IEEE P802.11
Wireless LANs

Proposed TGax draft specification

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Abstract

This document contains a proposal for the TGax draft amendment. It captures the feature requirements outlined in the TGax specification framework document (11-15/0132) in detailed draft text.

1 Preface

1.1 Revision history

Revision	Date	Changes
0	January 15, 2016	Initial draft
1	March 2, 2016	Created a new MAC clause and moved most of the MAC stuff there. Added text contributions for recent SFD additions. Additional authors.

1.2 Notation

Editing instructions are shown in ***bold italic***.

Editor's notes in ***red bold italics*** are provided to aid in drafting the document. For example, missing text or indicating the placement of future text.

1.3 Baseline document

This document is written as an amendment to the Draft P802.11-REVmc/D5.00 revision of the 802.11 specification as amended by Draft P802.11ai/D6.3 and Draft P802.11ah/D6.0.

2 Normative references

3 Definitions, acronyms, and abbreviations

3.1 Definitions

3.2 Definitions specific to IEEE Std 802.11

3.3 Definitions specific to IEEE 802.11 operation in some regulatory domains

3.4 Abbreviations and acronyms

Insert the following acronym definitions:

DL	Dowlink
DL MU	Downlink multi-user
HE	High Efficiency
OFDMA	Orthogonal Frequency-Division Multiple Access
MU-RTS	Multi-user request to send
UL	Uplink

3.5 Abbreviations and acronyms in some regulatory domains

4 General description

4.3 Components of the IEEE Std 802.11 architecture

4.3.12a High efficiency (HE) STA

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

An HE STA is VHT STA that, in addition to the features supported as a VHT STA, supports the MAC features defined in Clause 25 and the PHY features defined in Clause 26.

5 MAC service definition

6 Layer management

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

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	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

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	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

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	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

6.3.8.3.1 Semantics of the service primitive

Insert the following new parameter into the MLME-START.request primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	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

Insert the following new parameters into the MLME-START.request primitive:

HE Capbilities

HE Operation

Insert the following new entires to the unnumbered table in this subclause:

Name	Type	Valid Range	Description
HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	The HE capabilities to be advertised for the BSS. The parameter is present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in frame format HE Operation element.	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.

7 DS SAP specification

8 PHY service specification

9 Frame formats

9.1 General requirements

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 8-1 as follows:

Table 9-1 - Valid type and subtype combinations

Type value B3 B2	Type	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 as follows:

The Order field is 1 bit in length. It is used for two purposes:

— 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, ~~or~~ VHT, or HE for the FORMAT parameter of the TXVECTOR to indicate that the frame contains an HT Control field.

Otherwise, the Order field is set to 0.

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

9.2.4.6 HT Control field

9.2.4.6.1 General

Remove Figure 9-7 (HT Control field).

Insert Table 9-9a (HT Control field) 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	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~~ different forms, the HT variant, ~~and~~ the VHT variant, and the HE variant. These forms differ in the values of the VHT and/or HE subfields and in their formats, which are shown in Table 8-9a (HT Control field).

The VHT subfield is set to 0 to indicate a 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 a HE variant HE Control field.

The two forms differ in the format of tThe HT Control Middle subfield, described is defined in 8.2.4.6.2 (HT variant) for the HT variant and

The VHT Control Middle subfield is defined in 8.2.4.6.3 (VHT variant)~~ for the VHT variant and in the value of the VHT subfield~~.

The Aggregated Control subfield is defined in 8.2.4.6.4 (HE variant).

~~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 9-12 (VHT Control Middle subfield of the VHT variant HT Control field).

Change Figure 9-12 as follows:

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

Figure 9-12 — 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 HE variant

9.2.4.6.4.1 General

The format of the Aggregated Control (A-Control) subfield of the HE variant HT Control is shown in Figure 9.14a (HE variant HT Control field format).

	B2		B31
Control 1	…	Control N	Padding
Bits:		30	

Figure 9-14a - A-Control subfield of the HE variant HT Control field

The A-Control subfield contains a sequence of one or more Control subfields. The format of each Control subfield is defined in Figure 9.14b (Control subfield format). The Control subfield with Control ID subfield equal to 0, if present, is the first subfield of the sequence.

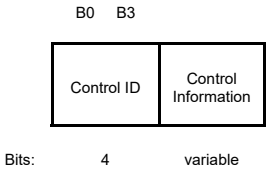


Figure 9-14b - Control subfield format

The Control ID subfield indicates the type of information carried in the Control Information subfield, and the length of the Control Information subfield, which is fixed and that corresponds to each value of the Control ID subfield. 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, in bits, of the Control Information subfield	Contents of the Control Information subfield
0	UL MU response scheduling	*TBD*	See 8.2.4.6.4.2 (UL MU response scheduling)
1	Receive operation mode indication	*TBD*	See 8.2.4.6.4.3 (Receive operation mode indication)
2	HE link adaptation	*TBD*	See 8.2.4.6.4.4 (HE link adaptation)
TBD	…		
8-15	Reserved		

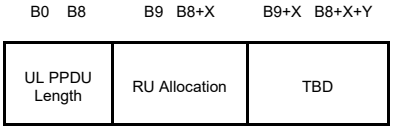
The Control Information subfield carries control information that depends on the Control ID value, as defined in Table 9-18a (Control ID subfield values).

The Padding subfield follows the last Control subfield and is set to a sequence of zeros so that the length of the A-Control subfield is 30 bits.

9.2.4.6.4.2 UL MU response scheduling

The Control Information subfield, when the Control ID subfield is 0, contains scheduling information for an HE trigger-based PPDU that carries an immediate acknowledgement, which is sent as a response to the soliciting A-MPDU (see 9.42.2 (UL MU operation)).

The format of the Control Information subfield is defined in Figure 9-14c (Control Information subfield format when Control ID subfield is 0).



Bits:	9	X	Y

Figure 9-14c - Control Information subfield format when Control ID subfield is 0

The UL PPDU Length subfield indicates the length of the HE trigger-based PPDU response and is set to a nonzero value that is TBD.

The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE trigger-based PPDU response and is set to TBD.

9.2.4.6.4.3 Receive operation mode indication

The Control Information subfield, when the Control ID subfield is 1, contains information related to the receive operation mode of the STA transmitting the frame containing this information (see 25.8 (Receive operating mode indication)).

The format of the Control Information subfield is defined in Figure 9-14d (Control Information subfield format when Control ID subfield is 1).

	B0 B2	B3 B4	B5 B4+X
	RX NSS	RX Channel Width	TBD
Bits:	3	2	X

Figure 9-14d - Control Information subfield format when Control ID subfield is 1

The RX NSS subfield indicates the maximum number of spatial streams, N_{SS}, supported by the STA in reception, 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

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

The format of the Control Information subfield is defined in Figure 9-14e (Control Information subfield format when Control ID subfield is 2).

	B0 B2	B3 B6	B7 B6+X
	NSS	HE-MCS	*TBD*
Bits:	3	4	X

Figure 9-14e - 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)).

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 of this subclause as follows:

The Duration/ID field is determined as follows:

a) Single protection settings.
   1) In an RTS frame that is not part of a dual clear-to-send (CTS) exchange, 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 of this subclause as follows:

b) Multiple protection settings. The Duration/ID field is set to a value D as follows:
   1) If $T_{TXOP} = 0$ and $T_{END\_NAV} = 0$, then $D = T_{SINGLE\text{-}MSDU} - T_{PPDU}$
   2) Else if $T_{TXOP} = 0$ and $T_{END\_NAV} > 0$, then $D = \max(0, T_{END\text{-}NAV} - T_{PPDU})$
   3) Else if $T_{END\text{-}NAV} = 0$, then $\min(T_{PENDING}, T_{TXOP} - T_{PPDU}) \le D \le T_{TXOP} - T_{PPDU}$
   4) Else $T_{END\text{-}NAV} - T_{PPDU} \le D \le T_{TXOP\text{-}REMAINING} - T_{PPDU}$

   where

   $T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 9.22.2.8 (TXOP limits) (for a TXOP limit of 0), including applicable IFSs

   $T_{PENDING}$ 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
   - Any RDG
   - 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 dot11EDCATable-TXOPLimit (dot11QAP-EDCATableTXOPLimit for the AP) for that AC

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

   $T_{END\text{-}NAV}$ 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 with the Individual/Group bit forced to the value 0.

9.3.1.9 BlockAck frame format

Change Figure 9-32 as follows:

	B0	B1	B2	B3	B4	~~B4~~B5 B11	B12 B15
	BA Ack Policy	Multi-TID	Compressed Bitmap	GCR	Multi-STA	Reserved	TID_INFO
Bits	1	1	1	1	1	~~8~~7	4

Figure 9-32 - BA Control field

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 BlockAck frame with the Multi-STA subfield equal to 1 is not sent under Delayed and HT-delayed agreements.

Change Table 9-24 as follows:

Table 9-24 - Block Ack frame variant encoding

Multi-TID subfield value	Compressed Bitmap subfield value	GCR subfield value	Multi-STA Subfield value	BlockAck frame variant
0	0	0	0	Basic BlockAck
0	1	0	0	Compressed BlockAck
1	0	0	0	Extended Compressed BlockAck
1	1	0	0	Multi-TID BlockAck
0	0	1	0	Reserved
0	1	1	0	GCR Block Ack
1	0	1	0	Reserved
1	1	1	0	Reserved
0	0	0	1	Reserved
0	1	0	1	Reserved
1	0	0	1	Reserved
1	1	0	1	Multi-STA BlockAck
0	0	1	1	Reserved
0	1	1	1	Reserved
1	0	1	1	Reserved
1	1	1	1	Reserved

Change the 7th paragraph of this subclause as follows:

The values of the Multi-TID, Compressed Bitmap, ~~and~~ GCR and Multi-STA subfields of the BA Control field determine which of the BlockAck frame variants is represented, as indicated in the Table 9-24.

9.3.1.9.3 Compressed BlockAck variant

Change subclause 9.3.1.9.3 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 9-34 (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 frames by an HT STA or DMG STA). ~~The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.~~

When the Fragment Number subfield is 0, ~~T~~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 field 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 field 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.

When 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 MSDUs and A-MSDUs. Bit position *n* of the Block Ack Bitmap field, if equal to 1, acknowledges receipt of an MPDU with sequence number value, *SN* and fragment number value, *FN* with *n* equal to 4 × (*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. When bit position *n* of the Block Ack Bitmap field is equal to 0 it indicates that the MPDU has not been received.

NOTE—When the Fragment Number subfield is equal to 1 then the BlockAck Bitmap field is split into 16 subbitmaps, each of which indicates receive status for 4 fragments of each of the 16 MSDUs.

Insert a new subclause after 9.3.1.9.6:

9.3.1.9.7 Multi-STA BlockAck variant

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 instances of the Per STA Info subfields. The Per STA Info subfield is shown in Figure 9-37a.

	Per-AID TID Info	Block Ack Starting Sequence Control	Block Ack Bitmap
Octets	2	0 or 2	0 or 8

Figure 9-37a - Per STA Info subfield format

The Per AID TID Info subfield is shown in Figure 9-37b.

	B0 B10	B11	B12-B15
	AID	ACK Type	TID
Bits	11	1	4

Figure 9-37b - Per AID TID Info subfield format

The AID field carries the AID of the STA for which the Per STA Info field is intended.

The TID field contains the TID for which the acknowledgement or block acknowledgement applies.

If the ACK Type field is 0, then the Block Ack Starting Sequence Control and Block Ack Bitmap are not present and the Per STA Info field indicates the acknowledgement of successful reception of either a single MPDU or of all the MPDUs carried in the eliciting (A-) MPDU. If the ACK Type subfield is 1, then the Block Ack Starting Sequence Control and Block Ack Bitmap fields are present.

When the Fragment Number subfield is 1, the Block Ack Starting Sequence Control subfield is as shown in Figure 9-27. The Block Ack Bitmap subfield of the BA Information field of the Multi-STA BlockAck frame contains an 8-octet block ack bitmap. 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 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 the Fragment Number subfield 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 MSDUs and A-MSDUs. Bit position *n* of the Block Ack Bitmap field, if equal to 1, acknowledges receipt of an MPDU with sequence number value, *SN* and fragment number value, *FN* with n equal to $4 \times (SN - SSN) + FN$, 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. When bit position *n* of the Block Ack Bitmap field is equal to 0 it indicates that the MPDU has not been received.

NOTE—When the Fragment Number subfield is equal to 1 then the BlockAck Bitmap field is split into 16 subbitmaps, each of which indicates receive status for 4 fragments of each of the 16 MSDUs.

Insert a new subclause after 9.3.1.22:

9.3.1.23 Trigger frame

The Trigger frame is used to allocate resource for UL MU transmission and to solicit an UL MU transmission at [TBD IFS] after the PPDU that carries the Trigger frame. The Trigger frame also carries other information required by the responding STA to send UL MU.

The frame format for the Trigger frame is as defined in Figure 9-51a (Trigger frame).

	Frame Control	Duration	(RA)	TA	Common Info	Per User Info	…	Per User Info	Padding	FCS
Octets:	2	2	6	6	TBD	TBD		TBD		4

Figure 9-51a - Trigger frame

The Duration/ID 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. Whether RA is not part of Trigger frame is TBD.

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

The Common Info field is defined in Figure 9-51b.

	Length	Cascade Indication	CS Required	HE-SIG-A Info	CP and LTF Type	Trigger Type	Trigger-dependent Common Info
Bits:	12	1	1	TBD	TBD	TBD	variable

Figure 9-51b - Common Info field

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 follows the current Trigger frame. Otherwise the Cascade Indication subfield is 0.

The CS Required subfield is set to 1 to indicate that the STAs identified in the Per User Info 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 repond. The CS Requred subfield is set to 0 to indicate that the STAs identified in the Per User Info fields are not required consider the medium state or the NAV in determining whether or not to respond.

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 may be implicitly known by all responding STAs can be excluded.

The CP and LTF Type subfield of the Common Info field indicates the CP and HE-LTF type of the HE trigger-based PPDU response. The CP and LTF field encoding is defined in Table 9-2.

Table 9-2 - CP and LTF field encoding

CP and LTF field value	Description
0	2x LTF + 0.8 µs CP
1	2x LTF + 1.6 µs CP
2	4x LTF + 3.2 µs CP
3-TBD	Reserved

The Trigger Type subfield indicates the type of the Trigger frame. The Trigger frame can include an optional type-specific Common Info and optional type-specific Per User Info. Table 9-3 defines the valid Trigger Type.

Table 9-3 - Trigger Type field encoding

Trigger Type value	Trigger Type description
0	Basic Trigger
1	Beamforming Report Poll Trigger
2	MU-BAR
3	MU-RTS
4-TBD	Reserved

The Per User Info field is defined in Figure 9-1.

	User Indentifier	RU Allocation	Coding Type	MCS	DCM	SS Allocation	Trigger dependent Per User Info
Bits:	12	TBD	TBD	TBD	TBD	TBD	variable

Figure 9-1 - Per User Info field

The User Identifier subfield of the Per User Info field indicates the AID of the STA allocated the RU to transmit the MPDU(s) in the HE trigger-based PPDU.

The RU Allocation subfield of the Per User Info field indicates the RU used by the HE trigger-based PPDU of the STA identified by User Identifier subfield. The length and coding of RU Allocation subfield are TBD.

The Coding Type subfield of the Per User Info field indicates the code type of the HE trigger-based PPDU response of the STA identified by User Identifier subfield. Set to 0 for BCC and set to 1 for LDPC.

The MCS subfield of the Per User Info field indicates the MCS of the HE trigger-based PPDU response of the STA identified by User Identifier field. The encoding of the MCS field is as defined in Section XXX.

The DCM subfield of the Per User Info field indicates dual carrier modulation of the HE trigger-based PPDU response of the STA identified by User Identifier subfield. A value of 1 indicates that the HE trigger-based PPDU response shall use DCM as defined in section XXX. Set to 0 to indicate that DCM shall not be used.

The SS Allocation subfield of the Per User Info field indicates the spatial streams of the HE trigger-based PPDU response of the STA identified by User Identifier field.

The Padding field extends the frame length to give the recipient STAs more time to prepare a response. The length and the content of Padding field are TBD.

9.3.1.23.1 MU-BAR variant

If the Trigger frame is an MU-BAR vaiant, then the Trigger-dependent Common Info field is define in Figure 9-2.

GCR indication	GCR Address

Bits: 48

Figure 9-2 – Trigger-dependent Common Info field for MU-BAR variant

If the Trigger frame is an MU-BAR vaiant, then the Trigger-dependent Per User Info field is define in Figure 9-3.

BAR Control	BAR Information

Bits:

Figure 9-3 - Trigger-dependent Per User Info field for MU-BAR variant

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).

9.3.1.23.2 MU-RTS variant

The MU-RTS frame format is a variant of Trigger frame format as shown in Figure 9-51a.

If an MU-RTS frame requests a STA to respond with a CTS frame carried in a non-HT or non-HT duplicate PPDU, the RU Allocation subfield in the Per-User Info field addressed to the STA 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.

The Duration/ID field is defined in 9.2.5.2 Duration/ID field (QoS STA).

9.3.2 Data frames

9.3.3 Management frames

9.3.3.2 Beacon frame format

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

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

9.3.3.5 Association Request frame format

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

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented 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 (Beacon frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.7 Reassociation Request frame format

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

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):

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

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

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

Insert the following two sublauses:

9.4.1.62 HE Compressed Beamforming Report field

The format of the HE Compressed Beamforming Report field is based on the VHT Compressed Beamforming Report field in 9.4.1.48 (VHT Compressed Beamforming Report field) except for the following modifications.

The supported values for the tone grouping factor Ng shall be *Ng* = 4 and *Ng* = 16 for SU-MIMO, MU-MIMO and OFDMA. Here, the tone grouping factor Ng is defined with respect to data tones of the HE PPDU.

Other modification are TBD.

9.4.1.63 HE MU Exclusive Beamforming Report field

The HE MU Exclusive Beamforming Report Field is based on the VHT Exclusive Beamforming Report Field in 9.4.1.50, except for the following modifications.

The MU Exclusive Beamforming Report information consists of Delta SNR subfields for each space-time stream (1 to *Nc*) of a subset of the subcarriers spaced *Ng* apart (where *Ng* is the tone grouping factor). Specifically, the locations of the feedback tones for delta SNR subfields shall be identical to the tone locations of the compressed V matrices fed back.

Other modification are TBD.

9.4.2 Elements

9.4.2.1 General

Insert the following new rows into Table 9-75 Element IDs (header row shown for convenience):

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 bit B3 from "Reserved" to "Broadcast" in Figure 8-577ax (Control field format).

Insert the following paragraph after Table 9-248l (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 9.44.3 (Broadcast TWT Operation). The Broadcast field is set to 1 to indicate that the TWT(s) defined by the TWT element are broadcast TWT(s); otherwise, it is set to 0.

Change bit B4 from "Reserved" to "Trigger" in Figure 9-577ay (Request Type field format).

Insert the following paragraph after Table 9-248l (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:

For a TWT SP that is not a broadcast TWT SP, Tthe 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 9-248l1 (TWT Flow Identifier field for a broadcast TWT element).

Table 9-248l1 - 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 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 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 TWT, the TWT wake interval indicates the value of the listen interval (see 10.44.3.4 (Negotiation of TBTT and listen interval).

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^(TWT Wake Interval Exponent).

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". 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 9-248l – TWT Setup Command field values by adding two new columns as shown:

Table 9-248l – 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	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* are suggested by the TWT scheduled STA in the TWT request.	N/A

		STA in the TWT request.			
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 accommodate, 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 accommodate, then the TWT setup will be rejected.	N/A		N/A
3	TWT Grouping		N/A	N/A	N/A
4	Accept TWT	N/A	TWT responding STA accepts the TWT request with the TWT parameters* indicated in the TWT element transmitted by the responding STA.	N/A	TWT scheduling STA accepts the TWT request with the TWT parameters* 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
*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.

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 9-554aa (HE Capabilities element format).

	Element ID	Length	HE Capabilities Information	PPE Thresholds (optional)
Octets:	1	1	2	variable

Figure 9-554aa - 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 9-554ab (HE Capabilities field format).

	B0	B1	B2	B3 B4	B5 B15
	PPE Thresholds Present	TWT Requester Support	TWT Responder Support	Fragmentation Support	Reserved
Bits:	1	1	1	2	12

Figure 9-554b - HE Capabilities field format

The PPE Thresholds Present field indicates if the HE PPE Thresholds field 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 HE PPE Thresholds field 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 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 9-554ae (Fragmentation Support field encoding).

Table 9-554ae - Fragmentation Support field encoding

Fragmentation Support field value	Meaning
0	No support for HE Fragmentation
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 per MSDU within a single A-MPDU
3	Support for multiple fragments per MSDU within an A-MPDU

The format of the PPE Thresholds field is defined in Figure 9-554ac (PPE Thresholds field format).

	B0 B1	B2 B3		
	NSS M1	RU Count	PPE Threshold Info	PPE Pad
Bits:	3	2	variable	variable

Figure 9-554ac -- 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. For example, if the number of NSS values represented is 4, then the NSS M1 subfield contains the value 3.

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) x RU Count x 6 bits in length. The format of the PPE Threshold Info field is defined in Figure 8-554ae (PPE Threshold Info field format).

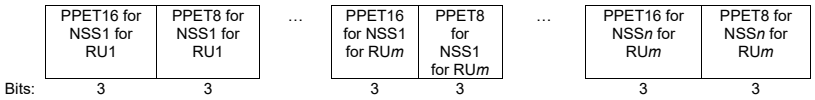


Figure 9-554ae - PPE Threshold Info field format

Each PPET8 for NSS*n* for RU*m* subfield contains a Constellation Index value.

Each PPET16 for NSS*n* for RU*m* subfield contains a Constellation Index value.

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 9-554af (PPET8 and PPET16 encoding).

Table 9-554af - 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	PPET16 == NONE	0 µs
PPET8 not present	PPET16 not present	0 µs

The RU Allocation Index encoding is indicated in Table 9-554ag (RU Allocation Index encoding).

Table 9-554ag - RU Allocation Index encoding

RU Allocation Index value	**RU allocation value**
0	2x996
1	996
2	484
3	242

The Constellation Index encoding is indicated in Table 9-554ah (Constellation Index encoding).

Table 9-554ah - Constellation Index encoding

Constellation Index value	**Corresponding Transmission Constellation**
0	BPSK
1	QPSK
2	16-QAM
3	64-QAM
4	256-QAM
5	1024-QAM

6	Reserved
7	NONE

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 quantity of octets.

STA that declare support for HE trigger-based PPDU shall also declare whether they belong to class A or class B. Class A STAs that are high capability devices and Class B STAs are low capability devices.

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 9-554ba (HE Operation element format).

	Element ID	Length	HE Operation Parameters
Octets:	1	1	2

Figure 9-554ba - HE Operation element format

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

The format of the HE Operation Parameters field is defined in Figure 9-554bb (HE Operation Parameters field format).

	B0	B15
	BSS Color	Reserved
Bits:	TBD	TBD

Figure 9-554bb - HE Operation Parameters field format

The BSS Color field is an unsigned integer whose value is the BSS Color 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 for this BSS.

9.4.3 Subelements

9.4.4 TLV encodings

9.4.5 Access network query protocol (ANQP) elements

9.4.6 Registered location query protocol (RLQP) elements

9.5 Fields used in Management and Extension frame bodies and Control frames

9.6 Action frame format details

9.7 Aggregate MPDU (A-MPDU)

9.7.3 A-MPDU contents

Change the first paragraph as follows:

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 HE

Insert the following paragraph:

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

Insert the following three rows in Table 9-420 (A-MPDU Contexts):

Name of Context	Definition of Context	Table defining permitted content
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 9-426a (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 8-426b (Multiple TID A-MPDU contents in the data enabled no immediate response context)
UL MU Context	An A-MPDU intended for a STA that is UL MU capable	Table 9-426c (A-MPDU content in the UL MU Context)

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

Table 9-426a - Multiple TID A-MPDU contents in the data enabled immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedule resource for following UL MU transmission and HE A-Control field in data/management frames don't include trigger information.	
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 implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BA frame.	
Action No Ack	Action No Ack frames	
Data frames sent under an HTimmediate block ack agreement	QoS Data frames with the multiple TIDs, with TID being corresponding to an HT-immediate block ack agreement	
QoS Null MPDUs with Ack Policy set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy set to No Acknowledgment.	
Action frame	At most one Action frame	
Data frame whith TID that has no block ack agreement and with Ack Policy set to Normal Ack	At most one data frame of the TID	
Immediate BlockAckReq frames	At most one data frame for one TID that there is no data frames sent under	

Table 9-426b – Multiple TID A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedule resource for following UL MU transmission and HE A-Control field in data/management frames don't include trigger information.	
Ack frame	If the preceding PPDU contains an MPDU that requires an Ack frame response.	

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.	At most one of the MPDUs is present
Multi-STA BlockAck frame	If the preceding PPDU contains implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BA frame.	
Action No Ack	Action No Ack frames	
Data frames without immediate block ack agreement and with Ack Policy 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 set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy set to No Acknowledgment.	

Table 9-426c – A-MPDU content in the UL MU context

MPDU Description	Condition
A control frame of subtype Trigger	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 may be included

10MAC sublayer functional description

10.1 Introduction

10.2 MAC architecture

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 as defined in 10.3.2.8a is one 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 as follows:

A virtual CS mechanism shall be provided by the MAC. This 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 PS-Poll frames, and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The mechanism for setting the NAV using RTS/CTS or MU-RTS/CTS or RTS/DMG CTS in the DCF is described in 10.3.2.4 (Setting and resetting the NAV),

use of the NAV in PCF is described in 10.4.3.3 (NAV operation during the CFP), and use of the NAV in HCF is described in 10.22.2.2 (EDCA backoff procedure) and 10.22.3.4 (NAV operation of a TXOP under HCCA). Additional details regarding NAV use appear in 10.3.2.5 (RTS/CTS with fragmentation), 10.3.2.13 (NAV distribution), 10.36.10 (Updating multiple NAV timers), and 10.26 (Protection mechanisms).

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:

10.3.2.8a MU RTS/CTS procedure

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

Figure 10-1 shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect DL MU PPDU and acknowledgement responses.

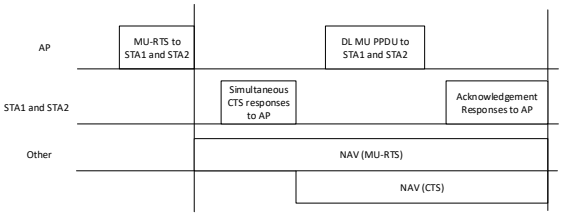


Figure 1 – Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting

Figure 10-1 – Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting

Figure 10-2 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.

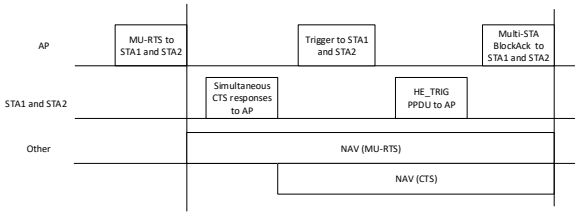


Figure 2 – Example of MU-RTS/CTS/Trigger/HE_TRIG PPDU/Multi-STA BlockAck and NAV setting

Figure 10-2 - Example of MU-RTS/CTS/Trigger/HE trigger-based PPDU/Multi-STA BlockAck and NAV setting

9.3.2.8a.1 MU-RTS procedure

An MU-RTS frame shall not request a STA to send CTS responses in any 20 MHz channel that is not occupied by the immediately preceding DL PPDU that contains an MU-RTS frame. In each 20 MHz channel occupied by the immediately preceding DL PPDU that contains an MU-RTS frame, there is at least one STA that is requested to send CTS responses on the 20 MHz channel.

If an MU-RTS frame requests a STA to send CTS responses in a non-HT or non-HT duplicate PPDU, the RU Allocation subfield in the Per-User Info field addressed to the STA shall be set to a value indicating either primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel. Other indications are TBD.

9.3.2.8a.2 CTS Repsonse to MU-RTS

If a HE STA receives an MU-RTS frame, the HE STA shall commence the transmission of a CTS 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 Per-User Info 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

— Other transmission conditions TBD are met.

HE STAs may transmit CTS responses to an MU-RTS frame in a non-HT or non-HT duplicate PPDU with frame format as defined in 9.3.1.3 based on the request in MU-RTS frame. The method of request is TBD.

The Scrambler Initialization in the SERVICE field of the CTS sent in response to an MU-RTS frame shall be copied from the Scrambler Initialization in the SERVICE field of the MU-RTS frame. The rate of the CTS response is defined in 10.7.6.

The CTS sent in response to an MU-RTS frame shall be transmitted on one or more 20 MHz channels.

If the CTS sent in response to an MU-RTS frame is transmitted in a non-HT or non-HT duplicate PPDU, then the CTS response shall be transmitted on the indicated 20 MHz channels identified in the RU Allocation subfield of the Per-User Info field.

Figure 10-3 shows an example of the exchange of MU-RTS and simultaneous CTS responses on primary 40 MHz channel. In this example, MU-RTS is transmitted in a 40 MHz non-HT duplicate PPDU on primary 40 MHz channel. Further, MU-RTS requests STA1 to transmit CTS response in a non-HT PPDU on primary 20 MHz channel and STA2 to transmit CTS response in a 40 MHz non-HT duplicate PPDU on primary 40 MHz channel.

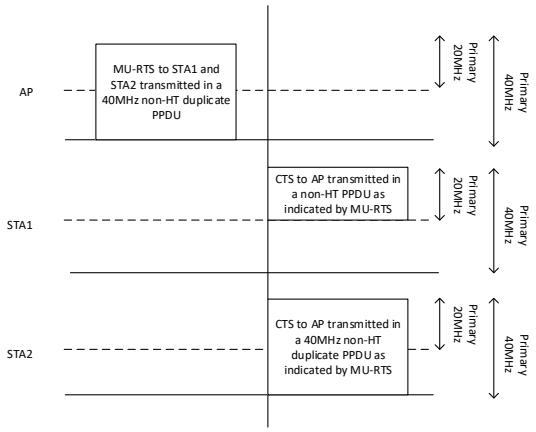


Figure 3 - Example of MU-RTS and CTS Responses on Primary 40MHz Channel

Figure 10-3 - Example of MU-RTS and CTS responses on the primary 40 MHz channel

10.3.2.11 MU acknowledgment procedure

Insert a new subclause heading before the first paragraph of 10.2.3.11:

10.3.2.11.1 General

Insert a new subclauses at the end of 10.2.3.11:

10.3.2.11.2 MU acknowledgement procedure for DL MU PPDU in SU format

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 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).

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 or the HE MU PPDU.

10.3.2.11.3 MU acknowledgement procedure for HE MU PPDU in MU format

A non-AP STA that is the recipient, within a HE MU PPDU, of an MPDU that solicits an immediate response with Ack Policy '01' 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 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 10-4.

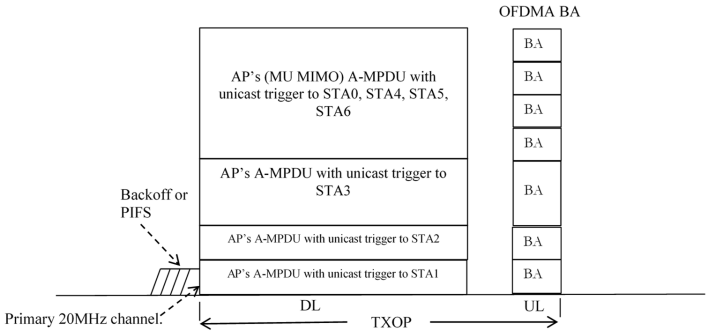


Figure 10-4 - An example of a TXOP containing an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement

An AP shall not set Ack Policy to "01" in QoS Control field in MPDUs of HE MU PPDU if both UL MU OFDMA Capable subfield and UL MU MIMO Capable subfield of the HE Capabilities element of the receiver of the MPDUs are set to 0.

10.3.2.11.4 MU acknowledgement procedure for an UL MU transmission

When receiving multiple frames from more than one STA that are part of an UL MU transmission (Clause 9.42.2) and that require an immediate acknowledgement, an AP may send multiple BlockAck frames (or ACK frames) in an OFDMA HE MU PPDU or a Multi-STA BlockAck (M-BA) frame. Additional conditions to transmit multiple BlockAck frames (or ACK frames) in an OFDMA HE MU PPDU or Multi-STA BlockAck are TBD. 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.

The example of DL OFDMA BA shown in Figure 10-5, and examples for Multi-STA BlockAck frame acknowledgement to a UL MU PPDU is given in Figure 10-6, Figure 10-7 and Figure 10-8.

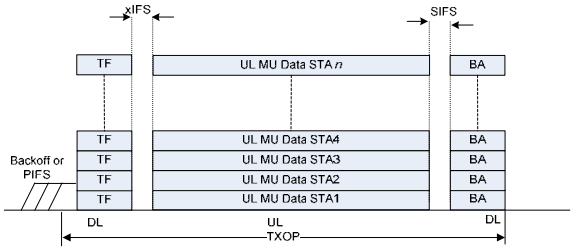


Figure 10-5 - An example of a TXOP containing an UL MU transmission with an immediate DL MU transmission containing unicast BlockAck frames acknowledging the frames received from the respective STAs

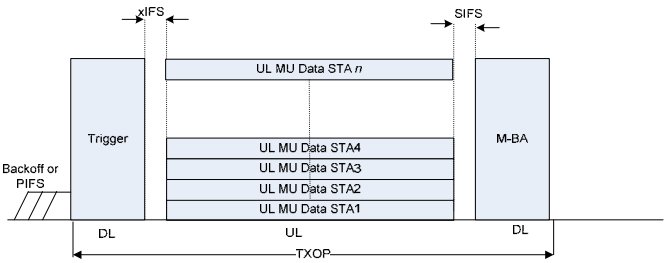


Figure 10-6 - An example of a TXOP containing UL MU transmissions with an immediate Multi-STA BlockAck (M-BA) frame acknowledging the MPDUs that were correctly received from each STA. The UL MU transmission may be OFDMA or MU-MIMO

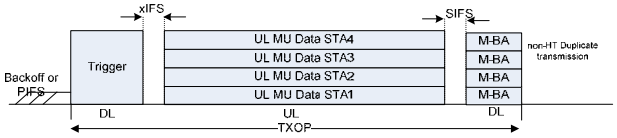


Figure 10-7 - An example of a TXOP containing UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the M-BA frame. The UL MU transmissions may be OFDMA or MU-MIMO.

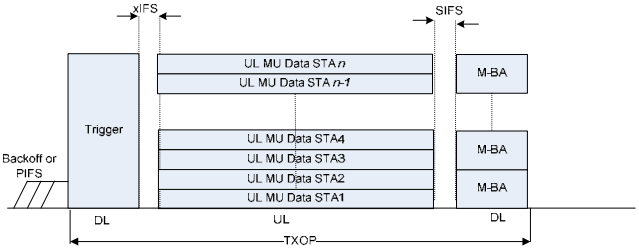


Figure 10-8 - An example of a TXOP containing UL MU transmissions with an immediate OFDMA HE MU PPDU containing Multi-STA BlockAck frames. The UL MU transmissions may be OFDMA or MU-MIMO.

10.7 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 a MU RTS/CTS exchange, the simultaneous CTS shall be transmitted with the primary rate based on the rate or MCS of the MU-RTS frame that triggers the simultaneous CTS. 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 ackowlegement frame is sent as an immediate response to an UL HE PPDU, the AP may ignore the <HE-MCS, NSS> tuples that are used for MPDUs in UL HE PPDU from non-AP STAs that elicits the DL acknowledgement.

A Multi-STA BlockAck frame is carried in a non-HT PPDU shall be transmitted by the AP using a rate supported by all the recipients.

A Multi-STA BlockAck frame is carried in an HT or VHT PPDU shall be transmitted by the AP using an HT-MCS or <VHT-MCS, NSS> tuple supported by all the recipients.

A Multi-STA BlockAck frame is carried in an HE PPDU shall be transmitted by the AP using an <HE-MCS, NSS> tuple supported by all the recipients.

10.9 HT Control field operation

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 the value of the dot11HEControlFieldOptionImplemented is true, a STA shall set the +HTC-HE Support subfield of the HE Capabilies 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 that has a value of true for at least one of dot11ULMUOFDMAOptionImplemented,

dot11MCSFeedbackOptionImplemented, and dot11ROMIOptionImplemented shall set the dot11HEControlFieldOptionImplemented 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 9.4.2.55 (HT Capabilities element)).

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 **Error! Reference source not found.**.

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 aControl subfield supported by the intended receiver that has:

— A value of 0 in the Control ID subfield when the transmitting STA expects an UL MU PPDU that carries an immediate acknowledgement, as described in 9.42.2 (UL MU operation).

— A value of 1 in the Control ID subfield when the transmitting STA changes the receive operation mode, as described in 10.45.2 (Receive operating mode indication).

— 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).

— ...

If the HT Control field is present in an MPDU aggregated in an A-MPDU, 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 shall contain an HT Control field. The HT Control field of all MPDUs containing the HT Control field aggregated in the same A-MPDU shall be set to the same value.

10.22 HCF

10.22.2 HCF contention based channel access (EDCA)

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.

10.24 Block acknowledgment (block ack)

10.24.10 GCR block ack

Insert the following sentences at the end of 2nd paragraph of section 10.24.10.3:

The originator may send a MU-BAR frame (MU-BAR Trigger variant of UL-Trigger Frame) to one or more of the HE STAs that have a GCR block ack agreement for this group address. Upon reception of the BlockAck frame, an originator may send a MU-BAR frame to other one or more HE STAs that have a block ack agreement for this group address, and this process may be repeated multiple times.

Insert the following sentences at the end of 4th paragraph of section 10.24.10.3:

When HE STA receives a MU-BAR frame with User identifier field 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 acknowledge the HE STA's reception status of the block of group addressed frames requested by the MU-BAR frame.

Insert the following sentences and a picture at the end of 5th paragraph of section 10.24.10.3:

Figure 10-9 (Example of a frame exchange with GCR block ack retransmission policy) 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 a MU-BAR to group member 1 and 2 of the GCR group, waits for the BlockAck frames, and then sends a MU-BAR to group member 3. After receiving the BlockAck frame from GCR group member 3, the HE 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.

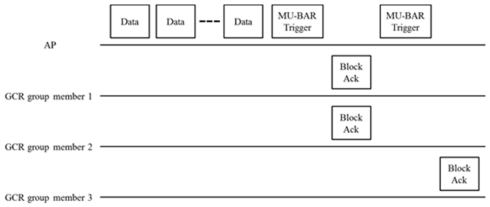


Figure 10-9 - Example of a frame exchange with GCR block ack retransmission policy

Change the following sentences in 6th paragraph of section 10.24.10.3:

After completing the BlockAckReq and BlockAck frame exchanges <u>or the MU-BAR and BlockAck frame exchanges</u>, 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.

Change the following sentences in 7th paragraph of section 10.24.10.3

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 <u>or an MU-BAR frame</u> has been sent, whichever occurs first.

Insert the following sentences at the end of 8th paragraph of section 10.24.10.3

An originator may also regularly send an MU-BAR frame with User identifier field 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.

Change the following in 12th paragraph of section 10.24.10.3

If the beginning of such reception does not occur during the first slot time following a SIFS <u>in case of a BlockAckReq frame or a [TBD IFS] in case of an MU-BAR</u>, then the originator may perform error recovery

by retransmitting a BlockAckReq frame or an MU-BAR 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 BlockAck 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.

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:

A STA that transmits a frame carrying a TWT element to an HE STA may set the Trigger subfield of the element 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 **Error! Reference source not found.** (UL MU operation), 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 Indicaion 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 Indicaion 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 (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 a Trigger frame from the TWT responding STA with a Cascade Indicaion field equal to 0 that is not intended to it.

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.

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 9.44.3.2 (Rules for TWT scheduling STA).

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 10-10 (Example of broadcast TWT operation), where the AP is the TWT scheduling STA and STA 1 and STA 2 are the TWT scheduled STAs.

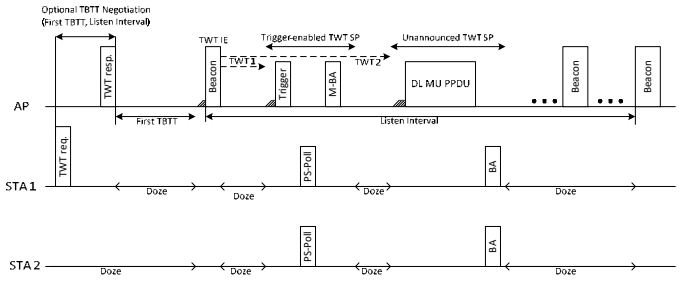


Figure 10-10 - Example of broadcast TWT operation

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 intended to 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 trigger-enabled TWT SP shall set the Cascade Indicaion 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 Indicaion 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).

25High Efficiency (HE) MAC specification

25.1 Introduction

25.2 Channel access

25.2.1 Updating two NAVs

Mandatory or optional support of two NAVs is TBD.

For the two NAVs maintained by a HE STA, one is identified as Intra-BSS 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 can update its Intra-BSS 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 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 or Inter-BSS 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 a HE PPDU and identifies the HE-SIG-A as Intra-BSS can update its Intra-BSS NAV with the information from the TXOP Duration field in the HE-SIG-A.

A STA that receives a valid HE-SIG-A in a HE PPDU and identifies the HE-SIG-A as Inter-BSS 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 NAV or regular NAV with the information from the Duration field.

When a STA receives both a valid HE-SIG-A in a HE PPDU and a valid frame in the PSDU of the HE PPDU, the STA shall not update its Intra-BSS 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, the STA shall update its Intra-BSS NAV when the received value of the Duration field is greater than the STA's current Intra-BSS NAV value.

For all other received frames that are identified by the STA as Inter-BSS or cannot be identified as Intra-BSS or Inter-BSS, 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, the STA shall update its Intra-BSS NAV when the received value of the TXOP Duration field is greater than the STA's current Intra-BSS NAV value.

For all other received HE-SIG-As that are identified by the STA as Inter-BSS, the STA shall update its Inter-BSS 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 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.

25.3.2 Procedure at the originator

A dynamic fragment is an MPDU, the payload of which carries a portion of an MSDU or MMPDU, which generation follows the rules defined in 9.5 (Fragmentation), except for:

- Reception of dynamic fragments is not mandatory. An HE STA declares its capability of receiving dynamic fragments by setting the HE Fragmentation Support field of the HE Capabilities element it transmits to a nonzero value as described below.
- The length of each fragment is not required to be equal for all fragments. The length of each fragment may be of any nonzero value. Other conditions may be TBD.

An HE STA may transmit to a receiver STA an individually addressed (A)-MPDU that contains:

- One dynamic fragment of an MSDU or MMPDU in a VHT single MPDU if the receiver STA has indicated a nonzero value in the HE Fragmentation Support field of its HE Capabilities element
    - The originator STA shall follow the rules defined in 9.13.8 (Transport of VHT single MPDUs) for generating the VHT single MPDU
- Up to one dynamic fragment for each MSDU in an A-MPDU if the receiver STA has indicated a value of 2 in the HE Fragmentation Support field of its HE Capabilities element
    - The originator STA shall follow the rules defined in in 9.24.7 (HT-immediate block ack extensions) for generating the A-MPDU
- Up to four dynamic fragments for each MSDU in an A-MPDU if the receiver STA has indicated a value of 3 in the HE Fragmentation Support field of its HE Capabilities element
    - 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 (HT-immediate block ack extensions) for generating the A-MPDU with the following exceptions:

- The A-MPDU should contain MPDUs whose range of the Sequence Number subfields does not exceed 16. Other conditions may be TBD.

An HE STA shall not transmit a PSDU that contains dynamic fragments of an MSDU or MMPDU whose number is greater than the maximum number of fragments or that are carried in an A-MPDU format that is not supported by the receiver STA, as determined by the value of the HE Fragmentation Support field of the HE Capabilities element sent by the receiver STA.

25.3.3 Procedure at the receiver

An HE STA that transmits an HE Capabilities element with a nonzero value in the HE Fragmentation Support subfield shall set dot11DynamicFragmentation to true. Otherwise, the HE STA may set dot11DynamicFragmentation to false.

Defragmentation of dynamic fragments shall follow the rules defined in 10.6 (Defragmentation), except for:

— The receiver STA may support the concurrent reception of dynamic fragments of TBD number of MSDUs/MMPDUs under TBD conditions

NOTE— The receiver STA is still subject to the Receive Timer rules for each fo the MSDUs/MMPDUs as defined in 9.6 (Defragmentation).

Upon reception of a PSDU that carries one or more dynamic fragments, the receiver STA responds with:

— An Ack frame when the received fragment is contained in a 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

— A BlockAck frame when the received fragments, up to one fragment for each MSDU, are contained in the A-MPDU that solicits the immediate response and is sent by an HE STA whose HE Fragmentation Support subfield in its HE Capabilities element is 2
  - The receiver STA shall follow the rules defined in 10.24.7 (HT-immediate block ack extensions) for generating the BlockAck frame, except that the STA shall:
    - Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield of a successfully received fragment contained in the soliciting A-MPDU
    - Update the corresponding block acknowledgement record when an MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)).

— 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 and is sent by an HE STA whose HE Fragmentation Support subfield in its HE Capabilities element is 3
  - The receiver 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 Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame
    - Set to 1 each bit in location *B* of the Block Ack Bitmap field that corresponds to a successfully received fragment and shall set it to 0 otherwise, with *B* 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 acknowledgement record when an MSDU that is received in fragments is successfully reconstructed (see 9.6 (Defragmentation)).

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. A Multi-STA BlockAck frame with BA Information for multiple AIDs shall have RA field set to the broadcast address.

An HE STA that supports Multi-STA BA shall examine each received Mulit-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 field is 1 then the BA Start Sequence Control, TID and BA Bitmap of the BA information field are processed according the procedure given in 10.24.7.

— If the ACK type field is 0, the field indicates an ACK of either a single MPDU or all MPDUs carried in the eliciting PPDU that was transmitted by the STA.

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 RUs (see 25.3.9.8.3), unless the STA set the DL OFDMA Capable subfield of the HE Capabilities element to 1.

An AP shall not transmit to a STA a 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 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 shall end at the same time, indicated by the L-SIG field as described in 26.3.9.5.

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 individual A-MPDU in an HE MU PPDU is based on the rules specified in 10.13.1 (A-MPDU contents).

The frame type and address type (unicast, groupcast) of MPDUs may be different across A-MPDUs within a same HE MU PPPDU.

A groupcast 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 immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE trigger-based PPDU format, in either UL MU OFDMA UL MU-MIMO, or both.

An HE STA with dot11ULMUOFDMAOptionImplemented set to true shall set the UL MU OFDMA Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the STA shall set it to 0.

An HE STA with dot11ULMUMIMOOptionImplemented set to true shall set the UL MU MIMO Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the STA shall set it to 0.

A non-AP STA with dot11ULMUOFDMAOptionImplemented or dot11ULMUMIMOOptionImplemented equal to true is referred to as an UL MU capable STA.

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 the transmission of a PPDU with the TXVECTOR parameter FORMAT set to HE_TRIG, unless the STA is UL MU Capable.

An AP may transmit a PPDU that elicits 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 per-User Info field addressed to the recipient STA(s).
    - For recipient STAs that are associated with the AP, the per-User Info field is addressed to a recipient STA if the value of the AID subfield of the Per-User Info field is equal to the AID of the STA.
    - For recipient STAs that are not associated with the AP, TBD
- An “Trigger Information TBD contained in the MAC Header” of individually addressed MPDUs contained in the PPDU

The following two frames shall not be present at the same time in an A-MPDU

- A Trigger frame with a per-User Info field addressed to a STA
- an MPDU addressed to the same STA that includes “Trigger Information Field info in MAC header TBD”

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

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 Commin Info field 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 Per User Info field to a value that is not supported by the recipient STAs of the Per User Info field.

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

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, the frame exchange initiated by the trigger frame is successful.

25.5.2.3 STA behavior

A STA shall not transmit an HE trigger-based PPDU unless is it explicitly enabled by an AP in one of the operation modes described in this section.

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 a Trigger Frame with a Per User Info field addressed to the STA, or the PPDU contains an MPDU addressed to the STA which carries a "Trigger Information Field info in MAC header TBD". The Per User Info field is addressed to a STA if the AID subfield is equal to the AID of the STA, if 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 shall set the TXVECTOR parameter as follows:

— The L_LENGTH parameter shall be set to the value indicated by the L-SIG Length field of the eliciting Trigger frame or of the "Trigger Information Field info in MAC header TBD".

— The CP_LTF_TYPE parameter shall be set to the value indicated by the CP-LTF subfield of the Common Info field of the eliciting Trigger frame

— 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 per-User Info field of the eliciting Trigger frame

— The CODING_TYPE parameter shall be set to the value indicated by the Coding Type subfield of the Per User Info 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

— The NSTS parameter shall be set to TBD

The MAC padding procedure is descried in 10.42.2.1.2

The content of each individual A-MPDU in an HE MU PPDU is based on the rules specified in 9.13.1 (A-MPDU contents) and the additional rules described in this clause.

If the Trigger Type value of a Trigger frame is not equal to 0, the STA shall include in the reponse 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 PPPDU

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 is described in 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.

Note that 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) and the virtual carrier sense (NAV) before UL MU transmission in response to the Trigger Frame. 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 UL RUs in the Trigger frame are considered idle; if the STA detects that the 20 MHz channels containing the allocated UL RUs are not all idle, then the STA shall not transmit anything in the allocated UL RUs.

If the CS Required subfield in a Trigger frame is set to 0, the STA may transmit an HE trigger-based PPDU without the carrier sense.

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

— All HE trigger-based PPDU(s) solicited by the Trigger frame containing ACK/BA and the length of the HE trigger-based PPDU is below a TBD threshold.

— Other conditions are TBD.

25.5.2.5 HE buffer status feedback operation for UL MU

The buffer status report from HE STAs may be utilized to support the efficient UL MU operation. An AP may poll HE STAs for buffer status reports using the frame carrying the trigger information. The frame may be a broadcast Trigger frame, a unicast Trigger frame, a Trigger frame for random access, or a Data type of frame carrying the trigger information. An AP may request an HE STA to send its buffer status information by TBD indication in the Trigger frame or in the HE A-Control field in a Data type of frame. In this case, an AP may indicate TBD granularity of the Queue Size for an HE STA to report (signalling method TBD). Upon reception of the frame including the TBD indication in the Trigger frame or in the HE A-Control field, the HE STA may respond with the frame including the Queue Size subfield in a QoS Control field or TBD HE A-Control field. To report the buffer status for a given TID, an HE STA shall set the Queue Size subfield in a QoS Data or a QoS Null frame to the amount of queued traffic present in the output queue belonging to the TID.

25.5.2.6 UL OFDMA-based random access

UL OFDMA-based distributed random access is a random access mechanism for HE STAs that randomly select resource units (RUs) assigned by an AP for transmission of UL PPDUs. 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 sub-section, the random access procedure is described with respect to UL OFDMA contention parameters. The procedure is also illustrated in Figure 25-1. An HE STA that uses the random access procedure maintains an internal counter termed as OBO counter. The OFDMA contention window (OCW) is an integer with an initial value of OCWmin. Other parameters for random access are TBD.

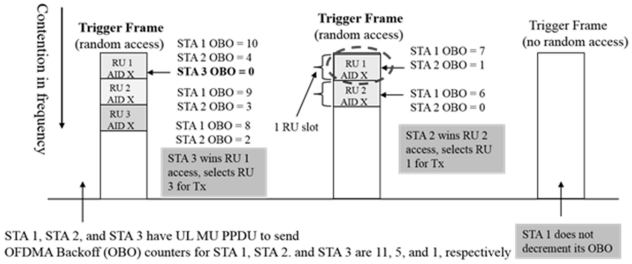


Figure 25-1 - Illustration of the UL OFDMA-based random access procedure

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, 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.

If the OBO counter for an HE STA is a zero value or if the OBO counter decrements to 0, it 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.

A 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.

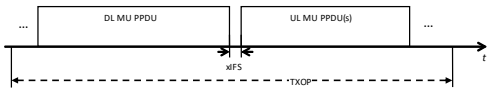


Figure 25-2 - An example of cascading sequence of MU PPDUs

The cascading sequence has only one DL transmitter. The cascading sequence may have different UL transmitters within each HE trigger-base PPDU. 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

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.

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

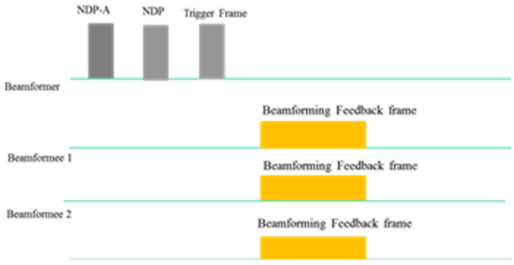


Figure 25-3 – An example of the HE sounding protocol using MU operation

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 10.41 (Notificaion of operating mode changes), or the procedure describes in this subclause. 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 to 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 frame of type Data. 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 [HE variant HT Control field]). 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 11.41 (Notification of operating mode changes), 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 address frame of type Data 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 for 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 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 failures, the transmitting HE STA can attempt recovery procedure as defined in 9.19.2.4 (Multiple frame transmission in an EDCA TXOP), 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 bandwith 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 transmistting STA is capable of receiving, the responding HE STA shall not sent any PPDU to 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 and the utilization of the spectrum resources 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

An STA determines whether a detected frame is an inter-BSS or an intra-BSS frame by using BSS color or MAC address in the MAC header. The detected frame is intra-BSS frame if one of the following conditions is true:

— The BSS color in the detected PPDUis same as the BSS color announced by its associated AP,

— The RA or TA of the detected frame is same as the BSSID or its bandwidth signalling variant of its associated AP

— Its associated AP is identified by TBD Multiple BSSID element and the RA or TA of the detected frame is same as one of the BSSID or its bandwidth signalling variant defined by TBD Multiple BSSID element

If the detected frame is an inter-BSS frame, under TBD condition, uses TBD OBSS PD level that is greater than the minimum receives sensitivity level.

A STA 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 from an inter-BSS, but not longer than the time indicated as the length of the PPDU payload.

A STA should revise the NAV depending on TBD conditions at the recipient of the ongoing OBSS frame.

25.9.3 Adaptive CCA and transmit power control

When the color code based CCA rule is used, as described in **Error! Reference source not found.**, an HE STA is allowed to adjust the OBSS_PD 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 STA is allowed to adjust the setting of one or more following parameters, 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 is as defined in 10.13 (A-MPDU operation), except for A-MPDU padding, which is defined in 25.10.2 and except for an A-MPDU that includes QoS Data frames from from two or more different TSs, the rules for which are defined in 25.10.3.

25.10.2 A-MPDU padding

The A-MPDU padding per each HE STA in an HE MU PPDU follows the same procedure as for VHT STA11ac procedure as defined in Section 10.13.6 (A-MPDU padding for VHT PPDU).

A non-AP STA that transmits an HE trigger-based PPDU shall construct the PSDU carried in the HE trigger-based PPDU as follows.

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 fullfilled:

— 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

And provided that

— 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.

Then, padding shall be 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, 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 an 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)).

25.10.3 A-MPDU with multiple TIDs

An HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true shall set the A-MPDU with Multiple TIDs Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the HE STA shall set it to 0.

An HE AP shall not send A-MPDU with multiple TIDs to an HE non-AP STA that associates with the AP, unless the HE non-AP STA is A-MPDU With Multiple TIDs capable.

An HE non-AP STA shall not send an A-MPDU with multiple TIDs to its associated HE AP, unless the HE AP is A-MPDU With Multiple TIDs capable.

In an HE MU PPDU, an HE STA may aggregate the frames in an A-MPDU with multiple TIDs as defined in Table 9-426a (Multiple TID A-MPDU contents in the data enabled immediate response context) or Table 9-426b (Multiple TID A-MPDU contents in the data enabled no immediate response context). An A-MPDU with multiple TIDs shall not be transmitted in an SU PPDU.

Multi-STA BlockAck frame shall be used to acknowledge the Multi-TID A-MPDU in MU PPDU. The value of TID field in Multi-STA BlockAck frame is TBD.

25.11 TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG and BSS_COLOR for an HE PPDU

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 STA's AID. If an RU is intended for a group of STAs then the STA_ID_LIST element is set as follows:

— For a single BSS AP, if the RU is intended for all STAs in the BSS, the STA_ID_LIST element is set to 0;

— For a multiple BSS AP, if the RU is intended for all STAs in one of its BSSs, the STA_ID_LIST element is set to the group addressed AID assignment in the TIM according to the existing Multi-BSSID TIM operation;

— For a multiple BSS AP, 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, shall set the TXVECTOR parameter UPLINK_FLAG to 0

NOTE—The (T) DLS 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 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 9.X.Y (Spatial Reuse) or reduce power consumption as described in 25.13.1 (Intra-PPDU power save for HE non-AP STAs).

An HE AP shall select a value in the range 1 to TBD to include in the BSS Color subfield of the HE Operation elements that it transmits and shall maintain that single value of the BSS Color subfield for the duration of the existence of the BSS. An HE AP transmitting an HE PPDU shall set the TXVECTOR parameter BSS_COLOR to the value indicated in the BSS Color subfield of its HE Operation element.

A non-AP HE STA transmitting an HE PPDU shall set the TXVECTOR parameter BSS_COLOR to the value indicated in the BSS Color subfield of the HE Operation element received from the AP with which it is associated.

The virtual APs which are defined by TBD Multiple BSSID element shall select a same BSS Color.

25.12 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 asetermined by the post-FEC padding a-factor (see 26.3.10 (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.

25.13 Power management

25.13.1 Intra-PPDU power save for HE non-AP STAs

An HE non-AP STA that is in awake state (see 11.2.2.2 (STA Power Management modes)) and 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 received PPDU when one of the following conditions is met:

— The PPDU is an HE MU PPDU with:

- The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated and,

- The value of the RXVECTOR parameter UL_FLAG is equal to 0 and,
- The values obtained from the RXVECTOR parameter STA_ID_LIST do not match the identifier of the STA or the broadcast identifier(s) intended for the STA

— The PPDU is an HE MU PPDU, HE SU PPDU, or HE extended range SU PPDU with:

- The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated and,
- The value of the RXVECTOR parameter UL_FLAG is equal to 1

— The PPDU is an HE trigger-based PPDU with:

- The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated

An HE STA that is in intra-PPDU power save mode and has entered doze state shall continue to operate its NAV timer 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 timer.

25.13.2 Power save with UL OFDMA-based random access

This section illustrates the power save mechanisms for HE STAs using random access procedure (see 25.5.2.6.1).

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 25-4.

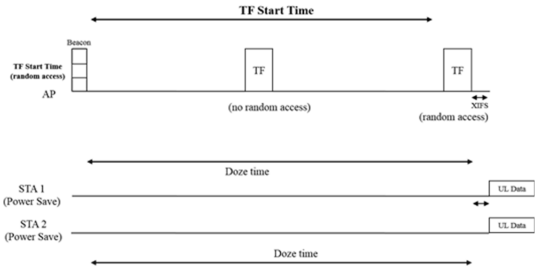


Figure 25-4 - Illustration of Trigger frame (TF) Start Time in Beacon frame for power save operation with random access operation

When an HE STA receives a Beacon with the value of Trigger frame start time for random access, it may enter the doze state till the expiration of the value indicated in the Beacon.

If random acces 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 that 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 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.

26High 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 PHY specifications defined in Clause 20 and Clause 22.

The HE PHY is based on the VHT PHY defined in Clause 22, which in turn is based on the HT PHY defined in Clause 20, which in turn is further based on the OFDM PHY defined in Clause 18. 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 divisional 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.

NOTE—An HE SU PPDU includes individually addressed and group addressed transmissions.

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. Tones of one or more secondary channels in 80 MHz and 160 (80+80) MHz could be nulled when using OFDMA PPDU transmission. The modes of non-contiguous channel bonding are TBD. The non-contiguous channels within primary or secondary 80 MHz only exists at AP side.

The HE PHY provides support for 800 ns, 1600 ns, and 3200 ns 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 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:

— Binary convolutional coding for RU sizes less than or equal to 242 tones (transmit and receive)

— LDPC as the only coding scheme for RU sizes of 484 tones, 996 tones (transmit and receive)

— LDPC when declaring support for at least one of HE 80/160/80+80 SU-PPDU bandwidths, or declaring support for more than 4 spatial streams (transmit and receive)

— 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:

— Other combinations of LTF durations and GI durations

— LDPC (transmit and receive) for RU sizes less than or equal to 242 tones

— LDPC (transmit and receive) when declaring support for less than or equal to 4 spatial streams

— Dual carrier modulation (transmit and receive)

NOTE--Once mandatory vs optional TBDs are decided, above text will have additions.

26.1.2 Scope

The services provided to the MAC by the HE PHY consist of the following protocol functions:

a) A function that defines a method of mapping the PSDUs into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs.

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 22 (Very High Throughput (VHT) PHY specification), Clause 20 (High Throughput (HT) PHY specification) and Clause 18 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PHYs.

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.

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 HE PPDU formats

The structure of the PPDU transmitted by an HE STA is determined by the TXVECTOR parameters as defined in Table 25-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU:

— 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 MU PPDU format (HE_MU) carries one or more PSDUs to one or more users. It is similar to the SU format, except that an HE-SIG-B field is present. Support for the HE MU 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 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).

26.2 HE PHY service interace

26.2.1 Introduction

26.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 26-1 (TXVECTOR and RXVECTOR parameters) 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

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 18 (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	Y	Y
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.		
BEAM_CHANGE	FORMAT is HE_SU	Indicates beam change between pre-HE and HE modulated fields. 1 indicates that the beam is changed between the two portions. NOTE—BEAM_CHANGE shall be set to 1 if $N_{SS} > 2$ or the PPDU is the first PPDU in a TXOP.		
	Otherwise	Set to 1		

	(To be added)			
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 *TBD* (see 25.11 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	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 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 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	MU	Y
	Otherwise	Not present	N	N

NOTE 1—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, HE extended range SU PPDU and HE trigger-based PPDU and present per user for an HE MU PPDU. Parameters specified to be present per user are conceptually supplied as an array of values indexed by *u*, where *u* 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.

The format of the HE SU PPDU is defined as in Figure 26-1. This PPDU is used for SU transmission and in this format the HE-SIG-A field is not repeated.

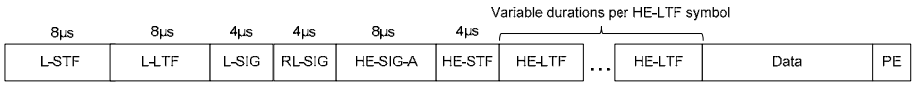


Figure 26-1 - HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 26-2. This format is used for MU transmission that is not a response of a Trigger frame. An HE-SIG-B field is present in this format.

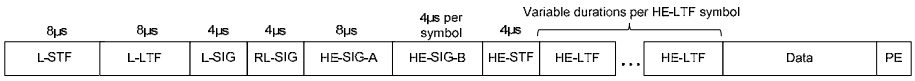


Figure 26-2 - HE MU PPDU format

The format of the HE extended range SU PPDU is defined as in Figure 26-3. This format is used for SU transmission and in this format 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. This format is used for a transmission that is a response to a Trigger frame. 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.

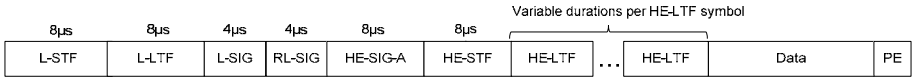


Figure 26-4 - HE trigger-based PPDU format

The fields of the HE PPDU formats are summarized in Table 26-2.

Table 26-2 - HE PPDU fields

Field	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field
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
HT-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. In the HE NDP PPDU the Data field is not present. The number of OFDM symbols in the HE-LTF field, $N_{HE\text{-}LTF}$, is 1, 2, 4, 6, or 8 and the duration of each symbol in the HE-LTF field is 3.2 µs, 6.4 µs, or 12.8 µs plus the GI duration. 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.

DL HE NDP is one DL HE sounding format.

The format of a HE NDP PPDU is shown in Figure 26-5.

L-STF	L-LTF	L-SIG	RL-SIG	HE-SIG-A	HE-STF	HE-LTFs	Packet Extension

Figure 26-5 - HE NDP PPDU format

NOTE 1—The number of HE-LTF OFDM symbols, $N_{HE\text{-}LTF}$ in the NDP is a function of the total number of space-time streams N_{STS} as shown in Table 26-6.

NOTE 2—The combination of HE-LTF modes and GI duration is indicated in HE-SIG-A field.

NOTE 3—The duration of each HE-LTF OFDM symbol, $T_{HE\text{-}LTF}$, is defined in Table 26-3.

NOTE 4—The presence and duration of PE are TBD.

The HE NDP PPDU has the following properties:

— It uses the HE SU PPDU format but without the Data field
— is an HE SU PPDU as implied by the value of L-Length field in L-SIG field

26.3.3 Transmitter block diagram

The generation of each field in a 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_{VHTLTF}
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder
p) Cyclic shift diversity (CSD) per STS insertion
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 26-6 to Figure 26-13 show example transmitter block diagrams. The actual structure of the transmitter is implementation dependent.

In particular, Figure 26-6 shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of a 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 other pre-HE-SIG-B fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 1, with the following exceptions applied:

— 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.

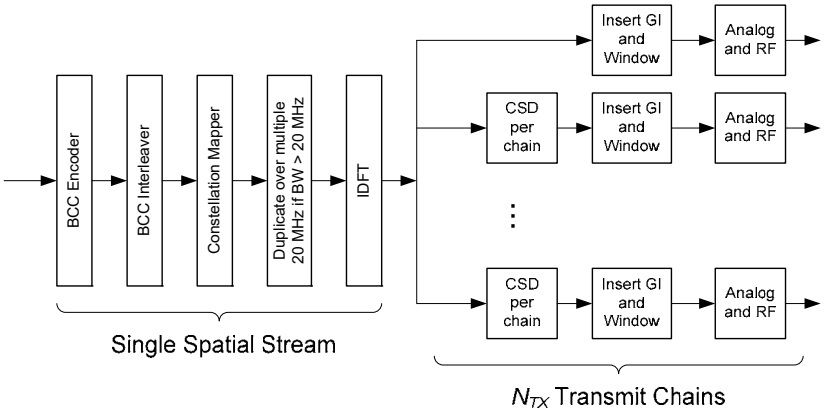


Figure 26-6 - Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam Change field is 1

Figure 26-7 shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of a 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 other pre-HE-SIG-B fields 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.

— 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.

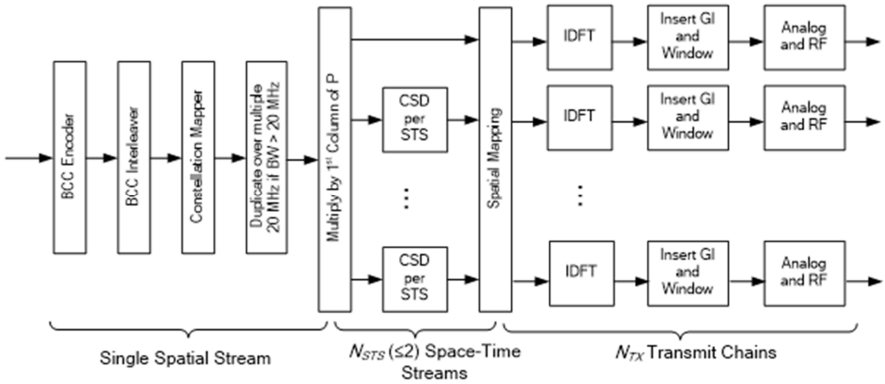


Figure 26-7 – Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam Change field is 0

Figure 26-8 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 26.3.9.8.1 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. (TBD: MCS0-DCM)

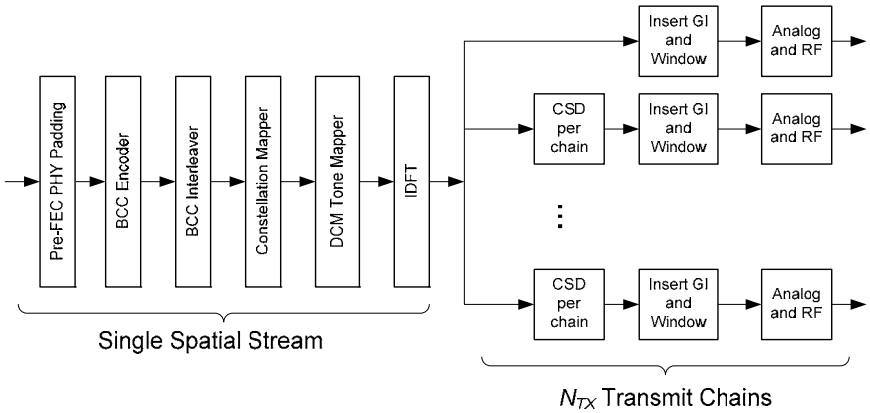


Figure 26-8 - Transmitter block diagram for the HE-SIG-B field

Figure 26-9 shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, or 242-RU 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 26-29. 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-STF field. (TBD: MCS0-DCM). This figure also applies to the data field with BCC encoding in a HE trigger-based PPDU.

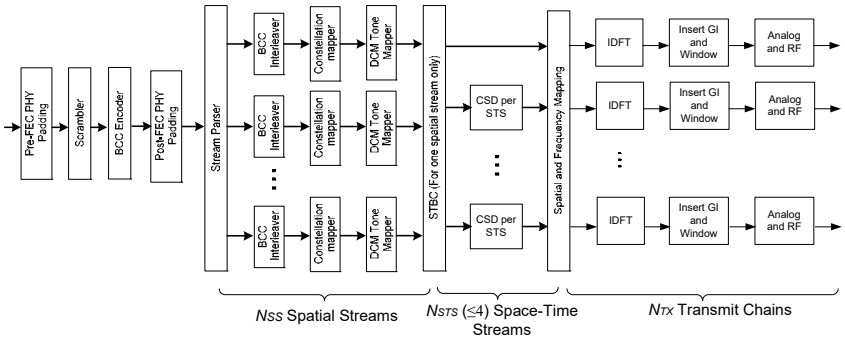


Figure 26-9 - Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-RU with BCC encoding

Figure 26-10 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-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. (TBD: MCS0-DCM) This figure also applies to the data field with LDPC encoding in a HE trigger-based PPDU.

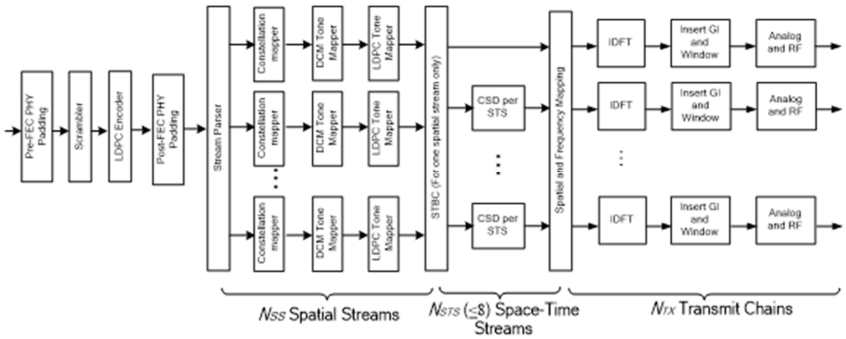


Figure 26-10 - Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-RU with LDPC encoding

Figure 26-11 shows the transmitter blocks used to generate the Data field of a HE downlink MU-MIMO transmission within a 106-, 242-, 484-, or 996-RU with LDPC encoding. This also includes the downlink MU-MIMO transmission in an RU that is part of a downlink or uplink OFDMA PPDU.

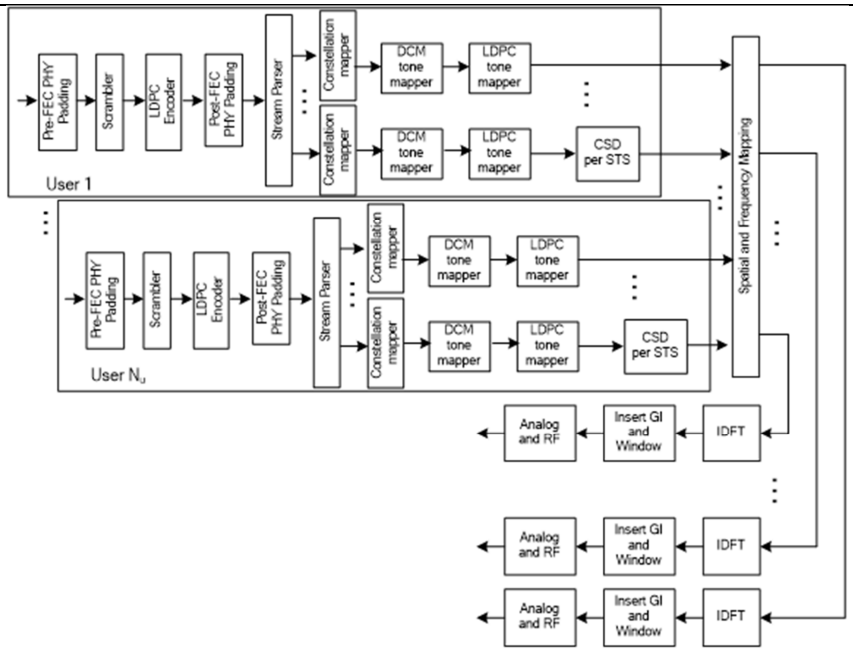


Figure 26-11 - Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-RU with LDPC encoding

Figure 26-12 shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 160 MHz with LDPC encoding.

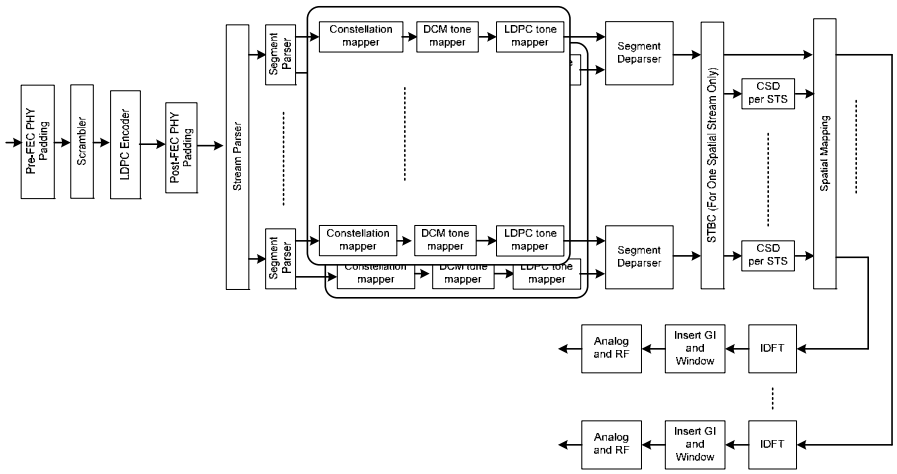


Figure 26-12 - Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding

Figure 26-13 shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 80+80 MHz with LDPC encoding.

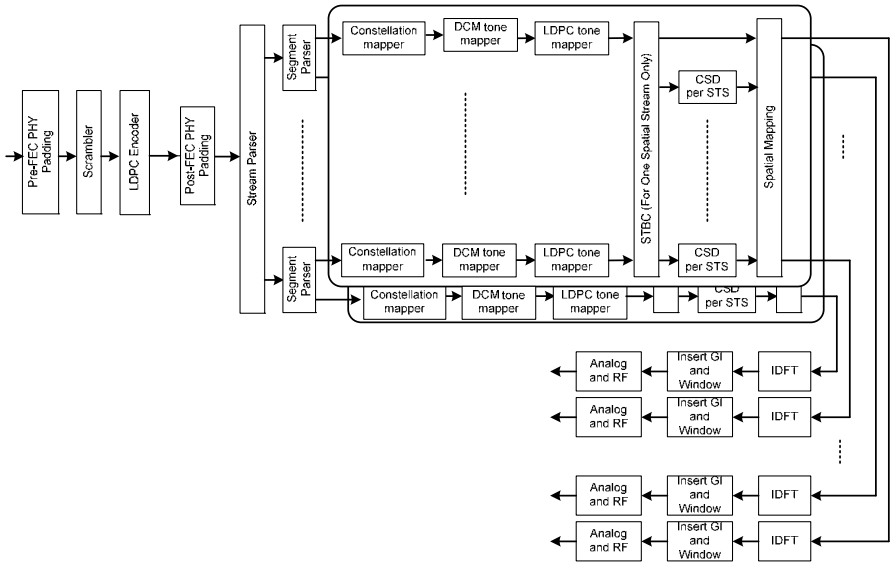


Figure 26-13 - Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding

26.3.4 Overview of the PPDU encoding process

26.3.5 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a value that determines the modulation and coding used in the HE-SIG-B field and the Data field of the PPDU. It is a compact representation that is carried in the HE-SIG-A field for the HE-SIG-B field in an HE MU PPDU and for the Data field in an HE SU PPDU and HE extended range SU PPDU and carried in the HE-SIG-B field for the Data field in an HE MU PPDU. Rate-dependent parameters for the full set of HE-MCSs are shown in Table 25-x (HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1) to Table 25-y (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) (in 26.5 (Parameters for HE-MCSs)). 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 SU PPDU can only be transmitted with MCS0, MCS1, MCS2 and only with 1 spatial stream on the primary 20 MHz channel.

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 20-6 and Table 22-5 (Timing-related constants) for timing-related parameters for non-HE PPDU formats.

Table 26-3 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 portion.
$\Delta_{F,\text{HE}}$	78.125 kHz	Subcarrier frequency spacing for the HE portion.
$T_{DFT,Pre-HE}$	3.2 µs	IDFT/DFT period for the pre-HE portion.
$T_{DFT,HE}$	12.8 µs	IDFT/DFT period for the HE portion.
$T_{GI,Pre-HE}$	0.8 µs	Guard interval duration for the legacy preamble, RL-SIG, HE-SIG-A and HE-SIG-B
$T_{GI,HE-LTF}$	$T_{GI1,Data}$, $T_{GI2,Data}$ 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 = $T_{DFT,HE} + T_{GI1,Data} = 1.0625 \times T_{DFT,HE}$	Normal GI symbol interval
T_{SYM2}	14.4 µs = $T_{DFT,HE} + T_{GI2,Data} = 1.125 \times T_{DFT,HE}$	Double GI symbol interval
T_{SYM4}	16 µs = $T_{DFT,HE} + T_{GI4,Data} = 1.25 \times T_{DFT,HE}$	Quadruple GI symbol interval
T_{SYM}	T_{SYM1}, T_{SYM2}, or T_{SYM4} depending on the GI used (see Table xx-x (Tone scaling factor and guard interval duration values for PHY fields))	Symbol interval
T_{L-STF}	8 µs = 10 x $T_{DFT,\ Pre-HE}$ /4	Non-HT Short Training field duration
T_{L-LTF}	8 µs = 2 x $T_{DFT,Pre-HE} + T_{GI2,Data}$	Non-HT Long Training field duration
T_{L-SIG}	4 µs	Non-HT SIGNAL field duration
T_{RL-SIG}	4 µs	Repeated non-HT SIGNAL field duration
$T_{HE-SIG-A}$	8 µs = 2 × 4 µs	HE-SIG-Afield duration in an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU
$T_{HE-SIG-A-R}$	8 µs or 16 µs (TBD)	HE-SIG-A field duration in an HE extended range SU PPDU
$T_{HE-STF-T}$	8 µs = 5 × 1.6 µs	HE-STF field duration for an HE trigger-based PPDU
$T_{HE-STF-NT}$	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_{HE-LTF}	$T_{HE-LTF-1X}$, $T_{HE-LTF-2X}$ or $T_{HE-LTF-4X}$ depending upon the LTF duration used	Duration of each HE-LTF field OFDM symbol without GI
$T_{HE-LTF-1X}$	3.2 µs	Duration of each 1x HE-LTF OFDM symbol without GI
$T_{HE-LTF-2X}$	6.4 µs	Duration of each 2x HE-LTF OFDM symbol without GI
$T_{HE-LTF-4X}$	12.8 µs	Duration of each 4x HE-LTF OFDM symbol without GI
$T_{HE-LTF,SYM}$	sum of T_{HE-LTF} and $T_{GI,HE-LTF}$	Duration of each HE-LTF OFDM symbol including GI
$T_{HE-SIG-B}$	4 µs = $T_{DFT,Pre-HE} + T_{GI,Pre-HE}$	Duration of each HE-SIG-B field OFDM symbol
T_{PE}	0, 4 µs, 8 µs, 12 µs, 16 µs depending on actual extension duration used	Duration of the Packet Extension field
$N_{service}$	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

Table 26-4 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

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description
$N_{Guard,Left}$	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 defines tone allocation related parameters for an 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: $N_{ST} = N_{SD} + N_{SP}$							

Table 26-6 defines parameters used frequently in Clause 26.

Table 26-6 - Frequently used parameters

Symbol	Explanation
N_{CBPS}, $N_{CBPS,r,u}$	Number of coded bits per symbol at *r*-th RU for user *u*, r = 0, …, $N_{RU} - 1$, *u* = 0, ..., $N_{user,r} - 1$. For an HE SU PPDU, $N_{CBPS} = N_{CBPS,0,0}$ 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, …, 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, …, $N_{RU} - 1$, *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}, $N_{BPSCS,r,u}$	Number of coded bits per subcarrier per spatial stream at *r*-th RU for user *u*, r = 0, …, $N_{RU} - 1$, *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).
$N_{user,r}$	For pre-HE modulated fields, $N_{user,r} = 1$. For HE modulated fields, $N_{user,r}$ 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_{user_total}	For pre-HE modulated fields, $N_{user\_total} = 1$. For HE modulated fields, N_{user_total} represents the number of users in the transmission (equal 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 2). For HE modulated fields, $N_{STS,r,u}$ 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, $N_{STS,r,total}$ 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.
N_{SS}, $N_{SS,r,u}$	Number of spatial streams. For the Data field, NSS,r,u is the number of spatial streams at r-th RU for user u, $u = 0,\ldots,N_{user,r} - 1$ 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_{ES}, $N_{ES,r,u}$	The number of BCC encoders. This parameter should be 1 in all BCC cases in 11ax. For a Data field encoded using BCC, $N_{ES,r,u}$ is the number of BCC encoders at r-th RU for user u, $u = 0, \ldots, N_{user,r} - 1$. For the Data field encoded using LDPC, $N_{ES} = 1$ for an HE SU PPDU and $N_{ES,r,u} = 1$ for an HE MU PPDU at r-th RU for user u, $u = 0, \ldots N_{user,r} - 1$. For the Data field of an HE SU PPDU, $N_{ES} = N_{ES,0,0}$ For the Data field of an HE MU PPDU, N_{ES} is undefined.
$N_{HE\text{-}LTF}$	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, $u = 0, \ldots, N_{user} - 1$. 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 $u = 1, \ldots N_{user,r} - 1$.
NOTE 1—Pre-HE modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, HE-SIG-A-R, and HE-SIG-B fields, while HE modulated fields refer to the HE-STF, HE-LTF, and Data fields (see Timing boundaries for HE PPDU fields). NOTE 2—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 subcarriers that form a RU are physically adjacent (contiguous except at the middle of the band where nulls are placed at DC).

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.

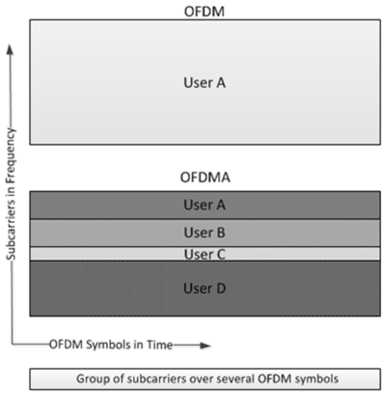


Figure 26-14 - Illustration of OFDM and OFDMA Concepts

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:

$$T_{CP} \geq \tau_{RMS} \quad \text{(to prevent ISI due to delay spread)} \qquad \textbf{(26-1)}$$
$$T_{CP}\Delta f \ll 1 \quad \text{(for spectral efficiency improvement)}$$

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 section 25.3.7.1, 2) Pilot subcarriers which are utilized for phase information and parameter tracking; defined in section 25.3.7.3, and 3) unused subcarriers which are not used for data/pilot transmission. The unused subcarriers are the DC subcarrier (defined in section 23.3.7.1), the Guard band subcarriers at the band edges (defined in section 23.3.7.1), and the Null subcarriers (defined in section 25.3.7.2).

26.3.7.1 Resource unit, edge and DC tones

The OFDMA structure consists of a 26-subcarrier resource unit (RU), 52-subcarrier RU, 106-subcarrier RU, 242-subcarrier RU, 484-subcarrier RU and 996-subcarrier RU. Resource allocations for single user (SU) consist of a 242 subcarrier RU, 484-subcarrier RU, 996-subcarrier RU and 2x996-subcarrier RU.

The 26-subcarrier RU and 52-subcarrier RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA HE PPDU formats. The 106-subcarrier RU is used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 242-subcarrier RU is used in the 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 484-subcarrier RU is used in the 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 996-subcarrier RU is used in the 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats.

The 242-subcarrier and larger RUs are used in the HE SU PPDU and non-OFDMA, MU-MIMO HE PPDU formats. The 242-subcarrier RU is used in the 20 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 484-subcarrier RU is used in the 40 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 996-subcarrier RU is used in the 80 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 2x996-subcarrier RU is used in the 160 MHz and 80+80 MHz HE SU PPDU and MU-MIMO HE PPDUs.

The maximum numbers 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. Cases of 1 RU indicate the HE SU and a HE MU-MIMO PPDU allocation.

Table 26-7 - Total number of RUs for BWs

RU type	CBW20	CBW40	CBW80	CBW160 and CBW80+80
26-subcarrier RU	9	18	37	74
52-subcarrier RU	4	8	16	32
106-subcarrier RU	2	4	8	16
242-subcarrier RU	1-SU/MU-MIMO	2	4	8
484-subcarrier RU	N/A	1-SU/MU-MIMO	2	4
996-subcarrier RU	N/A	N/A	1-SU/MU-MIMO	2
2x996 subcarrier RU	N/A	N/A	N/A	1-SU/MU-MIMO

An OFDMA HE PPDU can carry a mixture of 26-subcarrier, 52-subcarrier and 106-subcarrier RUs within any of the 242-subcarrier RU boundaries.

Table 26-8 - Subcarrier indices for RUs in a 20 MHz HE PPDU

RU type					
26-subcarrier	RU 1 [-121 : -96]	RU 2 [-95 : -70]	RU 3 [-68 : -43]	RU 4 [-42 : -17]	RU 5 [-16 : -4, 4 : 16]
	RU 6 [17 : 42]	RU 7 [43 : 68]	RU 8 [70 : 95]	RU 9 [96 : 121]	-
52-subcarrier	RU 1 [-121 : -70]	RU 2 [-68 : -17]	RU 3 [17: 68]	RU 4 [70 : 121]	-
106-subcarrier	RU 1 [-122 : -17]		RU 2 [17: 122]		-
242-subcarrier	RU 1 [-122 : -2, 2:122]				

Table 26-9 - Subcarrier indices for RUs in a 40 MHz HE PPDU

RU type					
26-subcarrier	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-subcarrier	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-subcarrier	RU 1 [-243:-138]	RU 2 [-109 : -4]	RU 3 [4 : 109]	RU 4 [138 : 243]	-
242-subcarrier	RU 1 [-244 : -3]		RU2 [3 : 244]		
484-subcarrier	RU 1 [-244 : -3, 3 : 244]				

Table 26-10 - Subcarrier indices for RUs in a 80 MHz HE PPDU

RU type					
26-subcarrier	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-subcarrier	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-subcarrier	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-subcarrier	RU 1 [-500: -259]	RU 2 [-258: -17]	RU 3 [17: 258]	RU 4 [259: 500]	
484-subcarrier	RU 1 [-500 : -17]		RU 2 [17 , 500]		
996-subcarrier	RU 1 [-500 : -3 , 3: 500]				

A 26-subcarrier RU consists of 24 data subcarriers and 2 pilot subcarriers. The position of the pilots for the 26-subcarrier RU is defined in 26.3.7.3. The location of the 26-subcarrier RUs are fixed as defined in Table 26-8 and shown in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used for the 80 MHz OFDMA HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The

center 26-subcarrier RU in the 20 MHz and 80 MHz OFDMA HE PPDU (Figure 26-15 and Figure 26-17) is located on subcarriers [-16:-4, 4:16].

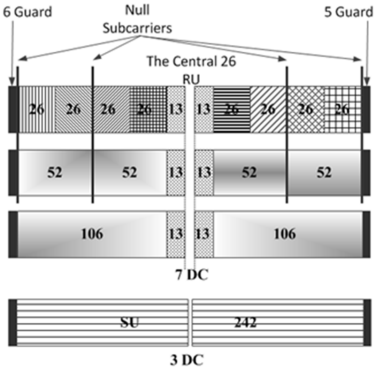


Figure 26-15 - RU locations in a 20 MHz HE PPDU

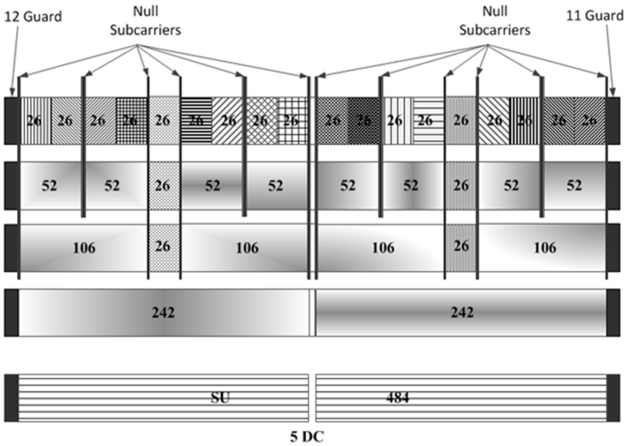


Figure 26-16 - RU locations in a 40 MHz HE PPDU

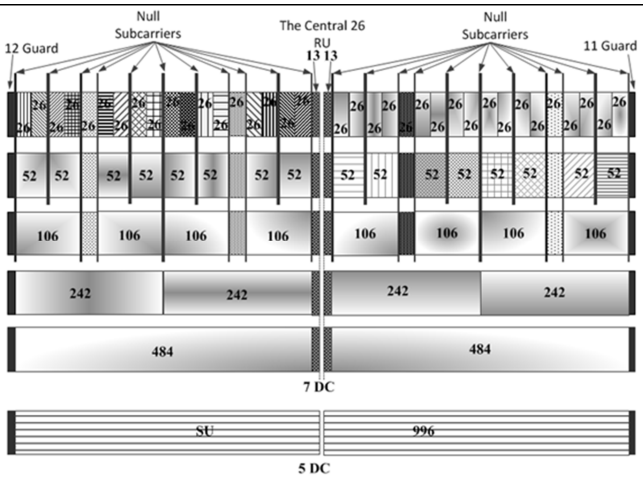


Figure 26-17 - RU locations in an 80 MHz HE PPDU

A 52-subcarrier RU consists of 48 data subcarriers and 4 pilot subcarriers. The position of the pilots for the 52-subcarrier RU is defined in 25.3.7.3. The locations of the 52-subcarrier RUs are fixed as defined in Table 26-8, Table 26-9 and Table 26-10 and illustrated in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU format is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats.

A 106-subcarrier RU consists of 102 data subcarriers and 4 pilot subcarriers. The position of the pilots for the 106-subcarrier RU is defined in 25.3.7.3. The locations of the 106-subcarrier RUs are fixed as defined in Table 26-8, Table 26-9 and Table 26-10 and illustrated in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats.

A 242-subcarrier RU consists of 234 data subcarriers and 8 pilot subcarriers. The position of pilots for the 242-subcarrier RU is defined in 25.3.7.3. The locations of the 242-subcarrier RUs are fixed as defined in Table 26-9 and Table 26-10 and illustrated in Figure 26-16 and Figure 26-17 for the 40 MHz, 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats. A 20 MHz HE SU PPDU and MU-MIMO HE PPDU with a 242-subcarrier RU is shown in Figure 26-15.

A 484-subcarrier RU consists of 468 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 484-subcarrier RU is defined in 25.3.7.3. The locations of the 484-subcarrier RUs are fixed as defined in Table 26-10 and illustrated in Figure 26-17 for the 80 MHz HE PPDU. The same structure as used for the 80 MHz OFDMA HE PPDU is used for for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The 40 MHz HE SU PPDU and MU-MIMO HE PPDU with a 484-subcarrier RU is shown in Figure 26-16.

A 996-subcarrier RU consists of 980 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 996-subcarrier RU is defined in 25.3.7.3. The locations of the 996-subcarrier RUs are fixed and located on subcarrier [-1012:-515, -509:-12] and [12:509, 515:1012] for each half of the BW, respectively, for 160/80+80 MHz HE OFDMA PPDUs.

The 20 MHz OFDMA HE PPDU has 7 DC subcarriers located at [-3:3]. The 20 MHz HE SU PPDU and 20 MHz MU-MIMO HE PPDU with a 242 subcarrier RU has 3 DC subcarriers located at [-1:1]. The 40 MHz OFDMA HE PPDU, HE SU PPDU and a HE MU-MIMO PPDU with 484 subcarries have 5 DC subcarriers located at [-2:2]. An 80 MHz HE OFDMA PPDU has 7 DC subcarriers located at [-3:3]. The 80 MHz HE SU PPDU and 80 MHz HE MU-MIMO PPDU with 996 a subcarrier allocation have 5 DC subcarriers located at [-2:2]. The same structure as used in the 80 MHz OFDMA HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The DC tones are located on subcarriers [-11:11]. The same structure as used in the 80 MHz HE SU PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU.

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. The 40 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [-256:-245] and [245:255] as shown in Figure 26-16. The 80 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [-512:-501] and [501:511] as shown in Figure 26-17. 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.

26.3.7.2 Null subcarriers

There are null subcarriers between the 26-, 52- and 106-subcarrier RU locations as illustrated in Figure 26-15, Figure 26-16 and Figure 26-17. The null subcarriers have zero energy. The indices of the null subcarrier are enumerated in Table 26-11.

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. The pilot tone locations for 20 MHz, 40 MHz and 80 MHz bandwidth are as shown in Figure 26-18, Figure 26-19 and Figure 26-20, respectively. All pilot tones are at the even indices enumerated in Table 26-12.

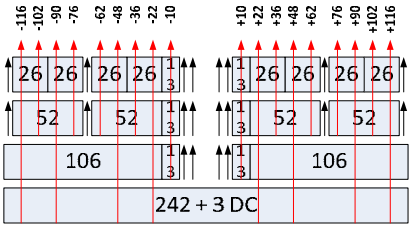


Figure 26-18 - Pilot tone locations for 20 MHz

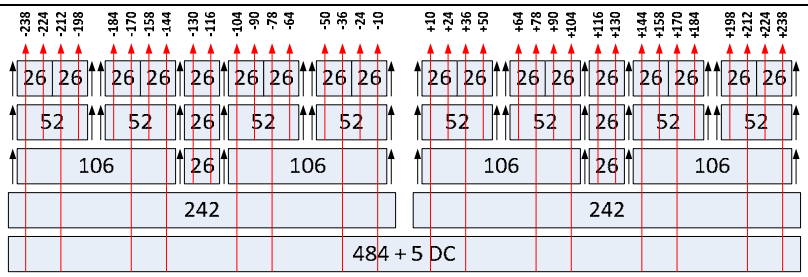


Figure 26-19 - Pilot tone locations for 40 MHz

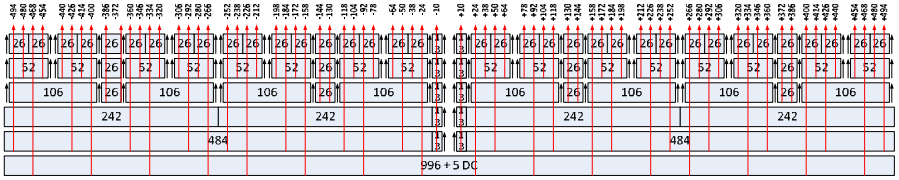


Figure 26-20 - Pilot tone locations for 80 MHz

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.

26.3.8 Mathematical description of the signals

For a description of the conventions used for the mathematical description of the signals, see 18.3.2.5 (Mathematical conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 25 (High Efficiency (HE) PHY specification):

$[Q]_{m,n}$ indicates the element in row *m* and column *n* of matrix , where $1 \le m \le N_{row}$, $1 \le n \le N_{col}$

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* 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 HE Non-OFDMA PPDU 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 HE OFDMA PPDU 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 HE Non-OFDMA or OFDMA PPDU 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 HE Non-OFDMA PPDU 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 HE OFDMA PPDU 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 a 80 MHz HE PPDU transmission, depending on Non-OFDMA or OFDMA transmission within the correspond 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).

$$r_{RF}^{(i_{Seg},i_{TX})}(t) = \mathrm{Re}\left\{\frac{1}{\sqrt{N_{Seg}}} r_{PPDU}^{(i_{Seg},i_{TX})}(t)\exp\left(j2\pi f_c^{(i_{Seg})}t\right)\right\}, \quad i_{Seg} = 0,\ldots,N_{Seg}-1;\ i_{TX} = 1,\ldots,N_{TX} \tag{26-2}$$

where

N_{Seg} represents the number of frequency segments in the transmit signal, as defined in Table 26-3;

$r_{PPDU}^{(i_{Seg},i_{TX})}$ 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 26-21, where $N_{HE\text{-}LTF}$ is the number of HE-LTF symbols and is defined in Table 26-6, $N_{HE\text{-}SIG\text{-}B}$ is the number of symbols in the HE-SIG-B field, and N_{SYM} is the number of symbols in the Data field.

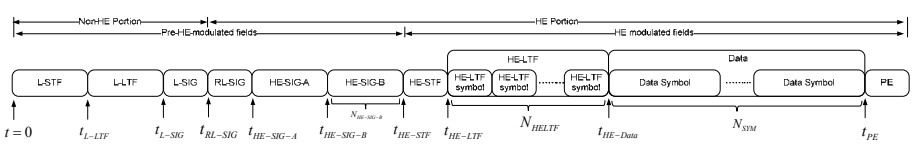


Figure 26-21 - Tlming boundaries for HE PPDU fields

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 frequenct segment i_{Seg} of transmit chain i_{TX} shall be as shown in Equation (26-3).

$$
\begin{aligned}
r_{\text{PPDU}}^{(i_{Seg},i_{\text{TX}})}(t) = {} & r_{\text{L-STF}}^{(i_{Seg},i_{\text{TX}})}(t) + r_{\text{L-LTF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{L-LTF}}) \\
& + r_{\text{L-SIG}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{L-SIG}}) + r_{\text{RL-SIG}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{RL-SIG}}) \\
& + r_{\text{HE-SIG-A}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-SIG-A}}) + r_{\text{HE-SIG-B}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-SIG-B}}) \\
& + r_{\text{HE-STF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-STF}}) + r_{\text{HE-LTF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-LTF}}) \\
& + r_{\text{HE-Data}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-Data}}) + r_{\text{HE-PE}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-PE}})
\end{aligned}
\qquad \textbf{(26-3)}
$$

where

$0 \le i_{Seg} \le N_{Seg} - 1$

$1 \le i_{TX} \le N_{TX}$

$t_{L\text{-}LTF} = T_{L\text{-}STF}$

$t_{L\text{-}SIG} = t_{L\text{-}LTF} + T_{L\text{-}LTF}$

$t_{RL\text{-}SIG} = t_{L\text{-}SIG} + T_{L\text{-}SIG}$

$t_{HE\text{-}SIG-A} = t_{RL\text{-}SIG} + T_{RL\text{-}SIG}$

$$t_{HE-SIG-B} = \begin{cases} t_{HE-SIG-A} + T_{HE-SIG-A}, & \text{for an HE MU PPDU} \\ undefined, & \text{otherwise} \end{cases}$$

$$t_{HE-STF} = \begin{cases} t_{HE-SIG-A} + T_{HE-SIG-A}, & \text{for an HE SU PPDU and HE trigger-based PPDU} \\ t_{HE-SIG-A} + T_{HE-SIG-A-R}, & \text{for an HE extended range SU PPDU} \\ t_{HE-SIG-B} + N_{HE-SIG-B} T_{HE-SIG-B}, & \text{for an HE MU PPDU} \end{cases}$$

where $N_{HE\text{-}SIG\text{-}B}$ is the number of OFDM symbols in the HE-SIG-B field

$$t_{HE-LTF} = \begin{cases} t_{HE-STF} + T_{HE-STF-T}, & \text{for an HE trigger-based PPDU} \\ \mathrm{t}_{HE-STF} + T_{HE-STF-NT}, & \text{otherwise} \end{cases}$$

$$t_{HE\text{-}Data} = \begin{cases} t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF-1X} + T_{GI,HE-LTF}\right), & \text{for 1x HE-LTF} \\ t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF-2X} + T_{GI,HE-LTF}\right), & \text{for 2x HE-LTF} \\ t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF-4X} + T_{GI,HE-LTF}\right), & \text{for 4x HE-LTF} \end{cases}$$

$t_{PE} = t_{HE\text{-}Data} + N_{SYM} . T_{SYM}$

In an HE SU PPDU, HE MU PPDU and HE extended range SU PPDU, each field, $r_{Field}^{(i_{Seg},i_{\text{TX}})}(t)$, 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).

$$
\begin{aligned}
r_{\text{Field}}^{(i_{Seg},i_{\text{TX}})}(t) = \eta_{\text{Field}} w_{T_{\text{Field}}}(t) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{Norm,r}}} \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} \Upsilon_{k,\text{BW}} X_{k,r,u}^{(i_{Seg},m)} \\
\exp\left(j 2\pi k \Delta_{F,\text{Field}} (t - T_{GI,Field} - T_{CS,HE}(M_{r,u} + m)) \right)
\end{aligned}
\qquad \textbf{(26-4)}
$$

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).

$$r_{\text{Field}}^{(i_{Seg},i_{\text{TX}})}(t)=\frac{\eta_{\text{Field}}\alpha_r\beta_r}{\sqrt{N_{Norm,r}}}w_{T_{\text{Field}}}(t)\sum_{k\in K_r}\sum_{m=1}^{N_{STS,r,u}}\left[Q_k^{(i_{Seg})}\right]_{i_{TX},(M_{r,u}+m)}\Upsilon_{k,\text{BW}}X_{k,r,u}^{(i_{Seg},m)}\exp\left(j2\pi k\Delta_{F,\text{Field}}(t-T_{GI,Field}-T_{CS,HE}(M_{r,u}+m))\right) \quad \textbf{(26-5)}$$

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 26-21. 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 notions are used:

N_{Field}^{Tone} Table 26-13 summarizes the various values of N_{Field}^{Tone} as a function of bandwidth per frequency segment. 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.

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	$T_{GI2,Data}$
L-SIG	56	112	224	448	$T_{GI,LegacyPreamble}$
RL-SIG	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-SIG-A	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-SIG-B	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-STF not in HE_TRIG	14	30	62	126	-
HE-STF in HE_TRIG	30	60	124	248	-
HE-LTF 1x Duration	60	122	250	500	$T_{GI,HE\text{-}LTF1}$
HE-LTF 2x Duration	122	242	498	996	$T_{GI,HE\text{-}LTF2}$
HE-LTF 4x Duration	242	484	996	1992	$T_{GI,HE\text{-}LTF4}$
HE-Data	242	484	996	1992	$T_{GI,Data}$ or $T_{GI2,Data}$ or $T_{GI4,Data}$

NON_HT_DUP_ OFDM-Data	56	112	224	448	$T_{GI,LegacyPreamble}$
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.					

$N_{\text{Norm},r}$ If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields, $N_{\text{Norm},r} = N_{TX}$. If the TXVECTOR parameter BEAM_CHANGE is 0, then for pre-HE modulated fields $N_{\text{Norm},r} = N_{STS,r,total}$, where $N_{STS,r,total}$ is given in Table 26-6. For HE modulated fields $N_{\text{Norm},r} = N_{STS,r,total}$.

$w_{T_{\text{Field}}}(t)$ is a windowing function. An example function, $w_{T_{\text{Field}}}(t)$, is given in 18.3.2.5 (Mathematical conventions in the signal descriptions).

K_r For pre-HE modulated fields, K_r is the set of subcarriers indices from $-N_{SR}$ to N_{SR}. For HE modulated fields in a non-OFDMA HE PPDU, K_r 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.

η_{Field} is the power boost factor per OFDM symbol, which is $\sqrt{2}$ for the L-STF and L-LTF fields in the HE extended range SU PPDU, and 1 otherwise.

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 (26-6)

$$\beta_r = \begin{cases} \dfrac{1}{\sqrt{N_{Field}^{Tone}}}, \text{ Pre-HE modulated Fields when BEAM\_CHANGE=1} \\ \sqrt{\dfrac{|K_r|}{|K_r^{Field}|}} \Big/ \sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}, \text{ otherwise} \end{cases} \quad \textbf{(26-6)}$$

$|K_r|$ 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 (26-7) for the HE-LTF field.

$$K_r^{HELTF} = \begin{cases} |K_r|/4 & \text{for 1x HE-LTF} \\ |K_r|/2 & \text{for 2x HE-LTF} \\ |K_r| & \text{for 4x HE-LTF} \end{cases} \quad \textbf{(26-7)}$$

$Q_k^{(i_{Seg})}$ 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 $exp\left(-j2\pi k \Delta_{F,Pre-HE} T_{CS}^{i_{TX}}\right)$, 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 modulation fields.

$\Delta_{F,\text{Field}}$ is the subcarrier frequency spacing. For pre-HE modulated fields, $\Delta_{F,\text{Field}} = \Delta_{F,\text{Pre-HE}}$ given in Table 26-3. For HE modulated fields, $\Delta_{F,\text{Field}} = \Delta_{F,\text{HE}}$ given in Table 26-3.

$X_{k,r,u}^{(i_{Seg},m)}$ 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 $X_{k,u}^{(i_{Seg},m)}$ within $-N_{\text{SR}} \le k \le N_{\text{SR}}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the leftover tones 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_{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_{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 25-2 (Tone scaling factor and guard interval duration values for PHY fields).

$T_{CS,HE}(l)$ For pre-HE modulated fields, $T_{CS,HE}(l) = 0$. For HE modulated fields, $T_{CS,HE}(l)$ 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).

$\Upsilon_{k,\text{BW}}$ is used to represent a rotation of the tones. In HE modulated fields, $\Upsilon_{k,\text{BW}} = 1$ in all the subcarriers. In pre-HE modulated fields, BW in $\Upsilon_{k,\text{BW}}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 26-14.

Table 26-14 - CH_BANDWIDTH and $\Upsilon_{k,\text{BW}}$ for pre-HE modulated fields

CH_BANDWIDTH	$\Upsilon_{k,\text{BW}}$
CBW20	$\Upsilon_{k,20}$
CBW40	$\Upsilon_{k,40}$
CBW80	$\Upsilon_{k,80}$
CBW160	$\Upsilon_{k,160}$
CBW80+80	$\Upsilon_{k,80}$ per frequency segments

For a 20 MHz PPDU transmission,

$$\Upsilon_{k,20} = 1 \quad \textbf{(26-8)}$$

For a 40 MHz PPDU transmission,

$$\Upsilon_{k,40} = \text{TBD} \tag{26-9}$$

For an 80 MHz PPDU transmission,

$$\Upsilon_{k,80} = \text{TBD} \tag{26-10}$$

For a noncontiguous 80+80 MHz PPDU transmission, each 80 MHz frequency segment shall use the phase rotation for 80 MHz PPDU transmissions as defined in Equation (26-10).

For a contiguous 160 MHz PPDU transmission,

$$\Upsilon_{k,160} = \text{TBD} \tag{26-11}$$

26.3.9 HE preamble

26.3.9.1 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 and HE-LTF fields. The pre-HE modulated fields depend on the structure of the PPDU and consist of the following:

— 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

26.3.9.2 Cyclic shift for Pre-HE modulated fields

26.3.9.3 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 (26-12). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{seg},i_{TX})}(t) = \frac{\eta}{\sqrt{N_{\text{TX}} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{\text{T}_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-26}^{26} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} S_{k,20} \\ \cdot \exp\left(j2\pi\left(k - K_{\text{Shift}}(i_{\text{BW}})\right)\Delta_{F,\text{Pre-HE}}\left(t - T_{GI,\text{LegacyPreamble}} - T_{CS}^{i_{TX}}\right)\right) \end{array} \right) \tag{26-12}$$

where

η is an PPDU format dependent scaling factor, with the following value

$$\eta = \begin{cases} \sqrt{2}, & \text{HE extended range PPDU} \\ 1, & \text{otherwise} \end{cases} \tag{26-13}$$

N_{20MHz} is defined in 22.3.8.3.4 (L-SIG definition)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$\Gamma_{k,\text{BW}}$ is defined by Equation (22-14), Equation (22-15), Equation (22-16) and Equation (22-17).

$N_{\text{L-STF}}^{\text{Tone}}$ has the value given in Table 22-8 (Tone scaling factor and guard interval duration values for PHY fields(11ac)).

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 (26-14). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{\left(i_{seg},i_{TX}\right)}\left(t\right)=\frac{\eta}{\sqrt{N_{\text{TX}}\cdot N_{\text{L-STF}}^{\text{Tone}}}}w_{\text{T}_{\text{L-STF}}}\left(t\right)\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-26}^{26}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\Upsilon_{\left(k-K_{\text{Shift}}\left(i_{BW}\right)\right),\text{BW}}\left[Q_{4\left(k-K_{\text{Shift}}\left(i_{BW}\right)\right)}^{\left(i_{seg}\right)}\right]_{i_{TX},m}\left[A_{HELTF}^{4\left(k-K_{\text{Shift}}\left(i_{BW}\right)\right)}\right]_{m,1}S_{k,20}\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}\left(i_{\text{BW}}\right)\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-14)}$$

where

$T_{CS,\text{HE}}\left(n\right)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$Q_{k}^{\left(i_{seg}\right)}$ is defined in **Error! Reference source not found.**

A_{HELTF}^{k} is defined in Equation (26-57)

26.3.9.4 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 (26-15). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{\left(i_{seg},i_{TX}\right)}\left(t\right)=\frac{\eta}{\sqrt{N_{\text{TX}}\cdot N_{\text{L-LTF}}^{\text{Tone}}}}w_{\text{T}_{\text{L-LTF}}}\left(t\right)\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-26}^{26}\left(\begin{array}{l}\Upsilon_{\left(k-K_{\text{Shift}}\left(i_{BW}\right)\right),\text{BW}}L_{k,20}\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}\left(i_{\text{BW}}\right)\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-15)}$$

where

η is an PPDU format dependent scaling factor, as defined in Equation (26-13).

N_{20MHz} is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i)\cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$\Gamma_{k,\text{BW}}$ is defined by Equation (22-14), Equation (22-15), Equation (22-16) and Equation (22-17).

$N_{\text{L-LTF}}^{\text{Tone}}$ has the value given in Table 22-8 (Tone scaling factor and guard interval duration values for PHY ields(11ac)).

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 (26-16). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{seg},i_{TX})}(t)=\frac{\eta}{\sqrt{N_{\text{TX}}\cdot N_{\text{L-LTF}}^{\text{Tone}}}}w_{\text{T}_{\text{L-LTF}}}(t)$$
$$\sum_{i_{BW}=0}^{N_{20\,MHz}-1}\sum_{k=-26}^{26}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}L_{k,20}\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}(i_{\text{BW}})\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-16)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^k is defined in Equation (26-57)

26.3.9.5 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 18-5 (SIGNAL field bit assignment).

In a HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 18-6 (Contents of the SIGNAL field). In a non-HT duplicate PPDU, the RATE field is defined in 18.3.4.2 (RATE field) using the L_DATARATE parameter in the TXVECTOR.

The LENGTH field shall be set to the value given by Equation (26-17).

$$\text{Length}=\frac{\text{TXTIME}-20}{4}\times 3-3-m \quad \textbf{(26-17)}$$

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 18.3.4.3 (LENGTH field) 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.

The SIGNAL TAIL field shall be set to 0.

The L-SIG field shall be encoded, interleaved, and mapped following the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), and 18.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by $d_k, k=0,\cdots,47$. Pilots shall be inserted as described in 18.3.5.9 (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].

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform of the L-SIG field shall be as given by Equation (26-18).

$$r_{\text{L-SIG}}^{(i_{seg},i_{TX})}(t) = \frac{1}{\sqrt{N_{L-SIG}^{\text{Tone}} N_{TX}}} w_{T_{L-SIG}}(t) \cdot \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} \left(D_{k,20} + p_0 P_k \right) \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - T_{GI,\text{LegacyPreamble}} - T_{CS}^{i_{TX}} \right) \right) \end{array} \right) \quad \textbf{(26-18)}$$

where

N_{20MHz} is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ \pm 1(TBD), k = \pm 27, \pm 28 \\ d_{M_{20}^r(k)}, \text{otherwise} \end{cases}$$

$$M_{20}^r(k) = \begin{cases} k+26, -26 \le k \le -22 \\ k+25, -20 \le k \le -8 \\ k+24, -6 \le k \le -1 \\ k+23, 1 \le k \le 6 \\ k+22, 8 \le k \le 20 \\ k+21, 22 \le k \le 26 \end{cases}$$

P_k is defined in 18.3.5.10 (OFDM modulation)

p_0 is the first pilot value in the sequence defined in 18.3.5.10 (OFDM modulation)

$N_{\text{L-SIG}}^{\text{Tone}}$ has the value given in **Error! Reference source not found.**

$\Upsilon_{k,\text{BW}}$ is defined in Equation (26-8), Equation (26-9), Equation (26-10) and Equation (26-11).

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

NOTE—$M_{20}^r(k)$ is a "reverse" function of the function M(k) defined in 18.3.5.10 (OFDM modulation).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the L-SIG field shall be as given by Equation (26-19).

$$r_{L-SIG}^{(i_{seg},i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{L-SIG}}^{\text{Tone}} N_{STS,total}}} w_{T_{L-SIG}}(t) \cdot \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-28}^{28} \sum_{m=0}^{N_{STS,total}-1} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})} \right]_{i_{TX},m} \left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,1} \left(D_{k,20} + p_0 P_k \right) \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{BW}) \right) \Delta_{F,\text{Pre-HE}} \left(t - T_{GI,\text{LegacyPreamble}} - T_{CS,HE}(m) \right) \right) \end{array} \right) \quad \textbf{(26-19)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^{k} is defined in **Error! Reference source not found.**

26.3.9.6 RL-SIG

The RL-SIG field is used to identify a 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 (26-20).

$$r_{RL-SIG}^{(i_{Seg},i_{TX})}(t) = r_{L-SIG}^{(i_{Seg},i_{TX})}(t) \quad \textbf{(26-20)}$$

26.3.9.7 HE-SIG-A

26.3.9.7.1 General

The HE-SIG-A field carries information required to interpret HE PPDUs. The structure of the HE-SIG-A field for the first part (HE-SIG-A1) and for the second part (HE-SIG-A2) is TBD.

26.3.9.7.2 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.

Table 26-15 - Fields in the HE-SIG-A for an HE SU PPDU and HE extended range SU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
TBD	TBD	DL/UL	1	Indicates whether the PPDU is sent UL or DL. 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.
	TBD	Format	1	Differentiate between an HE SU PPDU and an HE trigger-based PPDU or between an HE extended range SU PPDU and an HE trigger-based PPDU
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, 3 for 160 MHz and 80+80 MHz
	TBD	MCS	4	HE-MCS index
	TBD	CP+LTF Size	3	To indicate the CP length and HE-LTF size, the current combinations are 1x HE-LTF + 0.8 µs, 2x HE-LTF + 0.8 µs, 2x HE-LTF + 1.6 µs and 4x HE-LTF + 3.2 µs. Other combinations are TBD.
	TBD	Coding	2	Indication of BCC/LDPC and presence of the extra OFDM symbol for LDPC. Detailed indication is TBD.
	TBD	Nsts	3	Indicates the number of spatial streams: Set to 0 for 1 space time stream Set to 1 for 2 space time streams Set to 2 for 3 space time streams Set to 3 for 4 space time streams Set to 4 for 5 space time streams Set to 5 for 6 space time streams Set to 6 for 7 space time streams Set to 7 for 8 space time streams
	TBD	STBC	1	Set to 1 if space time block coding is used and set to 0 otherwise.

	TBD	TxBF	1	Set to 1 if a Beamforming steering matrix is applied to the waveform in an SU transmission, set to 0 otherwise.
	TBD	DCM	1	Set to 1 indicates that the payload of the SU PPDU is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual sub-carrier modulation for the MCS.
	TBD	Packet Extension	3	The first two bits indicate the "*a-factor*" and the third bit indicates the PE-Disambiguity.
	TBD	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.
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—The HE-SIG-A field contents for the HE extended range SU PPDU may be subject to change.

The HE-SIG-A field of an HE MU PPDU contains the fields listed in Table 26-16.

Table 26-16 - Fields in the HE-SIG-A for a HE MU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of Bits	Description
TBD	TBD	DL/UL	1	Indicates whether the HE MU PPDU is UL or DL. 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 11ax MPDU.
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	≥ 2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, 3 for 160 MHz and 80+80 MHz
	TBD	SIGB MCS	3	Indication the MCS of HE-SIG-B. Set to 0 for MCS0 Set to 1 for MCS1 Set to 2 for MCS2 Set to 3 for MCS3 Set to 4 for MCS4 Set to 5 for MCS5
	TBD	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.
	TBD	SIGB Number Of Symbols	4	Indciates the number of HE-SIG-B symbols.
	TBD	SIGB Compression	1	Set to 1 for full BW MU-MIMO. Set to 0 otherwise.
	TBD	Number of HE-LTF Symbols	3	Indicates the number of HE-LTF symbols.

	TBD	CP+LTF Size	3	To indicate the CP length and HE-LTF size, the current combinations are 1x HE-LTF + 0.8 µs, 2x HE-LTF + 0.8 µs, 2x HE-LTF + 1.6 µs and 4x HE-LTF + 3.2 µS. Other combinations are TBD.
	TBD	LPDC Extra Symbol	1	Indication of the presence of the extra OFDM symbol for LDPC.
	TBD	Packet Extension	3	The first two bits indicate the "a-factor" and the third bit indicates the PE-Disambiguity.
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

The HE-SIG-A field for an HE trigger-based PPDU contains the fields listed in Table 26-17.

Table 26-17 - HE Fields in the HE-SIG-A for a HE trigger-based PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of Bits	Description
TBD	TBD	Format	1	Set to 0 for an HE SU PPDU Set to 1 for an HE trigger-based PPDU
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	TBD	TBD
	TBD	Reserved	TBD	TBD
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

26.3.9.7.3 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 protects bits 0–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

$$crc(D) = \big(M(D) + I(D)\big)D^8 \; mod \; G(D)$$

where

$$M(D) = \sum_{i=0}^{L} m_{L-i} D^i$$

where

m_i is bit i in the field

$$I(D) = \sum_{i=L-7}^{L} D^i$$

G(D) and *crc(D)* are defined in Equation (20-18).

The CRC field is transmitted from c_5 to c_7 with c_7 first.

Figure 20-8 (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 c_4.

26.3.9.7.4 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 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively. The constellation mappings of HE-SIG-A in HE SU PPDU, HE MU PPDU and HE trigger-based PPDU are shown in Figure 26-22. 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 (26-21).

$$r_{\text{HE-SIG-A}}^{(i_{\text{Seg}},i_{TX})}(t) = \frac{1}{\sqrt{N_{HE-SIG-A}^{\text{Tone}} N_{TX}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \cdot \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} \left(D_{k,n,BW} + p_{n+2} P_k \right) \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - nT_{SYML} - T_{GI,LEgacy\,\text{Preamble}} - T_{CS}^{i_{TX}} \right) \right) \end{array} \right) \quad \textbf{(26-21)}$$

where

N_{20MHz} is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k,n,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^{r'}(k),n}, \text{otherwise} \end{cases}$$

$$M_{20}^{r'}(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 25, -20 \le k \le -8 \\ k + 24, -6 \le k \le -1 \\ k + 23, 1 \le k \le 6 \\ k + 22, 8 \le k \le 20 \\ k + 21, 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 18.3.5.10 (OFDM modulation).

$N_{HE-SIG-A}^{Tone}$ has the value given in **Error! Reference source not found.**

$\Upsilon_{k,\text{BW}}$ is defined in Equation (26-8), Equation (26-9), Equation (26-10) and Equation (26-11).

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (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 (26-22).

$$r_{HE-SIG-A}^{(i_{seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{\text{HE-SIG-A}}^{\text{Tone}}N_{STS,total}}}\sum_{n=0}^{1}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}(D_{k,20}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}(i_{BW})\right)\Delta_{F,\text{Pre-HE}}\left(t-nT_{SYML}-T_{GI,\text{LegacyPreamble}}-T_{CS,HE}(m)\right)\right)\end{array}\right) \quad \textbf{(26-22)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^k is defined in Equation (26-57)

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 and have pilots inserted. The constellation mappings of the HE-SIG-A field in an HE extended range SU PPDU is shown in Figure 26-22. QBPSK constellation on HE-SIG-A2 is used to differentiate between an HE extended range SU PPDU and an HE MU PPDU. HE-SIG-A4 shall be BCC encoded at rate, R=1/2, mapped to a BPSK constellation and have pilots inserted. BCC encoding, Data interleaving, constellation mapping and pilot insertion follow the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively.

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 (26-23).

$$r_{\text{HE-SIG-A}}^{(i_{\text{Seg}},i_{TX})}(t)=\frac{1}{\sqrt{N_{HE-SIG-A}^{\text{Tone}}N_{TX}}}\sum_{n=0}^{3}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\left(\begin{array}{l}\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}(R_nD_{k,n,BW}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}(i_{\text{BW}})\right)\Delta_{F,\text{Pre-HE}}\left(t-nT_{SYML}-T_{GI,LEgacyPreamble}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-23)}$$

where

R is a phase rotation vector defined as $[1, j, 1, 1]$.

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 (26-24).

$$r_{HE-SIG-A}^{(i_{seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{\text{HE-SIG-A}}^{\text{Tone}}N_{STS,total}}}\sum_{n=0}^{3}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}(R_nD_{k,20}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}(i_{BW})\right)\Delta_{F,\text{Pre-HE}}\left(t-nT_{SYML}-T_{GI,\text{LegacyPreamble}}-T_{CS,HE}(m)\right)\right)\end{array}\right) \quad \textbf{(26-24)}$$

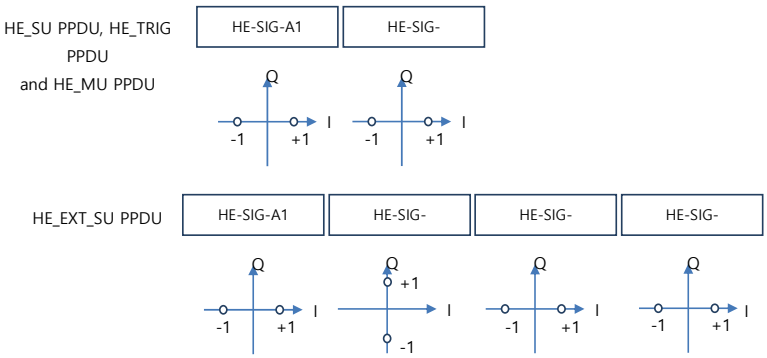


Figure 26-22 - Data tone constellation of HE-SIG-A symbols

26.3.9.8 HE-SIG-B

26.3.9.8.1 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 26-23. It consists of a Common Block field followed by a User Specific field.

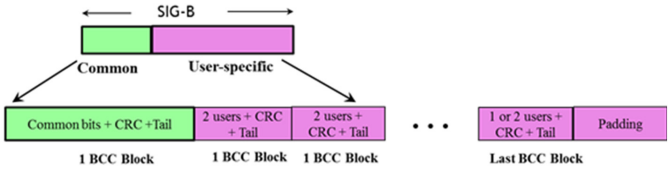


Figure 26-23 – HE-SIG-B field encoding structure in each 20 MHz

The Common Block field 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 25.3.9.2.5.2

The User Specific field consists of multiple User Block fields. Each User Block field contains information for two STAs to decode their payloads. The last User Block field may contain information for only one STA, if the number of user fields indicated by the RU allocation signaling in the common block is odd. See 25.3.9.2.5.3 for a description of the contents of the User Block field.

26.3.9.8.1.1 Frequency domain mapping

For 20 MHz and 40 MHz PPDUs, the Common Block field and the User field for a STA are transmitted in the same 20 MHz band as the STA's data as shown in Figure 26-24 and Figure 26-25.

Figure 26-24 HE-SIG-B content channel for a 20 MHz PPDU

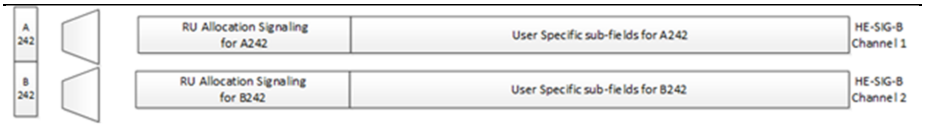


Figure 26-25 - HE-SIG-B content channels for a 40 MHz PPDU

For an 80 MHz PPDU, the default frequency mapping of the Common Block field and User Specific fields is shown in Figure 26-26. The HE-SIG-B field content in the 1st and 3rd 20 MHz bands from the top are identical. The information carried in either of these bands is called HE-SIG-B content channel 1. HE-SIG-B content channel 1 carries signaling information for all STAs whose payloads occupy some tones in A242 or C242. Similarly, the HE-SIG-B contents on the 2nd and 4th 20 MHz bands are identical. The information carried in either of these bands is called HE-SIG-B content channel 2. HE-SIG-B content channel 2 carries signaling information for all STAs whose payloads occupy some tones in B242 or D242.

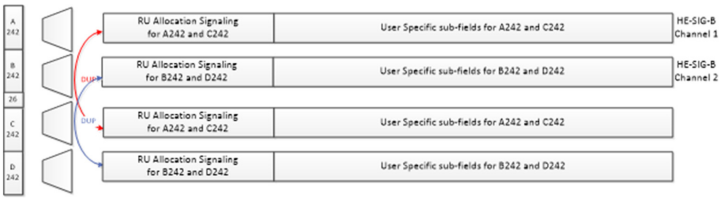


Figure 26-26 - Default mapping of the two HE-SIG-B channels and their duplication in an 80 MHz PPDU

For a 160 MHz PPDU, the default frequency mapping of the Common Block field and User Specific fields is shown in Figure 26-27. The HE-SIG-B content in the 1st, 3rd, 5th and 7th 20 MHz bands from top are all identical. The information carried in any of these bands is called HE-SIG-B content channel 1. HE-SIG-B content channel 1 carries signaling information for all STAs whose payloads occupy some tones in A1-242 or C1-242 or A2-242 or C2-242. Similarly, the HE-SIG-B contents in the 2nd, 4th, 6th and 8th 20 MHz bands from top are identical. The information carried in any of these bands is called HE-SIG-B content channel 2. HE-SIG-B content channel 2 carries signaling information for all STAs whose payloads occupy some tones in B1-242 or D1-242 or B2-242 or D2-242.

Figure 26-27 - Default mapping of the two HE-SIG-B channels and their duplication in a 160 MHz PPDU

For MU-MIMO allocation of RU size > 20 MHz, 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 25.3.9.2.5.2 and 25.3.9.2.5.3 for more details.

26.3.9.8.1.2 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. 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 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 18.3.5.6. If the number of users is even, padding bits are added to round up the number of symbols to the nearest integer. If the number of users is odd, the User Block field corresponding to the last user, who is not grouped, is encoded after adding tail and CRC bits and only then are any padding bits added. The padding bits added ensure that both content channels have the same number of symbols. The specific method of generating padding bits is TBD. 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 continuously as described in 18.3.5.6 (Convolutional encoder).

The number of data tones in each symbol is N_{SD} = 52. The coded bits are interleaved as in 22.3.10.8, with the parameter N_{col} = 13 (as in Table 22-17, for 20 MHz). 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 18.3.5.7 (Data Interleaving), 18.3.5.8 (Subcarrier modulation mapping) and 18.3.5.9 (Pilot subcarriers) respectively.

The cyclic prefix used for HE-SIG-B shall be 0.8 µs. The number of symbols in HE-SIG-B, denoted by $N_{SYM,HE\text{-}SIG\text{-}B}$, shall be signaled in HE-SIG-A in the default mode (see Section 25.3.9.2.4). For the cth content channel (c = 1 or 2), denote the sample on the kth subcarrier of the nth symbol by $d_{k,n,c}$. The time domain waveform for the HE-SIG-B follows Equation (26-25).

$$r_{HE-SIG-B}^{(i_{Seg},i_{Tx})}(t) = \frac{1}{\sqrt{N_{HE-SIG-B}^{Tone} N_{Tx}}} \sum_{n=0}^{N_{sym,HE-SIG-B}} w_{T_{HE-SIG-B}}(t - nT_{SYML}) \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-N_{SR}}^{N_{SR}} \Upsilon_{(k-K_{shift}(i_{BW})),BW}$$
$$\left(D^{i_{Seg}}_{k,n,i_{BW}} + p_{n+4}P_k\right)\exp\left(j2\pi(k - K_{shift}(i_{BW}))\Delta_{F,Pre-HE}(t - nT_{SYML} - T_{GI,LEgacy\,Preamble} - T_{CS}^{i_{TX}})\right) \quad \textbf{(26-25)}$$

where

N_{20MHz} and $K_{shift}(i)$ are defined in 22.3.8.2.4 (L-SIG definition)

$$D^{i_{Seg}}_{k,n,i_{BW}} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^r(k),n,(i_{BW} \bmod 2)+1}, otherwise \end{cases}$$

$$M_{20}^r(k) = \begin{cases} k+28, -28 \le k \le -22 \\ k+27, -20 \le k \le -8 \\ k+26, -6 \le k \le -1 \\ k+25, 1 \le k \le 6 \\ k+24, 8 \le k \le 20 \\ k+23, 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 18.3.5.10 (OFDM modulation)

$\Upsilon_{k,BW}$ is defined in Equation (25-4), Equation (25-7), Equation (24-7) and Equation (24-8)

$N_{sym,HE-SIG-B}$ is the number of symbols in HE-SIG-B

26.3.9.8.2 HE-SIG-B common content

The Common block field in the HE-SIG-B carries RU allocation subfields. Depending on the PPDU bandwidth, the Common block field can contain multiple RU allocation subfields.

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 26-18. 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 unit in 80 MHz is [TBD].

Table 26-18 - RU allocation signalling: Arrangement and number of MU-MIMO allocations

8 bits indices	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
000 0 0000	26	26	26	26	26	26	26	26	26	1
000 0 0001	26	26	26	26	26	26	26	52		1
000 0 0010	26	26	26	26	26	52		26	26	1
000 0 0011	26	26	26	26	26	52		52		1
000 0 0100	26	26	52		26	26	26	26	26	1
000 0 0101	26	26	52		26	26	26	52		1
000 0 0110	26	26	52		26	52		26	26	1
000 0 0111	26	26	52		26	52		52		1
000 0 1000	52		26	26	26	26	26	26	26	1
000 0 1001	52		26	26	26	26	26	52		1
000 0 1010	52		26	26	26	52		26	26	1
000 0 1011	52		26	26	26	52		52		1
000 0 1100	52		52		26	26	26	26	26	1
000 0 1101	52		52		26	26	26	52		1
000 0 1110	52		52		26	52		26	26	1
000 0 1111	52		52		26	52		52		1
000 1 xxxx	Definition TBD									16
00100 yyy	26	26	26	26	26	106				8
00101 yyy	26	26	52		26	106				8
00110 yyy	52		26	26	26	106				8
00111 yyy	52		52		26	106				8
01000 yyy	106				26	26	26	26	26	8
01001 yyy	106				26	26	26	52		8
01010 yyy	106				26	52		26	26	8
01011 yyy	106				26	52		52		8
011 xxxxx	Definition TBD									32
10 yyy yyy	106				26	106				64
11 0 00yyy	242									8
11 0 01yyy	484									8
11 0 10yyy	996									8
11 0 11yyy	2*996									8
11 1 xxxxx	Definition TBD									32

NOTE: yyy' = 000~111 indicates number of STAs multiplexed in an RU. Binary vector yyy 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. The definition for entries with 'x' bits is TBD.

The number of RU allocation subfields in the HE-SIG-B common block field depends on the total PPDU bandwidth

— In the default mode, for 20 MHz and 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 the 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 the 160 MHz PPDU, each HE-SIG-B content channel contains four RU allocation signaling fields 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.

26.3.9.8.3 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. 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 26-28. 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.

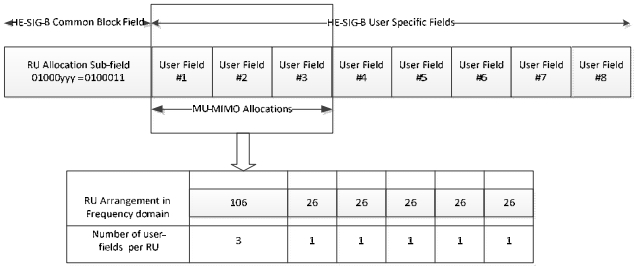


Figure 26-28 - Illustration for the mapping of the 8-bit RU allocation subfield and the position of the user-field to the STA's assignment

The contents of the user field differ based on whether the field addresses a single-STA in an RU or a STA in a MU-MIMO allocation in an RU. Irrespective of whether the allocation is for a STA in a SU or an MU-MIMO allocation, the size of the userfield is the same.

The HE-SIG-B user field for a SU allocation contain the subfields shown in Table 26-19.

Table 26-19 - Fields of the HE-SIG-B user field for a SU allocation

Bit	Subfield	Number of bits	Description
TBD	STA-ID	11	The STA identifier that addresses a STA – reference to MAC section(?). 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 will have a special STAID value reserved.
TBD	NSTS	3	Number of spatial streams
TBD	Tx Beamforming	1	Use of transmit beamforming
TBD	MCS	4	Modulation and Coding Scheme
TBD	DCM	1	Indication for use of dual carrier modulation
TBD	Coding	1	Indication for use of LDPC

The HE-SIG-B user field for an STA in MU-MIMO allocation contain the subfields shown in Table 26-20.

Table 26-20 - Fields of the HE-SIG-B user field for a MU-MIMO allocation

Bit	Subfield	Number of bits	Description
TBD	STA-ID	11	The STA identifier that addresses an STA – reference to MAC section(?)
TBD	Spatial Configuration	4	Indication for the number of spatial streams for a STA in a MU-MIMO allocation. See Table 26-21.
TBD	MCS	4	Modulation and Coding Scheme
TBD	DCM	1	Use of dual carrier modulation
TBD	Coding	1	Use of LDPC

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 26-21 is constructed by using the entries corresponding to the value of number of users (Nuser) multiplexed using MU-MIMO in an RU. When MU-MIMO is used in an RU of size ≤ 20 MHz, the number of users (Nuser) in an MU-MIMO allocation is equal to the number of user-fields per RU signalled 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 20 MHz or greater, the number of users (Nuser) 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 Nuser, the four bits of the spatial configuration subfield are used as follows: A STA with a STA-ID that matches the 11-bit ID signalled in the user field for an MU-MIMO allocation derives the number of spatial streams allocated to it using the row corresponding to the signalled 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 > 20 MHz 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 user-field 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 26-21 - Spatial Configuration subfield encoding

Nuser	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	
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

26.3.9.9 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 $T_{HE\text{-}STF\text{-}NT}$ (peridiocity of 0.8 µs with 5 periods) and the duration of the HE-STF field for an HE trigger-based PPDU is $T_{HE\text{-}STF\text{-}T}$ (peridiocity 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 (26-26).

$$i_{STF} \bmod 16 = 0, \quad \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR} \qquad (25-1) \qquad \textbf{(26-26)}$$

i_{STF} : HE-STF tone index

The tone indices for HE-STF fields for an HE trigger-based PPDU are defined in Equation (26-27).

$$i_{STF} \bmod 8 = 0, \quad \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR} \qquad (25-2) \qquad \textbf{(26-27)}$$

i_{STF} : HE-STF tone index

For the HE-STF field, the M sequence is defined by Equation (26-28).

$$M = \{-1, -1, -1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, -1, 1\} \qquad \textbf{(26-28)}$$

The HE-STF field is constructed from the M sequence(s) by multiplying integer coefficient(s) to each 20 MHz subchannel and inserting appropriate coefficients into tone indices which are null after mapping M sequences.

For a 20 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-29).

$$HES_{-112:16:112} = \{M\} \cdot (1+j)/\sqrt{2} \qquad (25-3)$$
$$HES_0 = 0$$ **(26-29)**

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 (26-30).

$$HES_{-240:16:240} = \{M,\ 0,\ -M\} \cdot (1+j)/\sqrt{2} \qquad (25-4)$$ **(26-30)**

For an 80 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-31).

$$HES_{-496:16:496} = \{M,\ 1,\ -M,\ 0,\ -M,\ 1,\ -M\} \cdot (1+j)/\sqrt{2} \qquad (25-5)$$ **(26-31)**

For a 20 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-32).

$$HES_{-120:8:120} = \{M,\ 0,\ -M\} \cdot (1+j)/\sqrt{2} \qquad (25-6)$$ **(26-32)**

For a 40 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-33).

$$HES_{-248:8:248} = \{M,\ -1,\ -M,\ 0,\ M,\ -1,\ M\} \cdot (1+j)/\sqrt{2} \qquad (25-7)$$
$$HES_{\pm 248} = 0$$ **(26-33)**

For an 80 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-34).

$$HES_{-504:8:504} = \{M,\ -1,\ M,\ -1,\ -M,\ -1,\ M,\ 0,\ -M,\ 1,\ M,\ 1,\ -M,\ 1,\ -M\} \cdot (1+j)/\sqrt{2}$$ **(26-34)**
$$HES_{\pm 504} = 0 \qquad (25-8)$$

For an OFDMA transmission, the coefficients in Equation (25-3) to (25-8) are set to zero if those values are corresponding to tone indices on which no RUs defined in 25.3.7.1 are assigned.

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 (26-35).

$$r_{\text{HE-STF}}^{(i_{Seg}, i_{TX})}(t) = w_{T_{\text{HE-STF-NT}}}(t) \cdot \eta_{EXT} \cdot \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} HES_k \\ \cdot \exp\left(j2\pi k \Delta_{F,\text{HE}} \left(t - T_{\text{CS,HE}} \left(M_{r,u} + m \right) \right) \right) \end{array} \right)$$ **(26-35)**

where

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

η_{EXT} is an PPDU format dependent scaling factor, with the following value

$$\eta_{EXT} = \begin{cases} \sqrt{2}, & \text{HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

β_r is the per-RU power normalization factor and defined by

$$\beta_r = \sqrt{\frac{|K_r|}{\left|K_r^{\text{HE-STF}}\right|}} \Bigg/ \sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}$$

$|K_r|$ 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

$T_{\text{CS,HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 25.3.10.10.x (Transmission in HE format)

$w_{T_{\text{HE-STF-NT}}}(t)$ is the windowing function for HE-STF field in the non-HE trigger-based PPDU.

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 (26-36).

$$r_{\text{HE-STF}}^{(i_{Seg},i_{TX})}(t) = \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}} w_{T_{\text{HE-STF-T}}}(t) \cdot \sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} HES_k \\ \cdot \exp\left(j2\pi k \Delta_{F,\text{HE}} \left(t - T_{\text{CS,HE}}(M_{r,u}+m) \right) \right) \end{array} \right) \quad \textbf{(26-36)}$$

where

$w_{T_{\text{HE-STF-T}}}(t)$ is the windowing function for HE-STF field in the HE trigger-based PPDU.

26.3.9.10 HE-LTF

The HE Long Training field (HE-LTF) field 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 MU PPDU or HE extended range SU 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 $P_{HE\text{-}LTF}$, to enable channel estimation at the receiver. The pilot tones of each HE-LTF symbol are multiplied by the entries of a matrix $R_{HE\text{-}LTF}$ defined in the following text. The multiplication of the pilot tones in the HE-LTF symbol by the $R_{HE\text{-}LTF}$ matrix instead of the $P_{HE\text{-}LTF}$ matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the HE-LTF. In an HE SU PPDU and HE extended range SU PPDU, the number of HE-LTF symbols, $N_{HE\text{-}LTF}$, is a function of the total number of space-time streams N_{STS} as shown in **Error! Reference source not found.**. In an HE trigger-based PPDU, $N_{HE\text{-}LTF}$ is indicated in the Trigger frame that triggers the transmission of the PPDU. In an HE MU PPDU, $N_{HE\text{-}LTF}$ is indicated in the HE-SIG-A field. In an HE MU PPDU and HE trigger-based PPDU,

$N_{HE\text{-}LTF}$ is selected to be not smaller than the maximum value of the functions for each $N_{STS,r,total}$. As a result the HE-LTF field consists of one, two, four, six or eight symbols.

A HE PPDU supports 3 HE-LTF modes, which are 1x HE-LTF, 2x HE-LTF, and 4x HE-LTF. It is optional to support 1x HE-LTF in an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU. In an HE SU PPDU, HE MU PPDU or 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*, $T_{GI,Data}$
— *2x HE-LTF*, $T_{GI,Data2}$
— *4x HE-LTF*, $T_{GI,Data4}$

The optional combinations of HE-LTF mode and GI duration are:

— *1x HE-LTF*, $T_{GI,Data}$ in a HE SU PPDU or HE extended SU PPDU
— *1x HE-LTF*, $T_{GI,Data}$ in a non-OFDMA, MU-MIMO HE MU PPDU
— *1x HE-LTF*, $T_{GI,Data2}$ in a non-OFDMA, MU-MIMO HE trigger-based PPDU

The duration of each HE-LTF symbol is $T_{HE\text{-}LTF}$ is defined in Equation (26-37). 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.

$$T_{HE-LTF} = \begin{cases} T_{HE-LTF-1X} & \text{if 1x HE-LTF} \\ T_{HE-LTF-2X} & \text{if 2x HE-LTF} \\ T_{HE-LTF-4X} & \text{if 4x HE-LTF} \end{cases} \quad \text{(26-37)}$$

where $T_{HE\text{-}LTF\text{-}1X}$, $T_{HE\text{-}LTF\text{-}2X}$, $T_{HE\text{-}LTF\text{-}4x}$ are defined in Table 26-3 (Timing related constants).

In a 20 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation **(26-38)**.

$HELTF_{-122,122}$ =

{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} **(26-38)**

In a 20 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-39).

$HELTF_{-122,122}$ =

{-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, 0, +1} **(26-39)**

In a 20 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-40).

$HELTF_{-122, 122}$ =
{-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, -1, +1, -1, +1, +1, +1, 0, 0, **(26-40)**
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 In a 40 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation **(26-41)**.

$HELTF_{-244,244}$ =
{ +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, **(26-41)**
0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 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}

2 In a 40 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-42).

$HELTF_{-244,244}$ =
{+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, **(26-42)**
0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, 0, 0, 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, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0,
-1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1,
0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -
1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0,
+1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1}

3 In a 40 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-43).

$HELTF_{-244,244}$ =
{+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, - **(26-43)**
1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -

1, +1, +1, +1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, -1, -1, +1, -1,
+1, +1, +1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, +1,
-1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1,
+1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1,
+1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1,
-1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1,
+1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -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 In an 80 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation Equation (26-44).

$HELTF_{-500,500}$ =

{ -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, -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, 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,

(26-44)

-1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1}

In an 80 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-45).

$HELTF_{-500,500}$ =
{+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, **(26-45)**
+1, 0, +1, 0, +1, 0, 0, 0, 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, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1,
0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1,
0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1,
0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -
1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1,
0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1,
-1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1,
0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1,
0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0,
+1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 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 an 80 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-46).

$HELTF_{-500,500}$ =
{+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, -

(26-46)

1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1,
-1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1,
+1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, -1, +1,
+1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -
1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -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}

In a 160 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-47).

$$HELTF_{-1012,1012} = \{ \text{1x LTF}_{\text{80MHz\_primary}}, \text{zeros}(1,23), \text{1x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-47)}$$

where $\text{1x LTF}_{\text{80MHz\_primary}} = \{\text{L-LTF}_{\text{80MHz\_1x}}, 0, \text{R-LTF}_{\text{80MHz\_1x}}\}$, $\text{1x LTF}_{\text{80MHz\_ secondary}} = \{\text{L-LTF}_{\text{80MHz\_1x}}, 0, (-1)*\text{R-LTF}_{\text{80MHz\_1x}}\}$.

In a 160 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-48).

$$HELTF_{-1012,1012} = \{ \text{2x LTF}_{\text{80MHz\_primary}}, \text{zeros}(1,23), \text{2x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-48)}$$

where

$$\text{2x LTF}_{\text{80MHz\_primary}} = \{ \{1^{st}\text{ 242-RU}\}, \{2^{nd}\text{ 242-RU}\}, \{\text{central 26-RU}\}, \{3^{rd}\text{ 242-RU}\}, \{4^{th}\text{ 242-RU}\} \quad \textbf{(26-49)}$$

$$\text{2x LTF}_{\text{80MHz\_secondary}} = \{ \{1^{st}\text{ 242-RU}\}, (-1)*\{2^{nd}\text{ 242-RU}\}, \{\text{central 26-RU}\}, \{3^{rd}\text{ 242-RU}\}, (-1)*\{4^{th}\text{ 242-RU}\} \} \quad \textbf{(26-50)}$$

In a 160 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-51).

$$HELTF_{-1012,1012} = \{ \text{4x LTF}_{\text{80MHz\_primary}}, \text{zeros}(1,23), \text{4x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-51)}$$

where

$$\text{4x LTF}_{\text{80MHz\_primary}} = \{\text{L-LTF}_{\text{80MHz\_4x}}, 0, \text{R-LTF}_{\text{80MHz\_4x}}\} \quad \textbf{(26-52)}$$

$$\text{4x LTF}_{\text{80MHz\_ secondary}} = \{\text{L-LTF}_{\text{80MHz\_4x}}, 0, (-1)*\text{R-LTF}_{\text{80MHz\_4x}}\} \quad \textbf{(26-53)}$$

For a noncontiguous 80+80 MHz transmission, the 1x HE-LTF sequence is given by Equation (26-54).

$$HELTF_{80+80MHz} = \{ \text{1x LTF}_{\text{80MHz\_primary}}, \text{1x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-54)}$$

For a noncontiguous 80+80 MHz transmission, the 2x HE-LTF sequence is given by Equation (26-55).

$$HELTF_{80+80MHz} = \{ \text{2x LTF}_{\text{80MHz\_primary}}, \text{2x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-55)}$$

For a noncontiguous 80+80 MHz transmission, the 4x HE-LTF sequence is given by Equation (26-56).

$$HELTF_{80+80MHz} = \{ \text{4x LTF}_{\text{80MHz\_primary}}, \text{4x LTF}_{\text{80MHz\_secondary}} \} \quad \textbf{(26-56)}$$

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 26-29 where A^k_{HELTF} is given by Equation (26-57).

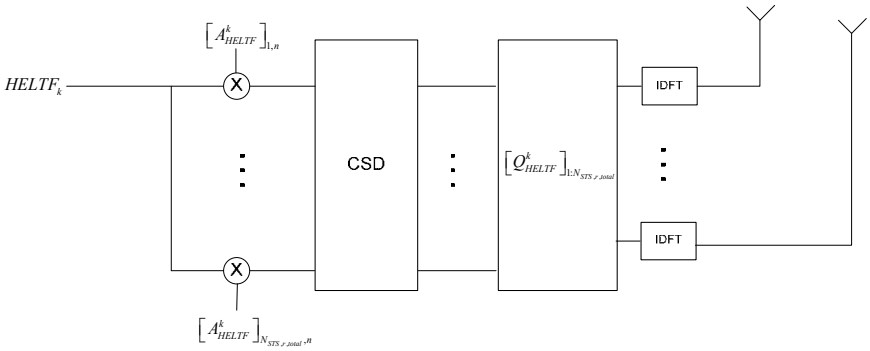


Figure 26-29 – Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots

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 26-30.

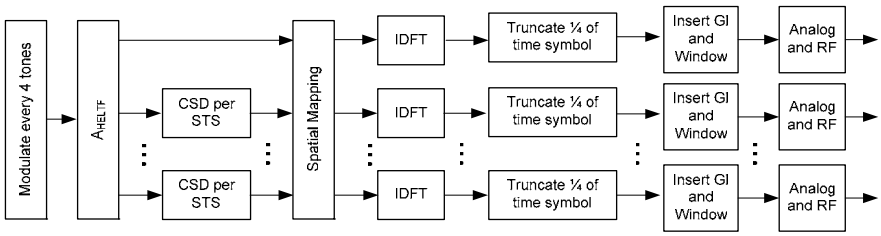


Figure 26-30 - Generation of 1x HE-LTF symbols per frequency segment

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 26-31.

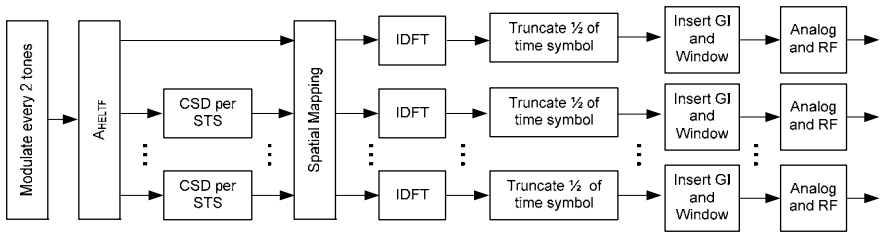


Figure 26-31 - Generation of 2x HE-LTF symbols per frequency segment

A^k_{HELTF} is given by Equation (26-57).

$$A^k_{HELTF} = \begin{cases} R_{HELTF}, \text{ if } k \in K_{\text{Pilot}} \\ P_{HELTF}, \text{ otherwise} \end{cases} \quad \textbf{(26-57)}$$

where K_{Pilot} is the set of subcarrier indices for the pilot tones as defined in 25.x (xx).

R_{HELTF} is a $N_{HELTF} \times N_{HELTF}$ matrix whose elements are defined in Equation (26-58).

$$\left[R_{HELTF}\right]_{m,n} = \left[P_{HELTF}\right]_{1,n}, \; 1 \le m,n \le N_{HELTF} \quad \textbf{(26-58)}$$

P_{HELTF} is defined in (26-59).

$$P_{HELTF} = \begin{cases} P_{4\times4}, N_{HELTF} \le 4 \\ P_{6\times6}, N_{HELTF} = 6 \\ P_{8\times8}, N_{HELTF} = 8 \end{cases} \quad \textbf{(26-59)}$$

where $P_{4\times4}$ is defined in Equation (20-17), $P_{6\times6}$ is defined in Equation (22-45), and $P_{8\times8}$ is defined in Equation (22-46).

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 (26-60).

$$r^{(i_{seg},i_{TX})}_{HE-LTF}(t) = \frac{\eta_{HE-LTF}\cdot\eta_{EXT}}{\sqrt{\sum_{r=1}^{N_{RU}}\alpha_r^2\left|K_r\right|}} \sum_{n=0}^{N_{HELTF}-1} w_{T_{HE-LTF}}\left(t - nT_{HE-LTF}\right) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}}$$
$$\cdot \sum_{k\in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{seg})}\right]_{i_{TX},(M_{r,u}+m)} \left[A^k_{HELTF}\right]_{(M_{r,u}+m),(n+1)} HELTF_k \\ \cdot\exp\left(j2\pi k\Delta_{F,HE}\left(t - nT_{HE-LTF} - T_{GI} - T_{CS,HE}\left(M_{r,u}+m\right)\right)\right) \end{array} \right) \quad \textbf{(26-60)}$$

Field Code Changed

where

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

η_{EXT} is an PPDU format dependent scaling factor, with the following value

$$\eta_{EXT} = \begin{cases} \sqrt{2}, & \text{HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

$N_{\text{HE-LTF}}^{\text{Tone}}$ has the value given in Table 25-xx (Tone scaling factor and guard interval duration values for PHY fields)

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in 25.xx (Transmission in HE format)

A_{HELTF}^k is defined in Equation (26-57)

K_r is the set of subcarrier indices for the tones in the *r*-th RU as defined in 25.x.

η_{HELTF} is the power scaling factor as defined in (25-xx)

$$\eta_{HE-LTF} = \begin{cases} 2 & \text{for 1x HE-LTF} \\ \sqrt{2} & \text{for 2x HE-LTF} \\ 1 & \text{for 4x HE-LTF} \end{cases}$$

26.3.10 Data field

26.3.10.1 General

The number of OFDM symbols in the Data field is determined by the Length field in L-SIG (see Equation (25-x)), the preamble duration and the setting of the CP+LTF Size field in HE-SIG-A (see 25.3.9.2.4.x HE-SIG-A definition). 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 section.

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.

26.3.10.1.1 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 torward 4 possible boundaries in the last one (in the case of non STBC), or two (in the case of STBC) OFDM symbols of a HE PPDU, the 4 possible boundaries participate 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*, called *a-factor*.

Figure 26-32 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 26-33, are modulated into the last two OFDM symbols by STBC encoding, each with the same number of effective symbol segments, *a-factor,* being 1.

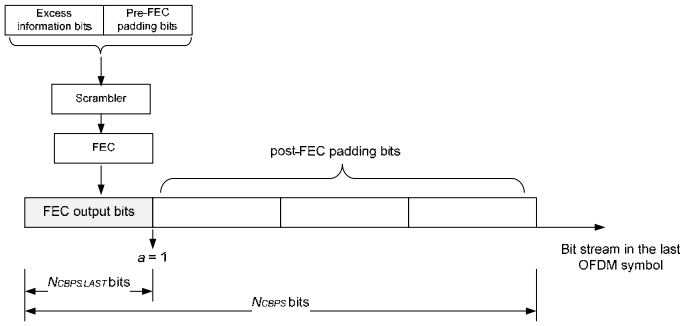


Figure 26-32 - HE PPDU padding process in the last OFDM symbol (non STBC) when *a* = 1

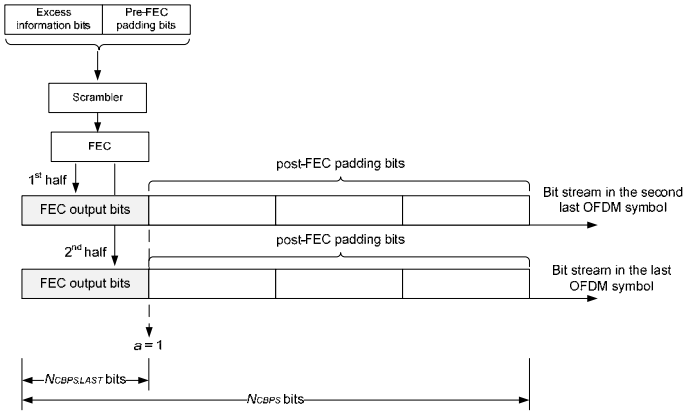


Figure 26-33 – HE PPDU padding process in the last OFDM symbol (STBC) when *a* = 1

The pre-FEC padding process is described in this subclause, and the encoding and post-FEC padding process are described in 26.3.10.3. 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 (26-61).

$$N_{\text{Excess}} = \text{mod}\left(8.\text{APEP\_LENGTH} + N_{Tail} + N_{service},\ m_{STBC}.N_{DBPS}\right) \quad \textbf{(26-61)}$$

where

m_{STBC} is 2 when STBC is used, and 1 otherwise;

APEP_LENGTH is the TXVECTOR parameter APEP_LENGTH.

For a HE SU PPDU with LDPC encoding, the number of excess bits is calculated based on Equation (26-62):

$$N_{\text{Excess}} = \text{mod}\left(8.\text{APEP\_LENGTH} + N_{service},\ m_{STBC}.N_{DBPS}\right) \quad \textbf{(26-62)}$$

Then based 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 (26-63):

$$a_{init} = \begin{cases} 4 & \text{if } N_{\text{EXCESS}} = 0 \\ \left\lceil \dfrac{N_{\text{Excess}}}{m_{STBC} \cdot N_{DBPS,SHORT}} \right\rceil & \text{otherwise} \end{cases} \quad \textbf{(26-63)}$$

where

$N_{DBPS.SHORT} = N_{CBPS.SHORT}.R$, in which R is the coding rate, and

$N_{CBPS.SHORT} = N_{SD.SHORT}.N_{SS}.N_{BPSCS}$;

The parameter $N_{SD.SHORT}$ values for different RU sizes are as shown in Table 26-22.

Table 26-22 - $N_{SD.SHORT}$ values

RU Size	$N_{SD.SHORT}$	
	DCM = 0	***DCM = 1***
26	6	2 (TBD)
52	12	6 (TBD)
106	24	12 (TBD)
242	60	30 (TBD)
484	120	60 (TBD)
996	240	120 (TBD)
996x2	492	246 (TBD)

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 (26-64):

$$N_{DBPS.LAST.init} = \begin{cases} a_{init}.N_{DBPS.SHORT}, & \text{if } a_{init} < 4 \\ N_{DBPS,} & \text{if } a_{init} = 4 \end{cases}$$
$$N_{CBPS.LAST.init} = \begin{cases} a_{init}.N_{CBPS.SHORT}, & \text{if } a_{init} < 4 \\ N_{CBPS,} & \text{if } a_{init} = 4 \end{cases} \quad \textbf{(26-64)}$$

For a HE SU PPDU with BCC encoding, the number of pre-FEC pad bits is calculated using Equation (26-65).

$$N_{PAD,PRE-FEC} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - 8.APEP\_LENGTH - N_{Tail} - N_{service} \quad \textbf{(26-65)}$$

where $N_{SYM.init}$ is defined as in Equation (26-68) for BCC encoding, and Equation (26-73) for LDPC encoding.

For a HE SU PPDU with LDPC encoding, the number of pre-FEC pad bits is calculated using Equation (26-66).

$$N_{PAD,PRE-FEC} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - 8.APEP\_LENGTH - N_{service} \quad \textbf{(26-66)}$$

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 (26-67).

$$N_{PAD,PRE-FEC,MAC} = \left\lfloor \frac{N_{PAD,PRE-FEC}}{8} \right\rfloor \cdot 8 \qquad \textbf{(26-67)}$$

$$N_{PAD,PRE-FEC,PHY} = N_{PAD,PRE-FEC} \bmod 8$$

26.3.10.2 SERVICE field

The SERVICE field of HE PPDU is as shown in Table 26-23.

Table 26-23 – SERVICE field

Bits	Field	Description
B0-B6	Scrambler Initialization	Set to 0
B7-B15	Reserved	Set to 0

26.3.10.3 Coding

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 26.3.10.3.1 or the low density parity check (LDPC) code defined in 25.3.10.3.2 (LDPC coding). 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 a HE MU PPDU, as defined in 26.3.9.7 and 26.3.9.8 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-RU, a 996-RU or a 996x2-RU. Support of BCC code is limited to less than or equal to four spatial streams (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-RU. 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, or for HE STAs declaring support for more than 4 spatial streams, according to HE capabilities field as defined in clause 8.4.2.1 (HE Capabilities Element). Otherwise, support of LDPC code for either transmit or receive is optional.

26.3.10.3.1 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 18.3.5.6 (Convolutional encoder). After encoding, the encoded data is punctured by the method defined in 18.3.5.6 (Convolutional encoder) (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 20.3.11.6 (Binary convolutional coding and puncturing).

The initial number of OFDM symbols in the Data field with BCC encoding in a HE SU PPDU is calculated as in Equation (26-68),

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8.APEP\_LENGTH + N_{Tail}.N_{ES} + N_{service}}{m_{STBC}.N_{DBPS}} \right\rceil \qquad \textbf{(26-68)}$$

For a HE SU PPDU with BCC encoding,

$$N_{SYM} = N_{SYM.init} \qquad \textbf{(26-69)}$$

and

$$a = a_{init} \tag{26-70}$$

The number of coded bits per symbol in the last OFDM symbol(s) of a HE SU PPDU is

$$N_{CBPS.LAST} = \begin{cases} a \cdot N_{CBPS.SHORT}, & \text{if } a < 4 \\ N_{CBPS,} & \text{if } a = 4 \end{cases} \tag{26-71}$$

26.3.10.3.2 LDPC coding

For a HE SU PPDU using LDPC coding to encode the Data field, the LDPC code and encoding process described in 20.3.11.7 (LDPC codes) 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 (26-72) instead of Equation (20-35).

$$N_{pld} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.LAST.init} \tag{26-72}$$

where

$N_{SYM.init}$ is given by Equation (26-73):

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8.APEP\_LENGTH + N_{service}}{m_{STBC}.N_{DBPS}} \right\rceil \tag{26-73}$$

Following the calculation of N_{pld}, N_{avbits} shall be computed using (26-74) instead of Equation (20-36).

$$N_{avbits} = (N_{SYM.init} - m_{STBC}).N_{CBPS} + m_{STBC}.N_{CBPS.LAST.init} \tag{26-74}$$

In addition, in step d) of LDPC encoding process as described in clause 20.3.11.7.5 (LDPC PPDU encoding process) , if the following condition is met:

$\left(\left(N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1-R)\right) \text{ AND } \left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1-R}\right)\right)$ is true OR if $\left(N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1-R)\right)$ 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 (26-75) instead of Equations (20-39), followed by recomputing N_{punc} as in Equation (20-40):

$$N_{avbits} = \begin{cases} N_{avbits} + m_{STBC}.\left(N_{CBPS} - 3.N_{CBPS.SHORT}\right), & \text{if } a_{init} = 3 \\ N_{avbits} + m_{STBC}.N_{CBPS.SHORT}, & \text{otherwise} \end{cases} \tag{26-75}$$

and then update a and N_{SYM} values by the following Equation (26-76):

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC}, \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init}, \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \tag{26-76}$$

If in step d) of LDPC encoding process as described in clause 20.3.11.7.5 (LDPC PPDU encoding process), the above mentioned condition is not met, then the LDPC Extra OFDM Symbol field of HE-SIG-A shall be set to 0, and:

$$a = a_{init},\ N_{SYM} = N_{SYM.init} \tag{26-77}$$

With the final *a-factor* value a, update the N_{CBPS} of the last symbol as:

$$N_{CBPS.LAST} = \begin{cases} a \cdot N_{CBPS.SHORT}, & \text{if } a < 4 \\ N_{CBPS,} & \text{if } a = 4 \end{cases} \tag{26-78}$$

LDPC codes used in HE MU PPDUs shall also follow the definitions in 20.3.11.7 (LDPC codes). 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.

26.3.10.3.3 Post-FEC padding

The number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed by:

$$N_{PAD,POST-FEC} = N_{CBPS} - N_{CBPS.LAST} \tag{26-79}$$

$N_{PAD.POST\text{-}FEC}$ bits with arbitrary 0 or 1 values (TBD) are appended after the FEC output bits in each of the last m_{STBC}OFDM symbols.

26.3.10.3.4 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 (26-63), and the initial number of OFDM symbols ($N_{init,u}$) for each user u using Equation (26-68) if user u is BCC encoded, or Equation (26-73) if user u is LDPC encoded. Among all the users, derive the user index with the longest encoded packet duration, as in Equation (26-80):

$$u_{\max} = \arg\max_{u=0}^{N_U-1}(N_{SYM.init.u} - m_{STBC} + 0.25.m_{STBC}.a_{init.u}) \tag{26-80}$$

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 (26-81):

$$N_{SYM.init} = N_{SYM.init.u_{\max}} \tag{26-81}$$
$$a_{init} = a_{init.u_{\max}}$$

Update each user's initial number of coded bits in its last symbol as below:

$$N_{DBPS.LAST.init.u} = \begin{cases} a_{init}.N_{DBPS.SHORT.u}, & \text{if } a_{init} < 4 \\ N_{DBPS.u,} & \text{if } a_{init} = 4 \end{cases} \tag{26-82}$$
$$N_{CBPS.LAST.init.u} = \begin{cases} a_{init}.N_{CBPS.SHORT.u}, & \text{if } a_{init} < 4 \\ N_{CBPS.u,} & \text{if } a_{init} = 4 \end{cases}$$

For each user with LDPC encoding, the number of pre-FEC padding bits is computed as in Equation (26-83):

$$N_{PAD,PRE-FEC,u} = (N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.init.u} - 8APEP\_LENGTH_u - N_{service} \quad \textbf{(26-83)}$$

For each user with LDPC encoding, the parameters $N_{pld,u}$ and $N_{avbits,u}$ are computed using Equations (26-84) and (26-85) respectively:

$$N_{pld,u} = (N_{SYM.init} - m_{STBC}).N_{DBPS,u} + m_{STBC}.N_{DBPS.LAST.init,u} \quad \textbf{(26-84)}$$

$$N_{avbits,u} = (N_{SYM.init} - m_{STBC}).N_{CBPS,u} + m_{STBC}.N_{CBPS.LAST.init,u} \quad \textbf{(26-85)}$$

Each user with LDPC encoding continue LDPC encoding process as in clause 20.3.11.7.5 (LDPC PPDU encoding process) starting with the parameters $N_{pld,u}$ and $N_{avbits,u}$. If there is at least one user with LDPC encoding, where step d) of its LDPC encoding process of clause 20.3.11.7.5 (LDPC PPDU encoding process), meets the following condition:

$\left(\left(N_{punc,u} > 0.1 \times N_{CW,u} \times L_{LDPC,u} \times (1-R_u)\right) \text{ AND } \left(N_{shrt,u} < 1.2 \times N_{punc,u} \times \frac{R_u}{1-R_u}\right)\right)$ is true OR if $\left(N_{punc,u} > 0.3 \times N_{CW,u} \times L_{LDPC,u} \times (1-R_u)\right)$ is true, where $N_{punc,u}$, $N_{CW,u}$, $L_{LDPC,u}$, $N_{shrt,u}$ are the LDPC encoding paraters for user u, as defined in 20.3.11.7.5 (LDPC PPDU encoding process), 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 *Navbits* and recomputed *Npunc*, by the following two equations once:

$$N_{avbits,u} = \begin{cases} N_{avbits,u} + m_{STBC}.\left(N_{CBPS,u} - 3.N_{CBPS.SHORT,u}\right), & \text{if } a_{init} = 3 \\ N_{avbits,u} + m_{STBC}.N_{CBPS.SHORT,u}, & \text{otherwise} \end{cases} \quad \textbf{(26-86)}$$

$$N_{punc,u} = \max\left(0,\ (N_{CW,u} \times L_{LDPC,u}) - N_{avbits,u} - N_{shrt,u}\right) \quad \textbf{(26-87)}$$

Update the common *a-factor* and *NSYM* values for all users by the following equation:

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC}, \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init}, \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \quad \textbf{(26-88)}$$

Note that users with BCC encoding shall also use the common N_{SYM} and a parameters as in Equation (26-76).

If among all the users with LDPC encoding, in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), 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:

$$a = a_{init},\ N_{SYM} = N_{SYM.init} \quad \textbf{(26-89)}$$

Update the *NCBPS* and *NDBPS* of the last symbol for each user as:

$$N_{DBPS.LAST.u} = \begin{cases} a.N_{DBPS.SHORT.u}, & \text{if } a < 4 \\ N_{CBPS.u,} & \text{if } a = 4 \end{cases}$$
$$N_{CBPS.LAST.u} = \begin{cases} a.N_{CBPS.SHORT.u}, & \text{if } a < 4 \\ N_{CBPS.u,} & \text{if } a = 4 \end{cases} \quad \textbf{(26-90)}$$

For the users with BCC encoding, the number of pre-FEC padding bits is shown in Equation (26-91).

$$N_{PAD,PRE-FEC,u} = (N_{SYM} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.u} - 8APEP\_LENGTH_u - N_{Tail} - N_{service} \quad \textbf{(26-91)}$$

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 (26-92):

$$N_{PAD,POST-FEC,u} = m_{STBC}.(N_{CBPS,u} - N_{CBPS.LAST,u}) \quad \textbf{(26-92)}$$

26.3.10.3.5 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 clause 25.3.10.1.1 (pre-FEC padding process), clause 25.3.10.3.1 (Binary convolutional coding and puncturing), and 25.3.10.3.3 (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 26.3.10.1.1 (pre-FEC encoding process), 26.3.10.3.2 (LDPC coding), and 26.3.10.3.3 (Post-FEC padding), with the following exceptions:

When the Trigger frame indicates LDPC Extra Symbol = 1, set the initial parameters following Equation (26-93):

$$\begin{cases} a_{init} = 4,\ N_{SYM.init} = N_{SYM} - m_{STBC}, & \text{if } a = 1 \\ a_{init} = a - 1,\ N_{SYM.init} = N_{SYM}, & \text{otherwise} \end{cases} \quad \textbf{(26-93)}$$

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 clause 20.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), always increment *Navbits* as in Equation (26-75), and always recompute N_{punc} as in Equation (20-40), followed by updating *a = ainit + 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 clause 20.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), *Navbits* and N_{punc} are not changed, and $a = a_{init}$.

26.3.10.4 Stream parser

After coding, 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 a HE MU transmission). This operation is referred to as "stream parsing" and is described in this section.

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 (26-94).

$$s = \max\left\{1, \frac{N_{BPSCS}}{2}\right\} \quad \textbf{(26-94)}$$

The sum of these over all streams is $S = N_{SS}.s$.

Consecutive blocks of s bits are assigned to different spatial streams in a round robin fashion.

Let

$$N_{\text{Block}} = \left\lfloor \frac{N_{CBPS}}{S} \right\rfloor \quad \textbf{(26-95)}$$

For the $N_{\text{Block}}.S$ 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 in all the different RU sizes, $N_{CBPS} = N_{\text{Block}}.S$, therefore the coded bits of each OFDM symbol are always evenly allocated to Nss spatial streams.

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

$$i = (i_{SS} - 1)s + S \cdot \left\lfloor \frac{k}{s} \right\rfloor + k \bmod s, \quad k = 0,1,\ldots,N_{Block} \cdot s - 1$$

where

$$i_{SS} = 1,\ 2,\ \ldots,\ N_{SS}$$
$$i = 0,\ 1,\ \ldots,\ N_{CBPS} - 1$$
$$k = 0,\ 1,\ \ldots,\ N_{CBPS} - 1$$

26.3.10.5 Segment parser

For a 160 MHz and 80+80 MHz HE SU PPDU, a 160 MHz and 80+80 MHz HE MU PPDU, and a HE trigger-based PPDU with the RU spanning the entire PPDU bandwidth, the output bits of each stream parser are segment parsed as specified in 22.3.10.7.

26.3.10.6 BCC interleavers

There is some duplication here. I think we need to delete the Table 25-24 and its reference sentence.

The BCC interleaver parameters are defined in Table 26-24.

Table 26-24 - BCC interleaver and LDPC tone mapper parameters

RU size (tones)	BCC		LDPC
	N_{col}	N_{rot}	D_{TM}
26	8	2	1
52	16	11	3
106	17	29	6
242	26	58	9
484	-	-	12
996	-	-	20

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 22.3.10.8 (BCC interleaver). The values of the interleaver parameters, N_{COL}, N_{ROW}, and N_{ROT} are selected based on the RU size of the user, and are given in Table 26-25.

Table 26-25 - BCC interleaver parameters

Parameter	RU Size (tones)			
	26	52	106	242
N_{COL}	8	16	17	26
N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$6 \times N_{BPSCS}$	$9 \times N_{BPSCS}$
N_{ROT} ($N_{SS} \leq 4$)	2	11	29	58

26.3.10.7 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 22.3.10.9 (constellation mapping).

1024-QAM is used as an optional feature for SU and MU using resource units equal to or larger than 242 tones in 11ax. For 1024-QAM, the constellation mapping is TBD.

Dual sub-carrier modulation (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.

When DCM is employed, bit sequences are mapped to a pair symbols $(d_k, d_{q(k)})$ where k is in the range of $0 \leq k \leq \frac{N_{SD}}{2} - 1$ and $q(k)$ is in the range of $\frac{N_{SD}}{2} \leq k \leq N_{SD} - 1$ in order to exploit frequency diversity.

To maximize the frequency diversity, the indices of a pair of DCM subcarriers $(k, q(k))$ is $q(k) = k + \frac{N_{SD}}{2}$.

For QPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} *or* $N_{CBPS,ru}$ bits $(B_0, B_1, \cdots, B_{N_{CBPS,ru}-1})$. 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 sub-carriers in the RU, $d_{q(k)} = conj(d_k)$.

For BPSK and 16-QAM modulation with DCM, the constellation mapping is TBD.

26.3.10.8 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 clause 22.3.10.9.4 (Space-time block coding), with $N_{SS,0} = 1$ and $N_{STS,0} = 2$.

26.3.10.9 LDPC tone mapper

The LDPC tone mapper parameters are defined in Table 26-24.

The LDPC tone mapping shall be performed on all LDPC encoded streams mapped in a RU as described in this subclause. LDPC tone mapping shall not be performed on streams that are encoded using BCC. When DCM is applied to LDPC encoded streams, D_{TM_DCM} shall be applied on both the lower half data subcarriers in a RU and the upper half data subcarriers of the RU. The LDPC tone-mapping distance parameter 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.

Table 26-26 – LDPC tone mapping distance for each RU size

Parameter	RU Size (tones)						
	26	52	106	242	484	996	2x996
D_{TM}	1	3	6	9	12	20	20
D_{TM_DCM}	1	1	3	9	9	14	20

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 26.3.10.7) to

$$\begin{aligned} d''_{t(k),i,n,l,r,u} = d'_{k,i,n,l,r,u};\ & k = 0,1,\ldots,N_{SD}-1 \text{ for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ & k = 0,1,\ldots,\frac{N_{SD}}{2}-1 \text{ for a RU of } 996\times 2 \text{ tones} \\ & i = 1,\ldots,N_{SS,r,u} \\ & n = 0,1,\ldots,N_{SYM}-1 \\ & l = 0 \text{ for a RU of 26, 52, 106, 242, 494, and 996 tones} \\ & l = 0,1 \text{ for a RU of } 996\times 2 \text{ tones} \\ & u = 0,\ldots,N_{user,r}-1 \\ & r = 0,\ldots,N_{RU}-1 \end{aligned} \quad \textbf{(26-96)}$$

where N_{SD} is the number of data tones in the r-th RU.

$$t(k) = \begin{cases} D_{TM}\left(k \bmod \frac{N_{SD}}{D_{TM}}\right) + \left\lfloor \frac{k \cdot D_{TM}}{N_{SD}} \right\rfloor, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM}\left(k \bmod \frac{N_{SD}/2}{D_{TM}}\right) + \left\lfloor \frac{k \cdot D_{TM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of } 996\times 2 \text{ tones} \end{cases} \quad \textbf{(26-97)}$$

For a 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

$$d''_{t(k),i,n,l,r,u} = \begin{cases} d'_{k,i,n,l,r,u}; \\ d'_{k',i,n,l,r,u}; \end{cases} \quad \textbf{(26-98)}$$

where

$$k = 0,1,...,\frac{N_{SD}}{2} - 1$$

$$k' = k - \frac{N_{SD}}{2}, for\, k = \frac{N_{SD}}{2}, \frac{N_{SD}}{2} + 1,..., N_{SD}\text{-}1$$

$$i = 1,\ldots, N_{SS,r,u}$$

$$n = 0,1,\ldots, N_{SYM} - 1$$

$l = 0$ for a RU of 26, 52, 106, 242, 494, and 996 tones

$l = 0,1$ for a RU of 996×2 tones

$$u = 0,\ldots, N_{user,r} - 1$$

$$r = 0,\ldots, N_{RU} - 1$$

N_{SD} is the number of data tones in the r-th RU and

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM\_DCM}\left(k' \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k' \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor + \frac{N_{SD}}{2}, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM\_DCM}\left(k \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of } 996 \times 2 \text{ tones} \end{cases} \quad \textbf{(26-99)}$$

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 segement. LDPC tone mapping is performed separately for the upper and lower 80 MHz frequency segments of a 2x996-tone RU as indicated by the frequency subblock index l in Error! Reference source not found. and Error! Reference source not found.

Since LDPC tone apping is not performed on BCC-coded streams, for BCC-coded streams, the following applies:

$$\begin{aligned} d''_{k,i,n,l,r,u} = d'_{k,i,n,l,r,u};\ & k = 0,1,...,N_{SD} - 1 \text{ for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ & k = 0,1,...,\frac{N_{SD}}{2} - 1 \text{ for a RU of } 996 \times 2 \text{ to}nes \\ & i = 1,\ldots, N_{SS,r,u} \\ & n = 0,1,\ldots, N_{SYM} - 1 \\ & l = 0 \text{ for a RU of 26, 52, 106, 242, 494, and 996 tones} \\ & l = 0,1 \text{ for a RU of } 996 \times 2 \text{ tones} \\ & u = 0,\ldots, N_{user,r} - 1 \\ & r = 0,\ldots, N_{RU} - 1 \end{aligned} \quad \textbf{(26-100)}$$

26.3.10.10 Segment deparser

In a transmission over a RU of 26, 52, 106, 242, 484 and 996 subcarriers, the segment deparsing is not performed (see Equation (22-90)).

For a 160 MHz HE SU PPDU, or a 160 MHz HE MU PPDU or HE trigger-based PPDU with the RU spanning the entire PPDU bandwidth, the two frequency subblocks at the output of the LDPC tone mapper are combined into one frequency segment as specified in Equation (22-89).

In an 80+80 MHz HE PPDU transmission, the segment deparsing is not performed (see Equation (22-91)).

26.3.10.11 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 *i*-th pilot index set in the row of given PPDU BW of Table 26-27.

Table 26-27 - Pilot indices for 26-tone RU transmission

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 $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-101).

$$P_n^{K_{R26_i}} = \{\Psi_{i,n \bmod 2}, \Psi_{i,(n+1) \bmod 2}\} \qquad \textbf{(26-101)}$$
$$P_n^{k \notin K_{R26_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 26-tone RU in a given PPDU BW.

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 *i*-th pilot index set in the row of given PPDU BW of Table 26-28.

Table 26-28 - Pilot indices for 52-tone RU transmission

PPDU 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 $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-102).

$$P_n^{K_{R52_i}} = \{\Psi_{i,n \bmod 4}, \Psi_{i,(n+1) \bmod 4}, \Psi_{i,(n+2) \bmod 4}, \Psi_{i,(n+3) \bmod 4}\} \qquad \textbf{(26-102)}$$
$$P_n^{k \notin K_{R52_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 52-tone RU in a given PPDU BW.

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 *i*-th pilot index set in the row of given PPDU BW of Table 26-29.

Table 26-29 - Pilot indices for 106-tone RU transmission

PPDU 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 80MHz -512, pilot tone indices in 80MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-103).

$$P_n^{K_{\mathrm{R106}_i}} = \{\Psi_{i,n \bmod 4}, \Psi_{i,(n+1) \bmod 4}, \Psi_{i,(n+2) \bmod 4}, \Psi_{i,(n+3) \bmod 4}\}\} \quad \textbf{(26-103)}$$
$$P_n^{k \notin K_{\mathrm{R106}_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for i-th 106-tone RU in a given PPDU BW.

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 i-th pilot index set in the row of given PPDU BW of Table 26-30.

Table 26-30 - Pilot indices for 242-tone RU transmission

PPDU BW	K_{R242_i}
20 MHz, i=1	-116/-90/-48/-22/22/48/90/116
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 $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-104).

$$P_n^{K_{\mathrm{R242}_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}\} \quad \textbf{(26-104)}$$
$$P_n^{k \notin K_{\mathrm{R242}_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for i-th 242-tone RU in a given PPDU BW.

For 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 i-th pilot index set in the row of given PPDU BW of Table 26-31.

Table 26-31 - Pilot indices for 484-tone RU transmission

PPDU BW	K_{R484_i}
20 MHz	N/A
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 $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-105).

$$P_n^{K_{R484_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\} \quad \textbf{(26-105)}$$
$$P_n^{k \notin K_{R484_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 484-tone RU in a given PPDU BW.

For 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 *i*-th pilot index set in the row of given PPDU BW of Table 26-32.

Table 26-32 - Pilot indices for 996-tone RU transmission

PPDU BW	K_{R996_i}
20 MHz	N/A
40 MHz	N/A
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	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}: -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 $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-106).

$$P_n^{K_{R996_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\} \quad \textbf{(26-106)}$$
$$P_n^{k \notin K_{R996_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for 996-tone RU in 80 MHz PPDU BW.

For a 160 MHz transmission, the 80 MHz 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 $k \in K_{R2x996}$, where $K_{R2\times996}$ 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 $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-107) .

$$P_n^{K_{R2x996}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}, \cdots$$
$$\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\} \quad \textbf{(26-107)}$$
$$P_n^{k \notin K_{R2x996}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for 996-tone RU in 80 MHz PPDU BW.

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 (26-106) 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.

26.3.10.12 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 (26-108).

$$r_{\text{HE-Data}}^{(i_{seg},i_{TX})}(t) = \frac{1}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{HE-Data}}(t - nT_{SYM}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{seg})} \right]_{i_{TX},(M_{r,u}+m)} \left(\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+2+N_{HE-SIG-A}+N_{HE-SIG-B}} P_n^k \right) \\ \cdot \exp\left(j2\pi k \Delta_{F,HE} \left(t - nT_{SYM} - T_{\text{GI,Data}} - T_{CS,HE}(M_{r,u}+m) \right) \right) \end{array} \right) \quad \textbf{(26-108)}$$

where

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in **Error! Reference source not found.**

$\tilde{D}_{k,m,n,BW}^{(i_{Seg},r,u)}$ 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 in **Error! Reference source not found.**.

$N_{\text{HE-Data}}^{\text{Tone}}$ has the value given in **Error! Reference source not found.**

$T_{CS,HE}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$T_{\text{GI, Data}}$ is the guard interval duration as defined in Table 25-xxx (Timing related constants) of 25.3.6 (Timing related parameters).

$$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} = \begin{cases} 0, k \in K_{\text{Pilot}} \\ \tilde{d}_{M_r(k),m,n,r,u}^{(i_{Seg})}, \text{otherwise} \end{cases} \quad \textbf{(26-109)}$$

where

K_{Pilot} is the set of subcarrier indices of pilot tones, as defined in 25.3.7.3 (Pilot tones).

$M_r(k)$ is defined in Equation (26-110).

$$M_r(k) = k - K_{r,\min} - \left| \left\{ k' : K_{r,\min} \le k' < k \right\} \cap K_{\text{Pilot}} \right| \quad \textbf{(26-110)}$$

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 a RU ($0 \le M_r(k) \le N_{SD,r}$). 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 (26-111).

$$r_{\text{HE-Data}}^{(i_{seg},i_{TX})}(t) = \frac{\alpha_r}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{HE-Data}}(t - nT_{SYM}) \frac{1}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{seg})} \right]_{i_{TX},(M_{r,u}+m)} \left(\tilde{D}_{k,m,n,r}^{(i_{seg},u)} + p_{n+4} P_n^k \right) \\ \cdot \exp\left(j2\pi k \Delta_{F,HE} \left(t - nT_{SYM} - T_{\text{GI,Data}} - T_{CS,HE}(M_{r,u}+m) \right) \right) \end{array} \right) \quad \textbf{(26-111)}$$

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 $Q_k^{(i_{seg})}$.

26.3.10.13 Dual carrier modulation

Dual sub-carrier modulation (DCM) 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 25.3.10.6. The DCM tone mapper is TBD.

26.3.10.14 Packet extension

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 a 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 (8.4.2.1 (HE Capabilities Element)).

For a 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 25.3.10.9-1 (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 25.3.10.9-2 (PE field when maximum PE duration is 16 µs (non STBC)).

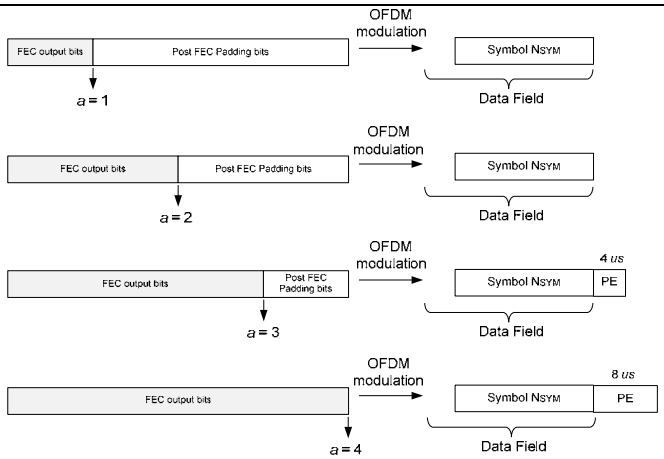


Figure 26-34 - PE field when maximum PE duration is 8 µs (non STBC)

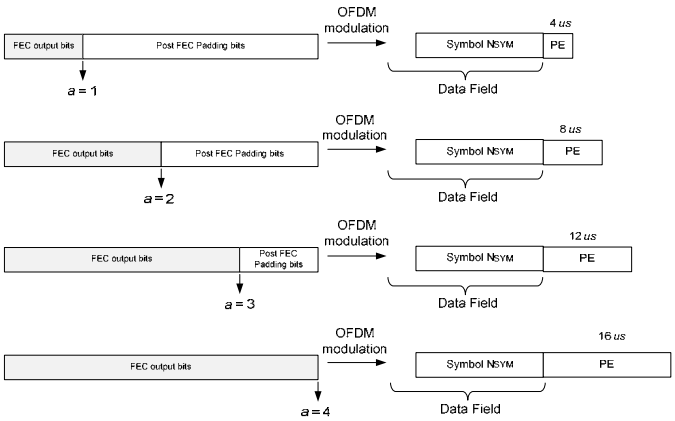


Figure 26-35 - PE field when maximum PE duration is 16 µs (non STBC)

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 26.3.10.3.4, 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:

$$T_{PE} = \max_{u}\left(T_{PE,u}\right) \quad \textbf{(26-112)}$$

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 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 T_{PE} is TBD.

Should the HE-SIG-A bits definition below be moved into 25.3.9.2.4 (HE-SIG-A)?

The 3-bit Packet Extension field in HE-SIG-A are defined as in Table 26-33.

Table 26-33 - 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

The a-factor subfield of the Packet Extension field is encoded as shown in Table 26-34.

Table 26-34 - a-factor subfield encoding

a-factor value	a-factor subfield encoding
1	b01
2	b10
3	b11
4	b00

The PE Disabmbituity 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.

$$T_{PE} + 4 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil - \left(\frac{TXTIME - 20}{4} \right) \right) \geq T_{SYM} \quad \textbf{(26-113)}$$

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.

Based on PE disambiguity field and a-factor field, the recipient shall compute N_{SYM} and T_{PE} listed in 26.3.15.

26.3.11 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 18.3.4 (SIGNAL field).

In a 40 MHz non-HT duplicate transmission, the Data field shall be as defined by Equation (20-61).

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.**.

26.3.12 MU-MIMO

26.3.12.1 Introduction

DL MU MIMO is specified in 22.3.11 for full band transmission. In this amendment, MU-MIMO is also applicable on a subset of active RUs within PPDU bandwidth in both DL and UL. The non-AP STAs in the

same MU-MIMO group are allocated the same resource unit. The combination of SU-MIMO and MU-MIMO on different RU for different non-AP STA in one PPDU is supported.

26.3.12.2 Minimum RU size in MU MIMO transmission

Both DL and UL MU MIMO shall transmit on the RU of at least 106 tones.

26.3.12.3 DL MU-MIMO

26.3.12.3.1 Introduction

For 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, $\boldsymbol{y}_{k,u} = \left[y_{k,0}, y_{k,1}, \cdots, y_{k,N_{RX_u}-1}\right]^T$, is shown in Equation (26-114), where $\boldsymbol{x}_k = \left[\boldsymbol{x}_{k,0}^T, \boldsymbol{x}_{k,1}^T, \cdots, \boldsymbol{x}_{k,N_{user,r}-1}^T\right]^T$ denotes the transmit signal vector in subcarrier k for all N_{user} beamformees, with $\boldsymbol{x}_{k,u} = \left[x_{k,0}, x_{k,1}, \cdots, x_{k,N_{STS,r,u}-1}\right]^T$ being the transmit signal for beamformee u.

$$\boldsymbol{y}_{k,u} = \boldsymbol{H}_{k,u} \times \left[Q_{k,0}, Q_{k,1}, \cdots, Q_{k,N_{user}-1}\right] \times \boldsymbol{x}_k + \boldsymbol{n} \quad \textbf{(26-114)}$$

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 $N_{TX} \times N_{STS,r,u}$

$N_{user,r}$ is the number of HE MU PPDU recipients in RU r (see Table 26-6)

$\boldsymbol{n}$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q_k = \left[Q_{k,0}, Q_{k,1}, \cdots, Q_{k,N_{user,r}-1}\right]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\cdots,N_{user,r} - 1$. The feedback report format is TBD. 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. The beamformee group for the DL MU transmission is signaled in HE-SIG-B (see 26.3.9.8.3 and 26.3.12.3.4).

26.3.12.3.2 Beamforming feedback

TBD

26.3.12.3.3 Maximum number of total spatial streams in a VHT MU PPDU

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.

26.3.12.3.4 Resource indication and STA self identification

AP shall transmit HE MU PPDU. The UL/DL field in the HE-SIG-A shall be set TBD (for DL). 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 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 26-18. If the value of SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B common field. The number of STAs in the

MU MIMO group is indicated in the TBD field in HE-SIG-A. the number of spatial streams $N_{ss,r,u}$ is indicated by NSTS field in user specific block as defined in Table 26-19 and Table 26-20.The allocated spatial streams for a designated MU MIMO 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 STA as defined in Table 26-21.

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,…, $N_{users,u}$, could be 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 HE DL 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.

26.3.12.4 UL MU-MIMO

26.3.12.4.1 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 at multiple transmitters.

For UL MU-MIMO transmissions, support for both single stream pilots and the masking the LTF sequence of each spatial stream by a distinct orthogonal code is mandatory at the transmitter side (non-AP STA).

26.3.12.4.2 Resource Indication and STA Self Identification

UL MU-MIMO transmissions are preceded by a Trigger frame from the AP. Similar as UL OFDMA cases, the Trigger frame indicates the transmitting STAs in the common part about when to transmit the UL MU-MIMO PPDUs, the duration of the payload, and packet-extension. The CP length for UL OFDMA/MU-MIMO transmissions shall also be explicitly indicated by AP in the Trigger frame. The value of CP length for all users addressed by the Trigger frame shall be the same. The Trigger frame shall use 1 bit to indicate whether the UL MU-MIMO 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. The allocated RU and spatial streams are carried in the fields of RU allocation info and SS allocation of Per User Info field, where Address field is set as the AID of designated MU MIMO STA. Details TBD.

If a STA finds that there is no Per User Info 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.

26.3.12.4.3 Pre-corrections in UL MU-MIMO

Since multiple transmitters take part in an UL MU-MIMO transmission, it requires time, frequency, sampling 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 done through power control described in **Error! Reference source not found.**. The Trigger frame serves as a reference DL frame for the STAs to do the aforementioned pre-corrections to the UL PPDUs. The accuracy requirements on these pre-corrections are specified in section x.x.x.

26.3.12.4.4 Power control in UL MU-MIMO

TBD

26.3.12.4.5 Maximum number of spatial streams in UL MU-MIMO PPDUs

An UL MU-MIMO capable STA shall support transmission of UL MU PPDUs with the number of space-time streams being less than or equal to its UL MU-MIMO STS Capability in HE Capabilities.

26.3.12.4.6 Requirements for STAs transmitting HE trigger-based PPDUs

A STA that transmits an HE trigger-based PPDU shall support per chain max(P-32, -10 dBm) as the minimum transmit power, with P the maximum power the STA can transmit at the antenna connector of that chain using MCS0 while meeting the TX EVM and spectral mask requirements. A STA transmitting at and above the minimum power shall support the EVM requirements for MCS7 (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 26-35.

Table 26-35 - Transmit power and RSSI measurement accuracy

Parameter	Minimum Requirement		Comments
	Class A	Class B	
Absolute transmit power accuracy	±3 dB	±9 dB	Accuracy of achieving a specified transmit power
RSSI measurement accuracy	±2 dB	±5 dB	Difference between the actual RSSI and the measured RSSI Requirements are valid from minimum Rx to maximum Rx input power

A STA that transmits an HE trigger-based PPDU shall pre-compensate for carrier frequency offset (CFO) error and timing drift. 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 20MHz. The residual CFO error measurement shall be made on the HE trigger-based PPDU following the HE-SIG-A field.

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.

26.3.13 Transmit specification

26.3.13.1 Transmit spectral mask

26.3.13.2 Spectral flatness

26.3.13.3 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.

26.3.13.4 Modulation accuracy

26.3.13.4.1 Introduction to modulation accuracy tests

26.3.13.4.2 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.

26.3.13.4.3 Transmitter constellation error

26.3.14 HE transmit procedure

TBD

26.3.15 HE receive procedure

TBD

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 a HE PPDU using Equation (26-115) for an HE SU PPDU and HE trigger-based PPDU, Equation (26-116) for an HE MU PPDU and Equation (26-117) for an HE extended range SU PPDU.

$$\text{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + T_{HE\_PREAMBLE} + N_{SYM}T_{SYM} + T_{PE} \quad \textbf{(26-115)}$$

$$\text{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + N_{HE-SIG-B}T_{HE-SIG-B} + T_{HE\_PREAMBLE} + N_{SYM}T_{SYM} + T_{PE} \quad \textbf{(26-116)}$$

$$\text{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + T_{HE-SIG-A-R} + T_{HE\_PREAMBLE} + N_{SYM}T_{SYM} + T_{PE} \quad \textbf{(26-117)}$$

where

$T_{\text{LEG\_PREAMBLE}} = T_{\text{L-STF}} + T_{\text{L-LTF}}$

$$T_{\text{HE\_PREAMBLE}} = \begin{cases} T_{\text{HE-STF}-T} + N_{HELTF} T_{\text{HE-LTF,SYM}}, & \text{for the HE\_TRIG} \\ T_{\text{HE-STF}-NT} + N_{HELTF} T_{\text{HE-LTF,SYM}}, & \text{Otherwise} \end{cases}$$

$T_{\text{L-STF}}$, $T_{\text{L-LTF}}$, $T_{\text{HE-STF}-T}$, $T_{\text{HE-STF}-NT}$, $T_{\text{HE-LTF,SYM}}$, $T_{\text{L-SIG}}$, $T_{\text{RL-SIG}}$, $T_{\text{HE-SIG-A}}$, $T_{\text{HE-SIG-A-R}}$, $T_{\text{HE-SIG-B}}$ and T_{SYM} are defined in Table 26-3 (Timing-related constants)

$N_{HE-SIG-B}$ and N_{HE-LTF} are defined in Table 26-6 (Frequently used parameters)

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 (26-118).

$$N_{SYM} = m_{\text{STBC}} \times \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{service} + N_{tail} \cdot N_{ES}}{m_{\text{STBC}} \cdot N_{DBPS}} \right\rceil \quad \textbf{(26-118)}$$

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 26.3.10.3.2 (LDPC coding).

For an HE MU PPDU (including both MU-MIMO and OFDMA), the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.10.3.4 (Encoding process for an HE MU PPDU).

For an HE trigger-based PPDU, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.10.3.5 (Encoding process for an HE trigger-based PPDU).

T_{PE} is given by Equation (26-112).

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 (26-119).

$$\text{PSDU\_LENGTH} = \begin{cases} \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - N_{service} - N_{tail} \cdot N_{ES}}{8} \right\rfloor & \text{for BCC encoding} \\ \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - N_{service}}{8} \right\rfloor & \text{for LDPC encoding} \end{cases} \quad \textbf{(26-119)}$$

where

$N_{SYM.init}$ is given by Equation (26-68) for BCC encoding and by Equation (26-73) 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 (26-64)

The value of the PSDU_LENGTH parameter for user *u* returned in the PLME-TXTIME.confirm primitive and in the RXVECTOR for a HE MU PPDU is calculated using Equation (26-120).

$$\text{PSDU\_LENGTH}_u = \begin{cases} \left\lfloor \dfrac{(N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.u} - N_{service} - N_{tail} \cdot N_{ES}}{8} \right\rfloor & \text{when BCC is used for user } u \\ \left\lfloor \dfrac{(N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.init.u} - N_{service}}{8} \right\rfloor & \text{when LDPC is used for user } u \end{cases} \quad \textbf{(26-120)}$$

where

$N_{SYM.init}$ is given by Equation (26-81)

$N_{DBPS.Last.init}$ is given by Equation (26-82)

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE NDP PPDU is 0.

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 26-36. The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 26-36 - HE PHY characteristics

Characteristics	Value
aTxPHYDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aCCAMidTime	25 µs
aPPDUMaxTime	5.484 ms
aPSDUMaxLength	TBD

26.5 Parameters for HE-MCSs

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 26-85 through Table 26-92. 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. N_{ES} values were chosen to yield an integer number of punctured blocks for each BCC encoder per OFDM symbol.

Table 26-37 to Table 26-92 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.

In the tables below, the number of streams and RU sizes that DCM is applicable to are TBD.

Table 26-37 - HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 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	24	2	24	6	1	0.4	0.4	0.4
0	0		1/2	1			24	12	1	0.9	0.8	0.8
1	1	QPSK	1/4	2			48	12	1	0.9	0.8	0.8
1	0		1/2	2			48	24	1	1.8	1.7	1.5
2	N/A		3/4	2			48	36	1	2.6	2.5	2.3
3	1	16-QAM	1/4	4			96	24	1	1.8	1.7	1.5
3	0		1/2	4			96	48	1	3.5	3.3	3.0
4	1		3/8	4			96	36	1	2.6	2.5	2.3
4	0		3/4	4			96	72	1	5.3	5.0	4.5
5	N/A	64-QAM	2/3	6			144	96	1	7.1	6.7	6.0
6			3/4	6			144	108	1	7.9	7.5	6.8
7			5/6	6			144	120	1	8.8	8.3	7.5
8		256-QAM	3/4	8			192	144	1	10.6	10.0	9.0
9			5/6	8			192	160	1	11.8	11.1	10.0

Table 26-38 HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 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	24	2	48	12	1	0.9	0.8	0.8
0	0		1/2	1			48	24	1	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1	1.8	1.7	1.5
1	0		1/2	2			96	48	1	3.5	3.3	3.0
2	N/A		3/4	2			96	72	1	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	1	3.5	3.3	3.0
3	0		1/2	4			192	96	1	7.1	6.7	6.0
4	1		3/8	4			192	72	1	5.3	5.0	4.5
4	0		3/4	4			192	144	1	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	1	14.1	13.3	12.0
6			3/4	6			288	216	1	15.9	15.0	13.5
7			5/6	6			288	240	1	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	1	21.2	20.0	18.0
9			5/6	8			384	320	1	23.5	22.2	20.0

Table 26-39 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	72	18	1	1.3	1.3	1.1
0	0		1/2	1			72	36	1	2.6	2.5	2.3
1	1	QPSK	1/4	2			144	36	1	2.6	2.5	2.3
1	0		1/2	2			144	72	1	5.3	5.0	4.5
2	N/A		3/4	2			144	108	1	7.9	7.5	6.8
3	1	16-QAM	1/4	4			288	72	1	5.3	5.0	4.5
3	0		1/2	4			288	144	1	10.6	10.0	9.0
4	1		3/8	4			288	108	1	7.9	7.5	6.8
4	0		3/4	4			288	216	1	15.9	15.0	13.5
5	N/A	64-QAM	2/3	6			432	288	1	21.2	20.0	18.0
6			3/4	6			432	324	1	23.8	22.5	20.3
7			5/6	6			432	360	1	26.5	25.0	22.5
8		256-QAM	3/4	8			576	432	1	31.8	30.0	27.0
9			5/6	8			576	480	1	35.3	33.3	30.0

Table 26-40 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	96	24	1	1.8	1.7	1.5
0	0		1/2	1			96	48	1	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	1	3.5	3.3	3.0
1	0		1/2	2			192	96	1	7.1	6.7	6.0
2	N/A		3/4	2			192	144	1	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	1	7.1	6.7	6.0
3	0		1/2	4			384	192	1	14.1	13.3	12.0
4	1		3/8	4			384	144	1	10.6	10.0	9.0
4	0		3/4	4			384	288	1	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	1	28.2	26.7	24.0
6			3/4	6			576	432	1	31.8	30.0	27.0
7			5/6	6			576	480	1	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	1	42.4	40.0	36.0
9			5/6	8			768	640	1	47.1	44.4	40.0

Table 26-41 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	120	30	1	2.2	2.1	1.9
0	0		1/2	1			120	60	1	4.4	4.2	3.8
1	1	QPSK	1/4	2			240	60	1	4.4	4.2	3.8
1	0		1/2	2			240	120	1	8.8	8.3	7.5
2	N/A		3/4	2			240	180	1	13.2	12.5	11.3
3	1	16-QAM	1/4	4			480	120	1	8.8	8.3	7.5
3	0		1/2	4			480	240	1	17.6	16.7	15.0
4	1		3/8	4			480	180	1	13.2	12.5	11.3
4	0		3/4	4			480	360	1	26.5	25.0	22.5
5	N/A	64-QAM	2/3	6			720	480	1	35.3	33.3	30.0
6			3/4	6			720	540	1	39.7	37.5	33.8
7			5/6	6			720	600	1	44.1	41.7	37.5
8		256-QAM	3/4	8			960	720	1	52.9	50.0	45.0
9			5/6	8			960	800	1	58.8	55.6	50.0

Table 26-42 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	144	36	1	2.6	2.5	2.3
0	0		1/2	1			144	72	1	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	1	5.3	5.0	4.5
1	0		1/2	2			288	144	1	10.6	10.0	9.0
2	N/A		3/4	2			288	216	1	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	1	10.6	10.0	9.0
3	0		1/2	4			576	288	1	21.2	20.0	18.0
4	1		3/8	4			576	216	1	15.9	15.0	13.5
4	0		3/4	4			576	432	1	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	1	42.4	40.0	36.0
6			3/4	6			864	648	1	47.6	45.0	40.5
7			5/6	6			864	720	1	52.9	50.0	45.0
8		256-QAM	3/4	8			1152	864	1	63.5	60.0	54.0
9			5/6	8			1152	960	1	70.6	66.7	60.0

Table 26-43 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	168	42	1	3.1	2.9	2.6
0	0		1/2	1			168	84	1	6.2	5.8	5.3
1	1	QPSK	1/4	2			336	84	1	6.2	5.8	5.3
1	0		1/2	2			336	168	1	12.4	11.7	10.5
2	N/A		3/4	2			336	252	1	18.5	17.5	15.8
3	1	16-QAM	1/4	4			672	168	1	12.4	11.7	10.5
3	0		1/2	4			672	336	1	24.7	23.3	21.0
4	1		3/8	4			672	252	1	18.5	17.5	15.8
4	0		3/4	4			672	504	1	37.1	35.0	31.5
5	N/A	64-QAM	2/3	6			1008	672	1	49.4	46.7	42.0
6			3/4	6			1008	756	1	55.6	52.5	47.3
7			5/6	6			1008	840	1	61.8	58.3	52.5
8		256-QAM	3/4	8			1344	1008	1	74.1	70.0	63.0
9			5/6	8			1344	1120	1	82.4	77.8	70.0

Table 26-44 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 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	24	2	192	48	1	3.5	3.3	3.0
0	0		1/2	1			192	96	1	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	1	7.1	6.7	6.0
1	0		1/2	2			384	192	1	14.1	13.3	12.0
2	N/A		3/4	2			384	288	1	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	1	14.1	13.3	12.0
3	0		1/2	4			768	384	1	28.2	26.7	24.0
4	1		3/8	4			768	288	1	21.2	20.0	18.0
4	0		3/4	4			768	576	1	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1152	768	1	56.5	53.3	48.0
6			3/4	6			1152	864	1	63.5	60.0	54.0
7			5/6	6			1152	960	1	70.6	66.7	60.0
8		256-QAM	3/4	8			1536	1152	1	84.7	80.0	72.0
9			5/6	8			1536	1280	1	94.1	88.9	80.0

Table 26-45 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	48	12	1	0.9	0.8	0.8
0	0		1/2	1			48	24	1	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1	1.8	1.7	1.5
1	0		1/2	2			96	48	1	3.5	3.3	3.0
2	N/A		3/4	2			96	72	1	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	1	3.5	3.3	3.0
3	0		1/2	4			192	96	1	7.1	6.7	6.0
4	1		3/8	4			192	72	1	5.3	5.0	4.5
4	0		3/4	4			192	144	1	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	1	14.1	13.3	12.0
6			3/4	6			288	216	1	15.9	15.0	13.5
7			5/6	6			288	240	1	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	1	21.2	20.0	18.0
9			5/6	8			384	320	1	23.5	22.2	20.0

Table 26-46 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	96	24	1	1.8	1.7	1.5
0	0		1/2	1			96	48	1	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	1	3.5	3.3	3.0
1	0		1/2	2			192	96	1	7.1	6.7	6.0
2	N/A		3/4	2			192	144	1	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	1	7.1	6.7	6.0
3	0		1/2	4			384	192	1	14.1	13.3	12.0
4	1		3/8	4			384	144	1	10.6	10.0	9.0
4	0		3/4	4			384	288	1	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	1	28.2	26.7	24.0
6			3/4	6			576	432	1	31.8	30.0	27.0
7			5/6	6			576	480	1	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	1	42.4	40.0	36.0
9			5/6	8			768	640	1	47.1	44.4	40.0

Table 26-47 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	144	36	1	2.6	2.5	2.3
0	0		1/2	1			144	72	1	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	1	5.3	5.0	4.5
1	0		1/2	2			288	144	1	10.6	10.0	9.0
2	N/A		3/4	2			288	216	1	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	1	10.6	10.0	9.0
3	0		1/2	4			576	288	1	21.2	20.0	18.0
4	1		3/8	4			576	216	1	15.9	15.0	13.5
4	0		3/4	4			576	432	1	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	1	42.4	40.0	36.0
6			3/4	6			864	648	1	47.6	45.0	40.5
7			5/6	6			864	720	1	52.9	50.0	45.0
8		256-QAM	3/4	8			1152	864	1	63.5	60.0	54.0
9			5/6	8			1152	960	1	70.6	66.7	60.0

Table 26-48 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	192	48	1	3.5	3.3	3.0
0	0		1/2	1			192	96	1	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	1	7.1	6.7	6.0
1	0		1/2	2			384	192	1	14.1	13.3	12.0
2	N/A		3/4	2			384	288	1	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	1	14.1	13.3	12.0
3	0		1/2	4			768	384	1	28.2	26.7	24.0
4	1		3/8	4			768	288	1	21.2	20.0	18.0
4	0		3/4	4			768	576	1	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1152	768	1	56.5	53.3	48.0
6			3/4	6			1152	864	1	63.5	60.0	54.0
7			5/6	6			1152	960	1	70.6	66.7	60.0
8		256-QAM	3/4	8			1536	1152	1	84.7	80.0	72.0
9			5/6	8			1536	1280	1	94.1	88.9	80.0

Table 26-49 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	240	60	1	4.4	4.2	3.8
0	0		1/2	1			240	120	1	8.8	8.3	7.5
1	1	QPSK	1/4	2			480	120	1	8.8	8.3	7.5
1	0		1/2	2			480	240	1	17.6	16.7	15.0
2	N/A		3/4	2			480	360	1	26.5	25.0	22.5
3	1	16-QAM	1/4	4			960	240	1	17.6	16.7	15.0
3	0		1/2	4			960	480	1	35.3	33.3	30.0
4	1		3/8	4			960	360	1	26.5	25.0	22.5
4	0		3/4	4			960	720	1	52.9	50.0	45.0
5	N/A	64-QAM	2/3	6			1440	960	1	70.6	66.7	60.0
6			3/4	6			1440	1080	1	79.4	75.0	67.5
7			5/6	6			1440	1200	1	88.2	83.3	75.0
8		256-QAM	3/4	8			1920	1440	1	105.9	100.0	90.0
9			5/6	8			1920	1600	1	117.6	111.1	100.0

Table 26-50 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	288	72	1	5.3	5.0	4.5
0	0		1/2	1			288	144	1	10.6	10.0	9.0
1	1	QPSK	1/4	2			576	144	1	10.6	10.0	9.0
1	0		1/2	2			576	288	1	21.2	20.0	18.0
2	N/A		3/4	2			576	432	1	31.8	30.0	27.0
3	1	16-QAM	1/4	4			1152	288	1	21.2	20.0	18.0
3	0		1/2	4			1152	576	1	42.4	40.0	36.0
4	1		3/8	4			1152	432	1	31.8	30.0	27.0
4	0		3/4	4			1152	864	1	63.5	60.0	54.0
5	N/A	64-QAM	2/3	6			1728	1152	1	84.7	80.0	72.0
6			3/4	6			1728	1296	1	95.3	90.0	81.0
7			5/6	6			1728	1440	1	105.9	100.0	90.0
8		256-QAM	3/4	8			2304	1728	1	127.1	120.0	108.0
9			5/6	8			2304	1920	1	141.2	133.3	120.0

Table 26-51 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	336	84	1	6.2	5.8	5.3
0	0		1/2	1			336	168	1	12.4	11.7	10.5
1	1	QPSK	1/4	2			672	168	1	12.4	11.7	10.5
1	0		1/2	2			672	336	1	24.7	23.3	21.0
2	N/A		3/4	2			672	504	1	37.1	35.0	31.5
3	1	16-QAM	1/4	4			1344	336	1	24.7	23.3	21.0
3	0		1/2	4			1344	672	1	49.4	46.7	42.0
4	1		3/8	4			1344	504	1	37.1	35.0	31.5
4	0		3/4	4			1344	1008	1	74.1	70.0	63.0
5	N/A	64-QAM	2/3	6			2016	1344	1	98.8	93.3	84.0
6			3/4	6			2016	1512	1	111.2	105.0	94.5
7			5/6	6			2016	1680	1	123.5	116.7	105.0
8		256-QAM	3/4	8			2688	2016	1	148.2	140.0	126.0
9			5/6	8			2688	2240	1	164.7	155.6	140.0

Table 26-52 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 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	48	4	384	96	1	7.1	6.7	6.0
0	0		1/2	1			384	192	1	14.1	13.3	12.0
1	1	QPSK	1/4	2			768	192	1	14.1	13.3	12.0
1	0		1/2	2			768	384	1	28.2	26.7	24.0
2	N/A		3/4	2			768	576	1	42.4	40.0	36.0
3	1	16-QAM	1/4	4			1536	384	1	28.2	26.7	24.0
3	0		1/2	4			1536	768	1	56.5	53.3	48.0
4	1		3/8	4			1536	576	1	42.4	40.0	36.0
4	0		3/4	4			1536	1152	1	84.7	80.0	72.0
5	N/A	64-QAM	2/3	6			2304	1536	1	112.9	106.7	96.0
6			3/4	6			2304	1728	1	127.1	120.0	108.0
7			5/6	6			2304	1920	1	141.2	133.3	120.0
8		256-QAM	3/4	8			3072	2304	1	169.4	160.0	144.0
9			5/6	8			3072	2560	1	188.2	177.8	160.0

Table 26-53 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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 26-54 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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

Table 26-55 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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 26-56 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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

Table 26-57 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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 26-58 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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

Table 26-59 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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 26-60 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 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

Table 26-61 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-62 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-63 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-64 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-65 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-66 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-67 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-68 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 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

Table 26-69 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-70 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-71 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-72 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-73 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-74 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-75 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-76 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 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

Table 26-77 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-78 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-79 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-80 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-81 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-82 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-83 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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

Table 26-84 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 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 26-85 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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

Table 26-86 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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 26-87 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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

Table 26-88 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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 26-89 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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

Table 26-90 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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 26-91 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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

Table 26-92 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 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

Annex C

26.6 C.3 MIB Detail

Insert the following (after getting some sucker to validate MIB compilation, etc.):

```
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 Extension Thresholds exist and are
          provided in the dot11PPEThresholdsTable MIB."
     DEFVAL { false }
     ::= { dot11StationConfigEntry <ANA> }

*****************************************************************
******
--
*****************************************************************
******
-- * 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>, 9.47 (HE Post-FEC
Padding and Packet Extension)"
     ::= { dot11smt 4 }

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 16QAM, 3 is 64QAM, 4 is 256QAM, 5 is
          1024QAM, 6 is reserved, 7 is the special value of
          NONE."
     ::= { dot11PPEThresholdsMappingsEntry 4 }


dot11PPEThresholdsMappingPPET16 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 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 16QAM, 3 is 64QAM, 4 is 256QAM, 5 is 1024QAM, 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
--
*****************************************************************
******
```