPSCS};$$

The parameter $N_{SD,SHORT}$ values for different RU sizes are as shown in Table 26-23 (NSD,SHORT values(#1857)).

Table 26-23—$N_{SD,SHORT}$ values(#1857)

RU Size	$N_{SD,SHORT}$	
	DCM = 0	DCM = 1
26-tone	6	2
52-tone	12	6
106-tone	24	12
242-tone	60	30
484-tone	120	60
996-tone	240	120
2×996-tone	492	246

Given the a_{init} values, the initial number of data bits per symbol and the initial number of coded bits per symbol in the last OFDM symbol(s) are defined in Equation (26-65).

$$N_{DBPS.LAST.init} = \begin{cases} a_{init} N_{DBPS.SHORT}, \text{ if } a_{init} < 4 \\ N_{DBPS}, \text{ if } a_{init} = 4 \end{cases}$$
$$N_{CBPS.LAST.init} = \begin{cases} a_{init} N_{CBPS.SHORT}, \text{ if } a_{init} < 4 \\ N_{CBPS}, \text{ if } a_{init} = 4 \end{cases} \quad (26\text{-}65)$$

For an(#2829) HE SU PPDU with BCC encoding, the number of pre-FEC pad bits is calculated using Equation (26-66).

$$N_{PAD,\text{Pre-FEC}} = (N_{SYM.init} - m_{STBC}) N_{DBPS} + m_{STBC} N_{DBPS.LAST.init} - 8 \cdot \text{APEP\_LENGTH} - N_{Tail} - N_{service} \quad (26\text{-}66)$$

where $N_{SYM.init}$ is defined as in Equation (26-69) for BCC encoding, and Equation (26-74)(#2802) for LDPC encoding.

For an(#2829) HE SU PPDU with LDPC encoding, the number of pre-FEC pad bits is calculated using Equation (26-67).

$$N_{PAD,\text{Pre-FEC}} = (N_{SYM.init} - m_{STBC}) N_{DBPS} + m_{STBC} N_{DBPS.LAST.init} - 8 \cdot \text{APEP\_LENGTH} - N_{service} \quad (26\text{-}67)$$

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Among the pre-FEC padding bits, the MAC delivers a PSDU that fills the available octets in the Data field of the HE PPDU, toward the desired pre-FEC padding boundary, represented by a_init value, in the the last OFDM symbol(s). The PHY then determines the number of pad bits to add and appends them to the PSDU. The number of pre-FEC pad bits added by PHY will always be 0 to 7. The procedure is defined in Equation (26-68).

$$N_{PAD,\text{ Pre-FEC,MAC}} = \left\lfloor \frac{N_{PAD,\text{ Pre-FEC}}}{8} \right\rfloor \cdot 8$$
$$N_{PAD,\text{ Pre-FEC,PHY}} = N_{PAD,\text{ Pre-FEC}} \bmod 8 \quad (26\text{-}68)$$

26.3.11.3 SERVICE field

The SERVICE field of HE PPDU is as shown in Table 26-24 (SERVICE field).

Table 26-24—SERVICE field

Bits	Field	Description
B0-B6	Scrambler Initialization	Set to 0
B7-B15	Reserved	Set to 0

26.3.11.4 Coding

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 26.3.11.4.1 (Binary convolutional coding and puncturing) or the low density parity check (LDPC) code defined in 26.3.11.4.2 (LDPC coding)(#2803). The encoder is selected by the Coding field in HE-SIG-A in an HE SU PPDU or an HE extended range SU PPDU, or HE-SIG-B per-user subfield(s) in an(#2829) HE MU PPDU, as defined in 26.3.10.7 (HE-SIG-A) and 26.3.10.8 (HE-SIG-B) respectively.

When conducting BCC FEC encoding for an HE PPDU, the number of encoders is always 1.

LDPC is the only FEC coding scheme in the HE PPDU Data field for a 484-, 996-, and 2×996-tone RU(#838). LDPC is the only FEC coding scheme in the HE PPDU Data field for MCS10 and MCS11 in a 242- 484-, 996- and 2×996-tone RU.(PHY Motion #158) Support of BCC code is limited to less than or equal to four spatial streams and MCS0 to MCS9 (per user in case of MU-MIMO), and is mandatory (for both transmit and receive) for RU sizes less than or equal to a 242-tone RU(#838). Support of LDPC code (for both transmit and receive) is mandatory for HE STAs declaring support for at least one of HE 40/80/160/80+80 SU PPDU bandwidths, for HE STAs declaring support for more than 4 spatial streams, or for HE STAs declaring support for MCS10 and MCS11(PHY Motion #158), according to HE capabilities field as defined in 9.4.2.213 (HE Capabilities element). Otherwise, support of LDPC code for either transmit or receive is optional.

26.3.11.4.1 Binary convolutional coding and puncturing

The information bits and pre-FEC padding bits of user u are encoded by a rate R = ½ convolutional encoder defined in 17.3.5.6 (Convolutional encoder). After encoding, the encoded data is punctured by the method defined in 17.3.5.6 (Convolutional encoder)(#2804) (except for rate 5/6), to achieve the rate selected by the modulation and coding scheme. In the case that rate 5/6 coding is selected, the puncturing scheme will be the same as described in 21.3.10.5.3 (Binary convolutional coding and puncturing)(#2805).

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The initial number of OFDM symbols in the Data field with BCC encoding in an(#2829) HE SU PPDU is calculated as in Equation (26-69).

$$N_{SYM,\,init} = m_{STBC} \cdot \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}}{m_{STBC} N_{DBPS}} \right\rceil \text{(\#282)} \quad (26\text{-}69)$$

For an(#2829) HE SU PPDU with BCC encoding,

$$N_{SYM} = N_{SYM.init} \quad (26\text{-}70)$$

and

$$a = a_{init} \quad (26\text{-}71)$$

The number of coded bits per symbol in the last OFDM symbol(s) of an(#2829) HE SU PPDU is

$$N_{CBPS,\,LAST} = \begin{cases} a \cdot N_{CBPS,\,SHORT}, & \text{if } a < 4 \\ N_{CBPS}, & \text{if } a = 4 \end{cases} \quad (26\text{-}72)$$

26.3.11.4.2 LDPC coding

For an(#2829) HE SU PPDU using LDPC coding to encode the Data field, the LDPC code and encoding process described in 19.3.11.7 (LDPC codes)(#2806) shall be used with the following modifications. First, all bits in the Data field including the scrambled SERVICE, PSDU, and pre-FEC pad bits are encoded. Thus, N_{pld} for HE PPDUs shall be computed using Equation (26-73) instead of Equation (20-35).

$$N_{pld} = (N_{SYM.init} - m_{STBC}) N_{DBPS} + m_{STBC} N_{DBPS.LAST.init} \quad (26\text{-}73)$$

where

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{service}}{m_{STBC} \cdot N_{DBPS}} \right\rceil \quad (26\text{-}74)$$

Following the calculation of N_{pld}, N_{avbits} shall be computed using Equation (26-75) instead of Equation (20-36).

$$N_{avbits} = (N_{SYM,\,init} - m_{STBC}) \cdot N_{CBPS} + m_{STBC} \cdot N_{CBPS,\,LAST,\,init} \quad (26\text{-}75)$$

In addition, in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process)(#1405)(#2807), if the following condition is met:

$(N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1 - R))$ AND $\left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1 - R}\right)$ is true OR if

$N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1 - R)$ is true,

then the LDPC Extra OFDM Symbol field of HE-SIG-A shall be set to 1, and increment N_{avbits} by the following Equation (26-76) instead of Equations (19-39), followed by recomputing N_{punc} as in Equation (19-40)(#2808):

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$$N_{avbits} = \begin{cases} N_{avbits} + m_{STBC} \cdot (N_{CBPS} - 3N_{CBPS.SHORT}), & \text{if } a_{init} = 3 \\ N_{avbits} + m_{STBC} \cdot N_{CBPS.SHORT}, & \text{otherwise} \end{cases} \quad (26\text{-}76)$$

and then update a and N_{SYM} values by the following Equation (26-77):

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC} \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init} \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \quad (26\text{-}77)$$

If in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process)(#1405)(#2809), the above mentioned condition is not met, then the LDPC Extra OFDM Symbol field of HE-SIG-A shall be set to 0, and

$$N_{SYM} = N_{SYM, init} \quad (\#2068)$$
$$a = a_{init} \quad (26\text{-}78)$$

With the final *a-factor* value a, update the N_{CBPS} of the last symbol as:

$$N_{CBPS.LAST} = \begin{cases} a \cdot N_{CBPS.SHORT}, & \text{if } a < 4 \\ N_{CBPS}, & \text{if } a = 4 \end{cases} \quad (26\text{-}79)$$

LDPC codes used in HE MU PPDUs shall also follow the definitions in 19.3.11.7 (LDPC codes)(#2810). Refer to 25.3.10.3.4 (Encoding process for HE MU PPDUs) for a description of the LDPC encoding process for HE MU PPDUs.

26.3.11.4.3 Post-FEC padding

The number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed by:

$$N_{PAD.POST\text{-}FEC} = N_{CBPS} - N_{CBPS.LAST} \quad (26\text{-}80)$$

$N_{PAD.POST\text{-}FEC}$ bits with arbitrary 0 or 1 values (TBD) are appended after the FEC output bits in each of the last m_{STBC} OFDM symbols.

26.3.11.4.4 Encoding process for an HE MU PPDU

For an HE MU PPDU, all the users shall use a common *a-factor* value and a common N_{SYM} value. The padding process is described as follows.

First compute initial *a-factor* value ($a_{init,u}$) for each user u using Equation (26-64), and the initial number of OFDM symbols ($N_{init,u}$) for each user u using Equation (26-69) if user u is BCC encoded, or Equation (26-74) if user u is LDPC encoded. Among all the users, derive the user index with the longest encoded packet duration, as in Equation (26-81).

$$u_{\max} = \arg\max_{u=0}^{N_u - 1} (N_{SYM.init.u} - m_{STBC} + 0.25 m_{STBC} a_{init.u}) \quad (26\text{-}81)$$

where m_{STBC} is the common STBC setting among all the users, as described in 26.3.10.8.

Then the common a_{init} and N_{init} values among all the users are derived by Equation (26-82):

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$$N_{SYM.init} = N_{SYM.init.u_{\max}}$$
$$a_{init} = a_{init.u_{\max}} \quad (26\text{-}82)$$

Update each user's initial number of coded bits in its last symbol as below:

$$N_{DBPS.LAST.init.u} = \begin{cases} a_{init} N_{DBPS.SHORT.u}, \text{ if } a_{init} < 4 \\ N_{DBPS.u}, \text{ if } a_{init} = 4 \end{cases}$$
$$N_{CBPS.LAST.init.u} = \begin{cases} a_{init} N_{CBPS.SHORT.u}, \text{ if } a_{init} < 4 \\ N_{CBPS.u}, \text{ if } a_{init} = 4 \end{cases} \quad (26\text{-}83)$$

For each user with LDPC encoding, the number of pre-FEC padding bits is computed as in Equation (26-84):

$$N_{PAD,\text{ Pre-FEC},u} = (N_{SYM.init} - m_{STBC}) N_{DBPS,u} + m_{STBC} N_{DBPS.LAST.init.u} - 8 \cdot \text{APEP\_LENGTH}_u - N_{service} \quad (26\text{-}84)$$

For each user with LDPC encoding, the parameters $N_{pld,u}$ and $N_{avbits,u}$ are computed using Equation (26-85) and Equation (26-86) respectively:

$$N_{pld,u} = (N_{SYM.init} - m_{STBC}) N_{DBPS,u} + m_{STBC} N_{DBPS.LAST.init.u} \quad (26\text{-}85)$$

$$N_{avbits,u} = (N_{SYM.init} - m_{STBC}) N_{CBPS,u} + m_{STBC} N_{CBPS.LAST.init.u} \quad (26\text{-}86)$$

For each user(#2072) with LDPC encoding continue LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process)(#1405)(#2811) starting with the parameters $N_{pld,u}$ and $_{avbits,u}$. If there is at least one user with LDPC encoding, where step d) of its LDPC encoding process of 19.3.11.7.5 (LDPC PPDU encoding process)(#1405)(#2812), meets the following condition:

$(N_{punc,u} > 0.1 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u))$ AND $\left(N_{shrt,u} < 1.2 \times N_{punc,u} \times \frac{R_u}{1 - R_u}\right)$ is true OR if

$N_{punc,u} > 0.3 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u)$ is true,

where $N_{punc,u}$, $N_{CW,u}$, $L_{LDPC,u}$ and $N_{shrt,u}$ are the LDPC encoding parameters for user u, as defined in 19.3.11.7.5 (LDPC PPDU encoding process)(#2813), and R_u is the coding rate of user u, then the LDPC Extra symbol bit in HE-SIG-A shall be set to 1, and all the users with LDPC encoding shall increment N_{avbits} and recomputed N_{punc}, by the following two equations once:

$$N_{avbits,u} = \begin{cases} N_{avbits,u} + m_{STBC} \cdot (N_{CBPS} - 3N_{CBPS.SHORT.u}), \text{ if } a_{init} = 3 \\ N_{avbits,u} + m_{STBC} \cdot N_{CBPS.SHORT.u}, \text{ otherwise} \end{cases} \quad (26\text{-}87)$$

$$N_{punc,u} = \max(0, (N_{CW,u} \times L_{LDPC,u}) - N_{avbits,u} - N_{shrt,u}) \quad (26\text{-}88)$$

Update the common *a-factor* and N_{SYM} values for all users by the following equation:

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC} \text{ and } a = 1, \text{ if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init} \text{ and } a = a_{init} + 1, \text{ otherwise} \end{cases} \quad (26\text{-}89)$$

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Note that users with BCC encoding shall also use the common N_{SYM} and a parameters as in Equation (26-77).

If among all the users with LDPC encoding, in step d) of 19.3.11.7.5 (LDPC PPDU encoding process)(#1405)(#2814), the above mentioned condition is not met, or if all the users in the HE MU PPDU are BCC encoded, then the LDPC Extra symbol bit in HE-SIG-A shall be set to 0, and:

$$a = a_{init},\ N_{SYM} = N_{SYM,\,init} \tag{26-90}$$

Update the N_{CBPS} and N_{DBPS} of the last symbol for each user as:

$$\begin{aligned} N_{DBPS.LAST.u} &= \begin{cases} a \cdot N_{DBPS.SHORT.u}, \text{ if } a < 4 \\ N_{DBPS.u}, \text{ if } a = 4 \end{cases} \\ N_{CBPS.LAST.u} &= \begin{cases} a \cdot N_{CBPS.SHORT.u}, \text{ if } a < 4 \\ N_{CBPS.u}, \text{ if } a_{init} = 4 \end{cases} \end{aligned} \tag{26-91}$$

For the users with BCC encoding, the number of pre-FEC padding bits is shown in Equation (26 91).

$$\begin{aligned} N_{PAD,\,\text{Pre-FEC},\,u} = {} & (N_{SYM} - m_{STBC})N_{DBPS,\,u} + m_{STBC}N_{DBPS.LAST.u} \\ & - 8 \cdot \text{APEP\_LENGTH}_u - N_{Tail} - N_{service} \end{aligned} \tag{26-92}$$

For each user with either LDPC or BCC encoding, the number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed as in Equation (26-93):

$$N_{PAD,\,\text{Post-FEC},\,u} = m_{STBC} \cdot (N_{CBPS,\,u} - N_{CBPS.LAST.u}) \tag{26-93}$$

26.3.11.4.5 Encoding process for an HE trigger-based PPDU

The AP indicates the common N_{SYM}, *a-factor*, STBC indication and LDPC Extra Symbol in the Trigger frame.

For an HE trigger-based PPDU with BCC encoding, follow the HE SU PPDU padding and encoding process as introduced in 25.3.10.1.1 (pre-FEC padding process), 26.3.11.4.1 (Binary convolutional coding and puncturing), and 26.3.11.4.3 (Post-FEC padding), with initial parameters setting to $N_{SYM.init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and *a-factor* parameters indicated in the Trigger frame, respectively.

For an HE trigger-based PPDU with LDPC encoding, follow the HE SU PPDU padding and encoding process as introduced in 26.3.11.2 (Pre-FEC encoding process), 26.3.11.4.2 (LDPC coding), and 26.3.11.4.3 (Post-FEC padding), with the following exceptions:

When the Trigger frame indicates LDPC Extra Symbol = 1, set the initial parameters following Equation (26-94):

$$\begin{cases} a_{init} = 4 \text{ and } N_{SYM.init} = N_{SYM} - m_{STBC}, \text{ if } a = 1 \\ a_{init} = a - 1 \text{ and } N_{SYM.init} = N_{SYM}, \text{ otherwise} \end{cases} \tag{26-94}$$

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where N_{SYM} and a are the common number of symbols and *a-factor* parameters indicated in the Trigger frame respectively, and m_{STBC} is 2 if the Trigger frame indicates STBC and 1 otherwise. Then continue with the LDPC encoding process as in 20.3.11.7.5 (LDPC PPDU encoding process)(#1405), during which in step d) of 20.3.11.7.5 (LDPC PPDU encoding process)(#1405), always increment N_{avbits} as in Equation (26-76), and always recompute N_{punc} as in Equation (20-40), followed by updating $a = a_{init} + 1$ if $a_{init} < 4$, or $a = 1$ if $a_{init} = 4$.

When the Trigger frame indicates LDPC Extra Symbol = 0, set initial parameters to $N_{SYM,init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and a-factor parameters indicated in the Trigger frame respectively. Then continue with the LDPC encoding process as in 20.3.11.7.5 (LDPC PPDU encoding process)(#1405), during which in step d) of 20.3.11.7.5 (LDPC PPDU encoding process)(#1405), N_{avbits} and N_{punc} are not changed, and $a = a_{init}$.

26.3.11.5 Stream parser

After coding, scrambling,(#2078) puncturing and post-FEC padding, the data bit streams at the output of the FEC encoder are processed in groups of N_{CBPS} bits. Each of these groups is re-arranged into N_{SS} blocks of N_{CBPSS} bits ($N_{SS,u}$ blocks of $N_{CBPSS,u}$ bits in the case of an(#2829) HE MU transmission). This operation is referred to as "stream parsing" and is described in this subclause(#1304).

The description is given in terms of an SU transmission. For MU transmissions, the rearrangements are carried out in the same way per user.

The number of bits assigned to a single axis (real or imaginary) in a constellation point in a spatial stream is denoted by Equation (26-95).

$$s = max(1, \frac{N_{BPSCS}}{2}) \quad (26\text{-}95)$$

The sum of these over all streams is $S = N_{SS} \cdot s$.

Consecutive blocks of s bits are assigned to different spatial streams in a round robin fashion.

For the N_{CBPS} bits of each OFDM symbol, S bits from the output of the encoder are divided among all spatial streams, s bits per stream.

Note that for all RU sizes the coded bits of each OFDM symbol are always evenly allocated to N_{SS} spatial streams.(#2079)(#Ed)

The following equations are an equivalent description to the above procedure. Bit i at the output of the encoder is assigned to input bit k of spatial stream i_{SS} where

$$i = (i_{SS} - 1)s + S \cdot \left\lfloor \frac{k}{s} \right\rfloor + (k \bmod s) \text{ (\#2080)}$$

$$i_{SS} = 1, 2, \ldots, N_{SS}$$

$$i = 0, 1, \ldots, N_{CBPS} - 1$$

$$k = 0, 1, \ldots, N_{CBPSS} - 1 \text{ (\#2081)}$$

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26.3.11.6 Segment parser

The description in this subclause is for an SU transmission. For an MU transmissions, the rearrangements are carried out in the same way but per user.(#Ed)

For a 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz transmission with a 26-, 52-, 106-, 242-, 484- or 996-tone RU, the segment parser is bypassed and the output bits of each stream parser are as specified in Equation (26-96).

$$y_{k,\,l} = x_k \tag{26-96}$$

where

x_k is bit k of a block of N_{CBPSS} bits, $k = 0$ to $N_{CBPSS} - 1$

l is the frequency subblock index and $l = 0$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU.

$y_{k,l}$ is bit k of the frequency subblock l

For a 160 MHz and 80+80 MHz transmission with a 2×996-tone RU, the output bits of each stream parser are first divided into blocks of N_{CBPSS} bits ($N_{CBPSS,u}$ bits in the case of an MU transmission). Then, each block is further divided into two frequency subblocks of $N_{CBPSS}/2$ bits as shown in Equation (26-97).

$$y_{k,\,l} = x_m \tag{26-97}$$

$$m = 2s \cdot \left\lfloor \frac{k}{s} \right\rfloor + l \cdot s + (k \bmod s), \quad k = 0, 1, \ldots, \frac{N_{CBPSS}}{2} - 1 \tag{26-98}$$

and

x_m is bit m of a block of N_{CBPSS} bits and $m = 0, \ldots, N_{CBPSS} - 1$

l is the frequency subblock index and $l = 0, 1$

$y_{k,l}$ is bit k of the frequency subblock l

s is defined in Equation (26-95)(#2566)

26.3.11.7 BCC interleavers

(#1866)For ease of explanation, the operation of the interleaver is described only for the SU case. For user u in the r-th RU of an MU transmission, the interleaver operates in the same way on the output bits for the user from the stream parser by replacing N_{SS}, N_{CBPSS}, N_{CBPSSI}, and N_{BPSCS} with $N_{SS,r,u}$, $N_{CBPSS,r,u}$, $N_{CBPSSI,r,u}$ and $N_{BPSCS,r,u}$, respectively. That is, the operation of the interleaver is the same as if the transmission were an SU one, consisting of bits from only that user.

The BCC interleaver operation is specified in 21.3.10.8 (BCC interleaver). When DCM is used with BPSK modulation in a 106-tone RU or a 242-tone RU with $N_{SS} = 1$, after the $2 \times N_{DBPS}$ coded bits in each OFDM symbol, 1 padding bit is added before the bits are interleaved.(#482) (#2183)The interleaver parameters,

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N_{COL}, N_{ROW}, and N_{ROT}, for the Data field depend on the RU size and whether or not DCM is used and are defined in the RU size column of Table 26-25 (BCC interleaver parameters).

Table 26-25—BCC interleaver parameters

DCM	Parameter	RU size (tones)				HE-SIG-A/ HE-SIG-B (tones)
		26	52	106	242	56
Not used	N_{COL}	8	16	17	26	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$6 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$4 \times N_{BPSCS}$
	N_{ROT} ($2 \le N_{SS} \le 4$)	2	11	29	58	-
Used	N_{COL}	48	8	17	13	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$2 \times N_{BPSCS}$
	N_{ROT} ($N_{SS} = 2$)	2	2	11	29	-

The interleaver parameters, N_{COL} and N_{ROW}, for the HE-SIG-A and HE-SIG-B fields are defined in the HE-SIG-A/HE-SIG-B column of Table 26-25 (BCC interleaver parameters).

NOTE—DCM is not used on the HE-SIG-A field.

26.3.11.8 Constellation mapping

The mapping between the input bits of the constellation mapper and complex constellation points for BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM is as defined in 21.3.10.9 (Constellation mapping).

1024-QAM is optional for SU and MU for RUs equal to or larger than 242 subcarriers(#1782)(#Ed). For 1024-QAM, the mapping of the bits at the output of the interleaver to the complex constellation points is defined in Figure 26-31 (Constellation bit encoding for 1024-QAM (1st quadrant)), Figure 26-32

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(Constellation bit encoding for 1024-QAM (2nd quadrant)), Figure 26-33 (Constellation bit encoding for 1024-QAM (3rd quadrant)) and Figure 26-34 (Constellation bit encoding for 1024-QAM (4th quadrant)).



Figure 26-31—Constellation bit encoding for 1024-QAM (1st quadrant)

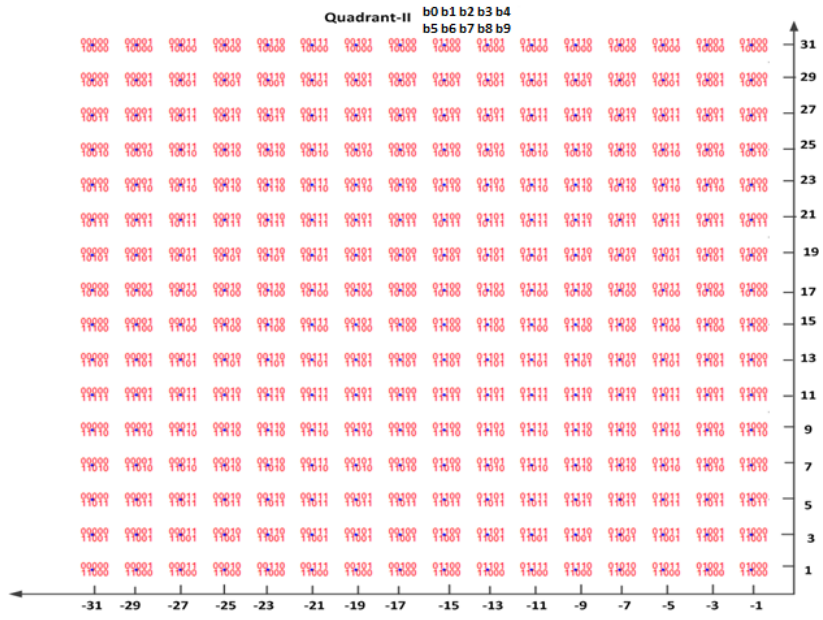


Figure 26-32—Constellation bit encoding for 1024-QAM (2nd quadrant)

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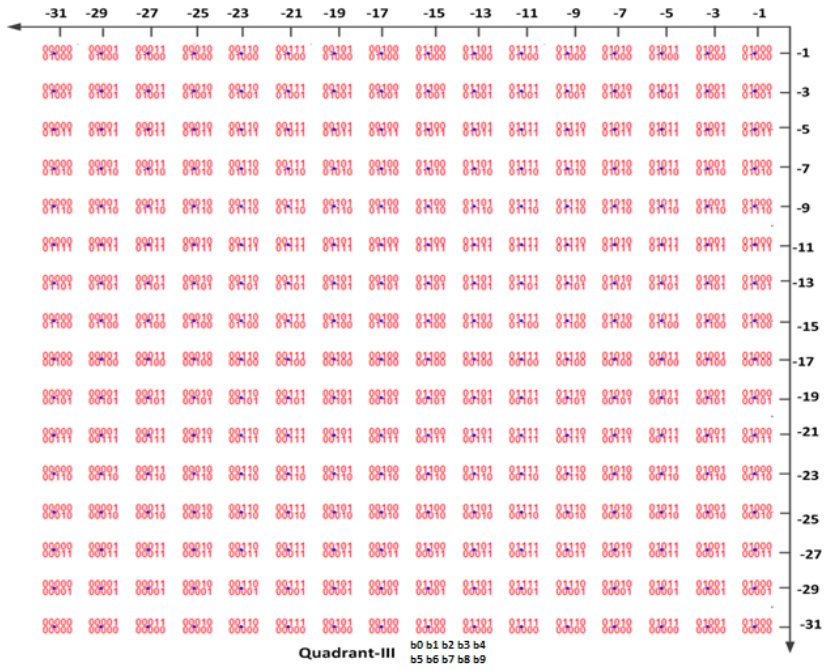


Figure 26-33—Constellation bit encoding for 1024-QAM (3rd quadrant)

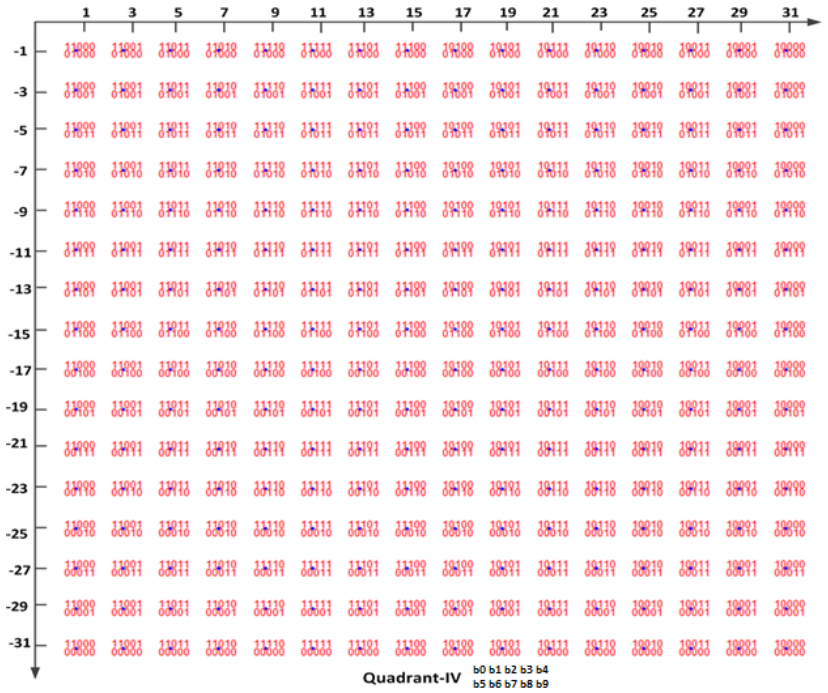


Figure 26-34—Constellation bit encoding for 1024-QAM (4th quadrant)

The normalization factor K_{mod} for 1024 QAM is $1/\sqrt{682}$.(#1782)

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Dual subcarrier modulation (DCM) is an optional modulation scheme for the HE-SIG-B and Data fields. DCM can be applied to an HE SU PPDU and an HE extended range SU PPDU. In an HE MU PPDU, DCM can be applied only to RUs containing data for 1 user.(#482)

DCM is only applied to MCS0, MCS 1, MCS 3 and MCS 4. DCM is applied only with $N_{SS} = 1$ or $N_{SS} = 2$ (in the case of single user RU in an HE MU PPDU, $N_{SS,r,u} = 1$ or $N_{SS,r,u} = 2$). DCM is not applied with MU-MIMO or with STBC.

When DCM is employed, bit sequences are mapped to a pair symbols $(d_k, d_{q(k)})$ where k is in the range of $0 \le k \le N_{SD} - 1$ and $q(k)$ is in the range of $N_{SD} \le k \le N_{SD} - 1$ in order to exploit frequency diversity. To maximize the frequency diversity, the indices of a pair of DCM subcarriers $(k, q(k))$ is $q(k) = k + N_{SD}$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.(#482)

For BPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,r,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,r,u}-1})$. Each bit B_k is BPSK modulated to a sample d_k. This generates the samples for the lower half of the data subcarriers. For the upper half of the subcarriers, the samples are generated as $d_{k+N_{SD}} = d_k \times e^{j(k+N_{SD})\pi}$, $k = 0, 1, \ldots, N_{SD} - 1$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.(#482)

For QPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,r,u}$(#333) bits $(B_0, B_1, \ldots, B_{N_{CBPS,r,u}-1})$. Each pair of bits (B_{2k}, B_{2k+1}) is QPSK modulated to a symbol d_k. This generates the constellation points for the lower half the data subcarriers in the RU. For the upper half of the data subcarriers in the RU, $d_{k+N_{SD}} = conj(d_k)$ (#482).

For 16-QAM modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,r,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,r,u}-1})$. A group of 4 bits $(B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3})$ is 16-QAM modulated to a sample d_k as described in 18.3.5.8. This is the sample on subcarrier k in the lower half. In the upper half, the sample $d_{k+N_{SD}}$ on subcarrier $k + N_{SD}$ is obtained by 16-QAM modulating a permutation of the bits (B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3}). Specifically, $d_{k+N_{SD}}$ is obtained by applying the 16-QAM modulation procedure in 18.3.5.8 to the bit group (B_{4k+1}, B_{4k}, B_{4k+3}, B_{4k+2}). he N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.(#482)

26.3.11.9 Space-time block coding

This subclause defines a set of optional robust transmission techniques that are applicable only when using STBC coding. For an HE PPDU, STBC is allowed only with single spatial stream and two space-time streams, and its application is as indicated by the STBC bit in HE-SIG-A (TBD: undecided whether in HE-SIG-A for HE_MU). In an HE MU PPDU, STBC coding is used in all RUs or not used in any of the RUs. If in an RU, DL MU-MIMO is applied, STBC shall not be used in any RU in the HE MU PPDU.

The STBC encoding process is as described in 22.3.10.9.4 (Space-time block coding)(#1405), with $N_{SS,0} = 1$ and $N_{STS,0} = 2$.

26.3.11.10 LDPC tone mapper

(#1859)The LDPC tone mapping shall be performed on all LDPC encoded streams mapped in an(#Ed) RU as described in this subclause. LDPC tone mapping shall not be performed on streams that are encoded using

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BCC. When DCM is applied to LDPC encoded streams, $D_{\text{TM\_DCM}}$(#1860) shall be applied on both the lower half data subcarriers in an(#Ed) RU and the upper half data subcarriers of the RU. The LDPC tone-mapping distance parameters D_{TM} and D_{TM_DCM} are constant for each RU size and the values for different RU sizes are given in Table 26-26 (LDPC tone mapping distance for each RU size).

Table 26-26—LDPC tone mapping distance for each RU size

Parameter	RU Size (tones)						
	26	52	106	242	484	996	2×996(#1337)
D_{TM}	1	3	6	9	12	20	20
D_{TM_DCM}	1	1	3	9	9	14	20

NOTE—The LDPC tone mapping parameters D_{TM} and D_{TM_DCM} are applied for each frequency subblock, $l = 0$ and $l = 1$.(#1866)

For an HE PPDU without DCM, the LDPC tone mapping for the LDPC encoded stream for user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 26.3.11.8 (Constellation mapping)) to

$$d''_{t(k),\,i,\,n,\,l,\,r,\,u} = d'_{k,\,i,\,n,\,l,\,r,\,u};$$

$k = 0, 1, \ldots, N_{SD} - 1$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU

$k = 0, 1, \ldots, \frac{N_{SD}}{2} - 1$ for a 2x996-tone RU

$i = 1, \ldots, N_{SS,\,r,\,u}$

$n = 0, 1, \ldots, N_{SYM} - 1$

$l = 0$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU

$l = 0, 1$ for a 2x996-tone RU

$u = 0, \ldots, N_{user,\,r} - 1$

$r = 0, \ldots, N_{RU} - 1$ (26-99)

where N_{SD} is the number of data tones in the r-th RU.

$$t(k) = \begin{cases} D_{TM}\left(k \bmod \frac{N_{SD}}{D_{TM}}\right) + \left\lfloor \frac{k \cdot D_{TM}}{N_{SD}} \right\rfloor, & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ D_{TM}\left(k \bmod \frac{N_{SD}/2}{D_{TM}}\right) + \left\lfloor \frac{k \cdot D_{TM}}{N_{SD}/2} \right\rfloor, & \text{for a 2x996-tone RU} \end{cases} \quad (26\text{-}100)$$

For an(#2829) HE PPDU with DCM, the LDPC tone mapping for the LDPC encoded stream corresponding to user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 25.3.10.7) to

$$d''_{t(k),i,n,l,r,u} = \begin{cases} d'_{k,i,n,l,r,u}; \\ d'_{k',i,n,l,r,u}; \end{cases} \quad (26\text{-}101)$$

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where

$k = 0, 1, \ldots, \frac{N_{SD}}{2} - 1$

$k' = k - \frac{N_{SD}}{2}$, for $k = \frac{N_{SD}}{2}, \frac{N_{SD}}{2} + 1, \ldots, N_{SD} - 1$

$i = 1, \ldots, N_{SS,r,u}$

$n = 0, 1, \ldots, N_{SYM} - 1$

$l = \begin{cases} 0 \text{ for a 26-, 52-, 106-, 242-, 494- and 996-tone RU} \\ 0, 1 \text{ for a 2x996-tone RU} \end{cases}$

$u = 0, \ldots, N_{user,r} - 1$

$r = 0, \ldots, N_{RU} - 1$

N_{SD} is the number of data tones in the r-th RU and

$$t(k) = \begin{cases} D_{\text{TM\_DCM}}\left(k \bmod \frac{N_{SD}/2}{D_{\text{TM\_DCM}}}\right) + \left\lfloor \frac{k \cdot D_{\text{TM\_DCM}}}{N_{SD}/2} \right\rfloor, & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ D_{\text{TM\_DCM}}\left(k' \bmod \frac{N_{SD}/2}{D_{\text{TM\_DCM}}}\right) + \left\lfloor \frac{k' \cdot D_{\text{TM\_DCM}}}{N_{SD}/2} \right\rfloor + \frac{N_{SD}}{2}, & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ D_{\text{TM\_DCM}}\left(k \bmod \frac{N_{SD}/2}{D_{\text{TM\_DCM}}}\right) + \left\lfloor \frac{k \cdot D_{\text{TM\_DCM}}}{N_{SD}/2} \right\rfloor, & \text{for a 2x996-tone RU} \end{cases} \quad (26\text{-}102)$$

D_{TM_DCM} is the LDPC tone mapping distance for the r-th RU when DCM is applied.

NOTE—LDPC tone mapper for a 26-, 52-, 106-, 242-, 484- and 996-tone RU is defined as one segment(#2088). LDPC tone mapping is performed separately for the upper and lower 80 MHz frequency segments of a 2×996-tone RU(#1337) as indicated by the frequency subblock index l in Error! Reference source not found. and Error! Reference source not found.

Since LDPC tone mapping is not performed on BCC-coded streams, for BCC-coded streams, the following applies:

$$d''_{k,i,n,l,r,u} = d'_{k,i,n,l,r,u};$$

$k = 0, 1, \ldots, N_{SD} - 1$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU

$k = 0, 1, \ldots, \frac{N_{SD}}{2} - 1$ for a 2x996-tone RU

$i = 1, \ldots, N_{SS,r,u}$

$n = 0, 1, \ldots, N_{SYM} - 1$ (26-103)

$l = 0$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU

$l = 0, 1$ for a 2x996-tone RU

$u = 0, \ldots, N_{user,r} - 1$

$r = 0, \ldots, N_{RU} - 1$

26.3.11.11 Segment deparser

For a 26-, 52-, 106-, 242-, 484- and 996-tone RU(#Ed), the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,l,r,u}$ is specified in Equation (26-104).

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$$d^{(i_{Seg})}_{k,i,n,l,r,u} = d''_{k,i,n,0,r,u}, \quad \text{if } 0 \le k \le N_{SD}-1, i_{Seg} = 0 \tag{26-104}$$

For a 2×996-tone RU in a 160 MHz HE PPDU(#Ed), the two frequency subblocks at the output of the LDPC tone mapper are combined into one frequency segment as specified in Equation (26-105).

$$d^{(i_{Seg})}_{k,i,n,l,r,u} = \begin{cases} d''_{k,i,n,0,r,u}, & \text{if } 0 \le k \le \frac{N_{SD}}{2}-1 \\ d''_{k-\frac{N_{SD}}{2},i,n,l,r,u}, & \text{if } \frac{N_{SD}}{2} \le k \le N_{SD}-1 \end{cases}, i_{Seg} = 0 \tag{26-105}$$

For a 2×996-tone RU in an 80+80 MHz HE PPDU, the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,l,r,u}$ is specified in Equation (26-106).

$$d^{(i_{Seg})}_{k,i,n,r,u} = d''_{k,i,n,i_{Seg},r,u}, \quad \text{if } 0 \le k \le N_{SD}-1, i_{Seg} = 0, 1 \tag{26-106}$$

NOTE—As per Table 21-7 (center frequency for frequency segment iSeg = 0), $f_c^{(0)}$ is always less than $f_c^{(1)}$ in case of 80+80 MHz HE PPDU. Hence, $d''_{k,i,n,0,r,u}$ (frequency subblock 0) is always transmitted in the frequency segment lower in frequency, while $d''_{k,i,n,1,r,u}$ (frequency subblock 1) is always transmitted in the frequency segment higher in frequency.(#2092)

26.3.11.12 Pilot subcarriers

For a user transmitting on the *i*-th 26-tone RU in a given PPDU BW, two pilot tones shall be inserted in subcarriers $k \in K_{R26_i}$, where K_{R26_i} is given by the(#926) *i*-th pilot index set in the row of given PPDU BW of Table 26-27 (Pilot indices for a 26-tone RU).

Table 26-27—Pilot indices for a 26-tone RU

PPDU BW	K_{R26_i}
20 MHz, *i* = 1:9	−116/−102, −90/−76, −62/−48, −36/−22, −10/10, 22/36, 48/62, 76/90, 102/116
40 MHz, *i* = 1:18	−238/−224, −212/−198, −184/−170, −158/−144, −130/−116, −104/−90, −78/−64, −50/−36, −24/−10, 10/24, 36/50, 64/78, 90/104, 116/130, 144/158, 170/184, 198/212, 224/238
80 MHz, *i* = 1:37	−494/−480, −468/−454, −440/−426, −414/−400, −386/−372, −360/−346, −334/−320, −306/−292, −280/−266, −252/−238, −226/−212, −198/−184, −172/−158, −144/−130, −118/−104, −92/−78, −64/−50, −38/−24, −10/10, 24/38, 50/64, 78/92, 104/118, 130/144, 158/172, 184/198, 212/226, 238/252, 266/280, 292/306, 320/334, 346/360, 372/386, 400/414, 426/440, 454/468, 480/494
160 MHz, *i* = 1:74	{pilot tone indices in 80 MHz −512, pilot tone indices in 80 MHz +512}

The pilot mapping P_n^k (#346) for the(#927) subcarrier *k* for symbol *n* shall be as specified in Equation (26-107).

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$$P_n^{K_{R26_i}} = \{\Psi_{n \bmod 2}, \Psi_{(n+1) \bmod 2}\} \text{ (\#347)}$$
$$P_n^{k \notin K_{R26_i}} = 0 \quad \text{(26-107)}$$

where

Ψ_m is defined in Table 26-28 (The 2 pilot values for a 26-tone RU(#347))

Table 26-28—The 2 pilot values for a 26-tone RU(#347)

Ψ_0	Ψ_1
1	−1

For a user transmitting on the *i*-th 52-tone RU in a given PPDU BW, four pilot tones shall be inserted in subcarriers $k \in K_{R52_i}$, where K_{R52_i} is given by the(#Ed) *i*-th pilot index set in the row of given PPDU BW of Table 26-29 (Pilot indices for 52-tone RU transmission).

Table 26-29—Pilot indices for 52-tone RU transmission

PPD BW	K_{R52_i}
20 MHz, *i* = 1:4	−116/−102/−90/−76, −62/−48/−36/−22, 22/36/48/62, 76/90/102/116
40 MHz, *i* = 1:8	−238/−224/−212/−198, −184/−170/−158/−144, −104/−90/−78/−64, −50/−36/−24/−10, 10/24/36/50, 64/78/90/104, 144/158/170/184, 198/212/224/238
80 MHz, *i* = 1:16	−494/−480/−468/−454, −440/−426/−414/−400, −360/−346/−334/−320, −306/−292/−280/−266, −252/−238/−226/−212, −198/−184/−172/−158, −118/−104/−92/−78, −64/−50/−38/−24, 24/38/50/64, 78/92/104/118, 158/172/184/198, 212/226/238/252, 266/280/292/306, 320/334/346/360, 400/414/426/440, 454/468/480/494
160 MHz, *i* = 1:32	{pilot tone indices in 80 MHz −512, pilot tone indices in 80 MHz +512}

The pilot mapping P_n^k (#346) for the(#933) subcarrier *k* for symbol *n* shall be as specified in Equation (26-108).

$$P_n^{K_{R52_i}} = \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\} \text{ (\#347)}$$
$$P_n^{k \notin K_{R52_i}} = 0 \quad \text{(26-108)}$$

where

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Ψ_m is defined in Table 26-30 (The 4 pilot values in a 52- and 106-tone RU(#347))

Table 26-30—The 4 pilot values in a 52- and 106-tone RU(#347)

Ψ_0	Ψ_1	Ψ_2	Ψ_3
1	1	1	−1

For a user transmitting on the *i*-th 106-tone RU in a given PPDU BW, four pilot tones shall be inserted in subcarriers $k \in K_{R106_i}$, where K_{R106_i} is given by the(#932) *i*-th pilot index set in the row of given PPDU BW of Table 26-31 (Pilot indices for 106-tone RU transmission).

Table 26-31—Pilot indices for 106-tone RU transmission

PPD BW	K_{R106_i}
20 MHz, *i* = 1:2	−116/−90/−48/−22, 22/48/90/116
40 MHz, *i* = 1:4	−238/−212/−170/−144, −104/−78/−36/−10, 10/36/78/104, 144/170/212/238
80 MHz, *i* = 1:8	−494/−468/−426/−400, −360/−334/−292/−266, −252/−226/−184/−158, −118/−92/−50/−24, 24/50/92/118, 158/184/226/252, 266/292/334/360, 400/426/468/494
160 MHz, *i* = 1:16	{pilot tone indices in 80 MHz −512, pilot tone indices in 80 MHz +512}

The pilot mapping P_n^k(#346) for the(#930) subcarrier *k* for symbol *n* shall be as specified in Equation (26-109).

$$P_n^{K_{R106_i}} = \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\}$$
$$P_n^{k \notin K_{R106_i}} = 0 \qquad (26\text{-}109)$$

where

Ψ_m is defined in Table 26-30 (The 4 pilot values in a 52- and 106-tone RU(#347))

For a user transmitting on the *i*-th 242-tone RU in a given PPDU BW, eight pilot tones shall be inserted in subcarriers $k \in K_{R242_i}$, where K_{R242_i} is given by the(#929) *i*-th pilot index set in the row of given PPDU BW of Table 26-32 (Pilot indices for 242-tone RU transmission).

Table 26-32—Pilot indices for 242-tone RU transmission

PPD BW	K_{R242_i}
20 MHz, *i* = 1	−116/−90/−48/−22/22/48/90/116

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Table 26-32—Pilot indices for 242-tone RU transmission *(continued)*

40 MHz, i = 1:2	−238/−212/−170/−144/−104/−78/−36/−10, 10/36/78/104/144/170/212/238
80 MHz, i = 1:4	−494/−468/−426/−400/−360/−334/−292/−266,−252/−226/−184/−158/−118/−92/−50/−24, 24/50/92/118/158/184/226/252, 266/292/334/360/400/426/468/494
160 MHz, i = 1:8	{pilot tone indices in 80 MHz −512, pilot tone indices in 80 MHz +512}

The pilot mapping P_n^k (#346) for the(#936) subcarrier k for symbol n shall be as specified in Equation (26-110).

$$P_n^{K_{R242_i}} = \{\Psi_{n \bmod 8}, \Psi_{n+1 \bmod 8}, \Psi_{n+2 \bmod 8}, \Psi_{n+3 \bmod 8}, \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}\} \quad (26\text{-}110)$$

$$P_n^{k \notin K_{R242_i}} = 0$$

where

Ψ_m is defined in Table 26-33 (The 8 pilot values in a 242-tone RU(#347))

Table 26-33—The 8 pilot values in a 242-tone RU(#347)

Ψ_0	Ψ_1	Ψ_2	Ψ_3	Ψ_4	Ψ_5	Ψ_6	Ψ_7
1	1	1	−1	−1	1	1	1

For a 484-tone RU transmission, the pilot mapping for 8 pilots in 242-tone RU is replicated in the two 242-RUs of the 484-tone RU transmission. Specifically, for(#347) a user transmitting on the i-th 484-tone RU in a given PPDU BW, sixteen pilot tones shall be inserted in subcarriers $k \in K_{R484_i}$, where K_{R484_i} is given by the(#938) i-th pilot index set in the row of given PPDU BW of Table 26-34 (Pilot indices for 484-tone RU transmission).

Table 26-34—Pilot indices for 484-tone RU transmission

PPD BW	K_{R484_i}
40 MHz, i = 1	−238/−212/−170/−144/−104/−78/−36/−10/10/36/78/104/144/170/212/238
80 MHz, i = 1:2	−494/−468/−426/−400/−360/−334/−292/−266/−252/−226/−184/−158/−118/−92/−50/−24, 24/50/92/118/158/184/226/252/266/292/334/360/400/426/468/494
160 MHz, i = 1:4	{pilot tone indices in 80 MHz −512, pilot tone indices in 80 MHz +512}

The pilot mapping P_n^k (#346) for the(#942) subcarrier k for symbol n shall be as specified in Equation (26-111).

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$$P_n^{K_{R484_i}} = \{\Psi_{n \bmod 8}, \Psi_{n+1 \bmod 8}, \Psi_{n+2 \bmod 8}, \Psi_{n+3 \bmod 8}, \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8}\}$$ (#347) (26-111)

$$P_n^{k \notin K_{R484_i}} = 0$$

where

Ψ_m is defined in Table 26-33 (The 8 pilot values in a 242-tone RU(#347))

For a 996-tone RU transmission, the pilot mapping for its 16 pilots is the same as the mapping for 484-tone RU transmission. Specifically, for(#347) a user transmitting on the *i*-th 996-tone RU in a given PPDU BW, sixteen pilot tones shall be inserted in subcarriers $k \in K_{R996_i}$, where K_{R996_i} is given by the(#941) *i*-th pilot index set in the row of given PPDU BW of Table 26-35 (Pilot indices for 996-tone RU transmission).

Table 26-35—Pilot indices for 996-tone RU transmission

PPD BW	K_{R996_i}
80 MHz, $i = 1$	−468/−400/−334/−266/−226/−158/−92/−24/24/92/158/226/266/334/400/468
160 MHz, $i = 1{:}2$	{for $i = 1$ pilot tone indices in 80 MHz −512, for $i = 2$ pilot tone indices in 80 MHz +512}(#2095)

The pilot mapping P_n^k (#346) for the(#939) subcarrier *k* for symbol *n* shall be as specified in Equation (26-112).

$$P_n^{K_{R996_i}} = \{\Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8}\}$$ (#347) (26-112)

$$P_n^{k \notin K_{R996_i}} = 0$$

where

Ψ_m is defined in Table 26-33 (The 8 pilot values in a 242-tone RU(#347))

For a 160 MHz transmission (equivalently two 996-tone RU transmissions), the 80 MHz (equivalently 996-tone RU)(#347) pilot mapping is replicated in the two 80 MHz subchannels of the 160 MHz transmission. Specifically, thirty-two pilot tones shall be inserted in subcarriers $k \in K_{\mathrm{R2x996}_i}$, where K_{R2x996_i} is given by {–980, –912, –846, –778, –738, –670, –604, –536, –488, –420, –354, –286, –246, –178, –112, –44, 44, 112, 178, 246, 286, 354, 420, 488, 536, 604, 670, 738, 778, 846, 912, 980}. The pilot mapping P_n^k (#346) for the(#944) subcarrier *k* for symbol *n* shall be as specified in Equation (26-113).

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$$
\begin{aligned}
P_n^{K_{R2x996_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\
& \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\
& \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\
& \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8}, \\
& \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \quad \text{(\#347)} \\
& \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\
& \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\
& \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \}
\end{aligned}
\qquad \text{(26-113)}
$$

$$
P_n^{k \notin K_{R2x996_i}} = 0
$$

where

Ψ_m is defined in Table 26-33 (The 8 pilot values in a 242-tone RU(#347))

For a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz pilot tone allocation and values defined for 996-tone RU in 80 MHz transmission as specified in Equation (26-112) and TBD pilot values for 996-tone RU in 80 MHz PPDU BW.

The above pilot mapping shall be copied to all space-time streams before the space-time stream cyclic shifts are applied.

26.3.11.13 OFDM modulation

The time domain waveform of the Data field of an HE PPDU that is not an HE trigger-based PPDU, from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as defined in Equation (26-114).

$$
\begin{aligned}
r_{\text{HE-Data}}^{(i_{Seg} i_{TX})}(t) = & \frac{1}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \\
& \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{Seg})} \right]_{i_{TX}, (M_{r,u}+m)} (\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+2+N_{\text{HE-SIG-A}}+N_{\text{HE-SIG-B}}} P_n^k) \\ \cdot \exp(j2\pi k \Delta_{F,\text{HE}} (t - nT_{SYM} - T_{GI,Data} - T_{CS,\text{HE}}(M_{r,u}+m))) \end{array} \right)
\end{aligned}
\qquad \text{(26-114)}
$$

where

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in 26.3.11.12 (Pilot subcarriers)(#1056)(#334)

$N_{\text{HE-Data}}^{\text{Tone}}$ is defined in Table 26-13 (Tone scaling factor and guard interval duration values for HE PPDU fields)(#476)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space time stream $M_{r,u}+m$ as defined in 26.3.10.2.2 (Cyclic shift for HE modulated fields)(#1052)

$T_{GI,Data}$ is the guard interval duration as defined in Table 26-3 (Timing-related constants)

$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)}$ is the transmitted constellation for user u in the r-th RU at subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined by Equation (26-115).

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$$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} = \begin{cases} 0, k \in K_{\text{Pilot}} \\ \tilde{d}_{M_r(k),m,n,r,u}^{(i_{Seg})}, \text{otherwise} \end{cases} \quad (26\text{-}115)$$

where

K_{Pilot} is the set of subcarrier indices of pilot tones, as defined in 26.3.7.3 (Pilot tones)

$M_r(k)$ is defined in Equation (26-116)

$$M_r(k) = k - K_{r,\min} - \left|\{k' : K_{r,\min} \le k' < k\} \cap K_{\text{Pilot}}\right| \quad (26\text{-}116)$$

where

$K_{r,min}$ is the minimum value of the set K_r

$|\Phi|$ is the cardinality of a set Φ

NOTE – $M_r(k)$ translates a subcarrier index k ($-N_{SR} \le k \le N_{SR}$) into the index of data symbols in a transmission over an RU(#1948) ($0 \le M_r(k) \le N_{SD,r}$). The subcarrier index k for the data tone is first offset by the minimum value of subcarrier index $K_{r,min}$ (for the lower edge tone) in this RU, and then subtracted by the number of pilot tones falling in between the data tone and the edge tone.

In a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz HE subcarrier mapping as specified in 26.3.7 (OFDMA and SU tone allocation).

The time domain waveform of the Data field of an HE trigger-based PPDU for user u in the r-th RU from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ shall be as defined in Equation (26-117).

$$r_{\text{HE-Data}}^{(i_{Seg}i_{TX})}(t) = \frac{\alpha_r}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \frac{1}{\sqrt{N_{STS,r,total}}} \sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} (\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+4} P_n^k) \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{SYM} - T_{GI,Data} - T_{CS,HE}(M_{r,u}+m))) \right) \quad (26\text{-}117)$$

where

$Q_k^{(i_{Seg})}$ is a spatial mapping/steering matrix with N_{TX} rows and $N_{STS,r,total}$ columns for subcarrier k in frequency segment i_{Seg}. $Q_k^{(i_{Seg})}$ may be frequency dependent, and the dimension may be variant in each RU. Refer to the descriptions in 22.3.10.11.1 (Transmission in VHT format) for examples of $Q_k^{(i_{Seg})}$.

26.3.11.14 Dual carrier modulation

Dual carrier modulation (DCM)(#2567) modulates the same information on a pair of sub-carriers. DCM is an optional modulation scheme for the HE-SIG-B and Data fields. DCM is only applied to BPSK, QPSK and 16-QAM modulations.

The constellation mapper for DCM is defined in 26.3.11.8 (Constellation mapping). The LDPC tone mapper for DCM is defined in 26.3.11.10 (LDPC tone mapper). The BCC interleaver for DCM is defined in 26.3.11.7 (BCC interleavers)(#2183).(#335)

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26.3.12 Packet extension(#1781)

A HE PPDU may have a Packet Extension (PE) field appended at the end of the PPDU, with possible durations being 0 µs, 4 µs, 8 µs, 12 µs, or 16 µs. The PE field, when present, shall be transmitted with the same average power as the Data field, and its content is arbitrary (PE content TBD).

The PE field is applied for the recipient of the PPDU to obtain longer processing time at the end of an(#2829) HE PPDU, and its duration is determined by both the *a-factor* value in the last OFDM symbol(s) of the Data field, and the maximum PE duration requested by the recipient for the signal bandwidth (or RU size), the number of spatial streams, and the constellation size of the current PPDU, which is based on the Maximum PE capabilities as defined in HE Capabilities field (9.4.2.213 (HE Capabilities element))(#1460).

For an(#2829) HE PPDU, the maximum PE durations as defined by the Maximum PE capabilities in HE capabilities (8.4.2.1 (HE Capabilities Element)) are 0 µs, 8 µs and 16 µs.

— A 0 µs maximum PE duration means no PE is present.

— A 8 µs maximum PE duration means that a PE field of 0 µs, 0 µs, 4 µs, and 8 µs are appended at the end of the PPDU, corresponding to *a-factor* being 1, 2, 3 and 4, respectively, as shown in Figure 26-35 (PE field when maximum PE duration is 8 µs (non STBC)).

— A 16 µs maximum PE duration means that a PE field of 4 µs, 8 µs, 12 µs, and 16 µs are appended at the end of the PPDU, corresponding to *a-factor* being 1, 2, 3 and 4, respectively, as shown in Figure 26-36 (PE field when maximum PE duration is 16 µs (non STBC)).

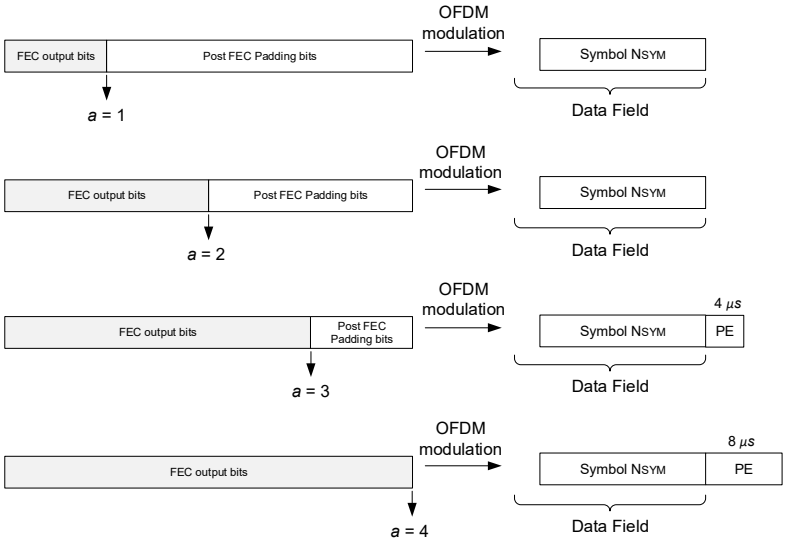


Figure 26-35—PE field when maximum PE duration is 8 µs (non STBC)

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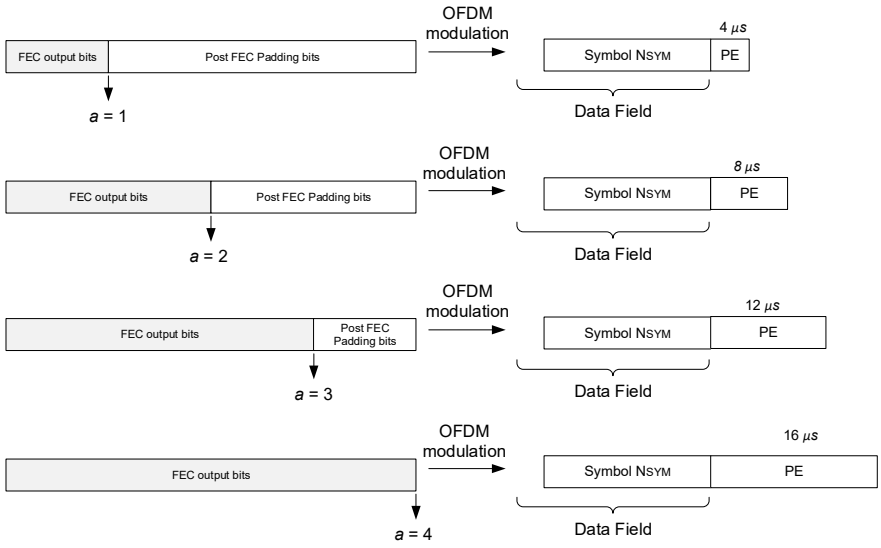


Figure 26-36—PE field when maximum PE duration is 16 μs (non STBC)

For an HE MU PPDU, the AP computes the PE duration, $T_{PE,u}$, for each user u, according to the common a-factor value among all users as described in 26.3.11.4.4 (Encoding process for an HE MU PPDU), the Maximum PE Duration capabilities, the RU size, the number of spatial streams and constellation size for user u. The AP shall choose the largest PE duration among all the users as the common PE duration of the current HE MU PPDU as:

$$T_{PE} = \max_u(T_{PE,u}) \quad (26\text{-}118)$$

and then append the PE field at the end of the current HE MU PPDU, with duration T_{PE}.

For an HE trigger-based PPDU, the AP indicates the common PE duration, T_{PE}, for all the users in the Trigger frame. Each user, when responding to(#2103) the Trigger frame with an HE trigger-based PPDU, shall append PE field at the end of the current HE trigger-based PPDU, with a duration T_{PE}. The value of TPE is TBD.

Editor's Note: The HE-SIG-A bits definition below should be moved into 26.3.10.7 (HE-SIG-A)

The 3-bit Packet Extension field in HE-SIG-A are defined as in Table 26-36 (Packet Extension field in HE-SIG-A).

Table 26-36—Packet Extension field in HE-SIG-A

Name	bits	Definition
a-factor	B0-B1	Indicates a-factor value of current PPDU
PE Disambiguity	B2	Indicates PE disambiguity

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The a-factor subfield of the Packet Extension field is encoded as shown in Table 26-37 (a-factor subfield encoding).

Table 26-37—a-factor subfield encoding

a-factor value	a-factor subfield encoding
1	b01
2	b10
3	b11
4	b00

The PE Disambiguity(#1049) subfield of the Packet Extension field shall be set to 1 if the condition in Equation (26 113) is met, otherwise it shall be set to 0.

$$T_{PE} + 4 \times \left(\left\lceil \frac{\text{TXTIME} - 20}{4} \right\rceil - \left(\frac{\text{TXTIME} - 20}{4} \right) \right) \geq T_{SYM} \quad (26\text{-}119)$$

where

T_{PE} is the PE field duration

T_{SYM} is the symbol duration of the Data field as defined in 26.3.6 (Timing-related parameters)

TXTIME (in μs) is defined in 26.4.3 (TXTIME and PSDU_LENGTH calculation).

Based on PE disambiguity field and a-factor field, the recipient shall compute N_{SYM} and T_{PE} listed in 26.3.15.

26.3.13 Non-HT duplicate transmission

When the TXVECTOR parameter FORMAT is NON_HT and the TXVECTOR parameter NON_HT_MODULATION is NON_HT_DUP_OFDM, the transmitted PPDU is a non-HT duplicate. Non-HT duplicate transmission is used to transmit to non-HT OFDM STAs, HT STAs, VHT STAs, HE STAs that may be present in a part of a 40 MHz, 80 MHz, or 160 MHz channel (see Error! Reference source not found.). The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF fields are not transmitted. The L-STF, L-LTF, and L-SIG fields shall be transmitted in the same way as in the HE transmission when the TXVECTOR parameter BEAM_CHANGE is 0, with the exceptions for the Rate and Length fields which shall follow 17.3.4 (SIGNAL field).

In a 40 MHz non-HT duplicate transmission, the Data field shall be as defined by Equation (26-62).

For 80 MHz and 160 MHz non-HT duplicate transmissions, the Data field shall be as defined by Error! Reference source not found..

In a noncontiguous 80+80 MHz non-HT duplicate transmission, data transmission in each frequency segment shall be as defined for an 80 MHz non-HT duplicate transmission in Error! Reference source not found..

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26.3.14 MU transmission(#507)

26.3.14.1 Introduction

The MU transmissions include DL MU transmissions and UL MU transmissions.

The DL MU transmission allows an AP to simultaneously transmit frames to more than one non-AP STAs. For the DL MU transmission, the AP uses the HE MU PPDU format, and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. The UL MU transmission allows an AP to receive simultaneous frames from more than one non-AP STAs. Non-AP STAs transmit their frames using HE trigger-based PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both.

The HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 26.3.7 (OFDMA and SU tone allocation)). On an RU in a PPDU, it is allowed to have single stream transmissions to one user or spatial multiplexing to one user (SU-MIMO) or spatial multiplexing to multiple users (MU-MIMO). Note that the VHT PHY supports only full bandwidth DL MU-MIMO as described in 21.3.11 (SU-MIMO and DL-MU-MIMO Beamforming). The HE PHY defines DL MU-MIMO and UL MU-MIMO, for the full bandwidth case as well as for the case where they are being used on only certain RUs in the PPDU. The combination of SU transmissions and MU-MIMO transmissions on different RUs in one PPDU is also supported.

26.3.14.2 DL MU transmission

DL MU transmission allows an AP to simultaneously transmit to more than one non-AP STA. The AP uses the HE MU PPDU for DL MU transmission.

26.3.14.3 DL MU-MIMO

26.3.14.3.1 Minimum RU size in DL MU-MIMO

A STA capable of receiving DL MU-MIMO transmission on an RU that does not span the entire PPDU bandwidth in an HE MU PPDU shall support reception of DL MU-MIMO transmissions for all RU sizes greater than or equal to 106-tones.

26.3.14.3.2 Maximum number of spatial streams in an HE MU PPDU

An HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with maximum number of space-time streams (per user) equal to minimum of 4 and the maximum number of space-time streams supported for reception of HE SU PPDUs. The maximum number of space-time streams supported for reception of HE SU PPDUs is indicated for various bandwidths in 'HE-MCS and Nss Map' field in the HE Capabilities element.

An HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with the total number of space-time streams (across NUM_USERS) less than or equal to a maximum value indicated by the Beamformee STS Capability in the HE Capabilities element(#1785).

All of the aforementioned restrictions on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

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26.3.14.3.3 Maximum number of total spatial streams in an HE MU PPDU(#1863)

A DL MU-MIMO capable STA shall support reception of DL MU PPDUs with the total number of space-time streams across the N_{user} users being less than or equal to its DL MU-MIMO STS Capability in the HE Capabilities.

26.3.14.3.4 Resource indication in an HE MU PPDU(#Ed)

An AP that transmits an HE MU PPDU shall set the UL/DL field in the HE-SIG-A field to 0.(#1862) A full bandwidth MU MIMO transmission using HE MU PPDU format has a value of 1 for the SIGB Compression field in HE-SIG-A and the SIGB Common field is not present.(#2126) If the value of SIGB Compression field in HE-SIG-A is 0, the RU allocation signaling in the HE-SIG-B common field indicates the combination of RUs in current PPDU bandwidth and the number of STAs on each RU for SU/MU-MIMO(#1507) transmission. The number of users in RU r for MU-MIMO transmission, $N_{user,r}$ is indicated together with the RU allocation as defined in Table 26-19 (RU allocation signaling: arrangement and number of MU-MIMO allocations(#2032)). If the value of the SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B Common field and HE-SIG-B contains only User specific fields. The number of STAs in the MU-MIMO(#1507) group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field(#853) in HE-SIG-A. For bandwidths larger than 20 MHz, the User block fields are split equitably between two SIG-B channels, i.e., for a k user MU-MIMO PPDU, 1, …., ceil(k/2) User fblock fields are carried in HE-SIG-B content channel 1 and ceil(k/2) + 1, …, k User block fields in HE-SIG-B content channel 2.(#1005) The number of spatial streams, $N_{SS,r,u}$, is indicated by the NSTS field in user specific block as defined in Table 26-20 (Fields of the HE-SIG-B user field for an(#916) non-MU-MIMO(#1101) allocation(#2037)) and Table 26-21 (Fields of the HE-SIG-B user field for an(#2817) MU-MIMO allocation(#2037)).(#946) The allocated spatial streams for a designated MU-MIMO(#1507) user and the total number of spatial streams on the RU are indicated in spatial configuration field of user specific block containing the STA ID of designated MU-MIMO(#1507) STA as defined in Table 26-22 (Spatial Configuration subfield encoding).

When processing the HE-SIG-B, a STA will look at information of each RU to find out its membership status, i.e., if it belongs to a beamformee group in a certain RU. If $N_{user,r}$ STAs are scheduled in RU r, there are $N_{user,r}$ user specific blocks for RU r. Each user specific block has an 11-bit field indicating the STA ID. A STA identifies itself as a member in the beamformee group in the RU, if its STA ID matches one of the STA IDs. The user position is indicated by the block index. From a multiplexing information lookup table for $N_{user,r}$, the ordered number of spatial streams for all members in the beamformee group in RU r, $N_{SS,r,u}$, $u = 1, \ldots, N_{user,r}$, is obtained. The spatial streams of different users are ordered in accordance to user position values, i.e., the spatial streams for the user in user position 0 come first, followed by the spatial streams for the user in position 1, followed by the spatial streams for the user in position 2, and followed by the spatial streams for the user in position 3, and so on.

A STA is also able to identify the space-time streams intended for other STAs that act as interference. HE-LTF symbols in the DL HE MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, it is recommended that the STA uses the channel knowledge for all space-time streams to reduce the effect of interfering space-time streams.

If a STA finds that it is a member of the beamformee group in RU r, its corresponding $N_{STS,r,u}$ interpreted from the HE-SIG-B user specific blocks shall not be zero for the STA in the PPDU. If a STA finds that it is not a member of the beamformee group in RU r, then the STA may elect not to process RU r in the remainder of the PPDU.

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26.3.14.4 UL MU transmission

26.3.14.4.1 Introduction

UL MU transmissions allow an AP to receive simultaneous frames from more than one non-AP STA. UL MU transmissions are preceded by a Trigger frame from the AP. The non-AP STA uses the HE trigger-based PPDU for UL MU transmission.

26.3.14.5 UL MU-MIMO

26.3.14.5.1 Introduction

UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs.

26.3.14.5.2 Minimum RU size in UL MU-MIMO

A STA capable of an UL MU-MIMO transmission on an RU that does not span the entire PPDU bandwidth in an HE trigger-based PPDU shall support UL MU-MIMO transmission for all RU sizes greater than or equal to 106 subcarriers.(#1862)

26.3.14.5.3 MU-MIMO LTF Mode

A STA capable of UL MU-MIMO transmission on full bandwidth shall support single stream pilot and masking LTF sequence of each spatial stream by a distinct orthogonal code.

A STA capable of UL OFDMA with MU-MIMO transmission on an RU in an HE trigger-based PPDU shall support single stream pilot for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmission on an RU in an HE trigger-based PPDU.

26.3.14.5.4 Maximum number of spatial streams in an HE trigger-based PPDU

A STA capable of UL MU-MIMO transmission shall support UL MU-MIMO transmissions on full bandwidth with maximum number of space-time streams (per user) equal to minimum of 4 and the maximum number of space-time streams supported for transmission of HE SU PPDUs. The maximum number of space-time streams supported for transmission of HE SU PPDUs is indicated for various bandwidths in 'HE-MCS and Nss Map' field in the HE Capabilities element(#1785).

A STA capable of UL MU-MIMO transmission on the full bandwidth shall support a total of up to 8 space-time streams in the UL MU-MIMO transmission.

All of the aforementioned restrictions on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

26.3.14.5.5 Resource allocation for an HE trigger-based PPDU

UL MU transmissions are preceded by a Trigger frame from the AP. The Trigger frame indicates the transmitting STAs in the Common Info field(#948) about when to transmit the UL MU-MIMO PPDUs, the duration of the payload, and packet-extension. The GI duration(#1420) for UL OFDMA/MU-MIMO transmissions shall also be explicitly indicated by AP in the Trigger frame. The value of GI duration(#1420)

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for all users addressed by the Trigger frame shall be the same. The Trigger frame indicates whether the UL MU transmission following it uses single stream pilots or a mask on each spatial stream of the LTF sequence by a distinct orthogonal code. When single stream pilot is used, no masking is applied to the HE-LTF. Single stream pilot is used for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmissions. The appropriate MU-MIMO LTF mode indicated by the Trigger frame is used for full bandwidth UL MU-MIMO transmission.(#1862) The allocated RU and spatial streams are carried in the fields of RU allocation info and SS allocation of User Info(#1520) field, where Address field is set as the AID of designated MU-MIMO(#1507) STA. Details TBD.

If a STA finds that there is no User Info(#1520) field in Trigger frame carrying the STA's AID in the Address field, then the STA will not transmit in the following HE trigger-based PPDU.

26.3.15 Transmit requirements for an HE trigger-based PPDU(#340)

26.3.15.1 Introduction

HE trigger-based PPDU transmissions are preceded by a Trigger frame from the AP. Since multiple transmitters take part in an HE trigger-based PPDU transmission, it requires transmission time, frequency, sampling symbol clock, and power pre-correction by the participating STAs to mitigate the synchronization related issues at the AP. Frequency and sampling clock pre-corrections are needed to prevent inter-carrier interference. Power pre-correction is required to control interference among participating STAs HE trigger-based PPDU transmission. An AP can schedule in the same HE trigger-based PPDU transmission both Class A and Class B devices. A STA participating in HE trigger-based PPDU transmissions shall support power pre-correction described in 26.3.15.2 (Power pre-correction) and shall meet pre-correction accuracy requirements described in 26.3.15.3 (Pre-correction accuracy requirements).

26.3.15.2 Power pre-correction

An AP indicates in the AP Tx Power subfield of the Common Info field in Trigger frame the combined transmit power of all the transmit antennas used to transmit the Trigger frame normalized to 20 MHz bandwidth. An AP indicates in the Target RSSI subfield of the User Info field in Trigger frame the target receive signal power averaged over the AP's antennas for the HE trigger-based PPDU.

Each STA that is scheduled in the Trigger frame calculates UL transmit power, Tx_{pwr}^{STA}, of the HE trigger-based PPDU for the assigned MCS using Equation (26-120).

$$Tx_{pwr}^{STA} = PL_{DL} + \mathrm{Target}_{RSSI} \quad (26\text{-}120)$$

where PL_{DL} represents DL pathloss and $Target_{RSSI}$ represents target receive signal power averaged over the AP's antennas for the HE trigger-based PPDU. $Target_{RSSI}$ is dBm value of Target RSSI subfield of User Info field in Trigger frame, the encoding of which is specified in Table 9-ax8 (Target RSSI subfield encoding). Note that an encoded value of 127 in Target RSSI subfield indicates to the STA to transmit an HE trigger-based PPDU at its maximum transmit power for the assigned MCS.

Each STA computes PL_{DL} using Equation (26-121).

$$PL_{DL} = Tx_{pwr}^{AP} - DL_{RSSI} \quad (26\text{-}121)$$

where Tx_{pwr}^{AP} represents AP's combined transmit power of all the transmit antennas used to transmit the Trigger frame normalized to 20 MHz bandwidth and DL_{RSSI} represents measured received power from the

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legacy preamble portion of the Trigger frame at the STA, also normalized to 20 MHz bandwidth. Tx_{pwr}^{AP} is dBm value of AP Tx Power subfield of the Common Info field in Trigger frame, the encoding of which is specified in Table 9-ax6 (AP Tx Power subfield encoding). DL_{RSSI} is an average of the received power over the antennas on which the average PL_{DL} is being computed.

The UL transmit power of HE trigger-based PPDU is further subject to a STA's minimum and maximum transmit power limit due to hardware capability, regulatory requirements as well as non-802.11 in-device coexistence requirements.

Each STA that is scheduled in the Trigger frame transmits UL Power headroom HR_{STA} in the HE trigger-based PPDU to assist in the AP's MCS selection. The UL power headroom for the assigned MCS is defined in Equation (26-122).

$$HR_{STA} = Tx_{pwr}^{Max} - Tx_{pwr}^{STA} \quad (26\text{-}122)$$

where Tx_{pwr}^{Max} and Tx_{pwr}^{STA} represent maximum UL transmit power of HE trigger-based PPDU for the assigned MCS and current UL transmit power of HE trigger-based PPDU for the assigned MCS, respectively. HR_{STA} is dB value of UL Headroom in HE trigger-based PPDU, the encoding of which is specified in 9.2.4.6.5.1 (UL power headroom). Note that the MSB bit of the UL Headroom subfield being set to 1 indicates that the STA is transmitting the HE trigger-based PPDU at its minimum Tx_{pwr}^{STA} for the assigned MCS.

26.3.15.3 Pre-correction accuracy requirements

A STA that transmits an HE trigger-based PPDU shall support per chain max(P−32, −10 dBm)(#1422) as the minimum transmit power, with P the maximum power the STA can transmit at the antenna connector of that chain using MCS 0(#1616) while meeting the TX EVM and spectral mask requirements. A STA transmitting at and above the minimum power shall support the EVM requirements for MCS 7(#1616) (TBD whether support for higher MCS).

A STA that transmits an HE trigger-based PPDU shall support the absolute transmit power requirements and the RSSI measurement accuracy requirements defined in Table 26-38 (Transmit power and RSSI measurement accuracy). The absolute transmit power accuracy is applicable for the entire range of transmit

Table 26-38—Transmit power and RSSI measurement accuracy

Parameter	Minimum Requirement		Comments
	Class A	Class B	

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Table 26-38—Transmit power and RSSI measurement accuracy *(continued)*

Absolute transmit power accuracy	±3 dB	±9 dB	Accuracy of achieving a specified transmit power
RSSI measurement accuracy	±3 dB(#340)	±5 dB	The difference between the RSSI and the received power(#1786) Requirements are valid from minimum Rx to maximum Rx input power
Relative transmit power accuracy	-	±3 dB	Accuracy of achieving a change in transmit power for consecutive HE trigger-based PPDU The relative transmit power accuracy is applicable only to Class B devices.(#340)

power that the STA is capable of. The RSSI accuracy requirements shall be applied to receive signal level range from −82 dBm to −20 dBm in 2.4 GHz and −82 dBm to −30 dBm in 5 GHz. The requirements are for nominal (room) temperature conditions. The RSSI shall be measured during the reception of the PHY legacy preamble.(#340)

A STA that transmits an HE trigger-based PPDU shall pre-compensate for carrier frequency offset (CFO) error and symbol clock error. After compensation, the absolute value of residual CFO error with respect to the PPDU carrying the associated Trigger frame shall not exceed 350 Hz for data subcarriers when measured as the 10% point of CCDF of CFO errors in AWGN at a received power of −60 dBm in the primary 20 MHz. The residual CFO error measurement shall be made on the HE trigger-based PPDU following the HE-SIG-A field. The symbol clock error shall be pre-compensated by the same ppm amount as CFO error.(#340)

A STA that transmits an HE trigger-based PPDU shall have timing accuracy of ±0.4 μs relative to the PPDU carrying the Trigger frame. This requirement does not include round trip delay.

26.3.16 SU-MIMO and DL MU-MIMO beamforming

26.3.16.1 General

(#507)For SU-MIMO DL MU-MIMO beamforming in RU r, the receive signal vector in subcarrier k (where subcarrier k is one of the subcarriers in RU r, $k \in K_r$) at beamformee u, $\boldsymbol{y}_{k,u} = [y_{k,0}, y_{k,1}, \ldots, y_{k,N_{RX_u}-1}]^T$, is shown in Equation (26-123), where $\boldsymbol{x}_k = [\boldsymbol{x}_{k,0}^T, \boldsymbol{x}_{k,1}^T, \ldots, \boldsymbol{x}_{k,N_{user,r}-1}^T]^T$ denotes the transmit signal vector in subcarrier k for all N_{user} beamformees, with $\boldsymbol{x}_{k,u} = [x_{k,0}, x_{k,1}, \ldots, x_{k,N_{STS,r,u}-1}]^T$ being the transmit signal for beamformee u.

$$\boldsymbol{y}_{k,u} = \boldsymbol{H}_{k,u} \times [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}] \times \boldsymbol{x}_k + \boldsymbol{n} \quad (26\text{-}123)$$

where

$\boldsymbol{H}_{k,u}$ is the channel matrix from the beamformer to beamformee u in subcarrier k with dimensions $N_{RX_u} \times N_{TX}$

N_{RX_u} is the number of receive antennas at beamformee u

$Q_{k,u}$ is a steering matrix for beamformee u in subcarrier k with dimensions $N_{TX} \times N_{STS,r,u}$

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$N_{user,r}$ is the number of HE MU PPDU recipients (see Table 26-6 (Frequently used parameters(#282))) in RU r

$\boldsymbol{n}$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.63 (HE Compressed Beamforming Report field) and 9.4.1.64 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission.

For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.63 (HE Compressed Beamforming Report field).

26.3.16.2 Beamforming feedback matrix *V*

Upon receipt of a HE NDP PPDU, the beamformee computes a set of matrices for feedback to the beamformer as described in 21.3.11.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU) from the measured channel before computing a set of matrices for feedback to the beamformer.

The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k in RU r shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,v)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is set by the beamformer, i.e., HE AP. The number of bits for quantization, tone grouping factor, and the number of columns in the HE Compressed beamforming feedback are set by the beamformee, i.e., non-AP STA, only if the NDP Announcement frame is addressed to a single non-AP STA and SU type feedback is solicited. The compressed beamforming feedback matrix as defined in(#Ed) 19.3.12.3.6 (Compressed beamforming feedback matrix) is the only Clause 26 beamforming feedback matrix defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP.

After receiving the angle information, $\phi(k,v)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer uses $V_{k,0}$, matrix to determine the steering matrix Q_k. For MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ ($0 \le u \le N_{user,r}-1$) in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

26.3.16.3 CQI-only feedback

Whenever the HE NDP Announcement frame is requesting a CQI-only feedback, upon receipt of the HE NDP, the beamformee computes HE CQI-only feedback as described in 9.4.1.64. The CQI-only feedback $CQI_{s,r,u}$, in RU r for space time stream s shall be estimated using the method described in 9.4.1.64. The CQI values to be fed back are derived from quantized SNRs according to Table XX-4. The beamformee shall transmit the HE CQI-only feedback for space-time stream 1, …, Nc for each of the RU indices for which the CQI-only report is being requested by the beamformer. After receiving the CQI information, the

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beamformer may use it to identify the best range of RUs for compressed beamforming feedback or for RU assignment during subsequent MU transmissions. The actual use is implementation specific.

26.3.17 Transmit specification

26.3.17.1 Transmit spectral mask

(PHY Motion #161)When channel puncturing happens in an HE MU PPDU, the HE MU PPDU is still treated as an 80 MHz or 160 MHz (80+80 MHz) PPDU, therefore the spectral mask is the same as those defined for the total channel width.

26.3.17.2 Spectral flatness

26.3.17.3 Transmit center frequency and symbol clock frequency tolerance

Transmit center frequency and the symbol clock frequency for all transmit antennas and frequency segments shall be derived from the same reference oscillator.

26.3.17.4 Modulation accuracy

26.3.17.4.1 Introduction to modulation accuracy tests

26.3.17.4.2 Transmit center frequency leakage

The TX LO leakage requirement for all transmission modes shall be the following. The power measured at the location of the RF LO using resolution BW 78.125 kHz shall not exceed the maximum of –32 dB relative to the total transmit power and –20 dBm, or equivalently max(P–32, –20), where P is the transmit power per antenna in dBm. The transmit center frequency leakage is specified per antenna.

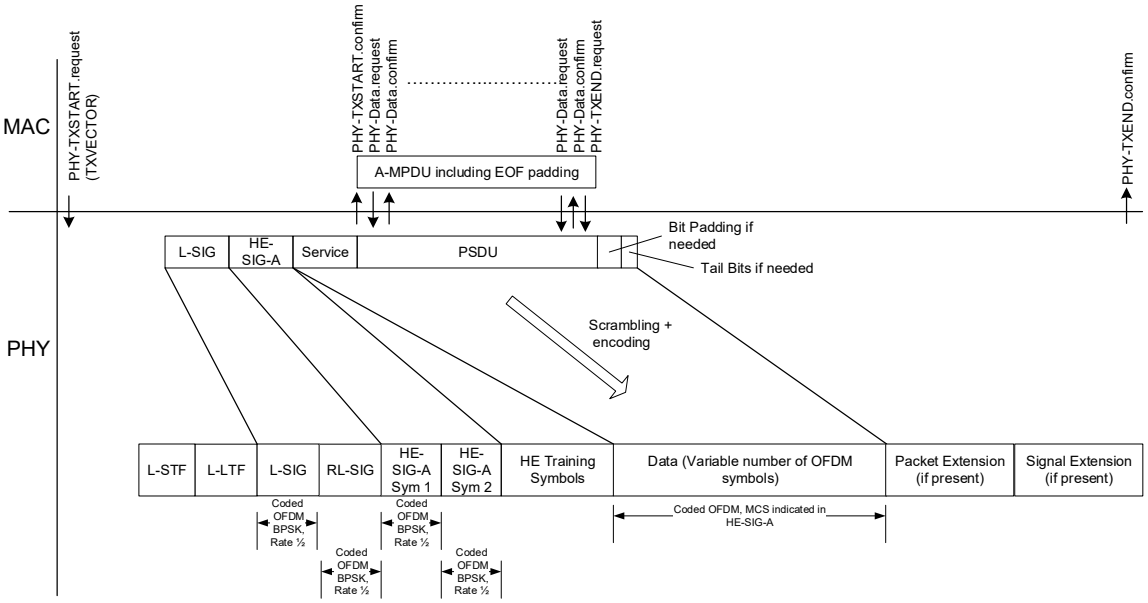
26.3.17.4.3 Transmitter constellation error

26.3.18 HE transmit procedure

(#493)There are five options for the transmit PHY procedure. The first four options, for which typical transmit procedures are shown in Figure 26-37 (PHY transmit procedure for an HE SU PPDU), Figure 26-39 (PHY transmit procedure for an HE MU PPDU), Figure 26-38 (PHY transmit procedure for an HE extended range SU PPDU) and Figure 26-40 (PHY transmit procedure for an HE trigger-based PPDU), are selected if the FORMAT field of the PHY-TXSTART.request(TXVECTOR) primitive is equal to HE_SU,

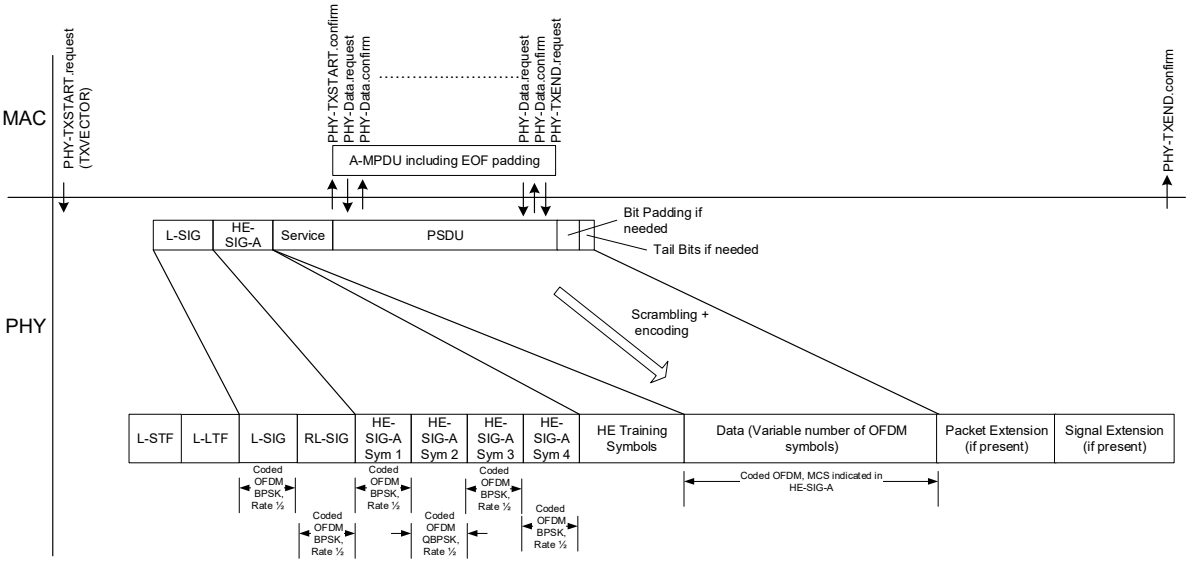
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HE_MU, HE_EXT_SU, or HT_TRIG, respectively. These transmit procedures do not describe the operation of optional features, such as DCM and TBDs.



NOTE—This procedure does not describe the operation of optional features, such as xxx.

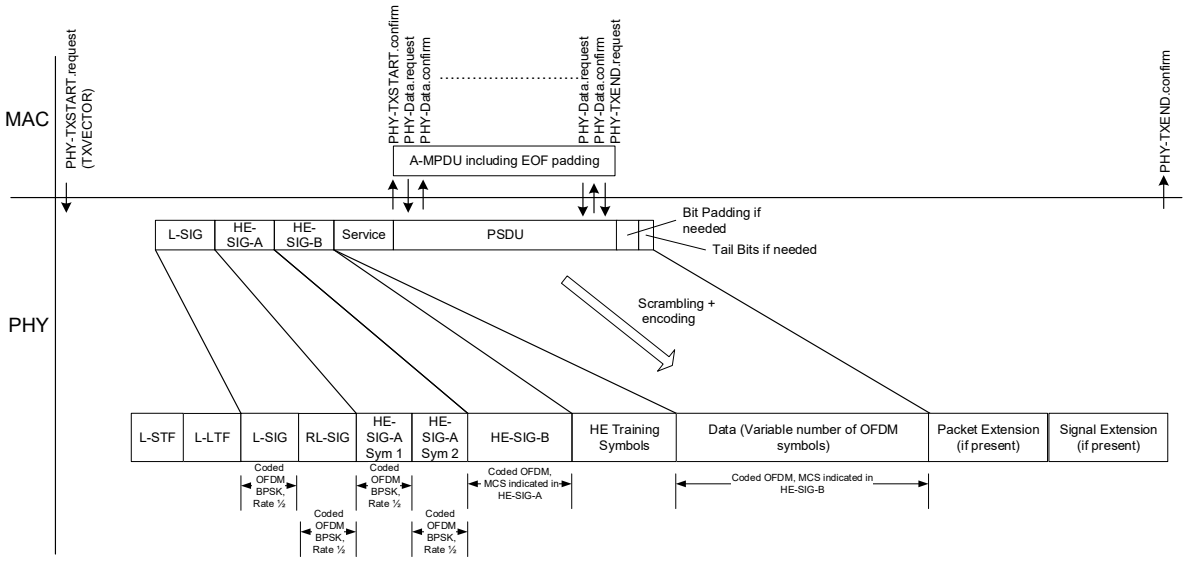
Figure 26-37—PHY transmit procedure for an HE SU PPDU



NOTE—This procedure does not describe the operation of optional features, such as xxx.

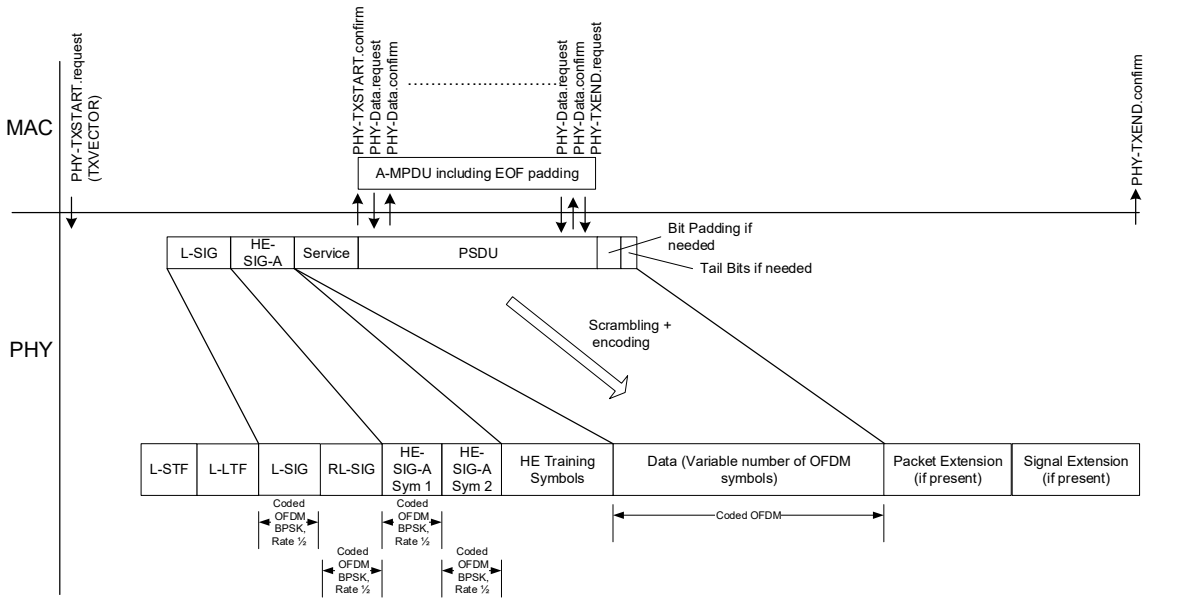
Figure 26-38—PHY transmit procedure for an HE extended range SU PPDU

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NOTE—This procedure does not describe the operation of optional features, such as xxx.

Figure 26-39—PHY transmit procedure for an HE MU PPDU



NOTE—This procedure does not describe the operation of optional features, such as xxx.

Figure 26-40—PHY transmit procedure for an HE trigger-based PPDU

The fifth option is to follow the transmit procedure in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) if the FORMAT parameter of the PHYTXSTART.request(TXVECTOR) primitive is NON_HT and the NON_HT_MODULATION parameter is set to NON_HT_DUP_OFDM except that the signal referred to in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) is instead generated simultaneously on each of the

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20 MHz channels that are indicated by the CH_BANDWIDTH parameter as defined in 26.3.10 (HE preamble) and 26.3.13 (Non-HT duplicate transmission).

NOTE 1—For an HE MU PPDU the A-MPDU is per user in the MAC sublayer and the HE Training Symbols, and Data are per user in the PHY in Figure 26-39 (PHY transmit procedure for an HE MU PPDU), with the number HE Training Symbols depending on the maximum total number of space-time streams across all RUs.

NOTE 2—The transmit procedure for NON_HT, HT_MF, HT_GF, and VHT format are specified in 26.2.x (Support for NON-HT, HT, and VHT formats).

In all options, in order to transmit data, the MAC generates a PHY-TXSTART.request primitive, which causes the PHY entity to enter the transmit state. Further, the PHY is set to operate at the appropriate frequency through station management via the PLME, as specified in 26.4 (HE PLME). Other transmit parameters, such as HE-MCS Coding types and transmit power, are set via the PHY-SAP using the PHYTXSTART.request(TXVECTOR) primitive, as described in 26.2.2 (TXVECTOR and RXVECTOR parameters). The remainder of the clause applies to the first four options.

The PHY indicates the state of the primary channel and other channels (if any) via the PHY-CCA.indication primitive (see 22.3.18.5 (CCA sensitivity) and 7.3.5.12 (PHY-CCA.indication)). Transmission of the PPDU shall be initiated by the PHY after receiving the PHY-TXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request primitive are specified in Table 26-1 (TXVECTOR and RXVECTOR parameters(#1780)).

Transmission of the PHY preamble may start if TIME_OF_DEPARTURE_REQUESTED is false, and shall start immediately if TIME_OF_DEPARTURE_REQUESTED is true, based on the parameters passed in the PHY-TXSTART.request primitive.

If all of the following conditions are met:

— if dot11TODImplemented and dot11TODActivated are true or if dot11TimingMsmtActivated is true,

— the TXVECTOR parameter TIME_OF_DEPARTURE_REQUESTED is true,

then the PHY shall issue a PHY-TXSTART.confirm(TXSTATUS) primitive to the MAC, forwarding the TIME_OF_DEPARTURE corresponding to the time when the first frame energy is sent by the transmitting port and TIME_OF_DEPARTURE_ClockRate parameter within the TXSTATUS vector. If dot11TimingMsmtActivated is true, then the PHY shall forward the value of TX_START_OF_FRAME_OFFSET in TXSTATUS vector.

After the PHY preamble transmission is started, the PHY entity immediately initiates data scrambling and data encoding. The encoding method for the Data field is based on the FEC_CODING, CH_BANDWIDTH, NUM_STS, STBC, MCS, and NUM_USERS parameter of the TXVECTOR, as described in 26.3.2 (HE PPDU formats).

The SERVICE field and PSDU are encoded as described in 26.3.3 (Transmitter block diagram). The data shall be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. PHY padding bits are appended to the PSDU to make the number of bits in the coded PSDU an integral multiple of the number of coded bits per OFDM symbol.

Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PSDU transmission is terminated by receiving a PHY-TXEND.request primitive. Each PHYTXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY.

A packet extension and/or a signal extension may be present in the PPDU. When no packet extension and signal extension are present, the PHY-TXEND.confirm primitive is generated at the end of last symbol of

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the PPDU. When a packet extension and/or a signal extension present, the PHY-TXEND.confirm primitive is generated at the end of the packet extension or signal extension.

In the PHY, the GI with GI duration indicated in GI_TYPE parameter of the TXVECTOR is inserted in every data OFDM symbol as a countermeasure against delay spread.

When the PPDU transmission is completed the PHY entity enters the receive state.

A typical state machine implementation of the transmit PHY for an HE PPDU transmission is provided in Figure 26-41 (PHY transmit state machine for an HE PPDU). Request (.request) and confirmation(.confirm) primitives are issued once per state as shown. This state machine does not describe the operation of optional features, such as DCM.

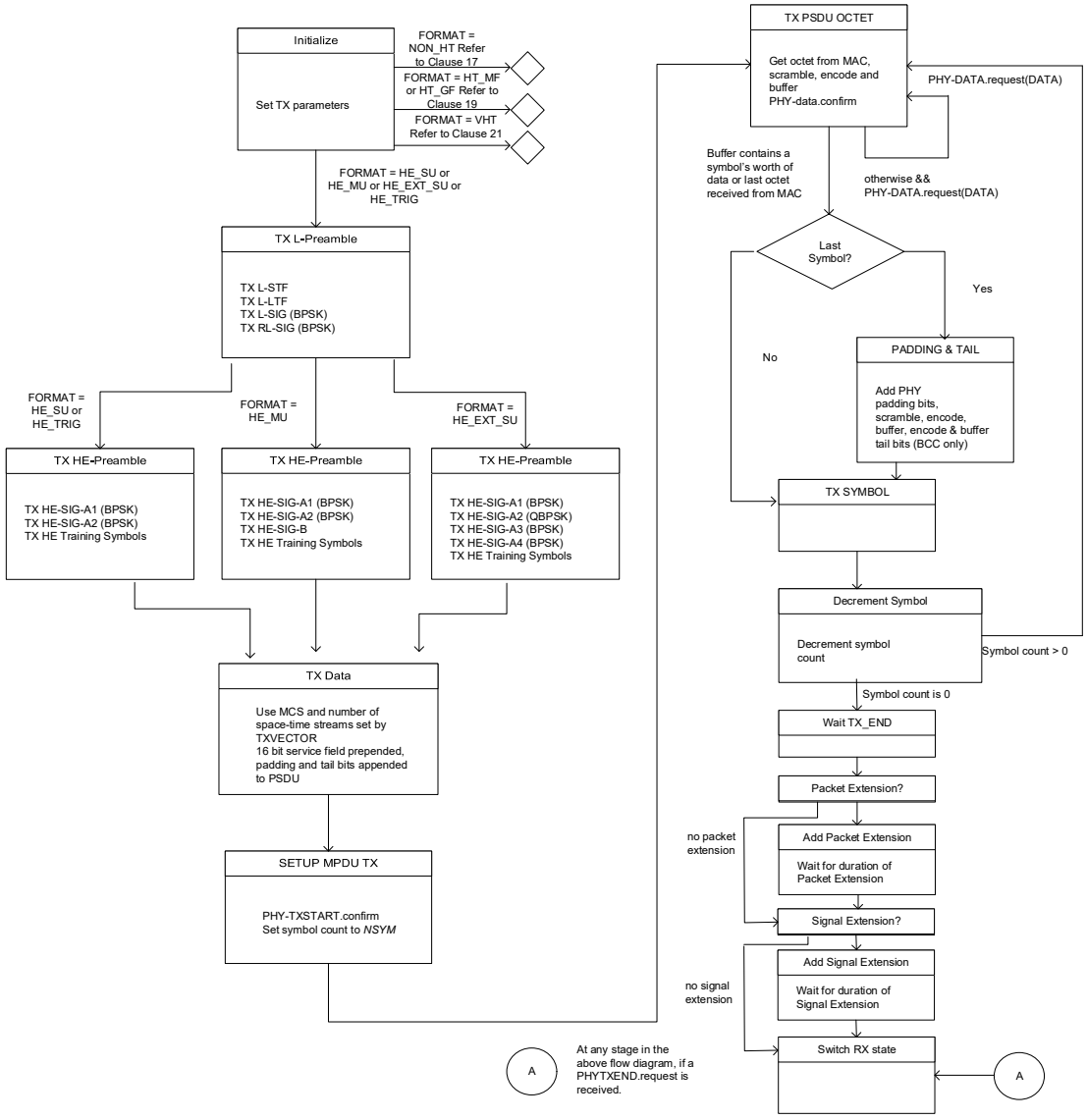
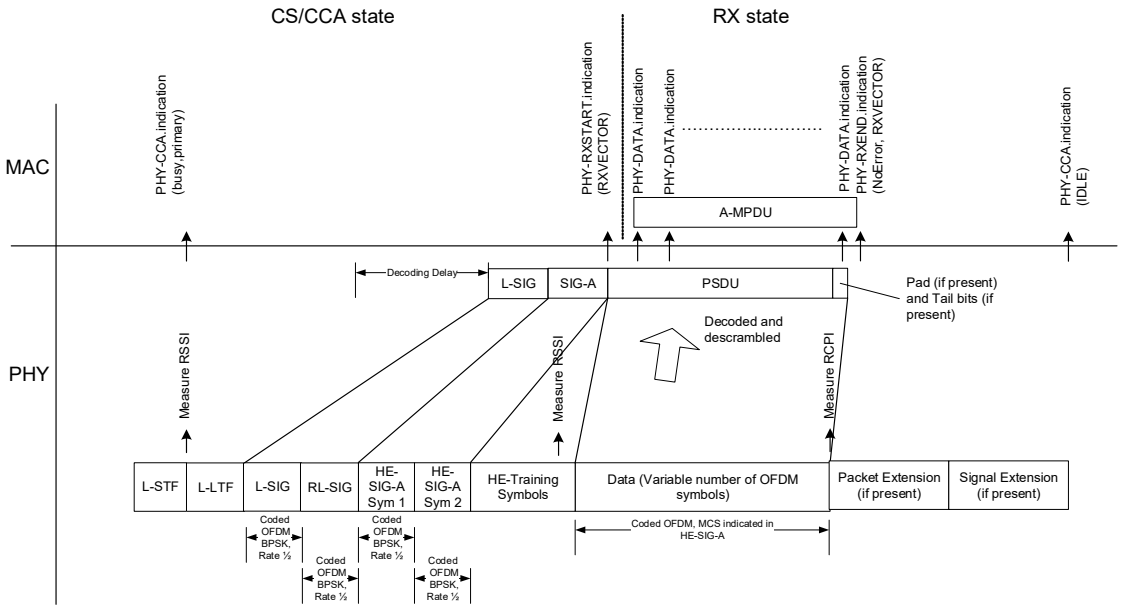


Figure 26-41—PHY transmit state machine for an HE PPDU

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26.3.19 HE receive procedure

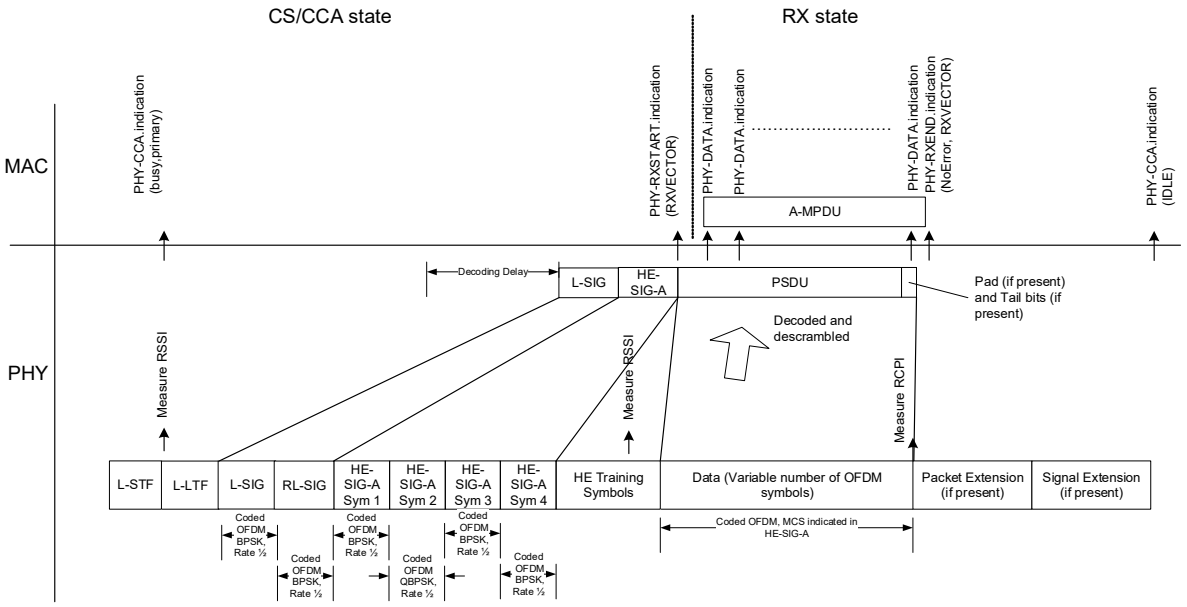
(#494)Typical PHY receive procedures are shown in Figure 26-42 (PHY receive procedure for an HE SU PPDU), Figure 26-43 (PHY receive procedure for an HE extended range SU PPDU), Figure 26-44 (PHY receive procedure for an HE MU PPDU), and Figure 26-45 (PHY receive procedure for an HE trigger-based PPDU) respectively. A typical state machine implementation of the receive PHY is given in Figure 26-46 (PHY receive state machine). This receive procedure and state machine do not describe the operation of optional features, such as DCM. If the detected format indicates a Non-HT PPDU, refer to the receive procedure and state machine in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification). If the detected format indicates an HT PPDU format, refer to the receive procedure and state machine in Clause 19 (High Throughput (HT) PHY specification). If the detected format indicates a VHT PPDU format, refer to the receive procedure and state machine in Clause 21 (Very High Throughput (VHT) PHY specification).Through station management (via the PLME) the PHY is set to the appropriate frequency, as specified in 26.4 (HE PLME). The PHY has also been configured with cell identification information and STA identification information (i.e., BSS Color value and STA ID in the cell) so that it can receive data intended for the STA in the specific cell. Other receive parameters, such as RSSI and indicated DATARATE, may be accessed via the PHY-SAP.



NOTE—This procedure does not describe the operation of optional features, such as xxx.

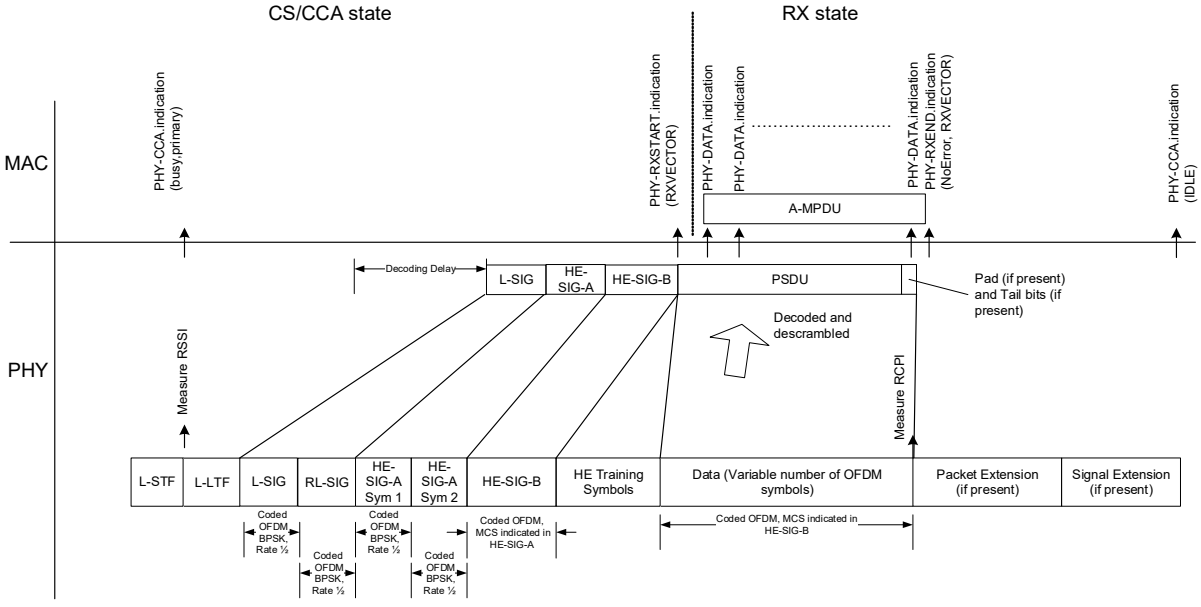
Figure 26-42—PHY receive procedure for an HE SU PPDU

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NOTE—This procedure does not describe the operation of optional features, such as xxx.

Figure 26-43—PHY receive procedure for an HE extended range SU PPDU



NOTE—This procedure does not describe the operation of optional features, such as xxx.

Figure 26-44—PHY receive procedure for an HE MU PPDU

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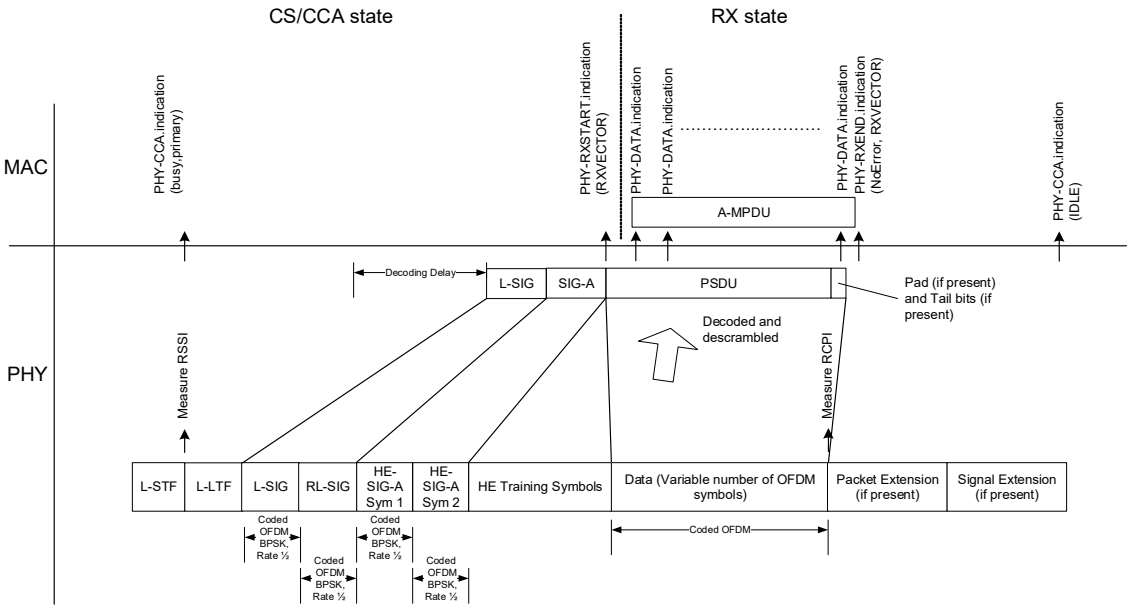


Figure 26-45—PHY receive procedure for an HE trigger-based PPDU

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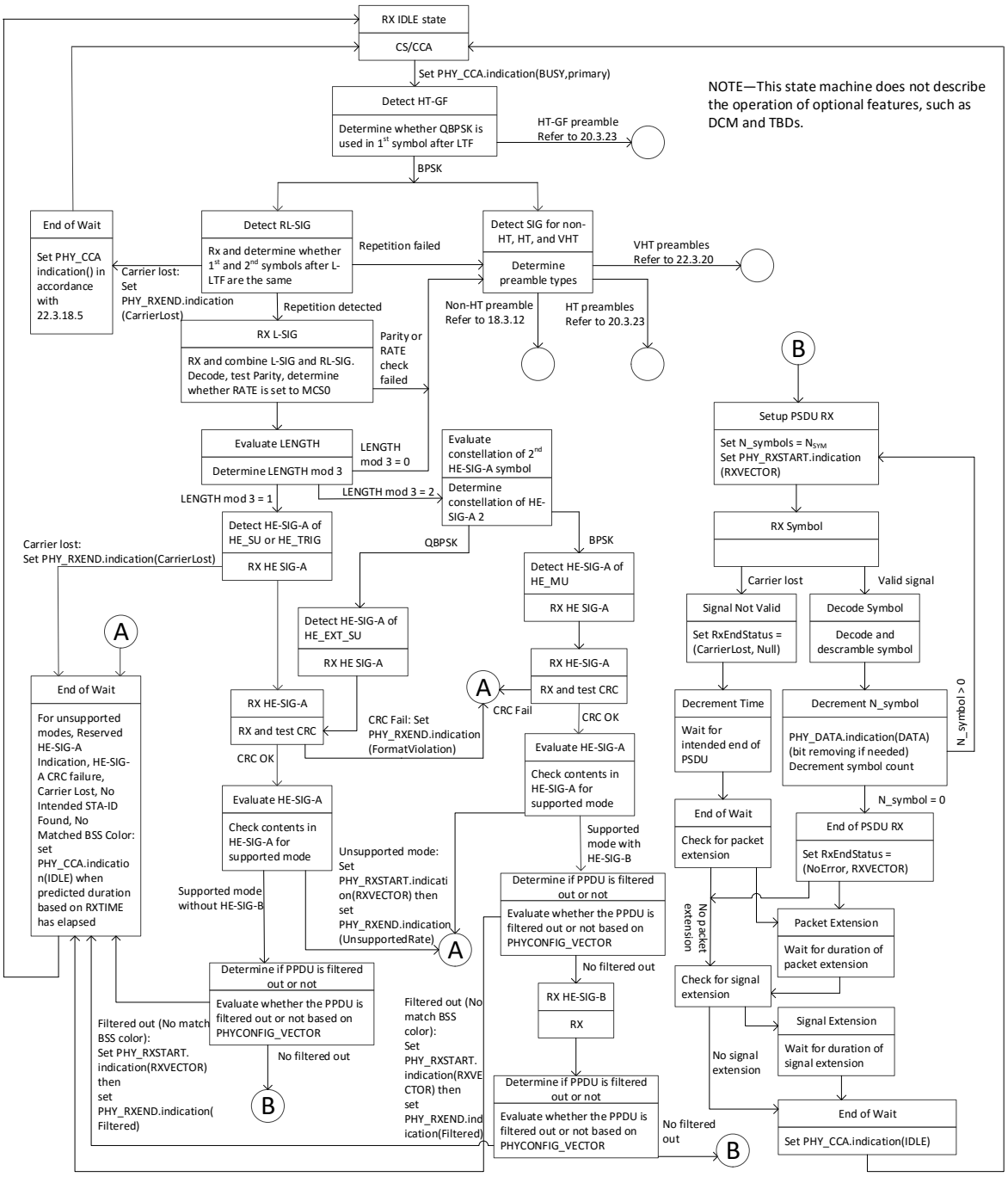


Figure 26-46—PHY receive state machine

Upon receiving the transmitted PHY preamble overlapping the primary 20 MHz channel in a greater than or equal to 20 MHz BSS, the PHY measures a receive signal strength. This activity is indicated by the PHY to the MAC via a PHY-CCA.indication primitive. A PHY-CCA.indication(BUSY, channel-list) primitive is also issued as an initial indication of reception of a signal as specified in 22.3.18.5 (CCA sensitivity). The channel-list parameter of the PHYCCA.indication primitive is absent when the operating channel width is

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20 MHz. The channel-list parameter is present and includes the element primary when the operating channel width is 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz.

The PHY shall not issue a PHY-RXSTART.indication primitive in response to a PPDU that does not overlap the primary channel, except when the PHY at an AP receives the HE-trigger based PPDU. In such case, the PHY shall issue a PHY-RXSTART.indication primitive in response to a PPDU transmission either at the primary or at the secondary channel.

The PHY includes the most recently measured RSSI value in the PHY-RXSTART.indication(RXVECTOR) primitive issued to the MAC. The RSSI measurement for HE-trigger based PPDU is TBD.

After the PHY-CCA.indication(BUSY, channel-list) primitive is issued, the PHY entity shall begin receiving the training symbols and searching for the preambles for NON-HT, HT, VHT, and HE PPDUs, respectively. If the constellation used in the first symbol after the first long traing field is QBPSK, the PHY entity shall continue to detect the received signal using the receive procedure for HT-GF depicted in Clause 19. Otherwise, for detecting the HE preamble, the PHY entity shall search for L-SIG and RL-SIG in order to set the maximum duration of the data stream. If RL-SIG is detected, the PHY entity should check the parity bit and RATE fields in L-SIG and RL-SIG. If either the check of the parity bit is invalid or the RATE field is not set to MCS0 in NON-HT, a PHY-RXSTART.indication primitive is not issued. If the check of the parity bit is valid and the RATE field is set to MCS0 but the LENGTH field value in L-SIG is a multiple of 3, a PHY-RXSTART.indication primitive is not issued. In both cases, the PHY should continue to detect the received signal using non-HT, HT, and VHT receive procedure in Clauses 17, 19, and 21, respectively.

If a valid parity bit and the RATE with MCS0 are indicated in L-SIG and RL-SIG and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 1 after LENGTH divided by 3, the PHY entity should begin receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for HE SU PPDU and HE trigger-based PPDU as shown in Figure 26-42 (PHY receive procedure for an HE SU PPDU) and Figure 26-45 (PHY receive procedure for an HE trigger-based PPDU), respectively. After RL-SIG, the PHY entity shall receive two symbols of HE-SIG-A immediately followed by HE-STF. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color and check Format field, and continue to receive HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color doesn't contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). The PHY entity shall check Format field in HE-SIG-A. If the Format field indicates an HE SU PPDU, the PHY entity shall receive HE-STF for 4 μs after HE-SIG-A. If the Format field indicates an HE trigger-based PPDU, the PHY entity shall receive HE-STF for 8 μs after HE-SIG-A. The PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (21-106), for all supported modes, unsupported modes, Reserved HE-SIG-A Indication, and invalid HE-SIG-A CRC. Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or TBD. If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate)primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation)primitive.

If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is QBPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for HE_EXT_SU PPDU shown in Figure 26-42. After RL-SIG, the PHY entity shall receive four symbols of HE-SIG-A immediately followed by HE-STF. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color, and continue to receive HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color doesn't contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). The PHY entity

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shall receive HE-STF for 4 μs after HE-SIG-A. The PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (21-106), for all supported modes, unsupported modes, Reserved HE-SIG-A Indication, and invalid HE-SIG-A CRC. Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or TBD. If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate)primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation)primitive.

If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is BPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF for HE_MU PPDU shown in Figure 26-43. After RL-SIG, the PHY entity shall receive two symbols of HE-SIG-A immediately followed by HE-SIG-B. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color, and continue to receive HE-SIG-B. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color doesn't contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). After HE-SIG-A, the PHY entity shall receive HE-SIG-B for the number of symbols predicted from HE-SIG-A. If the common field presents in HE-SIG-B, the PHY entity shall check the CRC of the common field. If the CRC in the common field is valid or the common field is not present, the PHY entity shall search for intended STA-ID in each user-specific subfield with a valid CRC. If no CRC is valid or no intended STA-ID is detected, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). If a complete allocation of an intended STA-ID is detected in block with valid CRC, the PHY entity shall continue receiving HE-STF for 4 μs after HE-SIG-B for the detected and intended STA. The PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (26-124), for all supported modes, unsupported modes, Reserved HE-SIG-A Indication, and invalid HE-SIG-A CRC. Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or TBD. If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate)primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation)primitive.

If signal loss occurs during reception prior to completion of the PSDU reception, the error condition PHYRXEND. indication(CarrierLost) shall be reported to the MAC. After waiting for the end of the PPDU as determined by Equation (26-124) the PHY shall set the PHY-CCA.indication (IDLE) primitive and return to the RX IDLE state.

$$\text{RXTIME}(\mu s) = \left\lceil \frac{\text{L\_LENGTH} + 3}{3} \right\rceil 4 + 20 + \text{Signal Extension} \qquad (26\text{-}124)$$

Signal Extension is 0 μs when TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table xxx of 26.3 (HE PHY) when TXVECTOR parameter NO_SIG_EXTN is false.

Except in an HE NDP PPDU, a Data field follows the HE-STF and HE-LTF fields. The number of symbols in Data field is determined by Equation (26-125) for an HE SU PPDU and HE trigger-based PPDU.

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - T_{\text{HE\_PREAMBLE}} \right) / T_{SYM} \right\rfloor - b_2 \qquad (26\text{-}125)$$

The number of symbols in Data field is determined by Equation (26-126) for HE extended range SU PPDU.

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$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - T_{\text{HE-SIG-A-R}} - T_{\text{HE\_PREAMBLE}} \right) / T_{SYM} \right\rfloor - b_2 \quad (26\text{-}126)$$

The number of symbols in Data field is determined by Equation (26-127) for HE MU PPDU.

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}} - T_{\text{HE\_PREAMBLE}} \right) / T_{SYM} \right\rfloor - b_2 \quad (26\text{-}127)$$

The PE field duration for an HE SU PPDU and HE trigger-based PPDU is determined by Equation (26-128).

$$T_{\text{PE}} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - T_{\text{HE\_PREAMBLE}} \right) - N_{SYM} T_{SYM}}{4} \right\rfloor \times 4 \quad (26\text{-}128)$$

The PE field duration for an HE extended range SU PPDU is determined by Equation (26-129).

$$T_{\text{PE}} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - T_{\text{HE-SIG-A-R}} - T_{\text{HE\_PREAMBLE}} \right) - N_{SYM} T_{SYM}}{4} \right\rfloor \times 4 \quad (26\text{-}129)$$

The PE field duration for an HE MU PPDU is determined by Equation (26-130).

$$T_{\text{PE}} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 + 20 - T_{\text{LEG\_PREAMBLE}} - T_{\text{L-SIG}} - T_{\text{RL-SIG}} - T_{\text{HE-SIG-A}} - N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}} - T_{\text{HE\_PREAMBLE}} \right) - N_{SYM} T_{SYM}}{4} \right\rfloor \times 4 \quad (26\text{-}130)$$

where

L_LENGTH is the LENGTH field in L-SIG;

b_2 indicates PE disambiguity in packet extension field in HE-SIG-A.

The received PSDU bits are assembled into octets, decoded, and present to the MAC using a series of PHY-DATA.indication(DATA) primitive exchanges. Any final bits that cannot be assembled into a complete octet are considered pad bits and discarded. After the reception of the final bit of the last PSDU octet, and possible padding and tail bits, the PHY entity shall check whether packet extension and/or signal extension is applied. If packet extension and/or signal extension is applied, the PHY entity shall wait until the packet extension and/or signal extension expires before returning to the RX IDLE state, as shown in Figure 26-46 (PHY receive state machine).

The receiving procedures are subject to further changes depending on the decisions of spatial reuse and 20 MHz only devices.

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26.4 HE PLME

26.4.1 PLME_SAP sublayer management primitives

Table 25-1 (HE PHY MIB attributes (11ax)) lists the MIB attributes that may be accessed by the PHY entities and the intralayer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5 (PLME SAP interface).

26.4.2 PHY MIB

TBD

26.4.3 TXTIME and PSDU_LENGTH calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an(#2829) HE PPDU using Equation (26-131) for an HE SU PPDU and HE trigger-based PPDU, Equation (26-132) for an HE MU PPDU and Equation (26-133) for an HE extended range SU PPDU.

$$\text{TXTIME} = T_{\text{LEG\_PREAMBLE}} + T_{\text{L-SIG}} + T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE\_PREAMBLE}} + N_{SYM}T_{SYM} + T_{PE} \quad (26\text{-}131)$$

$$\text{TXTIME} = T_{\text{LEG\_PREAMBLE}} + T_{\text{L-SIG}} + T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + N_{\text{HE-SIG-B}}T_{\text{HE-SIG-B}} + T_{\text{HE\_PREAMBLE}} + N_{SYM}T_{SYM} + T_{PE} \quad (26\text{-}132)$$

$$\text{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + T_{HE-SIG-A-R} + T_{HE\_PREAMBLE} + N_{SYM}T_{SYM} + T_{PE} \quad (26\text{-}133)$$

where

$T_{\text{LEG\_PREAMBLE}} = T_{L-STF} + T_{L-LTF}$

$$T_{\text{HE\_PREAMBLE}} = \begin{cases} T_{\text{HE-STF-T}} + N_{HELTF}T_{\text{HE-LTF,SYM}}, & \text{for an HE trigger-based PPDU} \\ T_{\text{HE-STF-NT}} + N_{HELTF}T_{\text{HE-LTF,SYM}}, & \text{otherwise} \end{cases}$$

$T_{\text{L-STF}}$, $T_{\text{L-LTF}}$, $T_{\text{HE-STF-T}}$, $T_{\text{HE-STF-NT}}$, $T_{\text{HE-LTF,SYM}}$, $T_{\text{L-SIG}}$, $T_{\text{RL-SIG}}$, $T_{\text{HE-SIG-A}}$, $T_{\text{HE-SIG-A-R}}$, $T_{\text{HE-SIG-B}}$, and T_{SYM} are defined in Table 26-3 (Timing-related constants)

$N_{\text{HE-SIG-B}}$ and $N_{\text{HE-LTF}}$ are defined in Table 26-6 (Frequently used parameters(#282))

For an HE NDP PPDU, there is no Data field and $N_{SYM} = 0$.

For an HE SU PPDU and HE extended range SU PPDU using BCC encoding, the total number of OFDM symbols in the Data field is given by Equation (26-134).

$$N_{SYM} = m_{STBC} \times \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{service} + N_{tail}}{m_{STBC} \cdot N_{DBPS}} \right\rceil \text{(\#282)} \quad (26\text{-}134)$$

where

m_{STBC} is equal to 2 when STBC is used, and 1 otherwise.

For an HE SU PPDU and HE extended range SU PPDU using LDPC encoding, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.11.4.2 (LDPC coding).

For an HE MU PPDU (including both MU-MIMO and OFDMA), the total number of OFDM symbols in the Data field, NSYM, is given in 26.3.11.4.4 (Encoding process for an HE MU PPDU).

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For an HE trigger-based PPDU, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.11.4.5 (Encoding process for an HE trigger-based PPDU).

T_{PE} is given by Equation (26-118).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE SU PPDU and HE extended range SU PPDU is calculated using Equation (26-135).

$$\text{PSDU\_LENGTH} = \begin{cases} \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,Last,init} - N_{service} - N_{tail}N_{ES}}{8} \right\rfloor, & \text{for BCC encoding} \\ \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,Last,init} - N_{service}}{8} \right\rfloor, & \text{for LDPC encoding} \end{cases} \quad (26\text{-}135)$$

where

$N_{SYM,init}$ is given by Equation (26-69) for BCC encoding and by Equation (26-74) for LDPC encoding;

m_{STBC} is 2 when STBC is used, and 1 otherwise;

N_{DBPS} is given in 26.5 (Parameters for HE-MCSs);

$N_{DBPS,Last,init}$ is given by Equation (26-65)

The value of the PSDU_LENGTH parameter for user u returned in the PLME-TXTIME.confirm primitive and in the RXVECTOR for an(#2829) HE MU PPDU is calculated using Equation (26-136).

$$\text{PSDU\_LENGTH}_u = \begin{cases} \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,Last,init} - N_{service} - N_{tail}N_{ES}}{8} \right\rfloor, & \text{when BCC is used for user } u \\ \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,Last,init} - N_{service}}{8} \right\rfloor, & \text{when LDPC is used for user } u \end{cases} \quad (26\text{-}136)$$

$N_{SYM,init}$ is given by Equation (26-82)

$N_{DBPS,Last,init}$is given by Equation (26-83)

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE NDP PPDU is 0.

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26.4.4 HE PHY

The static HE PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-25 (HT PHY characteristics) unless otherwise listed in Table 26-39 (HE PHY characteristics). The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 26-39—HE PHY characteristics

Characteristic	Value
aTxPHYDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aCCAMidTIme	25 μs
aPPDUMaxTime	5.484 ms
aPSDUMaxLength	TBD

26.5 Parameters for HE-MCSs(#552)

The rate-dependent parameters for 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU and non-OFDMA 20 MHz, 484-tone RU and non-OFDMA 40 MHz, 996-tone RU and non-OFDMA 80 MHz, non-OFDMA 160 MHz and 80+80 MHz N_{SS} = 1, …, 8 are given in Table 26-88 (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 1) through Table 26-95 (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8). Support for HE-MCS 8, 9, 10, and 11 (when valid) is optional in all cases. HE-MCS 10 and 11 (1024-QAM) are applicable only to RU sizes equal to or larger than 242 tones.

Dual sub-carrier modulation (DCM) is an optional modulation scheme for any OFDMA and non OFDMA transmissions. DCM is only applicable to MCS 0, 1, 3 and 4 with up to TBD number of streams and for TBD RU sizes. A HE STA shall support single spatial stream HE-MCSs within the range HE-MCS 0 to HE-MCS 7 for all channel widths for which it has indicated support regardless of the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported HE-MCS and NSS Set field. When more than one spatial stream is supported, the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported HE-MCS and NSS Set field may result in a reduced HE-MCS range (cut-off) for N_{SS} = 2, …, 8. Support for OFDMA 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU and 996-tone RU with N_{SS} = 1 is TBD mandatory/optional. Support for non-OFDMA 20 MHz, 40 MHz, and 80 MHz with N_{SS} = 1 is mandatory. Support for more than one spatial stream is optional in all cases. Support for OFDMA and non-OFDMA 160 MHz and 80+80 MHz with N_{SS} = 1, …, 8 is optional.(#282)

Table 26-40 (HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1) to Table 26-95 (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) define HE-MCSs not only for SU transmission but also for user u at r-th RU of an MU transmission. In the case of HE-MCSs for MU transmissions, the parameters, N_{SS}, R, N_{BPSCS}, N_{CBPS}, N_{DBPS}, and N_{ES} are replaced with $N_{SS,r,u}$, $R_{r,u}$, $N_{BPSCS,r,u}$, $N_{CBPS,r,u}$, $N_{DBPS,r,u}$, and $N_{ES,r,u}$, respectively.

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In the tables below, the number of streams and RU sizes that DCM is applicable to are TBD.

Table 26-40—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	24	6	0.4	0.4	0.4
0	0		1/2	1			24	12	0.9	0.8	0.8
1	1	QPSK	1/4	2			48	12	0.9	0.8	0.8
1	0		1/2	2			48	24	1.8	1.7	1.5
2	N/A		3/4	2			48	36	2.6	2.5	2.3
3	1	16-QAM	1/4	4			96	24	1.8	1.7	1.5
3	0		1/2	4			96	48	3.5	3.3	3.0
4	1		3/8	4			96	36	2.6	2.5	2.3
4	0		3/4	4			96	72	5.3	5.0	4.5
5	N/A	64-QAM	2/3	6			144	96	7.1	6.7	6.0
6			3/4	6			144	108	7.9	7.5	6.8
7			5/6	6			144	120	8.8	8.3	7.5
8		256-QAM	3/4	8			192	144	10.6	1.0	9.0
9			5/6	8			192	160	11.8	11.1	10.0

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Table 26-41—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	48	12	0.9	0.8	0.8
0	0		1/2	1			48	24	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1.8	1.7	1.5
1	0		1/2	2			96	48	3.5	3.3	3.0
2	N/A		3/4	2			96	72	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	3.5	3.3	3.0
3	0		1/2	4			192	96	7.1	6.7	6.0
4	1		3/8	4			192	72	5.3	5.0	4.5
4	0		3/4	4			192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	14.1	13.3	12.0
6			3/4	6			288	216	15.9	15.0	13.5
7			5/6	6			288	240	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	21.2	20.0	18.0
9			5/6	8			384	320	23.5	22.2	20.0

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Table 26-42—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	72	18	1.3	1.3	1.1
0	0		1/2	1			72	36	2.6	2.5	2.3
1	1	QPSK	1/4	2			144	36	2.6	2.5	2.3
1	0		1/2	2			144	72	5.3	5.0	4.5
2	N/A		3/4	2			144	108	7.9	7.5	6.8
3	1	16-QAM	1/4	4			288	72	5.3	5.0	4.5
3	0		1/2	4			288	144	10.6	10.0	9.0
4	1		3/8	4			288	108	7.9	7.5	6.8
4	0		3/4	4			288	216	15.9	15.0	13.5
5	N/A	64-QAM	2/3	6			432	288	21.2	20.0	20.3
6			3/4	6			432	324	23.8	22.5	20.3
7			5/6	6			432	360	26.5	25.0	22.5
8		256-QAM	3/4	8			576	432	31.8	30.0	27.0
9			5/6	8			576	480	35.3	33.3	30.0

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Table 26-43—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	96	24	1.8	1.7	1.5
0	0		1/2	1			96	48	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	3.5	3.3	3.0
1	0		1/2	2			192	96	7.1	6.7	6.0
2	N/A		3/4	2			192	144	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	7.1	6.7	6.0
3	0		1/2	4			384	192	14.1	13.3	12.0
4	1		3/8	4			384	144	10.6	10.0	9.0
4	0		3/4	4			384	288	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	28.2	26.7	24.0
6			3/4	6			576	432	31.8	30.0	27.0
7			5/6	6			576	480	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	42.4	40.0	36.0
9			5/6	8			768	640	47.1	44.4	40.0

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Table 26-44—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	120	30	2.2	2.1	1.9
0	0		1/2	1			120	60	4.4	4.2	3.8
1	1	QPSK	1/4	2			240	60	4.4	4.2	3.8
1	0		1/2	2			240	120	8.8	8.3	7.5
2	N/A		3/4	2			240	180	13.2	12.5	11.3
3	1	16-QAM	1/4	4			480	120	8.8	8.3	7.5
3	0		1/2	4			480	240	17.6	16.7	15.0
4	1		3/8	4			480	180	13.2	12.5	11.3
4	0		3/4	4			480	360	26.5	25.0	22.5
5	N/A	64-QAM	2/3	6			720	480	35.3	33.3	30.0
6			3/4	6			720	540	39.7	37.5	33.8
7			5/6	6			720	600	44.1	41.7	37.5
8		256-QAM	3/4	8			960	720	52.9	50.0	45.0
9			5/6	8			960	800	58.8	55.6	50.0

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Table 26-45—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	144	36	2.6	2.5	2.3
0	0		1/2	1			144	72	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	5.3	5.0	4.5
1	0		1/2	2			288	144	10.6	10.0	9.0
2	N/A		3/4	2			288	216	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	10.6	10.0	9.0
3	0		1/2	4			576	288	21.2	20.0	18.0
4	1		3/8	4			576	216	15.9	15.0	13.5
4	0		3/4	4			576	432	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	42.4	40.0	36.0
6			3/4	6			864	648	47.6	45.0	40.5
7			5/6	6			864	720	52.9	50.0	45.0
8		256-QAM	3/4	8			1 152	864	63.5	60.0	54.0
9			5/6	8			1 152	960	70.6	66.7	60.0

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Table 26-46—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	168	42	3.1	2.9	2.6
0	0		1/2	1			168	84	6.2	5.8	5.3
1	1	QPSK	1/4	2			336	84	6.2	5.8	5.3
1	0		1/2	2			336	168	12.4	11.7	10.5
2	N/A		3/4	2			336	252	18.5	17.5	15.8
3	1	16-QAM	1/4	4			672	168	12.4	11.7	10.5
3	0		1/2	4			672	336	24.7	23.3	21.0
4	1		3/8	4			672	252	18.5	17.5	15.8
4	0		3/4	4			672	504	37.1	35.0	31.5
5	N/A	64-QAM	2/3	6			1 008	672	49.4	46.7	42.0
6			3/4	6			1 008	756	55.6	52.5	47.3
7			5/6	6			1 008	840	61.8	58.3	52.5
8		256-QAM	3/4	8			1 344	1 008	74.1	70.0	63.0
9			5/6	8			1 344	1 120	82.4	77.8	70.0

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Table 26-47—HE-MCSs for TBD mandatory/optional 26-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	24	2	192	48	3.5	3.3	3.0
0	0		1/2	1			192	96	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	7.1	6.7	6.0
1	0		1/2	2			384	192	14.1	13.3	12.0
2	N/A		3/4	2			384	288	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	14.1	13.3	12.0
3	0		1/2	4			768	384	28.2	26.7	24.0
4	1		3/8	4			768	288	21.2	20.0	18.0
4	0		3/4	4			768	576	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1 152	768	56.5	53.3	48.0
6			3/4	6			1 152	864	63.5	60.0	54.0
7			5/6	6			1 152	960	70.6	66.7	60.0
8		256-QAM	3/4	8			1 536	1 152	84.7	80.0	72.0
9			5/6	8			1 536	1 280	94.1	88.9	80.0

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Table 26-48—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	48	12	0.9	0.8	0.8
0	0		1/2	1			48	24	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1.8	1.7	1.5
1	0		1/2	2			96	48	3.5	3.3	3.0
2	N/A		3/4	2			96	72	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	3.5	3.3	3.0
3	0		1/2	4			192	96	7.1	6.7	6.0
4	1		3/8	4			192	72	5.3	5.0	4.5
4	0		3/4	4			192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	14.1	13.3	12.0
6			3/4	6			288	216	15.9	15.0	13.5
7			5/6	6			288	240	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	21.2	20.0	18.0
9			5/6	8			384	320	23.5	22.2	20.0

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Table 26-49—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	96	24	1.8	1.7	1.5
0	0		1/2	1			96	48	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	3.5	3.3	3.0
1	0		1/2	2			192	96	7.1	6.7	6.0
2	N/A		3/4	2			192	144	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	7.1	6.7	6.0
3	0		1/2	4			384	192	14.1	13.3	12.0
4	1		3/8	4			384	144	10.6	10.0	9.0
4	0		3/4	4			384	288	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	28.2	26.7	24.0
6			3/4	6			576	432	31.8	30.0	27.0
7			5/6	6			576	480	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	42.4	40.0	36.0
9			5/6	8			768	640	47.1	44.4	40.0

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Table 26-50—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	144	36	2.6	2.5	2.3
0	0		1/2	1			144	72	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	5.3	5.0	4.5
1	0		1/2	2			288	144	10.6	10.0	9.0
2	N/A		3/4	2			288	216	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	10.6	10.0	9.0
3	0		1/2	4			576	288	21.2	20.0	18.0
4	1		3/8	4			576	216	15.9	15.0	13.5
4	0		3/4	4			576	432	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	42.4	40.0	36.0
6			3/4	6			864	648	47.6	45.0	40.5
7			5/6	6			864	720	52.9	50.0	45.0
8		256-QAM	3/4	8			1 152	864	63.5	60.0	54.0
9			5/6	8			1 152	960	70.6	66.7	60.0

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Table 26-51—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	192	48	3.5	3.3	3.0
0	0		1/2	1			192	96	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	7.1	6.7	6.0
1	0		1/2	2			384	192	14.1	13.3	12.0
2	N/A		3/4	2			384	288	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	14.1	13.3	12.0
3	0		1/2	4			768	384	28.2	26.7	24.0
4	1		3/8	4			768	288	21.2	20.0	18.0
4	0		3/4	4			768	576	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1 152	768	56.5	53.3	48.0
6			3/4	6			1 152	864	63.5	60.0	54.0
7			5/6	6			1 152	960	70.6	66.7	60.0
8		256-QAM	3/4	8			1 536	1 152	84.7	80.0	72.0
9			5/6	8			1 536	1 280	94.1	88.9	80.0

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Table 26-52—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	240	60	4.4	4.2	3.8
0	0		1/2	1			240	120	8.8	8.3	7.5
1	1	QPSK	1/4	2			480	120	8.8	8.3	7.5
1	0		1/2	2			480	240	17.6	16.7	15.0
2	N/A		3/4	2			480	360	26.5	25.0	22.5
3	1	16-QAM	1/4	4			960	240	17.6	16.7	15.0
3	0		1/2	4			960	480	35.3	33.3	30.0
4	1		3/8	4			960	360	26.5	25.0	45.0
4	0		3/4	4			960	720	52.9	50.0	45.0
5	N/A	64-QAM	2/3	6			1 440	960	70.6	66.7	60.0
6			3/4	6			1 440	1080	79.4	75.0	67.5
7			5/6	6			1 440	1 200	88.2	83.3	75.0
8		256-QAM	3/4	8			1 920	1 440	105.9	100.0	90.0
9			5/6	8			1 920	1 600	117.6	111.1	100.0

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Table 26-53—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	288	72	5.3	5.0	4.5
0	0		1/2	1			288	144	10.6	10.0	9.0
1	1	QPSK	1/4	2			576	144	10.6	10.0	9.0
1	0		1/2	2			576	288	21.2	20.0	18.0
2	N/A		3/4	2			576	432	31.8	30.0	27.0
3	1	16-QAM	1/4	4			1 152	288	21.2	20.0	18.0
3	0		1/2	4			1 152	576	42.4	40.0	36.0
4	1		3/8	4			1 152	432	31.8	30.0	27.0
4	0		3/4	4			1 152	864	63.5	60.0	54.0
5	N/A	64-QAM	2/3	6			1 728	1 152	84.7	80.0	72.0
6			3/4	6			1 728	1 296	95.3	90.0	81.0
7			5/6	6			1 728	1 440	105.9	100.0	90.0
8		256-QAM	3/4	8			2 304	1 728	127.1	120.0	108.0
9			5/6	8			2 304	1 920	141.2	133.3	120.0

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Table 26-54—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	336	84	6.2	5.8	5.3
0	0		1/2	1			336	168	12.4	11.7	10.5
1	1	QPSK	1/4	2			672	168	12.4	11.7	10.5
1	0		1/2	2			672	336	24.7	23.3	21.0
2	N/A		3/4	2			672	504	37.1	35.0	31.5
3	1	16-QAM	1/4	4			1 344	336	24.7	23.3	21.0
3	0		1/2	4			1 344	672	49.4	46.7	42.0
4	1		3/8	4			1 344	504	37.1	35.0	31.5
4	0		3/4	4			1 344	1 008	74.1	70.0	63.0
5	N/A	64-QAM	2/3	6			2 016	1 344	98.8	93.3	84.0
6			3/4	6			2 016	1 512	111.2	105.0	94.5
7			5/6	6			2 016	1 680	123.5	116.7	105.0
8		256-QAM	3/4	8			2 688	2 016	148.2	140.0	126.0
9			5/6	8			2 688	2 240	164.7	155.6	140.0

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Table 26-55—HE-MCSs for TBD mandatory/optional 52-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)		
									0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/4	1	48	4	384	96	7.1	6.7	6.0
0	0		1/2	1			384	192	14.1	13.3	12.0
1	1	QPSK	1/4	2			768	192	14.1	13.3	12.0
1	0		1/2	2			768	384	28.2	26.7	24.0
2	N/A		3/4	2			768	576	42.4	40.0	36.0
3	1	16-QAM	1/4	4			1 536	384	28.2	26.7	24.0
3	0		1/2	4			1 536	768	56.5	53.3	48.0
4	1		3/8	4			1 536	576	42.4	40.0	36.0
4	0		3/4	4			1 536	1 152	84.7	80.0	72.0
5	N/A	64-QAM	2/3	6			2 304	1 536	112.9	106.7	96.0
6			3/4	6			2 304	1 728	127.1	120.0	108.0
7			5/6	6			2 304	1 920	141.2	133.3	120.0
8		256-QAM	3/4	8			3 072	2 304	169.4	160.0	144.0
9			5/6	8			3 072	2 560	188.2	177.8	160.0

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Table 26-56—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	102	25	1	1.8	1.7	1.6
0	0		1/2	1			102	51	1	3.8	3.5	3.2
1	1	QPSK	1/4	2			204	51	1	3.8	3.5	3.2
1	0		1/2	2			204	102	1	7.5	7.1	6.4
2	N/A		3/4	2			204	153	1	11.3	10.6	9.6
3	1	16-QAM	1/4	4			408	102	1	7.5	7.1	6.4
3	0		1/2	4			408	204	1	15.0	14.2	12.8
4	1		3/8	4			408	153	1	11.3	10.6	9.6
4	0		3/4	4			408	306	1	22.5	21.3	19.1
5	N/A	64-QAM	2/3	6			612	408	1	30.0	28.3	25.5
6			3/4	6			612	459	1	33.8	31.9	28.7
7			5/6	6			612	510	1	37.5	35.4	31.9
8		256-QAM	3/4	8			816	612	1	45.0	42.5	38.3
9			5/6	8			816	680	1	50.0	47.2	42.5

Table 26-57—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	204	51	1	3.8	3.5	3.2
0	0		1/2	1			204	102	1	7.5	7.1	6.4
1	1	QPSK	1/4	2			408	102	1	7.5	7.1	6.4
1	0		1/2	2			408	204	1	15.0	14.2	12.8
2	N/A		3/4	2			408	306	1	22.5	21.3	19.1
3	1	16-QAM	1/4	4			816	204	1	15.0	14.2	12.8
3	0		1/2	4			816	408	1	30.0	28.3	25.5
4	1		3/8	4			816	306	1	22.5	21.3	19.1
4	0		3/4	4			816	612	1	45.0	42.5	38.3
5	N/A	64-QAM	2/3	6			1224	816	1	60.0	56.7	51.0
6			3/4	6			1224	918	1	67.5	63.8	57.4
7			5/6	6			1224	1,020	1	75.0	70.8	63.8
8		256-QAM	3/4	8			1632	1,224	1	90.0	85.0	76.5
9			5/6	8			1632	1,360	1	100.0	94.4	85.0

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Table 26-58—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	306	76	1	5.6	5.3	4.8
0	0		1/2	1			306	153	1	11.3	10.6	9.6
1	1	QPSK	1/4	2			612	153	1	11.3	10.6	9.6
1	0		1/2	2			612	306	1	22.5	21.3	19.1
2	N/A		3/4	2			612	459	1	33.8	31.9	28.7
3	1	16-QAM	1/4	4			1224	306	1	22.5	21.3	19.1
3	0		1/2	4			1224	612	1	45.0	42.5	38.3
4	1		3/8	4			1224	459	1	33.8	31.9	28.7
4	0		3/4	4			1224	918	1	67.5	63.8	57.4
5	N/A	64-QAM	2/3	6			1836	1,224	1	90.0	85.0	76.5
6			3/4	6			1836	1,377	1	101.3	95.6	86.1
7			5/6	6			1836	1,530	1	112.5	106.3	95.6
8		256-QAM	3/4	8			2448	1,836	1	135.0	127.5	114.8
9			5/6	8			2448	2,040	1	150.0	141.7	127.5

Table 26-59—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	408	102	1	7.5	7.1	6.4
0	0		1/2	1			408	204	1	15.0	14.2	12.8
1	1	QPSK	1/4	2			816	204	1	15.0	14.2	12.8
1	0		1/2	2			816	408	1	30.0	28.3	25.5
2	N/A		3/4	2			816	612	1	45.0	42.5	38.3
3	1	16-QAM	1/4	4			1632	408	1	30.0	28.3	25.5
3	0		1/2	4			1632	816	1	60.0	56.7	51.0
4	1		3/8	4			1632	612	1	45.0	42.5	38.3
4	0		3/4	4			1632	1,224	1	90.0	85.0	76.5
5	N/A	64-QAM	2/3	6			2448	1,632	1	120.0	113.3	102.0
6			3/4	6			2448	1,836	1	135.0	127.5	114.8
7			5/6	6			2448	2,040	1	150.0	141.7	127.5
8		256-QAM	3/4	8			3264	2,448	1	180.0	170.0	153.0
9			5/6	8			3264	2,720	1	200.0	188.9	170.0

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Table 26-60—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	510	127	1	9.3	8.8	7.9
0	0		1/2	1			510	255	1	18.8	17.7	15.9
1	1	QPSK	1/4	2			1020	255	1	18.8	17.7	15.9
1	0		1/2	2			1020	510	1	37.5	35.4	31.9
2	N/A		3/4	2			1020	765	1	56.3	53.1	47.8
3	1	16-QAM	1/4	4			2040	510	1	37.5	35.4	31.9
3	0		1/2	4			2040	1,020	1	75.0	70.8	63.8
4	1		3/8	4			2040	765	1	56.3	53.1	47.8
4	0		3/4	4			2040	1,530	1	112.5	106.3	95.6
5	N/A	64-QAM	2/3	6			3060	2,040	1	150.0	141.7	127.5
6			3/4	6			3060	2,295	1	168.8	159.4	143.4
7			5/6	6			3060	2,550	1	187.5	177.1	159.4
8		256-QAM	3/4	8			4080	3,060	1	225.0	212.5	191.3
9			5/6	8			4080	3,400	1	250.0	236.1	212.5

Table 26-61—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	612	153	1	11.3	10.6	9.6
0	0		1/2	1			612	306	1	22.5	21.3	19.1
1	1	QPSK	1/4	2			1224	306	1	22.5	21.3	19.1
1	0		1/2	2			1224	612	1	45.0	42.5	38.3
2	N/A		3/4	2			1224	918	1	67.5	63.8	57.4
3	1	16-QAM	1/4	4			2448	612	1	45.0	42.5	38.3
3	0		1/2	4			2448	1,224	1	90.0	85.0	76.5
4	1		3/8	4			2448	918	1	67.5	63.8	57.4
4	0		3/4	4			2448	1,836	1	135.0	127.5	114.8
5	N/A	64-QAM	2/3	6			3672	2,448	1	180.0	170.0	153.0
6			3/4	6			3672	2,754	1	202.5	191.3	172.1
7			5/6	6			3672	3,060	1	225.0	212.5	191.3
8		256-QAM	3/4	8			4896	3,672	1	270.0	255.0	229.5
9			5/6	8			4896	4,080	1	300.0	283.3	255.0

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Table 26-62—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	714	178	1	13.1	12.4	11.1
0	0		1/2	1			714	357	1	26.3	24.8	22.3
1	1	QPSK	1/4	2			1428	357	1	26.3	24.8	22.3
1	0		1/2	2			1428	714	1	52.5	49.6	44.6
2	N/A		3/4	2			1428	1,071	1	78.8	74.4	66.9
3	1	16-QAM	1/4	4			2856	714	1	52.5	49.6	44.6
3	0		1/2	4			2856	1,428	1	105.0	99.2	89.3
4	1		3/8	4			2856	1,071	1	78.8	74.4	66.9
4	0		3/4	4			2856	2,142	1	157.5	148.8	133.9
5	N/A	64-QAM	2/3	6			4284	2,856	1	210.0	198.3	178.5
6			3/4	6			4284	3,213	1	236.3	223.1	200.8
7			5/6	6			4284	3,570	1	262.5	247.9	223.1
8		256-QAM	3/4	8			5712	4,284	1	315.0	297.5	267.8
9			5/6	8			5712	4,760	1	350.0	330.6	297.5

Table 26-63—HE-MCSs for TBD mandatory/optional 106-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	816	204	1	15.0	14.2	12.8
0	0		1/2	1			816	408	1	30.0	28.3	25.5
1	1	QPSK	1/4	2			1632	408	1	30.0	28.3	25.5
1	0		1/2	2			1632	816	1	60.0	56.7	51.0
2	N/A		3/4	2			1632	1,224	1	90.0	85.0	76.5
3	1	16-QAM	1/4	4			3264	816	1	60.0	56.7	51.0
3	0		1/2	4			3264	1,632	1	120.0	113.3	102.0
4	1		3/8	4			3264	1,224	1	90.0	85.0	76.5
4	0		3/4	4			3264	2,448	1	180.0	170.0	153.0
5	N/A	64-QAM	2/3	6			4896	3,264	1	240.0	226.7	204.0
6			3/4	6			4896	3,672	1	270.0	255.0	229.5
7			5/6	6			4896	4,080	1	300.0	283.3	255.0
8		256-QAM	3/4	8			6528	4,896	1	360.0	340.0	306.0
9			5/6	8			6528	5,440	1	400.0	377.8	340.0

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Table 26-64—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	234	58	1	4.3	4.0	3.6
0	0		1/2	1			234	117	1	8.6	8.1	7.3
1	1	QPSK	1/4	2			468	117	1	8.6	8.1	7.3
1	0		1/2	2			468	234	1	17.2	16.3	14.6
2	N/A		3/4	2			468	351	1	25.8	24.4	21.9
3	1	16-QAM	1/4	4			936	234	1	17.2	16.3	14.6
3	0		1/2	4			936	468	1	34.4	32.5	29.3
4	1		3/8	4			936	351	1	25.8	24.4	21.9
4	0		3/4	4			936	702	1	51.6	48.8	43.9
5	N/A	64-QAM	2/3	6			1404	936	1	68.8	65.0	58.5
6			3/4	6			1404	1,053	1	77.4	73.1	65.8
7			5/6	6			1404	1,170	1	86.0	81.3	73.1
8		256-QAM	3/4	8			1872	1,404	1	103.2	97.5	87.8
9			5/6	8			1872	1,560	1	114.7	108.3	97.5
10		1024-QAM	3/4	10			2340	1,755	1	129.0	121.9	109.7
11			5/6	10			2340	1,950	1	143.4	135.4	121.9

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Table 26-65—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	468	117	1	8.6	8.1	7.3
0	0		1/2	1			468	234	1	17.2	16.3	14.6
1	1	QPSK	1/4	2			936	234	1	17.2	16.3	14.6
1	0		1/2	2			936	468	1	34.4	32.5	29.3
2	N/A		3/4	2			936	702	1	51.6	48.8	43.9
3	1	16-QAM	1/4	4			1872	468	1	34.4	32.5	29.3
3	0		1/2	4			1872	936	1	68.8	65.0	58.5
4	1		3/8	4			1872	702	1	51.6	48.8	43.9
4	0		3/4	4			1872	1,404	1	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6			2808	1,872	1	137.6	130.0	117.0
6			3/4	6			2808	2,106	1	154.9	146.3	131.6
7			5/6	6			2808	2,340	1	172.1	162.5	146.3
8		256-QAM	3/4	8			3744	2,808	1	206.5	195.0	175.5
9			5/6	8			3744	3,120	1	229.4	216.7	195.0
10		1024-QAM	3/4	10			4680	3,510	1	258.1	243.8	219.4
11			5/6	10			4680	3,900	1	286.8	270.8	243.8

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Table 26-66—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	702	175	1	12.9	12.2	10.9
0	0		1/2	1			702	351	1	25.8	24.4	21.9
1	1	QPSK	1/4	2			1404	351	1	25.8	24.4	21.9
1	0		1/2	2			1404	702	1	51.6	48.8	43.9
2	N/A		3/4	2			1404	1,053	1	77.4	73.1	65.8
3	1	16-QAM	1/4	4			2808	702	1	51.6	48.8	43.9
3	0		1/2	4			2808	1,404	1	103.2	97.5	87.8
4	1		3/8	4			2808	1,053	1	77.4	73.1	65.8
4	0		3/4	4			2808	2,106	1	154.9	146.3	131.6
5	N/A	64-QAM	2/3	6			4212	2,808	1	206.5	195.0	175.5
6			3/4	6			4212	3,159	1	232.3	219.4	197.4
7			5/6	6			4212	3,510	1	258.1	243.8	219.4
8		256-QAM	3/4	8			5616	4,212	1	309.7	292.5	263.3
9			5/6	8			5616	4,680	1	344.1	325.0	292.5
10		1024-QAM	3/4	10			7020	5,265	1	387.1	365.6	329.1
11			5/6	10			7020	5,850	1	430.1	406.3	365.6

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Table 26-67—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	936	234	1	17.2	16.3	14.6
0	0		1/2	1			936	468	1	34.4	32.5	29.3
1	1	QPSK	1/4	2			1872	468	1	34.4	32.5	29.3
1	0		1/2	2			1872	936	1	68.8	65.0	58.5
2	N/A		3/4	2			1872	1,404	1	103.2	97.5	87.8
3	1	16-QAM	1/4	4			3744	936	1	68.8	65.0	58.5
3	0		1/2	4			3744	1,872	1	137.6	130.0	117.0
4	1		3/8	4			3744	1,404	1	103.2	97.5	87.8
4	0		3/4	4			3744	2,808	1	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6			5616	3,744	1	275.3	260.0	234.0
6			3/4	6			5616	4,212	1	309.7	292.5	263.3
7			5/6	6			5616	4,680	1	344.1	325.0	292.5
8		256-QAM	3/4	8			7488	5,616	1	412.9	390.0	351.0
9			5/6	8			7488	6,240	1	458.8	433.3	390.0
10		1024-QAM	3/4	10			9360	7,020	1	516.2	487.5	438.8
11			5/6	10			9360	7,800	1	573.5	541.7	487.5

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Table 26-68—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1170	292	1	21.5	20.3	18.3
0	0		1/2	1			1170	585	1	43.0	40.6	36.6
1	1	QPSK	1/4	2			2340	585	1	43.0	40.6	36.6
1	0		1/2	2			2340	1,170	1	86.0	81.3	73.1
2	N/A		3/4	2			2340	1,755	1	129.0	121.9	109.7
3	1	16-QAM	1/4	4			4680	1,170	1	86.0	81.3	73.1
3	0		1/2	4			4680	2,340	1	172.1	162.5	146.3
4	1		3/8	4			4680	1,755	1	129.0	121.9	109.7
4	0		3/4	4			4680	3,510	1	258.1	243.8	219.4
5	N/A	64-QAM	2/3	6			7020	4,680	1	344.1	325.0	292.5
6			3/4	6			7020	5,265	1	387.1	365.6	329.1
7			5/6	6			7020	5,850	1	430.1	406.3	365.6
8		256-QAM	3/4	8			9360	7,020	1	516.2	487.5	438.8
9			5/6	8			9360	7,800	1	573.5	541.7	487.5
10		1024-QAM	3/4	10			11700	8,775	1	645.2	609.4	548.4
11			5/6	10			11700	9,750	1	716.9	677.1	609.4

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Table 26-69—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1404	351	1	25.8	24.4	21.9
0	0		1/2	1			1404	702	1	51.6	48.8	43.9
1	1	QPSK	1/4	2			2808	702	1	51.6	48.8	43.9
1	0		1/2	2			2808	1,404	1	103.2	97.5	87.8
2	N/A		3/4	2			2808	2,106	1	154.9	146.3	131.6
3	1	16-QAM	1/4	4			5616	1,404	1	103.2	97.5	87.8
3	0		1/2	4			5616	2,808	1	206.5	195.0	175.5
4	1		3/8	4			5616	2,106	1	154.9	146.3	131.6
4	0		3/4	4			5616	4,212	1	309.7	292.5	263.3
5	N/A	64-QAM	2/3	6			8424	5,616	1	412.9	390.0	351.0
6			3/4	6			8424	6,318	1	464.6	438.8	394.9
7			5/6	6			8424	7,020	1	516.2	487.5	438.8
8		256-QAM	3/4	8			11232	8,424	1	619.4	585.0	526.5
9			5/6	8			11232	9,360	1	688.2	650.0	585.0
10		1024-QAM	3/4	10			14040	10,530	1	774.3	731.3	658.1
11			5/6	10			14040	11,700	1	860.3	812.5	731.3

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Table 26-70—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1638	409	1	30.1	28.4	25.6
0	0		1/2	1			1638	819	1	60.2	56.9	51.2
1	1	QPSK	1/4	2			3276	819	1	60.2	56.9	51.2
1	0		1/2	2			3276	1,638	1	120.4	113.8	102.4
2	N/A		3/4	2			3276	2,457	1	180.7	170.6	153.6
3	1	16-QAM	1/4	4			6552	1,638	1	120.4	113.8	102.4
3	0		1/2	4			6552	3,276	1	240.9	227.5	204.8
4	1		3/8	4			6552	2,457	1	180.7	170.6	153.6
4	0		3/4	4			6552	4,914	1	361.3	341.3	307.1
5	N/A	64-QAM	2/3	6			9828	6,552	1	481.8	455.0	409.5
6			3/4	6			9828	7,371	1	542.0	511.9	460.7
7			5/6	6			9828	8,190	1	602.2	568.8	511.9
8		256-QAM	3/4	8			13104	9,828	1	722.6	682.5	614.3
9			5/6	8			13104	10,920	1	802.9	758.3	682.5
10		1024-QAM	3/4	10			16380	12,285	1	903.3	853.1	767.8
11			5/6	10			16380	13,650	1	1,003.7	947.9	853.1

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Table 26-71—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1872	468	1	34.4	32.5	29.3
0	0		1/2	1			1872	936	1	68.8	65.0	58.5
1	1	QPSK	1/4	2			3744	936	1	68.8	65.0	58.5
1	0		1/2	2			3744	1,872	1	137.6	130.0	117.0
2	N/A		3/4	2			3744	2,808	1	206.5	195.0	175.5
3	1	16-QAM	1/4	4			7488	1,872	1	137.6	130.0	117.0
3	0		1/2	4			7488	3,744	1	275.3	260.0	234.0
4	1		3/8	4			7488	2,808	1	206.5	195.0	175.5
4	0		3/4	4			7488	5,616	1	412.9	390.0	351.0
5	N/A	64-QAM	2/3	6			11232	7,488	1	550.6	520.0	468.0
6			3/4	6			11232	8,424	1	619.4	585.0	526.5
7			5/6	6			11232	9,360	1	688.2	650.0	585.0
8		256-QAM	3/4	8			14976	11,232	1	825.9	780.0	702.0
9			5/6	8			14976	12,480	1	917.6	866.7	780.0
10		1024-QAM	3/4	10			18720	14,040	1	1,032.4	975.0	877.5
11			5/6	10			18720	15,600	1	1,147.1	1,083.3	975.0

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Table 26-72—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	468	117	1	8.6	8.1	7.3
0	0		1/2	1			468	234	1	17.2	16.3	14.6
1	1	QPSK	1/4	2			936	234	1	17.2	16.3	14.6
1	0		1/2	2			936	468	1	34.4	32.5	29.3
2	N/A		3/4	2			936	702	1	51.6	48.8	43.9
3	1	16-QAM	1/4	4			1872	468	1	34.4	32.5	29.3
3	0		1/2	4			1872	936	1	68.8	65.0	58.5
4	1		3/8	4			1872	702	1	51.6	48.8	43.9
4	0		3/4	4			1872	1,404	1	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6			2808	1,872	1	137.6	130.0	117.0
6			3/4	6			2808	2,106	1	154.9	146.3	131.6
7			5/6	6			2808	2,340	1	172.1	162.5	146.3
8		256-QAM	3/4	8			3744	2,808	1	206.5	195.0	175.5
9			5/6	8			3744	3,120	1	229.4	216.7	195.0
10		1024-QAM	3/4	10			4680	3,510	1	258.1	243.8	219.4
11			5/6	10			4680	3,900	1	286.8	270.8	243.8

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Table 26-73—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	936	234	1	17.2	16.3	14.6
0	0		1/2	1			936	468	1	34.4	32.5	29.3
1	1	QPSK	1/4	2			1872	468	1	34.4	32.5	29.3
1	0		1/2	2			1872	936	1	68.8	65.0	58.5
2	N/A		3/4	2			1872	1,404	1	103.2	97.5	87.8
3	1	16-QAM	1/4	4			3744	936	1	68.8	65.0	58.5
3	0		1/2	4			3744	1,872	1	137.6	130.0	117.0
4	1		3/8	4			3744	1,404	1	103.2	97.5	87.8
4	0		3/4	4			3744	2,808	1	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6			5616	3,744	1	275.3	260.0	234.0
6			3/4	6			5616	4,212	1	309.7	292.5	263.3
7			5/6	6			5616	4,680	1	344.1	325.0	292.5
8		256-QAM	3/4	8			7488	5,616	1	412.9	390.0	351.0
9			5/6	8			7488	6,240	1	458.8	433.3	390.0
10		1024-QAM	3/4	10			9360	7,020	1	516.2	487.5	438.8
11			5/6	10			9360	7,800	1	573.5	541.7	487.5

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Table 26-74—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	1404	351	1	25.8	24.4	21.9
0	0		1/2	1			1404	702	1	51.6	48.8	43.9
1	1	QPSK	1/4	2			2808	702	1	51.6	48.8	43.9
1	0		1/2	2			2808	1,404	1	103.2	97.5	87.8
2	N/A		3/4	2			2808	2,106	1	154.9	146.3	131.6
3	1	16-QAM	1/4	4			5616	1,404	1	103.2	97.5	87.8
3	0		1/2	4			5616	2,808	1	206.5	195.0	175.5
4	1		3/8	4			5616	2,106	1	154.9	146.3	131.6
4	0		3/4	4			5616	4,212	1	309.7	292.5	263.3
5	N/A	64-QAM	2/3	6			8424	5,616	1	412.9	390.0	351.0
6			3/4	6			8424	6,318	1	464.6	438.8	394.9
7			5/6	6			8424	7,020	1	516.2	487.5	438.8
8		256-QAM	3/4	8			11232	8,424	1	619.4	585.0	526.5
9			5/6	8			11232	9,360	1	688.2	650.0	585.0
10		1024-QAM	3/4	10			14040	10,530	1	774.3	731.3	658.1
11			5/6	10			14040	11,700	1	860.3	812.5	731.3

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Table 26-75—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	1872	468	1	34.4	32.5	29.3
0	0		1/2	1			1872	936	1	68.8	65.0	58.5
1	1	QPSK	1/4	2			3744	936	1	68.8	65.0	58.5
1	0		1/2	2			3744	1,872	1	137.6	130.0	117.0
2	N/A		3/4	2			3744	2,808	1	206.5	195.0	175.5
3	1	16-QAM	1/4	4			7488	1,872	1	137.6	130.0	117.0
3	0		1/2	4			7488	3,744	1	275.3	260.0	234.0
4	1		3/8	4			7488	2,808	1	206.5	195.0	175.5
4	0		3/4	4			7488	5,616	1	412.9	390.0	351.0
5	N/A	64-QAM	2/3	6			11232	7,488	1	550.6	520.0	468.0
6			3/4	6			11232	8,424	1	619.4	585.0	526.5
7			5/6	6			11232	9,360	1	688.2	650.0	585.0
8		256-QAM	3/4	8			14976	11,232	1	825.9	780.0	702.0
9			5/6	8			14976	12,480	1	917.6	866.7	780.0
10		1024-QAM	3/4	10			18720	14,040	1	1,032.4	975.0	877.5
11			5/6	10			18720	15,600	1	1,147.1	1,083.3	975.0

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Table 26-76—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	2340	585	1	43.0	40.6	36.6
0	0		1/2	1			2340	1,170	1	86.0	81.3	73.1
1	1	QPSK	1/4	2			4680	1,170	1	86.0	81.3	73.1
1	0		1/2	2			4680	2,340	1	172.1	162.5	146.3
2	N/A		3/4	2			4680	3,510	1	258.1	243.8	219.4
3	1	16-QAM	1/4	4			9360	2,340	1	172.1	162.5	146.3
3	0		1/2	4			9360	4,680	1	344.1	325.0	292.5
4	1		3/8	4			9360	3,510	1	258.1	243.8	219.4
4	0		3/4	4			9360	7,020	1	516.2	487.5	438.8
5	N/A	64-QAM	2/3	6			14040	9,360	1	688.2	650.0	585.0
6			3/4	6			14040	10,530	1	774.3	731.3	658.1
7			5/6	6			14040	11,700	1	860.3	812.5	731.3
8		256-QAM	3/4	8			18720	14,040	1	1,032.4	975.0	877.5
9			5/6	8			18720	15,600	1	1,147.1	1,083.3	975.0
10		1024-QAM	3/4	10			23400	17,550	1	1,290.4	1,218.8	1,096.9
11			5/6	10			23400	19,500	1	1,433.8	1,354.2	1,218.8

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Table 26-77—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	2808	702	1	51.6	48.8	43.9
0	0		1/2	1			2808	1,404	1	103.2	97.5	87.8
1	1	QPSK	1/4	2			5616	1,404	1	103.2	97.5	87.8
1	0		1/2	2			5616	2,808	1	206.5	195.0	175.5
2	N/A		3/4	2			5616	4,212	1	309.7	292.5	263.3
3	1	16-QAM	1/4	4			11232	2,808	1	206.5	195.0	175.5
3	0		1/2	4			11232	5,616	1	412.9	390.0	351.0
4	1		3/8	4			11232	4,212	1	309.7	292.5	263.3
4	0		3/4	4			11232	8,424	1	619.4	585.0	526.5
5	N/A	64-QAM	2/3	6			16848	11,232	1	825.9	780.0	702.0
6			3/4	6			16848	12,636	1	929.1	877.5	789.8
7			5/6	6			16848	14,040	1	1,032.4	975.0	877.5
8		256-QAM	3/4	8			22464	16,848	1	1,238.8	1,170.0	1,053.0
9			5/6	8			22464	18,720	1	1,376.5	1,300.0	1,170.0
10		1024-QAM	3/4	10			28080	21,060	1	1,548.5	1,462.5	1,316.3
11			5/6	10			28080	23,400	1	1,720.6	1,625.0	1,462.5

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Table 26-78—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	3276	819	1	60.2	56.9	51.2
0	0		1/2	1			3276	1,638	1	120.4	113.8	102.4
1	1	QPSK	1/4	2			6552	1,638	1	120.4	113.8	102.4
1	0		1/2	2			6552	3,276	1	240.9	227.5	204.8
2	N/A		3/4	2			6552	4,914	1	361.3	341.3	307.1
3	1	16-QAM	1/4	4			13104	3,276	1	240.9	227.5	204.8
3	0		1/2	4			13104	6,552	1	481.8	455.0	409.5
4	1		3/8	4			13104	4,914	1	361.3	341.3	307.1
4	0		3/4	4			13104	9,828	1	722.6	682.5	614.3
5	N/A	64-QAM	2/3	6			19656	13,104	1	963.5	910.0	819.0
6			3/4	6			19656	14,742	1	1,084.0	1,023.8	921.4
7			5/6	6			19656	16,380	1	1,204.4	1,137.5	1,023.8
8		256-QAM	3/4	8			26208	19,656	1	1,445.3	1,365.0	1,228.5
9			5/6	8			26208	21,840	1	1,605.9	1,516.7	1,365.0
10		1024-QAM	3/4	10			32760	24,570	1	1,806.6	1,706.3	1,535.6
11			5/6	10			32760	27,300	1	2,007.4	1,895.8	1,706.3

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Table 26-79—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	3744	936	1	68.8	65.0	58.5
0	0		1/2	1			3744	1,872	1	137.6	130.0	117.0
1	1	QPSK	1/4	2			7488	1,872	1	137.6	130.0	117.0
1	0		1/2	2			7488	3,744	1	275.3	260.0	234.0
2	N/A		3/4	2			7488	5,616	1	412.9	390.0	351.0
3	1	16-QAM	1/4	4			14976	3,744	1	275.3	260.0	234.0
3	0		1/2	4			14976	7,488	1	550.6	520.0	468.0
4	1		3/8	4			14976	5,616	1	412.9	390.0	351.0
4	0		3/4	4			14976	11,232	1	825.9	780.0	702.0
5	N/A	64-QAM	2/3	6			22464	14,976	1	1,101.2	1,040.0	936.0
6			3/4	6			22464	16,848	1	1,238.8	1,170.0	1,053.0
7			5/6	6			22464	18,720	1	1,376.5	1,300.0	1,170.0
8		256-QAM	3/4	8			29952	22,464	1	1,651.8	1,560.0	1,404.0
9			5/6	8			29952	24,960	1	1,835.3	1,733.3	1,560.0
10		1024-QAM	3/4	10			37440	28,080	1	2,064.7	1,950.0	1,755.0
11			5/6	10			37440	31,200	1	2,294.1	2,166.7	1,950.0

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Table 26-80—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	980	245	1	18.0	17.0	15.3
0	0		1/2	1			980	490	1	36.0	34.0	30.6
1	1	QPSK	1/4	2			1960	490	1	36.0	34.0	30.6
1	0		1/2	2			1960	980	1	72.1	68.1	61.3
2	N/A		3/4	2			1960	1,470	1	108.1	102.1	91.9
3	1	16-QAM	1/4	4			3920	980	1	72.1	68.1	61.3
3	0		1/2	4			3920	1,960	1	144.1	136.1	122.5
4	1		3/8	4			3920	1,470	1	108.1	102.1	91.9
4	0		3/4	4			3920	2,940	1	216.2	204.2	183.8
5	N/A	64-QAM	2/3	6			5880	3,920	1	288.2	272.2	245.0
6			3/4	6			5880	4,410	1	324.3	306.3	275.6
7			5/6	6			5880	4,900	1	360.3	340.3	306.3
8		256-QAM	3/4	8			7840	5,880	1	432.4	408.3	367.5
9			5/6	8			7840	6,533	1	480.4	453.7	408.3
10		1024-QAM	3/4	10			9800	7,350	1	540.4	510.4	459.4
11			5/6	10			9800	8,166	1	600.4	567.1	510.4

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Table 26-81—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	1960	490	1	36.0	34.0	30.6
0	0		1/2	1			1960	980	1	72.1	68.1	61.3
1	1	QPSK	1/4	2			3920	980	1	72.1	68.1	61.3
1	0		1/2	2			3920	1,960	1	144.1	136.1	122.5
2	N/A		3/4	2			3920	2,940	1	216.2	204.2	183.8
3	1	16-QAM	1/4	4			7840	1,960	1	144.1	136.1	122.5
3	0		1/2	4			7840	3,920	1	288.2	272.2	245.0
4	1		3/8	4			7840	2,940	1	216.2	204.2	183.8
4	0		3/4	4			7840	5,880	1	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6			11760	7,840	1	576.5	544.4	490.0
6			3/4	6			11760	8,820	1	648.5	612.5	551.3
7			5/6	6			11760	9,800	1	720.6	680.6	612.5
8		256-QAM	3/4	8			15680	11,760	1	864.7	816.7	735.0
9			5/6	8			15680	13,066	1	960.7	907.4	816.6
10		1024-QAM	3/4	10			19600	14,700	1	1,080.9	1,020.8	918.8
11			5/6	10			19600	16,333	1	1,201.0	1,134.2	1,020.8

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Table 26-82—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	2940	735	1	54.0	51.0	45.9
0	0		1/2	1			2940	1,470	1	108.1	102.1	91.9
1	1	QPSK	1/4	2			5880	1,470	1	108.1	102.1	91.9
1	0		1/2	2			5880	2,940	1	216.2	204.2	183.8
2	N/A		3/4	2			5880	4,410	1	324.3	306.3	275.6
3	1	16-QAM	1/4	4			11760	2,940	1	216.2	204.2	183.8
3	0		1/2	4			11760	5,880	1	432.4	408.3	367.5
4	1		3/8	4			11760	4,410	1	324.3	306.3	275.6
4	0		3/4	4			11760	8,820	1	648.5	612.5	551.3
5	N/A	64-QAM	2/3	6			17640	11,760	1	864.7	816.7	735.0
6			3/4	6			17640	13,230	1	972.8	918.8	826.9
7			5/6	6			17640	14,700	1	1,080.9	1,020.8	918.8
8		256-QAM	3/4	8			23520	17,640	1	1,297.1	1,225.0	1,102.5
9			5/6	8			23520	19,600	1	1,441.2	1,361.1	1,225.0
10		1024-QAM	3/4	10			29400	22,050	1	1,621.3	1,531.3	1,378.1
11			5/6	10			29400	24,500	1	1,801.5	1,701.4	1,531.3

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Table 26-83—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	3920	980	1	72.1	68.1	61.3
0	0		1/2	1			3920	1,960	1	144.1	136.1	122.5
1	1	QPSK	1/4	2			7840	1,960	1	144.1	136.1	122.5
1	0		1/2	2			7840	3,920	1	288.2	272.2	245.0
2	N/A		3/4	2			7840	5,880	1	432.4	408.3	367.5
3	1	16-QAM	1/4	4			15680	3,920	1	288.2	272.2	245.0
3	0		1/2	4			15680	7,840	1	576.5	544.4	490.0
4	1		3/8	4			15680	5,880	1	432.4	408.3	367.5
4	0		3/4	4			15680	11,760	1	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6			23520	15,680	1	1,152.9	1,088.9	980.0
6			3/4	6			23520	17,640	1	1,297.1	1,225.0	1,102.5
7			5/6	6			23520	19,600	1	1,441.2	1,361.1	1,225.0
8		256-QAM	3/4	8			31360	23,520	1	1,729.4	1,633.3	1,470.0
9			5/6	8			31360	26,133	1	1,921.5	1,814.8	1,633.3
10		1024-QAM	3/4	10			39200	29,400	1	2,161.8	2,041.7	1,837.5
11			5/6	10			39200	32,666	1	2,401.9	2,268.5	2,041.6

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Table 26-84—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	4900	1,225	1	90.1	85.1	76.6
0	0		1/2	1			4900	2,450	1	180.1	170.1	153.1
1	1	QPSK	1/4	2			9800	2,450	1	180.1	170.1	153.1
1	0		1/2	2			9800	4,900	1	360.3	340.3	306.3
2	N/A		3/4	2			9800	7,350	1	540.4	510.4	459.4
3	1	16-QAM	1/4	4			19600	4,900	1	360.3	340.3	306.3
3	0		1/2	4			19600	9,800	1	720.6	680.6	612.5
4	1		3/8	4			19600	7,350	1	540.4	510.4	459.4
4	0		3/4	4			19600	14,700	1	1,080.9	1,020.8	918.8
5	N/A	64-QAM	2/3	6			29400	19,600	1	1,441.2	1,361.1	1,225.0
6			3/4	6			29400	22,050	1	1,621.3	1,531.3	1,378.1
7			5/6	6			29400	24,500	1	1,801.5	1,701.4	1,531.3
8		256-QAM	3/4	8			39200	29,400	1	2,161.8	2,041.7	1,837.5
9			5/6	8			39200	32,666	1	2,401.9	2,268.5	2,041.6
10		1024-QAM	3/4	10			49000	36,750	1	2,702.2	2,552.1	2,296.9
11			5/6	10			49000	40,833	1	3,002.4	2,835.6	2,552.1

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Table 26-85—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	5880	1,470	1	108.1	102.1	91.9
0	0		1/2	1			5880	2,940	1	216.2	204.2	183.8
1	1	QPSK	1/4	2			11760	2,940	1	216.2	204.2	183.8
1	0		1/2	2			11760	5,880	1	432.4	408.3	367.5
2	N/A		3/4	2			11760	8,820	1	648.5	612.5	551.3
3	1	16-QAM	1/4	4			23520	5,880	1	432.4	408.3	367.5
3	0		1/2	4			23520	11,760	1	864.7	816.7	735.0
4	1		3/8	4			23520	8,820	1	648.5	612.5	551.3
4	0		3/4	4			23520	17,640	1	1,297.1	1,225.0	1,102.5
5	N/A	64-QAM	2/3	6			35280	23,520	1	1,729.4	1,633.3	1,470.0
6			3/4	6			35280	26,460	1	1,945.6	1,837.5	1,653.8
7			5/6	6			35280	29,400	1	2,161.8	2,041.7	1,837.5
8		256-QAM	3/4	8			47040	35,280	1	2,594.1	2,450.0	2,205.0
9			5/6	8			47040	39,200	1	2,882.4	2,722.2	2,450.0
10		1024-QAM	3/4	10			58800	44,100	1	3,242.6	3,062.5	2,756.3
11			5/6	10			58800	49,000	1	3,602.9	3,402.8	3,062.5

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Table 26-86—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	6860	1,715	1	126.1	119.1	107.2
0	0		1/2	1			6860	3,430	1	252.2	238.2	214.4
1	1	QPSK	1/4	2			13720	3,430	1	252.2	238.2	214.4
1	0		1/2	2			13720	6,860	1	504.4	476.4	428.8
2	N/A		3/4	2			13720	10,290	1	756.6	714.6	643.1
3	1	16-QAM	1/4	4			27440	6,860	1	504.4	476.4	428.8
3	0		1/2	4			27440	13,720	1	1,008.8	952.8	857.5
4	1		3/8	4			27440	10,290	1	756.6	714.6	643.1
4	0		3/4	4			27440	20,580	1	1,513.2	1,429.2	1,286.3
5	N/A	64-QAM	2/3	6			41160	27,440	1	2,017.6	1,905.6	1,715.0
6			3/4	6			41160	30,870	1	2,269.9	2,143.8	1,929.4
7			5/6	6			41160	34,300	1	2,522.1	2,381.9	2,143.8
8		256-QAM	3/4	8			54880	41,160	1	3,026.5	2,858.3	2,572.5
9			5/6	8			54880	45,733	1	3,362.7	3,175.9	2,858.3
10		1024-QAM	3/4	10			68600	51,450	1	3,783.1	3,572.9	3,215.6
11			5/6	10			68600	57,166	1	4,203.4	3,969.9	3,572.9

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Table 26-87—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	7840	1,960	1	144.1	136.1	122.5
0	0		1/2	1			7840	3,920	1	288.2	272.2	245.0
1	1	QPSK	1/4	2			15680	3,920	1	288.2	272.2	245.0
1	0		1/2	2			15680	7,840	1	576.5	544.4	490.0
2	N/A		3/4	2			15680	11,760	1	864.7	816.7	735.0
3	1	16-QAM	1/4	4			31360	7,840	1	576.5	544.4	490.0
3	0		1/2	4			31360	15,680	1	1,152.9	1,088.9	980.0
4	1		3/8	4			31360	11,760	1	864.7	816.7	735.0
4	0		3/4	4			31360	23,520	1	1,729.4	1,633.3	1,470.0
5	N/A	64-QAM	2/3	6			47040	31,360	1	2,305.9	2,177.8	1,960.0
6			3/4	6			47040	35,280	1	2,594.1	2,450.0	2,205.0
7			5/6	6			47040	39,200	1	2,882.4	2,722.2	2,450.0
8		256-QAM	3/4	8			62720	47,040	1	3,458.8	3,266.7	2,940.0
9			5/6	8			62720	52,266	1	3,843.1	3,629.6	3,266.6
10		1024-QAM	3/4	10			78400	58,800	1	4,323.5	4,083.3	3,675.0
11			5/6	10			78400	65,333	1	4,803.9	4,537.0	4,083.3

Table 26-88—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	1960	490	1	36.0	34.0	30.6
0	0		1/2	1			1960	980	1	72.1	68.1	61.3
1	1	QPSK	1/4	2			3920	980	1	72.1	68.1	61.3
1	0		1/2	2			3920	1,960	1	144.1	136.1	122.5
2	N/A		3/4	2			3920	2,940	1	216.2	204.2	183.8
3	1	16-QAM	1/4	4			7840	1,960	1	144.1	136.1	122.5
3	0		1/2	4			7840	3,920	1	288.2	272.2	245.0
4	1		3/8	4			7840	2,940	1	216.2	204.2	183.8
4	0		3/4	4			7840	5,880	1	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6			11760	7,840	1	576.5	544.4	490.0
6			3/4	6			11760	8,820	1	648.5	612.5	551.3
7			5/6	6			11760	9,800	1	720.6	680.6	612.5
8		256-QAM	3/4	8			15680	11,760	1	864.7	816.7	735.0
9			5/6	8			15680	13,066	1	960.7	907.4	816.6
10		1024-QAM	3/4	10			19600	14,700	1	1,080.9	1,020.8	918.8
11			5/6	10			19600	16,333	1	1,201.0	1,134.2	1,020.8

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Table 26-89—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	3920	980	1	72.1	68.1	61.3
0	0		1/2	1			3920	1,960	1	144.1	136.1	122.5
1	1	QPSK	1/4	2			7840	1,960	1	144.1	136.1	122.5
1	0		1/2	2			7840	3,920	1	288.2	272.2	245.0
2	N/A		3/4	2			7840	5,880	1	432.4	408.3	367.5
3	1	16-QAM	1/4	4			15680	3,920	1	288.2	272.2	245.0
3	0		1/2	4			15680	7,840	1	576.5	544.4	490.0
4	1		3/8	4			15680	5,880	1	432.4	408.3	367.5
4	0		3/4	4			15680	11,760	1	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6			23520	15,680	1	1,152.9	1,088.9	980.0
6			3/4	6			23520	17,640	1	1,297.1	1,225.0	1,102.5
7			5/6	6			23520	19,600	1	1,441.2	1,361.1	1,225.0
8		256-QAM	3/4	8			31360	23,520	1	1,729.4	1,633.3	1,470.0
9			5/6	8			31360	26,133	1	1,921.5	1,814.8	1,633.3
10		1024-QAM	3/4	10			39200	29,400	1	2,161.8	2,041.7	1,837.5
11			5/6	10			39200	32,666	1	2,401.9	2,268.5	2,041.6

Table 26-90—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	5880	1,470	1	108.1	102.1	91.9
0	0		1/2	1			5880	2,940	1	216.2	204.2	183.8
1	1	QPSK	1/4	2			11760	2,940	1	216.2	204.2	183.8
1	0		1/2	2			11760	5,880	1	432.4	408.3	367.5
2	N/A		3/4	2			11760	8,820	1	648.5	612.5	551.3
3	1	16-QAM	1/4	4			23520	5,880	1	432.4	408.3	367.5
3	0		1/2	4			23520	11,760	1	864.7	816.7	735.0
4	1		3/8	4			23520	8,820	1	648.5	612.5	551.3
4	0		3/4	4			23520	17,640	1	1,297.1	1,225.0	1,102.5
5	N/A	64-QAM	2/3	6			35280	23,520	1	1,729.4	1,633.3	1,470.0
6			3/4	6			35280	26,460	1	1,945.6	1,837.5	1,653.8
7			5/6	6			35280	29,400	1	2,161.8	2,041.7	1,837.5
8		256-QAM	3/4	8			47040	35,280	1	2,594.1	2,450.0	2,205.0
9			5/6	8			47040	39,200	1	2,882.4	2,722.2	2,450.0
10		1024-QAM	3/4	10			58800	44,100	1	3,242.6	3,062.5	2,756.3
11			5/6	10			58800	49,000	1	3,602.9	3,402.8	3,062.5

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Table 26-91—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	7840	1,960	1	144.1	136.1	122.5
0	0		1/2	1			7840	3,920	1	288.2	272.2	245.0
1	1	QPSK	1/4	2			15680	3,920	1	288.2	272.2	245.0
1	0		1/2	2			15680	7,840	1	576.5	544.4	490.0
2	N/A		3/4	2			15680	11,760	1	864.7	816.7	735.0
3	1	16-QAM	1/4	4			31360	7,840	1	576.5	544.4	490.0
3	0		1/2	4			31360	15,680	1	1,152.9	1,088.9	980.0
4	1		3/8	4			31360	11,760	1	864.7	816.7	735.0
4	0		3/4	4			31360	23,520	1	1,729.4	1,633.3	1,470.0
5	N/A	64-QAM	2/3	6			47040	31,360	1	2,305.9	2,177.8	1,960.0
6			3/4	6			47040	35,280	1	2,594.1	2,450.0	2,205.0
7			5/6	6			47040	39,200	1	2,882.4	2,722.2	2,450.0
8		256-QAM	3/4	8			62720	47,040	1	3,458.8	3,266.7	2,940.0
9			5/6	8			62720	52,266	1	3,843.1	3,629.6	3,266.6
10		1024-QAM	3/4	10			78400	58,800	1	4,323.5	4,083.3	3,675.0
11			5/6	10			78400	65,333	1	4,803.9	4,537.0	4,083.3

Table 26-92—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	9800	2,450	1	180.1	170.1	153.1
0	0		1/2	1			9800	4,900	1	360.3	340.3	306.3
1	1	QPSK	1/4	2			19600	4,900	1	360.3	340.3	306.3
1	0		1/2	2			19600	9,800	1	720.6	680.6	612.5
2	N/A		3/4	2			19600	14,700	1	1,080.9	1,020.8	918.8
3	1	16-QAM	1/4	4			39200	9,800	1	720.6	680.6	612.5
3	0		1/2	4			39200	19,600	1	1,441.2	1,361.1	1,225.0
4	1		3/8	4			39200	14,700	1	1,080.9	1,020.8	918.8
4	0		3/4	4			39200	29,400	1	2,161.8	2,041.7	1,837.5
5	N/A	64-QAM	2/3	6			58800	39,200	1	2,882.4	2,722.2	2,450.0
6			3/4	6			58800	44,100	1	3,242.6	3,062.5	2,756.3
7			5/6	6			58800	49,000	1	3,602.9	3,402.8	3,062.5
8		256-QAM	3/4	8			78400	58,800	1	4,323.5	4,083.3	3,675.0
9			5/6	8			78400	65,333	1	4,803.9	4,537.0	4,083.3
10		1024-QAM	3/4	10			98000	73,500	1	5,404.4	5,104.2	4,593.8
11			5/6	10			98000	81,666	1	6,004.9	5,671.3	5,104.1

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Table 26-93—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	11760	2,940	1	216.2	204.2	183.8
0	0		1/2	1			11760	5,880	1	432.4	408.3	367.5
1	1	QPSK	1/4	2			23520	5,880	1	432.4	408.3	367.5
1	0		1/2	2			23520	11,760	1	864.7	816.7	735.0
2	N/A		3/4	2			23520	17,640	1	1,297.1	1,225.0	1,102.5
3	1	16-QAM	1/4	4			47040	11,760	1	864.7	816.7	735.0
3	0		1/2	4			47040	23,520	1	1,729.4	1,633.3	1,470.0
4	1		3/8	4			47040	17,640	1	1,297.1	1,225.0	1,102.5
4	0		3/4	4			47040	35,280	1	2,594.1	2,450.0	2,205.0
5	N/A	64-QAM	2/3	6			70560	47,040	1	3,458.8	3,266.7	2,940.0
6			3/4	6			70560	52,920	1	3,891.2	3,675.0	3,307.5
7			5/6	6			70560	58,800	1	4,323.5	4,083.3	3,675.0
8		256-QAM	3/4	8			94080	70,560	1	5,188.2	4,900.0	4,410.0
9			5/6	8			94080	78,400	1	5,764.7	5,444.4	4,900.0
10		1024-QAM	3/4	10			117600	88,200	1	6,485.3	6,125.0	5,512.5
11			5/6	10			117600	98,000	1	7,205.9	6,805.6	6,125.0

Table 26-94—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	13720	3,430	1	252.2	238.2	214.4
0	0		1/2	1			13720	6,860	1	504.4	476.4	428.8
1	1	QPSK	1/4	2			27440	6,860	1	504.4	476.4	428.8
1	0		1/2	2			27440	13,720	1	1,008.8	952.8	857.5
2	N/A		3/4	2			27440	20,580	1	1,513.2	1,429.2	1,286.3
3	1	16-QAM	1/4	4			54880	13,720	1	1,008.8	952.8	857.5
3	0		1/2	4			54880	27,440	1	2,017.6	1,905.6	1,715.0
4	1		3/8	4			54880	20,580	1	1,513.2	1,429.2	1,286.3
4	0		3/4	4			54880	41,160	1	3,026.5	2,858.3	2,572.5
5	N/A	64-QAM	2/3	6			82320	54,880	1	4,035.3	3,811.1	3,430.0
6			3/4	6			82320	61,740	1	4,539.7	4,287.5	3,858.8
7			5/6	6			82320	68,600	1	5,044.1	4,763.9	4,287.5
8		256-QAM	3/4	8			109760	82,320	1	6,052.9	5,716.7	5,145.0
9			5/6	8			109760	91,466	1	6,725.4	6,351.8	5,716.6
10		1024-QAM	3/4	10			137200	102,900	1	7,566.2	7,145.8	6,431.3
11			5/6	10			137200	114,333	1	8,406.8	7,939.8	7,145.8

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Table 26-95—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	15680	3,920	1	288.2	272.2	245.0
0	0		1/2	1			15680	7,840	1	576.5	544.4	490.0
1	1	QPSK	1/4	2			31360	7,840	1	576.5	544.4	490.0
1	0		1/2	2			31360	15,680	1	1,152.9	1,088.9	980.0
2	N/A		3/4	2			31360	23,520	1	1,729.4	1,633.3	1,470.0
3	1	16-QAM	1/4	4			62720	15,680	1	1,152.9	1,088.9	980.0
3	0		1/2	4			62720	31,360	1	2,305.9	2,177.8	1,960.0
4	1		3/8	4			62720	23,520	1	1,729.4	1,633.3	1,470.0
4	0		3/4	4			62720	47,040	1	3,458.8	3,266.7	2,940.0
5	N/A	64-QAM	2/3	6			94080	62,720	1	4,611.8	4,355.6	3,920.0
6			3/4	6			94080	70,560	1	5,188.2	4,900.0	4,410.0
7			5/6	6			94080	78,400	1	5,764.7	5,444.4	4,900.0
8		256-QAM	3/4	8			125440	94,080	1	6,917.6	6,533.3	5,880.0
9			5/6	8			125440	104,533	1	7,686.3	7,259.2	6,533.3
10		1024-QAM	3/4	10			156800	117,600	1	8,647.1	8,166.7	7,350.0
11			5/6	10			156800	130,666	1	9,607.8	9,074.0	8,166.6

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Annex C

(normative)

ASN.1 encoding of the MAC and PHY MIB

C.3 MIB Detail

Insert the following (after getting some sucker to validate MIB compilation, etc.):

```
Dot11HEStationConfigEntry ::= SEQUENCE
    {
        dot11HEDynamicFragmentationImplemented,               TruthValue
    }

dot11HEDynamicFragmentationImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
         Its value is determined by device capabilities.

         This attribute, when true, indicates that the STA implementation is
         capable of receiving dynamic fragments. The capability is disabled,
         otherwise"
    DEFVAL { false }
::= { dot11HEStationConfigEntry <XX>}


dot11PPEThresholdsRequired OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
    "This is a capability variable.
     Its value is determined by device capabilities.
    This attribute, when true, indicates that Post-FEC Padding and Packet Exten-
        sion Thresholds exist and are provided in dot11PPEThresholdsTable(#1313)."
    DEFVAL { false }
    ::= { dot11StationConfigEntry <ANA>}(#1481)

-- ****************************************************************
-- * dot11PPEThresholdsMappings TABLE
-- ****************************************************************
dot11PPEThresholdsMappingsTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11PPEThresholdsMappingsEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Conceptual table for PPE Thresholds Mappings. The MIB supports the
         ability to share separate PPE Thresholds for each NSS/RU pair. The
         Thresholds Mappings Table contains one entry for each NSS/RU pair
         and contains two fields for each entry: PPET8 and PPET16. The PPE
         Thresholds mappings are logically WRITE-ONLY. Attempts to read the
         entries in this table return unsuccessful status and values of null or 0.
         The default value for all PPET8 fields is NONE."
    REFERENCE "IEEE Std 802.11-<year>, 25.13 (HE PPDU post FEC padding and packet
        extension)(#1632)"
::= { dot11smt 4 }
```

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```
dot11PPEThresholdsMappingsEntry OBJECT-TYPE
    SYNTAX Dot11PPEThresholdsMappingsEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An Entry (conceptual row) in the PPE Thresholds Mappings Table.
         ifIndex - Each IEEE Std 802.11 interface is represented by an ifEntry.
         Interface tables in this MIB module are indexed by ifIndex."
    INDEX { ifIndex, dot11PPEThresholdsMappingIndex }
::= { dot11PPEThresholdsMappingsTable 1 }

Dot11PPEThresholdsMappingsEntry ::= SEQUENCE {
    dot11PPEThresholdsMappingIndex                  Unsigned32,
    dot11PPEThresholdsMappingNSS                    Integer,
    dot11PPEThresholdsMappingRUIndex                Integer,
    dot11PPEThresholdsMappingPPET8                  Integer,
    dot11PPEThresholdsMappingPPET16                 Integer,
    dot11PPEThresholdsMappingStatus                 RowStatus}

dot11PPEThresholdsMappingIndex OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
    "The auxiliary variable used to identify instances of the columnar objects
     in the PPE Thresholds Mappings Table."
::= { dot11PPEThresholdsMappingsEntry 1 }

dot11PPEThresholdsMappingNSS OBJECT-TYPE
    SYNTAX Integer
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The NSS value portion of the NSS/RU pair for which the values from this
         Thresholds mapping entry are to be used."
::= { dot11PPEThresholdsMappingsEntry 2 }

dot11PPEThresholdsMappingRUIndex OBJECT-TYPE
    SYNTAX Integer
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The index of the RU value portion of the NSS/RU pair for which the values
         from this Thresholds mapping entry are to be used. The index values
         map to an RU as follows: RU Index of 0 is 996 tones, 1 is 448 tones,
         2 is TBD tones, 3 is reserved."
::= { dot11PPEThresholdsMappingsEntry 3 }

dot11PPEThresholdsMappingPPET8 OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a
         Post FEC Padding and Packet Extension value of at least 8 us is
         required for the given NSS/RU pair corresponding to the row of the
         entry. The index values are mapped as follows: 0 is BPSK, 1 is QPSK,
         2 is 16-QAM, 3 is 64-QAM, 4 is 256-QAM, 5 is 1024-QAM(#1633),
         6 is reserved, 7 is the special value of NONE."
::= { dot11PPEThresholdsMappingsEntry 4 }

dot11PPEThresholdsMappingPPET16 OBJECT-TYPE
    SYNTAX TruthValue
```


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```
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a
         Post FEC Padding and Packet Extension value of 16 us is required for
         the given NSS/RU pair corresponding to the row of the entry. The index
         values are mapped as follows: 0 is BPSK, 1 is QPSK, 2 is 16-QAM,
         3 is 64-QAM, 4 is 256-QAM, 5 is 1024-QAM#1633), 6 is reserved,
         7 is the special value of NONE."
::= { dot11PPEThresholdsMappingsEntry 5 }

dot11PPEThresholdsMappingStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status column used for creating, modifying, and deleting instances
         of the columnar objects in the PPE Thresholds mapping Table."
    DEFVAL { active }
::= { dot11PPEThresholdsMappingsEntry 6 }

-- ****************************************************************
-- * End of dot11PPEThresholdsMappings TABLE
-- ****************************************************************

dot11HEComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11HEDynamicFragmentationImplemented}
    STATUS current
    DESCRIPTION
        "Attributes that configure the HE Group for IEEE 802.11."
::= { dot11Groups <XX> }(#1481)
```

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