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(amendment to IEEE P802.11REVmd/D3.0)

IEEE P802.11ax™/D6.0

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

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

Amendment 1: Enhancements for High Efficiency WLAN

Prepared by the 802.11 Working Group of the

LAN/MAN Standards Committee
of the
IEEE Computer Society

Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 7.125 GHz.

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

Introduction

This introduction is not part of IEEE P802.11ax/D6.0, November 2019, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area network—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 1: Enhancements for High Efficiency WLAN.

This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 7.125 GHz.

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

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

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

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space. The table can appear to move out of the subclause it is referenced first from, and can even split a paragraph. This is the intended IEEE-SA behavior, please do not report it as a defect in the draft. In many cases, additional line feeds have been inserted to force tables to follow text, rather than float beyond sequential text. The additional line feeds will be removed before publication, please do not report them as a defect in the text.

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

Table 1—Draft Status

Draft	Date	Status
D0.1	2016-03-03	Converted to FrameMaker from 16/0024r1 Proposed draft specification
D0.2	2016-06-06	Includes tentative resolutions for most editorials. Includes resolutions for technical comments motioned in May 2016 session.
D0.3	2016-08-11	Includes resolutions for technical comments motioned in July 2016 session.
D0.4	2016-08-26	Included motioned draft changes from July 2016 session and corrected errors.
D0.5	2016-09-30	Included comment resolutions and other changes motioned at the September 2016 session.
D1.0	2016-11-30	Includes all approved changes. Ready for WG ballot.
D1.1	2017-02-09	Includes groundhogs (from 2017-02-02, start of editing), approved changes from the January 2017 session and a few editorials.
D1.2	2017-04-10	Include comment resolution approved during March 2017 session plus a few editorials.
D1.3	2017-05-19	Includes approved changes from May 2017 session plus a few editorials.
D1.4	2017-08-17	Includes approved changes from July 2017 session plus most remaining editorials.
D2.0	2017-10-02	Includes approved changes from September 2017 session.
D2.1	2018-01-02	Includes approved changes from November 2017 session plus some editorials.
D2.2	2018-02-15	Includes approved changes from January 2018 session.
D2.3	2018-04-17	Includes approved changes from the March 2018 session plus editorials.
D3.0	2018-05-23	Includes all approved changes. Ready for WG ballot.
D3.1	2018-08-23	Approved resolutions from the July session and tentative resolutions for most editorials.
D3.2	2018-10-11	Approved resolutions from the September session.
D3.3	2018-12-18	Approved resolutions from the November session with fixes.
D4.0	2019-02-01	Includes approved changes from January 2019 session. All comments resolved; ready for WG ballot.

Table 1—Draft Status

Draft	Date	Status
D4.1	2019-04-04	Includes approved changes from March 2019 session and tentative resolutions to around 159 editorial comments.
D4.2	2019-06-17	Includes approved changes from the May 2019 session and tentative resolutions to editorial comments.
D4.3	2019-08-02	Includes approved changes from the July 2019 session.
D5.0	2019-10-04	All comments on D4.0 resolved; ready for WG ballot
D5.1	2019-11-06	Resolutions to editorial comments and comments that identified problems with D5.0 edits.
D6.0	2019-11-26	All comments on D5.0 resolved; ready for WG ballot

2. Normative references

Insert the following (maintaining alphabetical order):

IETF RFC 8110, Opportunistic Wireless Encryption, D. Harkins, W. Kumari, March 2017.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

Change the following definitions:

aggregate medium access control (MAC) service data unit (A-MSDU): A structure that contains one or more MSDUs and is ~~transported within a single (unfragmented)~~ transmitted in one or more data ~~medium access control (MAC)~~ MAC protocol data units (MPDUs) with the same sequence number.

multi-user multiple input, multiple output (MU-MIMO): A technique by which multiple stations (STAs), each with one or more antennas, either simultaneously transmit to a single STA or simultaneously receive from a single STA independent data streams over the same radio frequencies.

~~NOTE—IEEE Std 802.11 supports only downlink (DL) MU-MIMO. See downlink multi-user multiple input, multiple output (DL-MU-MIMO) (in 3.2).~~

non-high-throughput (non-HT): A modifier meaning ~~neither~~ not high throughput (HT), not ~~nor~~ very high throughput (VHT) and not high efficiency (HE).

physical layer (PHY) protocol data unit (PPDU): The unit of data exchanged between ~~two peer~~ PHY entities to provide the PHY data service.

Insert the following definition maintaining alphabetical order:

orthogonal frequency division multiple access (OFDMA): An orthogonal frequency division multiple (OFDM)-based multiple access technique by which multiple stations (STAs) either simultaneously transmit to a single STA or simultaneously receive from a single STA independent data streams over different groups of subcarriers.

3.2 Definitions specific to IEEE 802.11

Change the following definitions:

20 MHz mask physical layer (PHY) protocol data unit (PPDU): One of the following PPDUs:

a) A Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU transmitted using the 20 MHz transmit spectral mask defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

b) A Clause 18 (Extended Rate PHY (ERP) specification) orthogonal frequency division multiplexing (OFDM) PPDU transmitted using the transmit spectral mask defined in Clause 18 (Extended Rate PHY (ERP) specification).

c) A high throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to CH_OFF_20 transmitted using the 20 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

d) A very high throughput (VHT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 20 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) A Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU transmitted by a VHT STA using the transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) An HT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to CH_OFF_20 transmitted by a VHT STA using the 20 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

g) A high efficiency (HE) PPDU with TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 20 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

h) A Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU transmitted by an HE STA using the 20 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

20 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) PPDU, Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU (when using 20 MHz channel spacing), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) PPDU, Clause 18 (Extended Rate PHY (ERP) specification) orthogonal frequency division multiplexing (OFDM) PPDU, Clause 19 (High Throughput (HT) PHY specification) 20 MHz high throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20, or Clause 21 (Very High Throughput (VHT) PHY specification(11ac)) 20 MHz very high throughput (VHT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20, or Clause 27 (High Efficiency (HE) PHY specification) 20 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20.

40 MHz mask physical layer (PHY) protocol data unit (PPDU): One of the following PPDUs:

a) A 40 MHz high throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

b) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to NON_HT_CBW40) transmitted by a non-very high throughput (non-VHT) STA using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

c) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by a very high throughput (VHT) STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 20 MHz HT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to either CH_OFF_20U or CH_OFF_20L transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

e) A 20 MHz VHT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) A 40 MHz VHT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW40 transmitted using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

g) A 40 MHz HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) transmitted by a VHT STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

h) A 20 MHz non-HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

i) A 20 MHz non-HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted by a VHT STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

j) A 40 MHz high efficiency (HE) PPDU with TXVECTOR parameter CH_BANDWIDTH equal to CBW40 transmitted using the 40 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

k) A 40 MHz VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by an HE STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very high throughput (VHT) PHY specification).

l) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by an HE STA using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

40 MHz physical layer (PHY) protocol data unit (PPDU): A 40 MHz high throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) or a 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to NON_HT_CBW40 or TXVECTOR parameter CH_BANDWIDTH equal to CBW40), or a 40 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40), or Clause 27 (High Efficiency (HE) PHY specification) 40 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW40.

80 MHz mask physical layer (PHY) protocol data unit (PPDU): ~~A PPDU that is transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification) and that is one~~ One of the following PPDUs:

a) An 80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) An 80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) A 20 MHz non-HT, high throughput (HT), or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 40 MHz non-HT duplicate, HT, or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) An 80 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

80 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80), or Clause 27 (High Efficiency (HE) PHY specification) 80 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW80.

80+80 MHz mask physical layer (PHY) protocol data unit (PPDU): A ~~PPDU that is transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification) and that is one~~ One of the following PPDUs:

a) An 80+80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) An 80+80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) An 80+80 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

80+80 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 80+80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 80+80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80)) or Clause 27 (High Efficiency (HE) PHY specification) 80+80 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80.

160 MHz mask physical layer (PHY) protocol data unit (PPDU): ~~A PPDU that is transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification(11ac)) and that is one~~ One of the following PPDUs:

a) A 160 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) A 160 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) A 20 MHz non-HT, high throughput (HT), or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 40 MHz non-HT duplicate, HT, or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) An 80 MHz non-HT duplicate or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) A 160 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 27 (High Efficiency (HE) PHY specification).

160 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 160 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 160 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) or Clause 27 (High Efficiency (HE) PHY specification) 160 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW160.

bandwidth signaling transmitter address (TA): A TA that is used by a very high throughput (VHT) station (STA) or a high efficiency (HE) STA to indicate the presence of additional signaling related to the bandwidth to be used in a subsequent transmission in an enhanced distributed channel access (EDCA) transmission opportunity (TXOP). It is ~~represented by~~ the IEEE medium access control (MAC) individual address of the transmitting ~~VHT~~ STA but with the Individual/Group bit set to 1.

fragmentation: The process of partitioning a medium access control (MAC) service data unit (MSDU), aggregate medium access control (MAC) service data unit (A-MSDU) or MAC management protocol data unit (MMPDU) into a sequence of smaller MAC protocol data units (MPDUs) prior to transmission. The process of recombining a set of fragment MPDUs into an MSDU, A-MSDU or MMPDU is known as defragmentation. These processes are described in 5.8.1.9 of ISO/IEC 7498-1:1994.

medium access control (MAC) management protocol data unit (MMPDU): The unit of data exchanged between two peer MAC entities, using services of the physical layer (PHY), to implement the MAC management protocol. The MMPDU is transported in one or more Management frames. The MMPDU might include a Mesh Control field or management message integrity code element (Management MIC element), but does not include a MAC header, a frame check sequence (FCS), or any other security encapsulation overhead.

NOTE—The MMPDU occupies a position in the management plane similar to that of the MAC service data unit (MSDU) in the data plane. An MSDU, A-MSDU or MMPDU is transmitted in one or more MAC protocol data units (MPDUs) (with the Type field set to Data, Data or Management, respectively). ~~An MSDU can be carried in an aggregate MAC service data unit (A-MSDU).~~ An A-MSDU is transmitted in one MPDU. An MSDU, A-MSDU, or MMPDU can be carried (in an MPDU) in an aggregate MAC protocol data unit (A-MPDU)

multiple basic service set identifier (BSSID) set: A collection of ~~cooperating~~ access points (APs), such that all APs use a common operating class, channel, and antenna connectors and advertise information for multiple BSSIDs using Beacon or Probe Response frames sent by the AP corresponding to the transmitted BSSID.

multi-user (MU) physical layer (PHY) protocol data unit (PPDU): A PPDU that carries one or more PHY service data units (PSDUs) for one or more stations (STAs) using the ~~downlink~~ multi-user multiple input, multiple output (DL-MU-MIMO) technique, orthogonal frequency division multiple access (DL OFDMA) technique, or a combination of the two techniques or that carries a PSDU for an AP and is in high efficiency (HE) MU PPDU format.

nontransmitted basic service set (BSS) identifier (BSSID): A BSSID corresponding to one of the basic service sets (BSSs) when the multiple BSSID capability is supported that is not transmitted explicitly, but that can be derived from the information encoded in Probe Response, Beacon and directional multi-gigabit (DMG) Beacon frames and Neighbor reports.

Replace the definition of "user" with the following:

user: An individual station or group of stations (STAs) using a single identifier, in the context of single input single output (SISO), single-user multiple input, multiple output (SU-MIMO), multi-user multiple input, multiple output (MU-MIMO), or orthogonal frequency division multiple access (OFDMA).

Insert the following definitions maintaining alphabetical order:

20 MHz-only non-access-point (non-AP) high efficiency station (HE STA): A non-AP HE STA that indicates in the Supported Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element that it supports only 20 MHz channel width for the frequency band in which it is operating.

20 MHz operating non-access-point (non-AP) high efficiency station (HE STA): A non-AP HE STA that is operating in 20 MHz channel width mode, such as a 20 MHz-only non-AP HE STA or an HE STA that has reduced its operating channel width to 20 MHz using operating mode indication (OMI).

80 MHz operating non-access-point (non-AP) high efficiency station (HE STA): A non-AP HE STA that is operating in 80 MHz channel width mode, such as a non-AP STA (excluding the 20 MHz-only non-AP HE STA) which is not capable of 160 MHz operation or a non-AP STA that has reduced its operating channel width to 80 MHz using operating mode indication (OMI).

ack-enabled single-traffic identifier (TID) aggregate medium access control (MAC) protocol data unit (ack-enabled single-TID A-MPDU): An A-MPDU that contains at least two A-MPDU subframes where more than one MPDU in the A-MPDU subframes from same traffic identified (TID) are not allowed and only one of the A-MPDU subframes includes an EOF MPDU that solicits an immediate acknowledgment.

NOTE—The single Management frame that solicits the acknowledgment in an ack-enabled single-TID A-MPDU is treated as a frame from a TID, e.g. soliciting Ack of TID 15 in multi-STA BlockAck frame.

ack-enabled multi-traffic identifier (TID) aggregate medium access control (MAC) protocol data unit (ack-enabled multi-TID A-MPDU): An A-MPDU where at least one EOF MPDU that solicits Ack acknowledgment is aggregated in the A-MPDU, and MPDUs from more than one TID that solicit Ack acknowledgment or Block Ack acknowledgment are aggregated in the A-MPDU.

NOTE—The single Management frame that solicits the acknowledgment in an ack-enabled multi-TID A-MPDU is treated as a frame from a TID, e.g. soliciting Ack of TID 15 in multi-STA BlockAck frame.

basic service set (BSS) color: An identifier for a BSS or for a set of BSSs belonging to a multiple BSSID set or a co-hosted BSSID set.

broadcast resource unit (RU): a resource unit in a high efficiency (HE) multi-user (MU) physical layer (PHY) protocol data unit (PPDU) transmitted by an access point (AP) that is intended for either unassociated STAs or more than one associated STA in the basic service set (BSS) or in any of the other BSSs in the multiple BSSID set to which the AP's BSS belongs.

broadcast target wake time (TWT): A specific time or set of times broadcast by an access point (AP) to multiple non-AP stations (non-AP STAs) to wake in order to exchange frames with the AP.

co-hosted basic service set identifier (BSSID) set: A collection of access points (APs) such that all APs use a common operating class, channel, and antenna connectors and each AP advertises information for its BSSID using Beacon or Probe Response frames.

co-located access point (AP) set: A set of two or more APs in the same physical device.

NOTE 1—APs in the co-located set might be operating on the same or different channel.

NOTE 2—The APs that are part of a co-located AP set and that are operating on the same channel might form a co-hosted BSSID set or multiple BSSID set.

detected access point (AP): An AP might be detected by a station (STA) if the STA and the AP are on the same channel and in range.

downlink (DL) high efficiency (HE) multi-user (MU) physical layer (PHY) protocol data unit (PPDU): An HE MU PPDU transmitted by an access point (AP). This PPDU carries one or more physical layer (PHY) service data units (PSDUs) for one or more users.

end of frame (EOF) media access control (MAC) protocol data unit (MPDU) (EOF MPDU): An MPDU carried in an aggregate MPDU (A-MPDU) subframe that has the EOF field in the MPDU delimiter set to 1.

enhanced multiple basic service set identifier (BSSID) advertisement (EMA) access point (AP): An AP with dot11MultiBSSIDImplemented set to true that supports enhancements related to the discovery of non-transmitted BSSIDs.

extended range (ER) beacon: A Beacon frame transmitted in a high efficiency (HE) ER single user (SU) physical layer (PHY) protocol data unit (PPDU) to form an ER basic service set (BSS).

high efficiency (HE) basic service set (BSS): A BSS in which the transmitted Beacon frame includes an HE Operation element.

high efficiency (HE) beacon: A Beacon frame transmitted in a high efficiency (HE) single user (SU) physical layer (PHY) protocol data unit (PPDU).

high efficiency (HE) beamformee: An HE station (STA) that receives an HE physical layer (PHY) protocol data unit (PPDU) that was transmitted using a beamforming steering matrix.

high efficiency (HE) beamformer: An HE station (STA) that transmits an HE physical layer (PHY) protocol data unit (PPDU) using a beamforming steering matrix.

high efficiency (HE) extended range (ER) single user (SU) physical layer (PHY) protocol data unit (PPDU) (HE ER SU PPDU): A PPDU transmitted with HE ER SU PPDU format. This PPDU carries a single service data unit (PSDU).

high efficiency (HE) masked HE-long training field (LTF) sequence mode: An HE-LTF mode used in HE TB PPDU. The masked HE-LTF sequence mode does not have any pilot subcarriers in the HE-LTF field and uses a masked HE-LTF sequence generated by multiplying an orthogonal code (distinct to each spatial stream) over groups of subcarriers.

high efficiency (HE) modulation and coding scheme (HE-MCS): A specification of the HE physical layer (PHY) parameters that consists of modulation order (e.g., BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM) and forward error correction (FEC) coding rate (e.g., 1/2, 2/3, 3/4, 5/6) and that is used in an HE PHY protocol data unit (PPDU).

high efficiency (HE) multi-user (MU) physical layer protocol data unit (PPDU): A PPDU transmitted with HE MU PPDU format.

high efficiency (HE) no pilot HE-long training field (LTF) mode: An HE-LTF mode used in HE TB PPDU. The no pilot HE-LTF mode does not have any pilot subcarriers in the HE-LTF field and does not use a masked HE-LTF sequence (see HE masked HE-LTF sequence mode).

high efficiency (HE) physical layer (PHY) protocol data unit (PPDU): A Clause 27 PPDU that is not a Clause 21 PPDU.

high efficiency (HE) single stream pilot: The same pilot sequence is applied to all spatial time streams for a given resource allocation.

high efficiency (HE) single stream pilot HE-long training field (LTF) mode: An HE-LTF mode used in an HE single user (SU), HE extended range (ER) SU, HE multi-user (MU) and HE trigger-based (TB) PPDU. The HE single stream pilot HE-LTF mode has single stream pilot subcarriers in the HE-LTF field.

high efficiency (HE) single-user (SU) physical layer (PHY) protocol data unit (PPDU): A PPDU transmitted with HE SU PPDU format. This PPDU carries a single physical layer service data unit (PSDU).

high efficiency (HE) trigger-based (TB) physical layer (PHY) protocol data unit (PPDU): A PPDU transmitted with HE TB PPDU format. This PPDU carries a single physical layer service data unit (PSDU).

non-ack-enabled single traffic identifier (TID) aggregate medium access control (MAC) protocol data unit (non-ack-enabled single TID A-MPDU): A legacy A-MPDU with the exception that a Trigger frame can be aggregated.

non-ack-enabled multi-traffic identifier (TID) aggregate medium access control (MAC) protocol data unit (non-ack-enabled multi-TID A-MPDU): An A-MPDU where EOF MPDUs are not aggregated, and the aggregated non-EOF MPDUs from at least two TIDs solicit block acknowledgment.

non-end of frame (non-EOF) medium access control (MAC) protocol data unit (MPDU) (non-EOF MPDU): An MPDU carried in an aggregate MPDU (A-MPDU) subframe that has the EOF field in the MPDU delimiter set to 0.

non-orthogonal frequency division multiple access (non-OFDMA) high efficiency (HE) physical layer (PHY) protocol data unit (PPDU): A 20 MHz HE PPDU with a 242-tone resource unit (RU), a 40 MHz HE PPDU with a 484-tone RU, an 80 MHz HE PPDU with a 996-tone RU, or a 160 MHz or 80+80 MHz HE PPDU with a 2×996-tone RU.

non-spatial reuse group (non-SRG): an adjective indicating the quality of not being a member of a particular spatial reuse group, or the quality of not originating from a station (STA) that is a member of a basic service set (BSS) that is part of a particular spatial reuse group.

opportunistic power save (OPS) access point (AP): A high efficiency (HE) AP that supports the opportunistic power save mechanism.

opportunistic power save (OPS) mechanism: A power save mechanism to allow OPS non-access-point (non-AP) stations (STAs) to opportunistically go to doze state or be unavailable for a defined period.

opportunistic power save (OPS) non-access point (non-AP) station (STA): A non-AP high efficiency (HE) STA that supports the opportunistic power save mechanism.

opportunistic power save (OPS) period: A period during which an OPS non-access-point (non-AP) station (STA) is allowed to be unavailable if it received an indication that it will not be scheduled by its associated OPS access point (AP).

orthogonal frequency division multiple access (OFDMA) high efficiency (HE) physical layer (PHY) protocol data unit (PPDU): A 20 MHz HE PPDU with resource units (RUs) smaller than 242-tone, or a 40 MHz HE PPDU with RUs smaller than 484-tone, or an 80 MHz HE PPDU with RUs smaller than 996-tone, or a 160 MHz or 80+80 MHz HE PPDU with RUs smaller than 2×996-tone.

overlapping basic service set (OBSS) packet detect (PD): A packet detection level used for spatial reuse procedure.

parameterized spatial reuse (PSR) opportunity: a spatial reuse opportunity that is established based on the value of a Spatial Reuse field in the HE-SIG-A field of a high efficiency (HE) trigger-based (TB) physical layer (PHY) protocol data unit (PPDU) and/or the UL Spatial Reuse subfield in the Common Info field of a Trigger frame.

parameterized spatial reuse reception (PSRR) physical layer (PHY) protocol data unit (PSRR PPDU): a PPDU that contains a Trigger frame that has a value in the UL Spatial Reuse subfield of the Common Info field that is neither PSR_DISALLOW nor PSR_AND_NON_SRG_OBSS_PD_PROHIBITED.

parameterized spatial reuse transmission (PSRT) physical layer (PHY) protocol data unit (PPDU) (PSRT PPDU): a PPDU that is transmitted during a parameterized spatial reuse (PSR) opportunity by an HE STA when PSR conditions for PSR-based spatial reuse operation are satisfied and that has the SR PPDU subfield of the CAS Control field equal to 1.

random access resource unit (RA-RU): A resource unit (RU) allocated in a Trigger frame to support the uplink (UL) orthogonal frequency division multiple access (OFDMA) based random access (UORA) procedure.

reported access point (AP): An AP that is described in an element such as a Neighbor Report element or a Reduced Neighbor Report element.

reporting access point (AP): An AP that is transmitting an element, such as a Neighbor Report element or a Reduced Neighbor Report element, describing a reported AP.

resource unit (RU): a group of 26, 52, 106, 242, 484, 996 or 2×996 subcarriers as an allocation of subcarriers for transmission.

spatial reuse (SR): the transmission of a physical layer (PHY) protocol data unit (PPDU) on the medium under certain conditions when a PPDU has been detected that would otherwise have prevented the transmission.

spatial reuse group (SRG): A group of basic service sets (BSSs) identified by their BSS colors or partial basic service set identifiers (BSSIDs) for overlapping basic service set packet detect (OBSS PD)-based spatial reuse operation with SRG OBSS PD level.

target wake time (TWT) scheduled station (STA): A STA that follows the broadcast TWT schedules provided in a broadcast TWT element.

target wake time (TWT) scheduling access point (AP): An AP that schedules broadcast TWTs and provides these broadcast TWT schedules in a broadcast TWT element.

triggered uplink access (TUA): A mechanism by which one or more non-access point (non-AP) stations (STAs) simultaneously participate in an uplink (UL) transmission to an access point (AP) using resource units (RUs) allocated in the preceding Trigger frame.

triggering frame: A Trigger frame or a frame carrying a TRS Control subfield.

triggering physical layer (PHY) protocol data unit (PPDU): A PPDU carrying a triggering frame.

uplink (UL) high efficiency (HE) multi-user (MU) physical layer (PHY) protocol data unit (PPDU): An HE MU PPDU transmitted by a non-access point (non-AP) station (STA). This PPDU carries a single physical layer service data unit (PSDU).

NOTE—The UL HE MU PPDU has an HE-SIG-B field that contains additional information (e.g., the identifier of the transmitter) that can be used by the recipient of the UL HE MU PPDU to determine the transmitter of the PPDU even in those cases where the Data field of the PPDU is not received. For example, this allows the originator of persistently failing PPDUs to be identified.

uplink (UL) orthogonal frequency division multiple access (OFDMA)-based random access (UORA): A random access mechanism for non-access point (non-AP) high efficiency (HE) stations (STAs) to participate in uplink OFDMA transmissions in one or more designated random access resource units (RUs).

3.4 Abbreviations and acronyms

Insert the following acronym definitions (maintaining alphabetical order):

A-Control	aggregated control
BQR	bandwidth query report
BQRP	bandwidth query report poll

BFRP	beamforming report poll
BSR	buffer status report
BSRP	buffer status report poll
CAS	command and status
CCDF	complementary cumulative distribution function
CQI	channel quality indication
DCM	dual carrier modulation
DL	downlink
DL MU	downlink multi-user
HE	high efficiency
LA	link adaptation
MU-BAR	multi-user block ack request
MUEDCATimer	multi-user EDCA timer
MU-RTS	multi-user request to send
NFRP	NDP feedback report poll
OBO	orthogonal frequency division multiple access (OFDMA) random access backoff
OCW	orthogonal frequency division multiple access (OFDMA) contention window
OFDMA	orthogonal frequency division multiple access
OM	operating mode
OMI	operating mode indication
PD	packet detect
PPE	physical layer (PHY) packet extension
PPET	physical layer (PHY) packet extension threshold
PSR	parameterized spatial reuse
QTP	quiet time period
RA-RU	random access resource unit
RDP	reverse direction protocol
ROM	receive operating mode
RPL	received power level
RU	resource unit
SF	scaling factor
SR	spatial reuse
SRG	spatial reuse group
TB	trigger-based
TOM	transmit operating mode
TRS	triggered response scheduling
TUA	triggered uplink access
UL	uplink
UL MU	uplink multi-user
UORA	uplink orthogonal frequency division multiple access (OFDMA) based random access
UPH	uplink (UL) power headroom

4. General description

4.3 Components of the IEEE Std 802.11 architecture

Insert a new subclause after subclause 4.3.15 (Very high throughput (VHT) STA) as follows:

4.3.15a High efficiency (HE) STA

The IEEE 802.11 HE STA operates in frequency bands between 1 GHz and 7.125 GHz.

An HE STA that is a mesh STA does not transmit and does not receive HE TB PPDUs.

In the 5 to 7.125 GHz bands, the following apply:

— An HE STA is also a VHT STA if operating in the 5 GHz band except that a 20 MHz-only HE STA does not support 40 MHz and 80 MHz channel widths

— Support for 20 MHz operating channel width is mandatory in an HE STA

— Support for 40 MHz and 80 MHz operating channel width is mandatory in an HE STA that is not a 20 MHz-only non-AP HE STA

— Support for 160 MHz and 80+80 MHz operating channel width is optional in an HE STA

In the 2.4 GHz band, the following apply:

— An HE STA is also an HT STA

— Support for 20 MHz operating channel width is mandatory in an HE STA

— Support for 40 MHz operating channel width is optional in an HE STA

The main PHY features in an HE STA that are not present in VHT STA or HT STA are the following:

— Mandatory support for DL and UL OFDMA

— Mandatory support for DL MU-MIMO by an HE AP that supports 4 or more spatial streams when MU-MIMO is done on the entire PPDU bandwidth

— Mandatory support for DL MU-MIMO reception for a non-AP HE STA

— Mandatory support for the HE sounding protocol to support beamforming for a non-AP STA beamformee and optional otherwise

— Optional support for HE-MCSs 10 and 11

— Optional support for UL MU-MIMO

— Optional support for preamble puncturing

NOTE—Preamble puncturing is a mechanism whereby OFDMA is used to avoid transmissions in certain subcarriers.

The main MAC features in an HE STA that are not present in VHT STA or HT STA are the following:

— In an AP, mandatory support for the role of operating mode indication (OMI) responder and optional support for the role of OMI initiator

— In an AP, mandatory support for individual target wake time (TWT) operation

— In a non-AP STA, mandatory support for two NAV operation

— In a non-AP STA, mandatory support for multiple BSSID operation

— In an AP, optional support for two NAV operation

— In a non-AP STA, optional support for the roles of OMI initiator and responder

— In a non-AP STA, optional support for individual TWT operation

— Optional support for dynamic fragmentation levels 1, 2 and 3

- Optional support for broadcast TWT
- Optional support for UL OFDMA-based random access (UORA)
- Optional support for spatial reuse operation
- Optional support for multi-TID A-MPDU operation
- Optional support for ER BSS
- Optional support for the NDP feedback report

An HE AP sends a Trigger frame to initiate OFDMA or MU-MIMO transmissions in the uplink direction or a TRS Control subfield to initiate OFDMA transmissions in the uplink direction. The Trigger frame or TRS Control subfield identifies non-AP STAs participating in the UL MU transmissions and assigns RUs and/or spatial streams to these STAs. Multi-STA BlockAck frames can be used by the AP to acknowledge the frames transmitted by multiple non-AP STAs. The scheduling of these Trigger frames can be set up between a non-AP STA and the AP using TWT operation to save power and reduce collisions.

These features can reduce protocol overhead and increase aggregate network throughput (e.g., DL and UL OFDMA, DL/UL MU-MIMO), enhance peak link throughput (e.g., HE-MCS 10, 11), enhance dense network efficiency (e.g., spatial reuse), and/or enhance power conservation (e.g., TWT). These features can, under certain circumstances, improve the average throughput per STA in a BSS by a factor of four, compared to VHT.

4.3.19 Wireless network management

4.3.19.8 Event reporting

Change as follows:

Event requests enable a STA to request a non-AP STA to send particular real-time event reports. The types of events include transition, RSNA, WNM log, BSS color collision, BSS color in use and peer-to-peer link events. A transition event is transmitted after a non-AP STA successfully completes a BSS transition. Transition events are used to diagnose transition performance problems. An RSNA event report describes the type of Authentication used for the RSNA. RSNA events are used to diagnose security and authentication performance problems. A WNM log event report enables a non-AP STA to transmit a set of WNM log event messages to the requesting STA. WNM log event reports are used to access the contents of a STA's WNM log. A BSS color collision event report enables a non-AP HE STA to signal BSS color collision to its associated AP. A BSS color in use event report enables a non-AP HE STA to signal a BSS color in use by the non-AP HE STA to its associated AP. A peer-to-peer link event report enables a non-AP STA to inform the requesting STA that a peer-to-peer link has been established. Peer-to-peer link event reports are used to monitor the use of peer-to-peer links in the network.

6. Layer management

6.3 MLME SAP interface

6.3.3 Scan

6.3.3.2 MLME-SCAN.request

6.3.3.2.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters are shown):

The primitive parameters are as follows:

MLME-SCAN.request(

…

Short SSID List,

HE Capabilities,

HE 6 GHz Band Capabilities,

VendorSpecificInfo

)

Name	Type	Valid range	Description
Short SSID List	A list of short SSIDs	As defined in 9.4.2.260 (Short SSID List element)	One or more Short SSID fields that are optionally present if dot11ShortSSIDList is true
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters in the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters in the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise not present.

6.3.3.3 MLME-SCAN.confirm

6.3.3.3.2 Semantics of the service primitive

Insert the following rows at the end of the BSSDescriptionSet table:

Name	Type	Valid range	Description	IBSS adoption

TWT	As defined in frame format	As defined in 9.4.2.199 (TWT element)	The value from the TWT element. The parameter is optionally present if dot11HEOptionImplemented is true, dot11TWTOptionActivated is true, and a TWT element was present in the broadcast Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
HE Capabilities	As defined in frame format	As defined in 9.4.2.247 (HE Capabilities element)	The value from the HE Capabilities element. The parameter is present if dot11HEOptionImplemented is true and an HE Capabilities element was present in the Probe Response or Beacon frame from which the BSSDescription was determined. Otherwise, the parameter is not present.	Do not adopt
HE 6 GHz Band Capabilities	As defined in frame format	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	The value from the HE 6 GHz Band Capabilities element. The parameter is present if dot11HE6GOptionImplemented is true and an HE 6 GHz Band Capabilities element was present in the Probe Response or Beacon frame from which the BSSDescription was determined. Otherwise, the parameter is not present.	Do not adopt
HE Operation	As defined in frame format	As defined in 9.4.2.248 (HE Operation element)	The value from the HE Operation element. The parameter is present if dot11HEOptionImplemented is true and an HE Operation element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Adopt

UORA Parameter Set	As defined in frame format	As defined in 9.4.2.249 (UORA Parameter Set element)	The value from the UORA Parameter Set element. The parameter is optionally present if dot11OFDMARandomAccessOptionImlemented is true and a UORA Parameter Set element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
MU EDCA Parameter Set	As defined in frame format	As defined in 9.4.2.250 (MU EDCA Parameter Set element)	The value from the MU EDCA Parameter Set element. The parameter is optionally present if dot11HEOptionImplemented is true and a MU EDCA Parameter Set element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
Spatial Reuse Parameter Set	As defined in frame format	As defined in 9.4.2.251 (Spatial Reuse Parameter Set element)	The value from the Spatial Reuse Parameter Set element. The parameter is optionally present if dot11HEOptionImplemented is true and a Spatial Reuse Parameter Set element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
NDP Feedback Report Parameter Set	As defined in frame format	As defined in 9.4.2.252 (NDP Feedback Report Parameter Set element)	The value from the NDP Feedback Report Parameter Set element. The parameter is optionally present if dot11HEOptionImplemented is true and an NDP Feedback Report Parameter Set element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt

BSS Color Change Announcement	As defined in frame format	As defined in 9.4.2.253 (BSS Color Change Announcement element)	The value from the BSS Color Change Announcement element. The parameter is optionally present if dot11HEOptionImplemented is true and a BSS Color Change Announcement element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
ESS Report	As defined in frame format	As defined in 9.4.2.255 (ESS Report element)	The value from the ESS Report element. The parameter is optionally present if an ESS Report element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
HE BSS Load	As defined in frame format	As defined in 9.4.2.257 (HE BSS Load element)	The value from the HE BSS Load element. The parameter is optionally present if dot11QBSSLoadImplemented and dot11HEOptionImplemented are true and an HE BSS Load element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Do not adopt
Multiple BSSID Configuration	As defined in frame format	As defined in 9.4.2.258 (Multiple BSSID Configuration element)	The value from the Multiple BSSID Configuration element. The parameter is present if dot11MultiBSSIDImplemented is true and the Multiple BSSID Configuration element was present in the Probe Response or Beacon frame from which the BSSDescription was determined. Otherwise, the parameter is not present.	Do not adopt

6.3.4 Synchronization

6.3.4.2 MLME-JOIN.request

6.3.4.2.2 Semantics of the service primitive

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

The primitive parameters are as follows:

MLME-JOIN.request(
…,
HE Capabilities,
HE 6 GHz Band Capabilities,
VendorSpecificInfo
)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.

6.3.4.2.4 Effect of receipt

Insert the following at the end of the subclause:

If the MLME of an HE STA receives an MLME-JOIN.request primitive with a SelectedBSS parameter containing a Basic HE-MCS And NSS Set field in the HE Operation parameter that contains any unsupported <HE-MCS, NSS> tuple, then the MLME response in the resulting MLME-JOIN.confirm primitive shall contain a ResultCode parameter that is not set to the value SUCCESS.

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Change the primitive parameters as follows (not all parameters are shown):

The primitive parameters are as follows:

MLME-ASSOCIATE.request(
…,
HE Capabilities,
HE 6 GHz Band Capabilities,
Channel Switch Timing,
UL MU Power Capabilities,
VendorSpecificInfo
)

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters in the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters in the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise not present.
Channel Switch Timing	As defined in the Channel Switch Timing element	As defined in 9.4.2.63 (Channel Switch Timing element)	Provides information regarding the channel switch timing. The parameter is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true; otherwise not present.
UL MU Power Capabilities	As defined in UL MU Power Capabilities element	As defined in 9.4.2.262 (UL MU Power Capabilities element)	Provides information regarding the UL MU power capabilities for the non-AP STA. The UL MU Power Capabilities element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Change the primitive parameters as follows (not all parameters are shown):

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm(
…,
HE Capabilities,
HE 6 GHz Band Capabilities,
HE Operation,
BSS Color Change Announcement,
Spatial Reuse Parameter Set,
MU EDCA Parameter Set,
UORA Parameter Set,
ESS Report,
VendorSpecificInfo
)

Change the unnumbered table in this subclause as follows:

Name	Type	Valid range	Description
TWT	TWT element	As defined in 9.4.2.199 (TWT element)	Specifies the parameters in the TWT element. This parameter is optionally present if dot11TWTOptionActivated is true and the TWT element is present in the Association Request frame that elicited the Association Response frame or the TWT Requester Support field in the HE Capabilities element in the Association Request frame that elicited the Association Response frame is 1; otherwise not present.

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.

HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element	As defined in 9.4.2.248 (HE Operation element)	Provides additional information for operating the HE BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.
UORA Parameter Set	As defined in UORA Parameter Set element	As defined in 9.4.2.249 (UORA Parameter Set element)	Indicates the metrics of the OFDMA-based random access mechanism. The parameter is optionally present if dot11OFDMARandomAccessOptionImlemented is true; otherwise not present.
MU EDCA Parameter Set	As defined in MU EDCA Parameter Set element	As defined in 9.4.2.250 (MU EDCA Parameter Set element)	Indicates MU EDCA parameters. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
Spatial Reuse Parameter Set	As defined in Spatial Reuse Parameter Set element	As defined in 9.4.2.251 (Spatial Reuse Parameter Set element)	Indicates parameters needed by STAs when performing OBSS PD-based spatial reuse. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
NDP Feedback Report Parameter Set	As defined in NDP Feedback Report Parameter Set element	As defined in 9.4.2.252 (NDP Feedback Report Parameter Set element)	Indicates NDP Feedback Report parameter values. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
BSS Color Change Announcement	As defined in BSS Color Change Announcement element	As defined in 9.4.2.253 (BSS Color Change Announcement element)	Indicates information on BSS Color Change. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.

ESS Report	As defined in ESS Report element	As defined in 9.4.2.255 (ESS Report element)	Provides information on ESS to assist BSS transition. The parameter is optionally present.

6.3.7.4 MLME-ASSOCIATE.indication

6.3.7.4.2 Semantics of the service primitive

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

The primitive parameters are as follows:

MLME-ASSOCIATE.indication(

…,

HE Capabilities,

HE 6 GHz Band Capabilities,

Channel Switch Timing,

UL MU Power Capabilities,

VendorSpecificInfo

)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the peer STA. The parameter is present if dot11HEOptionImplemented is true and the HE Capabilities element is present in the Association Request frame received from the STA; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the peer STA. The parameter is present if dot11HE6GOptionImplemented is true and the HE 6 GHz Band Capabilities element is present in the Association Request frame received from the STA; otherwise, this parameter is not present.

Channel Switch Timing	As defined in the Channel Switch Timing element	As defined in 9.4.2.63 (Channel Switch Timing element)	Provides information regarding the channel switch timing. The parameter is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true and the Channel Switch Timing element is present in the Association Request frame received from the STA; otherwise not present.
UL MU Power Capabilities	As defined in UL MU Power Capabilities element	As defined in 9.4.2.262 (UL MU Power Capabilities element)	Provides information regarding the UL MU power capabilities for the non-AP STA. The UL MU Power Capabilities element is present if dot11HEOptionImplemented is true and the HE Capabilities element and UL MU Power Capabilities element is present in the Association Request frame received from the STA; otherwise it is not present.

6.3.7.5 MLME-ASSOCIATE.response

6.3.7.5.2 Semantics of the service primitive

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

The primitive parameters are as follows:

MLME-ASSOCIATE.response(

…,

<u>HE Capabilities,</u>

<u>HE 6 GHz Band Capabilities,</u>

<u>HE Operation,</u>

<u>UORA Parameter Set,</u>

<u>MU EDCA Parameter Set,</u>

<u>Spatial Reuse Parameter Set,</u>

<u>NDP Feedback Report Parameter Set,</u>

<u>BSS Color Change Announcement,</u>

<u>ESS Report,</u>

VendorSpecificInfo

)

Change the unnumbered table in this subclause as follows:

Name	Type	Valid range	Description
TWT	TWT element	As defined in 9.4.2.199 (TWT element)	Specifies the parameters in the TWT element. This parameter is optionally present if dot11TWTOptionActivated is true and the TWT element is present in the Association Request frame that elicited the Association Response frame or the TWT Requester Support field in the HE Capabilities element in the Association Request frame that elicited the Association Response frame is 1; otherwise not present.

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element	As defined in 9.4.2.248 (HE Operation element)	Provides additional information for operating the HE BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.

UORA Parameter Set	As defined in UORA Parameter Set element	As defined in 9.4.2.249 (UORA Parameter Set element)	Indicates the metrics of the OFDMA-based random access mechanism. The parameter is optionally present if dot11OFDMARandomAccessOptionImlemented is true; otherwise not present.
MU EDCA Parameter Set	As defined in MU EDCA Parameter Set element	As defined in 9.4.2.250 (MU EDCA Parameter Set element)	Indicates MU EDCA parameters. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
Spatial Reuse Parameter Set	As defined in Spatial Reuse Parameter Set element	As defined in 9.4.2.251 (Spatial Reuse Parameter Set element)	Indicates parameters needed by STAs when performing OBSS PD-based spatial reuse. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
NDP Feedback Report Parameter Set	As defined in NDP Feedback Report Parameter Set element	As defined in 9.4.2.252 (NDP Feedback Report Parameter Set element)	Indicates NDP Feedback Report parameter values. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
BSS Color Change Announcement	As defined in BSS Color Change Announcement element	As defined in 9.4.2.253 (BSS Color Change Announcement element)	Indicates information on BSS Color Change. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
ESS Report	As defined in ESS Report element	As defined in 9.4.2.255 (ESS Report element)	Provides information on ESS to assist BSS transition. The parameter is optionally present.

6.3.8 Reassociate

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.2 Semantics of the service primitive

Change the primitive parameters as follows (not all parameters are shown):

The primitive parameters are as follows:

MLME-REASSOCIATE.request(

…,

<u>HE Capabilities,</u>

HE 6 GHz Band Capabilities,
Channel Switch Timing,
UL MU Power Capabilities,
VendorSpecificInfo
)

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters in the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters in the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise not present.
Channel Switch Timing	As defined in the Channel Switch Timing element	As defined in 9.4.2.63 (Channel Switch Timing element)	Provides information regarding the channel switch timing. The parameter is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true; otherwise not present.
UL MU Power Capabilities	As defined in UL MU Power Capabilities element	As defined in 9.4.2.262 (UL MU Power Capabilities element)	Provides information regarding the UL MU power capabilities for the non-AP STA. The UL MU Power Capabilities element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.2 Semantics of the service primitive

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

The primitive parameters are as follows:

MLME-REASSOCIATE.confirm(
…,
HE Capabilities,

HE 6 GHz Band Capabilities,
HE Operation,
UORA Parameter Set,
MU EDCA Parameter Set,
Spatial Reuse Parameter Set,
NDP Feedback Report Parameter Set,
BSS Color Change Announcement,
ESS Report,
VendorSpecificInfo
)

Change the unnumbered table in this subclause as follows:

Name	Type	Valid range	Description
TWT	TWT element	As defined in 9.4.2.199 (TWT element)	Specifies the parameters in the TWT element. This parameter is optionally present if dot11TWTOptionActivated is true and the TWT element is present in the Reassociation Request frame that elicited the Reassociation Response frame or the TWT Requester Support field in the HE Capabilities element in the Reassociation Request frame that elicited the Reassociation Response frame is 1; otherwise not present.

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.

HE Operation	As defined in HE Operation element	As defined in 9.4.2.248 (HE Operation element)	Provides additional information for operating the HE BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.
UORA Parameter Set	As defined in UORA Parameter Set element	As defined in 9.4.2.249 (UORA Parameter Set element)	Indicates the metrics of the OFDMA-based random access mechanism. The parameter is optionally present if dot11OFDMARandom-AccessOptionImlemented is true; otherwise not present.
MU EDCA Parameter Set	As defined in MU EDCA Parameter Set element	As defined in 9.4.2.250 (MU EDCA Parameter Set element)	Indicates MU EDCA parameters. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
Spatial Reuse Parameter Set	As defined in Spatial Reuse Parameter Set element	As defined in 9.4.2.251 (Spatial Reuse Parameter Set element)	Indicates parameters needed by STAs when performing OBSS PD-based spatial reuse. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
NDP Feedback Report Parameter Set	As defined in NDP Feedback Report Parameter Set element	As defined in 9.4.2.252 (NDP Feedback Report Parameter Set element)	Indicates NDP Feedback Report parameter values. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
BSS Color Change Announcement	As defined in BSS Color Change Announcement element	As defined in 9.4.2.253 (BSS Color Change Announcement element)	Indicates information on BSS Color Change. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
ESS Report	As defined in ESS Report element	As defined in 9.4.2.255 (ESS Report element)	Provides information on ESS to assist BSS transition. The parameter is optionally present.

6.3.8.4 MLME-REASSOCIATE.indication

6.3.8.4.2 Semantics of the service primitive

Change the primitive parameters as follows (not all parameters are shown):

The primitive parameters are as follows:

MLME-REASSOCIATE.indication(
…,
HE Capabilities,
HE 6 GHz Band Capabilities,
Channel Switch Timing,
UL MU Power Capabilities,
VendorSpecificInfo
)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the peer STA. The parameter is present if dot11HEOptionImplemented is true and the HE Capabilities element is present in the Reassociation Request frame received from the STA; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true and the HE 6 GHz Band Capabilities element is present in the Reassociation Request frame received from the STA; otherwise, this parameter is not present.
Channel Switch Timing	As defined in the Channel Switch Timing element	As defined in 9.4.2.63 (Channel Switch Timing element)	Provides information regarding the channel switch timing. The parameter is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true and the Channel Switch Timing element is present in the Reassociation Request frame received from the STA; otherwise not present.

UL MU Power Capabilities	As defined in UL MU Power Capabilities element	As defined in 9.4.2.262 (UL MU Power Capabilities element)	Provides information regarding the UL MU power capabilities for the non-AP STA. The UL MU Power Capabilities element is present if dot11HEOptionImplemented is true and the HE Capabilities element and UL MU Power Capabilities element is present in the Association Request frame received from the STA; otherwise it is not present.

6.3.8.5 MLME-REASSOCIATE.response

6.3.8.5.2 Semantics of the service primitive

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

The primitive parameters are as follows:

MLME-REASSOCIATE.response(
…,
HE Capabilities,
HE 6 GHz Band Capabilities,
HE Operation,
UORA Parameter Set,
MU EDCA Parameter Set,
Spatial Reuse Parameter Set,
NDP Feedback Report Parameter Set,
BSS Color Change Announcement,
ESS Report,
VendorSpecificInfo
)

Change the unnumbered table in this subclause as follows:

Name	Type	Valid range	Description
TWT	TWT element	As defined in 9.4.2.199 (TWT element)	Specifies the parameters in the TWT element. This parameter is optionally present if dot11TWTOptionActivated is true and the TWT element is present in the Reassociation Request frame that elicited the Reassociation Response frame or the TWT Requester Support field in the HE Capabilities element in the Reassociation Request frame that elicited the Reassociation Response frame is 1; otherwise not present.

Insert the following entries into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element	As defined in 9.4.2.248 (HE Operation element)	Provides additional information for operating the HE BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise not present.

UORA Parameter Set	As defined in UORA Parameter Set element	As defined in 9.4.2.249 (UORA Parameter Set element)	Indicates the metrics of the OFDMA-based random access mechanism. The parameter is optionally present if dot11OFDMARandomAccessOptionImlemented is true; otherwise not present.
MU EDCA Parameter Set	As defined in MU EDCA Parameter Set element	As defined in 9.4.2.250 (MU EDCA Parameter Set element)	Indicates MU EDCA parameters. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
Spatial Reuse Parameter Set	As defined in Spatial Reuse Parameter Set element	As defined in 9.4.2.251 (Spatial Reuse Parameter Set element)	Indicates parameters needed by STAs when performing OBSS PD-based spatial reuse. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
NDP Feedback Report Parameter Set	As defined in NDP Feedback Report Parameter Set element	As defined in 9.4.2.252 (NDP Feedback Report Parameter Set element)	Indicates NDP Feedback Report parameter values. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
BSS Color Change Announcement	As defined in BSS Color Change Announcement element	As defined in 9.4.2.253 (BSS Color Change Announcement element)	Indicates information on BSS Color Change. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise not present.
ESS Report	As defined in ESS Report element	As defined in 9.4.2.255 (ESS Report element)	Provides information on ESS to assist BSS transition. The parameter is optionally present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

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

MLME-START.request(

…,
HE Capabilities,
HE 6 GHz Band Capabilities,
HE Operation,
VendorSpecificInfo

)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.	As defined in 9.4.2.247 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE 6 GHz Band Capabilities	As defined in HE 6 GHz Band Capabilities element	As defined in 9.4.2.261 (HE 6 GHz Band Capabilities element)	Specifies the parameters within the HE 6 GHz Band Capabilities element that are supported by the STA. The parameter is present if dot11HE6GOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element.	As defined in 9.4.2.248 (HE Operation element)	Provides additional information for operating the HE BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.

6.3.11.2.4 Effect of receipt

Insert the following at the end of the subclause:

If the MLME of an HE STA receives an MLME-START.request primitive with a Basic HE-MCS And NSS Set field in the HE Operation parameter that contains any unsupported <HE-MCS, NSS> tuple, then the MLME response in the resulting MLME-START.confirm primitive shall not contain a ResultCode parameter that is set to SUCCESS.

Insert the following at the end of 6.3:

6.3.119 Quiet time period

6.3.119.1 Introduction

This mechanism supports quiet time period operation.

6.3.119.2 MLME-QTP.request

6.3.119.2.1 Function

This primitive requests a quiet time period for the quiet time period operation.

6.3.119.2.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-QTP.request (
Peer MAC Address,
Dialog Token,
Quiet Period Offset,
Quiet Period Duration,
Quiet Period Interval,
Repetition Count,
Service Specific Identifier
)

Name	Type	Valid range	Description
Peer MAC Address	MAC address	Any valid individually addressed MAC address	The address of the peer MAC entity to which the QTP Request frame is to be sent
Dialog Token	Integer	0–65 535	The dialog token to identify the QTP Request frame.
Quiet Period Offset	Integer	0–255	Indicates the offset of the first QTP period from the TBTT, expressed in TUs.
Quiet Period Duration	Integer	1–65 535	Indicates the duration of the QTP in units of 32 µs
Quiet Period Interval	Integer	1–255	Indicates the requested interval between the start of two consecutive QTP periods, expressed in TUs.
Repetition Count	Integer	0–255	Indicates the number of requested QTP periods. A repetition count equal to 0 indicates the setup time of the QTP period is for a one time operation. Repetition count equal to 255 indicates the setup of the QTP period is canceled.
Service Specific Identifier	Integer	0–65 535	Indicates an identifier assigned by a peer-to-peer application to identify frame exchanges using peer-to-peer links

6.3.119.2.3 When generated

This primitive is generated by the SME to request that a QTP Request frame to be sent to its associated AP.

6.3.119.2.4 Effect of receipt

On receipt of this primitive, the MLME constructs and transmits a QTP Request frame.

6.3.119.3 MLME-QTP.indicaton

6.3.119.3.1 Function

This primitive indicates that a QTP Request frame has been received for the quiet time period operation.

6.3.119.3.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-QTP.indication (
Peer MAC Address,
Dialog Token,
Status Code,
Quiet Period Offset,
Quiet Period Duration,
Quiet Period Interval,
Repetition Count,
Service Specific Identifier
)

Name	Type	Valid range	Description
Peer MAC Address	MAC address	Any valid individually addressed MAC address	The address of the peer MAC entity from which the QTP Request frame is received
Dialog Token	Integer	0–255	The dialog token to identify the QTP Request frame.
Quiet Period Offset	Integer	0–255	Indicates the offset of the first QTP period from the TBTT, expressed in TUs.
Quiet Period Duration	Integer	1–65 535	Indicates the duration of the QTP in units of 32 µs
Quiet Period Interval	Integer	1–255	Indicates the requested interval between the start of two consecutive QTP periods, expressed in TUs.
Repetition Count	Integer	0–255	Indicates the number of requested QTP periods. A repetition count equal to 0 indicates the setup time of the QTP period is for a one time operation. Repetition count equal to 255 indicates the setup of the QTP period is canceled.
Service Specific Identifier	Integer	0–65 535	Indicates an identifier assigned by a peer-to-peer application to identify frame exchanges using peer-to-peer links

6.3.119.3.3 When generated

This primitive is generated by the MLME when a QTP Request frame is received.

6.3.119.3.4 Effect of receipt

On receipt of this primitive, the SME constructs and transmits a QTP Response frame.

6.3.119.4 MLME-QTP.response

6.3.119.4.1 Function

This primitive requests the transmission of quiet time period information to a peer entity, in response to a QTP Request frame for the quiet time period operation.

6.3.119.4.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-QTP.response (
Peer MAC Address,
Dialog Token,
Status Code,
Quiet Period Offset,
Quiet Period Duration,
Quiet Period Interval,
Repetition Count,
Service Specific Identifier
)

Name	Type	Valid range	Description
Peer MAC Address	MAC address	Any valid individually addressed MAC address	The address of the peer MAC entity from which the QTP Request frame is received
Dialog Token	Integer	0–255	The dialog token to identify the QTP Request frame.
Status Code	Integer	0–255	Indicates the status of a requested operation.

Quiet Period Offset	Integer	1–255	Indicates the offset of the first QTP period from the TBTT, expressed in TUs.
Quiet Period Duration	Integer	1–65 535	Indicates the duration of the QTP in units of 32 µs
Quiet Period Interval	Integer	1–255	Indicates the responded interval between the start of two consecutive QTP periods, expressed in TUs.
Repetition Count	Integer	0–255	Indicates the number of responded QTP periods. A repetition count equal to 0 indicates the setup time of the QTP period is for a one time operation. Repetition count equal to 255 indicates the setup of the QTP period is canceled.
Service Specific Identifier	Integer	0–65 535	Indicates an identifier assigned by a peer-to-peer application to identify frame exchanges using peer-to-peer links

6.3.119.4.3 When generated

This primitive is generated by the SME to request that a QTP Response frame be sent to a peer entity as a response to an MLME-QTP.indication primitive.

6.3.119.4.4 Effect of receipt

On receipt of this primitive, the SME constructs and transmits a QTP Response frame.

6.3.119.5 MLME-QTP.confirm

6.3.119.5.1 Function

This primitive reports the result of a QTP request to send a QTP Response frame for the quiet time period operation.

6.3.119.5.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-QTP.confirm (
                Peer MAC Address,
                Dialog Token,
                Status Code,
                Quiet Period Offset,
                Quiet Period Duration,
                Quiet Period Interval,
                Repetition Count,
                Service Specific Identifier
```

)

Name	Type	Valid range	Description
Peer MAC Address	MAC address	Any valid individually addressed MAC address	The address of the peer MAC entity from which the QTP Response frame is received
Dialog Token	Integer	0–255	The dialog token to identify the QTP Response frame.
Status Code	Integer	0–255	Indicates the status of a requested operation.
Quiet Period Offset	Integer	1–255	Indicates the offset of the first QTP period from the TBTT, expressed in TUs.
Quiet Period Duration	Integer	1–65 535	Indicates the duration of the QTP in units of 32 µs
Quiet Period Interval	Integer	1–255	Indicates the responded interval between the start of two consecutive QTP periods, expressed in TUs.
Repetition Count	Integer	0–255	Indicates the number of responded QTP periods. A repetition count equal to 0 indicates the setup time of the QTP period is for a one time operation. Repetition count equal to 255 indicates the setup of the QTP period is canceled.
Service Specific Identifier	Integer	0–65 535	Indicates an identifier assigned by a peer-to-peer application to identify frame exchanges using peer-to-peer links

6.3.119.5.3 When generated

This primitive is generated by the MLME when the STA receives a QTP Response frame from the AP.

6.3.119.5.4 Effect of receipt

The SME is notified of the results of the QTP Request frame.

6.5 PLME SAP interface

6.5.6 PLME-TXTIME.confirm

6.5.6.2 Semantics of the service primitive

Change the 2nd paragraph as follows:

The TXTIME represents the time, in microseconds, required to transmit the PPDU described in the corresponding PLME-TXTIME.request primitive. If the calculated time includes a fractional microsecond and the TXVECTOR parameter FORMAT in the corresponding PLME-TXTIME.request primitive is not HE_SU, HE_MU, HE_TB or HE_ER_SU, a non-DMG STA rounds the TXTIME value to the next higher integer. A non-DMG STA does not round the TXTIME value up or down if the TXVECTOR parameter FORMAT in the corresponding PLME-TXTIME.request primitive is HE_SU, HE_MU, HE_TB or HE_ER_SU. A DMG STA does not round the TXTIME value up or down (see 20.11.3 (TXTIME calculation)).

8. PHY service specification

8.3 Detailed PHY service specifications

8.3.4 Basic service and options

8.3.4.2 PHY-SAP inter-(sub)layer service primitives

Insert a new last row in Table 8-2 as follows:

Table 8-2—PHY SAP inter-(sub)layer service primitives

Primitive	Request	Indication	Confirm
PHY-TRIGGER	X		

8.3.4.3 PHY SAP service primitives parameters

Change Table 8-3 as follows (inserting the new row at the end of the table):

Table 8-3—PHY SAP service primitive parameters

Parameter	Associated primitive	Value
STATE	PH-CCA.indication	(BUSY, [channel-list, per20bitmap]) (IDLE, [per20bitmap])
TRIGVECTOR	PHY-TRIGGER.request	A set of parameters

8.3.4.4 Vector descriptions

Change the 2nd and 3rd paragraph as follows:

The ~~Clause 19 (High-throughput (HT) PHY specification)~~ HT PHY TXVECTOR and RXVECTOR contain additional parameters related to the ~~operation of the Clause 19 (High-throughput (HT) PHY specification)~~ HT PHY modes of operation as described in 19.2 (HT PHY service interface). In certain modes of operation, the DATARATE parameter is replaced by MCS, CH_BANDWIDTH and GI_TYPE values. The mapping from these values to data rate is defined in 19.5 (Parameters for HT MCSs).

The ~~Clause 21 (Very high throughput (VHT) PHY specification)~~ VHT PHY TXVECTOR and RXVECTOR contain additional parameters related to the ~~operation of the Clause 21 (Very high throughput (VHT) PHY specification)~~ VHT PHY modes of operation as described in 21.2 (VHT PHY service interface). In certain modes of operation, the DATARATE parameter is replaced by MCS, CH_BANDWIDTH, NUM_STS, STBC and GI_TYPE values. The mapping from these values to data rate is defined 21.5 (Parameters for VHT-MCSs), where VHT-MCS is MCS and N_{SS} is NUM_STS / (STBC + 1)

Insert the following at the end of the subclause:

The HE PHY TXVECTOR and RXVECTOR contain additional parameters related to the HE PHY modes of operation as described in 27.2 (HE PHY service interface). In certain modes of operation, the DATA-RATE parameter is replaced by MCS, CH_BANDWIDTH, RU_ALLOCATION, NUM_STS, STBC, GI_-TYPE and DCM values. The mapping from these values to data rate is defined in 27.5 (Parameters for HE-MCSs), where HE-MCS is MCS and N_{SS} is NUM_STS / (STBC + 1).

The HE PHY TRIGVECTOR contains parameters for UL MU operation (see Table 27-2 (TRIGVECTOR parameters)).

8.3.5 PHY SAP detailed service specification

8.3.5.2 PHY-DATA.request

8.3.5.2.2 Semantics of the service primitive

Change the subclause as follows:

The primitive provides the following parameters:

PHY-DATA.request(
DATA,
USER_INDEX,
STA_INDEX
)

The DATA parameter is an octet of value X'00' to X'FF'.

The USER_INDEX parameter (typically identified as *u* for a VHT STA; see NOTE for MU usage at the end of Table 21-1 (TXVECTOR and RXVECTOR parameters)) is present for a VHT MU PPDU and indicates the index of the user in the TXVECTOR to which the accompanying DATA octet applies; otherwise, this parameter is not present.

The STA_INDEX parameter (identified as the STA_ID parameter; see STA_ID parameter in Table 27-1 (TXVECTOR and RXVECTOR parameters) and 26.11.1 (STA_ID)) is present for an HE MU PPDU; otherwise, this parameter is not present. If the TXVECTOR parameter UPLINK_FLAG is 0, this parameter indicates the STA or group of STAs that is the recipient of an RU to which the accompanying DATA octet applies. If the TXVECTOR parameter UPLINK_FLAG is 1, this parameter indicates the STA that is the transmitter of an RU to which the accompanying DATA octet applies.

8.3.5.3 PHY-DATA.indication

8.3.5.3.2 Semantics of the service primitive

Change the subclause as follows:

The primitive provides the following parameter:

PHY-DATA.indication(
DATA,
STA_INDEX
)

The DATA parameter is an octet of value X'00' to X'FF'.

The STA_INDEX parameter (identified as an AID of the transmitter of the DATA contained in an HE TB PPDU; see STA_ID parameter in Table 27-1 (TXVECTOR and RXVECTOR parameters)) is present for an

HE TB PPDU and indicates the STA of an RU from which the accompanying DATA octet applies; otherwise, this parameter is not present.

8.3.5.10 PHY-CCARESET.request

8.3.5.10.3 When generated

Insert the following after the 1st paragraph:

This primitive is also generated by the MAC sublayer for the local PHY entity when the spatial reuse conditions defined in 26.10 (Spatial reuse operation) are met.

8.3.5.12 PHY-CCA.indication

8.3.5.12.2 Semantics of the service primitive

Change the 1st paragraph as follows:

The primitive provides the following parameters:

PHY-CCA.indication(
STATE,
IPI-REPORT,
channel-list,
per20bitmap
)

Change Table 8-5 (The channel-list parameter elements) as follows (only modified rows shown):

Table 8-5—The channel-list parameter elements

channel-list element	Meaning
primary	In an HT STA that is ~~not~~ neither a VHT STA nor an HE STA, indicates that the primary 20 MHz channel is busy according to the rules specified in 19.3.19.5.2 (CCA-Energy Detect (CCA-ED)). In a VHT STA that is not an HE STA, indicates that the primary 20 MHz channel is busy according to the rules specified in 21.3.18.5.3 (CCA sensitivity for signals occupying the primary 20 MHz channel). In a TVHT STA, indicates that the primary channel is busy according to the rules specified in 22.3.18.6.3 (CCA sensitivity for signals occupying the primary channel). In an HE STA, indicates that the primary 20 MHz channel is busy according to the rules specified in 27.3.20.6.3 (CCA sensitivity for the primary 20 MHz channel).
secondary	In an HT STA that is ~~not~~ neither a VHT STA nor an HE STA, indicates that the secondary channel is busy according to the rules specified in 19.3.19.5.5 (CCA sensitivity in 40 MHz). In a VHT STA that is not an HE STA, indicates that the secondary 20 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In a TVHT STA, indicates that the secondary channel is busy according to the rules specified in 22.3.18.6.4 (CCA sensitivity for signals not occupying the primary channel). In an HE STA, indicates that the secondary 20 MHz channel is busy according to the rules specified in 27.3.20.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).
secondary40	In a VHT STA that is not an HE STA, indicates ~~Indicates~~ that the secondary 40 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In a TVHT STA, indicates that the secondary TVHT_2W channel is busy according to the rules specified in 22.3.18.6.4 (CCA sensitivity for signals not occupying the primary channel). In an HE STA, indicates that the secondary 40 MHz channel is busy according to the rules specified in 27.3.20.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).
secondary80	In a VHT STA that is not an HE STA, indicates ~~Indicates~~ that the secondary 80 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In an HE STA, indicates that the secondary 80 MHz channel is busy according to the rules specified in 27.3.20.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).

Insert the following at the end of the subclause:

If the STA is an HE STA with an operating channel width greater than 20 MHz, then the per20bitmap parameter is present; otherwise it is absent. If present, the per20bitmap parameter is a bitmap where each bit represents the busy/idle status of a 20 MHz subchannel in the operating channel width as defined in 27.3.20.6.5 (Per 20 MHz CCA sensitivity).

8.3.5.12.3 When generated

Change the 1st paragraph and remove the note as follows:

For Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHYs, this primitive is generated within aCCATime of the occurrence of a change in the status of the primary channel from channel idle to channel busy or from channel busy to channel idle or when the entries of the channel-list parameter change. For Clause 21 and Clause 22 PHYs, this primitive is generated when the status of the channel(s) changes from channel idle to channel busy or from channel busy to channel idle or when the entries of the channel-list parameter change. This includes the period of time when the PHY is receiving data. For Clause 27 PHYs, this primitive is generated when the status of the channel(s) changes from channel idle to channel busy or from channel busy to channel idle, when the entries of the channel-list parameter change, or when the per20bitmap parameter changes. The timing of PHY-CCA.indication primitives related to transitions on secondary channel(s) is PHY specific. Refer to specific PHY clauses for details about CCA behavior for a given PHY.

~~NOTE—For the VHT PHY, the timing information is omitted here and is defined in 21.3.18.5.~~

Insert a new subclause 8.3.5.16 at the end of 8.3.5:

8.3.5.16 PHY-TRIGGER.request

8.3.5.16.1 Function

This primitive is a request by the MAC sublayer to the local PHY entity to set parameters for the receipt of HE TB PPDU.

8.3.5.16.2 Semantics of the service primitive

The primitive provides the following parameter:

PHY-TRIGGER.request (
TRIGVECTOR
)

The TRIGVECTOR parameter provides the PHY with the information needed to demodulate of the expected HE TB PPDUs.

8.3.5.16.3 When generated

This primitive is issued by the MAC sublayer to the PHY entity after issuing PHY-TXSTART.request and before receiving HE TB PPDU.

8.3.5.16.4 Effect of receipt

The effect of receipt of this primitive by the PHY entity is to configure receiver module with parameters in TRIGVECTOR before HE TB PPDUs arrival.

9. Frame formats

9.2 MAC frame formats

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.3 Type and Subtype subfields

Change Table 9-1 (Valid type and subtype combinations) as follows:

Table 9-1—Valid type and subtype combinations

Type value B3 B2	Type description	Subtype value B7 B6 B5 B4	Subtype description
01	Control	0000 ~~0010~~0001	Reserved
01	Control	0010	Trigger
01	Control	0101	VHT/HE NDP Announcement

9.2.4.1.8 More Data subfield

Change paragraphs 3-4 as follows:

An AP optionally sets the More Data subfield to 1 in Ack frames sent to a non-DMG ~~and~~ non-S1G non-HE STA and in Ack, BlockAck and Multi-STA BlockAck frames sent to an HE STA. An HE AP indicates that it supports setting the More Data subfield to 1 in these control response frames by setting the More Data Ack subfield to 1 in the QoS Info field of elements it includes in frames transmitted to the STA.

The AP can set the More Data subfield to 1 to indicate that it has a pending transmission for the STA if it ~~from which it~~ has received a frame that contains a ~~QoS Capability element~~ QoS Info field in which the More Data Ack subfield is equal to 1 from the STA and ~~that has one or more ACs that are delivery enabled and that is in PS mode to indicate that the AP has a pending transmission for the STA~~ one of the following conditions is true:

— The STA is in PS mode and has one or more ACs that are delivery enabled (see 11.2.2.6 (AP operation during the CP)).

— The STA is in PS mode and is a TWT requester or a TWT scheduled STA (see 26.8 (TWT operation))

A TDLS peer STA optionally sets the More Data subfield to 1 in Ack frames sent to a non-HE STA and in Ack, BlockAck, and Multi-STA BlockAck frames sent to an HE STA. An HE TDLS peer STA indicates that it supports setting the More Data subfield to 1 in these control response frames by setting the More Data Ack subfield to 1 in the QoS Info field of the QoS Capability element it includes in frames transmitted to the STA.

The TDLS peer STA can set the More Data subfield to 1 to indicate that it has pending transmission for the STA if it has received from the STA a TDLS Setup Request frame or TDLS Setup Response frame ~~that has TDLS peer PSM enabled and~~ that has the More Data Ack subfield equal to 1 in the QoS Info field of the

QoS Capability element ~~of its transmitted TDLS Setup Request frame or TDLS Setup Response frame to indicate that it has a pending transmission for the STA.~~ and one of the following conditions is true:

— The STA has TDLS peer PSM enabled (see 11.2.3.6 (AP operation))
— The STA is in PS mode and is a TWT requester or a TWT scheduled STA (see 26.8 (TWT operation)).

9.2.4.1.10 +HTC subfield

Change as follows:

The +HTC subfield is 1 bit in length. The setting of the subfield is as follows:

— It is set to 1 in a QoS Data or Management frame transmitted with the FORMAT parameter of the TXVECTOR set to HT_GF, HT_MF, VHT, or S1G for to indicate that the frame contains an HT Control field.
— It is set to 1 in an RTS frame transmitted with the FORMAT parameter of the TXVECTOR set to S1G to indicate that the intended recipient of the frame has permission to extend the TXOP as described in 10.55.5.4 (Relay-shared TXOP protection mechanisms).
— It is set to 1 in a QoS Data or Management frame transmitted by a CMMG STA to indicate that the frame contains a CMMG variant HT Control field.
— It is set to 1 in a QoS Data, QoS Null, or Management frame transmitted by an HE STA to another HE STA to indicate that the frame contains an HT Control field.

Otherwise, the +HTC subfield is set to 0.

NOTE—The +HTC subfield is always set to 0 for frames transmitted by a DMG STA.

9.2.4.3 Address fields

9.2.4.3.5 DA field

Change as follows:

The DA field contains an IEEE MAC individual or group address that identifies the MAC entity or entities intended as the final recipient(s) of the MSDU (or fragment thereof) or A-MSDU (or fragment thereof), as defined in 9.3.2.1, contained in the frame body field.

9.2.4.3.6 SA field

Change as follows:

The SA field contains an IEEE MAC individual address that identifies the MAC entity from which the transfer of the MSDU (or fragment thereof) or A-MSDU (or fragment thereof), as defined in 9.3.2.1, contained in the frame body field was initiated. The Individual/Group bit is always transmitted as a 0 in the source address.

9.2.4.5 QoS Control field

9.2.4.5.2 TID subfield

Change the 1st paragraph as follows:

The TID subfield identifies the TC or TS to which the corresponding MSDU (or fragment thereof) or A-MSDU (or fragment thereof) in the Frame Body field belongs. The TID subfield also identifies the TC or TS of traffic for which a TXOP is being requested, through the setting of TXOP duration requested or queue size. The encoding of the TID subfield depends on the access policy (see 9.4.2.29 (TSPEC element)) and is shown in Table 9-12 (TID subfield). Additional information on the interpretation of the contents of this field appears in 5.1.1.3 (Interpretation of priority parameter in MAC service primitives).

9.2.4.5.4 Ack Policy Indicator subfield

Change Table 9-13 (Ack policy) as follows (only relevant rows shown):

Table 9-13—Ack policy

Ack policy	Bits in QoS Control field		Other conditions	Meaning
	Bit 5	Bit 6		
No Explicit Acknowledgment	0	1	Bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) is equal to 1 and the frame is not carried in an HE MU PPDU, HE SU PPDU or HE ER SU PPDU that contains a frame that solicits a response in an HE TB PPDU	There might be a response frame to the frame that is received, but it is neither the Ack frame nor any Data frame of subtype +CF-Ack. This ack policy is used for QoS CF-Poll and QoS CF-Ack +CF-Poll Data frames. NOTE—Bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) indicates the absence of a Frame Body field in a QoS Data frame. ~~When~~ If equal to 1, the QoS Data frame contains no Frame Body field, and any response is generated in response to a QoS CF-Poll or QoS CF-Ack +CF-Poll frame, but does not signify an acknowledgment of data.
PSMP Ack	0	1	Bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) is equal to 0 and the frame is not carried in an HE MU PPDU, HE SU PPDU or HE ER SU PPDU that contains a frame that solicits a response in an HE TB PPDU	The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP downlink transmission time (PSMP-DTT) is to be received in a later PSMP uplink transmission time (PSMP-UTT). The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP-UTT is to be received in a later PSMP-DTT. See 10.31.2.7 (PSMP acknowledgment rules).
HTP Ack	0	1	The frame is carried in an HE MU PPDU, HE SU PPDU or HE ER SU PPDU that contains a frame that solicits a response in an HE TB PPDU	The addressed recipient returns an Ack, Compressed BlockAck, or Multi-STA BlockAck frame carried in an HE TB PPDU a SIFS after the PPDU, subject to reception of a Trigger frame or TRS Control subfield in the PPDU, as defined in 10.3.3.13.2 (Acknowledgment procedure for DL MU PPDU in MU format) and 26.5.2 (UL MU operation).

9.2.4.5.6 Queue Size subfield

Replace 9.2.4.5.6 with the following:

The Queue Size subfield is an 8-bit field that indicates the amount of buffered traffic for a given TC or TS at the non-AP non-HE STA sending the frame that contains this subfield and the amount of buffered traffic for a given TC or TS at the non-AP HE STA for transmission to the HE STA identified by the receiver address of the frame that contains this subfield. The Queue Size subfield is present in QoS Data frames with bit 4 of the QoS Control field set to 1 sent by a non-AP STA and in QoS Null frames with bit 4 of the QoS Control field set to 1 sent by a non-AP HE STA. The AP might use information contained in the Queue Size subfield to determine the TXOP duration assigned to the STA or to determine the UL resources assigned to the non-AP HE STA (see 26.5.2 (UL MU operation)).

If sent by a non-HE STA or sent to a non-HE STA, the following apply:

— The queue size value is the approximate total size, rounded up to the nearest multiple of 256 octets and expressed in units of 256 octets, of all MSDUs and A-MSDUs buffered at the STA (excluding the MSDU or A-MSDU of the present QoS Data frame) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field.
— A queue size value of 0 is used solely to indicate the absence of any buffered traffic in the queue used for the specified TID.
— A queue size value of 254 is used for all sizes greater than 64 768 octets.
— A queue size value of 255 is used to indicate an unspecified or unknown size.

If sent by a non-AP HE STA to an HE STA, the remainder of the subclause applies.

The queue size, *QS*, is the approximate total size in octets, of all MSDUs and A-MSDUs buffered at the STA (including the MSDUs or A-MSDUs in the same PSDU as the frame containing the Queue Size subfield) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field.

NOTE 1—The queue size is based on data received by the STA at the MAC SAP (MA-UNITDATA.request).

NOTE 2—Buffered MSDUs are those that have been received in an MA-UNITDATA.request but that have not been successfully transmitted and have not been discarded.

The Queue Size subfield consists of a Scaling Factor subfield in B14–B15 of the QoS Control subfield and an unscaled value, *UV*, in B8–B13 of the QoS Control subfield. The Scaling Factor subfield provides the scaling factor, *SF*, with an encoding that is shown in Table 9-24e (Scaling Factor subfield encoding). A non-

AP HE STA sets the Queue Size subfield in a QoS frame it transmits as shown in Table 9-13a (Queue Size subfield encoding by a non-AP HE STA).

Table 9-13a—Queue Size subfield encoding by a non-AP HE STA

Queue Size subfields		Queue Size, *QS*
Scaling Factor	**UV**	
0	0	0
0	Ceil (*QS*, 16) / 16	0 < *QS* ≤ 1008
1	0	1008 < *QS* ≤ 1024
1	Ceil (*QS* – 1024, 256) / 256	1024 < *QS* ≤ 17 152
2	0	17 152 < *QS* ≤ 17 408
2	Ceil (*QS* – 17 408, 2048) / 2048	17 408 < *QS* ≤ 146 432
3	0	146 432 < *QS* ≤ 148 480
3	Ceil (*QS* – 148 480, 32 768) / 32 768	148 480 < *QS* ≤ 2 147 328
3	62	*QS* > 2 147 328
3	63	Unspecified or unknown

An HE STA obtains the queue size, *QS*, from a received QoS Control field, which contains a scaling factor and an unscaled value, as follows:

$$QS = \begin{cases} 16 \times UV\text{, if the Scaling Factor subfield is 0} \\ 1024 + 256 \times UV\text{, if the Scaling Factor subfield is 1} \\ 17\,408 + 2048 \times UV\text{, if the Scaling Factor subfield is 2} \\ 148\,480 + 32\,768 \times UV\text{, if the Scaling Factor subfield is 3 and UV subfield is < 62} \\ > 2\,147\,328\text{, if the Scaling Factor subfield is 3 and UV subfield is 62} \\ Unspecified\text{ or }Unknown\text{, if the Scaling Factor subfield is 3 and UV subfield is 63} \end{cases} \quad (9\text{-}0a)$$

The queue size value of QoS Data frames containing fragments might remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted (see 10.23.3.5.1 (General)). If the QoS Data frames containing fragments are carried in an A-MPDU, the queue size values of the MPDU containing the fragments are set according to the rules in 10.12.1 (A-MPDU contents).

9.2.4.6 HT Control field

9.2.4.6.1 General

Change the 1st and 2nd paragraphs as follows:

The HT Control field is always present in a Control Wrapper frame and is present in QoS Data, QoS Null and Management frames as determined by the +HTC subfield of the Frame Control field as defined in 9.2.4.1.10 (+HTC subfield).

NOTE—The only control frame subtype for which HT Control field is present is the Control Wrapper frame. A Control frame that is described as +HTC (e.g., an RTS+HTC, CTS+HTC, BlockAck+HTC or BlockAckReq+HTC frame) implies the use of the Control Wrapper frame to carry that Control frame.

The format of the HT Control field transmitted by a non-CMMG STA is ~~shown in Figure 9-11 (Non-CMMG variant HT Control field format)~~ defined in Table 9-13b (HT Control field format).

Remove Figure 9-11 (Non-CMMG variant HT Control field format).

Insert Table 9-13b (HT Control field format) as follows:

Table 9-13b—HT Control field format

Variant	B0	B1	B2–B29	B30	B31
HT	0	HT Control Middle		AC Constraint	RDG/More PPDU
VHT	1	0	VHT Control Middle	AC Constraint	RDG/More PPDU
HE	1	1	A-Control		

Change the 3rd and 4th paragraphs as follows:

The HT Control field transmitted by a non-CMMG STA has ~~two forms,~~three variants: the HT variant, ~~and~~ the VHT variant, and the HE variant. The variant formats are differentiated by the values of B0 and B1 as defined in Table 9-13b (HT Control field format). ~~The two forms differ in the format of the HT Control Middle subfield, described in 9.2.4.6.2 (HT variant) for the HT variant and in 9.2.4.6.3 (VHT variant) for the VHT variant and in the value of the VHT subfield.~~

The HT Control Middle subfield is defined in 9.2.4.6.2 (HT variant) and the VHT Control Middle subfield is defined in 9.2.4.6.3 (VHT variant). The A-Control subfield is defined in 9.2.4.6.3a (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:

In a non-S1G STA, the format of the VHT Control Middle subfield of the VHT variant HT Control field is shown in Figure 9-16 (VHT Control Middle subfield of the VHT variant HT Control field format).

Change Figure 9-15 as follows (remove Reserved field and change title):

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

Figure 9-16—VHT Control Middle subfield of the VHT variant HT Control field format

Insert a new subclause following 9.2.4.6.3:

9.2.4.6.3a HE variant

The format of the A-Control subfield of the HE variant HT Control field is shown in Figure 9-19a (A-Control subfield of the HE variant HT Control field format).

	Control List	Padding
Bits:	variable	0 or more

Figure 9-19a—A-Control subfield of the HE variant HT Control field format

The A-Control subfield is 30 bits in length.

The Control List subfield contains one or more Control subfields. The format of each Control subfield is shown in Figure 9-19b (Control subfield format).

	B0 B3	
	Control ID	Control Information
Bits:	4	variable

Figure 9-19b—Control subfield format

The Control ID subfield indicates the type of information carried in the Control Information subfield. The length of the Control Information subfield is fixed for each value of the Control ID subfield that is not reserved. The values of the Control ID subfield and the associated length of the Control Information subfield are defined in Table 9-22a (Control ID subfield values).

Table 9-22a—Control ID subfield values

Control ID value	Meaning	Length of the Control Information subfield (bits)	Content of the Control Information subfield
0	Triggered response scheduling (TRS)	26	See 9.2.4.6a.1 (TRS Control)
1	Operating mode (OM)	12	See 9.2.4.6a.2 (OM Control)
2	HE link adaptation (HLA)	26	See 9.2.4.6a.3 (HLA Control)
3	Buffer status report (BSR)	26	See 9.2.4.6a.4 (BSR Control)
4	UL power headroom (UPH)	8	See 9.2.4.6a.5 (UPH Control)
5	Bandwidth query report (BQR)	10	See 9.2.4.6a.6 (BQR Control)
6	Command and status (CAS)	8	See 9.2.4.6a.7 (CAS Control))
7-14	Reserved		
15	Ones need expansion surely (ONES)	26	See 10.8 (HT Control field operation)

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

Insert a new subclause following 9.2.4.6 as follows:

9.2.4.6aControl subfield variants of an A-Control subfield

9.2.4.6a.1 TRS Control

The Control Information subfield in a TRS Control subfield contains triggered response scheduling (TRS) information for soliciting an HE TB PPDU that follows an HE MU PPDU, HE SU PPDU or HE ER SU PPDU carrying the Control subfield (see 26.5.2.2 (Rules for soliciting UL MU frames)). See 26.5.2.4 (A-MPDU contents in an HE TB PPDU) for details on allowed content in an A-MPDU carried in an HE TB PPDU. The format of the subfield is shown in Figure 9-22a (Control Information subfield format in a TRS Control subfield).

	B0 B4	B5 B12	B13 B17	B18 B22	B23 B24	B25
	UL Data Symbols	RU Allocation	AP Tx Power	UL Target RSSI	UL HE-MCS	Reserved
Bits:	5	8	5	5	2	1

Figure 9-22a—Control Information subfield format in a TRS Control subfield

The UL Data Symbols subfield indicates the number of OFDM symbols in the Data field of the HE TB PPDU response and is set to the number of OFDM symbols minus 1.

The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE TB PPDU response and the encoding is defined in Table 9-31h (B7–B1 of the RU Allocation subfield).

The AP Tx Power subfield indicates, in units of dBm, the AP's combined transmit power at the antenna connectors of all the transmit antennas used to transmit the triggering PPDU, and normalized to 20 MHz bandwidth. The transmit power, P_{TX}, is calculated as $P_{TX} = –20 + 2×F_{Val}$, where F_{Val} is the value of the AP Tx Power subfield, except for the value 31, which is reserved.

The UL Target RSSI subfield indicates, in units of dBm, the expected receive power at the AP (i.e., averaged RSSI over all the AP's antennas) for the HE portion of the HE TB PPDU transmitted on the assigned RU. The target receive power is calculated as $Target_{RSSI} = –90 + 2×F_{Val}$, where F_{Val} is the value of the UL Target RSSI subfield, except that the value 31 indicates to the STA to transmit at maximum power for the assigned HE-MCS.

NOTE—It is possible that a STA is unable to satisfy the target RSSI due to its hardware or regulatory limitation (see 27.3.15.2 (Power pre-correction)).

The UL HE-MCS subfield indicates the HE-MCS, in the range HE-MCS 0 to 3, to be used by the receiving STA for the HE TB PPDU is set to the HE-MCS index (see 27.5 (Parameters for HE-MCSs)).

9.2.4.6a.2 OM Control

The Control Information subfield in an OM Control subfield contains information related to the operating mode (OM) change of the STA transmitting the frame containing this information (see 26.9 (Operating mode indication)). The format of the subfield is shown in Figure 9-22b (Control Information subfield format in an OM Control subfield).

	B0 B2	B3 B4	B5	B6 B8	B9	B10	B11
	Rx NSS	Channel Width	UL MU Disable	Tx NSTS	ER SU Disable	DL MU-MIMO Resound Recommendation	UL MU Data Disable
Bits:	3	2	1	3	1	1	1

Figure 9-22b—Control Information subfield format in an OM Control subfield

If the operating channel width of the STA is greater than 80 MHz, then the Rx NSS subfield indicates the maximum number of spatial streams, N_{SS}, that the STA supports in reception for PPDU bandwidths less than or equal to 80 MHz and is set to $N_{SS} – 1$. If the operating channel width of the STA is less than or equal to 80 MHz, then the Rx NSS subfield indicates the maximum number of spatial streams, N_{SS}, that the STA supports in reception and is set to $N_{SS} – 1$.

If the operating channel width of the STA is greater than 80 MHz, then the maximum number of spatial streams that the STA supports in reception for PPDU bandwidths greater than 80 MHz is defined in 26.9 (Operating mode indication).

The Channel Width subfield indicates the operating channel width supported by the STA for both reception and transmission. It is set to 0 for 20 MHz, 1 for primary 40 MHz, 2 for primary 80 MHz, and 3 for 160 MHz and 80+80 MHz. The value 0 indicates a primary 20 MHz, unless the STA is an HE SST STA in which case it indicates any of the negotiated 20 MHz subchannels of the SST operation (see 26.8.7 (HE subchannel selective transmission)).

The allowed UL MU operations and frame types that can be transmitted as a response to a Trigger frame or a frame carrying a TRS Control subfield are determined by the UL MU Disable subfield, UL MU Data Disable subfield and the recipient's setting of the OM Control UL MU Data Disable RX Support subfield in the HE Capabilities element, as indicated in Table 9-24a (UL MU Disable and UL MU Data Disable subfields encoding).

If the OM Control field is transmitted by an HE AP, then the UL MU Disable and UL MU Data Disable subfields are reserved.

Table 9-24a—UL MU Disable and UL MU Data Disable subfields encoding

UL MU Disable subfield	UL MU Data Disable subfield	Interpretation by an AP that transmits a value of 0 in the OM Control UL MU Data Disable RX Support	Interpretation by an AP that transmits a value of 1 in the OM Control UL MU Data Disable RX Support
0	0	All trigger based UL MU transmissions are enabled by the STA as defined in 26.5.2 (UL MU operation).	All trigger based UL MU transmissions are enabled by the STA as defined in 26.5.2 (UL MU operation).
0	1	N/A	Trigger based UL MU Data frame transmissions in response to a Basic Trigger frame are suspended by the STA as defined in 26.9.3 (Transmit operating mode (TOM) indication). Other trigger based UL MU transmissions remain enabled by the STA as defined in 26.9.3 (Transmit operating mode (TOM) indication).
1	0	All trigger based UL MU transmissions are suspended by the STA. The STA will not respond to a received Trigger frame or MPDU containing a TRS Control subfield.	All trigger based UL MU transmissions are suspended by the STA. The STA will not respond to a received Trigger frame or MPDU containing a TRS Control subfield.
1	1	Reserved	Reserved

The Tx NSTS subfield indicates the maximum number of space-time streams, N_{STS}, that the STA supports in transmission and is set to $N_{STS} – 1$.

A non-AP HE STA sets the ER SU Disable subfield to 1 to indicate that 242-tone HE ER SU PPDU reception is disabled and to 0 to indicate that 242-tone HE ER SU PPDU reception is enabled. If the OM Control field is transmitted by an HE AP, then the ER SU Disable subfield is reserved.

A non-AP HE STA sets the DL MU-MIMO Resound Recommendation subfield to 1 to indicate that the STA suggests that the AP either resound the channel or increase the channel sounding frequency with the STA. The subfield is set to 0 to indicate that the non-AP HE STA has no recommendation on the AP channel sounding frequency. If the OM Control field is transmitted by an HE AP, then the DL MU-MIMO Resound Recommendation subfield is reserved.

9.2.4.6a.3 HLA Control

The Control Information subfield in an HLA Control subfield contains information related to the HE link adaptation (HLA) procedure (see 26.13 (Link adaptation using the HLA Control subfield)). The format of the subfield is shown in Figure 9-22c (Control Information subfield format in an HLA Control subfield).

	B0	B1	B2 B4	B5 B8	B9	B10 B17
	Unsolicited MFB	MRQ	NSS	HE-MCS	DCM	RU Allocation
Bits:	1	1	3	4	1	8

	B18 B19	B20 B22	B23	B24	B25
	BW	MSI/Partial PPDU Parameters	Tx Beam-forming	UL HE TB PPDU MFB	Reserved
Bits:	2	3	1	1	1

Figure 9-22c—Control Information subfield format in an HLA Control subfield

The HLA Control subfields are defined in Table 9-24b (HLA Control subfields).

Table 9-24b—HLA Control subfields

Subfield	Meaning	Definition
Unsolicited MFB	Unsolicited MFB indicator	Set to 1 if the HLA Control is an unsolicited MFB. Set to 0 if the HLA Control is an MRQ or a solicited MFB.
MRQ	HLA feedback request indicator	Set to 1 and set Unsolicited MFB subfield to 0 to request an HLA feedback. Set to 0 and set Unsolicited MFB subfield to 0 to respond an HLA request. If the Unsolicited MFB subfield is 1, the MRQ subfield is reserved.
NSS	Recommended number of spatial stream	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the NSS subfield indicates the recommended number of spatial streams to the PPDU sent to the STA, N_{SS}, and is set to $N_{SS} - 1$. If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 1, the NSS subfield indicates the recommended number of spatial streams to the HE TB PPDU sent from the STA, N_{SS}, and is set to $N_{SS} - 1$. Otherwise, this subfield is reserved.

Table 9-24b—HLA Control subfields *(continued)*

Subfield	Meaning	Definition
HE-MCS	Recommended HE-MCS	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the HE-MCS subfield indicates the recommended HE-MCS of the PPDU sent to the STA, and is set to the HE-MCS index (see 27.5 (Parameters for HE-MCSs)). If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 1, the HE-MCS subfield indicates the recommended HE-MCS of the HE TB PPDU sent from the STA, and is set to the HE-MCS index (see 27.5 (Parameters for HE-MCSs)). Otherwise, this subfield is reserved.
DCM	Recommended usage of dual carrier modulation (DCM)	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the DCM subfield indicates the recommended usage of DCM. This subfield is set to 1 if DCM is recommended to the PPDU sent to the STA and is set to 0 otherwise. If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 1, the DCM subfield indicates the recommended usage of DCM. This subfield is set to 1 if DCM is recommended to the HE TB PPDU sent from the STA and is set to 0 otherwise. Otherwise, this subfield is reserved.
RU Allocation	RU of the recommended HE-MCS/RU specified by MFB requester to get feedback	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0, the RU Allocation subfield indicates the RU for which the recommended HE-MCS applies to the PPDU sent to the STA, as defined in 26.13 (Link adaptation using the HLA Control subfield). If the Unsolicited MFB subfield is 0 and the MRQ subfield is 1, the RU subfield indicates the RU requested by the MFB requester to get feedback. The RU Allocation subfield is interpreted with the BW subfield to specify the RU. The RU index encoding is as defined in Table 9-31h (B7–B1 of the RU Allocation subfield). If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 1, the RU Allocation subfield indicates the RU for which the recommended HE-MCS applies to the HE TB PPDU sent from the STA, as defined in 26.13 (Link adaptation using the HLA Control subfield) and that the actual allocation of the RU can be ignored by the recipient. Otherwise, this subfield is reserved.

Table 9-24b—HLA Control subfields *(continued)*

Subfield	Meaning	Definition
BW	Bandwidth of the recommended HE-MCS/Bandwidth specified by MFB requester to get feedback	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0, the BW subfield indicates the bandwidth for which the recommended HE-MCS applies to the PPDU sent to the STA, as defined in 26.13 (Link adaptation using the HLA Control subfield). If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 1, the BW subfield indicates the bandwidth for which the recommended HE-MCS applies to the HE TB PPDU sent from the STA, as defined in 26.13 (Link adaptation using the HLA Control subfield). If the Unsolicited MFB subfield is 0 and the MRQ subfield is 1, the BW subfield indicates the bandwidth requested by the MFB requester to get feedback. Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz
MSI/Partial PPDU Parameters	Partial parameters of the measured PPDU/ MRQ sequence identifier	If the Unsolicited MFB subfield is 0 and the MRQ subfield is 1, the MSI/Partial PPDU Parameters subfield contains a sequence number in the range 0 to 6 that identifies the specific HE-MCS feedback request. If the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the MSI/Partial PPDU Parameters subfield contains a sequence number in the range 0 to 6 that responds to the specific solicited HE-MCS feedback request. If the Unsolicited MFB subfield is 1, the MSI/Partial PPDU Parameters subfield contains the PPDU Format and Coding Type subfields as shown in Figure 9-22d (MSI/Partial PPDU Parameters subfield format if the Unsolicited MFB subfield is 1).
Tx Beamforming	Transmission type of the measured PPDU	If the Unsolicited MFB subfield is 1 and the UL HE TB PPDU MFB subfield is 0, then the Tx Beamforming subfield indicates whether or not the PPDU from which the unsolicited MFB was estimated is beamformed. Set to 0 for non-beamformed PPDU Set to 1 for beamformed PPDU Otherwise, this subfield is reserved.
UL HE TB PPDU MFB	UL HE TB PPDU MFB indication	If the Unsolicited MFB subfield is 1, a value of 1 in this subfield indicates that the NSS, HE-MCS, DCM, BW and RU Allocation fields represent the recommended MFB for the HE TB PPDU sent from the STA as defined in 26.13 (Link adaptation using the HLA Control subfield). Otherwise, this subfield is reserved.

The format of the MSI/Partial PPDU Parameters subfield is defined in Figure 9-22d (MSI/Partial PPDU Parameters subfield format if the Unsolicited MFB subfield is 1).

	B0 B1	B2
	PPDU Format	Coding Type
Bits:	2	1

Figure 9-22d—MSI/Partial PPDU Parameters subfield format if the Unsolicited MFB subfield is 1

The PPDU Format subfield indicates the format of the PPDU from which the unsolicited MFB was estimated:

- Set to 0 for an HE SU PPDU
- Set to 1 for an HE MU PPDU
- Set to 2 for an HE ER SU PPDU
- Set to 3 for an HE TB PPDU

The Coding Type subfield contains the coding information of the PPDU from which the unsolicited MFB was estimated:

- Set to 0 for BCC
- Set to 1 for LDPC

9.2.4.6a.4 BSR Control

The Control Information subfield in a BSR Control subfield contains buffer status information used for UL MU operation (see 26.5.3 (MU cascading sequence)). The format of the subfield is shown in Figure 9-22e (Control Information subfield format in a BSR Control subfield).

	B0 B3	B4 B5	B6 B7	B8 B9	B10 B17	B18 B25
	ACI Bitmap	Delta TID	ACI High	Scaling Factor	Queue Size High	Queue Size All
Bits:	4	2	2	2	8	8

Figure 9-22e—Control Information subfield format in a BSR Control subfield

The ACI Bitmap subfield indicates the access categories for which the buffer status is reported and its encoding is shown in Table 9-24c (ACI Bitmap subfield encoding). Each bit of the ACI Bitmap subfield is set to 1 to indicate that the buffer status of the corresponding AC is included in the Queue Size All subfield, and set to 0 otherwise, except that if the ACI Bitmap subfield is 0 and the Delta TID subfield is 3 then it indicates the buffer status of all 8 TIDs (see Table 9-24d (Delta TID subfield encoding)).

Table 9-24c—ACI Bitmap subfield encoding

B0	B1	B2	B3
AC_BE	AC_BK	AC_VI	AC_VO

The Delta TID subfield, together with the values of the ACI Bitmap subfield, indicate the number of TIDs for which the STA is reporting the buffer status. The encoding of the Delta TID subfield is defined in Table 9-24d (Delta TID subfield encoding).

Table 9-24d—Delta TID subfield encoding

Number of bits in the ACI Bitmap subfield that are set to 1	Mapping of Delta TID subfield value and number of TIDs, N_{TID}
0	Values 0 to 2 are not applicable; Value 3 indicates 8 TIDs (i.e., all ACs have traffic)
1	Value 0 indicates 1 TID; Value 1 indicates 2 TIDs; Values 2 to 3 are not applicable;
2	Value 0 indicates 2 TID; Value 1 indicates 3 TIDs; Value 2 indicates 4 TIDs; Value 3 is not applicable;
3	Value 0 indicates 3 TID; Value 1 indicates 4 TIDs; Value 2 indicates 5 TIDs; Value 3 indicates 6 TIDs;
4	Value 0 indicates 4 TID; Value 1 indicates 5 TIDs; Value 2 indicates 6 TIDs; Value 3 indicates 7 TIDs;
NOTE 1—The number of TIDs can be obtained as $N_{TID} = N_{ones} + D_{Val}$, where N_{ones} is the number of bits set to one in the AC Bitmap subfield, and D_{Val} is the value of the Delta TID subfield except if N_{ones} is equal to 0 for which there is the $N_{TID} = 8$ case. NOTE 2—The Delta TID might be used by an AP to determine the setting of the TID Aggregation Limit field in the User Info field addressed to the STA in a subsequent Basic Trigger frame.	

The ACI High subfield indicates the ACI of the AC for which the BSR is indicated in the Queue Size High subfield. The ACI to AC mapping is shown in Table 9-154 (ACI-to-AC coding).

NOTE—It is up to the non-AP STA that reports the buffer status to determine the queue that deserves higher priority with respect to the other queues. The determination might be based on the time the traffic has been outstanding, QoS delay requirements, amount of buffered traffic, etc., and is out of scope for this standard.

The Scaling Factor subfield indicates the unit *SF*, in octets, of the Queue Size High and Queue Size All subfields. The encoding of the Scaling Factor subfield is shown in Table 9-24e (Scaling Factor subfield encoding).

Table 9-24e—Scaling Factor subfield encoding

Scaling Factor subfield	Scaling factor, *SF*, in octets
0	16
1	256
2	2 048
3	32 768

The Queue Size High subfield indicates the amount of buffered traffic, in units of *SF* octets, for the AC identified by the ACI High subfield that is intended for the STA identified by the receiver address of the frame containing the BSR Control subfield.

The Queue Size All subfield indicates the amount of buffered traffic, in units of *SF* octets, for all the ACs identified by the ACI Bitmap subfield that is intended for the STA identified by the receiver address of the frame containing the BSR Control subfield.

The queue size values in the Queue Size High and Queue Size All subfields are the total sizes, rounded up to the nearest multiple of *SF* octets, of all MSDUs and A-MSDUs buffered at the STA (including the MSDUs or A-MSDUs in the same PSDU as the frame containing the BSR Control subfield) in the delivery queues used for MSDUs and A-MSDUs with AC(s) that are specified in the ACI High and ACI Bitmap subfields, respectively.

NOTE 1—The queue size is based on data received by the STA at the MAC SAP (MA-UNITDATA.request). Any data in layers above the MAC is not taken into account.

NOTE 2—Buffered MSDUs are those that have been received in an MA-UNITDATA.request but that have not been successfully transmitted and have not been discarded.

A queue size value of 254 in the Queue Size High and Queue Size All subfields indicates that the amount of buffered traffic is greater than 254 × *SF* octets. A queue size value of 255 in the Queue Size High and Queue Size All subfields indicates that the amount of buffered traffic is an unspecified or unknown size.

The queue size value of the QoS Data frames containing the fragments might remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted (see 10.23.3.5.1 (General)). If the QoS Data frames containing fragments are carried in the A-MPDU, the queue size values of the MPDUs containing the fragments are set according to the rules in 10.18 (HT Control field operation).

9.2.4.6a.5 UPH Control

The Control Information subfield in an UPH Control subfield contains the UL power headroom (UPH) used for power pre-correction (see 26.5.2.4 (A-MPDU contents in an HE TB PPDU)). The format of the subfield is shown in Figure 9-22f (Control Information subfield format in a UPH Control subfield).

The UL Power Headroom subfield indicates the available UL power headroom, in units of dB, for the current HE-MCS (see 26.5.2.4 (A-MPDU contents in an HE TB PPDU)). The UL Power Headroom subfield carries a value 0 to 31 that maps to 0 dB to 31 dB.

	B0 B4	B5	B6 B7
	UL Power Headroom	Minimum Transmit Power Flag	Reserved
Bits:	5	1	2

Figure 9-22f—Control Information subfield format in a UPH Control subfield

The Minimum Transmit Power Flag subfield is set to 1 to indicate that the minimum transmit power for the current HE-MCS is reached by the STA and set to 0 otherwise.

9.2.4.6a.6 BQR Control

The Control Information subfield in a BQR Control subfield contains the bandwidth query report (BQR) used for bandwidth query report operation to assist HE MU transmission (see 26.5.2 (UL MU operation)). The format of the subfield is shown in Figure 9-22g (Control Information subfield format in a BQR Control subfield).

	B0 B7	B8 B9
	Available Channel Bit-map	Reserved
Bits:	8	2

Figure 9-22g—Control Information subfield format in a BQR Control subfield

The Available Channel Bitmap subfield contains a bitmap indicating the subchannels available at the STA transmitting the BQR. Each bit in the bitmap corresponds to a 20 MHz subchannel within the operating channel width of the BSS in which the STA is associated, with the LSB corresponding to the lowest numbered operating subchannel of the BSS. The bit in position X in the bitmap is set to 1 to indicate that the subchannel $X + 1$ is idle; otherwise it is set to 0 to indicate that the subchannel is busy or unavailable. Availability of each 20 MHz subchannel is based on the ED-based CCA defined in 27.3.20.6.5 (Per 20 MHz CCA sensitivity) and is reported for the 20 MHz subchannels located in the operating channel of the reporting STA when the WM is idle as defined in 10.3.2.1 (CS mechanism) and in 26.5.2.5 (UL MU CS mechanism).

9.2.4.6a.7 CAS Control

The Control Information subfield in a CAS Control subfield contains the command and status (CAS) control. The format of the subfield frame is shown in Figure 9-22h (Control Information subfield format in a CAS Control subfield).

	B0	B1	B2	B3 B7
	AC Constraint	RDG/More PPDU	PSRT PPDU	Reserved
Bits:	1	1	1	5

Figure 9-22h—Control Information subfield format in a CAS Control subfield

The AC Constraint subfield is defined in Table 9-14 (AC Constraint subfield values), except that a value of 1 indicates to an HE STA that the response can contain RD Data frames from the same AC or higher priority ACs as defined in 10.29.4 (Rules for RD responder).

The RDG/More PPDU subfield is defined in Table 9-15 (RDG/More PPDU subfield values).

The PSRT PPDU subfield indicates whether or not the PPDU carrying the frame with the CAS Control subfield is an PSRT PPDU. The PSRT PPDU subfield is set to 1 if the PPDU is an PSRT PPDU; otherwise it is set to 0.

9.2.4.7 Frame Body field

9.2.4.7.1 General

Change as Table 9-25 (Maximum data unit sizes (in octets) and durations (in microseconds)) follows:

Table 9-25—Maximum data unit sizes (in octets) and durations (in microseconds)

	Non-HT non-VHT non-HE non-S1G non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	S1G PPDU	DMG PPDU
MMPDU size	2304	2304	See NOTE 1	See NOTE 1	See NOTE 1	2304
MSDU size	2304	2304	2304	2304	2304	7920
A-MSDU size	3839 or 4065 (see NOTE 2) (HT STA, see also Table 9-185 (Subfields of the HT Capability Information field)), or N/A (non-HT STA, see also 10.11 (A-MSDU operation))	3839 or 7935 (see also Table 9-185 (Subfields of the HT Capability Information field))	See NOTE 3	2.4 GHz band: 3839 or 7935 (see also Table 9-185 (Subfields of the HT Capability Information field)) Otherwise: see NOTE 3	See NOTE 3	7935

Table 9-25—Maximum data unit sizes (in octets) and durations (in microseconds) *(continued)*

	Non-HT non-VHT non-HE non-S1G non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	S1G PPDU	DMG PPDU
MPDU size	See NOTE 4	See NOTE 5	3895 or 7991 or 11 454 (see also Table 9-273 (Subfields of the VHT Capabilities Information field))	2.4 GHz band: see NOTE 5 Otherwise: 3895 or 7991 or 11 454 (see also Table 9-273 (Subfields of the VHT Capabilities Information field)). See NOTE 7.	3895 or 7991 (see also Table 9-302 (Subfields of the S1G Capabilities Information field))	See NOTE 5
PSDU size	2^{12}–1 (see Table 15-5 (DSSS PHY characteristics), Table 16-4 (HR/DSSS PHY characteristics), Table 17-21 (OFDM PHY characteristics), Table 18-5 (ERP characteristics))	2^{16}–1 (see Table 19-25 (HT PHY characteristics))	4 692 480 (~$2^{22.16}$) (see Table 21-29 (VHT PHY characteristics))	6 500 631 (~$2^{22.63}$) (see Table 27-55 (HE PHY characteristics))	797 160 (~$2^{19.60}$) (see Table 23-37 (S1G PHY characteristics))	2^{18}–1 (see Table 20-32 (DMG PHY characteristics))

Table 9-25—Maximum data unit sizes (in octets) and durations (in microseconds) *(continued)*

	Non-HT non-VHT non-HE non-S1G non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	S1G PPDU	DMG PPDU
PPDU duration	See NOTE 6	5484 (HT_MF; see 10.28.4 (L_LENGTH and L_DATARATE parameter values for HT-mixed format PPDUs)) or 10 000 (HT_GF; see Table 19-25 (HT PHY characteristics))	5484 (see Table 21-29 (VHT PHY characteristics))	5484 (see Table 27-55 (HE PHY characteristics))	27 840 (see Table 23-37 (S1G PHY characteristics))	2000 (see Table 20-32 (DMG PHY characteristics))

NOTE 1—No direct constraint on the maximum MMPDU size; indirectly constrained by the maximum MPDU size (see 9.3.3.2 (Beacon frame format)).

NOTE 2—Indirect constraint from the maximum PSDU size: 2^{12}–1 octets minus the minimum QoS Data frame overhead (26 octets for the MAC header and 4 octets for the FCS).

NOTE 3—No direct constraint on the maximum A-MSDU size; indirectly constrained by the maximum MPDU size.

NOTE 4—No direct constraint on the maximum MPDU size; indirectly constrained by the maximum MSDU/MMPDU or (for HT STAs only) A-MSDU size.

NOTE 5—No direct constraint on the maximum MPDU size; indirectly constrained by the maximum A-MSDU size.

NOTE 6—No direct constraint on the maximum duration, but an L_LENGTH value above 2332 might not be supported by some receivers (see last NOTE in 10.27.4 (L_LENGTH and L_DATARATE parameter values for HT-mixed format PPDUs)).

NOTE 7—The maximum MPDU size might be greater than the size declared as supported by the recipient if the MPDU is an HE Compressed Beamforming/CQI frame.

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 the 2nd paragraph as follows:

The STA selects between single and multiple protection when it transmits the first frame of a TXOP. All subsequent frames transmitted by the STA in the same TXOP use the same class of duration settings. A STA always uses multiple protection in a TXOP that includes:

- Frames that have the RDG/More PPDU subfield equal to 1
- PSMP frames
- VHT/HE NDP Announcement frames ~~or~~, Beamforming Report Poll frames or BFRP Trigger frames
- S1G Beacon frames
- Frames transmitted by an S1G STA with the TXVECTOR parameter RESPONSE INDICATION equal to Long Response

Change item a) of the 3rd paragraph 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 and is not part of a BDT 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 Trigger frame, the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame(s), plus one CTS frame, plus the time to transmit the solicited HE TB PPDU if required, plus the time to transmit the acknowledgment for the solicited HE TB PPDU if required, plus applicable IFSs.

NOTE—The pending frame(s) include a triggering frame if required.

...

3 In a BlockAckReq frame, the Duration/ID field is set to the estimated time required to transmit one Ack or BlockAck frame, as applicable, plus one SIFS.

3a In an MU-BAR Trigger frame, BSRP Trigger frame, GCR MU-BAR Trigger frame, BQRP Trigger frame, and NFRP Trigger frame, the Duration/ID field is set to the time required to transmit the solicited HE TB PPDU plus one SIFS.

...

6) In individually addressed QoS Data frames with an ack policy of No Ack or Block Ack, for Action No Ack frames, and for group addressed frames, the Duration/ID field is set to one of the following:

i) If the frame is the final frame of the TXOP, 0

ii) Otherwise, the estimated time required for the transmission of the following frame and its response frame, if required (including appropriate IFSs)

7) In a Basic Trigger frame, the Duration/ID field is set to the estimated time required to transmit the solicited HE TB PPDU, plus the estimated time required to transmit the acknowledgment for the solicited HE TB PPDU if required, plus applicable SIFSs.

Change item b) of the 3rd paragraph as follows:

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

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

where

$T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 10.23.2.9 (TXOP limits) (for a TXOP limit of 0), including applicable IFS durations

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

—Pending MPDUs~~ of the same AC~~

—Any associated immediate response frames

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

—Applicable IFSs

—Any RDG

—Any BDT

—Any pending QoS Null frame exchanges by paged STAs

—Any pending PS-Poll or NDP PS-Poll frame exchanges by paged STAs

T_{TXOP} is the duration given by dot11EDCATableTXOPLimit (dot11QAPEDCATableTXOPLimit 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

NOTE 1—The rules allowing or disallowing the transmission of MPDUs with different ACs are described in 10.22.2.6 (Sharing an EDCA TXOP), 10.22.2.7 (Multiple frame transmission in an EDCA TXOP), and 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU).

NOTE 2—The estimated time to transmit an acknowledgment in response to the frames carried in a solicited HE TB PPDU might be inexact. The TXOP holder might use the maximum time required to transmit the acknowledgment as the estimated time.

9.2.5.7 Setting for control response frames

Change paragraphs 1-4 as follows:

This subclause describes how to set the Duration/ID field for CTS, Ack, and BlockAck frames transmitted by a QoS STA.

In a CTS frame that is not part of a dual CTS sequence transmitted in response to an RTS frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the RTS frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the RTS frame and the end of the PPDU carrying the CTS frame.

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

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

In a BlockAck frame transmitted in response to a BlockAckReq frame, MU-BAR Trigger frame, ~~or transmitted in response to a~~ frame containing an implicit block ack request, or frame carried in HE TB PPDU under single protection settings, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the BlockAck frame.

Under multiple protection settings, the Duration/ID field in a BlockAck frame transmitted in response to a frame carried in HE TB PPDU is set according to the multiple protection settings defined in 9.2.5.2 (Setting for single and multiple protection under enhanced distributed channel access (EDCA)).

9.2.5.8 Setting for other response frames

Change as follows:

In any frame transmitted by a STA that is not the TXOP holder and is not specified by 9.2.5.1 (General) to 9.2.5.7 (Setting for control response frames), the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the frame. If the

<u>frame is contained in an HE TB PPDU, the time is equal to SIFS plus the duration of the HE TB PPDU, where the duration of the HE TB PPDU is defined in Equation (27-134).</u>

9.3 Format of individual frame types

9.3.1 Control frames

9.3.1.2 RTS frame format

Change the 3rd paragraph as follows:

The TA field is the address of the STA transmitting the RTS frame or the bandwidth signaling TA of the STA transmitting the RTS frame. In an RTS frame transmitted by a VHT STA<u> or an HE STA</u> in a non-HT or non-HT duplicate format to another VHT STA<u> or HE STA</u>, the scrambling sequence carries the TXVECTOR parameters CH_BANDWIDTH_IN_NON_HT and DYN_BANDWIDTH_IN_NON_HT (see 10.3.2.8 (VHT and S1G RTS procedure)) and the TA field is a bandwidth signaling TA.

9.3.1.3 CTS frame format

Change the 2nd paragraph of this subclause as follows:

~~When~~ <u>If</u> 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 set to 0. ~~When~~ <u>If</u> the CTS frame is the first frame in a frame exchange, the RA field is set to the MAC address of the transmitter. <u>If the CTS frame is a response to an MU-RTS Trigger frame, the value of the RA field of the CTS frame is set to the address from the TA field of the MU-RTS Trigger frame.</u>

9.3.1.5 PS-Poll frame format

Change the 2nd paragraph as follows:

The BSSID (RA) is set to the address of the STA contained in the AP. The TA field value is the address of the STA transmitting the frame or a bandwidth signaling TA. In a PS-Poll frame transmitted by a VHT STA <u>or an HE STA</u> in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA.

9.3.1.6 CF-End frame format

Change the last paragraph as follows:

~~When~~ <u>If</u> transmitted by a non-DMG STA, the BSSID (TA) field is the address of the STA contained in the AP except that the Individual/Group bit of the BSSID (TA) field is set to 1 in a CF-End frame transmitted by a VHT STA to a VHT AP <u>or an HE STA to an HE AP</u> in a non-HT or non-HT duplicate format to indicate that the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT. ~~When~~ <u>If</u> transmitted by a DMG STA, the TA field is the MAC address of the STA transmitting the frame.

9.3.1.7 BlockAckReq frame format

9.3.1.7.1 Overview

Change the 4th paragraph as follows:

The TA field value is the address of the STA transmitting the BlockAckReq frame or a bandwidth signaling TA. In a BlockAckReq frame transmitted by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA.

Change Figure 9-36 (BAR Control field format) as follows:

	B0	~~B1~~	~~B2~~	~~B3~~ ~~B4~~	B1 B4	B5 B11	B12 B15
	BAR Ack Policy	~~Multi-TID~~	~~Compressed Bitmap~~	~~GCR Mode~~	BAR Type	Reserved	TID_INFO
Bits:	1	~~1~~	~~1~~	~~2~~	4	7	4

Figure 9-36—BAR Control field format

Replace the 7th paragraph (table reference) and Table 9-28 (BlockAckReq frame variant encoding) with the following:

The BAR Type subfield indicates the BlockAckReq frame variant as defined in Table 9-28 (BlockAckReq frame variant encoding).

Table 9-28—BlockAckReq frame variant encoding

BAR Type	BlockAckReq frame variant
0	Reserved
1	Extended Compressed
2	Compressed
3	Multi-TID
4-5	Reserved
6	GCR
7-9	Reserved
10	GLK-GCR
11-15	Reserved

9.3.1.8 BlockAck frame format

9.3.1.8.1 Overview

Change paragraphs 3-4 as follows:

The RA field of ~~the BlockAck frame is the address of the recipient STA~~ a BlockAck frame that is not a Multi-STA BlockAck variant is set to the TA field of the soliciting frame or the address of the recipient STA from which Data frames are acknowledged. The RA field of a Multi-STA BlockAck frame is set as described in 9.3.1.8.7 (Multi-STA BlockAck variant).

The TA field value is the address of the STA transmitting the BlockAck frame or a bandwidth signaling TA in the context of HT-delayed block ack. In a BlockAck frame transmitted in the context of HT-delayed block ack by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA.

Change Figure 9-42 (BA Control field format) as follows:

	B0	~~B1~~	~~B2~~	~~B3~~ ~~B4~~	B1 B4	B5 B11	B12 B15
	BA Ack Policy	~~Multi-TID~~	~~Compressed Bitmap~~	~~GCR Mode~~	BA Type	Reserved	TID_INFO
Bits:	1	~~1~~	~~1~~	~~2~~	4	7	4

Figure 9-42—BA Control field format

Change the 6th paragraph as follows:

For BlockAck frames sent under HT-delayed agreements, the BA Ack Policy subfield of the BA Control field has the meaning shown in Table 9-29 (BA Ack Policy subfield). For BlockAck frames sent under other types of agreement, the BA Ack Policy subfield is reserved. An HE STA does not send a Multi-STA Block-Ack frame under Delayed and HT-delayed agreements.

Replace the paragraphs 7-8 and Table 9-30 (BlockAck frame variant encoding) with the following:

The BA Type subfield in the BA Control field indicates the BlockAck frame variant as defined in Table 9-30 (BlockAck frame variant encoding).

Table 9-30—BlockAck frame variant encoding

BA Type	BlockAck frame variant
0	Reserved
1	Extended Compressed
2	Compressed
3	Multi-TID
4-5	Reserved
6	GCR
7-9	Reserved
10	GLK-GCR
11	Multi-STA
12-15	Reserved

NOTE—Reference to “a BlockAck” frame without any other qualification from other subclauses applies to any of the variants, unless specific exclusions are called out.

The GCR BlockAck frame is used in response to a GCR BlockAckReq frame and the GLK-GCR BlockAck frame is used in response to a GLK-GCR BlockAckReq frame.

9.3.1.8.2 Compressed BlockAck variant

Change the 2nd paragraph and Figure 9-43 (BA Information field format (Compressed BlockAck)) as follows:

The BA Information field of the Compressed BlockAck frame ~~comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as~~ is shown in Figure 9-43 (BA Information field format (Compressed BlockAck))). The Block Ack Starting Sequence Control subfield is shown in Figure 9-37 (Block Ack Starting Sequence Control subfield format). 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. This subfield is defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA). ~~The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.~~

	Block Ack Starting Sequence Control	Block Ack Bitmap
Octets:	2	8 or 32

Figure 9-43—BA Information field format (Compressed BlockAck)

Insert the following paragraph and table after the 2nd paragraph:

The Fragment Number subfield of the Block Ack Starting Sequence Control field is set as defined in Table 9-30a (Fragment Number subfield encoding for the Compressed BlockAck variant). The Fragment

Number subfield of the Block Ack Starting Sequence Control subfield is set to all 0s if the Compressed BlockAck frame is sent to or from a non-HE STA.

Table 9-30a—Fragment Number subfield encoding for the Compressed BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	**B2-B1**	**B0**			
0	0	0	OFF	8	64
0	1	0		Reserved	Reserved
0	2	0		32	256
0	3	0		Reserved	Reserved
0	0	1	ON	8	16
0	1	1		Reserved	Reserved
0	2	1		32	64
0	3	1		Reserved	Reserved
1	Any	Any		Reserved	Reserved

NOTE—A Compressed BlockAck frame with B0 of the Fragment Number subfield set to 1 is not sent to an HE STA whose Dynamic Fragmentation Support subfield in the HE Capabilities element it transmits is not set to 3 (see 26.3 (Fragmentation and defragmentation)).

Change the remainder of the subclause as follows:

If B0 of the Fragment Number subfield is 0, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame indicates the receive status of up to 64 or 256 MSDUs and/or A-MSDUs depending upon the value of B2-B1 in the Fragment Number subfield as shown in Table 9-30a (Fragment Number subfield encoding for the Compressed BlockAck variant). ~~The Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is 8 octets in length and is used to indicate the received status of up to 64 entries, where each entry represents an MSDU or an A-MSDU.~~ Each bit that is equal to 1 in the compressed Block Ack Bitmap subfield acknowledges the 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, or fragment thereof with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

If B0 of the Fragment Number subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame indicates the receive status of up to 16 or 64 MSDUs and/or A-MSDUs depending upon the value B2-B1 in the Fragment Number subfield as shown in Table 9-30a (Fragment Number subfield encoding for the Compressed BlockAck variant). If bit position n of the Block Ack Bitmap subfield is 1, it acknowledges receipt of an MPDU with sequence number value SN and fragment number value FN with $n = 4 \times (SN - SSN) + FN$, where SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position n of the Block Ack Bitmap subfield is 0, it indicates that the MPDU has not been received.

NOTE—If the B0 of the Fragment Number subfield is equal to 1 then the Block Ack Bitmap subfield is split into (Block Ack Bitmap subfield length)/4 subbitmaps, each of which indicates receive status for 4 fragments of each of the MSDUs or A-MSDUs as indicated in Table 9-30a (Fragment Number subfield encoding for the Compressed BlockAck variant).

9.3.1.8.5 GCR Block Ack variant

Change the 3rd paragraph as follows:

The GCR Group Address subfield is set to the value from the Group Address subfield of the GCR BAR Information field in the BlockAckReq frame to which the BlockAck frame is sent in response. <u>If the BlockAck frame is sent in response to a GCR MU-BAR Trigger frame, the GCR Group Address subfield is set to the value from the RA field in the GCR MU-BAR Trigger frame.</u>

Insert the following new subclause after 9.3.1.8.6:

9.3.1.8.7 Multi-STA BlockAck variant

The Multi-STA BlockAck frame is supported if either UL MU or multi-TID A-MPDU operation is supported and acknowledges MPDUs carried in an HE TB PPDU or multi-STA multi-TID, multi-STA single TID, or single-STA multi-TID A-MPDUs.

An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are addressed to more than one STA sets the RA field to the broadcast address. An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are all addressed to a single recipient STA and that is sent in response to an HE TB PPDU sets the RA field of the Multi-STA BlockAck frame to either the address of the recipient STA or to the broadcast address. An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are all addressed to a single recipient STA and that is not sent in response to an HE TB PPDU sets the RA field of the Multi-STA BlockAck frame to the address of the recipient STA.

A non-AP HE STA sets the RA field to the TA field of the soliciting frame or to the address of the recipient STA whose Data or Management frames are acknowledged.

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 Per AID TID Info subfields as defined in Figure 9-47a (BA Information field format (Multi-STA BlockAck)).

	Repeated for each <AID, TID> tuple
	Per AID TID Info
Octets:	variable

Figure 9-47a—BA Information field format (Multi-STA BlockAck)

The AID TID Info subfield is shown in Figure 9-47b (AID TID Info subfield format).

	B0 B10	B11	B12 B15
	AID11	Ack Type	TID
Bits:	11	1	4

Figure 9-47b—AID TID Info subfield format

The AID11 subfield carries the 11 LSBs of the AID of the non-AP STA for which the Per AID TID Info subfield is intended. The format of the Per AID TID Info subfield depends on the value of the AID11 subfield. If the Multi-STA BlockAck frame is sent to an AP, the AID11 subfield is set to 0. A value of 2045 in the AID11 subfield is used as a unique identifier for any unassociated STA. If the AID11 subfield is set to 2045, then the Ack Type subfield and TID subfield are set to 0 and 15, respectively.

NOTE—More than one Per AID TID Info subfield with the same value in the AID11 subfield but different values in the TID subfield can be present in the Multi-STA BlockAck frame.

If the AID11 subfield of the AID TID Info subfield is not 2045, then the Per AID TID Info subfield has the format shown in Figure 9-47c (Per AID TID Info subfield format if the AID11 subfield is not 2045).

	AID TID Info	Block Ack Starting Sequence Control	Block Ack Bitmap
Octets:	2	0 or 2	0, 4, 8, 16 or 32

Figure 9-47c—Per AID TID Info subfield format if the AID11 subfield is not 2045

If the AID11 subfield is not 2045, then the context and the presence of each optional subfield in a Per AID TID Info subfield in a Multi-STA BlockAck frame is defined in Table 9-30b (Context of the Per AID TID Info subfield and presence of optional subfields if the AID11 subfield is not 2045).

Table 9-30b—Context of the Per AID TID Info subfield and presence of optional subfields if the AID11 subfield is not 2045

Ack Type subfield values	TID subfield values	Presence of Block Ack Starting Sequence Control subfield and Block Ack Bitmap subfields	Context of a Per AID TID Info subfield in a Multi-STA BlockAck frame
0	0–7	Present	Block acknowledgment context: Sent as an acknowledgment to QoS Data frames that solicit a BlockAck frame response or to a BlockAckReq frame.
1	0–7	Not present	Acknowledgment context: Sent as an acknowledgment to a QoS Data or QoS Null frame that solicits an Ack frame response.
0 or 1	8–13	N/A	Reserved
0	14	N/A	Reserved
1	14	Not present	All ack context: Sent as an acknowledgment to an A-MPDU that contains an MPDU that solicits an immediate response and all MPDUs contained in the A-MPDU are received successfully.
0	15	N/A	Reserved
1	15	Not present	Management/PS-Poll frame acknowledgment context: Sent as an acknowledgment to a Management or PS-Poll frame.

NOTE 1—Additional rules for acknowledgment, block acknowledgment and the all ack context are defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame) for a multi-TID A-MPDU.

NOTE 2—As HE STAs do not use HCCA (see 10.23.1 (General)), TID values from 8 to 15 are not used in QoS Data frames.

If the Ack Type subfield is 0, the Fragment Number subfield encoding indicates the length of the BlockAck bitmap subfield as defined in Table 9-30c (Fragment Number subfield encoding for the Multi-STA BlockAck variant).

Table 9-30c—Fragment Number subfield encoding for the Multi-STA BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/ OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2 B1	B0			
0	0	0	OFF	8	64
0	1	0		16	128
0	2	0		32	256
0	3	0		4	32
0	0	1	ON	8	16
0	1	1		16	32
0	2	1		32	64
0	3	1		4	8
1	Any	Any		Reserved	Reserved

NOTE—A Multi-STA BlockAck frame with B0 of the Fragment Number subfield set to 1 cannot be sent to an HE STA unless the HE Capabilities element received from the HE STA has the Dynamic Fragmentation Support subfield equal to 3 (see 26.3 (Fragmentation and defragmentation)).

If B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield is 0, the BA Information field of the Multi-STA BlockAck frame contains an 8-octet, 16-octet, 32-octet or 4-octet Block Ack Bitmap subfield depending on B2-B1 of the Fragment Number subfield as defined in Table 9-30c (Fragment Number subfield encoding for the Multi-STA BlockAck variant) indicating the receive status of up to 64, 128, 256 or 32 MSDUs (or fragments thereof) and/or A-MSDUs (or fragments thereof), respectively. Each bit that is equal to 1 in the Block Ack Bitmap subfield acknowledges the reception of a single MSDU (or fragment thereof) or A-MSDU (or fragment thereof) 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.

If B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Multi-STA BlockAck frame indicates the receive status of up to 16, 32, 64 or 8 MSDUs and/or A-MSDUs depending on B2-B1 of the Fragment Number subfield as shown in Table 9-30c (Fragment Number subfield encoding for the Multi-STA BlockAck variant). If bit position n of the Block Ack Bitmap subfield is 1, it acknowledges receipt of an MPDU with sequence number value SN and fragment number value FN with $n = 4 \times (SN - SSN) + FN$, where SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position n of the Block Ack Bitmap subfield is 0, it indicates that the MPDU has not been received.

NOTE—If B0 of the Fragment Number subfield is 1 then the Block Ack Bitmap field is split into Block Ack Bitmap field length/4 subbitmaps, each of which indicates receive status for 4 fragments of each of the MSDUs or A-MSDUs as indicated in Table 9-30c (Fragment Number subfield encoding for the Multi-STA BlockAck variant). For an A-MSDU, only the first bit of the subbitmap is used, if fragmentation is not allowed in an A-MSDU.

If the AID11 subfield of the AID TID Info subfield is 2045, then the Per AID TID Info subfield has the format shown in Figure 9-47d (Per AID TID Info subfield format if the AID11 subfield is 2045), where the RA subfield indicates the MAC address of an unassociated STA for which the Per AID TID Info subfield is intended.

	AID TID Info	Reserved	RA
Octets:	2	4	6

Figure 9-47d—Per AID TID Info subfield format if the AID11 subfield is 2045

NOTE—An associated non-AP HE STA that receives a Multi-STA BlockAck frame as a response from its AP and does not support the UORA procedure ignores the 10 octets following the AID TID Info subfield that are the remainder of the Per AID TID Info subfield if the AID11 subfield is 2045 and parses the following Per AID TID Info subfields if any.

Change the title of 9.3.1.19 as follows:

9.3.1.19 VHT/HE NDP Announcement frame format

Insert the following before the 1st paragraph:

The VHT/HE NDP Announcement frame has two variants, the VHT NDP Announcement frame and the HE NDP Announcement frame. The two formats are distinguished by the setting of the HE subfield in the Sounding Dialog Token field.

Change paragraphs 3-4 as follows:

The VHT/HE NDP Announcement frame contains at least one STA Info field. If the VHT/HE NDP Announcement frame contains only one STA Info field, then the RA field is set to the address of the STA that can provide feedback (see 10.37.5.2 (Rules for VHT sounding protocol sequences)). If the VHT/HE NDP Announcement frame contains more than one STA Info field, then the RA field is set to the broadcast address.

The TA field is set to the address of the STA transmitting the VHT/HE NDP Announcement frame or the bandwidth signaling TA of the STA transmitting the VHT/HE NDP Announcement frame. In a VHT/HE NDP Announcement frame transmitted by a VHT or HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field is set to a bandwidth signaling TA.

Change Figure 9-59 (Sounding Dialog Token field format) as follows:

	B0 ~~B1~~	B1	B2 B7
	Reserved	HE	Sounding Dialog Token Number
Bits:	~~2~~1	1	6

Figure 9-59—Sounding Dialog Token field format

Insert the following after the 5th paragraph ("The format of the Sounding…"):

The HE subfield in the Sounding Dialog Token field is set to 0 to identify the frame as a VHT NDP Announcement frame and set to 1 to identify the frame as an HE NDP Announcement frame.

Insert the following at the end of 9.3.1.19:

The format of the HE NDP Announcement frame is shown in Figure 9-61a (HE NDP Announcement frame format).

MAC header

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

Figure 9-61a—HE NDP Announcement frame format

The Duration, RA, and TA fields are set as in a VHT NDP Announcement frame.

The HE subfield in the Sounding Dialog Token field is set to 1 to identify the frame as an HE NDP Announcement frame.

The Sounding Dialog Token Number field in the Sounding Dialog Token field contains a value selected by the beamformer to identify the HE NDP Announcement frame.

The format of the STA Info field in an HE NDP Announcement Frame if the AID11 subfield is not set to 2047 is defined in Figure 9-61b (STA Info subfield format in an HE NDP Announcement frame if the AID11 subfield is not 2047).

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

Figure 9-61b—STA Info subfield format in an HE NDP Announcement frame if the AID11 subfield is not 2047

An HE NDP Announcement frame contains at most 1 STA Info field per STA.

If the AID11 subfield is not 2047, then it contains an identifier of a STA expected to process the following HE sounding NDP and prepare the sounding feedback.

The Partial BW Info subfield is defined in Figure 9-61c (Partial BW Info subfield format).

	B0 B6	B7 B13
	RU Start Index	RU End Index
Bits:	7	7

Figure 9-61c—Partial BW Info subfield format

The RU Start Index subfield in the Partial BW Info subfield indicates the first 26-tone RU for which the HE beamformer is requesting feedback. The RU End Index subfield of the Partial BW Info subfield indicates the last 26-tone RU for which the HE beamformer is requesting feedback. The value of the RU Start Index subfield is less than or equal to the value of the RU End Index subfield. The RU Start Index subfield and RU End Index subfield depends on the bandwidth of the HE NDP Announcement frame, which is indicated by the TXVECTOR parameter CH_BANDWIDTH if the frame is carried in an HE, VHT or HT PPDU and by the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT if the frame is carried in a non-HT duplicate PPDU, and is 20 MHz if the frame is carried in non-HT PPDU. The values of the RU Start Index subfield and RU End Index subfield are each selected from the following:

— Values 0 to 8 if the bandwidth of the HE NDP Announcement frame is 20 MHz, where 0 indicates 26-tone RU 1 and 8 indicates 26-tone RU 9. Values 9-127 are reserved. See Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU).

— Values 0 to 17 if the bandwidth of the HE NDP Announcement frame is 40 MHz, where 0 indicates 26-tone RU 1 and 17 indicates 26-tone RU 18. Values 18-127 are reserved. See Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU).

— Values 0 to 36 if the bandwidth of the HE NDP Announcement frame is 80 MHz, where 0 indicates 26-tone RU 1 and 36 indicates 26-tone RU 37. Values 37-127 are reserved. See Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU).

— Values 0 to 73 if the bandwidth of the HE NDP Announcement frame is 160 MHz, where 0 indicates 26-tone RU 1 and 73 indicates 26-tone RU 74. In the 80+80 MHz case, value 0 indicates the 26-tone RU 1 in the lower 80 MHz frequency segment and 36 indicates the 26-tone RU 37 in the lower 80 MHz frequency segment and 37 indicates the 26-tone RU 1 in the upper 80 MHz frequency segment and 73 indicates the 26-tone RU 74 in the upper 80 MHz frequency segment. Values 74-127 are reserved. For 80+80 MHz, feedback is not requested for the gap between the 80 MHz segments. See Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU).

The Feedback Type And Ng and Codebook Size subfields are defined in Table 9-31a (Feedback Type And Ng subfield and Codebook Size subfield encoding).

Table 9-31a—Feedback Type And Ng subfield and Codebook Size subfield encoding

Feedback Type And Ng		Codebook Size	Description
B25	B26	B28	
0	0	0	SU, Ng = 4, quantization resolution (ϕ, ψ) = {4, 2}
0	0	1	SU, Ng = 4, quantization resolution (ϕ, ψ) = {6, 4}
0	1	0	SU, Ng = 16, quantization resolution (ϕ, ψ) = {4, 2}
0	1	1	SU, Ng = 16, quantization resolution (ϕ, ψ) = {6, 4}
1	0	0	MU, Ng = 4, quantization resolution (ϕ, ψ) = {7, 5}
1	0	1	MU, Ng = 4, quantization resolution (ϕ, ψ) = {9, 7}
1	1	0	CQI
1	1	1	MU, Ng = 16, quantization resolution (ϕ, ψ) = {9, 7}

The Disambiguation subfield is set to 1 to prevent a non-HE VHT STA from wrongly determining its AID in the HE NDP Announcement frame. The Disambiguation subfield coincides with the MSB of the AID12 subfield of an expected VHT NDP Announcement frame if the HE NDP Announcement field is parsed by a non-HE VHT STA. The MSB of the AID12 subfield is always 0 for a non-HE VHT STA due to the limitation of the AID to a maximum of 2007.

In a broadcast HE NDP Announcement frame that has more than one STA Info field with a value other than 2047 in the AID11 field the following applies to each STA Info subfield with a value other than 2047:

— If the Feedback Type subfield indicates SU or MU, the Nc subfield indicates the number of columns, Nc, in the compressed beamforming feedback matrix and is set to $Nc - 1$
— If the Feedback Type subfield indicates CQI, the Nc subfield indicates the number of space-time streams, Nc, in the CQI report and is set to $Nc - 1$

In an individually addressed HE NDP Announcement frame that has only one STA Info field with a value other than 2047 in the AID11 subfield, the Nc subfield is reserved.

The format of the STA Info field in an HE NDP Announcement frame if the AID11 subfield is set to 2047 is defined in Figure 9-61d (STA Info subfield format in an HE NDP Announcement frame if the AID11 subfield is 2047).

	B0 B10	B11 B18	B19 B26	B27	B28 B31
	AID11	Disallowed Subchannel Bitmap	Reserved	Disambiguation	Reserved
Bits:	11	8	8	1	4

Figure 9-61d—STA Info subfield format in an HE NDP Announcement frame if the AID11 subfield is 2047

The Disallowed Subchannel Bitmap subfield indicates the 20 MHz subchannels and the 242-tone RUs that are present in HE sounding NDPs announced by the HE NDP Announcement frame and the 242-tone RUs that are to be included in requested sounding feedback. A 20 MHz subchannel is as defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) for the portions of the PPDU that use a tone plan as specified in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) and a 242-tone RU is as defined in 27.3.2 (Subcarrier and resource allocation)). The lowest numbered bit of the Disallowed Subchannel Bitmap subfield corresponds to the 20 MHz subchannel that lies within the BSS width and that has the lowest frequency of the set of all 20 MHz subchannels within the BSS width. Each successive bit in the bitmap corresponds to the next higher frequency 20 MHz subchannel. A bit in the bitmap is set to 1 to indicate that for the corresponding 20 MHz subchannel, no energy is present in the HE sounding NDP associated with this HE NDP Announcement frame. For each disallowed 20 MHz subchannel, the 242-tone RU that is most closely aligned in frequency with the 20 MHz subchannel is disallowed for PPDUs that use a tone plan as specified in Clause 27 (High Efficiency (HE) PHY specification). STAs addressed by the HE NDP Announcement frame do not include tones from disallowed 242-tone RUs when determining the average SNR of space time streams 1 to *Nc* and when generating requested sounding feedback. If a 20 MHz subchannel and its corresponding 242-tone RU is not disallowed, the corresponding bit in the bitmap is set to 0.

Insert a new subclause after 9.3.1.21:

9.3.1.22 Trigger frame format

9.3.1.22.1 General

A Trigger frame allocates resources for and solicits one or more HE TB PPDU transmissions. The Trigger frame also carries other information required by the responding STA to send an HE TB PPDU.

The format for the Trigger frame is defined in Figure 9-64a (Trigger frame format).

	MAC header							
	Frame Control	Duration	RA	TA	Common Info	User Info List	Padding	FCS
Octets:	2	2	6	6	8 or more	variable	variable	4

Figure 9-64a—Trigger frame format

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

The RA field is set as follows:

— For a Trigger frame that is not a GCR MU-BAR, NFRP or MU-RTS Trigger frame, and that has one User Info field and the AID12 subfield of the User Info field contains the AID of a non-AP STA, the RA field is set to the address of that STA

— For a Trigger frame that has at least one User Info field with the AID12 subfield that allocates an RA-RU, the RA field is set to the broadcast address

— For a Trigger frame that is not a GCR MU-BAR Trigger frame and that has more than one User Info field, the RA field is set to the broadcast address

— For a Trigger frame that is an NFRP Trigger frame or MU-RTS Trigger frame, the RA field is set to the broadcast address

— For a Trigger frame that is a GCR MU-BAR Trigger frame, the RA field is set to the MAC address of the group for which reception status is being requested

The TA field is the address of the STA transmitting the Trigger frame if the Trigger frame is addressed to STAs that belong to a single BSS. The TA field is the transmitted BSSID if the Trigger frame is addressed to STAs from at least two different BSSs of the multiple BSSID set. The rules for setting of the TA field are defined in 26.5.2.2.4 (Allowed settings of the Trigger frame fields and TRS Control subfield).

The Common Info field is defined in Figure 9-64b (Common Info field format).

	B0 B3	B4 B15	B16	B17	B18 B19	B20 B21	B22	B23 B25
	Trigger Type	UL Length	More TF	CS Required	UL BW	GI And HE-LTF Type	MU-MIMO HE-LTF Mode)	Number Of HE-LTF Symbols And Mid-amble Periodicity
Bits:	4	12	1	1	2	2	1	3

	B26	B27	B28 B33	B34 B35	B36	B37 B52	B53	B54 B62
	UL STBC	LDPC Extra Symbol Segment	AP TX Power	Pre-FEC Padding Factor	PE Disambiguity	UL Spatial Reuse	Doppler	UL HE-SIG-A2 Reserved
Bits:	1	1	6	2	1	16	1	9

	B63	
	Reserved	Trigger Dependent Common Info
Bits:	1	variable

Figure 9-64b—Common Info field format

The Trigger Type subfield identifies the Trigger frame variant and its encoding is defined in Table 9-31b (Trigger Type subfield encoding).

Table 9-31b—Trigger Type subfield encoding

Trigger Type subfield value	Trigger frame variant
0	Basic
1	Beamforming Report Poll (BFRP)
2	MU-BAR
3	MU-RTS
4	Buffer Status Report Poll (BSRP)
5	GCR MU-BAR
6	Bandwidth Query Report Poll (BQRP)
7	NDP Feedback Report Poll (NFRP)
8-15	Reserved

The UL Length subfield of the Common Info field indicates the value of the L-SIG LENGTH field of the solicited HE TB PPDU.

The More TF subfield of the Common Info field indicates whether or not a subsequent Trigger frame is scheduled for transmission. The More TF subfield is set as defined in 26.8.2 (Individual TWT agreements) and 26.8.3.2 (Rules for TWT scheduling AP).

The CS Required subfield of the Common Info field is set to 1 to indicate that the STAs identified in the 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 respond. The CS Required subfield is set to 0 to indicate that the STAs identified in the User Info fields are not required to consider the medium state or the NAV in determining whether or not to respond. See 26.5.2.3 (Non-AP STA behavior for UL MU operation) and 26.5.2.5 (UL MU CS mechanism) for details.

The UL BW subfield of the Common Info field indicates the bandwidth in the HE-SIG-A of the HE TB PPDU and is defined in Table 9-31c (UL BW subfield encoding).

Table 9-31c—UL BW subfield encoding

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

The GI And HE-LTF Type subfield of the Common Info field indicates the GI and HE-LTF type of the HE TB PPDU response. The GI And HE-LTF Type subfield encoding is defined in Table 9-31d (GI And HE-LTF Type subfield encoding).

Table 9-31d—GI And HE-LTF Type subfield encoding

GI And HE-LTF Type subfield value	Description
0	1x HE-LTF + 1.6 μs GI
1	2x HE-LTF + 1.6 μs GI
2	4x HE-LTF + 3.2 μs GI
3	Reserved

Table 9-31e—MU-MIMO HE-LTF Mode subfield encoding

MU-MIMO HE-LTF subfield value	Description
0	HE single stream pilot HE-LTF mode
1	HE masked HE-LTF sequence mode

The MU-MIMO HE-LTF Mode subfield of the Common Info field indicates the HE-LTF mode of the non-OFDMA MU-MIMO HE TB PPDU response when the GI And HE-LTF Type subfield of the Common Info field indicates either 2x HE-LTF + 1.6 μs GI or 4x HE-LTF + 3.2 μs GI, as defined in Table 9-31d (GI And HE-LTF Type subfield encoding). Otherwise, this subfield is set to indicate HE single stream pilot HE-LTF mode.

If the Doppler subfield of the Common Info field is 0, then the Number Of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field indicates the number of HE-LTF symbols present in the HE TB PPDU and is encoded as follows:

- 0 for 1 HE-LTF symbol
- 1 for 2 HE-LTF symbols
- 2 for 4 HE-LTF symbols
- 3 for 6 HE-LTF symbols
- 4 for 8 HE-LTF symbols
- 5-7 is reserved

If the Doppler subfield of the Common Info field is 1, then the Number Of HE-LTF Symbols And Midamble Periodicity subfield indicates the number of HE-LTF symbols and the periodicity of the midamble and is encoded as follows:

- 0 for 1 HE-LTF symbol and 10 symbol midamble periodicity
- 1 for 2 HE-LTF symbols and 10 symbol midamble periodicity
- 2 for 4 HE-LTF symbols and 10 symbol midamble periodicity
- 4 for 1 HE-LTF symbol and 20 symbol midamble periodicity

— 5 for 2 HE-LTF symbols and 20 symbol midamble periodicity

— 6 for 4 HE-LTF symbols and 20 symbol midamble periodicity

— 3 and 7 are reserved

The UL STBC subfield of the Common Info field indicates the status of STBC encoding the solicited HE TB PPDUs. It is set to 1 to indicate STBC encoding and set to 0 otherwise.

The LDPC Extra Symbol Segment subfield of the Common Info field indicates the status of the LDPC extra symbol segment. It is set to 1 if the LDPC extra symbol segment is present in the solicited HE TB PPDUs and set to 0 otherwise.

The AP Tx Power subfield of the Common Info field indicates, in units of dBm, the AP's combined transmit power at the antenna connectors of all the transmit antennas used to transmit the Trigger frame and normalized to 20 MHz bandwidth. The transmit power is reported with a resolution of 1 dB, with values in the range 0 to 60 representing –20 dBm to 40 dBm, respectively. Values above 60 are reserved.

The Pre-FEC Padding Factor and PE Disambiguity subfields are defined in Table 9-31f (Pre-FEC Padding Factor and PE Disambiguity subfields) and have the same encoding as their respective subfields in HE SIG-A (see Table 27-20 (HE-SIG-A field of an HE MU PPDU)).

Table 9-31f—Pre-FEC Padding Factor and PE Disambiguity subfields

Subfield	Description	Encoding
Pre-FEC Padding Factor	Indicates the pre-FEC padding factor	Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
PE Disambiguity	Indicates PE disambiguity	Set to 1 if the condition in Equation (27-118) is met; otherwise it is set to 0

The UL Spatial Reuse subfield of the Common Info field carries the values to be included in the Spatial Reuse fields in the HE-SIG-A field of the solicited HE TB PPDUs. The format of the UL Spatial Reuse subfield is shown in Figure 9-64c (UL Spatial Reuse subfield format), where each Spatial Reuse n subfield, $1 \leq n \leq 4$, is set to the same value as its corresponding subfield in the HE-SIG-A field of the HE TB PPDU, which are defined in Table 27-21 (HE-SIG-A field of an HE TB PPDU).

	B0 B3	B4 B7	B8 B11	B12 B15
	Spatial Reuse 1	Spatial Reuse 2	Spatial Reuse 3	Spatial Reuse 4
Bits:	4	4	4	4

Figure 9-64c—UL Spatial Reuse subfield format

The Doppler subfield of the Common Info field is set to 1 to indicate that a midamble is present in the HE TB PPDU and set to 0 otherwise.

The UL HE-SIG-A2 Reserved subfield of the Common Info field carries the value to be included in the Reserved field in the HE-SIG-A2 subfield of the solicited HE TB PPDUs. An HE AP sets the UL HE-SIG-A2 Reserved subfield to all 1s.

The Trigger Dependent Common Info subfield in the Common Info field is optionally present based on the value of the Trigger Type field (see 9.3.1.22.2 (Basic Trigger variant) to 9.3.1.22.9 (NDP Feedback Report Poll (NFRP) variant)).

The User Info List field contains zero or more User Info fields.

The User Info field is defined in Figure 9-64d (User Info field format) for all Trigger frame variants except the NFRP Trigger frame, which is defined in 9.3.1.22.9 (NDP Feedback Report Poll (NFRP) variant).

	B0 B11	B12 B19	B20	B21 B24	B25	B26 B31	B32 B38	B39	
	AID12	RU Allocation	UL FEC Coding Type	UL HE-MCS	UL DCM	SS Allocation/ RA-RU Information	UL Target RSSI	Reserved	Trigger Dependent User Info
Bits:	12	8	1	4	1	6	7	1	variable

Figure 9-64d—User Info field format

The AID12 subfield in the User Info field is encoded as defined in Table 9-31g (AID12 subfield encoding):

Table 9-31g—AID12 subfield encoding

AID12 subfield	Description
0	User Info field allocates one or more contiguous RA-RUs for associated STAs
1–2007	User Info field is addressed to an associated STA whose AID is equal to the value in the AID12 subfield
2008–2044	Reserved
2045	User Info field allocates one or more contiguous RA-RUs for unassociated STAs
2046	Unallocated RU
2047–4094	Reserved
4095	Start of Padding field
NOTE 1—The remaining subfields in the User Info field are reserved when the AID12 subfield is 2046. NOTE 2—The remaining subfields of the User Info field are not present when the AID12 subfield is 4095.	

The RU Allocation subfield along with the UL BW subfield in the Common Info field identifies the size and the location of the RU. If the UL BW subfield indicates 20 MHz, 40 MHz or 80 MHz PPDU, then B0 of the RU Allocation subfield is set to 0. If the UL BW subfield indicates 80+80 MHz or 160 MHz, then B0 of the RU Allocation subfield is set to 0 to indicate that the RU allocation applies to the primary 80 MHz channel and set to 1 to indicate that the RU allocation applies to the secondary 80 MHz channel. The mapping of B7–B1 of the RU Allocation subfield is defined in Table 9-31h (B7–B1 of the RU Allocation subfield).

Table 9-31h—B7–B1 of the RU Allocation subfield

B7-B1 of the RU Allocation subfield	UL BW subfield	RU size	RU Index
0–8	20 MHz, 40 MHz, 80 MHz, 80+80 MHz or 160 MHz	26	RU1 to RU9, respectively
9–17	40 MHz, 80 MHz, 80+80 MHz or 160 MHz		RU10 to RU18, respectively
18–36	80 MHz, 80+80 MHz or 160 MHz		RU19 to RU37, respectively
37–40	20 MHz, 40 MHz, 80 MHz, 80+80 MHz or 160 MHz	52	RU1 to RU4, respectively
41–44	40 MHz, 80 MHz, 80+80 MHz or 160 MHz		RU5 to RU8, respectively
45–52	80 MHz, 80+80 MHz or 160 MHz		RU9 to RU16, respectively
53, 54	20 MHz, 40 MHz, 80 MHz, 80+80 MHz or 160 MHz	106	RU1 and RU2, respectively
55, 56	40 MHz, 80 MHz, 80+80 MHz or 160 MHz		RU3 and RU4, respectively
57–60	80 MHz, 80+80 MHz or 160 MHz		RU5 to RU8, respectively
61	20 MHz, 40 MHz, 80 MHz, 80+80 MHz or 160 MHz	242	RU1
62	40 MHz, 80 MHz, 80+80 MHz or 160 MHz		RU2
63, 64	80 MHz, 80+80 MHz or 160 MHz		RU3 and RU4, respectively
65	40 MHz, 80 MHz, 80+80 MHz or 160 MHz	484	RU1
66	80 MHz, 80+80 MHz or 160 MHz		RU2
67	80 MHz, 80+80 MHz or 160 MHz	996	RU1
68	80+80 MHz or 160 MHz	2×996	RU1
NOTE—If the UL BW subfield indicates 80+80 MHz or 160 MHz, the description indicates the RU index for the Primary 80 MHz or Secondary 80 MHz channel as indicated by B0 of the RU Allocation subfield.			

If the UL BW subfield indicates 20 MHz, the mapping of the RU index to RU is defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU) in increasing order.

If the UL BW subfield indicates 40 MHz, the mapping of the RU index RU is defined in Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) in increasing order.

If the UL BW subfield indicates 80 MHz, 160 MHz or 80+80 MHz, the mapping of the RU index to RU is defined in Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU) in increasing order.

If the UL BW subfield indicates 160 MHz or 80+80 MHz, B7–B1 of the RU Allocation subfield is set to 68 and B0 is set to 1 to indicate a 2×996-tone RU. A non-AP STA ignores B0 for 2×996-tone RU indication.

If the AID12 subfield is in the range 1 to 2007, then the RU Allocation subfield indicates the RU allocated to the STA identified by the AID12 subfield. If the AID12 subfield is 0 or 2045, then the RU Allocation subfield indicates the starting RU of one or more contiguous RA-RUs allocated by the User Info field. If the AID12 subfield is 2046, then the RU Allocation subfield indicates an unallocated RU.

If there is more than one RA-RU (i.e., the Number Of RA-RU subfield of this User Info field has a value greater than 0), then the allocated RUs are contiguous and the RU sizes of all RA-RUs are the same and equal to the size of the first RU. Further, all the remaining subfields of the User Info field apply to all the RA-RUs.

The UL FEC Coding Type subfield of the User Info field indicates the code type of the solicited HE TB PPDU. The UL FEC Coding Type subfield is set to 0 to indicate BCC and set to 1 to indicate LDPC.

The UL HE-MCS subfield of the User Info field indicates the HE-MCS of the solicited HE TB PPDU. The encoding of the UL HE-MCS subfield is defined in 27.3.7 (HE modulation and coding schemes (HE-MCSs)).

The UL DCM subfield of the User Info field indicates DCM of the solicited HE TB PPDU. The UL DCM subfield is set to 1 to indicate that DCM is used in the solicited HE TB PPDU as defined in 27.3.12.15 (Dual carrier modulation). The UL DCM subfield is set to 0 to indicate that DCM is not used. The UL DCM subfield is set to 0 if the UL STBC subfield of the Common Info field is set to 1.

If the AID12 subfield is either 0 or 2045, then B26–B31 of the User Info field is the RA-RU Information subfield, otherwise B26–B31 of the User Info field is the SS Allocation subfield.

The SS Allocation subfield of the User Info field indicates the spatial streams of the solicited HE TB PPDU and the format is defined in Figure 9-64e (SS Allocation subfield format).

	B26 B28	B29 B31
	Starting Spatial Stream	Number Of Spatial Streams
Bits:	3	3

Figure 9-64e—SS Allocation subfield format

The Starting Spatial Stream subfield indicates the starting spatial stream and is set to the starting spatial stream minus 1.

The Number Of Spatial Streams subfield indicates the number of spatial streams, and is set to the number of spatial streams minus 1.

The RA-RU Information subfield of the User Info field indicates the RA-RU information and the format is defined in Figure 9-64f (RA-RU Information subfield format).

	B26 B30	B31
	Number Of RA-RU	More RA-RU
Bits:	5	1

Figure 9-64f—RA-RU Information subfield format

The Number Of RA-RU subfield indicates the number of contiguous RUs allocated for UORA. The value of the Number Of RA-RU subfield is equal to the number of contiguous RA-RUs minus one.

NOTE—The starting spatial stream and the number of spatial streams of the HE TB PPDU transmitted on each RA-RU are 1.

The More RA-RU subfield is set to 1 to indicate that RA-RUs of the type indicated by the AID12 subfield in this User Info field (see Table 9-31g (AID12 subfield encoding)) are allocated in subsequent Trigger frames that are sent until the end of the TWT SP in which the Trigger frame carrying this field is sent. Otherwise, the subfield is set to 0. The More RA-RU subfield is reserved if the More TF field in the Common Info field is set to 0.

The UL Target RSSI subfield of the User Info field indicates the expected receive signal power, averaged over the AP's antenna connectors, for the HE portion of the HE TB PPDU transmitted on the assigned RU. The resolution for the UL Target RSSI subfield in the User Info field is 1 dB. The UL Target RSSI subfield encoding is defined in Table 9-31i (UL Target RSSI subfield encoding).

Table 9-31i—UL Target RSSI subfield encoding

UL Target RSSI subfield	Description
0–90	Values 0 to 90 map to –110 dBm to –20 dBm
91–126	Reserved
127	Indicates to the STA to transmit an HE TB PPDU response at its maximum transmit power for the assigned HE-MCS

The Trigger Dependent User Info subfield in the User Info field is optionally present based on the value of the Trigger Type field (see 9.3.1.22.2 (Basic Trigger variant) to 9.3.1.22.9 (NDP Feedback Report Poll (NFRP) variant)).

The Padding field is optionally present in a Trigger frame to extend the frame length to give the recipient STAs enough time to prepare a response for transmission a SIFS after the frame is received. The Padding field, if present, is at least two octets in length and is set to all 1s. If the Padding field is present in a Trigger frame, its length is computed as described in 26.5.2.2.3 (Padding for Trigger frame or frame containing TRS Control subfield).

9.3.1.22.2 Basic Trigger variant

The Trigger Dependent Common Info subfield is not present in the Basic Trigger frame. The Trigger Dependent User Info subfield of the Basic Trigger frame is defined in Figure 9-64g (Trigger Dependent User Info subfield format in the Basic Trigger variant).

	B0 B1	B2 B4	B5	B6 B7
	MPDU MU Spacing Factor	TID Aggregation Limit	Reserved	Preferred AC
Bits:	2	3	1	2

Figure 9-64g—Trigger Dependent User Info subfield format in the Basic Trigger variant

The MPDU MU Spacing Factor subfield is used for calculating the value by which the minimum MPDU start spacing is multiplied (see 10.12.3 (Minimum MPDU Sstart Sspacing field rules)).

The TID Aggregation Limit subfield indicates the MPDUs allowed in an A-MPDU carried in the HE TB PPDU and the maximum number of TIDs that can be aggregated by the STA in the A-MPDU and is set as defined in 26.5.2.2.4 (Allowed settings of the Trigger frame fields and TRS Control subfield).

The value in the TID Aggregation Limit subfield in Trigger frame is less than or equal to $MT + 1$, where MT is the value indicated in the Multi-TID Aggregation Tx Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element transmitted by the non-AP STA that is the intended receiver of the User Info field.

The Preferred AC subfield indicates the lowest AC that is recommended for aggregation of MPDUs in the A-MPDU contained in the HE TB PPDU sent as a response to the Trigger frame. The encoding of the Preferred AC subfield as defined in Table 9-154 (ACI-to-AC encoding).

9.3.1.22.3 Beamforming Report Poll (BFRP) variant

The Trigger Dependent Common Info subfield is not present in the BFRP Trigger frame. The Trigger Dependent User Info subfield of the BFRP Trigger frame is defined in Figure 9-64h (Trigger Dependent User Info subfield format in the BFRP variant).

	Feedback Segment Retransmission Bitmap
Octets:	1

Figure 9-64h—Trigger Dependent User Info subfield format in the BFRP variant

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

9.3.1.22.4 MU-BAR variant

The Trigger Dependent Common Info subfield is not present in the MU-BAR Trigger frame. The Trigger Dependent User Info subfield for the MU-BAR Trigger frame is defined in Figure 9-64i (Trigger Dependent User Info subfield format in the MU-BAR variant).

	BAR Control	BAR Information
Octets:	2	variable

Figure 9-64i—Trigger Dependent User Info subfield format in the MU-BAR variant

The BAR Control subfield is defined in 9.3.1.7 (BlockAckReq frame format) and indicates either a Compressed BlockAckReq variant or a Multi-TID BlockAckReq variant.

The BAR Information subfield is defined in 9.3.1.7 (BlockAckReq frame format).

9.3.1.22.5 MU-RTS variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the MU-RTS Trigger frame.

The UL BW subfield in the Common Info field indicates the bandwidth of the PPDU carrying the MU-RTS Trigger frame and is defined in Table 9-31c (UL BW subfield encoding).

The UL Length, GI And HE-LTF Type, MU-MIMO HE-LTF Mode, Number Of HE-LTF Symbols And Midamble Periodicity, UL STBC, LDPC Extra Symbol Segment, AP TX Power, Pre-FEC Padding Factor, PE Disambiguity, UL Spatial Reuse, Doppler and UL HE-SIG-A2 Reserved subfields in the Common Info field are reserved.

The UL HE-MCS, UL FEC Coding Type, UL DCM, SS Allocation/RA-RU Information and UL Target RSSI fields in the User Info field are reserved.

The RU Allocation subfield in the 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.

B0 of the RU Allocation subfield is set to 0 to indicate primary 20 MHz channel, primary 40 MHz channel and primary 80 MHz channel. For 160 MHz and 80+80 MHz indication, B0 of the RU Allocation subfield is set to 1. A non-AP STA ignores B0 for 160 MHz and 80+80 MHz indication.

B7–B1 of the RU Allocation subfield is set to indicate the primary 20 MHz channel as follows:

— 61 if the primary 20 MHz channel is the only 20 MHz channel or the lowest frequency 20 MHz channel in the primary 40 MHz channel or primary 80 MHz channel

— 62 if the primary 20 MHz channel is the second lowest frequency 20 MHz channel in the primary 40 MHz channel or primary 80 MHz channel

— 63 if the primary 20 MHz channel is the third lowest frequency 20 MHz channel in the primary 80 MHz channel

— 64 if the primary 20 MHz channel is the fourth lowest frequency 20 MHz channel in the primary 80 MHz channel

B7–B1 of the RU Allocation subfield is set to indicate the primary 40 MHz channel as follows:

— 65 if the primary 40 MHz channel is the only 40 MHz channel or the lowest frequency 40 MHz channel in the primary 80 MHz channel

— 66 if the primary 40 MHz channel is the second lowest frequency 40 MHz channel in the primary 80 MHz channel

B7–B1 of the RU Allocation subfield is set to 67 to indicate the primary 80 MHz channel.

B7–B1 of the RU Allocation subfield is set to 68 to indicate the primary and secondary 80 MHz channel.

The settings for B7–B1 of the RU Allocation subfield are illustrated in Figure 9-64j (UL BW subfield and B7–B1 of RU Allocation subfield in MU-RTS Trigger frame).

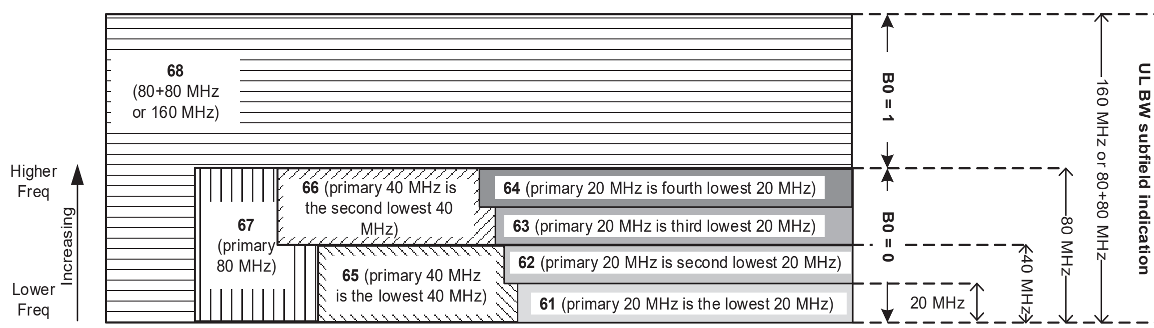

Figure 9-64j—UL BW subfield and B7–B1 of RU Allocation subfield in MU-RTS Trigger frame

9.3.1.22.6 Buffer Status Report Poll (BSRP) variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the BSRP Trigger frame.

9.3.1.22.7 GCR MU-BAR variant

The Trigger Dependent Common Info subfield of the GCR MU-BAR Trigger frame is defined in Figure 9-64k (Trigger Dependent Common Info subfield format in the GCR MU-BAR variant). The Trigger Dependent User Info subfield is not present in the GCR MU-BAR Trigger frame.

	BAR Control	BAR Information
Octets:	2	2

Figure 9-64k—Trigger Dependent Common Info subfield format in the GCR MU-BAR variant

The BAR Control subfield is defined in 9.3.1.7 (BlockAckReq frame format) and indicates a GCR BlockAckReq variant.

The BAR Information subfield is defined in 9.3.1.7.6 (GCR BlockAckReq variant) except that the GCR Group Address field is not present.

NOTE—A GCR MU-BAR Trigger frame is not a type of MU BAR Trigger frame.

9.3.1.22.8 Bandwidth Query Report Poll (BQRP) variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the BQRP Trigger frame.

9.3.1.22.9 NDP Feedback Report Poll (NFRP) variant

The UL BW subfield in the Common Info field indicates the bandwidth of the NDP feedback report response.

The UL STBC, LDPC Extra Symbol Segment, Pre-FEC Padding Factor, PE Disambiguity, UL Spatial Reuse, and Doppler subfields in the Common Info field are reserved.

The Number Of HE-LTF Symbols And Midamble Periodicity subfield in the Common Info field indicates the number of HE-LTF symbols present in the NDP feedback report response and is set to 1.

The GI And HE-LTF Type subfield in the Common Info field is set to 2.

The Trigger Dependent Common Info subfield is not present.

The User Info field for NFRP Trigger frame is defined in Figure 9-64l (User Info field format in the NFRP Trigger frame).

	Starting AID	Reserved	Feedback Type	Reserved	UL Target RSSI	Multiplexing Flag
Bits:	12	9	4	7	7	1

Figure 9-64l—User Info field format in the NFRP Trigger frame

The Feedback Type subfield encoding is defined in Table 9-31j (Feedback Type subfield encoding).

Table 9-31j—Feedback Type subfield encoding

Value	Description
0	Resource request
1-15	Reserved

The scheduled non-AP HE STAs are identified by a range of AIDs. The Starting AID field defines the first AID of the range of AIDs that are scheduled to respond to the NFRP Trigger frame.

The UL Target RSSI subfield indicates the target RSSI at the receiver's antenna connector(s), over the subcarriers assigned to a scheduled STA within the PPDU bandwidth, from the HE portion of the HE TB feedback NDP, averaged over all antennas used to receive the PPDU for each of the scheduled STAs. The resolution for the UL Target RSSI subfield is 1 dB. The UL Target RSSI subfield encoding is defined in Table 9-31i (UL Target RSSI subfield encoding).

The Multiplexing Flag subfield indicates the number of STAs that are multiplexed on the same set of tones in the same RU, and is encoded as the number of STAs minus 1.

The total number of STAs, N_{STA}, that are scheduled to respond to the NFRP Trigger frame is calculated using Equation (9-ax1).

$$N_{STA} = 18 \times 2^{BW} \times (MultiplexingFlag + 1) \qquad \text{(9-ax1)}$$

where *BW* is the value of the UL BW subfield in the Common Info field of the NFRP Trigger frame, and *MultiplexingFlag* is the value of the Multiplexing Flag subfield.

9.3.2 Data frames

9.3.2.1 Format of Data frames

9.3.2.1.2 Address and BSSID fields

Change the 1st paragraph as follows:

The content of the address fields of Data frames are dependent upon the values of the To DS and From DS subfields in the Frame Control field and whether the Frame Body field contains either an MSDU (or fragment thereof) or an ~~entire~~ A-MSDU (or fragment thereof), as determined by the A-MSDU Present subfield of the QoS Control field (see 9.2.4.5.9 (A-MSDU Present subfield)). The content of the address fields transmitted by nonmesh STAs is defined in Table 9-32 (Address field contents). The content of the address fields transmitted by mesh STAs is defined in 9.3.5 (Frame addressing in an MBSS), and the content of the fields transmitted by GLK STAs is defined in 10.66 (Addressing of GLK Data frame transmission). Where the content of a field is shown as not applicable (N/A), the field is omitted. Note that Address 1 always holds the receiver address of the intended receiver (or, in the case of group addressed frames, receivers), and that Address 2 always holds the address of the STA that is transmitting the frame.

Change the subsequent occurrences of the term "A-MSDU" to "A-MSDU (or fragment thereof)."

9.3.3 Management frames

9.3.3.2 Beacon frame format

Change the following rows in Table 9-34 (Beacon frame body) maintaining row order:

Table 9-34—Beacon frame body

Order	Information	Notes
19	EDCA Parameter Set	The EDCA Parameter Set element is present if dot11QosOptionImplemented is true, ~~and~~ dot11MeshActivated is false, and the QoS Capability element is not present; otherwise it is not present.
20	QoS Capability	The QoS Capability element is present if dot11QosOptionImplemented is true, ~~and~~ dot11MeshActivated is false, and neither the EDCA Parameter Set element nor the MU EDCA Parameter Set element are ~~is not~~ present; otherwise it is not present.
33	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.

Table 9-34—Beacon frame body *(continued)*

Order	Information	Notes
34	HT Operation	The HT Operation element is included by an AP and a mesh STA when dot11HighThroughputOptionImplemented is true and the AP or mesh STA is not a 6 GHz STA.
56	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
57	VHT Operation	The VHT Operation element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA, and is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
63	Reduced Neighbor Report	The Reduced Neighbor Report element is optionally present if dot11TVHTOptionImplemented or dot11FILSActivated or dot11CoLocatedRNRImplemented is true; otherwise not present.
76	Multiple BSSID Configuration	The Multiple BSSID Configuration element is optionally present if dot11MultiBSSIDImplemented is true.
77	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
78	HE Operation	The HE Operation element is present if dot11HEOptionImplemented is true; otherwise it is not present.
79	TWT	The TWT element is optionally present if dot11TWTOptionActivated is true; otherwise it is not present.
80	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11OFDMARandomAccessOptionImplemented is true; otherwise it is not present.
81	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
82	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
83	MU EDCA Parameter Set	The MU EDCA Parameter Set element is optionally present if dot11HEOptionImplemented is true and dot11MUEDCAParametersActivated is true; otherwise, it is not present.
84	ESS Report	The ESS Report element is optionally present.
85	NDP Feedback Report Parameter Set	The NDP Feedback Report Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
86	HE BSS Load	The HE BSS Load element is optionally present if dot11QBSSLoadImplemented and dot11HEOptionImplemented are true.
87	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.

9.3.3.5 Association Request frame format

Change the following rows in Table 9-36 (Association Request frame body) maintaining row order:

Table 9-36—Association Request frame body

Order	Information	Notes
13	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
22	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
45	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
46	Channel Switch Timing	The Channel Switch Timing element is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true; otherwise it is not present.
47	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true; otherwise it is not present.
48	UL MU Power Capabilities	The UL MU Power Capabilities element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.6 Association Response frame format

Change Table 9-37 (Association Response frame body) as follows maintaining numeric order:

Table 9-37—Association Response frame body

Order	Information	Notes
15	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
16	HT Operation	The HT Operation element is included by an AP and a mesh STA when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
29	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
30	VHT Operation	The VHT Operation element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA, and is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.

Table 9-37—Association Response frame body *(continued)*

Order	Information	Notes
40	TWT	The TWT element is present if dot11TWTOptionActivated is true and the TWT element is present in the Association Request frame that elicited the Association Response frame. The TWT element is optionally present if dot11TWTOptionActivated is true, dot11HEOptionImplemented is true, and the TWT Requester Support field in the HE Capabilities element in the Association Request frame that elicited this Association Response frame is 1. Otherwise, the TWT element is not present. If the TWT element is present in the Association Request frame that solicits the Association Response frame but the TWT element is not present in the Association Response frame then the STA can transmit another TWT request frame after association.
56	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
57	HE Operation	The HE Operation element is present if dot11HEOptionImplemented is true; otherwise it is not present.
58	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
59	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
60	MU EDCA Parameter Set	The MU EDCA Parameter Set element is present if dot11HEOptionImplemented is true and dot11MUEDCAParametersActivated is true; otherwise, it is not present.
61	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
62	ESS Report	The ESS Report element is optionally present.
63	NDP Feedback Report Parameter Set	The NDP Feedback Report Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
64	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.

9.3.3.7 Reassociation Request frame format

Change the following rows in Table 9-38 (Reassociation Request frame body) maintaining row order:

Table 9-38—Reassociation Request frame body

Order	Information	Notes
16	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
27	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
50	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
51	Channel Switch Timing	The Channel Switch Timing element is optionally present if dot11HESubchannelSelectiveTransmissionImplemented is true; otherwise it is not present.
52	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.
53	UL MU Power Capabilities	The UL MU Power Capabilities element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.8 Reassociation Response frame format

Change Table 9-39 (Reassociation Response frame body) as follows maintaining numeric order:

Table 9-39—Reassociation Response frame body

Order	Information	Notes
16	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
17	HT Operation	The HT Operation element is included by an AP when dot11HighThroughputOptionImplemented is true and the AP is not a 6 GHz STA.
32	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
33	VHT Operation	The VHT Operation element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA, and is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.

Table 9-39—Reassociation Response frame body *(continued)*

Order	Information	Notes
43	TWT	The TWT element is present if dot11TWTOptionActivated is true and the TWT element is present in the Reassociation Request frame that elicited this Reassociation Response frame. The TWT element is optionally present if dot11TWTOptionActivated is true, dot11HEOptionImplemented is true, and the TWT Requester Support field in the HE Capabilities element in the Reassociation Request frame that elicited this Reassociation Response frame is 1. Otherwise, the TWT element is not present. If the TWT element is present in the Reassociation Request frame that solicits the Reassociation Response frame but the TWT element is not present in the Reassociation Response frame then the STA can transmit another TWT request frame after association.
60	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
61	HE Operation	The HE Operation element is present if dot11HEOptionImplemented is true; otherwise it is not present.
62	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
63	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
64	MU EDCA Parameter Set	The MU EDCA Parameter Set element is present if dot11HEOptionImplemented is true and dot11MUEDCAParametersActivated is true; otherwise, it is not present.
65	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
66	ESS Report	The ESS Report element is optionally present.
67	NDP Feedback Report Parameter Set	The NDP Feedback Report Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
68	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.

9.3.3.9 Probe Request frame format

Change the following rows in Table 9-40 (Probe Request frame body) maintaining row order:

Table 9-40—Probe Request frame body

Order	Information	Notes
7	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
17	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
34	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
35	Known BSSID	The Known BSSID element is optionally present if dot11MultiBSSIDImplemented is true.
36	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.
37	Short SSID List	The Short SSID List element is optionally present if dot11ShortSSIDListImplemented is true; otherwise it is not present.

9.3.3.10 Probe Response frame format

Change the following rows in Table 9-41 (Probe Response frame body) maintaining numeric order:

Table 9-41—Probe Response frame body

Order	Information	Notes
31	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented is true and the STA is not a 6 GHz STA.
32	HT Operation	The HT Operation element is included by an AP and a mesh STA when dot11HighThroughputOptionImplemented is true and the AP is not a 6 GHz STA.
58	VHT Capabilities	The VHT Capabilities element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA.
59	VHT Operation	The VHT Operation element is present when dot11VHTOptionImplemented is true and the STA is not a 6 GHz STA, and is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
65	Reduced Neighbor Report	The Reduced Neighbor Report element is optionally present if dot11TVHTOptionImplemented~~, or~~ dot11FILSActivated or dot11CoLocatedRNRImplemented is true; otherwise not present.
93	Multiple BSSID Configuration	The Multiple BSSID Configuration element is optionally present if dot11MultiBSSIDImplemented is true.

Table 9-41—Probe Response frame body *(continued)*

Order	Information	Notes
94	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present.
95	HE Operation	The HE Operation element is present if dot11HEOptionImplemented is true; otherwise it is not present.
96	TWT	The TWT element is optionally present within broadcast Probe Response frames if dot11TWTOptionActivated, dot11HEOptionImplemented and dot11FILSOmitReplicateProbeResponses are true; otherwise it is not present. If the TWT element is present, then the Negotiation Type subfield of the TWT element is 2.
97	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11OFDMARandomAccessOptionImplemented is true; otherwise it is not present.
98	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
99	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise it is not present.
100	MU EDCA Parameter Set	The MU EDCA Parameter Set element is present if dot11HEOptionImplemented is true and dot11MUEDCAParametersActivated is true; otherwise, it is not present.
101	ESS Report	The ESS Report element is optionally present.
102	NDP Feedback Report Parameter Set	The NDP Feedback Report Parameter Set element is optionally present if dot11HEOptionImplemented is true; otherwise, it is not present.
103	HE BSS Load	The HE BSS Load element is optionally present if dot11QBSSLoadImplemented and dot11HEOptionImplemented are true.
104	HE 6 GHz Band Capabilities	The HE 6 GHz Band Capabilities element is present if dot11HEOptionImplemented and dot11HE6GOptionImplemented are true.

9.3.3.13 Action frame format

Change Table 9-45 (Action frame body and Action No Ack frame body) as follows:

Table 9-45—Action frame body and Action No Ack frame body

Order	Information
Last – 2	One or more vendor-specific elements are optionally present. These elements are absent when the Category subfield of the Action field is Vendor-Specific, Vendor-Specific Protected, or Self-protected or when the Category subfield of the Action field is VHT and the VHT Action subfield of the Action field is VHT Compressed Beamforming, or when the Category subfield of the Action field is HE and the HE Action subfield of the Action field is HE Compressed Beamforming/CQI.

9.3.4 Extension frames

9.3.4.2 DMG Beacon

Insert the following row in Table 9-47 (DMG Beacon frame body) maintaining numeric order:

Table 9-47—DMG Beacon frame body

Order	Information	Notes
55	Multiple BSSID Configuration	The Multiple BSSID Configuration element is optionally present if dot11MultiBSSIDImplemented is true.

9.3.4.3 S1G Beacon frame format

Insert the following row in Table 9-48 (Minimum and full set of optional elements) maintaining numeric order:

Table 9-48—Minimum and full set of optional elements

Order	Information	Notes	Allowed in minimum set	Allowed in full set
17	Multiple BSSID Configuration	The Multiple BSSID Configuration element is optionally present if dot11MultiBSSIDImplemented is true.	No	Yes

9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

9.4.1.7 Reason Code field

Insert a new row in Table 9-51 (Reason codes) as follows (maintaining numeric order and updating the reserved range):

Table 9-51—Reason codes

Status code	Name	Meaning
71	POOR_RSSI_CONDITIONS	Disassociated due to poor RSSI.

9.4.1.9 Status Code field

Change Table 9-52 (Status codes) as follows (maintaining numeric order and updating the reserved range):

Table 9-52—Status codes

Status code	Name	Meaning
18	REFUSED_BASIC_RATES_MISMATCH	Association denied due to requesting STA not supporting all of the data rates in the BSSBasicRateSet parameter, the Basic HT-MCS Set field of the HT Operation parameter, ~~or~~ the Basic VHT-MCS and NSS Set field in the VHT Operation parameter, or the Basic HE-MCS And NSS Set field in the HE Operation parameter.
124	DENIED_HE_NOT_SUPPORTED	Association denied because the requesting STA does not support HE features.

9.4.1.11 Action field

Insert the following rows into Table 9-53 (Category values) in numerical order and update the Reserved row:

Table 9-53—Category values

Code	Meaning	See subclause	Robust	Group addressed privacy
30	HE	9.6.31 (HE Action frame details)	No	No
31	Protected HE	9.6.32 (Protected HE Action frame details)	Yes	No

9.4.1.17 QoS Info field

Change Figure 9-100 (QoS Info field format when sent by an AP) as follows:

	B0 B3	B4	B5	B6	B7
	EDCA Parameter Set Update Count	Q-Ack	Queue Request	TXOP Request	~~Reserved~~ More Data Ack
Bits:	4	1	1	1	1

Figure 9-100—QoS Info field format when sent by an AP

Insert the following after the 6th paragraph ("APs set the TXOP Request subfield…"):

An HE AP sets the More Data Ack subfield to 1 to indicate that it can generate individually addressed Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1; otherwise the AP sets the More Data Ack subfield to 0. For a non-HE AP, the More Data Ack subfield is reserved.

Change the last paragraph of this subclause as follows:

Non-AP STAs set the More Data Ack subfield to 1 to indicate that they can process Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state.

Non-AP non-HE STAs set the More Data Ack subfield to 1 to indicate that they can process Ack frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state. Non-AP HE STAs set the More Data Ack subfield to 1 to indicate that they can process Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state. Non-AP STAs set the More Data Ack subfield to 0 otherwise. ~~For APs, the More Data Ack subfield is reserved.~~

An HE TDLS peer STA uses the More Data Ack subfield to indicate support for both processing and generating Ack and BlockAck frames.

9.4.1.45 Band ID field

Insert a new row in Table 9-69 (Band ID field) as follows and update the Reserved row as appropriate:

Table 9-69—Band ID field

Band ID value	Meaning
7	6 GHz

9.4.1.53 Operating Mode field

Change the Rx NSS row in Table 9-82 (Subfield values of the Operating Mode field) as follows:

Table 9-82—Subfield values of the Operating Mode field

Subfield	Description
Rx NSS	If the STA that transmits the Operating Mode field (STA1) and the receiver of the Operating Mode field (STA2) are not both HE STAs and if the Rx NSS Type subfield is 0, then this field, combined with other information described in 9.4.2.157.3 (Supported VHT-MCS and NSS Set field), indicates the maximum number of spatial streams that ~~the STA~~ STA1 can receive. If the STA that transmits the Operating Mode field (STA1) and the receiver of the Operating Mode field (STA2) are both HE STAs, and if the Rx NSS Type subfield is 0, then the following apply: — The value of this field, combined with other information described in 9.4.2.157.3 (Supported VHT-MCS and NSS Set field), indicates the maximum number of spatial streams that the HE STA can receive in a VHT PPDU — The value of this field, combined with other information described in 9.4.2.247.4 (Supported HE-MCS And NSS Set field), indicates the maximum number of spatial streams that STA1 can receive in an HE PPDU. If the Rx NSS Type subfield is 1, this field~~,~~ indicates the maximum number of spatial streams that the STA can receive as a beamformee in an SU PPDU using a beamforming steering matrix derived from a VHT Compressed Beamforming report with Feedback Type subfield indicating MU in the corresponding VHT Compressed Beamforming frame sent by the STA. In a non-S1G STA: Set to 0 for $N_{SS} = 1$ Set to 1 for $N_{SS} = 2$ … Set to 7 for $N_{SS} = 8$ In an S1G STA: Set to 0 for $N_{SS} = 1$ Set to 1 for $N_{SS} = 2$ Set to 2 for $N_{SS} = 3$ Set to 3 for $N_{SS} = 4$ NOTE—In a STA with dot11VHTExtendedNSSBWCapable equal to true, NSS might be further modified for VHT PPDUs per Table 9-83 (Setting of the Channel Width subfield and 160/80+80 BW subfield at a VHT STA transmitting the Operating Mode field). In an HE STA with dot11VHTExtendedNSSBWCapable equal to true, NSS might be further modified for HE PPDUs per Equation (9-2a).

Insert the following at the end of the subclause:

The maximum number of spatial streams that the STA supports in reception for a given HE-MCS as a function of the received HE PPDU bandwidth at an HE STA transmitting an Operating Mode field is defined as

$$\text{floor}\ (\textit{Rx-NSS-from-OMF} \times (\textit{Max-HE-NSS-at-BW} \,/\, \textit{Max-HE-NSS-at-80})) \qquad (9\text{-}2a)$$

where

Rx-NSS-from-OMF is Rx NSS from the Operating Mode field transmitted by the STA

Max-HE-NSS-at-BW is the maximum NSS among all HE-MCS at *BW* MHz from the Supported HE-MCS And NSS Set field transmitted by the STA

Max-HE-NSS-at-80 is the maximum NSS among all HE-MCS at 80 MHz from the Supported HE-MCS And NSS Set field transmitted by the STA

NOTE—For operating mode between two HE STAs, the Rx NSS subfield indicates the maximum number of spatial streams at channel widths less than or equal to 80 MHz.

9.4.1.60 TWT Information field

Change Figure 9-142 (TWT Information field format) as follows:

	B0 B2	B3	B4	B5 B6	B7	B8 Bn
	TWT Flow Identifier	Response Requested	Next TWT Request	Next TWT Subfield Size	~~Reserved~~ <u>All TWT</u>	Next TWT
Bits:	3	1	1	2	1	0, 32, 48, or 64

Figure 9-142—TWT Information field format

Change the 3rd paragraph as follows:

The TWT Flow Identifier subfield contains the TWT flow identifier for which TWT information is requested or being provided.<u> The TWT Flow Identifier subfield is reserved if the All TWT subfield is 1.</u>

Insert the following before the last paragraph:

The All TWT subfield is set to 1 by an HE STA to indicate that the TWT Information frame reschedules all TWTs as defined in 26.8.4 (Use of TWT Information frames). Otherwise, it is set to 0.

Insert the following subclauses after 9.4.1.63:

9.4.1.64 HE MIMO Control field

The HE MIMO Control field is defined in Figure 9-144a (HE MIMO Control field format).

	B0 B2	B3 B5	B6 B7	B8	B9	B10 B11	B12 B14	B15
	Nc Index	Nr Index	BW	Grouping	Codebook Information	Feedback Type	Remaining Feedback Segments	First Feedback Segment
Bits:	3	3	2	1	1	2	3	1

	B16 B22	B23 B29	B30 B35	B36	B37 B39	B40 B47	B48 B55
	RU Start Index	RU End Index	Sounding Dialog Token Number	Disallowed Subchannel Bitmap Present	Reserved	Disallowed Subchannel Bitmap	Reserved
Bits:	7	7	6	1	3	0 or 8	0 or 8

Figure 9-144a—HE MIMO Control field format

The subfields of the HE MIMO Control field are defined in Table 9-93a (HE MIMO Control field encoding).

Table 9-93a—HE MIMO Control field encoding

Subfield	Description
Nc Index	If the Feedback Type subfield indicates SU or MU, the Nc Index subfield indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix and is set to *Nc* – 1. If the Feedback Type subfield indicates CQI, the Nc Index subfield indicates the number of space time streams, *Nc*, in the CQI Report and is set to *Nc* – 1.
Nr Index	If the Feedback Type subfield indicates SU or MU, then the Nr Index subfield indicates the number of rows, *Nr*, in the compressed beamforming feedback matrix and is set to *Nr* – 1.The value 0 is reserved. If the Feedback Type subfield indicates CQI, then the Nr Index subfield is reserved.
BW	Indicates the channel width used to determine the starting and ending subcarrier indices when interpreting the RU Start Index and RU End Index subfields. Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz
Grouping	If the Feedback Type subfield indicates SU or MU, then the Grouping subfield indicates the subcarrier grouping, *Ng*, used for the compressed beamforming feedback matrix: Set to 0 for *Ng* = 4 Set to 1 for *Ng* = 16 If the Feedback Type subfield indicates CQI, then the Grouping subfield is reserved.

Table 9-93a—HE MIMO Control field encoding *(continued)*

Codebook Information	Indicates the size of codebook entries. If the Feedback Type subfield indicates SU: Set to 0 for 4 bits for ϕ and 2 bits for ψ Set to 1 for 6 bits for ϕ and 4 bits for ψ If the Feedback Type subfield indicates MU: Set to 0 for 7 bits for ϕ and 5 bits for ψ Set to 1 for 9 bits for ϕ and 7 bits for ψ If the Feedback Type subfield indicates CQI, then the Codebook Information subfield is reserved. NOTE—The codebook size for MU Feedback with *Ng* = 16 is limited to (ϕ, ψ) = {9, 7}
Feedback Type	Indicates the feedback type: Set to 0 for SU Set to 1 for MU Set to 2 for CQI 3 is reserved
Remaining Feedback Segments	Indicates the number of remaining feedback segments for the associated HE Compressed Beamforming/CQI frame: Set to 0 for the last feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to a value between 1 and 7 for a feedback segment that is not the last feedback segment of a segmented report. In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission.
First Feedback Segment	Set to 1 for the first feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to 0 if not the first feedback segment or if the HE Compressed Beamforming Report field and HE MU Exclusive Beamforming Report field are not present in the frame. In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission. NOTE—The First Feedback Segment subfield is always set to 0 if the Feedback Type subfield indicates CQI because the HE Compressed Beamforming/CQI Report frame is always less than 11 454 octets in length.
RU Start Index	The starting RU index indicates the first 26-tone RU for which the HE beamformer is requesting feedback.
RU End Index	The ending RU index indicates the last 26-tone RU for which the HE beamformer is requesting feedback.
Sounding Dialog Token Number	Set to the same value as the Sounding Dialog Token Number field in the corresponding HE NDP Announcement frame.

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

The Disallowed Subchannel Bitmap Present subfield indicates whether a Disallowed Subchannel Bitmap subfield and a reserved field of 8 bits are present in the HE MIMO Control field. These subfields are present if the Disallowed Subchannel Bitmap Present subfield is equal to 1. These subfields are not present if the Disallowed Subchannel Bitmap Present subfield is equal to 0.

The Disallowed Subchannel Bitmap subfield is defined in 9.3.1.19 (VHT/HE NDP Announcement frame format).

9.4.1.65 HE Compressed Beamforming Report field

The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices V for use by a transmit beamformer to determine steering matrices Q, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming).

The size of the HE Compressed Beamforming Report field depends on the values in the HE MIMO Control field. The HE Compressed Beamforming Report field contains HE Compressed Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE compressed beamforming/CQI report (see 26.7.4 (Rules for generating segmented feedback)). HE Compressed Beamforming Report information is included in the HE compressed beamforming/CQI report if the Feedback Type subfield in the HE MIMO Control field indicates SU or MU. If the HE MIMO Control field contains a Disallowed Subchannel Bitmap subfield, then the HE Compressed Beamforming Report field does not include information for tones that are included within 242-tone RUs that are indicated as disallowed by the bitmap.

The HE Compressed Beamforming Report information contains the channel matrix elements indexed, first, by matrix angles in order shown in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band), and second, by data and pilot subcarrier index from lowest frequency to highest frequency. An explanation of how these angles are generated from the beamforming feedback matrix V is given in 19.3.12.3.6 (Compressed beamforming feedback matrix), where Nc is the number of columns in a compressed beamforming feedback matrix determined by the Nc Index subfield of the HE MIMO Control field, and Nr is the number of rows in a compressed beamforming feedback matrix determined by the Nr Index subfield of the HE MIMO Control field.

The beamforming feedback matrix V is formed by the beamformee as follows. The beamformer transmits an HE sounding NDP with $N_{STS,NDP}$ space-time streams, where $N_{STS,NDP}$ takes a value between 2 and 8. Based on this HE sounding NDP, the beamformee estimates the $N_{RX,BFEE} \times N_{STS,NDP}$ channel, and based on that channel it determines a $Nr \times Nc$ orthogonal matrix V, where Nr and Nc satisfy Equation (9-1). $N_{RX,BFEE}$ is the number of receiver chains used to receive the HE sounding NDP at the beamformee.

Further restrictions on Nc are described in 27.2 (HE PHY service interface). The angles are quantized as defined in Table 9-76 (Quantization of angles) with b_ψ defined by the Codebook Information field of the HE MIMO Control field (see 9.4.1.64 (HE MIMO Control field)).

The HE Compressed Beamforming Report information has the structure and order defined in Table 9-93b (HE Compressed Beamforming Report information), where Na is the number of angles used for the compressed beamforming feedback matrix (see Table 9-73 (Order of angles in the compressed beamforming feedback matrix when used in a non-S1G band)).

Table 9-93b—HE Compressed Beamforming Report information

Field	Size (bits)	Meaning

Table 9-93b—HE Compressed Beamforming Report information *(continued)*

Average SNR of Space-Time Stream 1	8	Signal-to-noise ratio at the beamformee for space-time stream 1 averaged over all data subcarriers. See Table 9-79 (Average SNR of Space-Time Stream i subfield).
…		…
Average SNR of Space-Time Stream Nc	8	Signal-to-noise ratio at the beamformee for space-time stream Nc averaged over all data subcarriers. See Table 9-79 (Average SNR of Space-Time Stream i subfield).
Compressed beamforming feedback matrix V for subcarrier $k = scidx(0)$	$Na \times (b_\phi + b_\psi)/2$	Compressed beamforming feedback matrix defined in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band).
Compressed beamforming feedback matrix V for subcarrier $k = scidx(1)$	$Na \times (b_\phi + b_\psi)/2$	Compressed beamforming feedback matrix defined in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band).
Compressed beamforming feedback matrix V for subcarrier $k = scidx(2)$	$Na \times (b_\phi + b_\psi)/2$	Compressed beamforming feedback matrix defined in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band).
…		…
Compressed beamforming feedback matrix V for subcarrier $k = scidx(Ns - 1)$	$Na \times (b_\phi + b_\psi)/2$	Compressed beamforming feedback matrix defined in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band).

In Table 9-93b (HE Compressed Beamforming Report information), *Ns* is the number of subcarriers for which a compressed beamforming feedback matrix is sent back to the beamformer. A beamformer or beamformee, depending upon which of the two determines the feedback parameters, reduces *Ns* by using a method referred to as grouping, in which only a single compressed beamforming feedback matrix is reported for each group of *Ng* adjacent subcarriers. *Ns* is a function of the BW, RU Start Index, RU End Index and Grouping subfields in the HE MIMO Control field (see 9.4.1.64 (HE MIMO Control field)).

Subcarrier indices *scidx(0)* and *scidx(Ns –* 1*)* are identified by the RU Start Index and RU End Index subfields respectively, together with the BW and Grouping subfields, as defined in Table 9-93c (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 4) and Table 9-93d (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 16).

Table 9-93c—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 4

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
0	–122	–96	–244	–216	–500	–472	–1012	–984	–500(L)	–472(L)
1	–96	–68	–220	–192	–476	–448	–988	–960	–476(L)	–448(L)

Table 9-93c—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 4 *(continued)*

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
2	–68	–40	–192	–164	–448	–420	–960	–932	–448(L)	–420(L)
3	–44	–16	–164	–136	–420	–392	–932	–904	–420(L)	–392(L)
4	–16	16	–136	–108	–392	–364	–904	–876	–392(L)	–364(L)
5	16	44	–112	–84	–368	–340	–880	–852	–368(L)	–340(L)
6	40	68	–84	–56	–340	–312	–852	–824	–340(L)	–312(L)
7	68	96	–56	–28	–312	–284	–824	–796	–312(L)	–284(L)
8	96	122	–32	–4	–288	–260	–800	–772	–288(L)	–260(L)
9			4	32	–260	–232	–772	–744	–260(L)	–232(L)
10			28	56	–232	–204	–744	–716	–232(L)	–204(L)
11			56	84	–204	–176	–716	–688	–204(L)	–176(L)
12			84	112	–180	–152	–692	–664	–180(L)	–152(L)
13			108	136	–152	–124	–664	–636	–152(L)	–124(L)
14			136	164	–124	–96	–636	–608	–124(L)	–96(L)
15			164	192	–100	–72	–612	–584	–100(L)	–72(L)
16			192	220	–72	–44	–584	–556	–72(L)	–44(L)
17			216	244	–44	–16	–556	–528	–44(L)	–16(L)
18					–16	16	–528	–496	–16(L)	16(L)
19					16	44	–496	–468	16(L)	44(L)
20					44	72	–468	–440	44(L)	72(L)
21					72	100	–440	–412	72(L)	100(L)
22					96	124	–416	–388	96(L)	124(L)
23					124	152	–388	–360	124(L)	152(L)
24					152	180	–360	–332	152(L)	180(L)
25					176	204	–336	–308	176(L)	204(L)
26					204	232	–308	–280	204(L)	232(L)
27					232	260	–280	–252	232(L)	260(L)
28					260	288	–252	–224	260(L)	288(L)
29					284	312	–228	–200	284(L)	312(L)
30					312	340	–200	–172	312(L)	340(L)
31					340	368	–172	–144	340(L)	368(L)
32					364	392	–148	–120	364(L)	392(L)
33					392	420	–120	–92	392(L)	420(L)

Table 9-93c—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 4 *(continued)*

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
34					420	448	–92	–64	420(L)	448(L)
35					448	476	–64	–36	448(L)	476(L)
36					472	500	–40	–12	472(L)	500(L)
37							12	40	–500(H)	–472(H)
38							36	64	–476(H)	–448(H)
39							64	92	–448(H)	–420(H)
40							92	120	–420(H)	–392(H)
41							120	148	–392(H)	–364(H)
42							144	172	–368(H)	–340(H)
43							172	200	–340(H)	–312(H)
44							200	228	–312(H)	–284(H)
45							224	252	–288(H)	–260(H)
46							252	280	–260(H)	–232(H)
47							280	308	–232(H)	–204(H)
48							308	336	–204(H)	–176(H)
49							332	360	–180(H)	–152(H)
50							360	388	–152(H)	–124(H)
51							388	416	–124(H)	–96(H)
52							412	440	–100(H)	–72(H)
53							440	468	–72(H)	–44(H)
54							468	496	–44(H)	–16(H)
55							496	528	–16(H)	16(H)
56							528	556	16(H)	44(H)
57							556	584	44(H)	72(H)
58							584	612	72(H)	100(H)
59							608	636	96(H)	124(H)
60							636	664	124(H)	152(H)
61							664	692	152(H)	180(H)
62							688	716	176(H)	204(H)
63							716	744	204(H)	232(H)
64							744	772	232(H)	260(H)
65							772	800	260(H)	288(H)

Table 9-93c—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 4 *(continued)*

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
66							796	824	284(H)	312(H)
67							824	852	312(H)	340(H)
68							852	880	340(H)	368(H)
69							876	904	364(H)	392(H)
70							904	932	392(H)	420(H)
71							932	960	420(H)	448(H)
72							960	988	448(H)	476(H)
73							984	1012	472(H)	500(H)

NOTE 1—S denotes subcarrier index *scidx*(0), identified by the RU Start Index subfield; E denotes subcarrier index *scidx*(*Ns* – 1), identified by the RU End Index subfield.

NOTE 2—*x*(L) denotes subcarrier index *x* in the frequency segment lower in frequency, and *x*(H) denotes subcarrier index *x* in the frequency segment higher in frequency.

Table 9-93d—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 16

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
0	–122	–84	–244	–212	–500	–468	–1012	–980	–500(L)	–468(L)
1	–100	–68	–228	–180	–484	–436	–996	–948	–484(L)	–436(L)
2	–68	–36	–196	–164	–452	–420	–964	–932	–452(L)	–420(L)
3	–52	–4	–164	–132	–420	–388	–932	–900	–420(L)	–388(L)
4	–20	20	–148	–100	–404	–356	–916	–868	–404(L)	–356(L)
5	4	52	–116	–84	–372	–340	–884	–852	–372(L)	–340(L)
6	36	68	–84	–52	–340	–308	–852	–820	–340(L)	–308(L)
7	68	100	–68	–20	–324	–276	–836	–788	–324(L)	–276(L)
8	84	122	–36	–4	–292	–260	–804	–772	–292(L)	–260(L)
9			4	36	–260	–228	–772	–740	–260(L)	–228(L)
10			20	68	–244	–196	–756	–708	–244(L)	–196(L)
11			52	84	–212	–164	–724	–676	–212(L)	–164(L)
12			84	116	–180	–148	–692	–660	–180(L)	–148(L)
13			100	148	–164	–116	–676	–628	–164(L)	–116(L)
14			132	164	–132	–84	–644	–596	–132(L)	–84(L)
15			164	196	–100	–68	–612	–580	–100(L)	–68(L)

Table 9-93d—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 16 *(continued)*

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
16			180	228	–84	–36	–596	–548	–84(L)	–36(L)
17			212	244	–52	–4	–564	–516	–52(L)	–4(L)
18					–20	20	–532	–492	–20(L)	20(L)
19					4	52	–508	–460	4(L)	52(L)
20					36	84	–476	–428	36(L)	84(L)
21					68	100	–444	–412	68(L)	100(L)
22					84	132	–428	–380	84(L)	132(L)
23					116	164	–396	–348	116(L)	164(L)
24					148	180	–364	–332	148(L)	180(L)
25					164	212	–348	–300	164(L)	212(L)
26					196	244	–316	–268	196(L)	244(L)
27					228	260	–284	–252	228(L)	260(L)
28					260	292	–252	–220	260(L)	292(L)
29					276	324	–236	–188	276(L)	324(L)
30					308	340	–204	–172	308(L)	340(L)
31					340	372	–172	–140	340(L)	372(L)
32					356	404	–156	–108	356(L)	404(L)
33					388	420	–124	–92	388(L)	420(L)
34					420	452	–92	–60	420(L)	452(L)
35					436	484	–76	–28	436(L)	484(L)
36					468	500	–44	–12	468(L)	500(L)
37							12	44	–500(H)	–468(H)
38							28	76	–484(H)	–436(H)
39							60	92	–452(H)	–420(H)
40							92	124	–420(H)	–388(H)
41							108	156	–404(H)	–356(H)
42							140	172	–372(H)	–340(H)
43							172	204	–340(H)	–308(H)
44							188	236	–324(H)	–276(H)
45							220	252	–292(H)	–260(H)
46							252	284	–260(H)	–228(H)
47							268	316	–244(H)	–196(H)

Table 9-93d—Subcarrier indices *scidx*(0) and *scidx*(*Ns* – 1) for *Ng* = 16 *(continued)*

RU Index	20 MHz		40 MHz		80 MHz		160 MHz		80+80 MHz	
	S	E	S	E	S	E	S	E	S	E
48							300	348	–212(H)	–164(H)
49							332	364	–180(H)	–148(H)
50							348	396	–164(H)	–116(H)
51							380	428	–132(H)	–84(H)
52							412	444	–100(H)	–68(H)
53							428	476	–84(H)	–36(H)
54							460	508	–52(H)	–4(H)
55							492	532	–20(H)	20(H)
56							516	564	4(H)	52(H)
57							548	596	36(H)	84(H)
58							580	612	68(H)	100(H)
59							596	644	84(H)	132(H)
60							628	676	116(H)	164(H)
61							660	692	148(H)	180(H)
62							676	724	164(H)	212(H)
63							708	756	196(H)	244(H)
64							740	772	228(H)	260(H)
65							772	804	260(H)	292(H)
66							788	836	276(H)	324(H)
67							820	852	308(H)	340(H)
68							852	884	340(H)	372(H)
69							868	916	356(H)	404(H)
70							900	932	388(H)	420(H)
71							932	964	420(H)	452(H)
72							948	996	436(H)	484(H)
73							980	1012	468(H)	500(H)

NOTE 1—S denotes subcarrier index *scidx*(0), identified by the RU Start Index subfield; E denotes subcarrier index *scidx*(*Ns* – 1), identified by the RU End Index subfield.

NOTE 2—*x*(L) denotes subcarrier index *x* in the frequency segment lower in frequency, and *x*(H) denotes subcarrier index *x* in the frequency segment higher in frequency.

Subcarrier indices *scidx*(i), $i = 0, \ldots, Ns - 1$ are the subset of the subcarrier indices identified by the BW and Grouping subfields, as defined in Table 9-93e (Subcarrier indices for compressed beamforming feedback matrix), starting with *scidx*(0) and ending with *scidx*(*Ns* – 1), in the order given.

NOTE 1—This implicitly defines *Ns*.

NOTE 2—For full bandwidth feedback, subcarrier indices *scidx*(*i*), *i* = 0, …, *Ns* – 1 are the entire superset shown in Table 9-93e (Subcarrier indices for compressed beamforming feedback matrix), in the order given.

Table 9-93e—Subcarrier indices for compressed beamforming feedback matrix

Channel Width	*Ng*	Superset of subcarrier indices (*scidx*)
20 MHz	4	–122, –120, –116, …, –8, –4, –2, 2, 4, 8, …, 116, 120, 122
	16	–122, –116, –100, …, –20, –4, –2, 2, 4, 20, …, 100, 116, 122
40 MHz	4	–244, –240, …, –8, –4, 4, 8, …, 240, 244
	16	–244, –228, …, –20, –4, 4, 20, …, 228, 244
80 MHz	4	–500, –496, …, –8, –4, 4, 8, …, 496, 500
	16	–500, –484, …, –20, –4, 4, 20, …, 484, 500
160 MHz	4	–1012, –1008, …, –520, –516, –508, –504, …, –16, –12, 12, 16, …, 504, 508, 516, 520, …, 1008, 1012
	16	–1012, –996, …, –532, –516, –508, –492, …, –28, –12, 12, 28, …, 492, 508, 516, 532, …, 996, 1012
80+80 MHz	4	–500(L), –496(L), …, –8(L), –4(L), 4(L), 8(L), …, 496(L), 500(L), –500(H), –496(H), …, –8(H), –4(H), 4(H), 8(H), …, 496(H), 500(H)
	16	–500(L), –484(L), …, –20(L), –4(L), 4(L), 20(L), …, 484(L), 500(L), –500(H), –484(H), …, –20(H), –4(H), 4(H), 20(H), …, 484(H), 500(H)

NOTE 1—*x*(L) denotes subcarrier index *x* in the frequency segment lower in frequency, and *x*(H) denotes subcarrier index *x* in the frequency segment higher in frequency.

NOTE 2—"…" denotes an arithmetic progression in *Ng* increments.

NOTE 3—Pilot subcarriers are not skipped.

The Average SNR of Space-Time Stream *i* subfield in Table 9-93b (HE Compressed Beamforming Report information) is an 8-bit 2s complement integer defined in Table 9-79 (Average SNR of Space-Time Stream i subfield).

The $AvgSNR_i$ in Table 9-79 (Average SNR of Space-Time Stream i subfield) is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 9-93c (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 4) for *Ng* = 4 and Table 9-93d (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 16) for *Ng* = 16, and then computing the arithmetic mean of those values. Each SNR value per subcarrier in stream *i* (before being averaged) corresponds to the SNR associated with column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix *V*.

The computation of the $AvgSNR_i$ values does not include channel information from subcarriers that lie within 242-tone RUs that are indicated as punctured by the Disallowed Subchannel Bitmap subfield, if present, of the HE NDP Announcement frame that solicited the feedback.

Padding is not present between angles in the HE Compressed Beamforming Report information, even if they correspond to different subcarriers. If the size of the HE Compressed Beamforming Report information is not an integer multiple of 8 bits, up to seven 0s are appended to the end of the field to make its size an integer multiple of 8 bits.

9.4.1.66 HE MU Exclusive Beamforming Report field

The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices Q, as described in 27.3.3.1 (DL MU-MIMO).

The size of the HE MU Exclusive Beamforming Report field depends on the values in the HE MIMO Control field. The HE MU Exclusive Beamforming Report field contains HE MU Exclusive Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE compressed beamforming/CQI report (see 26.7.4 (Rules for generating segmented feedback)). HE MU Exclusive Beamforming Report information is included in the HE compressed beamforming/CQI report (in addition to HE Compressed Beamforming Report information) if the Feedback Type subfield in the HE MIMO Control field indicates MU. If the HE MIMO Control field contains a Disallowed Subchannel Bitmap subfield, then the HE MU Exclusive Beamforming Report field does not include information for tones that are included within 242-tone RUs that are indicated as disallowed by the bitmap.

The HE MU Exclusive Beamforming Report information consists of Delta SNR subfields for each of the space-time streams, 1 to Nc, of a subset of subcarriers typically spaced Ng apart, where Ng is signaled in the Grouping subfield of the HE MIMO Control field. The subset of subcarriers starts from the lowest frequency subcarrier and continues to the highest frequency subcarrier. The subcarrier indices of the feedback for each Delta SNR subfield are identical to the subcarrier indices for the compressed beamforming feedback matrix V.

No padding is present between $\Delta SNR_{k,i}$, in the HE MU Exclusive Beamforming Report field, even if they correspond to different subcarriers. The subset of subcarriers included is determined by the values of the RU Start Index, RU End Index, and Grouping subfields of the HE MIMO Control field. For each subcarrier included, the deviation in dB of the SNR of that subcarrier for each column of V relative to the average SNR of the corresponding space-time stream is computed using Equation (9-2) except that k is the subcarrier index in the range $scidx(0)$, …, $scidx(Ns - 1)$ and $\overline{SNRi}$ is the average SNR of space-time stream i reported in the Average SNR of Space-Time Stream i field of the HE Compressed Beamforming Report Information field. In Equation (9-2), the average SNR value is computed only for subcarriers that are not indicated as disallowed by a Disallowed Subchannel Bitmap subfield, when it is present.

The HE MU Exclusive Beamforming Report information has the structure and order defined in Table 9-93f (HE MU Exclusive Beamforming Report information).

Table 9-93f—HE MU Exclusive Beamforming Report information

Field	Size (bits)	Meaning
Delta SNR for space-time stream 1 for subcarrier $k = scidx(0)$	4	$\Delta SNR_{scidx(0),1}$ as defined in Equation (9-2) as modified above.
…		…
Delta SNR for space-time stream Nc for subcarrier $k = scidx(0)$	4	$\Delta SNR_{scidx(0),Nc}$ as defined in Equation (9-2) as modified above.

Table 9-93f—HE MU Exclusive Beamforming Report information

Delta SNR for space-time stream 1 for subcarrier $k = scidx(1)$	4	$\Delta SNR_{scidx(1),1}$ as defined in Equation (9-2) as modified above.
…		…
Delta SNR for space-time stream Nc for subcarrier $k = scidx(1)$	4	$\Delta SNR_{scidx(1),Nc}$ as defined in Equation (9-2) as modified above.
…		…
Delta SNR for space-time stream 1 for subcarrier $k = scidx(Ns - 1)$	4	$\Delta SNR_{scidx(Ns-1),1}$ as defined in Equation (9-2) as modified above.
…		…
Delta SNR for space-time stream Nc for subcarrier $k = scidx(Ns - 1)$	4	$\Delta SNR_{scidx(Ns-1),Nc}$ as defined in Equation (9-2) as modified above.

In Table 9-93f (HE MU Exclusive Beamforming Report information), *Ns* and *scidx()* are defined in 9.4.1.65 (HE Compressed Beamforming Report field).

9.4.1.67 HE CQI Report field

The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested. The HE CQI Report field contains information about the quality of the link.

The size of the HE CQI Report field depends on the values in the HE MIMO Control field. The HE CQI Report field contains HE CQI Report information. HE CQI Report information is included in the HE compressed beamforming/CQI report if the Feedback Type subfield in the HE MIMO Control field indicates CQI feedback. If the HE MIMO Control field contains a Disallowed Subchannel Bitmap subfield, then the HE CQI Report field does not include information for tones that are included within 26-tone RUs that are indicated as disallowed by the bitmap.

The HE CQI Report field has the structure and order defined in Table 9-93g (HE CQI Report information).

Table 9-93g—HE CQI Report information

Field	Size (bits)	Meaning
Average SNR for space-time stream 1 for RU index $k = ruidx(0)$	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).
…		…
Average SNR for space-time stream Nc for RU index $k = ruidx(0)$	6	SNR at the beamformee for space-time stream Nc averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).

Table 9-93g—HE CQI Report information *(continued)*

Average SNR for space-time stream 1 for RU index $k = ruidx(1)$	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).
…		…
Average SNR for space-time stream Nc for RU index $k = ruidx(1)$	6	SNR at the beamformee for space-time stream Nc averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).
…		…
Average SNR for space-time stream 1 for RU index $k = ruidx(Ncqi - 1)$	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).
…		…
Average SNR for space-time stream Nc for RU index $k = ruidx(Ncqi - 1)$	6	SNR at the beamformee for space-time stream Nc averaged over 26-tone RU. See Table 9-93h (Average SNR of RU index k for space-time stream i subfield).

$Ncqi$ is the number of RU indices for which the CQI report is sent back to the beamformer. $Ncqi = (ruidx(Ncqi - 1) - ruidx(0)) + 1$ – Disallowed # of RU26, where $ruidx(0)$ and $ruidx(Ncqi - 1)$ are equal to the RU Start Index and RU End Index subfields, respectively. The RU index $ruidx(i) = ruidx(i - 1) + 1$, where $1 \leq i \leq Ncqi - 2$. The 26-tone RU subcarrier indices for 20 MHz, 40 MHz and 80 MHz are defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU), respectively.

The Average SNR of space-time stream i for the RU index k subfield in the Table 9-93g (HE CQI Report information) is a 6-bit 2s complement integer whose definition is shown in Table 9-93h (Average SNR of RU index k for space-time stream i subfield).

Table 9-93h—Average SNR of RU index *k* for space-time stream *i* subfield

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

Table 9-93h—Average SNR of RU index *k* for space-time stream *i* subfield *(continued)*

…	…
30	52
31	≥ 53

The $AvgSNR_{k,i}$ in Table 9-93h (Average SNR of RU index k for space-time stream i subfield) is found by computing the arithmetic mean of the SNR per subcarrier in decibels for space-time stream *i* over the subcarriers in RU index *k* for which the feedback is being requested. The SNR per subcarrier calculation is defined in 9.4.1.65 (HE Compressed Beamforming Report field).

Padding is not present between per-RU average SNRs of each space-time stream information, even if they correspond to different RUs and space-time streams. If the size of the HE CQI Report information is not an integer multiple of 8 bits, up to seven 0s are appended to the end of the field to make its size an integer multiple of 8 bits.

9.4.2 Elements

9.4.2.1 General

Insert the following rows into Table 9-94 (Element IDs) and update Reserved rows as appropriate:

Table 9-94—Element IDs

Element	Element ID	Element ID Extension	Extensible	Fragmentable
HE Capabilities (see 9.4.2.247 (HE Capabilities element))	255	35	Yes	No
HE Operation (see 9.4.2.248 (HE Operation element))	255	36	Yes	No
UORA Parameter Set element (see 9.4.2.249 (UORA Parameter Set element))	255	37	Yes	No
MU EDCA Parameter Set (see 9.4.2.250 (MU EDCA Parameter Set element))	255	38	Yes	No
Spatial Reuse Parameter Set element (see 9.4.2.251 (Spatial Reuse Parameter Set element))	255	39	Yes	No
NDP Feedback Report Parameter Set element (see 9.4.2.252 (NDP Feedback Report Parameter Set element))	255	41	Yes	No

Table 9-94—Element IDs *(continued)*

BSS Color Change Announcement (see 9.4.2.253 (BSS Color Change Announcement element))	255	42	Yes	No
Quiet Time Period Setup (see 9.4.2.254 (Quiet Time Period element))	255	43	Yes	No
ESS Report (see 9.4.2.255 (ESS Report element))	255	45	Yes	No
OPS (see 9.4.2.256 (OPS element))	255	46	Yes	No
HE BSS Load (see 9.4.2.257 (HE BSS Load element))	255	47	Yes	No
Multiple BSSID Configuration (see 9.4.2.258 (Multiple BSSID Configuration element))	255	55	Yes	No
Known BSSID (see 9.4.2.259 (Known BSSID element))	255	57	No	No
Short SSID List (see 9.4.2.260 (Short SSID List element))	255	58	No	No
HE 6 GHz Band Capabilities (see 9.4.2.261 (HE 6 GHz Band Capabilities element))	255	59	Yes	No
UL MU Power Capabilities (see 9.4.2.262 (UL MU Power Capabilities element))	255	60	Yes	No

9.4.2.3 Supported Rates and BSS Membership Selectors element

Change Table 9-95 (BSS membership selector value encoding) as follows (only modified rows shown):

Table 9-95—BSS membership selector value encoding

Value	Feature	Interpretation
126	VHT PHY	Support for the mandatory features of Clause 21 (Very high throughput (VHT) PHY specification) is required in order to join the BSS that was the source of the Supported Rates and BSS Membership Selectors element or Extended Supported Rates and BSS Membership Selectors element containing this value, unless the STA is a 20 MHz-only non-AP HE STA and the BSS is an HE BSS.
122	HE PHY	Support for the mandatory features of Clause 27 (High Efficiency (HE) PHY specification) is required in order to join the BSS that was the source of the Supported Rates and BSS Membership Selectors element or Extended Supported Rates and BSS Membership Selectors element containing this value.

9.4.2.5 TIM element

9.4.2.5.1 General

Insert the following at the end of the subclause:

If included in an OPS frame or a FILS Discovery frame by an OPS AP for aperiodic opportunistic power save (see 26.14.3 (Opportunistic power save)), the following apply:

— The DTIM Count field is reserved

— The DTIM Period field is reserved

— Bit *N* in the traffic indication virtual bitmap that corresponds to an OPS non-AP STA with AID *N* is determined as follows:

  • Bit *N* in the traffic indication virtual bitmap is set to 0 if the OPS AP does not intend to transmit to the OPS non-AP STA including to trigger the OPS non-AP STA for an UL MU transmission during the OPS period.

  • Otherwise, bit *N* in the traffic indication virtual bitmap for the OPS non-AP STA is set to 1.

— Bit *N* in the traffic indication virtual bitmap that corresponds to an non-OPS non-AP STA with AID *N* is determined as follows:

  • Bit *N* in the traffic indication virtual bitmap is set to 1 to indicate that AP has buffered frames for the STA and set to 0 otherwise.

If included in a TIM frame or a FILS Discovery frame by an OPS AP for periodic opportunistic power save (see 26.14.3 (Opportunistic power save)), the following apply:

— The DTIM Count field is reserved

— The DTIM Period field is reserved

— Bit *N* in the traffic indication virtual bitmap that corresponds to an OPS non-AP STA with AID *N* is determined as follows:

  - Bit *N* in the traffic indication virtual bitmap is set to 0 if the OPS AP does not intend to transmit to the OPS non-AP STA including to trigger the OPS non-AP STA for an UL MU transmission during the TWT SP and before the next TWT SP.
  - Otherwise, bit *N* in the traffic indication virtual bitmap for the OPS non-AP STA is set to 1.
- Bit *N* in the traffic indication virtual bitmap that corresponds to an non-OPS non-AP STA with AID *N* is determined as follows:
  - Bit *N* in the traffic indication virtual bitmap is set to 1 to indicate that AP has buffered frames for the STA and set to 0 otherwise.

9.4.2.26 Extended Capabilities element

Change the following rows in Table 9-153 (Extended Capabilities element) maintaining row order:

Table 9-153—Extended Capabilities element

Bit	Information	Notes
77	TWT Requester Support	A STA sets the TWT Requester Support field to 1 if dot11TWTOptionActivated is true and TWT requester functionality is supported. Otherwise, the STA sets the TWT Requester Support field to 0. See 10.47 (Target wake time (TWT)).
78	TWT Responder Support	A STA sets the TWT Responder Support field to 1 if dot11TWTOptionActivated is true and TWT responder functionality is supported. Otherwise, the STA sets the TWT Responder Support field to 0. See 10.47 (Target wake time (TWT)).
79	OBSS Narrow Bandwidth RU In OFDMA Tolerance Support	An AP STA sets the OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field to 1 if dot11OBSSNarrowBWRUinOFDMATolerated is true, and sets it to 0 otherwise. A non-AP STA sets the OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field to 0.
80	Complete List of NonTxBSSID Profiles	This field is reserved for a non-AP STA or when the AP has dot11MultiBSSIDImplemented set to false. ~~When set to 1,~~ Set to 1 to indicate~~s~~ that the frame carrying this element includes a complete list of nontransmitted BSSID profiles. ~~When set to 0~~ Set to 0 by a non-HE AP, if there is no indication about the completeness of the list of nontransmitted BSSID profiles in the frame. Set to 0 by an HE AP to indicate that the frame carrying this element does not include a complete list of nontransmitted BSSID profiles. Also see 11.1.3.8 (Multiple BSSID procedure).
83	Enhanced MultiBSSID Advertisement Support	This field is reserved for a non-AP STA or when the AP has dot11MultiBSSIDImplemented set to false. Set to 1 to indicate that the AP supports enhancements related to discovery and advertisement of nontransmitted BSSIDs. Set to 0, otherwise. Also see 11.1.3.8 (Multiple BSSID procedure).
86	OCT	The non-AP STA sets the OCT field to 1 when dot11OCTOptionImplemented is true, and sets it to 0 otherwise. This field is reserved for an AP.

9.4.2.29 TSPEC element

Change the 1st paragraph as follows:

The TSPEC element contains the set of parameters that define the characteristics and QoS expectations of a traffic flow, in the context of a particular STA, for use by the HC or PCP and STA(s) or a mesh STA and its peer mesh STAs in support of QoS traffic transfer using the procedures defined in 11.4 (TS operation) and 11.22.16.3 (GCR procedures), or for use by HE STAs in support of HE APs' scheduling for contention based channel access (EDCA) or MU operations (see 26.5 (MU operation)). The element information format comprises the items as defined in this subclause, and the structure is defined in Figure 9-298 (TSPEC element format).

Change the 4th paragraph and associated tables as follows:

The subfields of the TS Info field are defined as follows:

— The Traffic Type subfield is set to 1 for a periodic traffic pattern (e.g., isochronous TS of MSDUs or A-MSDUs, with constant or variable sizes, that are originated at fixed rate) or set to 0 for an aperiodic, or unspecified, traffic pattern (e.g., asynchronous TS of low-duty cycles).

— The TSID subfield contains a value that is a TSID. Note that the MSB (bit 4 in TS Info field) of the TSID subfield is always set to 1 when the TSPEC element is included within an ADDTS Response frame. For HE STAs, the TSID subfield contains the TID associated with this TSPEC.

— The Direction subfield specifies the direction of data carried by the TS as defined in Table 9-158 (Direction subfield encoding).

Table 9-158—Direction subfield encoding

Bit 5	Bit 6	Usage
0	0	Uplink, defined as follows: — Non-DMG BSS: MSDUs or A-MSDUs are sent from the non-AP non-HE STA to HC or from the non-AP HE STA to the HE AP — DMG BSS: MSDUs or A-MSDUs are sent by the originator of the ADDTS Request frame
1	0	Downlink, defined as follows: — Non-DMG BSS: MSDUs or A-MSDUs are sent from the HC to the non-AP non-HE STA or from the HE AP to the non-AP HE STA — DMG BSS: MSDUs or A-MSDUs are sent by the recipient of the ADDTS Request frame
0	1	Direct link (MSDUs or A-MSDUs are sent from the non-AP STA to another non-AP STA)
1	1	Bidirectional link (equivalent to a downlink request plus an uplink request, each direction having the same parameters). The fields in the TSPEC element specify resources for a single direction. Double the specified resources are required to support both streams.

— The Access Policy subfield specifies the access method to be used for the TS, and is defined in Table 9-159 (Access Policy subfield).

— The Aggregation subfield is valid only when the access method is HCCA or SPCA or when the access method is EDCA and the Schedule subfield is equal to 1. It is set to 1 by a non-AP STA to indicate that an aggregate schedule is required. It is set to 1 by the AP if an aggregate schedule is being provided to the STA. It is set to 0 otherwise. In all other cases, the Aggregation subfield is reserved.

Table 9-159—Access Policy subfield

Bit 7	Bit 8	Usage
0	0	Reserved
1	0	For non-HE STAs: Contention based channel access (EDCA) For HE STAs: Contention based channel access (EDCA) or MU based access (see 26.5 (MU operation))
0	1	Controlled channel access (HCCA for non-DMG STAs and SPCA for DMG STAs)
1	1	Controlled and contention based channel access (HCCA, EDCA mixed mode (HEMM) for non-DMG STAs; SPCA, EDCA mixed mode (SEMM) for DMG STAs)

— The APSD subfield is set to 1 to indicate that automatic PS delivery is to be used for the traffic associated with the TSPEC and set to 0 otherwise.

— The UP subfield indicates the actual value of the UP to be used for the transport of MSDUs or A-MSDUs belonging to this TS ~~when~~ if relative prioritization is required. When the TCLAS element is present in the request, the UP subfield in TS Info field of the TSPEC element is reserved.

— The TS Info Ack Policy subfield indicates whether MAC acknowledgments are required for MPDUs or A-MSDUs belonging to this TSID and the form of those acknowledgments. The encoding of the TS Info Ack Policy subfield is shown in Table 9-160 (TS Info Ack Policy subfield encoding).

Table 9-160—TS Info Ack Policy subfield encoding

Bit 14	Bit 15	Usage
0	0	Normal ~~Acknowledgment~~ Ack The addressed recipient returns an Ack or QoS +CF-Ack frame after a SIFS, according to the procedures defined in 10.3.2.11 (Acknowledgment procedure) and 10.23.3.5 (HCCA transfer rules).
1	0	No Ack: The recipient(s) do not acknowledge the transmission.
0	1	Reserved
1	1	Block Ack: A separate block ack mechanism described in 10.25 (Block acknowledgment (block ack)) is used.

— The Schedule subfield specifies the requested type of schedule. The setting of the subfield when the access policy is EDCA is shown in Table 9-161 (Setting of Schedule subfield). When the Access Policy subfield is equal to any value other than EDCA, the Schedule subfield is reserved. When the Schedule and APSD subfields are equal to 1, the AP sets the Aggregation subfield to 1, indicating that an aggregate schedule is being provided to the STA.

Table 9-161—Setting of Schedule subfield

APSD	Schedule	Usage
0	0	No Schedule
1	0	Unscheduled APSD
0	1	Scheduled PSMP or GCR-SP
1	1	Scheduled APSD

Change the 10th and 11th paragraphs as follows:

The Inactivity Interval field is 4 octets long and contains an unsigned integer that specifies the minimum amount of time, in microseconds, that can elapse without arrival or transfer of an MPDU belonging to the TS before this TS is deleted by the MAC entity at the HC for a non-HE STA, or before the information provided in this TSPEC is considered invalid at HE STAs for HE STAs.

For non-HE STAs, the ~~The~~ Suspension Interval field is 4 octets long and contains an unsigned integer that specifies the minimum amount of time, in microseconds, that can elapse without arrival or transfer of an MSDU belonging to the TS before the generation of successive QoS(+)CF-Poll is stopped for this TS. A value of 4 294 967 295 (= $2^{32} - 1$) disables the suspension interval, indicating that polling for the TS is not to be interrupted based on inactivity. The suspension interval is always less than or equal to the inactivity interval. The Suspension Interval field is reserved for HE STAs.

9.4.2.36 Neighbor Report element

Change Figure 9-337 (BSSID Information field format) as follows:

	B0 B1	B2	B3	B4 B9	B10	B11	B12	B13
	AP Reachability	Security	Key Scope	Capabilities	Mobility Domain	High Throughput	Very High Throughput	FTM
Bits:	2	1	1	6	1	1	1	1

	B14	B15	B16	B17	B18	B19	B20	B~~14~~21 B31
	High Efficiency	ER BSS	Co-Located AP	Unsolicited Probe Responses Active	Member Of ESS With 2.4/5 GHz Co-Located AP	OCT Supported With Reporting AP	Co-Located With 6 GHz AP	Reserved
Bits:	1	1	1	1	1	1	1	~~18~~11

Figure 9-337—BSSID Information field format

Change paragraphs 11-12 as follows:

~~The High Throughput bit is set to 1 to indicate that the AP represented by this BSSID is an HT AP including the HT Capabilities element in its Beacons, and that the contents of that HT Capabilities element are identical in content to the HT Capabilities element advertised by the AP sending the report.~~

The High Throughput bit is set to 1 to indicate that the AP represented by this BSSID is an HT AP and that the HT Capabilities element (or HT Operation element), if included as a subelement in the report, is identical in content to the HT Capabilities element (or HT Operation element) included in the neighboring AP's Beacon. Otherwise the High Throughput subfield is set to 0.

The Very High Throughput bit is set to 1 to indicate that the AP represented by this BSSID is a VHT AP and that the VHT Capabilities element (or VHT Operation element), if included as a subelement in the report, is identical in content to the VHT Capabilities element (or VHT Operation element) included in the neighboring AP's Beacon frame. Otherwise the Very High Throughput subfield is set to 0.

Insert the following after paragraph 14 (beginning "The FTM field…"):

The High Efficiency subfield is set to 1 to indicate that the AP represented by this BSSID is an HE AP and that the HE Capabilities element (or HE Operation element), if included as a subelement in the report, is identical in content to the HE Capabilities element (or HE Operation element) included in the neighboring AP's Beacon frame. Otherwise the High Efficiency subfield is set to 0.

The ER BSS subfield is set to 1 if the BSS corresponding to the HE AP representing this BSSID is an ER BSS transmitting Beacon frames using an HE ER SU PPDU (see 26.17.6 (ER beacon generation in an ER BSS)). Otherwise the ER BSS subfield is set to 0.

The Co-Located AP subfield is set to 1 to indicate that the AP reported in this Neighbor Report element is in the same co-located AP set as the AP sending the Neighbor Report element.

The Unsolicited Probe Responses Active subfield is set to 1 if the reported AP is part of an ESS where all the APs that operate in the same channel as the reported AP and that might be detected by a STA receiving this frame have dot11UnsolicitedProbeResponseOptionActivated equal to true and so are transmitting unsolicited Probe Response frames every 20 TUs or less (see 26.17.2.3 (Scanning in the 6 GHz band)). It is set to 0 otherwise or if the reporting AP does not have that information.

The Member Of ESS With 2.4/5 GHz Co-Located AP subfield is set to 1 if the reported AP is part of an ESS where each AP in the ESS and operating in the same band as the reported AP (irrespective of the operating channel in that band) that might be detected by a STA receiving this frame has dot11MemberOfColocated6GHzESSOptionActivated equal to true and also has a corresponding AP operating in the 2.4 GHz or 5 GHz bands that is in the same co-located AP set as that AP. It is set to 0 otherwise or if the reporting AP does not have that information. It is reserved if the reported AP is operating in the 2.4 GHz or 5 GHz bands.

NOTE 1—This subfield indicates that the reported AP is part of an ESS that has no 6 GHz-only APs that might be detected by a STA receiving this frame. This means that all APs operating in the 6 GHz band that are part of that ESS that might be detected by a STA receiving this frame can be discovered in the 2.4 GHz and/or 5 GHz bands.

NOTE 2—An AP might be detected by a STA if the STA and the AP are on the same channel and in range.

The OCT Supported With Reported AP subfield is set to 1 to indicate that OCT is supported to exchange MMPDUs with the AP reported in the Neighbor Report element (see 11.32.5 (On-channel Tunneling (OCT) operation)), through over-the-air transmissions with the AP sending the Neighbor Report element. It is set to 0 otherwise.

The Co-Located With 6 GHz AP subfield is set to 1 to indicate that the AP reported by the Neighbor Report element is in the same co-located AP set as the 6 GHz AP and that the 6 GHz AP can be discovered by Management frames sent by the reported AP. It is set to 0 otherwise.

Delete paragraph 15 ("Bits 14-31 are reserved.")

Insert new rows in Table 9-173 (Optional subelement IDs for Neighbor report) as follows and update the reserved row:

Table 9-173—Optional subelement IDs for Neighbor report

Subelement ID	Name	Extensible
193	HE Capabilities	Yes
194	HE Operation	Yes
195	BSS Load	

Table 9-173—Optional subelement IDs for Neighbor report

Subelement ID	Name	Extensible
196	HE BSS Load	Yes
197	SSID	

Insert the following after the 2nd last paragraph (beginning "The VHT Operation subelement…"):

The HE Capabilities subelement has the same format as the HE Capabilities element (see 9.4.2.247 (HE Capabilities element)).

The HE Operation subelement has the same format as the HE Operation element (see 9.4.2.248 (HE Operation element)).

The BSS Load subelement has the same format as the BSS Load element (see 9.4.2.27 (BSS Load element)).

The HE BSS Load subelement has the same format as the HE BSS Load element (see 9.4.2.257 (HE BSS Load element)).

The SSID subelement has the same format as the SSID element (see 9.4.2.2 (SSID element)).

9.4.2.45 Multiple BSSID element

Change the 3rd paragraph as follows (line break paragraph after first sentence and add note):

The MaxBSSID Indicator field contains a value assigned to n, where 2^n is the maximum number of BSSIDs in the multiple BSSID set, including the reference BSSID (see 11.10.14 (Multiple BSSID set)).

NOTE—$1 \leq n \leq 8$ since the BSSID Index field in 9.4.2.73 (Multiple BSSID-Index element) indicates the number of BSSIDs in a multiple BSSID set.

Change the 7th paragraph as follows:

~~The Nontransmitted BSSID Profile subelement contains a list of elements for one or more APs or DMG STAs that have nontransmitted BSSIDs~~ A nontransmitted BSSID profile carried in one or more Nontransmitted BSSID Profile subelements across one or more multiple BSSID elements in the same frame contains a list of elements for the AP or the DMG STA that has a nontransmitted BSSID, and is defined as follows:

- ~~For each nontransmitted BSSID, t~~The Nontransmitted BSSID Capability element (see 9.4.2.71 (Nontransmitted BSSID Capability element)) is the first element included, followed by a variable number of elements, in the order defined in Table 9-34 (Beacon frame body) for a non-DMG non-S1G AP, Table 9-47 (DMG Beacon frame body) for a DMG AP or Table 9-48 (Minimum and full set of optional elements) for a S1G AP.
- The SSID element (see 9.4.2.2 (SSID element)) and Multiple BSSID-Index element (see 9.4.2.73 (Multiple BSSID-Index element)) are included as the second and third elements, respectively ~~in the Nontransmitted BSSID Profile subelement~~.
- The FMS Descriptor element (see 9.4.2.74 (FMS Descriptor element)) is included ~~in the Nontransmitted BSSID Profile subelement~~ if dot11FMSActivated is true for the BSS using this nontransmitted BSSID and if the Multiple BSSID element is included in a Beacon frame.
- Any element specific to the BSS or with content that is different from the transmitted BSSID.
- The Timestamp and Beacon Interval fields, TIM, DSSS Parameter Set, IBSS Parameter Set, Country, Channel Switch Announcement, Extended Channel Switch Announcement, Wide Bandwidth

Channel Switch, Transmit Power Envelope, Supported Operating Classes, IBSS DFS, ERP Information, HT Capabilities, HT Operation, VHT Capabilities, ~~and~~ VHT Operation, S1G Beacon Compatibility, Short Beacon Interval, S1G Capabilities, ~~and~~ S1G Operation, HE Capabilities, HE 6 GHz Band Capabilities, HE Operation, BSS Color Change Announcement, and Spatial Reuse Parameter Set elements are not included in the Nontransmitted BSSID Profile subelement; the values of these elements for each nontransmitted BSSID are always the same as the corresponding transmitted BSSID element values.

— When included in the Nontransmitted BSSID Profile subelement for this nontransmitted BSSID, the Non-Inheritance element (see 9.4.2.240 (Non-Inheritance element)) appears as the last element in the profile and carries a list of elements that are not inherited by this nontransmitted BSSID from the transmitted BSSID.

Each Nontransmitted BSSID Profile subelement contains only elements for a BSS with a nontransmitted BSSID.

9.4.2.63 Channel Switch Timing element

Change the last paragraph of 9.4.2.64 as follows:

The Switch Timeout field is set to a time in units of microseconds. The STA sending the Channel Switch Timing element waits for the first Data frame exchange on the off-channel for Switch Timeout microseconds before switching back to base channel. The time is measured from the end of the last symbol of the Ack frame that is transmitted in response to TDLS Channel Switch Response frame, as seen on the WM. If transmitted in a (Re)Association Request frame, the Switch Timeout field is not present in the Channel Switch Timing element.

9.4.2.66 Event Request element

9.4.2.66.1 Event Request definition

Insert rows in Table 9-193 (Event Type field definitions for event requests and reports) as follows and update the Reserved row:

Table 9-193—Event Type field definitions for event requests and reports

Name	Event Type
BSS Color Collision	4
BSS Color In Use	5

9.4.2.67 Event Report element

9.4.2.67.1 Event Report Definition

Replace the 6th paragraph ("The Event TSF, …") with the following:

If the Event Report Status field is 0 (Successful) and the Event Type field is neither 4 (BSS Color Collision) nor 5 (BSS Color In Use), then the Event TSF, UTC Offset, Event Time Error, and Event Report fields are present. If the Event Report Status field is 0 (Successful) and the Event Type field is either 4 (BSS Color Collision) or 5 (BSS Color In Use), then Event TSF and Event Report fields are present. Otherwise, the Event TSF, UTC Offset, Event Time Error, or Event Report fields are not present.

Change the 10th paragraph as follows:

The Event Report field contains the specification of a single event report, as described in 9.4.2.67.2 (Transition event report) to 9.4.2.67.5 (WNM log event report), 9.4.2.67.7 (BSS color collision event report) and 9.4.2.67.8 (BSS color in use event report).

Insert new subclauses at the end of 9.4.2.67 as follows:

9.4.2.67.7 BSS color collision event report

The Event Report field for a BSS color collision event report is 8 octets in length with each bit representing a BSS color value. A value of 1 at a bit position indicates that the BSS color value corresponding to that position is in use by OBSS as detected by the reporting non-AP HE STA.

9.4.2.67.8 BSS color in use event report

The Event Report field for a BSS color in use event report is 1 octet in length. If a reporting non-AP HE STA communicates with a peer STA with a BSS color that is different from the BSS color used by its associated AP, the Event Report field is set to the BSS color used in the communication with the peer STA.

A non-AP HE STA sets the Event Report field to 0 to cancel a previously sent BSS color in use event report. See 11.22.2.8 (BSS color in use event).

9.4.2.73 Multiple BSSID-Index element

Change paragraphs 3-5 as follows:

The BSSID Index field is a value between 1 and $2^n - 1$ that identifies the nontransmitted BSSID, where n is a nonzero, positive integer value (see MaxBSSID Indicator field in 9.4.2.45 (Multiple BSSID element)).

The DTIM Period field indicates the DTIM period for the BSSID as defined in 9.4.2.5.1 (General). This field is not present when the Multiple BSSID-Index element is included in the Probe Response frame.

The DTIM Count field indicates the DTIM count for the BSSID as defined in 9.4.2.5.1 (General). This field is not present when the Multiple BSSID-Index element is included in the Probe Response frame.

9.4.2.139 ADDBA Extension element

Change Figure 9-580 (ADDBA Capabilities field format) as follows:

	B0	B1 B2	~~B1~~B3 B7
	No-Fragmentation	HE Fragmentation Operation	Reserved
Bits:	1	2	~~7~~ 5

Figure 9-580—ADDBA Capabilities field format

Change the last paragraph as follows:

The No-Fragmentation subfield determines whether a fragmented MSDU can be carried in the MPDU sent under the block ack agreement. ~~When~~ If this subfield set to 1 in the ADDBA Request frame, it indicates that the non-HE originator is not fragmenting sent MSDUs. ~~When~~ If this subfield set to 1 in the ADDBA

Response frame, it indicates that the non-HE recipient is not capable of receiving fragmented MSDUs. The No-Fragmentation subfield is reserved when transmitted by an HE STA to another HE STA.

Insert the following as the new last paragraph:

If transmitted by an HE STA, the HE Fragmentation Operation subfield indicates the level of dynamic fragmentation that is under negotiation for the TID indicated in the ADDBA frame as defined in Table 9-265a (HE Fragmentation Operation subfield).

Table 9-265a—HE Fragmentation Operation subfield

Value	Meaning in ADDBA Request frame	Meaning in ADDBA Response frame
0	The originator does not intend to send fragmented MSDUs or A-MSDUs (if supported by the transmitter) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.	The recipient does not support the reception fragmented MSDUs or A-MSDUs for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.
1	The originator intends to send fragmented MSDUs or A-MSDU (if supported by the transmitter) under fragmentation level 1 (see 26.3.2.2 (Level 1 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.	The recipient supports the reception of fragmented MSDUs or A-MSDU (if supported) under fragmentation level 1 only for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.
2	The originator intends to send fragmented MSDUs or A-MSDUs (if supported by the transmitter) under fragmentation level 2 (see 26.3.2.3 (Level 2 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.	The recipient supports the reception of receiving fragmented MSDUs or A-MSDU (if supported) under fragmentation levels 1 and 2 for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.
3	The originator intends to send fragmented MSDUs or A-MSDUs (if supported by the transmitter) under fragmentation level 3 (see 26.3.2.4 (Level 3 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.	The recipient supports the reception of fragmented MSDUs or A-MSDU (if supported) under fragmentation levels 1, 2 and 3 for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.

9.4.2.157 VHT Capabilities

9.4.2.157.3 Supported VHT-MCS and NSS Set field

Insert the following at the end of this subclause:

The value of Max VHT NSS for a given MCS is equal to the smaller of:

- the maximum value of *n* for which the Max VHT-MCS for *n* SS has a value that indicates support for that MCS
- the maximum supported NSS as indicated in by the value of the Rx NSS field of the OM Control subfield (and further defined in the Table 26-9 (Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield))

NOTE—A VHT-MCS indicated as supported in the VHT-MCS Map fields for a particular number of spatial streams might not be valid at all bandwidths (see 21.5 (Parameters for VHT-MCSs)), might be limited by the declaration of Tx Highest Supported Long GI Data Rates and Rx Highest Supported Long GI Data Rates, and might be affected by 10.6.13.3 (Additional rate selection constraints for VHT PPDUs) and the value of the Extended NSS BW Support field of the VHT Capabilities Information field in 9.4.2.157.2 (VHT Capabilities Information field) and the 160/80+80 BW subfield of the Operating Mode field in 9.4.1.53 (Operating Mode field).

9.4.2.159 Extended BSS Load element

Change the description of the $T_{busy,W1}$ parameter in 7th paragraph as follows:

$T_{busy,W1}$ is computed as the sum of the times from PHY-CCA.indication(BUSY,{W2}, per20bitmap) to the next issue of a PHY-CCA.indication primitive and that overlap the measurement interval, for W1 = 20, 40, or 80~~, and where W2 equals secondary, secondary40, or secondary80 for W1 = 20, 40, or 80, respectively~~. For a VHT AP, for W1 = 20, 40, 80, W2 equals secondary, secondary40, or secondary80, respectively. For an HE AP, for W1= 20, W2 equals secondary or per20bitmap has the bit corresponding to the primary 20 MHz channel equal to 0 and the bit corresponding to the secondary 20 MHz channel is equal to 1; for W1= 40, W2 equals secondary40 or per20bitmap has the bits corresponding to the primary 20 MHz and secondary 20 MHz channels equal to 0, and at least one bit corresponding to any 20 MHz subchannel in the secondary 40 MHz channel equal to 1; for W1 = 80, W2 equals secondary80 or per20bitmap has the bits corresponding to the primary 20 MHz, secondary 20 MHz and secondary 40 MHz channels equal to 0, and at least one bit corresponding to any 20 MHz subchannel in the secondary 80 MHz channel is equal to 1.

9.4.2.161 Transmit Power Envelope element

Change the 6th paragraph as follows:

Local Maximum Transmit Power For *X* MHz fields (where *X* = 20, 40, 80, or 160/80+80) define the local maximum transmit power limit of *X* MHz PPDUs, except for an HE TB PPDU where *X* MHz is the bandwidth of the pre-HE modulated fields of the HE TB PPDU transmitted by a STA. Each Local Maximum Transmit Power For *X* MHz field is encoded as an 8-bit 2s complement signed integer in the range –64 dBm to 63 dBm with a 0.5 dB step. Setting this field to 63.5 dBm indicates 63.5 dBm or higher (i.e., no local maximum transmit power constraint).

9.4.2.170 Reduced Neighbor Report element

9.4.2.170.2 Neighbor AP Information field

Change the 4th paragraph as follows:

The Filtered Neighbor AP subfield is 1 bit in length. When included in an individually addressed Probe Response frame, it is set to 1 if the SSID corresponding to every AP in this Neighbor AP Information field matches the SSID in the corresponding Probe Request frame. When included in a Beacon, broadcast Probe Response or FILS Discovery frame transmitted by a non-TVHT AP, it is set to 1 if the SSID corresponding to every AP in this Neighbor AP Information field matches the SSID of the transmitting AP's BSS. It is set to 0 otherwise.

Change the 6th paragraph as follows:

The TBTT Information Length subfield is 1 octet in length and indicates the length of each TBTT Information field included in the TBTT Information Set field of the Neighbor AP Information field. ~~When~~ If the TBTT Information Field Type subfield is ~~set to~~ 0, the TBTT Information Length subfield:

— contains the length in octets of each TBTT Information field that is included in the TBTT Information Set field of the Neighbor AP Information field

— is set to 1, 5, 7, 8, ~~or~~ 11, or 12; other values are reserved.

— indicates the TBTT Information field contents as shown in Table 9-273 (TBTT Information field content).

Change Table 9-281 (TBTT Information field contents) as follows:

Table 9-281—TBTT Information field contents

TBTT Information Length subfield value	TBTT Information field contents
1	The Neighbor AP TBTT Offset subfield
2	The Neighbor AP TBTT Offset subfield and the BSS Parameters subfield
5	The Neighbor AP TBTT Offset subfield and the Short-SSID subfield
6	The Neighbor AP TBTT Offset subfield, the Short-SSID subfield, and the BSS Parameters subfield
7	The Neighbor AP TBTT Offset subfield and the BSSID subfield
8	The Neighbor AP TBTT Offset subfield, the BSSID subfield, and the BSS Parameters subfield
11	The Neighbor AP TBTT Offset subfield, the BSSID subfield and the Short-SSID subfield
12	The Neighbor AP TBTT Offset subfield, the BSSID subfield, the Short-SSID subfield and the BSS Parameters subfield
0, ~~2~~3–4, ~~6, 8–10, 12–255~~ 9–10	Reserved
13–255	Reserved, but the first 12 octets of the field are the same as for TBTT Information Length

Change 9-632 (TBTT Information field format) as follows:

	Neighbor AP TBTT Offset	BSSID (optional)	Short-SSID (optional)	BSS parameters
Octets:	1	0 or 6	0 or 4	0 or 1

Figure 9-632—TBTT Information field format

Change the 3rd to last paragraph as follows:

~~The Neighbor AP TBTT Offset subfield is 1 octet in length and indicates the offset in TUs, rounded down to nearest TU, to the next TBTT of an AP from the immediately prior TBTT of the AP that transmits this element. The value 254 indicates an offset of 254 TUs or higher. The value 255 indicates an unknown offset value.~~

The Neighbor AP TBTT Offset subfield indicates the offset in TUs, rounded down to nearest TU, to the following:

— The next TBTT of the reported AP from the immediately prior TBTT of the AP that transmits this element if the reported AP is not part of a multiple BSSID set or is the transmitted BSSID of a multiple BSSID set.

— The next TBTT of the transmitted BSSID of the multiple BSSID set of the reported AP from the immediately prior TBTT of the AP that transmits this element if the reported AP is part of a multiple BSSID set and is a nontransmitted BSSID.

The value 254 indicates an offset of 254 TUs or higher. The value 255 indicates an unknown offset value.

Insert at the end of this subclause:

The format of the BSS Parameters subfield is defined in Figure 9-632a (BSS Parameters subfield format).

	B0	B1	B2	B3	B4	B5	B6	B7
	OCT Recommended	Same SSID	Multiple BSSID	Transmitted BSSID	Member Of ESS With 2.4/5 GHz Co-Located AP	Unsolicited Probe Responses Active	Co-Located AP	Reserved
Bits:	1	1	1	1	1	1	1	1

Figure 9-632a—BSS Parameters subfield format

The OCT Recommended subfield is set to 1 to indicate that OCT is recommended to exchange MMPDUs with the AP identified in the TBTT Information field (see 11.32.5 (On-channel Tunneling (OCT) operation)), through over-the-air transmissions with the AP sending the Reduced Neighbor Report element. It is set to 0 otherwise.

The Same SSID subfield is set to 1 to indicate that the reported AP has the same SSID as the reporting AP. It is set to 0 otherwise.

The Multiple BSSID subfield is set to 1 to indicate that the reported AP is part of a multiple BSSID set. It is set to 0 otherwise.

The Transmitted BSSID subfield is set to 1 to indicate that the reported AP is a transmitted BSSID. It is set to 0 it the reported AP is a nontransmitted BSSID. It is reserved if the Multiple BSSID subfield is set to 0.

The Member Of ESS With 2.4/5 GHz Co-Located AP subfield is set to 1 if the reported AP is part of an ESS where each AP in the ESS and operating in the same band as the reported AP (irrespective of the operating channel in that band) that might be detected by a STA receiving this frame has dot11MemberOfColocated6GHzESSOptionActivated equal to true and also has a corresponding AP operating in the 2.4 GHz or 5 GHz bands that is in the same co-located AP set as that AP. It is set to 0 otherwise or if the reporting AP does not have that information. It is reserved if the reported AP is operating in the 2.4 GHz or 5 GHz bands.

NOTE 1—This subfield indicates that the reported AP is part of an ESS that has no 6 GHz-only APs that might be detected by a STA receiving this frame. This means that all APs operating in the 6 GHz band that are part of that ESS that might be detected by a STA receiving this frame can be discovered in the 2.4 GHz and/or 5 GHz bands.

NOTE 2—An AP might be detected by a STA if the STA and the AP are on the same channel and in range.

The Unsolicited Probe Responses Active subfield is set to 1 if the reported AP is part of an ESS where all the APs that operate in the same channel as the reported AP and that might be detected by a STA receiving this frame have dot11UnsolicitedProbeResponseOptionActivated equal to true and are transmitting unsolicited Probe Response frames every 20 TUs or less (see 26.17.2.3 (Scanning in the 6 GHz band)). It is set to 0 otherwise or if the reporting AP does not have that information.

The Co-Located AP subfield is set to 1 if every AP in this Neighbor AP Information field is in the same co-located AP set as the transmitting AP. It is set to 0 otherwise.

9.4.2.177 FILS Request Parameters element

Insert the following in Table 9-289 (PHY Support Criterion subfield) and update the Reserved row as appropriate:

Table 9-289—PHY Support Criterion subfield

Value	Explanation
3	Indicates that a responding FILS STA is HE capable.

9.4.2.199 TWT element

Replace Figure 9-686 (TWT element format) with the following:

	Element ID	Length	Control	TWT Parameter Information
Octets:	1	1	1	variable

Figure 9-686—TWT element format

Change Figure 9-687 (Control field format) as follows.

	~~B1~~B0	~~B2~~B1	B2 B3	B4	B5	~~B3~~B6 ~~B8~~B7
	NDP Paging Indicator	Responder PM Mode	Negotiation Type	TWT Information Frame Disabled	Wake Duration Unit	Reserved
Bits:	1	1	2	1	1	~~6~~2

Figure 9-687—Control field format

Insert the following (including table) after the 5th paragraph ("The Responder PM Mode subfield…"):

The Negotiation Type subfield indicates whether the information included in the TWT element is for the negotiation of parameters of broadcast or individual TWT(s) or a Wake TBTT interval. The MSB of the Negotiation Type subfield is the Broadcast field.

The TWT Information Frame Disabled subfield is set to 1 to indicate that the reception of TWT Information frames is disabled by the STA; otherwise, it is set to 0.

The Wake Duration Unit subfield indicates the unit of the Nominal Minimum TWT Wake Duration field. The Wake Duration Unit subfield is set to 0 if the unit is 256 us and is set to 1 if the unit is a TU. A non-HE STA sets the Wake Duration Unit subfield to 0.

If the Broadcast field of the Negotiation Type subfield is 1, then one or more broadcast TWT parameter sets are contained in the TWT element (see Figure 9-687b (Broadcast TWT Parameter Set field format)). If the Broadcast field of the Negotiation Type subfield is 0, then only one Individual TWT parameter set is contained in the TWT element (see Figure 9-687a (Individual TWT Parameter Set field format)). An S1G STA sets the Negotiation Type subfield to 0.

A TWT element that has the Broadcast field in the Control field set to 1 is referred to as broadcast TWT element.

The Negotiation Type subfield determines the interpretation of the Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent subfields of the TWT element as defined in Table 9-296a (Interpretation of Negotiation Type subfield, Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields).

Table 9-296a—Interpretation of Negotiation Type subfield, Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields

Negotiation Type subfield	Target Wake Time field	TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields	Description
0	A future Individual TWT SP start time	Interval between individual TWT SPs	Individual TWT negotiation between TWT requesting STA and TWT responding STA or individual TWT announcement by TWT responder. See 10.47 (Target wake time (TWT)), and 26.8.2 (Individual TWT agreements). The TWT element contains one individual TWT parameter set.

Table 9-296a—Interpretation of Negotiation Type subfield, Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields *(continued)*

1	Next Wake TBTT time	Interval between wake TBTTs	Wake TBTT and wake interval negotiation between TWT scheduled STA and TWT scheduling AP. See 26.8.6 (Negotiation of wake TBTT and wake interval). The TWT element contains one individual TWT parameter set.
2	A future Broadcast TWT SP start time	Interval between broadcast TWT SPs	Provide broadcast TWT schedules to TWT scheduled STAs by including the TWT element in broadcast Management frames sent by TWT scheduling AP. See 26.8.3.2 (Rules for TWT scheduling AP). The TWT element contains one or more broadcast TWT parameter sets.
3	A future Broadcast TWT SP start time	Interval between broadcast TWT SPs	Manage memberships in broadcast TWT schedules by including the TWT element in individually addressed Management frames sent by either a TWT scheduled STA or a TWT scheduling AP. See 26.8.3 (Broadcast TWT operation). The TWT element contains one or more broadcast TWT parameter sets.

The TWT Parameter Information field contains a single Individual TWT Parameter Set field with format defined in Figure 9-687a (Individual TWT Parameter Set field format) if the Broadcast subfield in the Control field is 0 and contains one or more Broadcast TWT Parameter Set fields with format defined in Figure 9-687b (Broadcast TWT Parameter Set field format) if the Broadcast subfield of the Control field is 1. The number of Broadcast TWT Parameter Set fields present is determined by the values of the Last Broadcast Parameter Set subfields of the Request Type fields.

	Request Type	Target Wake Time	TWT Group Assignment	Nominal Minimum TWT Wake Duration	TWT Wake Interval Mantissa	TWT Channel	NDP Paging (optional)
Octets:	2	0 or 8	0, 3 or 9	1	2	1	0 or 4

Figure 9-687a—Individual TWT Parameter Set field format

	Request Type	Target Wake Time	Nominal Minimum TWT Wake Duration	TWT Wake Interval Mantissa	Broadcast TWT Info
Octets:	2	2	1	2	2

Figure 9-687b—Broadcast TWT Parameter Set field format

Change the 6th paragraph as follows:

The format of the Request Type field of the Individual TWT Parameter Set field is shown in Figure 9-688 (Request Type field format in an Individual TWT Parameter Set field) and of a Broadcast TWT Parameter Set field is shown in Figure 9-688a (Request Type field format in a Broadcast TWT Parameter Set field).

Change Figure 9-688 (Request Type field format in an Individual TWT Parameter Set field) as follows:

	B0	B1 B3	B4	B5	B6	B7 B9	B10 B14	B15
	TWT Request	TWT Setup Command	~~Reserved~~ Trigger	Implicit	Flow Type	TWT Flow Identifier	TWT Wake Interval Exponent	TWT Protection
Bits:	1	3	1	1	1	3	5	1

Figure 9-688—Request Type field format in an Individual TWT Parameter Set field

Insert a new Figure 9-688a (Request Type field format in a Broadcast TWT Parameter Set field) as follows:

	B0	B1 B3	B4	B5	B6	B7 B9	B10 B14	B15
	TWT Request	TWT Setup Command	Trigger	Last Broadcast Parameter Set	Flow Type	Broadcast TWT Recomme ndation	TWT Wake Interval Exponent	Reserved
Bits:	1	3	1	1	1	3	5	1

Figure 9-688a—Request Type field format in a Broadcast TWT Parameter Set field

Change the 7th and 8th paragraphs as follows:

A STA that transmits a TWT element with the TWT Request subfield equal to 1 is a TWT requesting STA or TWT scheduled STA. Otherwise, it is a TWT responding STA or TWT scheduling AP.

The TWT Setup Command subfield values indicate the type of TWT command~~ as shown in Table 9-262k~~. The use of the TWT Setup Command field for the negotiation of individual and broadcast TWT is described in Table 9-297 (TWT Setup Command field values). The entries in the table apply to cases where the Negotiation Type subfield is not 1. For TWT Setup Command field use when the Negotiation Type subfield is 1, see 26.8.6 (Negotiation of wake TBTT and wake interval).

Change Table 9-297 (TWT Setup Command field values) as follows:

Table 9-297—TWT Setup Command field values

TWT Setup Command field value	Command name	~~Description when transmitted by a TWT requesting STA~~ <u>Description</u>	~~Description when transmitted by a TWT responding STA~~
0	Request TWT	~~The Target Wake Time field of the TWT element contains 0s as the TWT responding STA specifies the target wake time value for this case, other TWT parameters* are suggested by the TWT requesting STA in the TWT request.~~ <u>A TWT requesting or TWT scheduled STA requests to join a TWT without specifying a target wake time.</u> <u>This command is valid if the TWT Request field is equal to 1; otherwise the command is not applicable.</u>	~~N/A~~
1	Suggest TWT	~~TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup might still be accepted.~~ <u>A TWT requesting or TWT scheduled STA requests to join a TWT and specifies a suggested set of TWT parameters with the possibility that if the requested target wake time and/or other TWT parameters cannot be accommodated, then the TWT setup might still be accepted by the TWT requesting or TWT scheduled STA.</u> <u>This command is valid if the TWT Request field is equal to 1; otherwise it is not applicable.</u>	~~N/A~~
2	Demand TWT	~~TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup will be rejected.~~ <u>A TWT requesting or TWT scheduled STA requests to join a TWT and specifies a demanded set of TWT parameters. If the demanded set of TWT parameters is not accommodated by the responding STA or TWT scheduling AP, then the TWT requesting STA or TWT scheduled STA will reject the TWT setup.</u> <u>This command is valid if the TWT Request field is equal to 1; otherwise it is not applicable.</u>	~~N/A~~
3	TWT Grouping	~~N/A~~ <u>The TWT responding STA suggests TWT group parameters that are different from the suggested or demanded TWT parameters of the TWT requesting STA</u> <u>This command is valid if the TWT Request field is 0, the Negotiation Type subfield is 0 and is sent by an S1G STA; otherwise not applicable.</u>	~~TWT responding STA suggests TWT group parameters that are different from the suggested or demanded TWT parameters of the TWT requesting STA~~

Table 9-297—TWT Setup Command field values *(continued)*

4	Accept TWT	~~N/A~~ A TWT responding STA or TWT scheduling AP accepts the TWT request with the TWT parameters (see NOTE) indicated in the TWT element transmitted by the TWT requesting STA or TWT scheduled STA. This value is also used in unsolicited TWT responses. This command is valid if the TWT Request field is 0; otherwise not applicable.	~~TWT responding STA accepts the TWT request with the TWT parameters (See NOTE) indicated in the TWT element transmitted by the responding STA~~
5	Alternate TWT	~~N/A~~ A TWT responding STA or TWT scheduling AP suggests TWT parameters that are different from those suggested by the TWT requesting STA or TWT scheduled STA. This command is valid if the TWT Request field is 0; otherwise not applicable.	~~TWT responding STA suggests TWT parameters that are different from TWT requesting STA suggested or demanded TWT parameters~~
6	Dictate TWT	~~N/A~~ A TWT responding STA or TWT scheduling AP indicates TWT parameters that are different from those suggested by the TWT requesting STA or TWT scheduled STA. This command is valid if the TWT Request field is 0; otherwise not applicable.	~~TWT responding STA demands TWT parameters that are different from TWT requesting STA TWT suggested or demanded parameters~~
7	Reject TWT	~~N/A~~ A TWT responding STA or TWT scheduling AP rejects setup or a TWT scheduling AP terminates an existing broadcast TWT or a TWT scheduled STA terminates its membership in a broadcast TWT.	~~TWT responding STA rejects TWT setup~~
NOTE—TWT Parameters are: TWT, Nominal Minimum Wake Duration, TWT Wake Interval and TWT Channel subfield values indicated in the TWT element. The Trigger subfield value indicated in the TWT element is also a TWT parameter for an HE STA.			

Insert the following paragraph after the 8th paragraph ("The TWT Setup Command subfield…"):

The Trigger field indicates whether or not the TWT SP indicated by the TWT element includes Trigger frames or frames carrying a TRS Control subfield as defined in 26.8 (TWT operation). The Trigger field is set to 1 to indicate that at least one Trigger frame or frame carrying a TRS Control subfield is transmitted during the TWT SP. The Trigger field is set to 0 otherwise.

Change paragraphs 9-12 as follows:

~~When transmitted by a TWT requesting STA, t~~The Implicit subfield is set to 1 to ~~request~~ indicate an implicit TWT and is set to 0 to indicate an explicit TWT.

~~When transmitted by a TWT requesting STA, the Implicit subfield is set to 0 to request an explicit TWT.~~

The Last Broadcast Parameter Set subfield is set to 0 to indicate that another broadcast TWT Parameter set follows this set. The Last Broadcast Parameter Set subfield is set to 1 to indicate that this is the last broadcast TWT Parameter set in the broadcast TWT element.

The Flow Type subfield indicates the type of interaction between the TWT requesting STA or TWT scheduled STA and the TWT responding STA or TWT scheduling AP at a TWT. Setting the Flow Type subfield to 0 indicates an announced TWT in which the TWT requesting STA or TWT scheduled STA will send a PS-Poll or an APSD trigger frame (see 11.2.3.5 (Power management with APSD)) to signal its awake state to the TWT responding STA or TWT scheduling AP before a frame that is not a Trigger frame is sent from the TWT responding STA or TWT scheduling AP to the TWT requesting STA or TWT scheduled STA. Setting the Flow Type subfield to 1 indicates an unannounced TWT in which the TWT responding STA or TWT scheduling AP will send a frame to the TWT requesting STA or TWT scheduled STA at TWT without waiting to receive a PS-Poll or an APSD trigger frame from the TWT requesting STA or TWT scheduled STA.

NOTE—The TWT requesting STA is expected to send the PS-Poll or APSD trigger frame in response to a Trigger frame if the TWT is a trigger-enabled TWT.

The TWT Flow Identifier subfield contains a 3-bit value ~~which~~ that identifies the specific information for this TWT request uniquely from other requests made between the same TWT requesting STA and TWT responding STA pair. The Broadcast TWT Recommendation subfield contains a value that indicates recommendations on the types of frames that are transmitted by TWT scheduled STAs and scheduling AP during the broadcast TWT SP, encoded according to the Broadcast TWT Recommendation field for a broadcast TWT element as defined in Table 9-297a (Broadcast TWT Recommendation field for a broadcast TWT element). The Broadcast TWT Recommendation is reserved if transmitted by a TWT scheduled STA.

Insert a new table as follows:

Table 9-297a—Broadcast TWT Recommendation field for a broadcast TWT element

Broadcast TWT Recommendation 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 by a TWT scheduled STA are recommended to be limited to solicited status and solicited feedback: — PS-Poll and QoS Null frames — Feedback can be contained in the QoS Control field or in the HE variant HT Control field of the frame, if either is present (see 26.5.2 (UL MU operation), 26.9 (Operating mode indication), 26.13 (Link adaptation using the HLA Control subfield), etc.) — Feedback in an HE TB feedback NDP, if solicited by the AP (see 26.5.7 (NDP feedback report procedure)) — BQRs (see 26.5.2 (UL MU operation)) — BSRs (see 26.5.3 (MU cascading sequence)) — Frames that are sent as part of a sounding feedback exchange (see 26.7 (HE sounding protocol)) — Management frames: Action or Action No Ack frames — Control response frames Trigger frames transmitted by the TWT scheduling AP during the broadcast TWT SP do not contain RUs for random access (see 26.8.3.2 (Rules for TWT scheduling AP) and 26.5.4 (UL OFDMA-based random access (UORA))), otherwise, there are no other restrictions on the frames transmitted by the TWT scheduling AP.

Table 9-297a—Broadcast TWT Recommendation field for a broadcast TWT element

2	Frames transmitted during a broadcast TWT SP by a TWT scheduled STA are recommended to be limited to solicited status and solicited feedback: — PS-Poll and QoS Null frames — Feedback can be contained in the QoS Control field or in the HE variant HT Control field of the frame, if either is present (see 26.5.2 (UL MU operation), 26.9 (Operating mode indication), 26.13 (Link adaptation using the HLA Control subfield), etc.) — BQRs (see 26.5.2 (UL MU operation)) — BSRs (see 26.5.3 (MU cascading sequence)) — Frames that are sent as part of a sounding feedback exchange (see 26.7 (HE sounding protocol)) — Management frames: Action, Action No Ack frames or (Re)Association Request — Control response frames Trigger frames transmitted by the TWT scheduling AP during the broadcast TWT SP contain at least one RU for random access (see 26.8.3.2 (Rules for TWT scheduling AP) and 26.5.4 (UL OFDMA-based random access (UORA))), otherwise there are no restrictions on the frames transmitted by the TWT scheduling AP.
3	No constraints on the frames transmitted during a broadcast TWT SP except that the AP transmits a TIM frame or a FILS Discovery frame including a TIM element at the beginning of each TWT SP (see 26.14.3.2 (AP operation for opportunistic power save)).
4-7	Reserved

Change the 13th and 14th paragraphs as follows:

In a TWT element transmitted by a TWT requesting or TWT scheduled STA, the TWT wake interval is equal to the average time that the ~~TWT requesting~~ STA expects to elapse between successive TWT SPs start times (see Table 9-296a (Interpretation of Negotiation Type subfield, Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields)). In a TWT element transmitted by a TWT responding STA or TWT scheduling AP, the TWT wake interval is equal to the average time that the ~~TWT responding~~ STA expects to elapse between successive TWT SPs start times. In a TWT element contained in a TWT request that is sent by the TWT scheduled STA to negotiate its wake intervals, the TWT wake interval indicates the value of the wake interval (see 26.8.6 (Negotiation of wake TBTT and wake 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) × $2^{(\text{TWT Wake Interval Exponent})}$.

~~When~~ If transmitted by a TWT requesting STA or a TWT scheduled STA and the TWT Setup Command subfield contains a value corresponding to the command "Suggest TWT" or "Demand TWT", the Target Wake Time field contains ~~a positive~~ an unsigned integer corresponding to a TSF time at which the STA requests to wake~~, or 0 when the TWT Setup Command subfield contains the value corresponding to the command “Request TWT”~~. If transmitted by a TWT requesting STA or a TWT scheduled STA and the TWT Setup Command subfield contains the value corresponding to the command "Request TWT", the Target Wake Time field contains the value 0. The Target Wake Time field is 8 octets if the Broadcast field is 0; otherwise it is 2 octets with the lowest bit of the 2 octets corresponding to bit 10 of the relevant TSF value. ~~When~~ If a TWT responding 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 corresponding to a TSF time at which the TWT responding STA requests the TWT requesting STA to wake for the corresponding TWT SP and it does not contain the TWT Group Assignment field.

Insert the following paragraphs and figure after paragraph 21 (“The TWT Wake Interval Mantissa…”):

The Broadcast TWT Info subfield is defined in Figure 9-689a (Broadcast TWT Info subfield format).

	B0 B2	B3 B7	B8 B15
	Reserved	Broadcast TWT ID	Broadcast TWT Persistence
Bits:	3	5	8

Figure 9-689a—Broadcast TWT Info subfield format

Within a TWT element that includes a TWT setup command value of Request TWT, Suggest TWT or Demand TWT, the Broadcast TWT ID, if present, indicates a specific Broadcast TWT in which the transmitting STA is requesting to participate. Within a TWT element that includes a TWT setup command value of Accept TWT, Alternate TWT, Dictate TWT or Reject TWT, the Broadcast TWT ID, if present, indicates a specific Broadcast TWT for which the transmitting STA is providing TWT parameters. Within a TWT element that includes a TWT setup command value of TWT Grouping, the Broadcast subfield is 0 and the Broadcast TWT ID~~,~~ is not present. The value 0 in the Broadcast TWT ID subfield indicates the broadcast TWT whose membership corresponds to all STAs that are members of the BSS corresponding to the BSSID of the Management frame carrying the TWT element and that is permitted to contain Trigger frames with RA-RUs for unassociated STAs.

The Broadcast TWT Persistence subfield indicates the number of TBTTs during which the Broadcast TWT SPs corresponding to this broadcast TWT Parameter set are present. The number of beacon intervals during which the Broadcast TWT SPs are present is equal to the value in the Broadcast TWT Persistence subfield plus 1 except that the value 255 indicates that the Broadcast TWT SPs are present until explicitly terminated.

Change the 20th paragraph as follows:

The Nominal Minimum TWT Wake Duration field indicates the minimum amount of time, in the unit~~s of 256 µs~~ indicated by the Wake Duration Unit subfield, that the TWT requesting STA or TWT scheduled STA is expected ~~expects that it needs~~ to be awake in order to complete the frame exchanges ~~associated with the TWT flow identifier~~ for the period of TWT wake interval, where TWT wake interval is the average time that the TWT requesting STA or TWT scheduled STA expects to elapse between successive TWT SPs.

Change the 22nd and subsequent two paragraphs as follows:

~~When transmitted by a TWT requesting STA, the TWT Channel field contains a bitmap indicating which channel the STA requests to use as a temporary primary channel during a TWT SP. When transmitted by a TWT responding STA, the TWT Channel field contains a bitmap indicating which channel the TWT requesting STA is allowed to use as a temporary channel during the TWT SP.~~ The TWT Channel field includes a bitmap that provides the channel that is being negotiated by a STA as a temporary channel during a TWT SP. Each bit in the bitmap corresponds to one minimum width channel for the band in which the TWT responding STA's associated BSS is currently operating, with the least significant bit corresponding to the lowest numbered channel of the operating channels of the BSS. In an S1G BSS, the ~~The~~ minimum width channel is equal to the SST Channel Unit field of the SST Operation element if such an element has been previously received or is equal to 1 MHz for a BSS with a BSS primary channel width of 1 MHz and 2 MHz for a BSS with a BSS primary channel width of 2 MHz if no such element has been previously received from the AP to which the SST STA is associated. In an HE BSS, the minimum width channel is equal to 20 MHz. A value of 1 in a bit position in the bitmap transmitted by a TWT requesting STA means that operation with that channel as the ~~primary~~ temporary channel is requested during a TWT SP. A value of 1 in a bit position in the bitmap transmitted by a TWT responding STA means that operation with that channel as the ~~primary~~ temporary channel is allowed during the TWT SP. The TWT Channel field is used by an S1G STA as defined in 10.53 (Subchannel Selective Transmission (SST)) and is used by an HE STA as defined in 26.8.7

(HE subchannel selective transmission).If the TWT channel field is 0 then the STA operates as define in 10.47 (Target wake time (TWT)) or 26.8.2 (Individual TWT agreements).

~~A TWT requesting STA sets the TWT Protection subfield to 1 to request the TWT responding STA to provide protection of the set of TWT SPs corresponding to the requested TWT flow identifier by allocating RAW(s) that restrict access to the medium during the TWT SP(s) for that (those) TWTs. A TWT requesting STA sets the TWT Protection subfield to 0 if TWT protection by RAW allocation is not requested for the corresponding TWT(s).~~

A TWT requesting STA sets the TWT Protection subfield to 1 to request the TWT responding STA to provide protection of the set of TWT SPs corresponding to the requested TWT flow identifier by:

- Allocating RAW(s) that restrict access to the medium during the TWT SP(s) for the TWTs that are set up within an S1G BSS
- Enabling NAV protection during the TWT SP(s) for the TWTs that are set up within an HE BSS

A TWT requesting STA sets the TWT Protection subfield to 0 if TWT protection is not requested for the corresponding TWT(s).

~~When transmitted by a TWT responding STA that is an AP, the TWT Protection subfield indicates whether the TWT SP(s) identified in the TWT element will be protected. A TWT responding STA sets the TWT Protection subfield to 1 to indicate that the TWT SP(s) corresponding to the TWT flow identifier(s) of the TWT element will be protected by allocating RAW(s) that restrict access to the medium during the TWT SP(s) for that (those) TWT(s). A TWT responding STA sets the TWT Protection subfield to 0 to indicate that the TWT SP(s) identified in the TWT element might not be protected from TIM STAs by allocating RAW(s).~~

A TWT responding STA or TWT scheduling AP sets the TWT Protection subfield to 1 to indicate that the TWT SP(s) corresponding to the TWT flow identifier(s) of the TWT element will be protected by:

- Allocating RAW(s) that restrict access to the medium during the TWT SP(s) for the TWTs where the TWT responding STA is an S1G STA.
- Enabling NAV protection during the TWT SP(s) for the TWTs where the TWT responding STA is an HE STA.

A TWT responding STA sets the TWT Protection subfield to 0 to indicate that the TWT SP(s) identified in the TWT element might not be protected.

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

9.4.2.247 HE Capabilities element

9.4.2.247.1 General

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 9-787a (HE Capabilities element format).

	Element ID	Length	Element ID Extension	HE MAC Capabilities Information	HE PHY Capabilities Information	Supported HE-MCS And NSS Set	PPE Thresholds (optional)
Octets:	1	1	1	6	11	4, 8 or 12	variable

Figure 9-787a—HE Capabilities element format

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

The HE MAC Capabilities Information, HE PHY Capabilities Information, Supported HE-MCS And NSS Set, and PPE Thresholds fields are defined in the subclauses below.

9.4.2.247.2 HE MAC Capabilities Information field

The format of the HE MAC Capabilities Information field is defined in Figure 9-787b (HE MAC Capabilities Information field format).

	B0	B1	B2	B3 B4	B5 B7	B8 B9	B10 B11	B12 B14
	+HTC HE Support	TWT Requester Support	TWT Responder Support	Dynamic Fragmentation Support	Maximum Number Of Fragmented MSDUs/A-MSDUs Exponent	Minimum Fragment Size	Trigger Frame MAC Padding Duration	Multi-TID Aggregation Rx Support
Bits:	1	1	1	2	3	2	2	3

	B15 B16	B17	B18	B19	B20	B21	B22	B23
	HE Link Adaptation Support	All Ack Support	TRS Support	BSR Support	Broadcast TWT Support	32-bit BA Bitmap Support	MU Cascading Support	Ack-Enabled Aggregation Support
Bits:	2	1	1	1	1	1	1	1

	B24	B25	B26	B27 B28	B29	B30	B31	B32
	Reserved	OM Control Support	OFDMA RA Support	Maximum A-MPDU Length Exponent Extension	A-MSDU Fragmentation Support	Flexible TWT Schedule Support	Rx Control Frame To MultiBSS	BSRP BQRP A-MPDU Aggregation
Bits:	1	1	1	2	1	1	1	1

	B33	B34	B35	B36	B37	B38	B39 B41
	QTP Support	BQR Support	PSR Responder	NDP Feedback Report Support	OPS Support	A-MSDU Not Under BA In Ack-Enabled A-MPDU Support	Multi-TID Aggregation Tx Support
Bits:	1	1	1	1	1	1	3

	B42	B43	B44	B45	B46	B47
	HE Subchannel Selective Transmission Support	UL 2×996-tone RU Support	OM Control UL MU Data Disable RX Support	HE Dynamic SM Power Save	Punctured Sounding Support	HT And VHT Trigger Frame RX Support
Bits:	1	1	1	1	1	1

Figure 9-787b—HE MAC Capabilities Information field format

The subfields of the HE MAC Capabilities Information field are defined in Table 9-321a (Subfields of the HE MAC Capabilities Information field).

Table 9-321a—Subfields of the HE MAC Capabilities Information field

Subfield	Definition	Encoding
+HTC-HE Support	Indicates support for the reception of a frame that carries an HE variant HT Control field.	For a non-AP STA: Set to 1 if the STA supports reception of an HE variant HT Control field based on the description in 10.8 (HT Control field operation). Set to 0 otherwise. An AP sets the +HTC-HE Support subfield to 1.
TWT Requester Support	Indicates support for the role of TWT requesting STA as described in 26.8 (TWT operation)).	Set to 1 if dot11TWTOptionActivated is true and the STA supports TWT requesting STA functionality (see 26.8 (TWT operation)). Set to 0 otherwise.
TWT Responder Support	Indicates support for the role of TWT responder STA as described in 26.8 (TWT operation)).	Set to 1 if dot11TWTOptionActivated is true and the STA supports TWT responder STA functionality (see 26.8 (TWT operation)). Set to 0 otherwise. An AP sets the TWT Responder Support subfield to 1.

Table 9-321a—Subfields of the HE MAC Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Dynamic Fragmentation Support	Indicates the level of dynamic fragmentation that is supported by a STA as a recipient.	Set to 0 for no support for dynamic fragmentation. Set to 1 for support for up to one dynamic fragment that is a non-A-MPDU frame, no support for dynamic fragments within an A-MPDU that does not contain an S-MPDU. Set to 2 for support for up to one dynamic fragment that is a non-A-MPDU frame and support for up to one dynamic fragment for each MSDU, each A-MSDU (if supported by the recipient) and one MMPDU (if present, see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) within an A-MPDU that does not contain an S-MPDU. Set to 3 for support for up to one dynamic fragment that is a non-A-MPDU frame and support for up to 4 dynamic fragments for each MSDU and for each A-MSDU (if supported by the recipient) within an A-MPDU and up to one dynamic fragment for one MMPDU (if present, see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) in an A-MPDU that does not contain an S-MPDU.
Maximum Number Of Fragmented MSDUs/A-MSDUs Exponent	Indicates the maximum number of fragmented MSDUs and/or A-MSDUs (if supported by the recipient) that the STA is capable of receiving concurrently.	If the Dynamic Fragmentation Support subfield is greater than 0: The maximum number of fragmented MSDUs and/or A-MSDUs, N_{max}, defined by this field is $N_{max} = 2^{\text{Maximum Number Of Fragmented MSDUs/A-MSDUs Exponent}}$, except that a value 7 in the Maximum Number Of Fragmented MSDUs/A-MSDUs Exponent subfield indicates that there is no restriction. Reserved if the Dynamic Fragmentation Support subfield is 0.
Minimum Fragment Size	Indicates the minimum frame body size in octets of the first fragment of an MSDU, A-MSDU (if supported), or MMPDU that is supported by the recipient STA.	If the Dynamic Fragmentation Support subfield is greater than 0: Set to 0 to indicate no minimum frame body size. Set to 1 to indicate a minimum frame body size of 128 octets. Set to 2 to indicate a minimum frame body size of 256 octets. Set to 3 to indicate a minimum frame body size of 512 octets. Reserved if the Dynamic Fragmentation Support subfield is 0.
Trigger Frame MAC Padding Duration	Indicates *MinTrigProcTime*, which is used in 26.5.2.2.3 (Padding for Trigger frame or frame containing TRS Control subfield).	For a non-AP STA: Set to 0 to indicate 0. Set to 1 to indicate 8 µs. Set to 2 to indicate 16 µs. The value 3 is reserved. Reserved for an AP.

Table 9-321a—Subfields of the HE MAC Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Multi-TID Aggregation Rx Support	Indicates the number of TIDs of QoS Data frames that an HE STA can receive in a multi-TID A-MPDU as described in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU).	Set to the number of TIDs minus 1 of QoS Data frames that an HE STA can receive in a multi-TID A-MPDU.
Multi-TID Aggregation Tx Support	Indicates the number of TIDs of QoS Data frames that an HE STA can transmit in a multi-TID A-MPDU as described in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU).	Set to the number of TIDs minus 1 of QoS Data frames that an HE STA can transmit in a multi-TID A-MPDU.
HE Link Adaptation Support	Indicates support for link adaptation using the HLA Control subfield.	If +HTC-HE Support is 1: Set to 0 (No Feedback) if the STA does not provide HE MFB. Set to 2 (Unsolicited) if the STA can receive and provide only unsolicited HE MFB. Set to 3 (Solicited and unsolicited) if the STA is capable of receiving and providing HE MFB in response to HE MRQ and if the STA can receive and provide unsolicited HE MFB. The value 1 is reserved. HE MFB and HE MRQ are MFB and MRQ using HLA Control subfield, respectively. Reserved if +HTC-HE Support is 0.
All Ack Support	Indicates support for the reception of a Multi-STA BlockAck frame under the all ack context (see 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame))	Set to 1 if supported. Set to 0 otherwise.
TRS Support	For a non-AP STA, indicates support for receiving a frame with a TRS Control subfield.	For a non-AP STA that has set the +HTC-HE Support field to 1: Set to 1 if the STA supports reception of the TRS Control subfield. Set to 0 otherwise. Reserved for an AP or if the +HTC-HE Support field is 0.
BSR Support	For an AP, indicates support for receiving a frame with a BSR Control subfield. For a non-AP STA, indicates support for generating a frame with a BSR Control subfield.	If +HTC-HE Support is 1: Set to 1 if the STA supports the BSR Control subfield functionality. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
Broadcast TWT Support	For a non-AP STA, indicates support for the role of TWT scheduled STA. For an AP indicates support for the role of TWT scheduling AP as described in 26.8.3 (Broadcast TWT operation).	Set to 1 if the STA supports broadcast TWT functionality. Set to 0 otherwise.

Table 9-321a—Subfields of the HE MAC Capabilities Information field *(continued)*

Subfield	Definition	Encoding
32-bit BA Bitmap Support	Indicates support for the reception of a Multi-STA BlockAck frame that has a Per AID Info subfield addressed to it with a 32-bit Block Ack Bitmap subfield.	Set to 1 if the STA supports reception of a Multi-STA BlockAck frame that has a Per AID Info subfield addressed to it with a 32-bit Block Ack Bitmap subfield. Set to 0 otherwise.
MU Cascading Support	Indicates support for participating in an MU cascading sequence (see 26.5.3 (MU cascading sequence)).	For an HE AP: Set to 1 to indicate that the AP is capable of transmitting an A-MPDU that is constructed following the MU cascade sequence rules (see 26.5.3 (MU cascading sequence)) under MU cascade operation. Set to 0 otherwise. For a non-AP HE STA: Set to 1 to indicate that the non-AP STA is capable of receiving an A-MPDU that is constructed following the MU cascade sequence rules (see 26.5.3 (MU cascading sequence)). Set to 0 otherwise.
Ack-Enabled Aggregation Support	Indicates support by a STA to receive an A-MPDU that contains two or more frames at least one of which solicits an Ack frame or acknowledgment context in a Multi-STA BlockAck frame as described in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) and 26.5.1.1 (General).	Set to 1 if the STA supports reception of this A-MPDU format. Set to 0 otherwise.
OM Control Support	Indicates support for receiving a frame with an OM Control subfield.	If the +HTC-HE Support subfield is 1 in a non-AP STA: Set to 1 if the non-AP STA supports reception of the OM Control subfield. Set to 0 otherwise. Reserved if the +HTC-HE Support subfield is 0 in a non-AP STA. An AP sets the OM Control Support subfield to 1.
OFDMA RA Support	For a non-AP STA, indicates support for the OFDMA random access procedure. For an AP, indicates support for sending Trigger frames that allocate RA-RUs. See 26.5.4 (UL OFDMA-based random access (UORA)).	Set to 1 if supported. Set to 0 otherwise.
Maximum A-MPDU Length Exponent Extension	Indicates the exponent extension for the maximum A-MPDU length supported in reception (see 26.6 (A-MPDU operation in an HE PPDU)).	Set to the value of the maximum A-MPDU exponent extension value.

Table 9-321a—Subfields of the HE MAC Capabilities Information field *(continued)*

Subfield	Definition	Encoding
A-MSDU Fragmentation Support	Indicates support for the reception of fragmented A-MSDUs.	If the Dynamic Fragmentation Support subfield is not 0: Set to 1 to indicate support for the receipt of fragmented A-MSDUs. Set to 0 to indicate that reception of fragmented A-MSDUs is not supported. Reserved if the Dynamic Fragmentation Support subfield is 0.
Flexible TWT Schedule Support	Indicates support for the reception of TWT Information frames with flexible TWT schedules as defined in 26.8.4.4 (TWT Information frame exchange for flexible wake time).	Set to 1 if the STA supports reception of a TWT Information frame with flexible TWT schedules. Set to 0 otherwise.
Rx Control Frame To MultiBSS	For a non-AP STA associated with a BSS corresponding to a nontransmitted BSSID, indicates support for the reception of a Control frame with TA equal to the transmitted BSSID.	For a non-AP STA: Set to 1 if supported. Set to 0 otherwise. Reserved for an AP.
BSRP BQRP A-MPDU Aggregation	For a non-AP STA, indicates whether or not the STA accepts a BSRP Trigger frame or BQRP Trigger frame that is aggregated with other Control, Data and Management frames in an A-MPDU destined to the STA.	For a non-AP STA: Set to 1 if supported. Set to 0 otherwise. Reserved for an AP.
QTP Support	Indicates support for quiet time period (QTP) operation as described in 26.17.5 (Quiet HE STAs in an HE BSS).	Set to 1 if supported. Set to 0 otherwise.
BQR Support	For an AP, indicates support for receiving a frame with a BQR Control subfield. For a non-AP STA, indicates support for generating a frame with a BQR Control subfield.	If +HTC-HE Support is 1: Set to 1 if the STA supports the BQR Control subfield functionality. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
PSR Responder	Indicates support for the role of PSR responder.	Set to 1 if the STA supports the role of PSR responder. Set to 0 otherwise.
NDP Feedback Report Support	For an AP, indicates support for the NDP feedback report procedure. For a non-AP STA, indicates support for responding to an NFRP Trigger frame.	Set to 1 if supported. Set to 0 otherwise.

Table 9-321a—Subfields of the HE MAC Capabilities Information field *(continued)*

Subfield	Definition	Encoding
OPS Support	For an AP, indicates support for encoding OPS information in the TIM element of FILS Discovery frames, TIM frames or OPS frames as described in 26.14.3.2 (AP operation for opportunistic power save). For a non-AP STA, indicates support for receiving the opportunistic power save encoded TIM elements.	Set to 1 if supported. Set to 0 otherwise.
A-MSDU Not Under BA In Ack-Enabled A-MPDU Support	Indicates support by a STA to receive an ack-enabled single-TID A-MPDU that carries an A-MSDU that is not under a block ack agreement.	Set to 1 if supported. Set to 0 otherwise.
HE Subchannel Selective Transmission Support	Indicates whether an HE STA supports an HE subchannel selective transmission operation described in 26.8.7 (HE subchannel selective transmission).	Set to 1 if supported. Set to 0 otherwise.
UL 2×996-tone RU Support	Indicates support by a non-AP STA to receive a TRS Control subfield or a Trigger frame with a User Info field addressed to the STA with the RU Allocation subfield of the TRS Control subfield or the User Info field indicating 2×996-tone RU.	For a non-AP STA: Set to 1 if the STA supports reception of a TRS Control subfield with the RU Allocation subfield indicating a 2×996-tone RU or a Trigger frame with a User Info field addressed to the STA with the RU Allocation subfield indicating 2×996-tone RU. Set to 0, otherwise. Reserved for an AP.
OM Control UL MU Data Disable RX Support	Indicates whether an AP supports interpretation of the UL MU Data Disable subfield of the OM Control subfield as described in 26.5.2 (UL MU operation).	For an AP: Set to 1 if supported. Set to 0 otherwise. Reserved for a non-AP STA.
HE Dynamic SM Power Save	Indicates the spatial multiplexing power save mode after receiving a Trigger frame that is in operation immediately after (re)association. See 26.14.4 (HE dynamic SM power save).	For a non-AP STA: Set to 0 if HE dynamic SM power save is not supported. Set to 1 if HE dynamic SM power save is supported. Reserved for an AP.
Punctured Sounding Support	Indicates support for punctured sounding as described in 26.7 (HE sounding protocol).	Set to 1 if dot11HEPuncturedSoundingOptionImplemented is true (see 26.7 (HE sounding protocol)). Set to 0 otherwise.
HT And VHT Trigger Frame Rx Support	Indicates support for receiving a Trigger frame in an HT PPDU and receiving a Trigger frame in a VHT PPDU.	For a non-AP STA: Set to 1 if supported. Set to 0 otherwise. Reserved for an AP.

9.4.2.247.3 HE PHY Capabilities Information field

The format of the HE PHY Capabilities Information field is defined in Figure 9-787c (HE PHY Capabilities Information field format).

	B0	B1 B7	B8 B11	B12	B13	B14	B15 B16	B17
	Reserved	Supported Channel Width Set	Punctured Preamble Rx	Device Class	LDPC Coding In Payload	HE SU PPDU With 1x HE-LTF And 0.8 μs GI	Midamble Tx/Rx Max NSTS	NDP With 4x HE-LTF And 3.2 μs GI
Bits:	1	7	4	1	1	1	2	1

	B18	B19	B20	B21	B22	B23	B24 B25	B26
	STBC Tx ≤ 80 MHz	STBC Rx ≤ 80 MHz	Doppler Tx	Doppler Rx	Full Bandwidth UL MU-MIMO	Partial Bandwidth UL MU-MIMO	DCM Max Constellation Tx	DCM Max NSS Tx
Bits:	1	1	1	1	1	1	2	1

	B27 B28	B29	B30	B31	B32	B33	B34 B36	B37 B39
	DCM Max Constellation Rx	DCM Max NSS Rx	Rx Partial BW SU In 20 MHz HE MU PPDU	SU Beamformer	SU Beamformee	MU Beamformer	Beamformee STS ≤ 80 MHz	Beamformee STS > 80 MHz
Bits:	2	1	1	1	1	1	3	3

	B40 B42	B43 B45	B46	B47	B48	B49	B50
	Number Of Sounding Dimensions ≤ 80 MHz	Number Of Sounding Dimensions > 80 MHz	Ng = 16 SU Feedback	Ng = 16 MU Feedback	Codebook Size (ϕ, ψ) = {4, 2} SU Feedback	Codebook Size (ϕ, ψ) = {7, 5} MU Feedback	Triggered SU Beamforming Feedback
Bits:	3	3	1	1	1	1	1

	B51	B52	B53	B54	B55	B56	B57	B58
	Triggered MU Beamforming Partial BW Feedback	Triggered CQI Feedback	Partial Bandwidth Extended Range	Partial Bandwidth DL MU-MIMO	PPE Thresholds Present	PSR-based SR Support	Power Boost Factor Support	HE SU PPDU And HE MU PPDU With 4x HE-LTF And 0.8 μs GI
Bits:	1	1	1	1	1	1	1	1

	B59 B61	B62	B63	B64	B65	B66	B67	B68
	Max Nc	STBC Tx > 80 MHz	STBC Rx > 80 MHz	HE ER SU PPDU With 4x HE-LTF And 0.8 µs GI	20 MHz In 40 MHz HE PPDU In 2.4 GHz Band	20 MHz In 160/ 80+80 MHz HE PPDU	80 MHz In 160/ 80+80 MHz HE PPDU	HE ER SU PPDU With 1x HE-LTF And 0.8 µs GI
Bits:	3	1	1	1	1	1	1	1

	B69	B70 B71	B72	B73	B74	B75	B76	B77
	Midamble Tx/Rx 2x And 1x HE-LTF	DCM Max RU	Longer Than 16 HE-SIG-B OFDM Symbols Support	Non-Triggered CQI Feedback	Tx 1024-QAM < 242-tone RU Support	Rx 1024-QAM < 242-tone RU Support	Rx Full BW SU Using HE MU PPDU With Compressed HE-SIG-B	Rx Full BW SU Using HE MU PPDU With Non-Compressed HE-SIG-B
Bits:	1	2	1	1	1	1	1	1

	B78 B79	B80 B87
	Nominal Packet Padding	Reserved
Bits:	2	8

Figure 9-787c—HE PHY Capabilities Information field format

The subfields of the HE PHY Capabilities Information field are defined in Table 9-321b (Subfields of the HE PHY Capabilities Information field).

Table 9-321b—Subfields of the HE PHY Capabilities Information field

Subfield	Definition	Encoding
Supported Channel Width Set	In the 2.4 GHz band: — B0 indicates support for a 40 MHz channel width — B1, B2, and B3 are reserved — B4 indicates support of 242-tone RUs in a 40 MHz HE MU PPDU if a non-AP STA operates with a 20 MHz channel width and the 20 MHz In 40 MHz HE PPDU In 2.4 GHz subfield is 1; otherwise B4 is reserved — B5 and B6 are reserved In the 5 GHz and 6 GHz bands: — B0 is reserved — B1 indicates support for a 40 MHz and 80 MHz channel width — B2 indicates support for a 160 MHz channel width — B3 indicates support for a 160/80+80 MHz channel width — B4 is reserved — B5 indicates support of 242-tone RUs in a • 40 MHz and 80 MHz HE MU PPDU if a non-AP STA operates with 20 MHz channel width and the 20 MHz In 160/80+80 MHz HE PPDU subfield is set to 0, or • 40 MHz, 80 MHz, 160 MHz, 80+80 MHz HE MU PPDU if a non-AP STA operates with 20 MHz channel width and the 20 MHz In 160/80+80 MHz HE PPDU subfield is set to 1, or • Is reserved otherwise — B6 is reserved	B0 is set to 0 if not supported. B0 is set to 1 if supported. B1 is set to 0 if not supported, i.e., it indicates a 20 MHz-only non-AP HE STA in the 5 GHz band or 6 GHz band. B1 is set to 1 if supported. B2 is set to 0 if not supported. B2 is set to 1 if supported. If B2 is 1, then B1 is set to 1. B3 is set to 0 if not supported. B3 is set to 1 if supported. If B3 is 1, then B2 is set to 1. B4 is set to 0 if not supported. B4 is set to 1 if supported. B5 is set to 0 if not supported. B5 is set to 1 if supported. NOTE 1—If a non-AP STA operates with 20 MHz channel width and the 20 MHz In 40 MHz HE PPDU In 2.4 GHz subfield is 0, then B4 is set to 0. NOTE 2—If a non-AP STA operates with 20 MHz channel width and the 20 MHz In 160/80+80 MHz HE PPDU subfield is 0, then the 242-tone RU in a 160 MHz and 80+80 MHz HE MU PPDU in the 5 GHz band or 6 GHz band is not supported.
Punctured Preamble Rx	B0 indicates support for the reception of an 80 MHz preamble where the secondary 20 MHz subchannel is punctured. B1 indicates support for the reception of an 80 MHz preamble where one of the two 20 MHz subchannels in the secondary 40 MHz is punctured. B2 indicates support for the reception of a 160 MHz or 80+80 MHz preamble where only the secondary 20 MHz channel in the primary 80 MHz channel is punctured. B3 indicates support for the reception of a 160 MHz or 80+80 MHz preamble where the primary 40 MHz channel in the primary 80 MHz channel is present.	B0 is set to 0 if not supported. B0 is set to 1 if supported. B1 is set to 0 if not supported. B1 is set to 1 if supported. B2 is set to 0 if not supported. B2 is set to 1 if supported. B3 is set to 0 if not supported. B3 is set to 1 if supported.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Device Class	For a non-AP STA, indicates whether the STA is a Class A or a Class B device.	For a non-AP STA: Set to 1 for a Class A device. Set to 0 for a Class B device. Reserved for an AP.
LDPC Coding In Payload	Indicates support for the transmission and reception of LDPC encoded PPDUs.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 by a STA that supports more than 4 spatial streams, an HE PPDU bandwidth greater than 20 MHz, HE-MCS 10 or HE-MCS 11.
HE SU PPDU With 1x HE-LTF And 0.8 µs GI	Indicates support of the reception of an HE SU PPDU with 1x HE-LTF and 0.8 µs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
Midamble Tx/Rx Max NSTS	If the Doppler Rx subfield is 1, indicates the maximum number of space-time streams supported for reception when a midamble is present in the Data field. If the Doppler Tx subfield is 1, indicates the maximum number of space-time streams supported for transmission when a midamble is present in the Data field. If both Doppler Rx and Doppler Tx subfields are 1, indicates the maximum number of space-time streams supported for transmission and reception when a midamble is present in the Data field.	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
NDP With 4x HE-LTF And 3.2 µs GI	For a beamformee, indicates support for receiving an HE sounding NDP with 4x HE-LTF and 3.2 µs guard interval duration.	If the SU Beamformee field is 1: Set to 0 if not supported. Set to 1 if supported.
STBC Tx ≤ 80 MHz	Indicates support for the transmission of an HE TB PPDU using STBC that has a bandwidth less than or equal to 80 MHz.	For a non-AP STA: Set to 0 if not supported. Set to 1 if supported. Reserved for an AP.
STBC Rx ≤ 80 MHz	Indicates support for the reception of an HE PPDU using STBC that has a bandwidth less than or equal to 80 MHz.	Set to 0 if not supported. Set to 1 if supported.
Doppler Tx	Indicates support for transmitting HE PPDUs with midamble.	Set to 0 if not supported. Set to 1 if supported.
Doppler Rx	Indicates support for receiving HE PPDUs with midamble.	Set to 0 if not supported. Set to 1 if supported.
Full Bandwidth UL MU-MIMO	For an AP, indicates support for MU-MIMO reception of an HE TB PPDU on an RU that spans the entire PPDU bandwidth (UL MU-MIMO). For a non-AP STA, indicates support for the transmission of an HE TB PPDU on an RU that spans the entire PPDU bandwidth (UL MU-MIMO).	Set to 0 if not supported. Set to 1 if supported.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Partial Bandwidth UL MU-MIMO	For an AP, indicates support for receiving an HE TB PPDU on an RU where MU-MIMO is employed and where the RU does not span the entire PPDU bandwidth (UL MU-MIMO in OFDMA). For a non-AP STA, indicates support for transmitting an HE TB PPDU on an RU where MU-MIMO is employed and where the RU does not span the entire PPDU bandwidth (UL MU-MIMO in OFDMA). NOTE—The RU is a 106-tone or larger RU.	Set to 0 if not supported. Set to 1 if supported.
DCM Max Constellation Tx	Indicates the maximum supported constellation for DCM in the Data field of an HE TB PPDU that the STA is capable of transmitting.	For a non-AP STA: Set to 0 if DCM is not supported. Set to 1 for BPSK. Set to 2 for QPSK. Set to 3 for 16-QAM. Reserved for an AP.
DCM Max NSS Tx	Indicates the maximum number of spatial streams supported for transmission when DCM is used in the Data field of an HE TB PPDU.	For a non-AP STA, if the DCM Max Constellation Tx subfield is not 0: Set to 0 for 1 spatial stream. Set to 1 for 2 spatial streams. Reserved for an AP or if the DCM Max Constellation Tx subfield is 0.
DCM Max Constellation Rx	Indicates the maximum supported constellation for DCM in both the Data field and HE-SIG-B field that the STA is capable of receiving.	Set to 0 if DCM is not supported. Set to 1 for BPSK. Set to 2 for QPSK. Set to 3 for 16-QAM.
DCM Max NSS Rx	Indicates the maximum number of spatial streams supported for reception when DCM is used in the Data field.	Set to 0 for 1 spatial stream. Set to 1 for 2 spatial streams.
Rx Partial BW SU In 20 MHz HE MU PPDU	For an AP, TDLS STA or IBSS STA, indicates support for the reception of a 20 MHz HE MU PPDU with just a 106-tone RU. NOTE—It is mandatory for a non-AP HE STA to support reception of a 20 MHz HE MU PPDU with just a 106-tone RU.	For an AP, TDLS STA or IBSS STA: Set to 0 if not supported. Set to 1 if supported. Reserved for a non-AP STA.
SU Beamformer	Indicates support for operation as an SU beamformer.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 by an AP with support for 4 or more spatial streams.
SU Beamformee	Indicates support for operation as an SU beamformee.	For an AP: Set to 0 if not supported. Set to 1 if supported. Set to 1 for a non-AP STA.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
MU Beamformer	Indicates support for operation as an MU beamformer.	For an AP: Set to 0 if not supported. Set to 1 if the SU Beamformer field is 1 and operation as an MU beamformer is supported. Set to 0 for a non-AP STA. NOTE—Set to 1 by an AP with support for 4 or more spatial streams.
Beamformee STS ≤ 80 MHz	For a PPDU bandwidth less than or equal to 80 MHz, indicates the maximum number of space-time streams that the STA can receive in an HE sounding NDP, which is also the maximum total number of space-time streams over all the users that can be sent in a DL MU-MIMO transmission on an RU that includes that STA, where the RU might or might not span the entire PPDU bandwidth.	If the SU Beamformee subfield is 1: Set to the maximum number of space-time streams that the STA is capable of receiving in an HE sounding NDP minus 1. The minimum value of this field is 3. Reserved if the SU Beamformee field is 0.
Beamformee STS > 80 MHz	For a PPDU bandwidth greater than 80 MHz, indicates the maximum number of space-time streams that the STA can receive in an HE sounding NDP, which is also the maximum total number of space-time streams over all the users that can be sent in a DL MU-MIMO transmission on an RU that includes that STA, where the RU might or might not span the entire PPDU bandwidth.	If the SU Beamformee subfield is 1: Set to the maximum number of space-time streams that the STA is capable of receiving in an HE sounding NDP minus 1. The minimum value of this field is 3. Reserved if the SU Beamformee subfield is 0 or the Supported Channel Width Set field does not indicate support for bandwidths greater than 80 MHz.
Number Of Sounding Dimensions ≤ 80 MHz	For bandwidth less than or equal to 80 MHz, it indicates the beamformer's capability indicating the maximum value of the TXVECTOR parameter NUM_STS for an HE sounding NDP.	If the SU Beamformer subfield is 1: Set to the supported maximum TXVECTOR parameter NUM_STS value minus 1. Reserved if the SU Beamformer subfield is 0.
Number Of Sounding Dimensions > 80 MHz	For bandwidth greater than 80 MHz, indicates the beamformer's capability indicating the maximum value of the TXVECTOR parameter NUM_STS for an HE sounding NDP.	If the SU Beamformer subfield is 1: Set to the supported maximum TXVECTOR parameter NUM_STS value minus 1. Reserved if the SU Beamformer subfield is 0 or the Supported Channel Width Set field does not indicate support for bandwidths greater than 80 MHz.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Ng = 16 SU Feedback	Indicates HE beamformee support for a subcarrier grouping of 16 in the HE Compressed Beamforming Report field for SU feedback.	Set to 0 if not supported. Set to 1 if supported.
Ng = 16 MU Feedback	Indicates HE beamformee support for a subcarrier grouping of 16 in the HE Compressed Beamforming Report field for MU feedback.	Set to 0 if not supported. Set to 1 if supported.
Codebook Size (ϕ, ψ) = {4, 2} SU Feedback	Indicates HE beamformee support for a codebook size (ϕ, ψ) = {4, 2} in the HE Compressed Beamforming Report field for SU feedback.	Set to 0 if not supported. Set to 1 if supported.
Codebook Size (ϕ, ψ) = {7, 5} MU Feedback	Indicates HE beamformee support for a codebook size (ϕ, ψ) = {7, 5} in the HE Compressed Beamforming Report field for MU feedback.	Set to 0 if not supported. Set to 1 if supported.
Triggered SU Beamforming Feedback	For an AP, indicates support for the reception of partial and full bandwidth SU feedback in an HE TB sounding sequence. For a non-AP STA, indicates support for the transmission of partial and full bandwidth SU feedback in an HE TB sounding sequence.	Set to 0 if not supported. Set to 1 if supported.
Triggered MU Beamforming Partial BW Feedback	For an AP, indicates support for the reception of partial bandwidth MU feedback in an HE TB sounding sequence. For a non-AP STA, indicates support for the transmission of partial bandwidth MU feedback in an HE TB sounding sequence.	Set to 0 if not supported. Set to 1 if supported.
Triggered CQI Feedback	For an AP, indicates support for the reception of partial and full bandwidth CQI feedback in an HE TB sounding sequence. For a non-AP STA, indicates support for the transmission of partial and full bandwidth CQI feedback in an HE TB sounding sequence.	Set to 0 if not supported. Set to 1 if supported.
Partial Bandwidth Extended Range	Indicates support for the transmission and reception of an HE ER SU PPDU in which the HE modulated fields are transmitted over the higher frequency 106-tone RU within primary 20 MHz channel.	Set to 0 if not supported. Set to 1 if supported.
Partial Bandwidth DL MU-MIMO	For a non-AP STA, indicates support for the reception of a DL MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (DL MU-MIMO within OFDMA).	For a non-AP STA: Set to 0 if not supported. Set to 1 if supported. NOTE—A non-AP STA that sets this field to 0 supports receiving a partial bandwidth RU allocated to a single user within an HE MU PPDU where some other RU is employing DL MU-MIMO. Reserved for an AP.
PPE Thresholds Present	Indicates whether or not the PPE Thresholds field is present.	Set to 1 if PPE Thresholds field is present. Set to 0, otherwise

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
PSR-based SR Support	Indicates support for PSR-based SR operation.	Set to 0 if not supported. Set to 1 if supported.
Power Boost Factor Support	Indicates that the STA supports a power boost factor for the RUs in an HE MU PPDU in the range [0.5, 2].	Set to 0 if not supported. Set to 1 if supported.
HE SU PPDU And HE MU PPDU With 4x HE-LTF And 0.8 µs GI	Indicates support for the reception of an HE SU PPDU and HE MU PPDU with 4x HE-LTF and 0.8 µs guard interval duration.	Set to 0 if not supported. Set to 1 if supported. This subfield is set to 1 if the HE ER SU PPDU With 4x HE-LTF And 0.8 µs GI subfield is 1.
Max Nc	Indicates the maximum supported *Nc* for an HE compressed beamforming/CQI report.	If the SU Beamformee subfield is 1: Set to the maximum supported *Nc* for an HE compressed beamforming/CQI report minus 1. Reserved if the SU Beamformee subfield is 0.
STBC Tx > 80 MHz	Indicates support for the transmission of an HE TB PPDU using STBC that has a bandwidth greater than 80 MHz.	For a non-AP STA: Set to 0 if not supported. Set to 1 if supported. Reserved for an AP or if the Supported Channel Width Set field does not indicate support for bandwidths greater than 80 MHz.
STBC Rx > 80 MHz	Indicates support for the reception of an HE PPDU using STBC that has a bandwidth greater than 80 MHz.	Set to 0 if not supported. Set to 1 if supported. Reserved if the Supported Channel Width Set field does not indicate support for bandwidths greater than 80 MHz.
HE ER SU PPDU With 4x HE-LTF And 0.8 µs GI	Indicates support for the reception of an HE ER SU PPDU with 4x HE-LTF and 0.8 µs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
20 MHz In 40 MHz HE PPDU In 2.4 GHz Band	Indicates support for 26-, 52-, and 106-tone RU mapping for a 20 MHz operating non-AP HE STA that is the receiver of a 40 MHz HE MU PPDU in 2.4 GHz band, or the transmitter of a 40 MHz HE TB PPDU in 2.4 GHz band.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B0 of the Supported Channel Width Set subfield is 1. Reserved for an AP.
20 MHz In 160/80+80 MHz HE PPDU	Indicates support for 26-, 52-, and 106-tone RU mapping for a 20 MHz operating non-AP HE STA that is the receiver of an 80+80 MHz or a 160 MHz HE MU PPDU, or the transmitter of an 80+80 MHz or 160 MHz HE TB PPDU.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B2 of the Supported Channel Width Set subfield is 1. Reserved for an AP.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
80 MHz In 160/ 80+80 MHz HE PPDU	Indicates supports of 160/80+80 MHz OFDMA for a non-AP HE STA that sets B1 of Supported Channel Width Set to 1, and sets B2 and B3 of Supported Channel Width Set each to 0, when operating with 80 MHz channel width. The capability bit is applicable while receiving an 80+80 MHz or a 160 MHz HE MU PPDU, or transmitting an 80+80 MHz or a 160 MHz HE TB PPDU.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B2 of the Supported Channel Width Set subfield is 1. Reserved for an AP.
HE ER SU PPDU With 1x HE-LTF And 0.8 µs GI	Indicates support of the reception of an HE ER SU PPDU with 1x HE-LTF and 0.8 µs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
Midamble Tx/Rx 2x And 1x HE-LTF	If the Doppler Rx subfield is 1, indicates support for receiving midambles with 2x HE-LTF, 1x HE-LTF in HE SU PPDU if the HE SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1, and 1x HE-LTF in HE ER SU PPDU if the HE ER SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1. If the Doppler Tx subfield is 1, indicates support for transmitting midambles with 2x HE-LTF, 1x HE-LTF in HE TB PPDU when allowed. If both the Doppler Rx and Doppler Tx subfields are 1, indicates support for receiving midambles with 2x HE-LTF, 1x HE-LTF in HE SU PPDU if the HE SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1, and 1x HE-LTF in HE ER SU PPDU if the HE ER SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1; and also support for transmitting midambles with 2x HE-LTF, 1x HE-LTF in HE TB PPDU when allowed.	Set to 0 if not supported. Set to 1 if supported.
DCM Max RU	If the DCM Max Constellation Tx subfield is greater than 0, then the DCM Max RU subfield indicates the maximum RU size that the STA might transmit with DCM applied. If the DCM Max Constellation Rx subfield is greater than 0, then the DCM Max RU subfield indicates the maximum RU size with DCM applied that the STA can receive. If both the DCM Max Constellation Tx subfield and DCM Max Constellation Rx subfield are 0, then this subfield is reserved.	Set to 0 for 242-tone RU Set to 1 for 484-tone RU Set to 2 for 996-tone RU Set to 3 for 2×996-tone RU
Longer Than 16 HE-SIG-B OFDM Symbols Support	For a non-AP STA, indicates support for receiving a DL HE MU PPDU where the number of OFDM symbols in the HE-SIG-B field is greater than 16.	Set to 0 if not supported. Set to 1 if supported. A 20 MHz-only non-AP HE STA sets this to 0.
Non-Triggered CQI Feedback	For an AP, indicates support for the reception of full bandwidth non-triggered CQI feedback. For a non-AP STA, indicates support for the transmission of full bandwidth non-triggered CQI feedback.	Set to 0 if not supported. Set to 1 if supported.

Table 9-321b—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Tx 1024-QAM < 242-tone RU Support	For a non-AP STA, indicates support for the transmission of 1024-QAM on a 26-, 52-, and 106-tone RU.	For a non-AP STA: Set to 0 if not supported. Set to 1 if supported. Reserved for an AP.
Rx 1024-QAM < 242-tone RU Support	Indicates support for the reception of 1024-QAM on a 26-, 52-, and 106-tone RU.	Set to 0 if not supported. Set to 1 if supported.
Rx Full BW SU Using HE MU PPDU With Compressed HE-SIG-B	Indicates support for reception of an HE MU PPDU with a single user allocated an RU spanning the entire PPDU bandwidth and a compressed HE-SIG-B format.	Set to 0 if not supported. Set to 1 if supported.
Rx Full BW SU Using HE MU PPDU With Non-Compressed HE-SIG-B	Indicates support for reception of an HE MU PPDU with a bandwidth less than or equal to 80 MHz, a single user allocated an RU spanning the entire PPDU bandwidth and a noncompressed HE-SIG-B format.	Set to 0 if not supported. Set to 1 if supported.
Nominal Packet Padding	Indicates the nominal packet padding to be used for all constellations, NSS and RU allocations the STA supports if the PPE Thresholds Present subfield is set to 0.	Set to 0 if the nominal packet padding is 0 µs for all constellations, NSS and RU allocations the STA supports. Set to 1 if the nominal packet padding is 8 µs for all constellations, NSS and RU allocations the STA supports. Set to 2 if the nominal packet padding is 16 µs for all constellations, NSS and RU allocations the STA supports. The value 3 is reserved. Reserved if the PPE Thresholds Present subfield is 1.

9.4.2.247.4 Supported HE-MCS And NSS Set field

The Supported HE-MCS And NSS Set field indicates the combinations of HE-MCSs and spatial streams that a STA supports for reception and the combinations that it supports for transmission. The format of the field is shown in Figure 9-787d (Supported HE-MCS And NSS Set field format).

	Rx HE-MCS Map ≤ 80 MHz	Tx HE-MCS Map ≤ 80 MHz	Rx HE-MCS Map 160 MHz	Tx HE-MCS Map 160 MHz	Rx HE-MCS Map 80+80 MHz	Tx HE-MCS Map 80+80 MHz
Octets:	2	2	0 or 2	0 or 2	0 or 2	0 or 2

Figure 9-787d—Supported HE-MCS And NSS Set field format

The subfields of the Supported HE-MCS And NSS Set field, and their presence, are defined in Table 9-321c (Subfields of the Supported HE-MCS And NSS Set field).

Table 9-321c—Subfields of the Supported HE-MCS And NSS Set field

Subfield	Definition	Encoding
Rx HE-MCS Map ≤ 80 MHz	If the operating channel width of the STA is greater than 80 MHz, indicates the maximum value of the RXVECTOR parameter MCS of a PPDU that can be received by the STA for a PPDU with bandwidth less than or equal to 80 MHz for each number of spatial streams. If the operating channel width of this STA is less than or equal to 80 MHz, indicates the maximum value of the RXVECTOR parameter MCS for a PPDU that can be received by the STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map ≤ 80 MHz subfield is always present in the Supported HE-MCS And NSS Set field.
Tx HE-MCS Map ≤ 80 MHz	If the operating channel width of this STA is greater than 80 MHz, indicates the maximum value of the TXVECTOR parameter MCS of a PPDU that can be transmitted by the STA for a PPDU with bandwidth less than or equal to 80 MHz for each number of spatial streams. If the operating channel width of this STA is less than or equal to 80 MHz, indicates the maximum value of the TXVECTOR parameter MCS for a PPDU that can be transmitted by the STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map ≤ 80 MHz subfield is always present in the Supported HE-MCS And NSS Set field.
Rx HE-MCS Map 160 MHz	If the operating channel width of the STA is 160 MHz, indicates the maximum value of the RXVECTOR parameter MCS for a 160 MHz PPDU that can be received by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map 160 MHz subfield is present if B2 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field is 1; otherwise, it is not present.
Tx HE-MCS Map 160 MHz	If the operating channel width of the STA is 160 MHz, indicates the maximum value of the TXVECTOR parameter MCS for a 160 MHz PPDU that can be transmitted by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map 160 MHz subfield is present if B2 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field is 1; otherwise, it is not present.

Table 9-321c—Subfields of the Supported HE-MCS And NSS Set field *(continued)*

Subfield	Definition	Encoding
Rx HE-MCS Map 80+80 MHz	If the operating channel width of the STA is 160 MHz, indicates the maximum value of the RXVECTOR parameter MCS for an 80+80 MHz PPDU that can be received by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map 80+80 MHz subfield is present if B3 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field is 1; otherwise, it is not present.
Tx HE-MCS Map 80+80 MHz	If the operating channel width of the STA is 160 MHz, indicates the maximum value of the TXVECTOR parameter MCS for an 80+80 MHz PPDU that can be transmitted by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-787d (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map 80+80 MHz subfield is present if B3 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field is 1; otherwise, it is not present.

The Rx HE-MCS Map and Tx HE-MCS Map subfields have the format shown in Figure 9-787e (Rx HE-MCS Map subfield, Tx HE-MCS Map subfield and Basic HE-MCS And NSS Set field format).

	B0 B1	B2 B3	B4 B5	B6 B7	B8 B9	B10 B11	B12 B13	B14 B15
	Max HE-MCS For 1 SS	Max HE-MCS For 2 SS	Max HE-MCS For 3 SS	Max HE-MCS For 4 SS	Max HE-MCS For 5 SS	Max HE-MCS For 6 SS	Max HE-MCS For 7 SS	Max HE-MCS For 8 SS
Bits:	2	2	2	2	2	2	2	2

Figure 9-787e—Rx HE-MCS Map subfield, Tx HE-MCS Map subfield and Basic HE-MCS And NSS Set field format

The Max HE-MCS For *n* SS subfield (where *n* = 1, …, 8) is encoded as follows:

- 0 indicates support for HE-MCS 0-7 for *n* spatial streams
- 1 indicates support for HE-MCS 0-9 for *n* spatial streams
- 2 indicates support for HE-MCS 0-11 for *n* spatial streams
- 3 indicates that *n* spatial streams is not supported for HE PPDUs

The maximum receive NSS for a given HE-MCS is equal to the smaller of:

- The maximum value of *n* for which the Max HE-MCS For *n* SS has a value that indicates support for that HE-MCS
- The maximum supported NSS as indicated by the value of the Rx NSS field of the Operating Mode Notification frame if the value of Rx NSS Type is 0 or of the OM Control subfield

NOTE—An HE-MCS indicated as supported in the Rx HE-MCS Map fields for a particular number of spatial streams might not be valid at all bandwidths (see 27.5 (Parameters for HE-MCSs)) and might be affected by 26.15.4.3 (Additional rate selection constraints for HE PPDUs).

The maximum transmit NSS for a given HE-MCS is equal to the smaller of:

— The maximum value of *n* for which the Max HE-MCS For *n* SS has a value that indicates support for that HE-MCS (0, 1, or 2 for HE-MCS 0-7, 1 or 2 for HE-MCS 8-9, 2 for HE-MCS 10-11)

— The maximum supported NSTS as indicated by the value of the Tx NSTS field of the OM Control subfield sent by a non-AP STA

NOTE—An HE-MCS indicated as supported in the Tx HE-MCS Map fields for a particular number of space-time streams might not be valid at all bandwidths (see 27.5 (Parameters for HE-MCSs)) and might be affected by 26.15.4.3 (Additional rate selection constraints for HE PPDUs).

9.4.2.247.5 PPE Thresholds field

The PPE Thresholds field determines the nominal packet padding value (see 26.12 (HE PPDU post-FEC padding and packet extension)) for an HE PPDU of a particular RU allocation size and NSTS value. The format of the PPE Thresholds field is defined in Figure 9-787f (PPE Thresholds field format).

	B0 B2	B3 B6		
	NSTS	RU Index Bitmask	PPE Thresholds Info	PPE Pad
Bits:	3	4	variable	0 to 7

Figure 9-787f—PPE Thresholds field format

The NSTS subfield contains an unsigned integer that is the number of NSTS values minus 1 for which PPE threshold values are included in the PPE Thresholds List subfield.

The RU Index Bitmask subfield contains a bitmask that indicates whether the PPE Thresholds Info field contains PPET16 and PPET8 values for the four possible RU sizes indicated in Table 9-321e (RU allocation index). The PPET16 and PPET8 values for RU allocation index *k* is present in the PPE Thresholds Info field only if bit *k* of the RU Index Bitmask subfield (bit 3 + *k* of the PPE Thresholds field) is 1. For example, if B0 of the RU Index Bitmask subfield (B3 of the PPE Thresholds field) is 1, PPET16 and PPET8 values are present in the PPE Thresholds Info field for the RU allocation size corresponding to RU allocation index 0 (242-tone RU). If B0 of the RU Index Bitmask subfield is 0, PPET16 and PPET8 values are not present in the PPE Thresholds Info field for the RU allocation size corresponding to RU allocation index 0.

The PPE Thresholds List field contains 6 × (*NSTS* + 1) bits, where *NSTS* is the value in the NSTS field, for every bit in the RU Index Bitmask subfield that is nonzero. The format of the PPE Thresholds Info field is defined in Figure 9-787g (PPE Thresholds Info field format).

	B0 B2	B3 B5						
	PPET16 NSTS1 RU*x*	PPET8 NSTS1 RU*x*	…	PPET16 NSTS1 RU*m*	PPET8 NSTS1 RU*m*	…	PPET16 NSTS*n* RU*m*	PPET8 NSTS*n* RU*m*
Bits:	3	3		3	3		3	3

Figure 9-787g—PPE Thresholds Info field format

The PPET16 and PPET8 subfields for various NSTS and RU values appear in increasing NSTS value and increasing RU index value order. Lower numbered PPE Thresholds Info field bits contain PPET16 and PPET8 subfields corresponding to lower numbered NSTS values. Within a set of PPET16 and PPET8 subfields corresponding to a single value of *NSTS*, lower numbered PPE Thresholds Info field bits contain PPET16 and PPET8 subfields corresponding to lower numbered RU index values. The PPET16 NSTS*n*

RU*b* and PPET8 NSTS*n* RU*b* subfields are present for all values of *n* and *b* where $1 \leq n \leq (NSTS + 1)$ and where $b = [x, \ldots, m]$ is the set of integers equal to the ordered list of bit positions of all bits that are set to 1 in the RU Index Bitmask subfield, with *x* being the lowest value.

Each PPET8 NSTS*n* RU*b* and PPET16 NSTS*n* RU*b* subfield contains an integer as defined in Table 9-321d (Constellation index), which is used to compute the nominal packet padding value.

Table 9-321d—Constellation index

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

The value of the PPET8 NSTS*n* RU*b* subfield is always less than the value of the PPET16 NSTS*n* RU*b* subfield, except if the PPET8 subfield is 7.

The RU allocation index for each RU allocation size is defined in Table 9-321e (RU allocation index).

Table 9-321e—RU allocation index

RU allocation index	RU allocation size
0	242
1	484
2	996
3	2×996

The PPE Pad field contains all 0s. The number of bits in the PPE Pad field is the least number of bits required to round the length of the PPE Thresholds Info field to an integer number of octets.

9.4.2.248 HE Operation element

The operation of HE STAs in an HE BSS is controlled by the following:

- the HT Operation element and the HE Operation element if operating in the 2.4 GHz band
- the HT Operation element, VHT Operation element (if present) and the HE Operation element if operating in the 5 GHz band
- The HE Operation element if operating in the 6 GHz band

The format of the HE Operation element is defined in Figure 9-787h (HE Operation element format).

	Element ID	Length	Element ID Extension	HE Operation Parameters	BSS Color Information	Basic HE-MCS And NSS Set	VHT Operation Information	Max Co-Hosted BSSID Indicator	6 GHz Operation Information
Octets:	1	1	1	3	1	2	0 or 3	0 or 1	0 or 5

Figure 9-787h—HE Operation element format

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

The format of the HE Operation Parameters field is defined in Figure 9-787i (HE Operation Parameters field format).

	B0 B2	B3	B4 B13	B14	B15	B16	B17	B18 B23
	Default PE Duration	TWT Required	TXOP Duration RTS Threshold	VHT Operation Information Present	Co-Hosted BSS	ER SU Disable	6 GHz Operation Information Present	Reserved
Bits:	3	1	10	1	1	1	1	6

Figure 9-787i—HE Operation Parameters field format

The Default PE Duration subfield indicates the PE field duration in units of 4 µs for an HE TB PPDU that is solicited with a TRS Control subfield and its use is defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation). Values 5-7 of the Default PE Duration subfield are reserved.

The TWT Required subfield is set to 1 to indicate that the AP requires its associated non-AP HE STAs that have declared support for TWT by setting any one of TWT Requester Support or TWT Responder Support or Broadcast TWT Support subfield in HE Capabilities element that it transmits to 1 to operate in the role of either TWT requesting STA by following the rules in 26.8.2 (Individual TWT agreements), or TWT scheduled STA by following the rules in 26.8.3 (Broadcast TWT operation) and set to 0 otherwise.

The TXOP Duration RTS Threshold subfield enables an HE AP to manage RTS/CTS usage by non-AP HE STAs that are associated with it (see 26.2.1 (TXOP duration-based RTS/CTS)). The TXOP Duration RTS Threshold subfield contains the TXOP duration RTS threshold in units of 32 µs, which enables the use of RTS/CTS except for the value 1023. The value 1023 indicates that TXOP duration-based RTS is disabled. The value of 0 is allowed in Beacon and Probe Response frames and indicates that the previously announced TXOP duration RTS threshold remains in effect. In all other frames, the value of 0 is reserved.

The VHT Operation Information Present subfield is set to 1 to indicate that the VHT Operation Information field is present in the HE Operation element and set to 0 otherwise. The VHT Operation Information Present subfield is set as defined in 26.17 (HE BSS operation).

The Co-Hosted BSS subfield is set to 1 to indicate that the AP transmitting this element shares the same operating class, channel and antenna connectors with at least one other AP that is providing its BSS information by transmitting Beacon and Probe Response frames. Otherwise the subfield is set to 0. An AP operating in the 6 GHz band, a TDLS STA, an IBSS STA, a mesh STA, or an AP with dot11MultiBSSImplemented equal to true sets the subfield to 0.

The ER SU Disable subfield indicates whether 242-tone HE ER SU PPDU reception by the AP is disabled or enabled. The ER SU Disable subfield is set to 1 to indicate that it is disabled and set to 0 to indicate that it is enabled.

The 6 GHz Operation Information Present field is set to 1 to indicate that the 6 GHz Operation Information field is present and set to 0, otherwise. The 6 GHz Operation Information Present field is set to 1 by an AP operating in the 6 GHz band.

The BSS Color Information field is defined in Figure 9-787j (BSS Color Information field format).

	B0 B5	B6	B7
	BSS Color	Partial BSS Color	BSS Color Disabled
Bits:	6	1	1

Figure 9-787j—BSS Color Information field format

The BSS Color subfield is an unsigned integer whose value is the BSS Color of the BSS corresponding to the AP, IBSS STA, mesh STA or TDLS STA that transmitted this element and is set as defined in 26.11.4 (BSS_COLOR).

The Partial BSS Color subfield is set to 1 to indicate that an AID assignment rule based on the BSS color as defined in 26.17.4 (AID assignment) is applied for the BSS. Otherwise, the Partial BSS Color subfield is set to 0.

The BSS Color Disabled subfield is set to 1 to temporarily disable the use of color for the BSS as described in 26.11.4 (BSS_COLOR); otherwise it is set to 0.

The Basic HE-MCS And NSS Set field indicates the HE-MCSs for each number of spatial streams in HE PPDUs that are supported by all HE STAs in the BSS (including IBSS and MBSS) in transmit and receive. The Basic HE-MCS And NSS Set field is defined in Figure 9-787e (Rx HE-MCS Map subfield, Tx HE-MCS Map subfield and Basic HE-MCS And NSS Set field format).

The format of the VHT Operation Information field is defined in Figure 9-564 (VHT Operation Information field) and its subfields are defined in Table 9-252 (VHT Operation Information subfields). The VHT Operation Information field is present if the VHT Operation Info Present field is 1; otherwise not present.

The Max Co-Hosted BSSID Indicator field contains a value assigned to n, where 2^n is the maximum number of BSSIDs in the co-hosted BSSID set as defined in 26.17.7 (Co-hosted BSSID set). This field is present if the Co-Hosted BSS subfield in HE Operation Parameters field is 1 and is not present otherwise.

NOTE—The Max Co-Hosted BSSID Indicator field does not provide the exact number or the identity of each co-hosted BSSID.

The 6 GHz Operation Information field provides channel and bandwidth information related to 6 GHz operation (see 27.3.23.2 (Channel allocation in the 6 GHz band)). The format of the 6 GHz Operation Information field is defined in Figure 9-787k (6 GHz Operation Information field format).

	Primary Channel	Control	Channel Center Frequency Segment 0	Channel Center Frequency Segment 1	Minimum Rate
Octets:	1	1	1	1	1

Figure 9-787k—6 GHz Operation Information field format

The Primary Channel field indicates the channel number of the primary channel in the 6 GHz band.

The Control field is defined in Figure 9-787l (Control field format).

	B0 B1	B2	B3 B7
	Channel Width	Duplicate Beacon	Reserved
Bits:	2	1	5

Figure 9-787l—Control field format

The Channel Width field indicates the BSS channel width and is set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 80+80 or 160 MHz.

The Duplicate Beacon subfield is set to 1 if the AP transmits Beacon frames in non-HT duplicate PPDU with a TXVECTOR parameter CH_BANDWIDTH value that is up to the BSS bandwidth and is set to 0 otherwise.

The Channel Center Frequency Segment 0 field indicates the channel center frequency index for the 20 MHz, 40 MHz, or 80 MHz, or 80+80 MHz channel on which the BSS operates in the 6 GHz band. If the BSS channel width is 80+80 MHz or 160 MHz then the Channel Center Frequency Segment 0 field indicates the channel center frequency index of the primary 80 MHz.

The Channel Center Frequency Segment 1 field indicates the channel center frequency index of the 160 MHz channel on which the BSS operates in the 6 GHz band. If the channel width is 80+80 MHz then it indicates the channel center frequency index of the secondary 80 MHz.

The Minimum Rate field indicates the minimum rate, in units of 1 Mb/s, that the non-AP STA is allowed to use for sending PPDUs (see 26.15.4.3 (Additional rate selection constraints for HE PPDUs)), where the rate is obtained with an NSS that is less than or equal to 3 and an MCS that is less than or equal to 3.

9.4.2.249 UORA Parameter Set element

The metrics of the OFDMA-based random access mechanism (see 26.5.4 (UL OFDMA-based random access (UORA))) are signaled in the UORA Parameter Set element. The format of the UORA Parameter Set element is defined in Figure 9-787m (UORA Parameter Set element format).

	Element ID	Length	Element ID Extension	OCW Range
Octets:	1	1	1	1

Figure 9-787m—UORA Parameter Set element format

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

The OCW Range field indicates the minimum and maximum values of the OCW (OFDMA contention window) derived from the fields defined in Figure 9-787n (OCW Range field format).

	B0 B2	B3 B5	B6 B7
	EOCWmin	EOCWmax	Reserved
Bits:	3	3	2

Figure 9-787n—OCW Range field format

The EOCWmin subfield indicates the minimum value of OCW for the initial HE TB PPDU transmission using UORA. The *OCWmin* parameter is used by a STA either for an initial transmission or following a successful HE TB PPDU transmission and is derived as follows:

$$OCWmin = 2^{EOCWmin} - 1$$

where
EOCWmin is the value in the EOCWmin subfield

The EOCWmax subfield indicates the maximum value of OCW for UORA. The *OCWmax* parameter used by a STA for its retransmission attempts of UORA and is derived as follows:

$$OCWmax = 2^{EOCWmax} - 1$$

where
EOCWmax is the value in the EOCWmax subfield

9.4.2.250 MU EDCA Parameter Set element

The format of the MU EDCA Parameter Set element is defined in Figure 9-787o (MU EDCA Parameter Set element format).

	Element ID	Length	Element ID Extension	QoS Info	MU AC_BE Parameter Record	MU AC_BK Parameter Record	MU AC_VI Parameter Record	MU AC_VO Parameter Record
Octets:	1	1	1	1	3	3	3	3

Figure 9-787o—MU EDCA Parameter Set element format

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

For an infrastructure BSS, the MU EDCA Parameter Set element is used by an AP to control the EDCA from non-AP HE STAs as defined in 26.2.7 (EDCA operation using MU EDCA parameters). The most recent MU EDCA Parameter Set element received by a non-AP HE STA is used to update the appropriate MIB values.

The format of the QoS Info field is defined in 9.4.1.17 (QoS Info field) when sent by the AP. The QoS Info field contains the EDCA Parameter Set Update Count subfield, which is initially set to 0 and is incremented each time any of the MU EDCA parameters in the MU EDCA Parameter Set element changes. This subfield is used by a non-AP HE STA to determine whether the MU EDCA Parameter Set has changed and requires updating the appropriate MIB attributes.

The format of the MU AC_BE, MU AC_BK, MU AC_VI, and MU AC_VO Parameter Record fields are identical and defined in Figure 9-787p (MU AC Parameter Record field format).

	ACI/AIFSN	ECWmin/ ECWmax	MU EDCA Timer
Octets:	1	1	1

Figure 9-787p—MU AC Parameter Record field format

The format of the ACI/AIFSN field is defined in Figure 9-262 (ACI/AIFSN field) and the encoding of its subfields is defined in 9.4.2.29 (EDCA Parameter Set element), except that the value 0 in the AIFSN field indicates that EDCA is disabled for the duration specified by the MUEDCATimer for the corresponding AC.

The format of the ECWmin/ECWmax field is defined in Figure 9-263 (ECWmin and ECWmax fields) and the encoding of its subfields is defined in 9.4.2.29 (EDCA Parameter Set element).

The MU EDCA Timer field indicates the duration of time, in units of 8 TUs, during which the HE STA uses the MU EDCA parameters for the corresponding AC, as defined in 26.2.7 (EDCA operation using MU EDCA parameters), except that the value 0 is reserved.

9.4.2.251 Spatial Reuse Parameter Set element

The Spatial Reuse Parameter Set element provides information needed by STAs when performing OBSS PD-based spatial reuse as defined in 26.10.2 (OBSS PD-based spatial reuse operation) and PSR-based spatial reuse as defined in 26.10.3 (PSR-based spatial reuse operation). The format of the Spatial Reuse Parameter Set element is defined in Figure 9-787q (Spatial Reuse Parameter Set element format).

	Element ID	Length	Element ID Extension	SR Control	Non-SRG OBSS PD Max Offset	SRG OBSS PD Min Offset	SRG OBSS PD Max Offset	SRG BSS Color Bitmap	SRG Partial BSSID Bitmap
Octets:	1	1	1	1	0 or 1	0 or 1	0 or 1	0 or 8	0 or 8

Figure 9-787q—Spatial Reuse Parameter Set element format

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

The SR Control field is defined in Figure 9-787r (SR Control field format).

	B0	B1	B2	B3	B4	B5 B7
	PSR Disallowed	Non-SRG OBSS PD SR Disallowed	Non-SRG Offset Present	SRG Information Present	HESIGA_Spatial_reuse_value15_allowed	Reserved
Bits:	1	1	1	1	1	3

Figure 9-787r—SR Control field format

The PSR Disallowed subfield in the SR Control field indicates whether or not PSR-based SR transmissions are allowed at non-AP STAs that are associated with the AP that transmitted this element. PSR-based SR transmissions are disallowed when the PSR Disallowed subfield is 1. PSR-based SR transmissions are allowed when the PSR Disallowed subfield is 0. The PSR Disallowed subfield also affects the value of the SPATIAL_REUSE parameter of the TXVECTOR as described in 26.11.6 (SPATIAL_REUSE).

The Non-SRG OBSS PD SR Disallowed subfield in the SR Control field indicates whether non-SRG OBSS PD SR transmissions are allowed or not at non-AP STAs that are associated with the AP that transmitted this element. Non-SRG OBSS PD SR transmissions are disallowed when the Non-SRG OBSS PD SR Disallowed subfield is 1. Non-SRG OBSS PD SR transmissions are allowed when the Non-SRG OBSS PD SR Disallowed subfield is 0.

The Non-SRG Offset Present subfield in the SR Control field indicates whether or not the Non-SRG OBSS PD Max Offset field is present in the element. If the Non-SRG Offset Present subfield is 1, then the Non-SRG OBSS PD Max Offset field is present; otherwise the Non-SRG OBSS PD Max Offset field is not present.

The SRG Information Present subfield in the SR Control field indicates whether or not the SRG OBSS PD Min Offset, SRG OBSS PD Max Offset, SRG BSS Color Bitmap and SRG Partial BSSID Bitmap fields are present in the element. If the SRG Information Present subfield is 1, then the subfields are present; otherwise the fields are not present.

The HESIGA_Spatial_reuse_value15_allowed subfield in the SR Control field indicates whether non-AP STAs that are associated with the AP that transmitted this element can set the TXVECTOR parameter SPATIAL_REUSE to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED. The subfield is set as described in 26.11.6 (SPATIAL_REUSE).

The Non-SRG OBSS PD Max Offset field contains an unsigned integer that is added to –82 dBm to generate the value of the Non-SRG OBSS PD Max parameter.

The SRG OBSS PD Min Offset field contains an unsigned integer that is added to –82 dBm to generate the value of the SRG OBSS PD Min parameter.

The SRG OBSS PD Max Offset field contains an unsigned integer that is added to –82 dBm to generate the value of the SRG OBSS PD Max parameter.

The SRG BSS Color Bitmap field is a bitmap that indicates the BSS color values used by members of the SRG of which the transmitting STA is a member. Each bit of the bitmap corresponds to one of the 64 BSS colors, where the lowest numbered bit corresponds to BSS color value 0 and the highest numbered bit corresponds to BSS color value 63. A BSS color value is used by at least one BSS that is a member of the same SRG of the transmitting STA if the corresponding bit of the bitmap is 1. If a bit in the bitmap is 0, then no BSS in the same SRG of the transmitting STA uses the corresponding BSS color value. The bit in the bitmap that corresponds to the BSS color value 0 is reserved.

The SRG Partial BSSID Bitmap field is a bitmap that indicates the Partial BSSID values used by members of the SRG of which the transmitting STA is a member. Each bit of the bitmap corresponds to one of the 64 possible values of BSSID[39:44], where the lowest numbered bit corresponds to Partial BSSID value 0 and the highest numbered bit corresponds to Partial BSSID value 63. A Partial BSSID value is used by at least one BSS that is a member of the same SRG of the transmitting STA if the corresponding bit of the bitmap is 1. If a bit in the bitmap is 0, then no BSS in the same SRG of the transmitting STA uses the corresponding Partial BSSID value.

9.4.2.252 NDP Feedback Report Parameter Set element

The format of the NDP feedback report Parameter Set element is defined in Figure 9-787s (NDP Feedback Report Parameter Set element format).

	Element ID	Length	Element ID Extension	Resource Request Buffer Threshold Exponent
Octets:	1	1	1	1

Figure 9-787s—NDP Feedback Report Parameter Set element format

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

The Resource Request Buffer Threshold Exponent field is used to calculate the buffer threshold between two different resource requests as defined in 26.5.7.4 (NDP feedback report for a resource request). The resource request buffer threshold value is equal to $2^{(\text{Resource Request Buffer Threshold Exponent})}$ octets.

The resource request buffer threshold is equal to 256 octets if no NDP Feedback Report Parameter Set element is sent by the AP.

9.4.2.253 BSS Color Change Announcement element

The BSS Color Change Announcement element is used by an AP to advertise an upcoming BSS color change and the new BSS color that will take effect after the BSS color change (see 26.17.3.4 (Selecting and advertising a new BSS color)). The format of the BSS Color Change Announcement element is shown in Figure 9-787t (BSS Color Change Announcement element format).

	Element ID	Length	Element ID Extension	Color Switch Countdown	New BSS Color Information
Octets:	1	1	1	1	1

Figure 9-787t—BSS Color Change Announcement element format

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

The Color Switch Countdown field is set to the number of TBTTs that remain until the HE AP sending the BSS Color Change Announcement element switches to the new BSS color. A value of 0 indicates that the switch occurs at the current TBTT if the element is carried in a Beacon frame or at the next TBTT following the frame that carried the element if the frame is not a Beacon frame.

The format of the New BSS Color Information field is defined in Figure 9-787u (New BSS Color Information field format). The New BSS Color subfield is set to the new BSS color value that the HE AP intends to use starting from the TBTT at which the color switch countdown reaches 0.

	B0 B5	B6 B7
	New BSS Color	Reserved
Bits:	6	2

Figure 9-787u—New BSS Color Information field format

9.4.2.254 Quiet Time Period element

9.4.2.254.1 General

The format of the Quiet Time Period element is shown in Figure 9-787v (Quiet Time Period element format).

	Element ID	Length	Element ID Extension	Control	Quiet Time Content
Octets:	1	1	1	1	variable

Figure 9-787v—Quiet Time Period element format

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

A one octet Control field specifies the subtype of the Quiet Time Period element. The two LSBs define the subtype and are referred to as the Quiet Time Period Subtype field. The remaining 6 bits are reserved. Table 9-321f (Quiet Time Period Subtype field encoding) shows the encoding of the Quiet Time Period Subtype field.

Table 9-321f—Quiet Time Period Subtype field encoding

Quiet Time Period Subtype field value	Meaning
0	Quiet Time Period Setup
1	Quiet Time Period Request
2	Quiet Time Period Response
3	Reserved

The Quiet Time Content field is a variable length field and carries information of quiet time operation indicated by the value in the Control field.

9.4.2.254.2 Quiet Time Period Setup

The Quiet Time Period Setup subtype defines a period of time for QTP (see 26.17.5 (Quiet HE STAs in an HE BSS)). The QTP can be used by an AP to mitigate interference by reducing the contention from HE STAs in a period that gives preference to HE STAs participating in the exchange of specific frames using peer-to-peer link.

The content of the Quiet Time Content subfield in the Quiet Time Period Setup subtype is shown Figure 9-787w (Quiet Time Content subfield format in Quiet Time Period Setup subtype).

	Quiet Period Duration	Service Specific Identifier
Octets:	2	2

Figure 9-787w—Quiet Time Content subfield format in Quiet Time Period Setup subtype

The Quiet Period Duration field is set to the duration of the QTP period, in units of 32 μs, that is no larger than the value indicated in the Quiet Period Interval subtype field of the Quiet Time Period Request subtype sent by the QTP requesting STA.

The Service Specific Identifier field contains an identifier assigned by a peer-to-peer application to identify specific frame exchanges using peer-to-peer links during which HE STAs that have requested participation of the specified frame exchanges might transmit frames during the quiet time period.

9.4.2.254.3 Quiet Time Period Request

The Quiet Time Period Request subtype defines a periodic sequence of QTP periods that the QTP requesting STA requests the QTP AP to schedule.

The content of the Quiet Time Content subfield in the Quiet Time Period Request subtype is shown Figure 9-787x (Quiet Time Content subfield format in Quiet Time Period Request subtype).

	Dialog Token	Quiet Period Offset	Quiet Period Duration	Quiet Period Interval	Repetition Count	Service Specific Identifier
Octets:	1	1	2	1	1	2

Figure 9-787x—Quiet Time Content subfield format in Quiet Time Period Request subtype

The Dialog Token field identifies the Quiet Time Period Response subtype to which the Quiet Time Period Request subtype corresponds.

The Quiet Period Offset field is set to the offset of the first QTP period from the TBTT expressed in TUs.

The Quiet Period Interval field is set to the requested interval between the start of two consecutive QTP periods, expressed in TUs.

The Quiet Period Duration field is set to the duration of the QTP in units of 32 µs.

The Repetition Count field is set to the number of requested QTP periods. A repetition count equal to 0 indicates the setup time of the QTP period is for an one time operation. Repetition count equals to 0xFF indicates the setup of the QTP period is canceled.

The Service Specific Identifier field contains an identifier assigned by a peer-to-peer application to identify specific frame exchanges using peer-to-peer links during which HE STAs that have requested the participation of the specified frame exchanges might transmit frames during the quiet time period.

9.4.2.254.4 Quiet Time Period Response

The Quiet Period Response subtype defines the feedback information from the AP that received the Quiet Time Period Request element. If an AP decides not to accept the value requested by the QTP requesting STA, the AP can set different values carried in the Quiet Period Response frame.

The content of the Quiet Time Content subfield in the Quiet Time Period Response subtype is shown in Figure 9-787y (Quiet Time Content subfield format in Quiet Time Period Response subtype).

	Dialog Token	Status Code	Quiet Period Offset	Quiet Period Duration	Quiet Period Interval	Repetition Count	Service Specific Identifier
Octets:	1	1	1	2	1	1	2

Figure 9-787y—Quiet Time Content subfield format in Quiet Time Period Response subtype

The Dialog Token field identifies the Quiet Time Period Request subtype to which this Quiet Time Period Response subtype corresponds.

The Status Code field indicates the status of a requested operation. The value of the status code is shown in Table 9-321g (Status Code).

Table 9-321g—Status Code

Value	Meaning
0	Success
1	Reject
2	Counter
3-255	Reserved

The Quiet Period Offset field is set to the offset of the first QTP period from the TBTT expressed in TUs.

The Quiet Period Interval field is set to the interval between the start of two consecutive quiet time periods, expressed in TUs.

The Quiet Period Duration field is a one octet field with resolution of 32 µs.

The Repetition Count field is set to the number of requested QTP periods.

The Service Specific Identifier field contains an identifier assigned by a peer-to-peer application to identify specific frame exchanges using peer-to-peer links which HE STAs that have requested the participation of the specific frame exchanges might transmit frames during the quiet time period.

9.4.2.255 ESS Report element

The format of the ESS Report element is shown in Figure 9-787z (ESS Report element format).

	Element ID	Length	Element ID Extension	ESS Information
Octets:	1	1	1	1

Figure 9-787z—ESS Report element format

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

The format of the ESS Information field is defined in Figure 9-787aa (ESS Information field format).

	Planned ESS	Edge Of ESS	Recommended BSS Transition RSSI Threshold Within ESS
Bits:	1	1	6

Figure 9-787aa—ESS Information field format

The Planned ESS subfield indicates whether the BSS is part of an ESS that is planned with several BSSs in an overlapping configuration. This subfield is set to 1 to indicate that the ESS is deployed to ensure blanket coverage over the Extended Service Area (ESA). Otherwise this subfield is set to 0 and the Edge Of ESS and Recommended BSS Transition RSSI Threshold Within ESS subfields are reserved.

The Edge Of ESS subfield indicates whether the BSS is at the edge of the ESS. This subfield is set to 1 to indicate the BSS is at the edge of the ESS. Otherwise this subfield is set to 0.

The Recommended BSS Transition RSSI Threshold Within ESS subfield indicates the RSSI below which an associated STA is recommended to initiate BSS transition to a neighbor BSS belonging to the ESS.

The resolution for the Recommended BSS Transition RSSI Threshold Within ESS subfield is 1 dB. The encoding is defined in Table 9-321h (Recommended BSS Transition RSSI Threshold Within ESS subfield encoding).

Table 9-321h—Recommended BSS Transition RSSI Threshold Within ESS subfield encoding

Value	Description
0–62	–100 dBm to –38 dBm
63	No recommendation

The use of the ESS Report element is described in 11.22.7.5 (Planned ESS).

9.4.2.256 OPS element

The OPS element provides information needed by STAs when operating with OPS as defined in 27.14.3 (Opportunistic power save). The format of the OPS element is shown in Figure 9-787ab (OPS element format).

	Element ID	Length	Element ID Extension	OPS Duration
Octets:	1	1	1	1

Figure 9-787ab—OPS element format

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

If the OPS element is included in an OPS frame or a FILS Discovery frame, the OPS Duration field indicates the OPS period duration, during which a STA can go to doze state if it is explicitly not scheduled during that period, as defined in 26.14.3 (Opportunistic power save). The OPS Duration field is encoded in units of milliseconds.

9.4.2.257 HE BSS Load element

The HE BSS Load element reported by the AP contains information on utilization, frequency underutilization and spatial stream underutilization. The element format is defined in Figure 9-787ac (HE BSS Load element format). A STA receiving the element might use the information it conveys in an implementation-specific AP selection algorithm.

	Element ID	Length	Element ID Extension	HE STA Count	Utilization	Frequency Underutilization	Spatial Stream Underutilization
Octets:	1	1	1	2	1	1	1

Figure 9-787ac—HE BSS Load element format

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

The HE STA Count field indicates the total number of STAs currently associated with this BSS that declare that they are HE STAs by transmitting their HE Capabilities elements.

The Utilization field, Frequency Underutilization field and Spatial Stream Underutilization field are defined as the percentage of time, linearly scaled with 255 representing 100%.

The Utilization field is that AP sensed the medium was busy due to a transmission between the AP and HE STAs, as indicated by the physical carrier sense (CS) mechanism. When more than one channels are in use for the BSS, the Utilization field value is calculated only for the primary channel. This percentage is computed using Equation (9-3a).

$$\text{Utilization} = \left\lfloor \frac{T_{busy}}{\text{dot11ChannelUtilizationBeaconInterval} \times \text{dot11BeaconPeriod} \times 1024} \times 255 \right\rfloor \tag{9-3a}$$

The Frequency Underutilization field is that AP has underutilized frequency domain resources for given busy time of the medium. This percentage is computed using Equation (9-3b).

$$\text{Frequency Underutilization} = \left\lfloor \frac{T_{busy} - \sum_{i=1}^{N} \left\{ \left(\sum_{j=1}^{N_{RU}} B_{j,i} \times RU_j \right) \times T_i \right\}}{T_{busy}} \times 255 \right\rfloor \tag{9-3b}$$

The Spatial Stream Underutilization field is that AP has underutilized spatial domain resources for given busy time of the medium. This percentage is computed using Equation (9-3c).

$$\text{Spatial Stream Underutilization} = \left\lfloor \frac{N_{maxSS} \times T_{busy} - \sum_{i=1}^{N} \left\{ \left(\sum_{j=1}^{N_{RUM}} N_{SS,j,i} \times RUM_j \right) \times T_i \right\}}{N_{maxSS} \times T_{busy}} \times 255 \right\rfloor \quad (9\text{-}3c)$$

where

dot11ChannelUtilizationBeaconIntervals represents the number of consecutive beacon intervals during which the channel busy time is measured (see 9.4.2.28 (BSS Load element)).

T_{busy} is the number of microseconds during which CCA indicated the channel was busy due to a transmission between the AP and HE STAs during the measurement duration. The resolution of the CCA busy measurement is in microseconds

T_i is the time interval, in units of microseconds, during which the primary 20 MHz channel is busy due to a transmission between the AP and HE STAs

N is the number of busy events that occurred during the total measurement time that is less than or equal to dot11ChannelUtilizationBeaconIntervals consecutive beacon intervals

N_{RU} is the number of RUs that are allocated within the BSS bandwidth during time interval T_i

RU_j is a normalizing factor depending on the RU size and equals the ratio of the j-th RU size to the maximum RU size within the BSS bandwidth, i.e., if the j-th RU is a 26-tone RU and the BSS bandwidth is 20 MHz, then RU_j = 26/242

$B_{j,i}$ is 1 if the j-th RU is occupied or interfered in the busy time T_i, otherwise it is 0. Any 20 MHz subchannels that are not occupied by a PPDU are regarded as interfered RUs if the bandwidth of PPDU is less than the BSS bandwidth.

N_{maxSS} is the maximum number of spatial streams supported by the AP

N_{RUM} is the number of RUs with a size of at least 106 tones and that are allocated within the BSS bandwidth during time interval T_i

RUM_j is a normalizing factor depending on the RU size. RUM is applied to RUs with a size of at least 106 tones and equals the ratio of the j-th RU size to the maximum RUM size within the BSS bandwidth, i.e., if the j-th RUM is a 106-tone RU and the BSS bandwidth is 20 MHz, then RUM_j = 106/242.

$N_{SS,j,i}$ is the number of streams over the j-th RUM in the busy time T_i.

If T_{busy} is 0, the Utilization field, Frequency Underutilization field and Spatial Stream Underutilization field are reserved.

9.4.2.258 Multiple BSSID Configuration element

The Multiple BSSID Configuration element is used to provide configuration information for a multiple BBSID set.

The format of the Multiple BSSID Configuration element is shown in Figure 9-787ad (Multiple BSSID Configuration element format).

	Element ID	Length	Element ID Extension	BSSID Count	Profile Periodicity
Octets:	1	1	1	1	1

Figure 9-787ad—Multiple BSSID Configuration element format

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

The BSSID Count field carries the total number of active BSSIDs in the multiple BSSID set.

Profile Periodicity field indicates the least number of Beacon frames or DMG Beacon frames a STA needs to receive in order to discover all the active nontransmitted BSSIDs in the set.

9.4.2.259 Known BSSID element

The Known BSSID element identifies the nontransmitted BSSIDs that a non-AP STA has discovered so far. A non-AP STA can include this element in a directed Probe Request frame to discover other nontransmitted BSSIDs not known to the requesting STA.

The format of the Known BSSID element is defined in Figure 9-787ae (Known BSSID element format).

	Element ID	Length	Element ID Extension	BSSID Bitmap
Octets:	1	1	1	variable

Figure 9-787ae—Known BSSID element format

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

The format of the BSSID Bitmap field is as defined in Figure 9-787af (BSSID Bitmap field format).

	Bitmap	Pad
Bits:	variable	0, 4 or 6

Figure 9-787af—BSSID Bitmap field format

The Bitmap subfield has a length of 2^n bits where n is the value carried in the MaxBSSID Indicator field of the Multiple BSSID element advertised by the AP to which the Probe Request frame is being sent. Bit position 0 is reserved. The remainder of the bits represent one of $2^n - 1$ possible BSSID Index values (see 9.4.2.73 (Multiple BSSID-Index element)) in the multiple BSSID set. A value of 1 at bit position k indicates that the non-AP STA has knowledge of nontransmitted BSSID with BSSID index k. Otherwise the bit is set to 0.

The Pad subfield contains additional bits set to 0 to make the total number of bits in the BSSID Bitmap field equal to an integer number of octets.

9.4.2.260 Short SSID List element

The format of the Short SSID List Element is shown in Figure 9-787ag (Short SSID List element format).

	Element ID	Length	Element ID Extension	Short SSID List
Octets:	1	1	1	variable

Figure 9-787ag—Short SSID List element format

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

The Short SSID List field contains the one or more four octet Short SSID fields for which the STA is requesting information. The use of the Short SSID List element and frames is described in 11.1.4.3.2 (Active scanning procedure for a non-DMG STA). The Short SSID field is defined in 9.4.2.170.3 (Calculating the Short SSID).

9.4.2.261 HE 6 GHz Band Capabilities element

An HE STA operating in the 6 GHz band declares its extended capabilities by transmitting the HE 6 GHz Band Capabilities element. The HE 6 GHz Band Capabilities element is defined in Figure 9-787ah (HE 6 GHz Band Capabilities element format).

	Element ID	Length	Element ID Extension	Capabilities Information
Octets:	1	1	1	2

Figure 9-787ah—HE 6 GHz Band Capabilities element format

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

The Capabilities Information field is defined in Figure 9-787ai (Capabilities Information field format).

	B0 B2	B3 B5	B6 B7	B8	B9 B10	B11	B12	B13	B14 B15
	Minimum MPDU Start Spacing	Maximum A-MPDU Length Exponent	Maximum MPDU Length	Reserved	SM Power Save	RD Responder	Rx Antenna Pattern Consistency	Tx Antenna Pattern Consistency	Reserved
Bits:	3	3	2	1	2	1	1	1	2

Figure 9-787ai—Capabilities Information field format

The Minimum MPDU Start Spacing subfield is defined in 9.4.2.55.3 (A-MPDU Parameters field).

The Maximum A-MPDU Length Exponent subfield is defined in Table 9-272 (Subfield of the VHT Capabilities Information field).

The Maximum MPDU Length subfield is defined in Table 9-271 (Subfields of the VHT Capabilities Information field).

The SM Power Save subfield is defined in defined in Table 9-184 (Subfields of the HT Capabilities Information field).

The RD Responder subfield is defined in defined in Table 9-187 (Subfields of the HT Extended Capabilities field).

The Rx Antenna Pattern Consistency subfield is defined in defined in Table 9-272 (Subfield of the VHT Capabilities Information field).

The Tx Antenna Pattern Consistency subfield is defined in defined in Table 9-272 (Subfield of the VHT Capabilities Information field).

9.4.2.262 UL MU Power Capabilities element

The UL MU Power Capabilities element specifies the relative maximum transmit powers with which a STA is capable of transmitting an HE TB PPDU when using an RU size greater than or equal to 242 tones, as a function of HE-MCS. The UL MU Power Capabilities element indicates the relative maximum transmit power that a STA is capable of transmitting an HE TB PPDU for each HE-MCS in the operating channel width when using RU size greater than or equal to 242 subcarriers. The format of the UL MU Power Capabilities element is shown in Figure 9-787aj (UL MU Power Capabilities element format).

	Element ID	Length	Element ID Extension	Relative Max Transmit Power HE-MCS 1	…	Relative Max Transmit Power HE-MCS 11
Octets:	1	1	1	1	9	1

Figure 9-787aj—UL MU Power Capabilities element format

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

The UL MU Power Capabilities element contains 11 Relative Max Transmit Power HE-MCS *n* fields in ascending order of HE-MCS) from 1 to 11.

The Relative Max Transmit Power HE-MCS *n* field (where $n = 1, \ldots, 11$) is an unsigned integer in dB and contains the difference between the nominal maximum transmit power in dBm of an HE TB PPDU using an RU size greater than or equal to 242 subcarriers for HE-MCS 0 and that for HE-MCS *n*. The Relative Max Transmit Power HE-MCS n fields corresponding to HE-MCSs that are not supported by the HE STA that transmits this element are reserved.

9.6 Action frame format details

9.6.7 Public Action details

9.6.7.16 TDLS Discovery Response frame format

Insert the following row into Table 9-374 (TDLS Discovery Response Action field format) after the row for Order 18:

Table 9-374—TDLS Discovery Response Action field format

Order	Information	Notes
19	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present, The HE Capabilities element is defined in 9.4.2.247 (HE Capabilities element)

9.6.7.36 FILS Discovery frame format

Insert the following rows into Table 9-383 (FILS Discovery frame format):

Table 9-383—FILS Discovery frame format

Order	Information	Notes
7	TIM element	The TIM element is optionally present if dot11HEOptionImplemented is true, otherwise it is not present.
8	TWT element	The TWT element is optionally present if dot11HEOptionImplemented is true, otherwise it is not present. If present, the Broadcast field of the TWT element is 1
9	OPS element	The OPS element is optionally present if dot11HEOptionImplemented is true, otherwise it is not present.

Change the header row of Table 9-384 (BSS Operating Channel Width) as follows:

Table 9-384—BSS Operating Channel Width

BSS Operating Channel Width field	HR/DSSS, OFDM, ERP, HT, ~~or~~ VHT or HE BSS operating channel width	TVHT BSS operating channel width

Insert a new row in Table 9-386 (PHY Index subfield) as follows and update the Reserved row as appropriate:

Table 9-386—PHY Index subfield

PHY Index subfield	PHY
4	HE (see Clause 27 (High Efficiency (HE) PHY specification))

Change Table 9-386 (PHY Index subfield) as follows:

Table 9-387—FILS Minimum Rate

FILS Minimum Rate subfield	PHY Index subfield is 0 (HR/DSSS)	PHY Index subfield is 1 (ERP-OFDM)	PHY Index subfield is 2 (HT)	PHY Index subfield is 3 (VHT or TVHT)	PHY Index subfield is 4 (HE)
0	1 Mbps	6 Mbps	MCS 0	MCS 0	HE-MCS 0
1	2 Mbps	9 Mbps	MCS 1	MCS 1	HE-MCS 1
2	5.5 Mbps	12 Mbps	MCS 2	MCS 2	HE-MCS 2
3	11 Mbps	18 Mbps	MCS 3	MCS 3	HE-MCS 3
4	Reserved	24 Mbps	MCS 4	MCS 4	HE-MCS 4
5-7	Reserved	Reserved	Reserved	Reserved	Reserved

Change the following paragraph:

The Channel Center Frequency Segment 1 subfield is set to the index of the channel center frequency of the frequency segment 1 for an 80+80 MHz VHT or HE BSS, if the FILS Discovery frame is transmitted as a non-HT duplicate PPDUs at an 80+80 MHz channel bandwidth; otherwise, the subfield is not present.

Insert the following at the end of the subclause:

The TIM element is defined in 9.4.2.5 (TIM element) and is included for operation as defined in 26.14.3 (Opportunistic power save).

The TWT element is defined in 9.4.2.199 (TWT element) and is included with the Broadcast field set to 1 to aid an unassociated STA determine the target transmission time of Trigger frames that contain at least one User Info field that allocates RA-RUs for unassociated STAs (see 26.5.4.5 (Additional considerations for unassociated STAs) and 26.8.3.1 (General)).

The OPS element is defined in 9.4.2.256 (OPS element).

9.6.12 TDLS Action field formats

9.6.12.2 TDLS Setup Request Action field format

Change Table 9-414 (Information for TDLS Setup Request Action field) as follows (maintaining numeric order):

Table 9-414—Information for TDLS Setup Request Action field

Order	Information	Notes
19	AID	The AID element containing the AID of the STA sending the frame is present if dot11VHTOptionImplemented, dot11HEOptionImplemented, or dot11S1GOptionImplemented is true.
23	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true; otherwise it is not present. The HE Capabilities element is defined in 9.4.2.247 (HE Capabilities element)
24	TWT	The TWT element is optionally present if dot11TWTOptionActivated is true; otherwise not present. The Trigger subfield and the Negotiation Type subfield of the TWT element are set to 0.

9.6.12.3 TDLS Setup Response Action field format

Change Table 9-415 (Information for TDLS Setup Response Action field) as follows (maintaining numeric order):

Table 9-415—Information for TDLS Setup Response Action field

Order	Information	Notes
20	AID	The AID element containing the AID of the STA sending the frame is present if dot11VHTOptionImplemented, dot11HE-OptionImplemented, or dot11S1GOptionImplemented is true.
25	HE Capabilities	The HE Capabilities element is present if dot11HEOptionImplemented is true and the Status Code is SUCCESS; otherwise it is not present. The HE Capabilities element is defined in 9.4.2.247 (HE Capabilities element)
26	TWT	The TWT element is present if dot11TWTOptionActivated is true and the TWT element is present in the TDLS Setup Request frame that elicited this TDLS Setup Response frame. The TWT element is optionally present if dot11TWTOption-Activated is true and the TWT Requester Support field or the TWT Responder Support field is equal to 1 in the HE Capabilities in the TDLS Setup Request frame that elicited this TDLS Setup Response frame. Otherwise, the TWT element is not present. The Trigger subfield and the Negotiation Type subfield of the TWT element are set to 0.

9.6.12.4 TDLS Setup Confirm Action field format

Insert the following row in Table 9-416 (Information for TDLS Setup Confirm Action field):

Table 9-416—Information for TDLS Setup Confirm Action field

Order	Information	Notes
14	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true, the TDLS Setup Response frame contained an HE Capabilities element and the Status Code is SUCCESS; otherwise it is not present. The HE Operation element is defined in 9.4.2.248 (HE Operation element).

9.6.15 Self-protected Action frame details

9.6.15.2 Mesh Peering Open frame format

9.6.15.2.2 Mesh Peering Open frame details

Insert the following rows in Table 9-436 (Mesh Peering Open frame Action field format):

Table 9-436—Mesh Peering Open frame Action field format

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

9.6.15.3 Mesh Peering Confirm frame format

9.6.15.3.2 Mesh Peering Confirm frame details

Insert the following rows in Table 9-437 (Mesh Peering Confirm frame Action field format):

Table 9-437—Mesh Peering Confirm frame Action field format

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

9.6.24 Unprotected S1G Action frame details

9.6.24.1 Unprotected S1G Action field

Change the 1st paragraph as follows:

~~Several Action frame formats are defined to support S1G functionality.~~ An Unprotected S1G Action field, in the octet immediately after the Category field, differentiates the Unprotected S1G Action frame formats. The Unprotected S1G Action field values associated with each frame format within the Unprotected S1G category are defined in Table 9-493 (Unprotected S1G Action field values).

9.6.24.8 TWT Setup frame format

Change the last paragraph as follows:

In a TWT Setup frame with a TWT Request field that is equal to 1, the Dialog Token field is set to a nonzero value chosen by the transmitting STA to identify the request/response transaction. In a TWT Setup frame with a TWT Request field equal to 0 that is sent in response to a TWT Setup frame with a TWT Request field that is equal to 1, the Dialog Token field is set to the value copied from the corresponding received TWT Setup frame with a TWT Request field equal to 1. In a TWT Setup frame with a TWT Request field set to 0 that is not sent in response to a TWT Setup frame with a TWT Request field equal to 1, the Dialog Token field is set to 0.

9.6.24.9 TWT Teardown frame format

Change the 4th paragraph as follows:

~~The TWT Flow field contains the TWT Flow Identifier field and 5 reserved bits as shown in Figure 9-943 (TWT Flow field format):~~ The format of the TWT Flow field if the Negotiation Type subfield is 0 or 1 is defined in Figure 9-957 (TWT Flow field format if the Negotiation Type subfield is 0 or 1). The format of the TWT Flow field if the Negotiation Type subfield is 3 is defined in Figure 9-957b (TWT Flow field format if the Negotiation Type subfield is 3). The format of the TWT Flow field if the Negotiation Type field is 2 is defined in Figure 9-957a (TWT Flow field format if the Negotiation Type subfield is 2).

Change Figure 9-957 (TWT Flow field format if the Negotiation Type subfield is 0 or 1) as follows:

	B0 B2	B3 ~~B7~~ B4	B5 B6	B7
	TWT Flow Identifier	Reserved	Negotiation Type	Teardown All TWT
Bits:	3	~~5~~ 2	2	1

Figure 9-957—TWT Flow field format if the Negotiation Type subfield is 0 or 1

Insert two figures as follows:

	B0 B4	B5 B6	B7
	Reserved	Negotiation Type	Reserved
Bits:	5	2	1

Figure 9-957a—TWT Flow field format if the Negotiation Type subfield is 2

	B0 B4	B5 B6	B7
	Broadcast TWT ID	Negotiation Type	Teardown All TWT
Bits:	5	2	1

Figure 9-957b—TWT Flow field format if the Negotiation Type subfield is 3

Change the last paragraph as follows (splitting it into two paragraphs and adding a third):

The TWT Flow Identifier/Broadcast TWT ID field contains the TWT Flow Identifier when the Negotiation Type subfield is 0 or 1 and contains the Broadcast TWT ID field when the Negotiation Type subfield is 3. The TWT Flow Identifier field and the Broadcast TWT ID field are ~~is~~ defined in 9.4.2.200 and are reserved if the Teardown All TWT field is 1.

~~In a TWT Teardown frame, the~~ The TWT Flow Identifier field in a TWT Teardown frame is set to the value of the TWT Flow Identifier field of the TWT element in the frame that successfully concluded the setup of the TWT that is the subject of the teardown request. The Broadcast TWT ID field of a TWT Teardown frame is set to the value of the Broadcast TWT identifier of the broadcast TWT schedule that is subject of the teardown request.

The Negotiation Type subfield indicates the type of negotiation that is subject to the teardown request and is set as defined in Table 9-296a (Interpretation of Negotiation Type subfield, Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields). An S1G STA sets the Negotiation Type subfield to 0. The Negotiation Type subfield is reserved if the Teardown All TWT field is 1.

The Teardown All TWT field is set to 1 by an HE STA to indicate that the TWT Teardown frame tears down all TWTs as defined in 26.8 (TWT operation). Otherwise, it is set to 0.

9.6.24.12 TWT Information frame format

Change the 1st paragraph as follows:

The TWT Information frame is sent by a STA to request or deliver information about a TWT ~~agreement~~ and is transmitted by either STA of an existing TWT agreement or is transmitted by a STA to a peer STA that has indicated support of its reception. The Action field of the TWT Information frame contains the information shown in Table 9-505 (TWT Information frame Action field format).

Insert subclauses 9.6.31 and 9.6.32 to at the end of 9.6:

9.6.31 HE Action frame details

9.6.31.1 HE Action field

An HE Action field, in the octet immediately after the Category field, differentiates the HE Action frame formats. The HE Action field values associated with each frame format within the HE category are defined in Table 9-526a (HE Action field values).

Table 9-526a—HE Action field values

Value	Meaning
0	HE Compressed Beamforming/CQI
1	Quiet Time Period
2	OPS
3-255	Reserved

9.6.31.2 HE Compressed Beamforming/CQI frame format

The HE Compressed Beamforming/CQI frame is an Action No Ack frame of category HE. The Action field of an HE Compressed Beamforming/CQI frame contains the information shown in Table 9-526b (HE Compressed Beamforming/CQI frame Action field format).

Table 9-526b—HE Compressed Beamforming/CQI frame Action field format

Order	Information
1	Category
2	HE Action
3	HE MIMO Control (see 9.4.1.64 (HE MIMO Control field))
4	HE Compressed Beamforming Report (see 9.4.1.65 (HE Compressed Beamforming Report field))
5	HE MU Exclusive Beamforming Report (see 9.4.1.66 (HE MU Exclusive Beamforming Report field))
6	HE CQI Report (see 9.4.1.67 (HE CQI Report field))

The Category field is defined in Table 9-53 (Category values).

The HE Action field is defined in Table 9-526a (HE Action field values).

The HE MIMO Control field is always present in the frame. The presence and contents of the HE Compressed Beamforming Report field, HE MU Exclusive Beamforming Report field and HE CQI Report field are dependent on the values of the Feedback Type subfield of the HE MIMO Control field (see 9.4.1.65 (HE Compressed Beamforming Report field), 9.4.1.66 (HE MU Exclusive Beamforming Report field) and 9.4.1.67 (HE CQI Report field)).

A Vendor Specific element is not present in the HE Compressed Beamforming/CQI frame.

9.6.31.3 Quiet Time Period Action frame details

The Quiet Time Period action frame is an Action No Ack frame of category HE. The Action field of a Quiet Time Period contains the information shown in Table 9-526c (Quiet Time Period Frame Body).

Table 9-526c—Quiet Time Period Frame Body

Order	Information
1	Category
2	HE Action
3	Quiet Time Period element (see 9.4.2.254 (Quiet Time Period element))

The Category field is defined in Table 9-53 (Category values).

The HE Action field is defined in Table 9-526a (HE Action field values).

The Quiet Time Period element is defined in 9.4.2.254 (Quiet Time Period element).

9.6.31.4 OPS frame format

The OPS frame is an Action No Ack frame of category HE. The Action field of an OPS frame contains the information shown in Table 9-526d (OPS frame Action field format).

Table 9-526d—OPS frame Action field format

Order	Information
1	Category
2	HE Action
3	TIM element (see 9.4.2.5 (TIM element))
4	OPS element (see 9.4.2.256 (OPS element))

The Category field is defined in Table 9-53 (Category values).

The HE Action field is defined in Table 9-526a (HE Action field values).

The TIM element and OPS element are always present in the frame.

9.6.32 Protected HE Action frame details

9.6.32.1 Protected HE Action field

A Protected HE Action field, in the octet immediately after the Category field, differentiates the Protected HE Action frame formats. The Protected HE Action field values associated with each frame format within the HE category are defined in Table 9-526e (Protected HE Action field values).

Table 9-526e—Protected HE Action field values

Value	Meaning
0	HE BSS Color Change Announcement
1	MU EDCA Control
1-255	Reserved

9.6.32.2 HE BSS Color Change Announcement frame format

The HE BSS Color Change Announcement frame is an Action or Action No Ack frame of category Protected HE. The Action field of an HE BSS Color Change Announcement frame contains the information shown in Table 9-526f (HE BSS Color Change Announcement frame Action field format).

Table 9-526f—HE BSS Color Change Announcement frame Action field format

Order	Information
1	Category
2	Protected HE Action
3	BSS Color Change Announcement element (see 9.4.2.253 (BSS Color Change Announcement element))

The Category field is defined in Table 9-53 (Category values).

The Protected HE Action field is defined in Table 9-526e (Protected HE Action field values).

A BSS Color Change Announcement element is always present in the frame.

9.6.32.3 MU EDCA Control frame format

The MU EDCA Control frame is an Action frame of category Protected HE. The Action field of an MU EDCA Control frame contains the information shown in Table 9-526g (MU EDCA Control frame Action field format).

Table 9-526g—MU EDCA Control frame Action field format

Order	Information
1	Category
2	Protected HE Action
3	MU EDCA Control

The Category field is defined in Table 9-53 (Category values).

The Protected HE Action field is defined in Table 9-526e (Protected HE Action field values).

The MU EDCA Control field is defined in Figure 9-959a (MU EDCA Control field format).

	B0 B3	B4 B7
	Affected ACs	Reserved
Bits:	4	4

Figure 9-959a—MU EDCA Control field format

The Affected ACs subfield contains a bitmap that indicates the ACs for which the MUEDCATimer[AC] as defined in 26.2.7 (EDCA operation using MU EDCA parameters) are reset to 0 upon receipt of the MU EDCA Control frame for affected STAs. Each bit in the bitmap corresponds to one AC with B0 mapped to AC_BK, B1 mapped to AC_BE, B2 mapped to AC_VI and B3 mapped to AC_VO. A value of 1 in the bit position corresponding to a given AC indicates that the MUEDCATimer[AC] for that AC is reset to 0, otherwise, the value of the bit is 0.

9.7 Aggregate MPDU (A-MPDU)

9.7.1 A-MPDU format

Change the 4th paragraph as follows:

The EOF Padding field is shown in Figure 9-971 (EOF Padding field format). This is present only in a VHT or HE PPDU.

Change the 6th and subsequent paragraphs as follows:

In a VHT or HE PPDU, the following padding is present, as determined by the rules in 10.12.6 (A-MPDU padding for VHT, HE or S1G PPDU):

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

— Zero or more EOF padding subframes in the EOF Padding Subframes subfield.

— 0–3 octets in the EOF Padding Octets subfield. The content of these octets is unspecified.

An A-MPDU pre-EOF padding refers to the contents of the A-MPDU up to, but not including, the EOF Padding field.

NOTE—A-MPDU pre-EOF padding includes any A-MPDU subframes with 0 in the MPDU Length field and 0 in the EOF field inserted in order to meet the minimum MPDU start spacing requirement.

The maximum length of an A-MPDU in an HT PPDU is 65 535 octets. The maximum length of an A-MPDU in a DMG PPDU is 262 143 octets. The maximum length of an A-MPDU pre-EOF padding in a VHT PPDU is 1 048 575 octets. The maximum length of an A-MPDU pre-EOF padding in an HE PPDU is 6 500 631 octets. The length of an A-MPDU addressed to a particular STA can be further constrained as described in 10.12.2 (A-MPDU length limit rules).

Change Table 9-527 (MPDU delimiter fields (non-DMG)) as follows:

Table 9-527— MPDU delimiter fields (non-DMG)

Field	Size (bits)	Description
EOF	1	End of frame indication and/or ack soliciting indication in combination with the MPDU Length field. Set to 1 in an A-MPDU subframe that has 0 in the MPDU Length field and that is used to pad the A-MPDU in a VHT or HE PPDU as described in 10.13.6 (A-MPDU padding for VHT PPDU). Set to 1 in the MPDU delimiter of an S-MPDU as described in 10.13.7 (Setting the EOF field of the MPDU delimiter)) and set to 1 in an MPDU delimiter preceding a QoS Data frame or Management frame soliciting an Ack or Per AID TID Info field with Ack Type field set to 1 in a Multi-STA BlockAck frame in a response that is contained in an ack-enabled multi-TID A-MPDU as described in 26.6.3.4 (Ack-enabled multi-TID A-MPDU operation) and ack-enabled single-TID A-MPDU as described in 26.6.3.1 (General). Set to 0 otherwise.
Reserved	1	
MPDU Length	14	Length of the MPDU in octets. Set to 0 if no MPDU is present. An A-MPDU subframe with 0 in the MPDU Length field is used as defined in 10.13.3 (Minimum MPDU Start Spacing field) to meet the minimum MPDU start spacing requirement and also to pad the A-MPDU to fill the available octets in a VHT or HE PPDU as defined in 10.13.6 (A-MPDU padding for VHT PPDU or S1G PPDU).
CRC	8	8-bit CRC of the preceding 16 bits
Delimiter Signature	8	Pattern that may be used to detect an MPDU delimiter when scanning for an MPDU delimiter. The unique pattern is 0x4E, which is the ASCII value of the character 'N' ~~(see NOTE below)~~.
~~NOTE—The ASCII value of the character 'N' was chosen as the unique pattern for the value in the Delimiter Signature field.~~		

Change the 12th paragraph as follows:

The format of the MPDU Length field when transmitted by a non-DMG STA is shown in Figure 9-965 (MPDU Length field (non-DMG)). The MPDU Length Low subfield contains the 12 low order bits of the MPDU length. In a VHT or HE PPDU, the MPDU Length High subfield contains the two high order bits of the MPDU length. In an HT PPDU, the MPDU Length High subfield is reserved.

Replace Equation (9-5) with the equation below (introductory sentence and variable list unchanged):

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

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

where

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

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

L is the value of the MPDU Length field

Change the NOTE as follows:

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

9.7.3 A-MPDU contents

Change the 1st paragraph of this subclause 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 S1G, S1G_DUP_1M, or S1G_DUP_2M and the AGGREGATION parameter set to 1

— The FORMAT parameter set to HE_SU, HE_MU, HE_TB or HE_ER_SU

Insert the following after the 1st paragraph:

An A-MPDU carried in an HE SU PPDU, HE ER SU PPDU, HE TB PPDU or HE MU PPDU can include MPDUs with different values of the TID field as described in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU).

Change the 3rd paragraph as follows:

All of the MPDUs within an A-MPDU are addressed to the same RA. All of the MPDUs within an A-MPDU have the same TA. All QoS Data frames within an A-MPDU that have a TID for which an HT-immediate block ack agreement exists have the same value for the Ack Policy Indicator subfield of the QoS Control field.

Change paragraphs 5-7 and Table 9-529 (A-MPDU Contexts) as follows:

The Duration/ID fields in the MAC headers of all MPDUs in an A-MPDU carry the same value. The Duration/ID fields in the MAC headers of the MPDUs in the A-MPDUs carried in ~~the same~~ a VHT MU PPDU and an HE MU PPDU ~~all~~ carry the same value.

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

An A-MPDU is transmitted in one of the contexts specified in Table 9-529 (A-MPDU Contexts) as defined by the description in the “Definition of context” column~~, independently of whether the A-MPDU is contained in a VHT MU PPDU or an SU PPDU~~. The content of an A-MPDU depends on the context in which it is transmitted as defined in the tables below. Ordering of MPDUs within an A-MPDU is not constrained, except where noted in these tables. See 10.12.1 (A-MPDU contents).

Table 9-529—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
Non-HE Data Enabled Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder or an RD responder including potential immediate responses.	Table 9-530 (A-MPDU contents in the non-HE data enabled immediate response context)
Data Enabled No Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder, TXOP responder when transmitted by an HE STA to another HE STA, and the A-MPDU ~~that~~ does not include or solicit an immediate response. See NOTE.	Table 9-531 (A-MPDU contents in the data enabled no immediate response context)
PSMP	The A-MPDU is transmitted within a PSMP sequence.	Table 9-530 (A-MPDU contents in the PSMP context)
Control Response	The A-MPDU is transmitted by a STA that is neither a TXOP holder nor an RD responder or the A-MPDU is transmitted by an HE AP in response to an HE TB PPDU, and the transmitter ~~that~~ also needs to transmit one of the following immediate response frames: — Ack frame — BlockAck frame with a TID for which an HT-immediate block ack agreement exists — Multi-STA BlockAck frame for acknowledging multi-TID A-MPDU	Table 9-532 (A-MPDU contents in the control response context)
S-MPDU context	The A-MPDU is transmitted within a VHT PPDU or an HE PPDU and contains an S-MPDU.	Table 9-533 (A-MPDU contents in the S-MPDU context)
HE Non-Ack-Enabled Single-TID Immediate Response	The A-MPDU is transmitted by a TXOP holder or TXOP responder in an HE PPDU and solicits block acknowledgment for single TID.	Table 9-532a (A-MPDU contents in the HE non-ack-enabled single-TID immediate response context)
HE Ack-Enabled Single-TID Immediate Response	The A-MPDU is transmitted by a TXOP holder or TXOP responder in an HE PPDU and solicits single acknowledgment.	Table 9-532b (A-MPDU contents in the HE ack-enabled single-TID immediate response context)
HE Non-Ack Enabled Multi-TID Immediate Response	The A-MPDU is transmitted by a TXOP holder or TXOP responder in an HE PPDU, and solicits block acknowledgments for multiple TIDs.	Table 9-532c (A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context)

Table 9-529—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
HE Ack-Enabled Multi-TID Immediate Response	The A-MPDU is transmitted by a TXOP holder or TXOP responder in an HE PPDU, and solicits at least one acknowledgment and zero or more block acknowledgments.	Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context)
NOTE—This context includes cases when no response is generated or when a response is generated later by the operation of the HT-delayed block ack rules.		

NOTE—If the number qualifier for a frame subtype does not exist, zero or more frames of the frame subtype can be aggregated in the A-MPDU.

A VHT MU PPDU~~, or~~ S1G MU PPDU and HE MU PPDU do~~es~~ not carry more than one A-MPDU that contains one or more MPDUs soliciting an immediate response if the immediate response is carried in a PPDU that is not an HE TB PPDU. An HE MU PPDU can carry more than one A-MPDU each of which contains one or more MPDUs soliciting an immediate response if the immediate response is carried in an HE TB PPDU.

NOTE 1—The TIDs present in a data enabled A-MPDU context are also constrained by the channel access rules (for a TXOP holder; see 10.23.2 (HCF contention based channel access (EDCA)) and 10.23.3 (HCF controlled channel access (HCCA))), the TXOP responder rules (see 26.6 (A-MPDU operation in an HE PPDU), and 26.5.2 (UL MU operation)) and the RD response rules (for an RD responder, see 10.29.4 (Rules for RD responder)). This is not shown in these tables.

NOTE 2—If a STA supports A-MSDUs of 7935 octets (indicated by the Maximum A-MSDU Length field in the HT Capabilities element), A-MSDUs transmitted by that STA within an A-MPDU carried in a PPDU with FORMAT HT_MF or HT_GF are constrained so that the length of the QoS Data frame carrying the A-MSDU is no more than 4095 octets. The 4095-octet MPDU length limit does not apply to A-MPDUs carried in VHT, HE or DMG PPDUs. The use of A-MSDU within A-MPDU might be further constrained as described in 9.4.1.13 (Block Ack Parameter Set field) through the operation of the A-MSDU Supported field.

Change Table 9-530 (A-MPDU contents in the non-HE data enabled immediate response context) as follows:

Table 9-530—A-MPDU contents in the non-HE data enabled immediate response context

<table>
<tr><th>MPDU Description</th><th colspan="2">Conditions</th></tr>
<tr><td>Ack</td><td>If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A-MPDU.</td><td rowspan="2">Of these, in a non-DMG STA: at most one of these MPDUs is present.

Of these, in a DMG STA: at most one Ack frame is present, and zero or more HT-immediate BlockAck frames are present.</td></tr>
<tr><td>HT-immediate BlockAck</td><td>In a non-DMG STA: 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, in which case it occurs at the start of the A-MPDU.

In a DMG STA: if the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, one or more copies of the same BlockAck for this TID.</td></tr>
<tr><td>HT-delayed BlockAcks</td><td colspan="2">BlockAck frames with the BA Ack Policy subfield equal to No Acknowledgment with a TID for which an HT-delayed block ack agreement exists.</td></tr>
<tr><td>HT-delayed block ack data</td><td colspan="2">QoS Data frames with a TID that corresponds to an HT-delayed block ack agreement.
These have Block Ack ack policy.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Action No Ack frames.</td></tr>
<tr><td>HT-delayed BlockAckReqs</td><td colspan="2">BlockAckReq frames with a TID that corresponds to an HT-delayed block ack agreement, and in which the BAR Ack Policy subfield is equal to No Acknowledgment.</td></tr>
<tr><td>Data frames sent under an HT-immediate block ack agreement</td><td>QoS Data frames with the same TID, which corresponds to an HT-immediate block ack agreement.
See NOTE.</td><td rowspan="3">Of these, at most one of the following is present in a non-DMG BSS:
— One or more QoS Data frames with Implicit BAR ack policy
— A BlockAckReq frame

Of these, at most one of the following is present in a DMG BSS:
— One or more QoS Data frames with Implicit BAR ack policy
— QoS Null frame with the No Ack ack policy
— A BlockAckReq frame with an optional QoS Null frame with No Ack ack policy</td></tr>
<tr><td>QoS Null frames with the No Ack ack policy</td><td>In a DMG BSS, QoS Null frames with the No Ack ack policy.</td></tr>
<tr><td>Immediate BlockAckReq</td><td>At most one BlockAckReq frame with a TID that corresponds to an HT-immediate block ack agreement.
This is the last MPDU in the A-MPDU.

It is not present if any QoS Data frames for that TID are present.</td></tr>
<tr><td colspan="3">NOTE—These MPDUs all have the same ack policy, which is either Implicit BAR or Block Ack.</td></tr>
</table>

Change Table 9-531 (A-MPDU contents in the data enabled no immediate response context) as follows:

Table 9-531—A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions
Delayed BlockAcks	For a non-HE STA: BlockAck frames for a TID for which an HT-delayed block ack agreement exists with the BA Ack Policy subfield equal to No Acknowledgment.
Delayed Block Ack data	For a non-HE STA: QoS Data frames with a TID that corresponds to an HT-delayed block ack agreement. These have the Block Ack ack policy.
Data without a block ack agreement	QoS Data frames with a TID that does not correspond to a block ack agreement. These have No Ack ack policy and the A-MSDU Present subfield equal to 0.
Action No Ack	Action No Ack frames.
HT-delayed BlockAckReqs	For a non-HE STA: BlockAckReq frames with the BAR Ack Policy subfield equal to No Acknowledgment and with a TID that corresponds to an HT-delayed block ack agreement.
Trigger	For an HE AP: Trigger frames where the Trigger Type field is Basic Trigger frame or BSRP Trigger frame. The Trigger frames are the first MPDUs of the A-MPDU unless the A-MPDU also carries an Ack or BlockAck frame in which case the Trigger frames are included immediately after the Ack or BlockAck frame.
QoS Null frame with No Ack ack policy	For an HE STA: QoS Null frames with No Ack ack policy.

Change Table 9-532 (A-MPDU contents in the control response context) as follows:

Table 9-532—A-MPDU contents in the control response context

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Ack</td><td>Ack frame transmitted in response to an MPDU that requires an Ack frame.</td><td rowspan="2">One of Ack and compressed BlockAck frame is present at the start of the A-MPDU between two STAs that are not both HE STAs; these are not present other than at the start of the A-MPDU.

~~One of these~~ One of Ack, Compressed BlockAck, and Multi-STA BlockAck frame is present at the start of the A-MPDU between two HE STAs; these are not present other than at the start of the A-MPDU.</td></tr>
<tr><td>BlockAck</td><td>Compressed BlockAck frame with a TID that corresponds to an HT-immediate block ack agreement.

Multi-STA BlockAck frame if the preceding PPDU is either an HE TB PPDU that solicits an immediate response (see 26.4.4.5 (Responding to an HE TB PPDU with an SU PPDU)) or is an HE PPDU that carries a multi-TID A-MPDU or ack-enabled multi-TID A-MPDU (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)).</td></tr>
<tr><td>Action No Ack</td><td colspan="2">In an A-MPDU between two STAs that are not both HE STAs: +HTC Action No Ack frames carrying a Management Action Body containing an explicit feedback response or BRP frame.
Flow Control Action No Ack frames carrying a flow suspension frame or a flow resumption frame.

In an A-MPDU between two HE STAs: Action No Ack frames.</td></tr>
<tr><td>QoS Null frame with No Ack ack policy</td><td colspan="2">For an HE STA: QoS Null frames with No Ack ack policy.</td></tr>
</table>

Insert new tables as follows:

Table 9-532a—A-MPDU contents in the HE non-ack-enabled single-TID immediate response context

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Ack</td><td>If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A-MPDU.</td><td rowspan="2">At most one non-EOF MPDU that is Ack, Compressed BlockAck, or Multi-STA BlockAck frame is present</td></tr>
<tr><td>HT-immediate BlockAck</td><td>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 Compressed BlockAck frame for this TID at the start of the A-MPDU.

If the preceding PPDU contains explicit block ack requests for multiple TIDs or a multi-TID A-MPDU, at most one Multi-STA BlockAck frame at the start of the A-MPDU.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Non-EOF MPDUs that are Action No Ack frames.</td></tr>
<tr><td>QoS Null frame with Ack Policy subfield set to No Ack</td><td colspan="2">non-EOF-MPDUs that are QoS Null frames with Ack Policy subfield set to No Ack.</td></tr>
</table>

Table 9-532a—A-MPDU contents in the HE non-ack-enabled single-TID immediate response context *(continued)*

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Data frames sent under an HT-immediate block ack agreement</td><td>One or more QoS Data frames with the same TID, which corresponds to an HT-immediate block ack agreement

See NOTE 1.</td><td rowspan="3">One of the following is present:
— One or more Non-EOF MPDUs each of which is a QoS Data frame with Implicit BAR, HTP Ack, or Block Ack ack policy and belonging to a block ack agreement, zero or more non-EOF MPDUs each of which is a Basic Trigger, BSRP Trigger, or BQRP Trigger frame
— One non-EOF MPDU that is BlockAckReq frame, zero or more non-EOF MPDUs each of which is a QoS Null frame with No Ack ack policy.
— One or more non-EOF MPDUs each of which is a Basic Trigger, MU-BAR Trigger, BQRP Trigger, or BSRP Trigger frame. The MU-BAR Trigger frame solicits block acknowledgment for one TID.</td></tr>
<tr><td>Compressed BlockAckReq</td><td>At most one BlockAckReq frame with a TID that corresponds to an HT-immediate block ack agreement.

This frame is the last MPDU in the A-MPDU.

BlockAckReq is not present if any QoS Data frames are present.</td></tr>
<tr><td>Trigger</td><td>Trigger frames where the Trigger Type field is Basic Trigger, MU-BAR Trigger, BQRP Trigger or BSRP Trigger.

MU BAR Trigger frame is not present if any QoS Data frames are present.

The Trigger frames are the first MPDUs of the A-MPDU unless the A-MPDU also carries an Ack or BlockAck frame in which case the Trigger frames are included immediately after the Ack or BlockAck frame.

See NOTE 2 and NOTE 3.</td></tr>
<tr><td colspan="3">NOTE 1—MPDUs from the same TID all have the same ack policy, which is Implicit BAR, HTP Ack or Block Ack.

NOTE 2—Only an HE AP is allowed to include a Trigger frame in the A-MPDU. The presence of more than one copy of a Trigger frame in an A-MPDU might increase the probability of the successful reception of the Trigger frame. The content of all Trigger frames in the A-MPDU is the same.

NOTE 3–The BSRP and BQRP Trigger frames can be aggregated with other MPDUs in the A-MPDU if the receiver has indicated the support of receiving these trigger types in the BSRP BQRP A-MPDU Aggregation field of the HE Capabilities element.</td></tr>
</table>

Table 9-532b—A-MPDU contents in the HE ack-enabled single-TID immediate response context

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Ack</td><td>If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A MPDU.</td><td rowspan="2">At most one non-EOF MPDU that is an Ack, Compressed BlockAck, or Multi-STA Block-Ack frame is present</td></tr>
<tr><td>HT-immediate Block-Ack</td><td>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 Compressed BlockAck frame for this TID at the start of the A-MPDU.

If the preceding PPDU contains explicit block ack requests for multiple TIDs or a multi-TID A-MPDU, at most one Multi-STA BlockAck frame at the start of the A-MPDU.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Non-EOF MPDUs that are Action No Ack frames.</td></tr>
<tr><td>Data frames not sent under an HT-immediate block ack agreement</td><td>At most one Data frame with a TID that does not correspond to an HT-immediate block ack agreement and ack policy Normal Ack or HTP Ack.</td><td rowspan="5">One EOF MPDU that is either a QoS Data frame with Normal Ack or HTP Ack ack policy, or a Management frame that solicits an immediate response, one or more non-EOF MPDUs, each of which is a QoS Null frame with No Ack ack policy, or a Trigger frame. The Trigger frame is a Basic Trigger, BSRP Trigger or BQRP Trigger frame.</td></tr>
<tr><td>Data frames sent under an HT-immediate block ack agreement</td><td>At most one QoS Data frame with a TID that corresponds to an HT-immediate block ack agreement</td></tr>
<tr><td>QoS Null frame with No Ack ack policy</td><td>QoS Null frames with No Ack ack policy.</td></tr>
<tr><td>Management frame</td><td>At most one Management frame that solicits an acknowledgment.</td></tr>
<tr><td>Trigger</td><td>Basic Trigger, BQRP Trigger or BSRP Trigger frames.

The Trigger frames are the first MPDUs of the A-MPDU unless the A-MPDU also carries an Ack or BlockAck frame in which case the Trigger frames are included immediately after the Ack or BlockAck frame.

See NOTE 2.</td></tr>
<tr><td colspan="3">NOTE 1—Only an HE AP is allowed to include a Trigger frame in the A-MPDU. Multiple Trigger frames in one A-MPDU increases robustness. The content of all Trigger frames in the A-MPDU is the same.

NOTE 2—The BSRP Trigger and BQRP Trigger frames can be aggregated with other MPDUs in the A-MPDU if the receiver has indicated the support of receiving these Trigger frame types in the BSRP BQRP A-MPDU Aggregation field of the HE Capabilities element.

NOTE 3—The single Management frame that solicits the acknowledgment in ack-enabled single-TID A-MPDU is treated as single-TID frame, e.g. soliciting Ack of TID 15 in multi-STA BlockAck frame.</td></tr>
</table>

Table 9-532c—A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Ack</td><td>If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A MPDU.</td><td rowspan="2">At most one non-EOF MPDU that is an Ack, Compressed BlockAck, or Multi-STA Block-Ack frame is present</td></tr>
<tr><td>HT-immediate Block-Ack</td><td>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 Compressed BlockAck frame for this TID at the start of the A-MPDU.

If the preceding PPDU contains explicit block ack requests for multiple TIDs or a multi-TID A-MPDU, at most one Multi-STA BlockAck frame at the start of the A-MPDU.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Non-EOF MPDUs that are Action No Ack frames.</td></tr>
<tr><td>QoS Null frame with Ack Policy subfield set to No Ack</td><td colspan="2">non-EOF-MPDUs that are QoS Null frames with Ack Policy subfield set to No Ack.</td></tr>
</table>

Table 9-532c—A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context *(continued)*

MPDU	Conditions	
Data frames sent under an HT-immediate block ack agreement	QoS Data frames with different TIDs each of which corresponds to an HT-immediate block ack agreement. See NOTE 1.	One of the following is present: — Two or more non-EOF MPDUs that are QoS Data frames that belong to two or more block ack agreements and with Implicit BAR, HTP Ack, or Block Ack ack policy, zero or more non-EOF MPDUs each of which is a Trigger frame. The Trigger frame is a Basic Trigger, BSRP Trigger, or BQRP Trigger frame — One non-EOF MPDU that is a Multi-TID BlockAckReq frame. — One or more non-EOF MPDUs each of which is an MU-BAR Trigger frame that solicits block acknowledgment for more than one TID.
Immediate BlockAck-Req	At most one multi-TID BlockAck-Req frame with TIDs that correspond to HT-immediate block ack agreements This frame is the last MPDU in the A-MPDU. Multi-TID BlockAckReq frame is not present if any QoS Data frames are present.	
Trigger	Basic Trigger, MU-BAR Trigger, BQRP Trigger or BSRP Trigger frames. MU-BAR Trigger frame is not present if any QoS Data frames are present. The Trigger frames are the first MPDUs of the A-MPDU unless the A-MPDU also carries an Ack or BlockAck frame in which case the Trigger frames are included immediately after the Ack or BlockAck frame. See NOTE 2 and NOTE 3.	

NOTE 1—MPDUs from the same TID all have the same ack policy, which is Implicit BAR, HTP Ack or Block Ack.

NOTE 2—Only an HE AP is allowed to include a Trigger frame in the A-MPDU. Multiple Trigger frames in one A-MPDU increases the robustness. The content of all Trigger frames in the A-MPDU is the same.

NOTE 3—The BSRP Trigger and BQRP Trigger frames can be aggregated with other MPDUs in the A-MPDU if the receiver has indicated the support of receiving these trigger types in the BSRP BQRP A-MPDU Aggregation field of the HE Capabilities element.

Table 9-532d—A-MPDU contents in the HE ack-enabled multi-TID immediate response context

MPDU	Conditions	
Ack	If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A MPDU.	At most one non-EOF MPDU that is an Ack, Compressed BlockAck, or Multi-STA Block-Ack frame is present
HT-immediate Block-Ack	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 Compressed BlockAck frame for this TID at the start of the A-MPDU. If the preceding PPDU contains explicit block ack requests for multiple TIDs or a multi-TID A-MPDU, at most one Multi-STA BlockAck frame at the start of the A-MPDU.	
Action No Ack	Non-EOF MPDUs that are Action No Ack frames.	
QoS Null frame with Ack Policy subfield set to No Ack	non-EOF-MPDUs that are QoS Null frames with Ack Policy subfield set to No Ack.	

Table 9-532d—A-MPDU contents in the HE ack-enabled multi-TID immediate response context *(continued)*

<table>
<tr><th>MPDU</th><th colspan="2">Conditions</th></tr>
<tr><td>Data frames without an HT-immediate block ack agreement</td><td>One or more QoS Data frames with each with different TIDs where none of the TID have HT-immediate block ack agreement

See NOTE 1.</td><td rowspan="4">One of the following is present:
— EOF MPDUs each of which is a QoS Data frame with Normal Ack or HTP Ack ack policy and where the TIDs of the QoS Data frames differ if there is more than one, zero or more non-EOF MPDUs each of which is a Basic Trigger, BSRP Trigger, or BQRP Trigger frame
— Zero or more non-EOF MPDUs each of which is a QoS Data frame with Implicit BAR, HTP Ack, or Block Ack ack policy and belonging to a block ack agreement, one or more EOF MPDUs each of which is a QoS Data frame with Normal Ack or HTP Ack ack policy and where the TIDs of the QoS Data frames differ if there is more than one, an EOF MPDU that is a Management frame, zero or more non-EOF MPDUs each of which is a Basic Trigger, BSRP Trigger, or BQRP Trigger frame
— Zero or more non-EOF MPDUs each of which is a QoS Data frame with Implicit BAR, HTP Ack, or Block Ack ack policy and belonging to a block ack agreement, and two or more EOF MPDUs each of which is a QoS Data frame with Normal Ack or HTP Ack ack policy and where the TIDs of the QoS Data frames differ if there is more than one, zero or more non-EOF MPDUs each of which is a Basic Trigger, BSRP Trigger, or BQRP Trigger frame</td></tr>
<tr><td>Data frames sent under an HT-immediate block ack agreement</td><td>One of the following:
— One or more QoS Data frames with a TID that corresponding to an HT-immediate block ack agreement
— QoS Data frames with TIDs that correspond to two or more HT-immediate block ack agreements
See NOTE 1.</td></tr>
<tr><td>Management</td><td>At most one Management frame that solicits an acknowledgment</td></tr>
<tr><td>Trigger</td><td>One or more Basic Trigger, BQRP Trigger or BSRP Trigger frames.

The Trigger frames are the first MPDUs of the A-MPDU unless the A-MPDU also carries an Ack or BlockAck frame in which case the Trigger frames are included immediately after the Ack or BlockAck frame.

See NOTE 2 and NOTE 3.</td></tr>
<tr><td colspan="3">NOTE 1—MPDUs with the same TID all have the same ack policy, which is Implicit BAR, HTP Ack or Block Ack.

NOTE 2—Only an HE AP is allowed to include a Trigger frame in the A-MPDU. Multiple Trigger frames in one A-MPDU increases the robustness. The content of all Trigger frames in the A-MPDU is the same.

NOTE 3—The BSRP Trigger and BQRP Trigger frames can be aggregated with other MPDUs in the A-MPDU if the receiver has indicated the support of receiving these trigger types in the BSRP BQRP A-MPDU Aggregation field of the HE Capabilities element.</td></tr>
</table>

10. MAC sublayer functional description

10.1 Introduction

Change as follows:

The MAC functional description is presented in this clause. The architecture of the MAC sublayer, including the distributed coordination function (DCF), the hybrid coordination function (HCF), the mesh coordination function (MCF), the triggered UL access (TUA), and their coexistence in an IEEE 802.11 LAN are introduced in 10.2 (MAC architecture). These functions are expanded on in 10.3 (DCF), 10.23 (HCF), ~~and~~ 10.24 (Mesh coordination function (MCF)), and 26.2 (HE channel access). Fragmentation and defragmentation are defined in 10.4 (MSDU, A-MSDU, and MMPDU fragmentation) and 10.5 (MSDU, A-MSDU, and MMPDU defragmentation). Multirate support is addressed in 10.6 (Multirate support). A number of additional restrictions to limit the cases in which MSDUs are reordered or discarded are described in 10.7 (MSDU transmission restrictions). Operation across regulatory domains is defined in 10.22 (Operation across regulatory domains). The block ack mechanism is described in 10.25 (Block acknowledgment (block ack)). The No Ack mechanism is described in 10.26 (No Acknowledgment (No Ack)). The protection mechanism is described in 10.27 (Protection mechanisms). Rules for processing MAC frames are described in 10.28 (MAC frame processing).

10.2 MAC architecture

10.2.1 General

Replace Figure 10-1 (Non-DMG non-CMMG non-S1G STA MAC architecture) with the following:

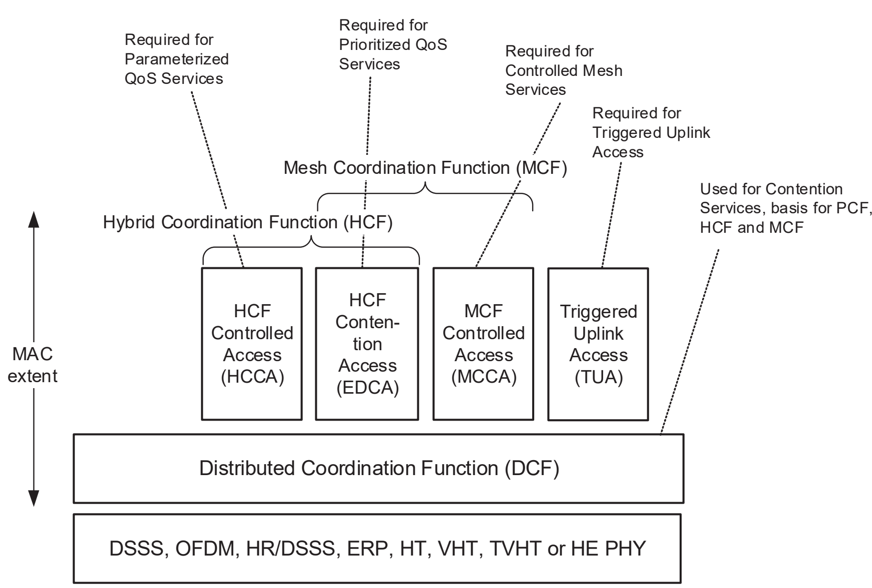

Figure 10-1—Non-DMG non-CMMG non-S1G STA MAC architecture

Change the 2nd paragraph as follows:

In a non-DMG non-CMMG non-S1G STA:

— The MAC provides the HCF, ~~and~~ MCF, and TUA services using the services of the DCF.

- The HCF is present in QoS STAs and absent otherwise.
- The MCF is present in mesh STAs and absent otherwise.
- The TUA is present in non-AP HE STAs and absent otherwise.

10.2.3 Hybrid coordination function (HCF)

10.2.3.2 HCF contention based channel access (EDCA)

Change the 2nd paragraph as follows:

For each AC an enhanced variant of the DCF, called an *enhanced distributed channel access function* (*EDCAF*), contends for TXOPs using a set of EDCA parameters. When communicating Data frames outside the context of a BSS (dot11OCBActivated is true), the EDCA parameters are the corresponding default values or are as set by the SME in dot11EDCATable (except for TXOP limits, which shall be set to 0 for each AC). When communicating within a non-mesh QoS BSS, the EDCA parameters used are from the EDCA Parameter Set element or (for a non-AP STA prior to association in an infrastructure BSS, a mesh STA, or a STA that operates OCB) from the default values for the parameters~~ when no EDCA Parameter Set element is received from the AP of the BSS with which the STA is associated or when the STA is a mesh STA~~. The parameters used by the EDCAF to control its operation are defined by dot11QAPEDCATable at the AP and by dot11EDCATable at the non-AP STA.

Change the 4th paragraph as follows:

The QoS AP shall announce the EDCA parameters in selected Beacon frames and in all Probe Response and (Re)Association Response frames by the inclusion of the EDCA Parameter Set element using the information from the MIB entries in ~~dot11ECDATable~~ dot11EDCATable. If no such element ~~is~~ has been received (e.g., prior to association in an infrastructure BSS), a non-AP QoS STA shall use the default values for the parameters. The fields following the QoS Info field in the EDCA Parameter Set element shall be included in all Beacon frames occurring within two (optionally more) delivery traffic indication map (DTIM) periods following a change in AC parameters, which provides all STAs an opportunity to receive the updated EDCA parameters. If any associated STAs are in WNM sleep mode or using FMS, these fields should be included by the AP for as many DTIM periods as needed to exceed the longest interval any STA is expected to not receive Beacon frames.

An HE AP can additionally provide MU EDCA parameters for non-AP HE STAs as defined in 26.2.7 (EDCA operation using MU EDCA parameters).

Change the 13th paragraph as follows:

BlockAckReq and BlockAck frames shall be sent using the same access category for medium access as the corresponding QoS Data frames. If an HE STA transmits a BlockAckReq, Multi-TID BlockAckReq or Multi-STA BlockAck frame, then further constraints defined in 26.4 (HE acknowledgment procedure) apply.

Insert a new subclause as follows after 10.2.4:

10.2.4a Triggered uplink access (TUA)

A non-AP HE STA also implements trigger-based UL access methods. Triggered UL access (TUA) is used when an HE AP triggers one or more non-AP HE STAs to transmit HE TB PPDUs simultaneously. The optional UORA additionally allows a non-AP HE STA to access one of a number of resource units designated for random access by the HE AP. See 26.5.2 (UL MU operation) and 26.5.4 (UL OFDMA-based random access (UORA)).

Change the title and first paragraph of 10.2.5 as follows:

10.2.5 Combined use of DCF, ~~and~~ HCF, and TUA

The DCF, ~~and the~~ hybrid coordination function and TUA are defined so they may operate within the same BSS. The HCF access methods (controlled and contention based) operate sequentially. Sequential operation allows the polled and contention based access methods to alternate, within intervals as short as the time to transmit a frame exchange sequence, under rules defined in 10.23 (HCF).

10.3 DCF

10.3.1 General

Change the 6th paragraph 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 an MU-RTS Trigger frame and simultaneous CTS frame responses by HE STAs prior to the actual Data frames is another means of distribution of this medium reservation information.

Change the 11th paragraph as follows:

The use of the RTS/CTS mechanism under control of dot11RTSThreshold if dot11TXOPDurationRTSThreshold is 1023 or is not present is described in 10.3.5 (Individually addressed MPDU transfer procedure).

The use of the RTS/CTS mechanism is under control of dot11TXOPDurationRTSThreshold if dot11TXOPDurationRTSThreshold is present and is not 1023. If this mechanism is enabled, a non-AP HE STA shall initiate a TXOP that is used for individually addressed frames with an RTS/CTS exchange as defined in 26.2.1 (TXOP duration-based RTS/CTS).

10.3.2 Procedures common to the DCF and EDCAF

10.3.2.1 CS mechanism

Change the 4th paragraph of the subclause as follows:

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 Trigger/CTS frames by HE STAs as defined in 26.2.6 (MU-RTS Trigger/CTS frame exchange procedure), 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 other than PV1 MAC frames and PS-Poll frames, and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The duration information in a frame transmitted by an S1G STA is also available in PS-Poll+BDT frames, in NDP CTS frames, in NDP Ack frames whose Idle Indication field value is 0, and in NDP_2M PS-Poll-Ack frames whose Idle Indication field is 0. The duration information might also be available in the RXVECTOR parameter TXOP_DURATION when an HE PPDU is received (see 26.11.5 (TXOP_DURATION)).

Change the 7th paragraph as follows:

The CS mechanism combines the NAV state, and in S1G STAs also the RID state, and the STA's transmitter status with physical CS to determine the busy/idle state of the medium. The NAV and RID may be thought of as a counter, which counts down to 0 at a uniform rate. In non-S1G STAs, when the NAV counter is 0, the virtual CS indication is that the medium is idle; when the counter is nonzero, the indication is busy. In S1G STAs, when both NAV and RID counters are 0, the virtual CS indication is that the medium is idle; when either the NAV counter or the RID counter is nonzero the indication is that the medium is busy. The virtual CS indication of medium for HE STAs with two NAVs is described in 26.2.4 (Updating two NAVs). If a DMG STA supports multiple NAVs as defined in 10.40.10 (Updating multiple NAV) and all counters are 0, the virtual CS indication is that the medium is idle; when at least one of the counters is nonzero, the indication is busy. The medium shall be determined to be busy when the STA is transmitting.

10.3.2.3 IFS

10.3.2.3.3 SIFS

Insert the following before the 1st paragraph:

An HE STA that transmits an HE TB PPDU a SIFS after the end of a received PPDU follows the procedure in 26.5.2.3 (Non-AP STA behavior for UL MU operation).

10.3.2.3.7 EIFS

Change as follows:

A DCF shall use EIFS before transmission, when it determines that the medium is idle following reception of a frame for which the PHY-RXEND.indication primitive contained an error or a frame for which the FCS value was not correct. Similarly, a STA's EDCA mechanism under HCF shall use the EIFS-DIFS+AIFS[AC] interval. The duration of an EIFS is defined in 10.3.7 (DCF timing relations). The EIFS or EIFS-DIFS+AIFS[AC] interval shall begin following indication by the PHY that the medium is idle after detection of the erroneous frame, without regard to the virtual CS mechanism. The STA shall not begin a transmission until the expiration of the later of the NAV and EIFS or EIFS-DIFS+AIFS[AC]. The EIFS and EIFS-DIFS+AIFS[AC] are defined to provide enough time for another STA to acknowledge what was, to this STA, an incorrectly received frame before this STA commences transmission. Reception of an error-free frame or reception of an HE PPDU with the RXVECTOR parameter TXOP_DURATION that is not set to UNSPECIFIED during the EIFS or EIFS-DIFS+AIFS[AC] resynchronizes the STA to the actual busy/idle state of the medium, so the EIFS or EIFS-DIFS+AIFS[AC] is terminated and medium access (using DIFS or AIFS as appropriate and, if necessary, backoff) continues following reception of ~~that~~ the error-free frame or following an expected end of the received HE PPDU. At the expiration or termination of the EIFS or EIFS-DIFS+AIFS[AC], the STA reverts to the NAV and physical CS to control access to the medium.

EIFS shall not be invoked if the NAV is updated by the frame that would have caused an EIFS. EIFS shall not be invoked for an A-MPDU if one or more of its frames are received correctly. EIFS shall not be invoked if the RXVECTOR parameter TXOP_DURATION of a received HE PPDU is not set to UNSPECIFIED.

10.3.2.4 Setting and resetting the NAV

Change paragraphs 1-2 as follows:

This subclause describes the setting and resetting of the NAV for non-DMG STAs and DMG STAs that support a single NAV. DMG STAs that support multiple NAVs shall update their NAVs according to the procedures described in 10.40.10 (Updating multiple NAVs). HE STAs with two NAV timers shall update their NAV timers according to the procedures described in 26.2.4 (Updating two NAVs).

A STA that receives at least one valid frame in a PSDU can update its NAV with the information from any valid Duration field in the PSDU. When the received frame's RA is equal to the STA's own MAC address, the STA shall not update its NAV. Further, when the received frame is a DMG CTS frame and its TA is equal to the STA's own MAC address, the STA shall not update its NAV. For all other received frames the STA shall update its NAV when the received Duration is greater than the STA's current NAV value. Upon receipt of a PS-Poll frame, a STA(11ah), except for an S1G STA for which the RXVECTOR parameter RESPONSE_INDICATION of the received PS-Poll frame is NDP Response, shall update its NAV settings as appropriate under the data rate selection rules using a duration value equal to the time, in microseconds, required to transmit one Ack frame plus one SIFS, but only when the new NAV value is greater than the current NAV value. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. When the NAV is reset, a PHY-CCARESET.request primitive shall be issued. This NAV update operation is performed when the PHY-RXEND.indication primitive is received, except when the PHY-RXEND.indication primitive is received before the end of the PPDU, in which case the NAV update is performed at the expected end of the PPDU.

Insert the following after the 4th paragraph:

An HE AP that is not a TXOP holder shall update the NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION for an HE PPDU if all of the following conditions are met, and shall not update the NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION otherwise:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED
— The HE AP does not receive a frame with a Duration field in the PPDU
— The duration indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current NAV value of the HE AP

An HE AP that is a TXOP holder shall update the NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION for an HE PPDU if all of the following conditions are met, and shall not update the NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION otherwise:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED
— The HE AP does not receive a frame with a Duration field in the PPDU
— The duration indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current NAV value of the HE AP
— The RXVECTOR parameter BSS_COLOR is not equal to the BSS color of the HE AP

NOTE 1—A non-AP HE STA maintains two NAVs, but an HE AP might only maintain one NAV (see 26.2.4 (Updating two NAVs)).

NOTE 2—If a STA receives an HE PPDU with the duration information indicated by both frame with a Duration field and the RXVECTOR parameter TXOP_DURATION, then the duration information indicated by the RXVECTOR parameter TXOP_DURATION is ignored.

Change the 6th and 7th paragraph as follows:

A STA that used information from an RTS frame or MU-RTS Trigger frame as the most recent basis to update its NAV setting is permitted to reset its NAV if no PHY-RXSTART.indication primitive is received from the PHY during a NAVTimeout period starting when the MAC receives a PHY-RXEND.indication primitive corresponding to the detection of the RTS frame or MU-RTS Trigger frame.

In non-DMG BSS, NAVTimeout period is equal to ~~(2 x aSIFSTime) + (CTS_Time) + aRxPHYStartDelay + (2 x aSlotTime)~~ (2 × aSIFSTime) + (CTS_Time) + aRxPHYStartDelay + (2 × aSlotTime). In a non-S1G STA, if an RTS frame is used for the most recent NAV update, ~~the "~~CTS_Time~~"~~ shall be calculated using the length of the CTS frame and the data rate at which the RTS frame used for the most recent NAV update was received. If an MU-RTS Trigger frame was used for the most recent NAV update, CTS_Time shall be calculated using the length of the CTS frame and the 6 Mb/s data rate (see 26.2.6 (MU-RTS Trigger/CTS frame exchange procedure)). In an S1G STA, ~~the "~~CTS_Time~~"~~ shall be calculated using the time required to transmit an NDP CTS frame that is equal to NDPTxTime, which is specified in 10.3.2.5.2 (RID update).

10.3.2.6 RTS/CTS with fragmentation

Change the 2nd paragraph as follows:

Each frame contains information that defines the duration of the next transmission. The duration information from RTS frames shall be used to update the NAV to indicate busy until the end of Ack frame 0. The duration information from the CTS frame shall also be used to update the NAV to indicate busy until the end of Ack frame 0. Both Fragment 0 and Ack frame 0 shall contain duration information to update the NAV to indicate busy until the end of Ack frame 1. This shall be done by using the Duration/ID field in the Data and Ack frames. This shall continue until the last fragment, which shall have a duration of one Ack time plus one SIFS, and its Ack frame, which shall have its Duration/ID field set to 0. Each fragment and Ack frame acts as a virtual RTS frame and CTS frame; therefore no further RTS/CTS frames need to be generated after the RTS/CTS that began the frame exchange sequence~~ even though the PSDUs carrying subsequent fragments may be larger than dot11RTSThreshold~~.

10.3.3 Random backoff time

Insert the following note after the 2nd to last paragraph:

NOTE—For non-HE STAs that use DCF for channel access, dot11TXOPDurationRTSThreshold is not present and the use of the RTS/CTS mechanism is under the control of dot11RTSThreshold.

10.3.3.13 MU acknowledgment procedure

Insert a new subclause heading before the 1st paragraph as follows:

10.3.3.13.1 Acknowledgment procedure for DL MU PPDU in SU PPDU

Change the subclause as follows:

The acknowledgment procedure performed by a STA that receives MPDUs that were transmitted within a VHT MU PPDU or an HE MU PPDU is the same as the acknowledgment procedure for MPDUs that were not transmitted within a VHT MU PPDU or an HE MU PPDU sent by an AP, except if the STA is an HE STA that follows the rules defined in 26.3 (Fragmentation and defragmentation) and in 26.4 (HE acknowledgment procedure).

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

Responses to A-MPDUs within a VHT MU PPDU or an HE MU PPDU for DL transmission 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 10-15 (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 10.23.2.8 (Multiple frame transmission in an EDCA TXOP). BlockAckReq~~uest~~ 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 carried in an SU PPDU to an S-MPDU in the VHT MU PPDU or the HE MU PPDU. Responses to S-MPDUs for more than one STA contained in an HE MU PPDU are transmitted as specified in 10.3.3.13.2 (Acknowledgment procedure for DL MU PPDU in MU format). A Multi-STA BlockAck frame is sent in immediate response to a Multi-TID BlockAckReq frame.

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

Insert a new subclauses 10.3.2.13.2 and 10.3.2.13.3 as follows:

10.3.3.13.2 Acknowledgment procedure for DL MU PPDU in MU format

A non-AP STA shall not set the ack policy to HTP Ack.

A non-AP STA that is the recipient, within an HE MU PPDU, of a QoS Data frame or QoS Null frame with ack policy HTP Ack, of an MU-BAR Trigger frame or a GCR MU-BAR Trigger frame, or of a Management frame that solicits acknowledgment, shall send the immediate response according to the scheduling information that is carried either in the Trigger frame(s) or TRS Control subfield. If a Basic Trigger frame (see 9.3.1.22 (Trigger frame format)) or frame carrying a TRS Control subfield (see 9.2.4.6a.1 (TRS Control)) is not received, then the STA shall not respond.

An example of UL OFDMA acknowledgment to an HE MU PPDU is shown in Figure 10-15a (An example of an HE MU PPDU transmission with an immediate UL OFDMA acknowledgment).

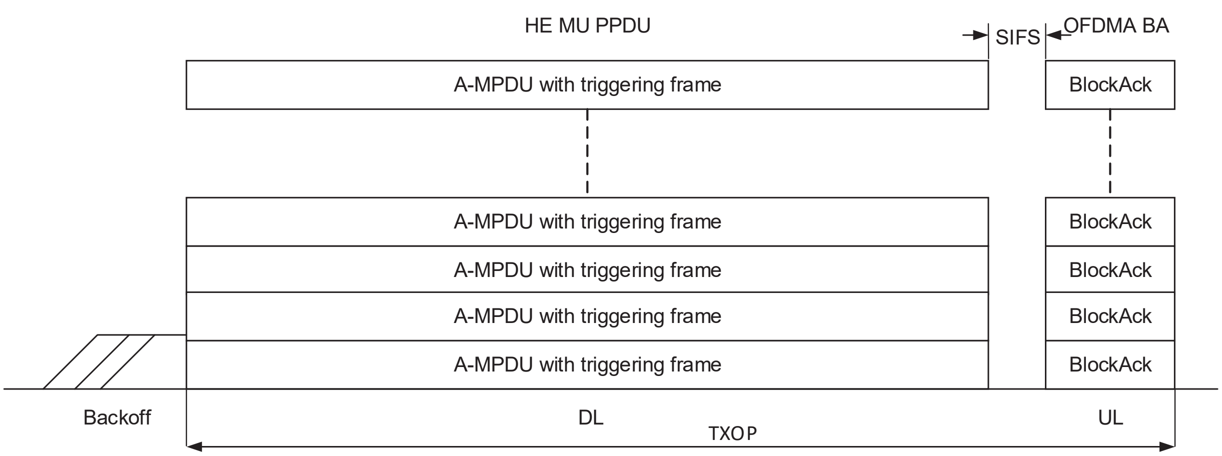

Figure 10-15a—An example of an HE MU PPDU transmission with an immediate UL OFDMA acknowledgment

An AP may use an MU-BAR Trigger frame or a GCR MU-BAR Trigger frame to solicit acknowledgment frames from multiple HE STAs to which the AP has sent QoS Data frames with Block Ack ack policy or from which the AP has not received immediate acknowledgment frames after sending QoS Data frames with HTP Ack ack policy in an HE MU PPDU.

10.3.3.13.3 Acknowledgment procedure for an UL MU transmission

An AP that receives frames from more than one STA that are part of an UL MU transmission (see 9.42.2) and that require an immediate acknowledgment (i.e., a QoS Data frame with ack policy Normal Ack or Implicit BAR or a Management frame other than an Action No Ack frame), shall send an immediate acknowledgment in either an SU PPDU (see 26.4.4.5 (Responding to an HE TB PPDU with an SU PPDU)) or an HE MU PPDU (see 26.4.4.6 (Responding to an HE TB PPDU with an HE MU PPDU)). The Multi-STA BlockAck frame may be transmitted in a non-HT PPDU, non-HT duplicate PPDU, HT PPDU, VHT PPDU, HE SU PPDU, HE ER SU PPDU or HE MU PPDU. After a successful reception of an UL frame requiring acknowledgment, transmission of the DL acknowledgment shall commence after a SIFS, without regard to the busy/idle state of the medium. When an AP transmits an immediate acknowledgment in an HE MU PPDU in response to an A-MPDU sent in an HE TB PPDU, the AP should send it within the 20 MHz channel(s) where the pre-HE modulated fields of the HE TB PPDU sent by the STA are located. The immediate acknowledgment is an Ack frame, Compressed BlockAck frame or Multi-STA BlockAck frame.

An example of multiple BlockAck frames sent in DL MU is shown in Figure 10-15b (An example of an UL MU transmission with an immediate DL MU transmission containing individually addressed BlockAck frames acknowledging the frames received from the respective STAs).

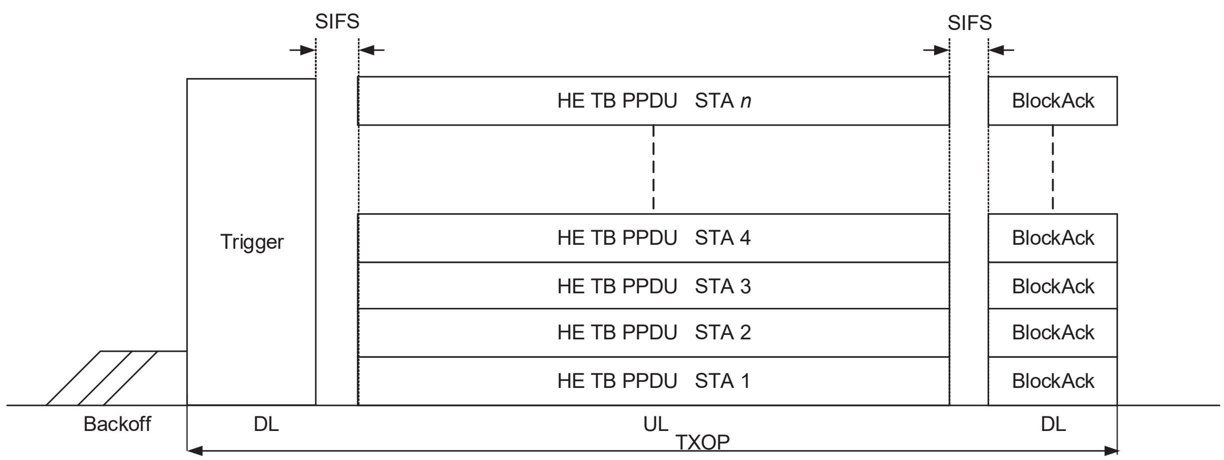

Figure 10-15b—An example of an UL MU transmission with an immediate DL MU transmission containing individually addressed BlockAck frames acknowledging the frames received from the respective STAs

An example of a Multi-STA BlockAck frame acknowledgment in a non-HT PPDU, HT PPDU, VHT PPDU, HE SU PPDU or HE ER SU PPDU is given in Figure 10-15c (An example of UL MU transmissions with an immediate Multi-STA BlockAck frame acknowledging the MPDUs).

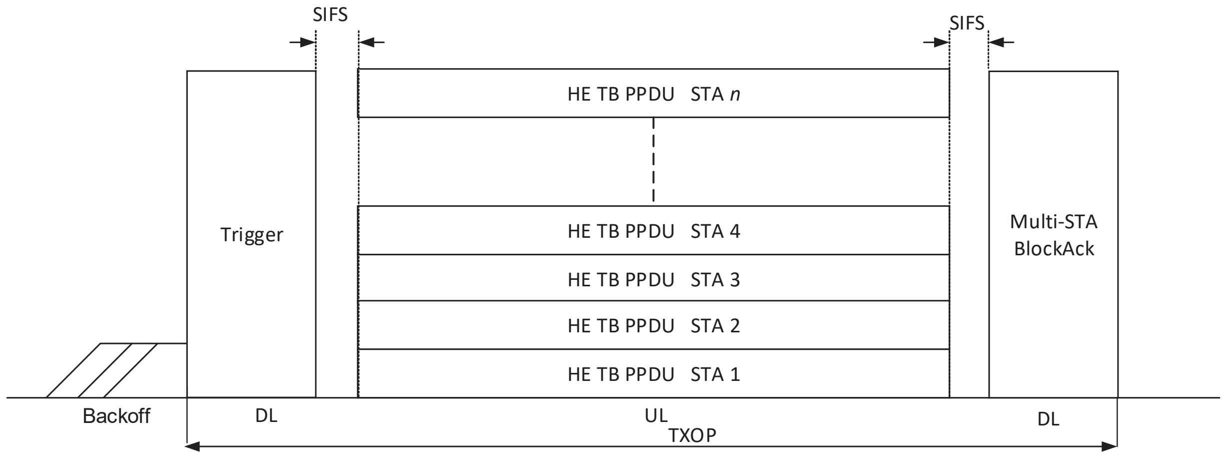

Figure 10-15c—An example of UL MU transmissions with an immediate Multi-STA BlockAck frame acknowledging the MPDUs

An example of a Multi-STA BlockAck frame acknowledgment in a non-HT Duplicate PPDU is given in Figure 10-15d (An example of UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame).

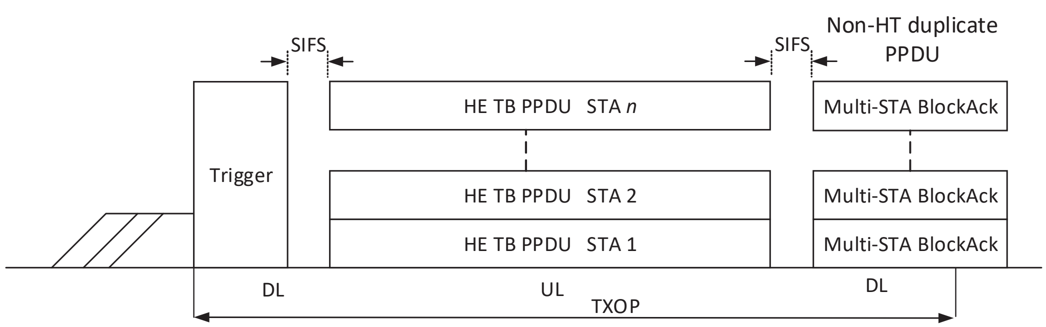

Figure 10-15d—An example of UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame

The Ack Policy Indication subfield of a QoS Data frame sent in an HE TB PPDU shall not be set to Block Ack.

A STA may send a BlockAckReq frame or Multi-TID BlockAckReq frame to solicit the acknowledgment frame(s) from an AP.

10.3.4 DCF access procedure

10.3.4.4 Recovery procedures and retransmit limits

Insert the following note after the 4th paragraph:

NOTE—For non-HE STAs that use DCF for channel access, dot11TXOPDurationRTSThreshold is not present and the use of the RTS/CTS mechanism is under the control of dot11RTSThreshold.

10.3.5 Individually addressed MPDU transfer procedure

Change as follows:

~~A~~ If dot11TXOPDurationRTSThreshold is 1023 or not present, a STA shall use an RTS/CTS preceding a frame exchange including an individually addressed Data or Management frame when the length of the PSDU is greater than the length threshold indicated by dot11RTSThreshold. If dot11TXOPDurationRTS-Threshold is present and is not 1023, a non-AP HE STA using EDCA shall use an RTS/CTS exchange as defined in 26.2.1 (TXOP duration-based RTS/CTS). A STA may also use an RTS/CTS exchange to protect the transmission of ~~for~~ individually addressed frames when it is necessary to distribute the NAV, or when it is necessary to establish protection (see 10.27 (Protection mechanisms)), or for other purposes.

NOTE 1—If dot11RTSThreshold is 0, an RTS/CTS exchange precedes all frame exchanges including an individually addressed Data or Management frame, except for a non-AP STA with dot11TXOPDurationRTSThreshold present and not equal to 1023, in which case use of an RTS/CTS exchange is controlled by dot11TXOPDurationRTSThreshold (see 26.2.1 (TXOP duration-based RTS/CTS)).

NOTE 2—A non-AP STA that transmits an HE TB PPDU outside the context of an RDG is exempt from requirements related to dot11RTSThreshold and dot11TXOPDurationRTSThreshold because the STA is not the TXOP holder.

~~When~~ If an RTS/CTS exchange is used, the PPDU containing the PSDU shall be transmitted starting one SIFS after the end of the CTS frame.

NOTE—No regard is given to the busy or idle status of the medium when transmitting this PSDU.

~~When~~ If an RTS/CTS exchange is not used, the PSDU shall be transmitted following the success of the basic access procedure. With or without the use of the RTS/CTS exchange procedure, the STA that is the destination of a Data frame shall follow the acknowledgment procedure.

10.3.7 DCF timing relations

Change the 9th paragraph as follows:

When dot11DynamicEIFSActivated is true, if the PPDU that causes the EIFS does not contain a single MPDU with a length equal to 14 or 32 octets, and the modulation of the PPDU that causes the EIFS is included in Table 10-8 (Determination of the EstimatedAckTxTime based on properties of the PPDU causing the EIFS), then EIFS is determined as shown in Equation (10-8).

$$\mathrm{EIFS} = \mathrm{aSIFSTime} + \mathrm{EstimatedAckTxTime} + \mathrm{DIFS} \tag{10-8}$$

where

EstimatedAckTxTime is based on an estimated duration of the PPDU that is the possible response to the PPDU that causes the EIFS, as specified in Table 10-8 (Determination of the EstimatedAckTxTime based on properties of the PPDU causing the EIFS).

NOTE—This also applies to an HE STA with dot11DynamicEIFSActivated set to true that receives an HE PPDU with the RXVECTOR parameter TXOP_DURATION set to UNSPECIFIED that causes the EIFS.

10.3.8 Signal extension

Change the 1st paragraph as follows:

Transmissions of frames with TXVECTOR parameter FORMAT of type NON_HT with NON_HT_MODULATION values of ERP-OFDM and NON_HT_DUP_OFDM and transmissions of frames with TXVECTOR parameter FORMAT with values of HT_MF ~~and~~, HT_GF, HE_SU, HE_MU, HE_ER_SU or HE_TB include a period of no transmission of duration aSignalExtension, except for RIFS transmissions. The purpose of this signal extension is to enable the NAV value of Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) STAs to be set correctly.

Change the title of 10.4 as follows:

10.4 MSDU, A-MSDU, and MMPDU fragmentation

Change the 3rd and 4th paragraph as follows:

A fragment is an MPDU, the Frame Body field of which carries only a portion of an MSDU, A-MSDU or MMPDU. When data are to be transmitted, the number of octets in the fragment (before processing by the security mechanism) shall be limited by dot11FragmentationThreshold and the number of octets in the MPDU that have yet to be assigned to a fragment at the instant the fragment is constructed for the first time. Once a fragment is transmitted for the first time, its frame body content and length shall be fixed until it is successfully delivered to the immediate receiving STA.

A STA shall be capable of receiving MPDUs, containing all or part of an MSDU, of arbitrary length that is less than or equal to the maximum MSDU size as specified in Table 9-25 (Maximum data unit sizes (in octets) and durations (in microseconds)) ~~defined in 9.2.3 (General frame format)~~, plus any security encapsulation overhead, plus MAC header and FCS.

Insert the following at the end of the subclause:

An HE STA may also use the dynamic fragmentation as defined in 26.3.2 (Dynamic fragmentation) if the conditions in 26.3.1 (General) are met. Dynamic fragmentation allows A-MSDUs to be fragmented.

Change the title of 10.5 as follows:

10.5 MSDU, A-MSDU, and MMPDU defragmentation

Insert the following at the end of the subclause:

An HE STA may also use the dynamic defragmentation as defined in 26.3.3 (Dynamic defragmentation) if the conditions in 26.3.1 (General) are met.Dynamic fragmentation allows A-MSDUs to be fragmented.

10.6 Multirate support

10.6.1 Overview

Change paragraphs 5-6 as follows:

For specific PHYs, the value of the Duration/ID field is determined using the PLME-TXTIME.request primitive and the PLME-TXTIME.confirm primitive. These specific PHYs are defined in:

— Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) for HR/DSSS

— Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) for OFDM
— Clause 18 (Extended Rate PHY (ERP) specification) for ERP
— Clause 19 (High Throughput (HT) PHY specification) for HT
— Clause 20 (Directional multi-gigabit (DMG) PHY specification) for DMG
— Clause 21 (Very High Throughput (VHT) PHY specification) for VHT
— Clause 22 (Television Very High Throughput (TVHT) PHY specification) for TVHT
— Clause 24 (China directional multi-gigabit (CDMG) PHY specification) for CDMG
— Clause 25 (China millimeter-wave multi-gigabit (CMMG) PHY specification) for CMMG
— Clause 27 (High Efficiency (HE) PHY specification) for HE

The two PLME-TXTIME primitives are defined in the respective PHY specifications:

— 16.3.4 (HR/DSSS TXTIME calculation) for HR TXTIME calculation
— 17.4.3 (OFDM TXTIME calculation) for OFDM TXTIME calculation
— 18.5.3.2 (ERP-OFDM TXTIME calculations)
— 19.4.3 (TXTIME calculation) for HT TXTIME calculation
— 20.11.3 (TXTIME calculation) for DMG PLME TXTIME calculation
— 21.4.3 (TXTIME and PSDU_LENGTH calculation) for VHT PLME TXTIME calculation
— 22.4.3 (TXTIME and PSDU_LENGTH calculation) for TVHT PLME TXTIME calculation
— 25.14.3 (TXTIME calculation) for CMMG PLME TXTIME calculation
— 27.4.3 (TXTIME and PSDU_LENGTH calculation) for HE PLME TXTIME calculation

10.6.5 Rate selection for Data and Management frames

10.6.5.1 Rate selection for non-STBC Beacon and non-STBC PSMP frames

Change the 2nd paragraph as follows:

If the BSSBasicRateSet parameter is not empty, a non-STBC PSMP frame or a non-STBC Beacon frame that is not an ER beacon or HE beacon shall be transmitted in a non-HT PPDU using one of the rates included in the BSSBasicRateSet parameter. An ER beacon is transmitted as defined 26.15.5 (Additional rules for ER beacons and group addressed frames) and an HE beacon is transmitted as defined in 26.15.6 (Additional rules for HE beacons and group addressed frames).

10.6.5.3 Rate selection for other group addressed Data and Management frames

Change the 1st paragraph as follows:

This subclause describes the rate selection rules for group addressed Data and Management frames, excluding the following:

— Non-STBC Beacon and non-STBC PSMP frames
— ER beacon and HE beacon
— STBC group addressed Data and Management frames
— Data frames located in an FMS stream (see 11.22.8 (FMS multicast rate processing))
— Group addressed frames transmitted to the GCR concealment address (see 11.22.16.3.5 (Concealment of GCR transmissions))
— Group addressed Data and Management frames transmitted in an HE ER SU PPDU (see 26.15.5 (Additional rules for ER beacons and group addressed frames))

- Group addressed Data and Management frames transmitted in an HE SU PPDU (see 26.15.6 (Additional rules for HE beacons and group addressed frames))
- Group addressed Data and Management frames transmitted in an HE MU PPDU (see 26.15.7 (Additional rules for group addressed frames in an HE MU PPDU))

10.6.6 Rate selection for Control frames

10.6.6.1 General rules for rate selection for Control frames

Insert the following as the last bullet to the 3rd paragraph:

The following rules determine whether a Control frame is carried in a non-HT, HT or VHT PPDU:

f) A control response frame may be carried in a VHT PPDU or HT PPDU if the eliciting frame was a Fine Timing Measurement frame carried in a VHT PPDU or HT PPDU respectively.

Insert the following at the end of the subclause:

An HE STA that transmits a Trigger frame, Multi-STA BlockAck frame or HE/VHT NDP Announcement frame addressed to more than one STA shall use a rate, HT-MCS, <VHT-MCS, NSS> tuple or <HE-MCS, NSS> tuple that is supported by all recipient STAs.

10.6.6.6 Channel Width selection for Control frames

Change the 2nd paragraph as follows:

If a VHT or HE STA transmits to another VHT or HE STA a Control frame that is not an RTS frame or a CF-End frame, if that Control frame is an HE NDP Announcement frame or elicits a control response frame, ~~or~~ a VHT Compressed Beamforming frame, or an HE Compressed Beamforming/CQI frame, and

- If the Control frame is transmitted in a non-HT duplicate PPDU (channel width 40 MHz or wider), the transmitting VHT or HE STA shall set the TA field to a bandwidth signaling TA.
- If the Control frame is transmitted in a non-HT PPDU (channel width 20 MHz), the transmitting VHT or HE STA may set the TA field to a bandwidth signaling TA.

10.6.10 Modulation classes

Change Table 10-9 (Modulation classes) as follows:

Table 10-9—Modulation classes

Description of modulation	Condition that selects this modulation class			
	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 18 (Extended Rate PHY (ERP) specification) PHYs or Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHY or Clause 24 (China directional multi-gigabit (CDMG) PHY specification) PHY, or Clause 25 (China millimeter-wave multigigabit (CMMG) PHY specification) PHY	Clause 19 (High-throughput (HT) PHY specification) PHY	Clause 21 (Very High Throughput (VHT) PHY specification) PHY	Clause 27 (High Efficiency (HE) PHY specification)
DSSS and HR/DSSS	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) or Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) transmission	FORMAT is NON_HT. NON_HT_MODULATION is ERP-DSSS or ERP-CCK.	N/A	FORMAT is NON_HT. NON_HT_MODULATION is ERP-DSSS or ERP-CCK.
ERP-OFDM	18.4 (ERP operating specifications (general)) transmission	FORMAT is NON_HT. NON_HT_MODULATION is ERP-OFDM.	N/A	FORMAT is NON_HT. NON_HT_MODULATION is ERP-OFDM.
OFDM	Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) transmission	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.
HT	N/A	FORMAT is HT_MF or HT_GF.	FORMAT is HT_MF or HT_GF.	FORMAT is HT_MF or HT_GF.

Table 10-9—Modulation classes *(continued)*

Description of modulation	Condition that selects this modulation class			
	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 18 (Extended Rate PHY (ERP) specification) PHYs or Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHY or Clause 24 (China directional multi-gigabit (CDMG) PHY specification) PHY, or Clause 25 (China millimeter-wave multigigabit (CMMG) PHY specification) PHY	Clause 19 (High-throughput (HT) PHY specification) PHY	Clause 21 (Very High Throughput (VHT) PHY specification) PHY	Clause 27 (High Efficiency (HE) PHY specification)
DMG Control	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and MCS is 0	NA	NA	N/A
DMG SC	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and $1 \leq \text{MCS} \leq 12.6$	NA	NA	N/A
DMG Low-power SC	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and $25 \leq \text{MCS} \leq 31$	NA	NA	N/A
VHT	N/A	N/A	FORMAT is VHT.	FORMAT is VHT
CDMG Control	Clause 24 (China directional multi-gigabit (CDMG) PHY specification) transmission and MCS is 0	N/A	N/A	N/A
CDMG SC	Clause 24 (China directional multi-gigabit (CDMG) PHY specification) transmission and $1 \leq \text{MCS} \leq 16$	N/A	N/A	N/A

Table 10-9—Modulation classes *(continued)*

Description of modulation	Condition that selects this modulation class			
	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 18 (Extended Rate PHY (ERP) specification) PHYs or Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHY or Clause 24 (China directional multi-gigabit (CDMG) PHY specification) PHY, or Clause 25 (China millimeter-wave multigigabit (CMMG) PHY specification) PHY	**Clause 19 (High-throughput (HT) PHY specification) PHY**	**Clause 21 (Very High Throughput (VHT) PHY specification) PHY**	**Clause 27 (High Efficiency (HE) PHY specification)**
CDMG Low-power SC	Clause 24 (China directional multi-gigabit (CDMG) PHY specification) transmission and $17 \leq MCS \leq 23$	N/A	N/A	N/A
CMMG Control	Clause 25 (China millimeter-wave multi-gigabit (CMMG) PHY specification) transmission and MCS is 0	N/A	N/A	N/A
CMMG SC	Clause 25 (China millimeter-wave multi-gigabit (CMMG) PHY specification) transmission and $1 \leq MCS \leq 8$	N/A	N/A	N/A
CMMG OFDM	Clause 25 (China millimeter-wave multi-gigabit (CMMG) PHY specification) transmission and $9 \leq MCS \leq 16$	N/A	N/A	N/A
HE	N/A	N/A	N/A	FORMAT is HE_SU, HE_ER_SU, HE_MU or HE_TB

10.6.11 Non-HT basic rate calculation

Change as follows:

This subclause defines how to convert an HT-MCS ~~or,~~ a VHT-MCS or an HE-MCS to a non-HT basic rate for the purpose of determining the rate of the response frame. It consists of two steps as follows:

a) Use the modulation and coding rate determined from the HT-MCS (defined in 19.5 (Parameters for HT-MCSs)) or VHT-MCS (defined in 21.5 (Parameters for VHT-MCSs)) or HE-MCS (defined in 27.5 (Parameters for HE-MCSs)) to locate a non-HT reference rate by lookup into Table 10-10 (Non-HT reference rate).[1] In the case of an MCS with UEQM, the modulation of stream 1 is used.

b) The non-HT basic rate is the highest rate in the BSSBasicRateSet that is less than or equal to this non-HT reference rate.

NOTE 1—The selection of a non-HT basic rate for the frame sent in response to an HE PPDU is not influenced by DCM encoding in the HE PPDU.

NOTE 2—In a TVWS band, the non-HT reference rate is scaled as described in 22.2.4.

Change Table 10-10 (Non-HT reference rate) as follows:

Table 10-10—Non-HT reference rate

Modulation	Coding rate (R)	Non-HT reference rate (Mb/s)
BPSK	1/2	6
BPSK	3/4	9
QPSK	1/2	12
QPSK	3/4	18
16-QAM	1/2	24
16-QAM	3/4	36
64-QAM	1/2	48
64-QAM	2/3	48
64-QAM	3/4	54
64-QAM	5/6	54
256-QAM	3/4	54
256-QAM	5/6	54
1024-QAM	3/4	54
1024-QAM	5/6	54

NOTE—In a TVWS band, the non-HT reference rate is scaled as described in 22.2.4 (Support for NON_HT and HT formats).

[1] For example, if an HT PPDU transmission uses 64-QAM and coding rate of 3/4, the related non-HT reference rate is 54 Mb/s.

10.6.13 Rate selection constraints for VHT STAs

10.6.13.3 Additional rate selection constraints for VHT PPDUs

Replace the 1st paragraph with the following:

A STA should not transmit a 20 MHz or 40 MHz VHT PPDU with a <VHT-MCS, NSS> tuple that has VHT-MCS 0, 1, 2 or 3 and NSS less than or equal to 4 to a receiver STA that has marked as unsupported the HT-MCS with value VHT-MCS + 8 × (NSS – 1) in the Rx MCS Bitmask subfield in the Supported MCS Set field in the HT Capabilities element it transmits. The transmission of a 20 MHz or 40 MHz VHT PPDU with VHT-MCS greater than 3 is not subject to this constraint.

A STA should not transmit an 80 MHz, 160 MHz or 80+80 MHz VHT PPDU with a <VHT-MCS, NSS> tuple that has VHT-MCS 0 or 1 and NSS less than or equal to 4 to a receiver STA that has marked as unsupported the HT-MCS values of both 2 × VHT-MCS + 8 × (NSS – 1) and 2 × VHT-MCS + 1 + 8 × (NSS – 1) in the Rx MCS Bitmask subfield in the Supported MCS Set field in the HT Capabilities element it transmits. The transmission of an 80 MHz, 160 MHz or 80+80 MHz VHT PPDU with VHT-MCS greater than 1 is not subject to this constraint.

10.8 HT Control field operation

Change as follows:

If the value of dot11HTControlFieldSupported is true, a STA shall set the +HTC Support subfield of the HT Extended Capabilities field of the HT Capabilities element to 1 in HT Capabilities elements that it transmits. If the value of dot11VHTControlFieldOptionImplemented is true, a STA shall set the +HTC-VHT Support subfield of the VHT Capabilities Information field of the VHT Capabilities element to 1 in VHT Capabilities elements that it transmits. If dot11HEControlFieldOptionImplemented is true, a STA shall set the +HTC-HE Support subfield in the HE MAC Capabilities Information field to 1 of the 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 at least one of dot11TRSOptionImplemented, dot11OMIOptionImplemented, dot11HEBSRControlImplemented, dot11HEBQRControlImplemented, dot11RDResponderOptionImplemented or dot11SRResponderOptionImplemented equal to true or has dot11HEMCSFeedbackOptionImplemented greater than zero shall set dot11HEControlFieldOptionImplemented to true. An HE AP shall set 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 9.2.4.6 (HT Control field)).

A VHT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-VHT in the VHT Capabilities Information field of its VHT Capabilities element or in the S1G Capabilities Information field of S1G Capabilities elements that it transmits.

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 10.3.2.4 (Setting and resetting the NAV).

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 MAC Capabilities Information field of the HE Capabilities element. The

HE variant HT Control field carried in the frame may contain one or more Control subfields under the conditions listed in Table 10-11a (Conditions for including Control subfield variants).

Table 10-11a—Conditions for including Control subfield variants

Control subfield variant	Condition
TRS	The transmitting STA expects an HE TB PPDU that follows the TRS information as described in 26.5.2.2 (Rules for soliciting UL MU frames) and the recipient STA has set the TRS Support subfield in the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to 1.
OM	The transmitting STA changes its operating mode, as described in 26.9 (Operating mode indication) and the recipient STA has set the OM Control Support subfield in the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to 1.
HLA	The transmitting STA follows the HE link adaptation procedure, as described in 26.13 (Link adaptation using the HLA Control subfield) and the recipient STA has set the HE Link Adaptation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to a nonzero value.
BSR	The transmitting STA follows the corresponding buffer status report procedure, as described in 26.5.3 (MU cascading sequence) and the recipient STA has set the BSR Support subfield in the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to 1.
UPH	The transmitting STA follows the UL MU operation procedure, as described in 26.5.2.3 (Non-AP STA behavior for UL MU operation).
BQR	The transmitting STA follows the bandwidth query report procedure, as described in 26.5.2 (UL MU operation) and the recipient STA has set the BQR Support subfield in the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to 1.
CAS	The transmitting STA follows either: — The reverse direction protocol procedure described in 10.28 (Reverse Direction Protocol) and the recipient STA has set the RD Responder of the HT Extended Capabilities field in the HT Capabilities elements it transmits to 1, or — The PSR procedure described in 26.10.3 (PSR-based spatial reuse operation) and the recipient STA has set the SR Responder subfield of the HE MAC Capabilities Information field of the HE Capabilities elements it transmits to 1.
ONES	The transmitting STA includes an A-Control subfield that contains a Control subfield with Control ID subfield equal to 15 and Control Information subfield equal to all 1s and whose content can be ignored by the HE recipient STA.

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.

An HE STA that transmits a frame containing an A-Control subfield shall include at least one Control subfield in the A-Control subfield and the Control subfields included shall be supported by the receiving STAs unless the Control ID subfield is 15.

An HE STA that receives a Control subfield in an A-Control subfield with a Control ID subfield value that is not recognized or not supported by the HE STA shall ignore the Control subfield and the remainder of the A-Control subfield. If more than one Control subfield is present in an A-Control subfield, the Control subfields shall not have the same Control ID value.

An HE STA that receives a Control subfield with Control ID subfield equal to 15 shall ignore the remainder of the A-Control subfield.

If the HT variant HT Control field is present in an MPDU, the DEI subfield provides information on the drop eligibility of the contents of the received MPDU. When there are insufficient resources in a STA, the STA arbitrarily discards frames in order to recover from the lack of resources. With the information from the DEI subfield, a STA may selectively drop frames with the DEI subfield set to 1 in preference to frames with the DEI subfield set to 0, if resources are insufficient. Note that this might not help in the recovery in all conditions, and the STA might still have to fall back to the arbitrary discard strategy. The mechanisms for determining whether resources are insufficient or when to discard MSDUs or A-MSDUs are beyond the scope of this standard.

If the value of dot11S1GControlFieldOptionImplemented is true, an S1G STA shall set the +HTC-VHT Capable subfield of the S1G Capabilities Information field of the S1G Capabilities element that it transmits to 1.

An S1G shall not use an HT Control field other than a VHT variant HT Control field. An S1G STA shall not use a VHT variant HT Control field for any purpose other than link adaptation (see 10.32.3 (Link adaptation using the VHT variant HT Control field)).

10.9 Control Wrapper operation

Change as follows:

A STA supporting the HT Control field that receives a Control Wrapper frame shall process it as though it received a frame of the subtype of the wrapped frame. An HE STA shall not send a Control Wrapper frame to another HE STA.

10.11 A-MSDU operation

Change the 3rd paragraph as follows:

If the A-MSDU Fragmentation Support subfield in the MAC Capabilities Information field in the HE Capabilities element transmitted by the recipient STA is 0, then an ~~An~~ A-MSDU shall be carried, without fragmentation, within a single QoS Data frame. If the A-MSDU Fragmentation Support subfield in the HE Capabilities element transmitted by the recipient STA is 1, then an A-MSDU may be fragmented and each fragment sent to the recipient in a QoS Data frame.

Change the 5th paragraph as follows:

The channel access rules for a QoS Data frame carrying an A-MSDU (or a fragment thereof) are the same as a Data frame carrying an MSDU (or fragment thereof) of the same TID.

Change the 16th paragraph as follows:

A STA shall support the reception of an A-MSDU, where the A-MSDU is carried in a QoS Data frame with Normal Ack ack policy in the following cases:

— By an HT STA ~~when~~ if the A-MSDU is not aggregated within an A-MPDU

— By a VHT or HE STA ~~when~~ if the A-MSDU is sent as an S-MPDU

— For a CMMG STA if the A-MSDU is not aggregated within an A-MPDU

Insert the following after the 17th paragraph:

An HE STA shall not transmit an A-MSDU that is carried in a QoS Data frame for which no block ack agreement exists and that is part of an ack-enabled single-TID A-MPDU unless the recipient has set the A-MSDU Not Under BA In Ack-Enabled A-MPDU Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1.

Change the 20th paragraph as follows:

The length of an A-MSDU transmitted in a VHT PPDU or HE PPDU is limited by the maximum MPDU size supported by the recipient STA (see 10.12.5 (Transport of A-MPDU by the PHY data service)).

NOTE 1—An A-MSDU that meets the A-MSDU length limit for transmission in a VHT PPDU or HE PPDU might exceed the A-MSDU length limit for an HT PPDU, in which case it cannot be retransmitted in an HT PPDU.

NOTE 2—Support for A-MSDU aggregation does not affect the maximum size of MSDU transported by the MA-UNITDATA primitives.

10.12 A-MPDU operation

10.12.1 A-MPDU contents

Change the 3rd paragraph as follows:

~~When~~ If an A-MPDU contains multiple QoS Control fields, then bit~~s~~ 4 of all the QoS Control fields shall have the same value and bits 8–15 of the~~se~~ QoS Control fields that have the same value in bits 0–3 shall ~~be identical~~ have the same value.

10.12.2 A-MPDU length limit rules

Change as follows:

A STA indicates in the Maximum A-MPDU Length Exponent field in its HT Capabilities element the maximum A-MPDU length that it can receive in an HT PPDU. A STA indicates in the Maximum A-MPDU Length Exponent field in its VHT Capabilities element the maximum length of the A-MPDU pre-EOF padding that it can receive in a VHT PPDU. A STA indicates in the Maximum A-MPDU Length Exponent field in its S1G Capabilities element the maximum length of the A-MPDU pre-EOF padding that it can receive in an S1G PPDU. A STA indicates in the Maximum A-MPDU Length Exponent field in its DMG Capabilities element the maximum A-MPDU length that it can receive. A STA indicates the maximum length of the A-MPDU pre-EOF padding that it can receive in an HE PPDU in the Maximum A-MPDU Length Exponent field in its HT Capabilities, VHT Capabilities, and HE 6 GHz Band Capabilities elements (if present) and the Maximum A-MPDU Length Exponent Extension field in its HE Capabilities element.

A VHT STA that sets the Maximum A-MPDU Length Exponent field in its VHT Capabilities element to a value in the range 0 to 3 shall set the Maximum A-MPDU Length Exponent in its HT Capabilities to the same value. A VHT STA that sets the Maximum A-MPDU Length Exponent field in the VHT Capabilities element to a value larger than 3 shall set the Maximum A-MPDU Length Exponent in its HT Capabilities element to 3.

Using the Maximum A-MPDU Length Exponent fields in the HT Capabilities, ~~and~~ VHT Capabilities, HE Capabilities and HE 6 GHz Band Capabilities elements (if present), the STA establishes at association the maximum length of an A-MPDU pre-EOF padding that can be sent to it. An HT STA shall be capable of receiving A-MPDUs of length up to the value indicated by the Maximum A-MPDU Length Exponent field in its HT Capabilities element. A VHT STA shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent field in its VHT Capabilities element. An S1G STA that sets the A-MPDU Supported subfield in the S1G Capabilities element to 1 shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent field in its S1G Capabilities element.

An HE STA shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent field in its HT Capabilities and VHT Capabilities elements, and the Maximum A-MPDU Length Exponent Extension field in its HE Capabilities element in the 2.4 GHz or 5 GHz bands. An HE STA shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent Extension field in the HE Capabilities element and the Maximum A-MPDU Length Exponent field in HE 6 GHz Band Capabilities element in the 6 GHz band.

A STA shall not transmit an A-MPDU in an HT PPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the HT Capabilities element received from the intended receiver. MPDUs in an A-MPDU carried in an HT PPDU shall be limited to a maximum length of 4095 octets. A STA shall not transmit an A-MPDU in a VHT PPDU where the A-MPDU pre-EOF padding length is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the VHT Capabilities element received from the intended receiver. An S1G STA shall not transmit an A-MPDU in an S1G PPDU where the AMPDU pre-EOF padding length field is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the S1G Capabilities element received from the intended receiver. A STA shall not transmit an A-MPDU in a DMG PPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the DMG Capabilities element received from the intended receiver.

A STA shall not transmit an A-MPDU in an HE PPDU where the A-MPDU pre-EOF padding length is greater than the value indicated by the Maximum A-MPDU Length Exponent field in the HT Capabilities and VHT Capabilities elements, and the Maximum A-MPDU Length Exponent Extension field in its HE Capabilities elements received from the intended receiver in the 2.4 GHz or 5 GHz bands. A STA shall not transmit an A-MPDU in an HE PPDU where the A-MPDU pre-EOF padding length is greater than the value indicated by the Maximum A-MPDU Length Exponent Extension field in the HE Capabilities element and the Maximum A-MPDU Length Exponent field in the HE 6 GHz Band Capabilities element received from the intended receiver in the 6 GHz band.

An S1G STA shall not transmit an A-MPDU, except for an S-MPDU, to an S1G STA from which it received a frame containing an S1G Capability element with the A-MPDU Supported subfield equal to 0.

Change the title and content of 10.13.3 as follows:

10.12.3 Minimum MPDU ~~S~~start ~~S~~spacing ~~field~~ rules

If the intended receiver is a non-HE STA, a ~~A~~ STA shall not start the transmission of more than one MPDU within the time limit described in the Minimum MPDU Start Spacing field declared by the intended receiver. If the intended receiver is an HE STA, an HE STA shall not start the transmission of more than one QoS Data frame, QoS Null frame or Management frame within the time limit described in the Minimum MPDU Start

Spacing field declared by the intended receiver. To satisfy this requirement, the number of octets between the start of two consecutive MPDUs in an A-MPDU, N, measured at the PHY SAP, shall ~~be equal to or greater than~~ meet the condition defined by Equation (10-9).

~~$t_{MMSS} \times r / 8$~~

$$N \geq \begin{cases} t_{MMSS} \times r/8, \text{ if the A-MPDU is not carried in an HE TB PPDU} \\ t_{MMSS} \times 2^{MMSF} \times r/8, \text{ if the A-MPDU is carried in an HE TB PPDU} \end{cases} \quad (10\text{-}9)$$

where

t_{MMSS} is the time (in microseconds) defined in the “Encoding” column of Table 9-185 (Subfields of the A-MPDU Parameters field) for an HT STA, of Table 9-301 (Subfields of the S1G Capabilities Information field) for an S1G STA for the value of the Minimum MPDU Start Spacing field and of Table 9-251 (Subfields of the A-MPDU Parameters subfield) for a DMG STA for the value of the Minimum MPDU Start Spacing field

$MMSF$ is the value of the MPDU MU Spacing Factor subfield of the User Info field addressed to the HE STA in the Trigger frame soliciting the HE TB PPDU (see 9.3.1.22 (Trigger frame format))

r is the value of the PHY Data Rate (in megabits per second) defined in 19.5 (Parameters for HT-MCSs) for HT PPDUs, in 21.5 (Parameters for VHT-MCSs) for VHT PPDUs, in 23.5 (Parameters for S1G-MCSs) for S1G PPDUs, and in Clause 20 (Directional multi-gigabit (DMG) PHY specification) for a DMG STA

If necessary, in order to satisfy this requirement, a STA shall add padding between MPDUs in an A-MPDU. Any such padding shall be in the form of one or more MPDU delimiters with the MPDU Length field set to 0.

QoS Null frames transmitted by DMG STAs are not subject to this spacing, i.e., no MPDU delimiters with zero length need to be inserted after the MPDU immediately preceding the QoS Null frame in an A-MPDU.

10.12.4 A-MPDU aggregation of group addressed Data frames

Change the second note following the first paragraph as follows:

A STA that is neither an AP nor a mesh STA shall not transmit an A-MPDU containing an MPDU with an RA that is a group address.

NOTE 1—An HT AP and an HT mesh STA can transmit an A-MPDU containing MPDUs with an RA that is a group address.

NOTE 2—As a VHT STA and an HE STA is an HT STA, NOTE 1 also applies to VHT APs, ~~and~~ VHT mesh STAs, HE APs, and HE mesh STAs.

Change the 4th paragraph as follows:

When a STA transmits a PPDU containing at least one A MPDU that contains MPDUs with an RA that is a group address, the following shall apply:

- If the PPDU is an HT PPDU ~~transmitted by an AP~~, the maximum A-MPDU length exponent value is the minimum value in the Maximum A-MPDU Length Exponent subfield of the A-MPDU Parameters field of the HT Capabilities elements across ~~of~~ all HT STAs associated with the transmitting AP or across all peer HT mesh STAs.

— ~~If the PPDU is an HT PPDU transmitted by a mesh STA, the maximum A-MPDU length exponent value is the minimum value in the Maximum A-MPDU Length Exponent subfield of the A-MPDU Parameters field of the HT Capabilities element of all peer HT mesh STAs.~~

— If the PPDU is a VHT PPDU, the ~~value of~~ maximum A-MPDU length exponent value ~~that applies~~ is the minimum value in the Maximum A-MPDU Length Exponent subfield~~s~~ of the ~~A-MPDU Parameters fields of the~~ VHT Capabilities elements across all VHT STAs associated with the transmitting AP or across all peer VHT mesh STAs.

— If the PPDU is an HE PPDU sent in the 2.4 GHz or 5 GHz band, the maximum A-MPDU length exponent value is the minimum value in the Maximum A-MPDU Length Exponent subfield of the VHT Capabilities elements across all HE STAs associated with the transmitting AP or across all peer HE mesh STAs.

— If the PPDU is an HE PPDU sent in the 6 GHz band, the maximum A-MPDU length exponent value is the minimum value in the Maximum A-MPDU Length Exponent subfield of the HE 6 GHz Band Capabilities elements across all HE STAs associated with the transmitting AP or across all peer HE mesh STAs.

— If the PPDU is a VHT PPDU, the ~~value of~~ minimum MPDU start spacing value ~~that applies~~ is the maximum value in the Minimum MPDU Start Spacing subfield~~s~~ of the A-MPDU Parameters fields of the HT Capabilities elements across all VHT STAs associated with the transmitting AP or across all peer VHT mesh STAs ~~of the transmitting mesh STA~~.

— If the PPDU is an HT PPDU ~~transmitted by an AP~~, the minimum MPDU start spacing value ~~that applies~~ is the maximum value in the Minimum MPDU Start Spacing subfield of the A MPDU Parameters field of the HT Capabilities element across ~~of~~ all HT STAs associated with the transmitting AP or across all peer HT mesh STAs.

— ~~If the PPDU is an HT PPDU transmitted by a mesh STA, the minimum MPDU start spacing value that applies is the maximum value in the Minimum MPDU Start Spacing subfield of the A MPDU Parameters field of the HT Capabilities element of all peer HT mesh STAs.~~

— If the PPDU is an HE PPDU sent in the 2.4 GHz or 5 GHz band, the minimum MPDU start spacing value is the maximum value in the Minimum MPDU Start Spacing subfield of the A-MPDU Parameters field of the HT Capabilities element across all HE STAs associated with the transmitting AP or across all peer HE mesh STAs.

— If the PPDU is an HE PPDU sent in the 6 GHz band, the minimum MPDU start spacing value is the maximum value in the Minimum MPDU Start Spacing subfield of the HE 6 GHz Band Capabilities elements across all HE STAs associated with the transmitting AP or across all peer HE mesh STAs.

— If the PPDU is a DMG PPDU, the maximum A MPDU length exponent value that applies is the minimum value in the Maximum A MPDU Length Exponent subfield of the A MPDU Parameters field of the DMG Capabilities element of all DMG STAs associated with the AP or PCP.

— If the PPDU is a DMG PPDU, the minimum MPDU start spacing value that applies is the maximum value in the Minimum MPDU Start Spacing subfield of the A MPDU Parameters field of the DMG Capabilities element of all DMG STAs associated with the AP or PCP.

— If the PPDU is an S1G PPDU, the ~~value of~~ maximum A-MPDU length exponent value that applies is the minimum value in the Maximum A-MPDU Length Exponent subfields of the S1G Capabilities Information field of the S1G Capabilities elements across all S1G STAs associated with the transmitting AP.

— If the PPDU is an S1G PPDU, the ~~value of~~ minimum MPDU start spacing value that applies is the maximum value in the Minimum MPDU Start Spacing subfields of the S1G Capabilities Information field of the S1G Capabilities elements across all S1G STAs associated with the transmitting AP.

Change the title of 10.13.6 as follows:

10.12.6 A-MPDU padding for VHT, HE or S1G PPDU

Change the second to last paragraph as follows:

An A-MPDU subframe with EOF set to 0 shall not be added after any A-MPDU subframe with EOF set to 1, except if the A-MPDU subframe is in an ack-enabled single-TID A-MPDU or ack-enabled multi-TID A-MPDU (see 9.7.3 (A-MPDU contents)).

10.13 PPDU duration constraint

Insert the following at the end of 10.14:

An HE STA shall not transmit an HE PPDU that has a duration (as determined by the PHY-TXTIME.confirm primitive defined in 6.5.6 (PLME-TXTIME.confirm) that is greater than *aPPDUMaxTime* defined in Table 27-55 (HE PHY characteristics).

10.15 LDPC operation

Insert the following at the end of the subclause:

An HE STA shall not transmit a frame in an HE PPDU with the TXVECTOR parameter FEC_CODING set to LDPC_CODING unless frame is addressed to an HE STA for which the LDPC Coding In Payload subfield of the HE Capabilities element received from that STA contained a value of 1 and dot11HELDPCCodingInPayloadImplemented is true.

10.23 HCF

10.23.1 General

Change the 3rd paragraph as follows:

HCCA is not used by ~~either~~ DMG, ~~or~~ S1G and HE STAs.

10.23.2 HCF contention based channel access (EDCA)

10.23.2.2 EDCA backoff procedure

Change the 2nd paragraph as follows:

For the purposes of this subclause, transmission failure of an MPDU is defined as follows:

— After transmitting an MPDU (even if it is carried in an A-MPDU or as part of a VHT or S1G MU PPDU or as part of an HE MU PPDU that is sent using TXVECTOR parameter NUM_USERS > 1) that requires an immediate response:

- The STA shall wait for a timeout interval of duration aSIFSTime + aSlotTime + aRxPHYStartDelay, starting when the MAC receives a PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the timeout interval, the transmission of the MPDU has failed.
- If a PHY-RXSTART.indication primitive does occur during the timeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to recognize a valid response MPDU (see Annex G) that either does not have a TA field or is sent by the recipient of the

MPDU requiring a response. If anything else, including any other valid frame, is recognized, the transmission of the MPDU has failed.

— The nonfinal (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (10.23.2.12.2 (Unsolicited retry procedure)) is defined to be a failure.

— In all other cases, the transmission of the MPDU has not failed.

Change the 4th and 5th paragraph as follows:

The backoff procedure shall be invoked by an EDCAF ~~when~~ if any of the following events occur~~s~~:

a) An MA-UNITDATA.request primitive is received that causes a frame with that AC to be queued for transmission such that one of the transmit queues associated with that AC has now become nonempty and any other transmit queues associated with that AC are empty; the medium is busy on the primary channel as indicated by any of the following:
   - physical CS;
   - virtual CS;
   - a nonzero TXNAV timer value;
   - a mesh STA that has dot11MCCAActivated true and a nonzero RAV timer value, and the backoff counter has a value of 0 for that AC.

b) The transmission of the MPDU in the final PPDU transmitted by the TXOP holder during the TXOP for that AC has completed and the TXNAV timer has expired, the PPDU does not solicit an HE TB PPDU, and the AC was a primary AC. (See 10.23.2.7).

c) The transmission of an MPDU in the initial PPDU of a TXOP fails, as defined in this subclause, the PPDU does not solicit HE TB PPDU, and the AC was a primary AC.

d) The transmission attempt collides internally with another EDCAF of an AC that has higher priority, that is, two or more EDCAFs in the same STA are granted a TXOP at the same time.

e) The transmission of at least one MPDU in the final PPDU transmitted by the TXOP holder during the TXOP for that AC has completed, the PPDU contains an MPDU that solicits an HE TB PPDU and the TXNAV timer has expired.

f) The transmission of all MPDUs in the initial PPDU of a TXOP fails, as defined in this subclause, and the PPDU contains an MPDU that solicits an HE TB PPDU.

g) If explicitly indicated, such as in 26.17.2.3.3 (Non-AP STA scanning behavior)

In addition, the backoff procedure may be invoked by an EDCAF ~~when~~ if:

h) The transmission by the TXOP holder of an MPDU in a non-initial PPDU of a TXOP fails, as defined in this subclause, and an MPDU in the non-initial PPDU does not solicit an HE TB PPDU.

i) The transmission by the TXOP holder of all MPDUs in a non-initial PPDU of a TXOP fails, as defined in this subclause, and the PPDU contains an MPDU that solicits an HE TB PPDU.

Change the last two paragraphs as follows:

If the backoff procedure is invoked for reason a) above, the value of CW[AC] shall be left unchanged. If the backoff procedure is invoked for reason b) and f) above, the value of CW[AC] shall be reset to CWmin[AC].

If the backoff procedure is invoked for reason c), d), e), g), h) or ~~f)~~ i) above, the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

— If the QSRC[AC] is less than dot11ShortRetryLimit,
   - QSRC[AC] shall be incremented by 1
   - CW[AC] shall be set to the lesser of CWmax[AC] and $2^{QSRC[AC]} \times (CWmin[AC] + 1) - 1$

— Else

  - QSRC[AC] shall be set to 0
  - CW[AC] shall be set to CWmin[AC]
- When dot11RobustAVStreamingImplemented is true and either the QSDRC[AC] or the QLDRC[AC] has reached dot11ShortDEIRetryLimit or dot11LongDEIRetryLimit, respectively, CW[AC] shall be reset to CWmin[AC].

NOTE—An HE STA updates its local MIB variables related to CWmin and CWmax as defined in 26.2.7 (EDCA operation using MU EDCA parameters).

Insert the following at the end of the subclause:

After transmission of an MPDU in an HE TB PPDU, an HE STA resumes the EDCA backoff procedure without modifying CW or the backoff counter for the associated EDCAF regardless of whether the STA has received the corresponding acknowledgment frame in response to the MPDU sent in the HE TB PPDU.

10.23.2.4 Obtaining an EDCA TXOP

Change the last paragraph as follows:

A STA shall save the TXOP holder address for the BSS in which it is associated~~, which~~. The TXOP holder address is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except ~~when~~ if this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame, a VHT STA or HE STA shall save the nonbandwidth signaling TA value obtained from the Address 2 field. If a non-VHT non-HE STA receives an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA or HE STA receives an RTS frame with the RA address matching the MAC address of the STA and the nonbandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. When a STA receives a frame addressed to it that requires an immediate response, except for RTS and Trigger frames (see 26.5.2.5 (UL MU CS mechanism)), it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

During an EDCA TXOP, the Address 2 field excluding the Individual/Group bit of all Control frames sent by an HE STA that is a TXOP holder and carried in a PPDU that is not an HE MU PPDU shall be set to the same address value.

Change the title of subclause 10.23.2.5 as follows:

10.23.2.5 EDCA channel access in a VHT, HE or TVHT BSS

Insert the following after the 1st paragraph:

If the MAC receives a PHY-CCA.indication primitive with the per20bitmap parameter present, the parameter indicates the busy/idle status of each of the 20 MHz subchannels that comprise the operating channel width.

Change 4th paragraph as follows:

If a STA is permitted to begin a TXOP (as defined in 10.23.2.4 (Obtaining an EDCA TXOP)) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following actions:

a) Transmit a 160 MHz or 80+80 MHz mask PPDU if the secondary channel, the secondary 40 MHz channel, and the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

b) Transmit an 80 MHz mask PPDU on the primary 80 MHz channel if both the secondary channel and the secondary 40 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

c) Transmit a 40 MHz mask PPDU on the primary 40 MHz channel if the secondary channel was idle during an interval of ~~PIFS~~ duration 1) DIFS if the PPDU is transmitted in the 2.4 GHz band or 2) PIFS otherwise, immediately preceding the start of the TXOP.

d) Transmit a 20 MHz mask PPDU on the primary 20 MHz channel.

e) Restart the channel access attempt by invoking the backoff procedure as specified in 10.23.2 (HCF contention based channel access (EDCA)) as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff counter has a value of 0.

f) Transmit a TVHT_4W or TVHT_2W+2W mask PPDU if the secondary TVHT_W channel and the secondary TVHT_2W channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

g) Transmit a TVHT_2W or TVHT_W+W mask PPDU if the secondary TVHT_W channel was idle during an interval of PIFS immediately preceding the start of the TXOP.

h) Transmit a TVHT_W mask PPDU on the primary TVHT_W channel.

i) Transmit an HE MU PPDU with preamble puncturing in 80 MHz where in the preamble only the secondary 20 MHz is punctured if the secondary 40 MHz channel was idle during an interval of PIFS immediately preceding the start of the TXOP.

j) Transmit an HE MU PPDU with preamble puncturing in 80 MHz where in the preamble only one of the two 20 MHz subchannels in the secondary 40 MHz is punctured if the secondary 20 MHz channel, and one of the two 20 MHz subchannels of the secondary 40 MHz were idle during an interval of PIFS immediately preceding the start of the TXOP.

k) Transmit an HE MU PPDU with preamble puncturing in 160 MHz or 80+80 MHz where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured if the secondary 40 MHz channel, and at least one of the four 20 MHz subchannels in the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

l) Transmit an HE MU PPDU with preamble puncturing in 160 MHz or 80+80 MHz where in the primary 80 MHz of the preamble only the primary 40 MHz is present if the secondary 20 MHz channel, and at least one of the four 20 MHz subchannels in the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

NOTE 1—In the case of rule e), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in 10.23.2.8 (Multiple frame transmission in an EDCA TXOP); backoff procedure invoked for event a)).

NOTE 2—~~For both an HT, and a VHT STA, an EDCA TXOP is obtained~~ An HT, VHT or HE STA obtains an EDCA TXOP based on activity on the primary channel (see 10.23.2.4 (Obtaining an EDCA TXOP)). The width of transmission is determined by the CCA status of the nonprimary channels during ~~the PIFS~~ an interval of duration 1) DIFS if transmitting in the 2.4 GHz band or 2) PIFS otherwise, before transmission (see ~~VHT description in~~ 10.3.2 (Procedures common to the DCF and EDCAF)).

NOTE 3—In the case of rule j), there is only one idle 20 MHz subchannel in the secondary 40 MHz channel and the other 20 MHz subchannel in the secondary 40 MHz is preamble punctured.

10.23.2.7 Sharing an EDCA TXOP

Change paragraphs 1-3 as follows:

The AC associated with the EDCAF that gains an EDCA TXOP is referred to as the primary AC. Frames from ACs other than the primary AC shall not be included in the TXOP, with the following exceptions (TXOP sharing):

- Frames from a higher priority AC may be included when at least one frame from the primary AC has been transmitted and all frames from the primary AC have been transmitted and frames from the AC(s) defined in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) for HE PPDUs.
- When an AP supports ~~DL-MU-MIMO~~ MU PPDUs, frames from a higher or lower priority AC may be included in a VHT or S1G MU PPDU with the TXVECTOR parameter NUM_USERS > 1 or an HE MU PPDU, when these frames do not increase the duration of the VHT or S1G beyond that required for the transmissions of the frames of the primary AC, targeting up to four STAs if it is transmitted in a VHT MU PPDU. In a non-HE MU PPDU, ~~F~~frames from the primary AC shall be transmitted first.The inclusion of secondary AC traffic in an HE MU PPDU is described in 10.23.2.8 (Multiple frame transmission in an EDCA TXOP). The inclusion of secondary AC traffic in an HE MU PPDU shall not cause the TXOP limit of the primary AC to be exceeded.

When sharing, the TXOP limit that applies is the TXOP limit of the primary AC.

With respect to admission control (see 10.23.4.2 (Contention based admission control procedures)), all frames transmitted under TXOP sharing shall be treated as if they were from the primary AC.

NOTE—An AP can protect an immediate response by preceding the VHT or SIG or the HE MU PPDU (which might have TXVECTOR parameter NUM_USERS > 1) with an RTS/CTS or MU-RTS Trigger/CTS frame exchange or a CTS-to-self transmission.

10.23.2.8 Multiple frame transmission in an EDCA TXOP

Change the 1st paragraph as follows:

A frame exchange, in the context of multiple frame transmission in an EDCA TXOP, may be one of the following:

- A frame not requiring immediate acknowledgment (such as a group addressed frame or a frame transmitted with an ack policy that does not require immediate acknowledgment) or an A-MPDU containing only such frames
- A frame requiring immediate acknowledgment (such as an individually addressed frame transmitted with an ack policy that requires immediate acknowledgment) or an A-MPDU containing at least one such frame, followed after SIFS by a corresponding acknowledgment frame
- A triggering frame or an A-MPDU containing at least one such frame, followed after SIFS by an HE TB PPDU where the HE TB PPDU is optionally followed after SIFS by an acknowledgment
- Either
  - a VHT NDP Announcement frame followed after SIFS by a VHT NDP followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames, or
  - a Beamforming Report Poll frame followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames
  - an HE NDP Announcement frame followed after SIFS by an HE sounding NDP followed after SIFS by a PPDU containing one or more HE Compressed Beamforming/CQI frames, or
  - a broadcast HE NDP Announcement frame followed after SIFS by an HE sounding NDP followed after SIFS by a BFRP Trigger frame followed by HE TB PPDUs, or
  - a BFRP Trigger frame followed after SIFS by an HE TB PPDU containing one or more HE Compressed Beamforming/CQI frames

Change the paragraphs 7-9 as follows:

If a TXOP is protected by an RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a PPDU as follows:

- To be the same or narrower than the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the last received CTS frame in the same TXOP, if the RTS frame with a bandwidth signaling TA and TXVECTOR parameter DYN_BANDWIDTH_IN_NON_HT set to Dynamic has been sent by the TXOP holder in the last RTS/CTS exchange.
- Otherwise, to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS exchange in the same TXOP.

If a TXOP is protected by an MU-RTS Trigger frame or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a PPDU as follows:

- To be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the MU-RTS Trigger frame that has been sent by the TXOP holder in the last MU-RTS Trigger/CTS frame exchange in the same TXOP, if the RU Allocation subfields of the MU-RTS Trigger frame for all intended receivers are equal to a value that corresponds to the channel bandwidth that is indicated in the UL BW subfield in the Common Info field of the MU-RTS Trigger frame.
- Otherwise, to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP.

If there is no RTS/CTS or MU-RTS Trigger/CTS frame exchange in non-HT duplicate format in a TXOP, and the TXOP includes at least one non-HT duplicate frame exchange that does not include a PS-Poll, then the TXOP holder shall set the CH_BANDWIDTH parameter in TXVECTOR of a PPDU sent after the first non-HT duplicate frame that is not a PS-Poll to be the same or narrower than the CH_BANDWIDTH parameter in TXVECTOR of the initial frame in the first non-HT duplicate frame exchange in the same TXOP.

If there is no non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a non-initial PPDU to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP, subject to the following constraints:

- If the preceding PPDU is a DL HE MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of the non-initial PPDU to a value whose corresponding 20 MHz channels are within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.
- If the non-initial PPDU is a DL HE MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter RU_ALLOCATION of the non-initial PPDU to a value whose corresponding RU is within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.

10.23.2.9 TXOP limits

Change as follows:

The duration of a TXOP is the time a STA obtaining a TXOP (the TXOP holder) maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions. The TXOP holder shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP limit, when nonzero.

The TXOP limits are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

A TXOP limit of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

a) One of the following at any rate, subject to the rules in 10.6 (Multirate support)
   1) One or more SU PPDUs carrying fragments of a single MSDU or MMPDU
   2) An SU PPDU or a VHT MU PPDU or an HE MU PPDU or an HE TB PPDU carrying a single MSDU, a single MMPDU, a single A-MSDU, or a single A-MPDU
   3) A VHT MU PPDU or an HE MU PPDU carrying A-MPDUs to different users (a single A-MPDU to each user)
   4) A QoS Null frame or PS-Poll frame that is not an PS-Poll+BDT frame
   5) A Basic Trigger frame, BSRP Trigger frame or BQRP Trigger frame
   6) An HE TB PPDU carrying A-MPDUs from different users (a single A-MPDU from each user)
b) Any required acknowledgments
c) Any frames required for protection, including one of the following:
   1) An RTS/CTS or MU-RTS Trigger/CTS frame exchange
   2) CTS to itself
   3) Dual CTS as specified in 10.3.2.10 (Dual CTS protection)
d) Any frames required for beamforming as specified in 10.32 (Sounding PPDUs), 10.37.5 (VHT sounding protocol), 26.7 (HE sounding protocol) and 10.43 (DMG beamforming).
e) Any frames required for link adaptation as specified in 10.33 (Link adaptation) and 27.13 (Link adaptation using the HE variant HT Control field).
f) Any number of BlockAckReq, MU-BAR Trigger or Multi-TID BlockAckReq or GCR MU-BAR Trigger frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD, BDT, and TXOP sharing when the TXOP limit is 0.

When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

The TXOP holder may exceed the TXOP limit only if it does not transmit more than one Data or Management frame in the TXOP, only if it does not transmit a DL-MU-MIMO PPDU in the TXOP, and only for the following situations:

— Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU, where the size of the retransmitted MPDU is the same as the initially transmitted MPDU
— Transmission of an MSDU or MMPDU less than 600 octets by an S1G non-sensor STA
— Transmission of a fragment of an MSDU or MMPDU, the fragment being less than 256 octets, by an S1G non-sensor STA
— Initial transmission of an MSDU under a block ack agreement, where the MSDU is not in an A-MPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
— Transmission of a Control frame or a QoS Null frame, not in an A-MPDU consisting of more than one MPDU
— Initial transmission of a non-dynamic fragment of an MSDU or MMPDU (see 10.4 (MSDU, A-MSDU, and MMPDU fragmentation)), if a previous fragment of that MSDU or MMPDU was retransmitted
— Transmission of a non-dynamic fragment of an MSDU or MMPDU fragmented into 16 fragments
— Transmission of the 16th dynamic fragment of an MSDU or MMPDU

— Initial transmission of the first dynamic fragment of an MSDU or MMPDU, where the size of the first fragment is equal to the minimum fragment size specified by the receiver STA and the MSDU or MMPDU is not in an A-MPDU consisting of more than one MPDU

— Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an MSDU and that is not an individually addressed Management frame

— Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU

— Transmission of a null data PPDU (NDP)

— Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame, where these fit within the TXOP limit and it is only the response and the immediately preceding SIFS that cause the TXOP limit to be exceeded.

— Transmission of one of the following sequences, provided that the sequence fits within the TXOP limit and it is only the response and the immediately preceding SIFS that causes the TXOP limit to be exceeded:

- An HE NDP Announcement frame and HE sounding NDP
- An HE NDP Announcement frame and HE sounding NDP and BFRP Trigger frame
- A BFRP Trigger frame

Except as described above, a STA shall fragment an individually addressed MSDU or MMPDU so that the initial transmission of the first fragment does not cause the TXOP limit to be exceeded.

NOTE—The TXOP limit is not exceeded for the following situations:

— Initial transmission of an MPDU containing an unfragmented though fragmentable (see 10.2.7 and 26.3 (Fragmentation and defragmentation)) MSDU/MMPDU

— Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except ~~for an~~ if the MSDU/MMPDU is fragmented into 16 fragments

— Initial transmission of an A-MSDU

— Initial transmission of a non-dynamic fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/ MMPDU was retransmitted, except ~~for an~~ if the MSDU/MMPDU is fragmented into 16 fragments

— Initial transmission of a dynamic fragment of a fragmented MSDU/MMPDU, except for, either the first dynamic fragment of a fragmented MSDU/MMPDU using the minimum fragment size specified by the receiver STA, or the 16th dynamic fragment of a fragmented MSDU/MMPDU

— Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management frame, unless this is a retransmission of that MPDU

— Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions

— Transmission of a Trigger frame, other than a BFRP Trigger frame, where either the Trigger frame or its response does not fit within the TXOP limit

If the TXOP holder exceeds the TXOP limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.

The duration of a TXOP for a mesh STA that has dot11MCCAActivated true shall not exceed the time between the start of the TXOP and the end of the current MCCAOP reservation.

NOTE—The rules in this subclause also apply to priority-downgraded MSDUs and A-MSDUs (see 10.23.4.2 (Contention based admission control procedures)).

If the Duration field in a frame carried in an HE TB PPDU is set to 0, the HE TB PPDU shall not include any frames that solicit a control response frame from the AP.

10.23.2.10 Truncation of TXOP

Change the 7th paragraph as follows:

In a non-DMG BSS, a non-S1G non-HE STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID(TA) without comparing Individual/Group bit, an AP may respond by transmitting a CF-End frame after SIFS. An HE STA interprets the reception of a CF-End frame as defined in 26.2.5 (Truncation of TXOP).

Change the 10th paragraph as follows:

Non-DMG non-S1G non-HE STAs ~~that are not S1G STAs~~ that receive a CF-End frame reset their NAV and can start contending for the medium without further delay. An HE STA that receive a CF-End frame may start contending for the medium without further delay as defined in 26.2.5 (Truncation of TXOP). A DMG STA that receives a CF-End frame can start contending for the medium at the end of the time interval equal to the value in Duration/ID field of the frame if none of its NAVs has a nonzero value (10.40.10 (Updating multiple NAVs)).

10.23.2.11 Termination of TXOP

Insert the following row at the end of Table 10-18 (Modulation classes eligible for TXOP termination) as follows:

Table 10-18—Modulation classes eligible for TXOP termination

Modulation classes eligible for TXOP termination (see Table 10-9)
HE

Change Table 10-19 (Rate and modulation class of a final transmission in a TXOP) as follows:

Table 10-19—Rate and modulation class of a final transmission in a TXOP

Modulation class and data rate of immediately preceding frame in TXOP	Rate and modulation class of final transmission
DSSS or HR/DSSS with long preamble, data rate > 1 Mb/s	1 Mb/s DSSS
HR/DSSS with short preamble, data rate > 2 Mb/s	2 Mb/s HR/DSSS short preamble
HE, any data rate	6 Mb/s OFDM
Other eligible modulation classes, ~~data rate > 6 Mb/s~~ except 6 Mb/s OFDM	6 Mb/s OFDM

10.23.2.12 Retransmit procedures

10.23.2.12.1 General

Insert the following at the end of the subclause:

If an HE STA transmits an HE TB PPDU, the QSRC[AC] and QLRC[AC] for the associated EDCAF are not changed.

10.23.3 HCF controlled channel access (HCCA)

10.23.3.5 HCCA transfer rules

10.23.3.5.3 Use of RTS/CTS

Change the 1st paragraph as follows:

In order to provide improved NAV protection, a STA may send an RTS frame as the first frame of any frame exchange sequence without regard for dot11RTSThreshold or dot11TXOPDurationRTSThreshold.

10.25 Block acknowledgment (block ack)

10.25.2 Setup and modification of the block ack parameters

Change the 11th paragraph as follows:

When a block ack agreement is established between two HT STAs, DMG STAs, or two S1G STAs, the originator may change the size of its transmission window if the value in the Buffer Size field of the ADDBA Response frame is larger than the value in the ADDBA Request frame. ~~If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window (WinSizeO) so that it is not greater than the value in the Buffer Size field of the ADDBA Response frame and is not greater than the value 64.~~ If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window (WinSizeO) so that it meets the following conditions:

- Not greater than the value in the Buffer Size field of the ADDBA Response frame
- Not greater than 64 if the sender of the ADDBA Response frame is a non-HE STA
- Not greater than 256 if the sender of the ADDBA Response frame is an HE STA

10.25.5 Selection of BlockAck and BlockAckReq variants

Replace the 1st seven paragraphs of this subclause with the following:

The Multi-TID BlockAck variant shall be used for all BlockAck frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall not be used otherwise. For non-HE STAs, the Multi-TID BlockAckReq variant shall be used for all BlockAckReq frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall not be used otherwise. The Multi-TID BlockAckReq variant can be used between HE STAs to solicit a Multi-STA BlockAck frame for Multi-TID A-MPDUs.

In a DMG BSS, if the Compressed BlockAckReq variant is used related to an HT-immediate agreement, then all of the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall use the Compressed BlockAck and Compressed BlockAckReq variants.

In a DMG BSS, if the Extended Compressed BlockAckReq variant is used related to an HT-immediate agreement, then all of the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall use the Extended Compressed BlockAck and Extended Compressed BlockAck-Req variants.

Where the terms BlockAck and BlockAckReq are used within 10.25.6 (HT-immediate block ack extensions) and 10.25.7 (HT-delayed block ack extensions), the appropriate variant according to this subclause (e.g., Compressed, Multi-TID) is referenced by the generic term. The term BlockAck as used within 10.25.6 (HT-immediate block ack extensions) includes the additional NDP_1M BlockAck, NDP_2M BlockAck, BAT and BlockAck frame variants.

GCR BlockAck and GCR BlockAckReq variants shall be used within a GCR block ack agreement. GLK-GCR BlockAck and GLK-GCR BlockAckReq variants shall be used within a GLK-GCR block ack agreement.

10.25.6 HT-immediate block ack extensions

10.25.6.1 Introduction to HT-immediate block ack extensions

Insert the following as the last paragraph in this subclause:

If the B0 of Fragment Number subfield of a Compressed BlockAck frame or Multi-STA BlockAck frame is equal to 0, then the parameter *BitmapLength* represents the maximum length, in bits, of the Block Ack Bitmap subfield in the Compressed BlockAck frame and Multi-STA BlockAck frame for a particular TID; otherwise, the parameter *BitmapLength* is derived by dividing by 4, the length represented in the Block Ack Bitmap subfield in the Compressed BlockAck frame and Multi-STA BlockAck frame for a particular TID. For a non-HE STA, *BitmapLength* is 64. For an HE STA, *BitmapLength* is negotiated when the block ack agreement is established as defined in 26.4.3 (Negotiation of block ack bitmap lengths).

10.25.6.3 Scoreboard context control during full-state operation

Change the first paragraph as follows (replace 64 with BitmapLength):

For each HT-immediate block ack agreement that uses full-state operation, a recipient shall maintain a block acknowledgment record. This record includes a bitmap, indexed by sequence number; a 12-bit unsigned integer starting sequence number, $WinStart_R$, representing the lowest sequence number position in the bitmap; a variable $WinEnd_R$; and the maximum transmission window size, $WinSize_R$, which is set to the smaller of ~~64~~ <u>*BitmapLength*</u> and the value of the Buffer Size field of the associated ADDBA Response frame that established the block ack agreement. $WinEnd_R$ is defined as the highest sequence number in the current transmission window. A STA implementing full-state operation for an HT-immediate block ack agreement shall maintain the block acknowledgment record for that agreement according to the following rules:

10.25.6.5 Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA

Change the 2nd paragraph as follows:

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with Implicit BAR ack policy during either full-state operation or partial-state operation, any adjustment to the value of $WinStart_R$ according to the procedures defined within 10.25.6.3 (Scoreboard context control during full-state operation) and 10.25.6.4 (Scoreboard context control during partial-state operation) shall be performed before the generation and transmission of the response BlockAck frame. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame shall be set to any value in the range ($WinEnd_R$ – ~~63~~ <u>*BitmapLength + 1*</u>) to $WinStart_R$. The Starting Sequence Number subfield stored in the Starting Sequence Control field of NDP BlockAck and BAT frames shall be set to *WinStartR*. The values in the recipient's record of status of MPDUs beginning with the MPDU for which the Sequence Number subfield value is equal to WinStartR and ending with the MPDU for which the Sequence Number subfield value is equal to *WinEndR* shall be included in the bitmap of the BlockAck frame. The bitmap of the NDP BlockAck frame is protected using the encoding procedure described in 10.58 (Bitmap protection for NDP BlockAck frames).

Change the 4th paragraph as follows:

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with Ack Policy equal to Normal Ack (i.e., implicit block ack request) during either full-state or partial-state operation, if the adjusted value of $WinEnd_R$ is less than the value of the starting sequence number of the BlockAck frame plus ~~63~~ *BitmapLength – 1*, within the bitmap of the BlockAck frame, the status of MPDUs with sequence numbers that are greater than the adjusted value of $WinEnd_R$ shall be reported as unsuccessfully received (i.e., the corresponding bit in the bitmap shall be set to 0).

10.25.6.6 Receive reordering buffer control operation

10.25.6.6.1 General

Change the 4th paragraph as follows:

$WinEnd_B$ is initialized to $WinStart_B + WinSize_B - 1$, where $WinSize_B$ is set to the smaller of ~~64~~ *BitmapLength* and the value of the Buffer Size field of the ADDBA Response frame that established the block ack agreement.

10.25.9 GCR and GLK-GCR block ack

Change the title of 10.25.9.1 as follows:

10.25.9.1 ~~Introduction~~ General

Insert as the last paragraph:

An HE AP shall not send a GCR MU-BAR Trigger frame to a non-AP HE STA if the most recently received Extended Capabilities element from the STA does not indicate support for Robust AV Streaming or Advanced GCR.

10.25.9.4 GCR block ack BlockAckReq and BlockAck frame exchanges

Change paragraphs 2-3 as follows:

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

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

~~When~~ If a recipient receives a BlockAckReq frame with the GCR Group Address subfield equal to a GCR group address, the recipient shall transmit a BlockAck frame at a delay of SIFS after the BlockAckReq frame. The BlockAck frame acknowledges the STA's reception status of the block of group addressed frames requested by the BlockAckReq frame. If an HE STA receives a GCR MU-BAR Trigger frame with the AID12 subfield set to the 12 LSBs of the AID of the HE STA, the HE STA shall include the BlockAck frame in the HE TB PPDU sent in response to the Trigger frame. The BlockAck frames acknowledge the HE STA's reception status of the block of group addressed frames requested by the GCR MU-BAR Trigger frame.

Insert the following paragraph and associated figure after the 4th paragraph:

Figure 10-37a (Example of a frame exchange with GCR MU-BAR Trigger frames) 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 GCR MU-BAR Trigger frame to group members 1 and 2 of the GCR group, waits for the BlockAck frames, and then sends a GCR MU-BAR Trigger frame to group members 3 and 4 and then waits for the BlockAck frames. The HE AP then sends a BlockAckReq frame to group member 5, which is a non-HE STA, and waits for the BlockAck frame. After receiving the BlockAck frames, 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.

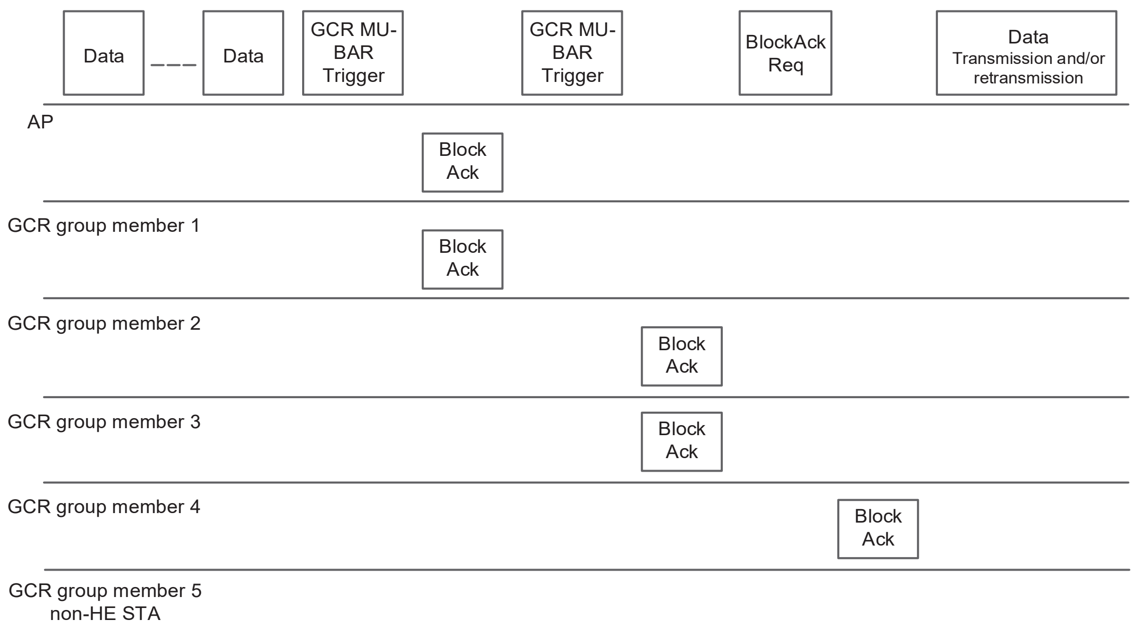

Figure 10-37a—Example of a frame exchange with GCR MU-BAR Trigger frames

Change paragraphs 6-8 as follows:

After completing the BlockAckReq or GCR MU-BAR Trigger and BlockAck frame exchanges, the originator determines from the information provided in the BlockAck bitmap and from the missing BlockAck frame ~~which, if any,~~ the A-MSDUs, if any, that need to be retransmitted.

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

For GCR streams with retransmission policy equal to GCR Block Ack, an originator may regularly send a BlockAckReq frame with the GCR Group Address subfield in the BAR Information field set to the GCR group address and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group. An originator may also send a GCR MU-BAR Trigger frame with the AID12 fields set to 12 LSBs of the AIDs of HE STAs that transmit the BlockAck frames and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group.

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

Change the last paragraph as follows:

If the beginning of such reception does not occur during the first slot time following a SIFS, then the originator may perform error recovery by retransmitting a BlockAckReq frame or a GCR MU-BAR Trigger frame PIFS after the previous BlockAckReq frame or a GCR MU-BAR Trigger frame if ~~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 (see Figure 10-26 (EDCA mechanism timing relationships)) 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 a GCR MU-BAR Trigger frame plus one slot time.

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

10.27 Protection mechanisms

Insert a new subclause at the end of 10.27 as follows:

10.27.6 Protection rules for HE STAs

An HE STA operating in the 2.4 GHz band is subject to all of the rules for HT STAs that apply to that band, except that a PPDU with the TXVECTOR parameter FORMAT set to HE_SU, HE_ER_SU, HE_MU or HE_TB may be substituted for a PPDU with the TXVECTOR parameter FORMAT set to HT_MF.

An HE STA operating in the 5 GHz band is subject to all of the rules for VHT STAs that apply to that band, except that a PPDU with the TXVECTOR parameter FORMAT set to HE_SU, HE_ER_SU, HE_MU or HE_TB may be substituted for a PPDU with the TXVECTOR parameter FORMAT set to VHT.

Additionally, an HE STA can use the MU-RTS/CTS frame exchange procedure.

10.29 Reverse direction protocol

10.29.1 General

Change the 2nd paragraph as follows:

An HT STA indicates support of the RD feature as an RD responder using the RD Responder subfield of the HT Extended Capabilities field of the HT Capabilities element or the RD Responder subfield of the HE 6 GHz Band Capabilities element. A STA shall set the RD Responder subfield to 1 in frames that it transmits containing the HT Capabilities element in the 2.4 GHz or 5 GHz band and sets the RD Responder subfield to 1 in frames that it transmits containing the HE 6 GHz Band Capabilities element in the 6 GHz band if dot11RDResponderOptionImplemented is true. Otherwise, the STA shall set the RD Responder subfield to 0. In ~~an~~ a non-HE HT STA the RDG/More PPDU subfield and the AC Constraint subfield are present in the HTC field. In an HE STA the RDG/More PPDU subfield and the AC Constraint subfield are present in the CAS Control subfield.

10.29.2 Reverse direction (RD) exchange sequence

Change NOTE 2 following the 1st paragraph as follows:

NOTE 2—If the RD responder is a VHT AP, the RD response burst can contain VHT MU PPDUs that might have TXVECTOR parameter NUM_USERS > 1. If the RD responder is an HE AP, the RD response burst can contain HE MU PPDUs that might have TXVECTOR parameter NUM_USERS > 1.

Insert the following after the 1st paragraph:

If the RD initiator is an HE STA and the RD responder is an HE AP, the RD response burst may contain one or more Basic Trigger frames. The Basic Trigger frames shall trigger the RD initiator and at least one other STA in a full bandwidth UL MU-MIMO transmission.

10.29.3 Rules for RD initiator

Change the 3rd and subsequent 3 paragraphs as follows:

Transmission of a +HTC or DMG frame by an RD initiator with the RDG/More PPDU subfield equal to 1 (either transmitted as a non-A-MPDU frame or within an A-MPDU) indicates that the duration indicated by the Duration/ID field is available for the RD response burst and RD initiator final PPDU (if present). Transmission of an MPDU by an HE RD initiator that contains a CAS Control subfield with the RDG/More PPDU subfield equal to 1 indicates that the duration indicated by the Duration/ID field is available for the RD response burst and RD initiator final PPDU (if present).

An RD initiator that sets the RDG/More PPDU field to 1 in a +HTC or DMG frame transmitted during a TXOP shall set the AC Constraint subfield to 1 in that frame if the TXOP was gained through the EDCA channel access mechanism and shall otherwise set it to 0. An RD initiator that sets the RDG/More PPDU field to 1 in a DMG frame transmitted during an SP can set the AC Constraint subfield to 1 to limit the Data frames transmitted by the RD responder. An HE STA RD initiator that sets the RDG/More PPDU field to 1 in a CAS Control subfield in a frame transmitted during a TXOP may set the AC Constraint subfield in the CAS Control subfield to 1.

An RD initiator shall not transmit a +HTC or DMG frame with the RDG/More PPDU subfield set to 1 that requires a response MPDU that is not one of the following frames:

- Ack
- Compressed BlockAck
- Extended Compressed BlockAck
- Multi-STA BlockAck

Subject to TXOP or SP constraints, after transmitting an RDG PPDU, an RD initiator may transmit its next PPDU as follows:

a) *Normal continuation:* The RD initiator may transmit its next PPDU a minimum of a SIFS after receiving a response PPDU that meets one of the following conditions:
   1) Contains one or more received +HTC or DMG frames with the RDG/More PPDU subfield equal to 0
   2) In an HT STA, contains one or more received frames that are capable of carrying the HT Control field but did not contain an HT Control field
   3) Contains a received frame that requires an immediate response
   4) In a DMG STA, none of the correctly received frames in the PPDU carry the QoS Control field
b) *Error recovery:* The RD initiator may transmit its next PPDU ~~when~~ if the CS mechanism (see 10.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (see Figure 10-26 (EDCA mechanism timing relationships)) (this transmission is a continuation of the current TXOP or SP).

NOTE 1—Error recovery of the RDG mechanism is the responsibility of the RD initiator.

NOTE 2—After transmitting a PPDU containing an RDG, if the response is corrupted so that the state of the RDG/More PPDU subfield is unknown, the RD initiator of the RD exchange is not allowed to transmit after a SIFS. Transmission can occur a PIFS after deassertion of CS.

NOTE 3—Control response frames generated by HE STAs do not carry the HT Control field.

10.29.4 Rules for RD responder

Change the 2nd paragraph as follows:

The recipient of an RDG may decline the RDG by

— Not transmitting any frames following the RDG PPDU ~~when~~ if no response is otherwise required, or
— Transmitting a control response frame with the RDG/More PPDU subfield set to 0, or
— Transmitting a control response frame that contains no HT Control field
— Transmitting a control response frame aggregated with other MPDUs with the RDG/More PPDU subfield set to 0

Change paragraphs 5-7 as follows:

An RD responder shall not transmit an MPDU (either individually or aggregated within an A-MPDU) that is not one of the following frames:

— Ack
— Compressed BlockAck
— Compressed BlockAckReq
— Extended Compressed BlockAck
— Extended Compressed BlockAckReq
— Multi-STA BlockAck
— QoS D~~d~~ata
— QoS Null
— Management
— Basic Trigger

~~If the AC Constraint subfield is equal to 1, the RD responder shall transmit Data frames of only the same AC as the last frame received from the RD initiator.~~ If the AC Constraint subfield is equal to 1 in last frame received from an RD initiator:

— A non-HE RD responder shall transmit Data frames of only the same AC as the last frame received from the RD initiator

— An HE RD responder may transmit A-MPDU with or multi-TID A-MPDU with MPDUs from one or more ACs that have a priority that is equal to or higher than the lowest priority AC of the MPDU(s) carried in the last PPDU received from the RD initiator (see 10.12 (A-MPDU operation) and if the RD initiator is an HE STA subject to the additional rules defined in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU).

For a BlockAckReq or BlockAck frame, the AC is determined by examining the TID field. For a Management frame, the AC is AC_VO. The RD initiator shall not transmit a +HTC or DMG MPDU with the RDG/More PPDU subfield set to 1 from which the AC cannot be determined. If the AC Constraint subfield is equal to 0, the RD responder may transmit Data frames of any TID.

NOTE—If the RD initiator's last PPDU contained an A-MPDU, the last frame is the last Data frame in the A-MPDU.

During an RD response burst any PPDU transmitted by an RD responder shall contain at least one MPDU with an Address 1 field that matches the MAC address of the RD initiator or at least one Trigger frame that addresses the RD initiator, and the inclusion of traffic to STAs other than the RD initiator in a VHT MU PPDU, ~~or an~~ S1G MU PPDU or HE MU PPDU shall not increase the duration of the ~~VHT MU~~ PPDU beyond that required to transport the traffic to the RD initiator. The RD responder shall not transmit ~~any frame causing~~ a frame that is not a Basic Trigger frame and that causes a response after SIFS with an Address 1 field that does not match the MAC address of the RD initiator. The RD responder shall not transmit any PPDUs with a CH_BANDWIDTH that is wider than the CH_BANDWIDTH of the PPDU containing the frame(s) that delivered the RD grant.

An RD responder that transmits a Basic Trigger frame shall set the CS Required subfield to 1 and shall allocate a number of streams for the RD initiator that is not smaller than the number of streams of the RD initiator's last PPDU.

If an RD initiator sets the RDG/More PPDU field to 1 in a +HTC frame transmitted during a TXOP and sets the AC Constraint subfield to 1 in that frame, the RD responder shall set the Preferred AC subfield of the Trigger Dependent User Info field in the Trigger frame to the same AC as the last frame received from the RD initiator.

10.36 null data PPDU (NDP) sounding

10.36.6 Transmission of a VHT NDP

Insert the following after the 2nd paragraph:

If an HE STA transmits a VHT NDP where at least one of the intended recipients of the VHT NDP is an HE STA, then the following conditions apply:

— If the bandwidth of an VHT NDP is less than or equal to 80 MHz, the number of space-time streams sounded as indicated by the TXVECTOR parameter NUM_STS shall not exceed the value indicated in the Beamformee STS ≤ 80 MHz subfield in the HE Capabilities element of any intended HE STA recipient of the VHT NDP.

— If the bandwidth of an VHT NDP is greater than 80 MHz, the number of space-time streams sounded as indicated by the TXVECTOR parameter NUM_STS shall not exceed the value indicated in the Beamformee STS > 80 MHz subfield in the HE Capabilities element of any intended HE STA recipient of the VHT NDP.

10.47 Target wake time (TWT)

10.47.1 TWT overview

Change the 5th paragraph as follows:

STAs that request a TWT agreement are called TWT requesting STAs and the STAs that respond to their requests are TWT responding STAs. A TWT requesting STA is assigned specific times to wake and exchange frames with the TWT responding STA. 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. 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 10.47.3 (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 10.47.4 (Implicit TWT operation). STAs need not be made aware of the TWT values of other STAs. A TWT requesting STA and a TWT responding STA shall set the Negotiation Type subfield to 0 in the TWT element of transmitted frames containing the TWT element, except when the STAs are HE STAs. Additional TWT setup exchanges between HE STAs for individual TWT operation are defined in 26.8 (TWT operation).

Change paragraphs 7-9 as follows:

An S1G 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 elements that it transmits. An S1G 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 elements that it transmits.

A STA that is not an S1G STA and is not an HE STA and 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 Extended Capabilities elements that it transmits. A STA that is not an S1G STA and is not an HE STA and 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 Extended Capabilities elements that it transmits.

If the TWT Responder Support subfield of the S1G Capabilities element, HE Capabilities element or Extended 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 Setup Command field and with the TWT Request field equal to 1.

An AP with dot11TWTOptionActivated equal to true shall transmit a TWT element to a STA that is associated to the AP and from which it received a frame containing a TWT element that contained a value of Request TWT, Suggest TWT or Demand TWT in the TWT Setup Command field and with the TWT Request field equal to 1. The transmitted TWT element shall be included in the frame that is the appropriate response frame to the received frame. The AP shall include a value of Accept TWT, Alternate TWT, Dictate TWT or Reject TWT in the TWT Setup Command field of the response and shall set the TWT Request field to 0. If the AP response's TWT Setup Command field includes anything other than Accept TWT or Reject TWT, the STA should send a new request for a TWT value by sending another frame that contains a TWT element, modifying the parameters of the request to indicate, for example, an acceptance of a proposed alternate TWT or dictated TWT value. If the STA receives a TWT response to a TWT request with the TWT Setup Command field value of Accept TWT, then the STA has successfully completed a TWT setup with that STA for the TWT Flow Identifier indicated in the TWT response and the STA becomes a TWT requesting STA and the STA may enter the doze state until the TSF matches the next TWT value of the STA, provided that the STA has indicated that it is in a power save mode and no other condition requires the STA to remain awake. The AP becomes a TWT responding STA of the TWT requesting STA.

NOTE 1—A TWT responding STA might choose a TWT Flow Identifier for the TWT response that is different from the TWT Flow Identifier of a received TWT request.

NOTE 2—A TWT requesting STA might renegotiate the TWT parameters of an existing TWT agreement by sending to the TWT responding STA a TWT request with a Flow Identifier that corresponds to that TWT agreement. The TWT response sent by the TWT responding STA containing the TWT Setup Command field of Accept TWT will indicate whether the newly requested TWT parameters are accepted or whether the previously negotiated TWT parameters are still in place.

Insert new paragraphs and table as follows after the 9th paragraph:

The result of an exchange of TWT Setup frames between a TWT requesting STA and a TWT responding STA is defined in Table 10-31a (TWT setup exchange command interpretation). The meaning of “Request TWT” is that the requesting STA does not provide a set of TWT parameters for a TWT agreement, leaving the choice of parameters to the responding STA, “Suggest TWT” indicates that the requesting STA offers a set of preferred TWT parameters for a TWT agreement but might accept alternative TWT parameters that the responding STA indicates and “Demand TWT” indicates that the requesting STA will currently accept only the indicated TWT parameters for a TWT agreement. When transmitted by a responding STA, “Accept TWT” indicates that the responding STA has initiated a TWT agreement with the given parameters, “Alternate TWT” indicates a counter-offer of TWT parameters (although alternative TWT parameters might be accepted as well) without the creation of a TWT agreement, “Dictate TWT” indicates that no TWT agreement is created, but one is likely to be accepted only if the requesting STA transmits a new TWT setup request with the indicated TWT parameters (i.e., no other TWT parameters will be accepted), and "Reject TWT" transmitted by a responding STA as part of a negotiation for a new TWT agreement is used to indicate that the negotiation has ended in failure to create a new TWT agreement.

Table 10-31a—TWT setup exchange command interpretation

TWT Setup Command field in an initiating frame	TWT Setup Command field value in a response frame	TWT condition after the completion of the exchange
Request TWT or Suggest TWT or Demand TWT	No frame transmitted	No new individual TWT agreement exists with the TWT flow identifier corresponding to the TWT flow identifier in the initiating frame. No new individual TWT agreement exists.
Demand TWT	Accept TWT	An individual TWT agreement exists that uses the TWT parameters identified in the initiating frame. The TWT parameters in the response frame match the TWT parameters of the initiating frame.
Suggest TWT or Request TWT	Accept TWT	An individual TWT agreement exists and that uses the TWT parameters identified in the response frame.
Demand TWT or Suggest TWT	Alternate TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame. The requesting STA can send a new request with any set of TWT parameters and the responder might create an individual TWT agreement using those parameters.

Table 10-31a—TWT setup exchange command interpretation

Demand TWT or Suggest TWT	Dictate TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responder offers an alternative set of parameters vs. those indicated in the TWT request. By selecting "Dictate TWT", the responder indicates that it is not willing to accept any other TWT parameters for the requesting STA at this time. The requesting STA can send a new request, but will only receive an Accept TWT if it uses the dictated TWT parameters.
Request TWT or Suggest TWT or Demand TWT	Reject TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responding STA will not create any new individual TWT agreement with the requester at this time.
NOTE 1—Negotiation Type subfield of the TWT element contained in these frames is equal to 0. NOTE 2—The initiating frame is a TWT request and the response frame is a TWT response.		

Change the last paragraph of 10.47.1 as follows:

A 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. A 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. In an S1G BSS, during ~~During~~ a TWT SP, access to a channel that is not the primary channel of the BSS shall be performed according to the procedure described in 10.53 (Subchannel selective transmission (SST)).

In an HE BSS, during a trigger-enabled TWT SP, access to a channel that is not the primary channel of the BSS shall be performed according to the procedure described in 26.8.7 (HE subchannel selective transmission).

11. MLME

11.1 Synchronization

11.1.3 Maintaining synchronization

11.1.3.8 Multiple BSSID procedure

Insert the following subclause heading before the 1st paragraph:

11.1.3.8.1 General

Change the 1st paragraph as follows:

A STA that supports the Multiple BSSID capability has dot11MultiBSSIDImplemented equal to true and shall set to 1 the Multiple BSSID field of the Extended Capabilities elements that it transmits. Support for the Multiple BSSID capability is mandatory for a FILS STA and non-AP HE STA. An AP that supports enhancements related to the discovery and advertisement of a nontransmitted BSSID shall set the Enhanced Multi-BSSID Advertisement Support bit in the Extended Capabilities element to 1 and is referred to as an EMA AP. A 6 GHz AP with dot11MultiBSSIDImplemented equal to true and advertising a partial list of nontransmitted BSSID profiles shall operate as an EMA AP. If an HE AP operating in the 2.4 GHz or 5 GHz bands has dot11MultiBSSIDImplemented equal to true, advertises a partial list of nontransmitted BSSID profiles and intends a non-AP STA to discover the complete list of nontransmitted BSSID profiles, where a complete list of nontransmitted BSSID profile comprises only BSSIDs that are discoverable, then the HE AP shall operate as an EMA AP.

NOTE—A BSSID is discoverable if the AP includes information of that BSSID in its Beacon and Probe Response frames (though not necessarily every frame).

Replace the 2nd paragraph and NOTE with the following:

An AP with dot11MultiBSSIDImplemented equal to true shall set the Co-Hosted BSS subfield in HE Operation element that it transmits to 0.

The BSSID of the AP belonging to a multiple BSSID set is referred to as the transmitted BSSID if the AP includes the Multiple BSSID element in the Beacon frame that it transmits. In a multiple BSSID set, there shall not be more than one AP corresponding to the transmitted BSSID. The BSSID of an AP belonging to a multiple BSSID set is a nontransmitted BSSID if the AP's BSSID is derived according to 9.4.2.45 (Multiple BSSID element) and 9.4.2.73 (Multiple BSSID-Index element). Among all AP STAs in multiple BSSID set, only the AP corresponding to the transmitted BSSID shall transmit a Beacon frame.

The 3rd paragraph remains unchanged:

See 11.1.4.3.4 (Criteria for sending a response) for the rules governing transmission of Probe Response frames in a multiple BSSID set.

Insert new subclauses 11.1.3.8.2 and 11.1.3.8.3 as follows:

11.1.3.8.2 Nontransmitted BSSID profile

A nontransmitted BSSID profile represents information about a particular nontransmitted BSSID and consists of a set of elements that are carried in one or more Nontransmitted BSSID Profile subelements across one or more multiple BSSID elements in the same frame. Each nontransmitted BSSID profile, at a minimum, shall include the elements that are mandatory for that BSS (i.e., Nontransmitted BSSID

Capability element, SSID element, Multiple BSSID-Index element as described in 9.4.2.45 (Multiple BSSID element)). An example of Multiple BSSID element carrying one or more Nontransmitted BSSID Profile subelements is shown in Figure 11-3a (Example of a Multiple BSSID element carrying Nontransmitted BSSID Profile subelements). The figure also shows the order in which the elements are present within each Nontransmitted BSSID Profile subelement.

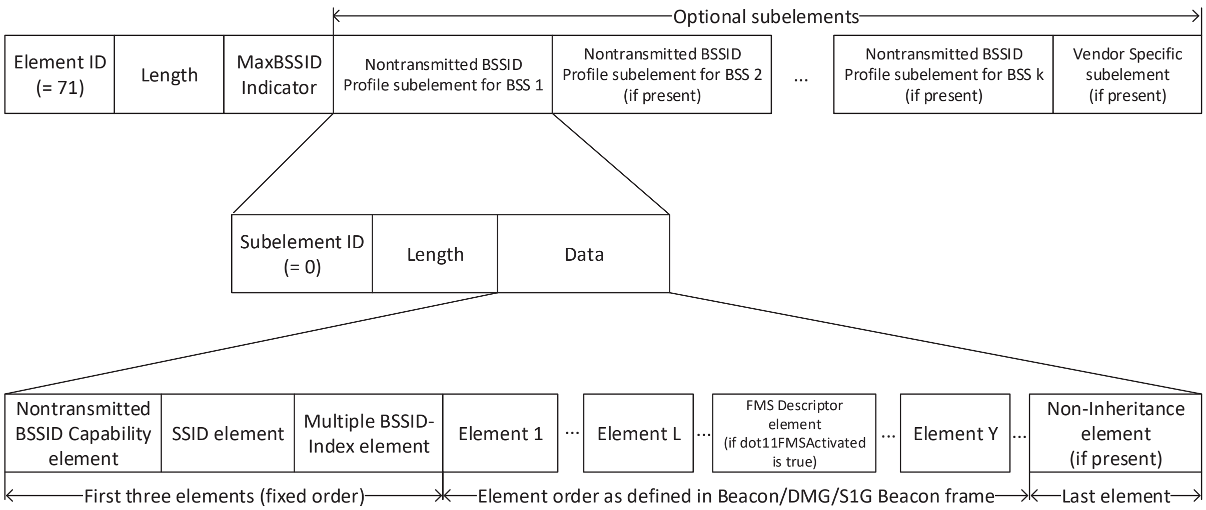

Figure 11-3a—Example of a Multiple BSSID element carrying Nontransmitted BSSID Profile subelements

A nontransmitted BSSID profile consists of all elements carried in all such Multiple BSSID elements sharing the same BSSID index. An AP shall not carry a nontransmitted BSSID profile across multiple Multiple BSSID elements in a frame unless the nontransmitted BSSID profile cannot be carried in one multiple BSSID element due to the size limit of the multiple BSSID element.

If there is a need to split a nontransmitted BSSID profile across more than one Multiple BSSID element in a frame, an AP shall not split an element in the profile into multiple Multiple BSSID elements, and it shall place the next element in the nontransmitted BSSID profile as the first element in the first nontransmitted BSSID profile subelement of the immediately following Multiple BSSID element.

An example of a nontransmitted BSSID profile split across two Multiple BSSID elements in a frame is shown in Figure 11-3b (Example of a nontransmitted BSSID profile split across multiple Multiple BSSID elements).

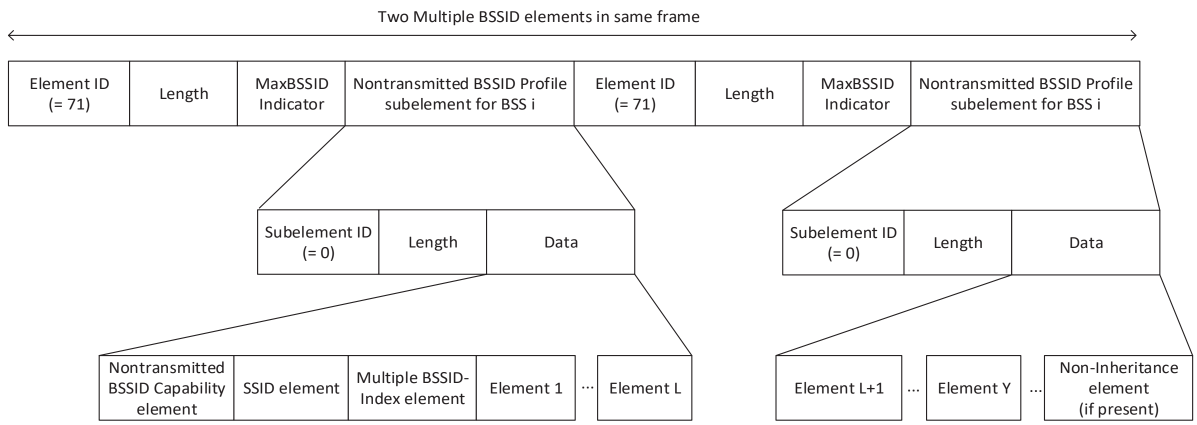

Figure 11-3b—Example of a nontransmitted BSSID profile split across multiple Multiple BSSID elements

NOTE—As described in 9.4.3 (Subelements), the Length field of the Nontransmitted BSSID Profile subelement indicates the number of octets only in the Data field of the subelement.

11.1.3.8.3 Discovery of a nontransmitted BSSID profile

An AP or PCP may choose to include only a partial list of nontransmitted BSSID profiles in the Beacon frame, S1G Beacon frame or DMG Beacon frame or to include different sets of nontransmitted BSSID profiles in different Beacon frames, S1G Beacon frames or DMG Beacon frames. An AP corresponding to the transmitted BSSID may choose to include only a partial list of nontransmitted BSSID profiles in an unsolicited broadcast Probe Response frame or a Probe Response frame sent in response to a Probe Request frame with Address 3 field set to wildcard BSSID and SSID set to wildcard. An AP advertising a complete list of nontransmitted BSSID profiles shall set the Complete List Of NonTxBSSID Profiles field of Extended Capabilities element to 1.

An EMA AP operating in the 2.4 GHz or 5 GHz band should include in Beacon and Probe Response frames a Reduced Neighbor Report element carrying information about nontransmitted BSSIDs that are not advertised in the Multiple BSSID element carried in that frame (see 11.50 (Reduced neighbor report)). The EMA AP does this to aid the fast discovery of all nontransmitted BSSIDs in the multiple BSSID set that are discoverable.

An EMA AP advertising a partial list of BSSID profiles, shall include the Multiple BSSID Configuration element (see 9.4.2.258 (Multiple BSSID Configuration element)) in its Beacon frame, S1G Beacon frame, or DMG Beacon frame and in any Probe Response frame it sends to indicate the configuration of the multiple BSSID set.

An AP shall set the BSSID Count field of the Multiple BSSID Configuration element to indicate the number of active BSSIDs in the multiple BSSID set, and shall set the Profile Periodicity field to indicate the number of beacons a scanning STA is required to receive in order to discover all the active nontransmitted BSSIDs in the set. An AP corresponding to the transmitted BSSID shall send a Probe Response frame carrying Multiple BSSID element that includes, at a minimum, the nontransmitted BSSID profiles requested by the soliciting Probe Request frame.

An unassociated non-AP STA may send a directed Probe Request frame containing a Known BSSID element (see 9.4.2.259 (Known BSSID element)) to an EMA AP that advertises partial list of nontransmitted BSSID profiles to gather information on nontransmitted BSSIDs it has not discovered. An EMA AP, when transmitting a Probe Response frame in response to a Probe Request frame containing Known BSSID element, should not include the nontransmitted BSSID profiles for BSSIDs listed in the Known BSSID element and shall, at a minimum, include the nontransmitted BSSID profiles requested by the soliciting Probe Request frame.

An EMA AP that includes a partial list of nontransmitted BSSID profiles in its Beacon frame, S1G Beacon frame, or DMG Beacon frame, shall advertise a particular nontransmitted BSSID profile in a repeating pattern such that the profile is present in at least one beacon in a sequence of beacons indicated by the Profile Periodicity field of the Multiple BSSID Configuration element unless the membership of the multiple BSSID set changes. If there is a change in a particular nontransmitted BSSID's profile (i.e., set of elements belong to the profile or the element values), the EMA AP shall include the profile in the next DTIM beacon of that BSS so that STAs with that BSS become aware of the change immediately.

NOTE 1—It is recommended that an AP select the periodicity in which a nontransmitted BSSID's profile repeats to be a multiple of the DTIM interval of the BSS with that nontransmitted BSSID so that STAs in PS mode that are associated with that BSSID do not have to wake for additional beacons.

NOTE 2—In order to aid fast discovery of nontransmitted BSSIDs via passive scanning, it is recommended that an AP select a small value for the Profile Periodicity field.

Insert a new subclause heading:

11.1.3.8.4 Inheritance of element values

Change the 4th paragraph as follows:

~~When a station receives a Beacon frame or DMG Beacon frame with a Multiple BSSID element that consists of a nontransmitted BSSID profile with only the mandatory elements, it may inherit the complete profile from a previously received Beacon frame, DMG Beacon frame, or Probe Response frame, or it may send a Probe Request frame to obtain the complete BSSID profiles. Each Beacon element not transmitted in a non-transmitted BSSID subelement is inherited from previous Beacon, DMG Beacon, or Probe Response frame in which the element is present, except for the Quiet element, which shall take effect only in the Beacon frame or DMG Beacon frame that contains it and not carry forward as a part of the inheritance. An AP or PCP is not required to include all supported nontransmitted BSSID profiles in a Probe Response frame, and may choose to only include a subset based on any criteria.~~ When a nontransmitted BSSID profile is present in ~~the~~ one or more Multiple BSSID elements of ~~the~~ a Probe Response frame or a Beacon frame, the AP or PCP shall include all elements that are specific to this BSS. An element is considered to be specific to a BSS if its value is different from the corresponding element advertised by the transmitted BSSID or if the non-transmitted BSSID satisfies the condition as specified in the Table 9-34 (Beacon frame body) for a non-DMG non-S1G AP, Table 9-47 (DMG Beacon frame body) for a DMG AP or Table 9-48 (Minimum and full set of optional elements) for a S1G AP for that element to be present while the transmitted BSSID does not satisfy the corresponding condition. If any of the ~~optional~~ elements carried in the Probe Response frame, Beacon frame or DMG Beacon frame or S1G Beacon frame of the transmitted BSSID are not present in a nontransmitted BSSID profile, the ~~corresponding values are the element~~ values to use for the nontransmitted BSSID are the values of the corresponding element of the transmitted BSSID unless the element is listed in the Non-Inheritance element (if included) in the nontransmitted BSSID profile for that BSS.

The 5th paragraph remains unchanged:

A non-AP and non-PCP STA derives its nontransmitted BSSID value according to 9.4.2.45 (Multiple BSSID element) and 9.4.2.73 (Multiple BSSID-Index element).

Insert a new subclause heading:

11.1.3.8.5 Traffic advertisement in a multiple BSSID set

Change the 6th paragraph as follows:

The Partial Virtual Bitmap field of the TIM element carried in the Beacon, S1G Beacon, DMG Beacon, or TIM frame shall indicate the presence or absence of traffic to be delivered to all stations associated to a transmitted or nontransmitted BSSID. The first 2^n bits of the bitmap are reserved for the indication of group addressed frame for the transmitted and all nontransmitted BSSIDs (see 9.4.2.5.1 (General)). The AID space is shared by all BSSs and the lowest AID value that shall be assigned to a non-S1G STA is 2^n (see 9.4.2.5 (TIM element)). The decimal value of the 11 LSBs of the AID assigned to an S1G STA shall be greater than 2^n. The Encoded Blocks that contain these first 2^n AIDs (if any) shall precede the Encoded Blocks that contain AIDs for the S1G STAs in the S1G Partial Virtual Bitmap field of each page. <u>Each BSS of the Multiple BSSID set may have a different DTIM interval which is signaled in the DTIM Period and DTIM Count fields that are present in the Multiple BSSID-Index element carried in the nontransmitted BSSID profile for that BSS.</u>

Insert the following paragraph and NOTE:

Based upon its knowledge of the capability of associated non-AP STAs to support the multiple BSSID capability, as indicated by the corresponding field in the Extended Capabilities element and the content of the traffic indication virtual bitmap, an AP shall encode the Partial Virtual Bitmap and the Bitmap Control field of the TIM element using one of the three methods (Method A, Method B or Method C) defined in 9.4.2.5.1 (General). Specifically, a non-S1G AP shall use Method B if it determines that the bit for each associated non-AP STA in the traffic indication virtual bitmap that is reconstructed by each non-AP STA from the received TIM element encoded using Method B is set correctly. Otherwise, a non-S1G AP shall use Method A and an S1G AP shall use Method C.

NOTE—If all the recipients of the TIM element are STAs that support the multiple BSSID capability, for example when the TIM element is carried in HE beacon, ER beacon, FILS Discovery frame or OPS frame where all the addressees are non-AP HE STAs, the transmitting AP uses Method B to encode the Partial Virtual Bitmap and the Bitmap Control fields of the TIM element.

The final paragraph remains unchanged:

Multiple BSSID rate selection is defined in 10.6.9 (Multiple BSSID Rate Selection).

11.1.4 Acquiring synchronization, scanning

11.1.4.3 Active scanning

11.1.4.3.2 Active scanning procedure for a non-DMG STA

Change item b), c) and d) in the 2nd paragraph as follows:

For each channel to be scanned:

b) If the STA is a FILS STA<u> or a 6 GHz HE STA</u>, set the FILSProbeTimer to 0 and starts the FILSProbeTimer. While the FILSProbeTimer is less than dot11FILSProbeDelay the STA may skip a probe request transmission and proceed to step i) after setting the ActiveScanningTimer to 0 and starting the ActiveScanningTimer, if one of the following conditions matches:

1) The STA receives a broadcast addressed Probe Request frame that the SME considers to be suitable to discover a candidate AP for association.

2) The STA receives one or more of Probe Response, Beacon, Measurement Pilot, or FILS Discovery frame that identify an AP that the SME considers a suitable candidate for association.

3) The STA successfully sent a Probe Request frame by following the UORA procedure as defined in 26.5.4 (UL OFDMA-based random access (UORA)).

NOTE—How an SME considers a probe request or AP suitable is outside the scope of this standard.

c) Perform the basic access procedure as defined in 10.3.4.2 (Basic access). While waiting for access to WM, STA may send one or more Probe Request frames by following the UORA procedure and proceed to step i)

d) Send a probe request to the broadcast destination address. The probe request is sent with the SSID and BSSID from the received MLME-SCAN.request primitive. When either the SSID List or Short SSID List or both are ~~is~~ present in the MLME-SCAN.request primitive, send one or more Probe Request frames, each with ~~an SSID~~ one or more SSIDs indicated in either the SSID List or Short SSID List or both, and the BSSID from the MLME-SCAN.request primitive

11.1.4.3.4 Criteria for sending a response

Change item g) in the first paragraph as follows:

A STA that receives a Probe Request frame shall not respond if any of the following apply:

g) The STA is not a mesh STA and none of the following criteria are met:

1) The SSID in the Probe Request frame is the wildcard SSID.

2) The SSID in the Probe Request frame matches the SSID of the STA's.

2a) The STA is an AP that is in the same co-located AP set as a 6 GHz AP, the SSID in the Probe Request frame matches the SSID of the 6 GHz AP, and the STA reports the co-located 6 GHz AP in Beacon and Probe Response frames, see 26.17.2.4 (Out of band discovery of a 6 GHz BSS).

3) The STA is a member of a multiple BSSID set and the SSID in the Probe Request frame matches any of the SSIDs of the members of that multiple BSSID set.

4) ~~The~~ dot11SSIDListImplemented is true, the SSID List element is present in the Probe Request frame and includes the SSID of the STA's BSS.

5) dot11SSIDListImplemented is true, the STA is an AP that is in the same co-located AP set as a 6 GHz AP, the SSID List element is present in the Probe Request frame and includes the SSID corresponding to the co-located 6 GHz AP, and the AP reports the co-located 6 GHz AP in Beacon and Probe Response frames, see 26.17.2.4 (Out of band discovery of a 6 GHz BSS).

6) dot11ShortSSIDListImplemented is true, the Short SSID List element is present in the Probe Request frame and includes the Short SSID field corresponding to the SSID of the STA's BSS.

7) dot11ShortSSIDListImplemented is true, the STA is an AP that is in the same co-located AP set as a 6 GHz AP, the Short SSID List element is present in the Probe Request frame and includes the Short SSID field corresponding to the SSID of the 6 GHz AP and the AP reports this 6 GHz AP in its Beacon and Probe Response frames, see 26.17.2.4 (Out of band discovery of a 6 GHz BSS).

Change the 2nd paragraph, inserting a new item in the list following item 3) as follows:

A FILS STA shall not respond to a Probe Request frame if any of the following criteria is met for a FILS Request Parameters element contained in the Probe Request frame:

3a) If the FILS Criteria field is present in the FILS Requests Parameters element and the PHY Support Criterion of the FILS Criteria field of the FILS Request Parameters element is 3 and the responding STA is not HE capable.

11.1.4.3.10 Enhanced FILS active scanning to preferred AP

Insert the following into bulleted list of the 1st paragraph after Fragment element and before Vendor specific element:

- TWT element
- MU EDCA Parameter Set element
- NDP Feedback Report Parameter set element
- UORA Parameter Set element
- Spatial Reuse Parameter Set element
- HE BSS Load element
- Quiet Time Parameter element

11.2 Power management

11.2.3 Power management in a non-DMG infrastructure network

11.2.3.2 Non-AP STA power management modes

Change the 1st paragraph as follows:

A non-AP STA can be in one of two power management modes:

- Active mode: The STA receives and transmits frames at any time if the STA is in awake state. The non-HE STA remains in the awake state. The HE STA remains in the awake state unless the STA is unavailable. A STA that is unavailable is not capable of receiving PPDUs. A STA is permitted to be unavailable as described in 26.14.3 (Opportunistic power save), 26.14.1 (Intra-PPDU power save for non-AP HE STAs) and 26.8.4.4 (TWT Information frame exchange for flexible wake time).
- Power save (PS) mode: The STA enters the awake state to receive or transmit frames. The STA remains in the doze state otherwise.

11.2.3.6 AP operation

Change the 1st paragraph as follows:

An AP shall maintain for each currently associated STA a Power Management status that indicates in which power management mode the STA is currently operating. APs that implement and signal their support of APSD shall maintain for each currently associated STA an APSD and an access policy status that indicates whether the STA is presently using APSD and shall maintain the schedule (if any) for the STA. An AP shall, depending on the power management mode of the STA, temporarily buffer BUs destined to the STA. An AP implementing APSD shall, if a STA is using APSD and is in PS mode, temporarily buffer BUs destined to that STA. No BUs addressed directly to STAs operating in the active mode shall be buffered for power management reasons. An HE AP should not transmit to an HE STA if the STA might be unavailable, as defined in 26.8.4.4 (TWT Information frame exchange for flexible wake time) and 26.14.3 (Opportunistic power save), unless the transmission is solicited by the STA.

Change items f) and g) in the 2nd paragraph as follows:

The following rules describe the operation:

f) When dot11FMSActivated is false, the AP shall transmit all buffered non-GCR-SP (11ak)non-SYNRA group addressed BUs immediately after every DTIM or during broadcast TWT SPs within that beacon interval as defined in 26.8.3.2 (Rules for TWT scheduling AP).

When dot11FMSActivated is true and the AP has established an FMS delivery interval for a multicast stream, the AP shall transmit all non-GCR-SP (11ak)non-SYNRA group addressed BUs belonging to particular FMS stream immediately after the DTIM that has the Current Count field of the FMS Counter field(M101) set to 0 for that particular FMS stream <u>or during broadcast TWT SPs within that beacon interval as defined in 26.8.3.2 (Rules for TWT scheduling AP)</u>.

The More Data subfield of each group addressed frame shall be set to indicate the presence of further buffered non-GCR-SP group addressed BUs that will be delivered using MPDUs with an RA other than a SYNRA. If the AP is unable, before the primary or secondary TBTT following the DTIM, to transmit all of the buffered non-GCR-SP group addressed BUs(11ak) that will be delivered using MPDUs with an RA other than a SYNRA, then the AP shall set the bit for AID 0 (zero) in the TIM element to 1 for a single BSSID or set the corresponding group address bit to 1 for multiple BSSIDs, as defined in 9.4.2.5 (TIM element), and when dot11FMSActivated is true, shall set the appropriate bits in the FMS Descriptor element as described in 9.4.2.74 (FMS Descriptor element) to indicate for which non-GCR-SP non-SYNRA group addresses there are still buffered BUs, until all buffered non-GCR-SP group addressed BUs that will be delivered using MPDUs with an RA other than a SYNRA have been transmitted.

When the AP transmits an STBC DTIM or TIM Beacon frame, the AP shall retransmit all non-GCR-SP group addressed BUs that will be delivered using MPDUs with an RA other than a SYNRA and that were transmitted following the non-STBC DTIM or TIM Beacon frame except that they are transmitted using the basic STBC MCS. It may be the case that a complete set of buffered non-GCR-SP non-SYNRA group addressed BUs is sent over a period of time during which non-STBC and STBC transmissions are interleaved, but the transition from non-STBC group addressed transmissions to STBC group addressed transmissions shall be preceded by the transmission of an STBC Beacon frame and the transition from STBC group addressed transmissions to non-STBC group addressed transmissions shall be preceded by the transmission of a non-STBC Beacon frame.

g) When the AP receives a PS-Poll frame from a STA that is in PS mode, it shall forward to the STA a single buffered BU. The AP shall respond after a SIFS either with a Data or Management frame, or with an Ack frame; in which case the corresponding Data or Management frame is delayed. Until the transmission of this BU either has succeeded or is presumed failed (when maximum retries are exceeded), the AP shall acknowledge but ignore all PS-Poll frames from the same STA. This prevents a retried PS-Poll frame from being treated as a new request to deliver a buffered BU.

For a STA using U-APSD, the AP transmits one BU destined for the STA from any AC that is not delivery-enabled in response to PS-Poll frame from the STA. The AP should transmit the BU from the highest priority AC that is not delivery-enabled and that has a buffered BU. When all ACs associated with the STA are delivery-enabled, the AP transmits one BU from the highest priority AC that has a BU.

For a STA in PS mode and not using U-APSD, the AP shall set the More Data subfield of the response Data or Management frame to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) for the polling STA. For a STA using U-APSD, the AP shall set the More Data subfield to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) that do not use delivery-enabled ACs. When all ACs associated with the STA are delivery-enabled, the AP shall set the More Data subfield to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) using delivery-enabled ACs.

If there are buffered BUs to transmit to the STA, the AP may set the More Data bit in a QoS +CFAck frame to 1 in response to a QoS Data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the QoS +CF-Ack frame. An AP may also set the More Data bit in an Ack frame to 1 in response to a QoS Data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the Ack frame, if that PS STA has set the More Data Ack subfield in the QoS Info field ~~QoS Capability element~~ to 1. An HE AP may also set the More Data bit in a BlockAck or Multi-STA BlockAck frame to 1 to indicate that it has one or more pending BUs buffered for the HE PS STA identified by the RA in the BlockAck or Multi-STA BlockAck frame, if that HE PS STA has set the More Data Ack subfield in the QoS Info field to 1. An HE AP indicates support of sending Ack, BlockAck, or Multi-STA BlockAck frames with a nonzero More Data subfield by setting the More Data Ack subfield to 1 in the QoS Info field of frames it transmits.

Unless indicated above, the AP shall set the More Data bit to 0.

11.2.3.7 Receive operation for STAs in PS mode

Change item e) in the 2nd paragraph as follows:

The following rules describe operation of a STA in PS mode:

e) When dot11FMSActivated is false and ReceiveDTIMs is true, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM sent by the AP of the BSS.

When dot11FMSActivated is true and ReceiveDTIMs is true and the STA has been granted by the AP an alternate delivery interval for a multicast stream, the STA shall wake up before the non-STBC DTIM or STBC DTIM having Current Count of FMS Counter field set to 0 for that particular FMS stream.

A STA that stays awake to receive group addressed BUs shall elect to receive all group addressed non-STBC transmissions or all group addressed STBC transmissions and remain awake until the More Data subfield of the appropriate type (non-STBC or STBC) of group addressed BUs indicates there are no further buffered group addressed BUs of that type, or until a TIM is received indicating there are no more buffered group addressed BUs of that type, or until an FMS Descriptor element is received indicating that there are no further buffered group addressed BUs for which the STA has previously received an FMS Response element in a frame that has a value in Address 1 that matches its MAC address or that has an Address 1 value that is a group address corresponding to a group of which it is a member and that was transmitted by the AP with which it is associated and which had an Element Status value in the FMS Status subelement of "Accept". If a STA receives a QoS +CFAck frame from its AP with the More Data bit equal to 1, then the STA shall operate ~~exactly~~ as if it received a TIM with its AID bit equal to 1. If a STA has set the More Data Ack subfield in the QoS Info field ~~QoS Capability element~~ to 1, then if it receives an Ack frame from its AP with the More Data bit equal to 1, the STA shall operate ~~exactly~~ as if it received a TIM with its AID bit equal to 1. If an HE STA has set the More Data Ack subfield in the QoS Info field to 1, then if it receives a BlockAck or Multi-STA BlockAck frame from its AP with the More Data bit equal to 1, the STA shall operate as if it received a TIM with its AID bit equal to 1. For example, a STA that is using the PS-Poll delivery method shall issue a PS-Poll frame to retrieve a buffered BU. See also 10.3.6 (Group addressed MPDU transfer procedure).

11.2.3.9 STAs operating in active mode

Change as follows:

A STA operating in this mode shall have its receiver activated continuously, unless the STA is allowed to be temporarily unavailable with opportunistic power save procedure as defined in 26.14.3 (Opportunistic power save), or with intra-PPDU power save procedure as defined in 26.14.1 (Intra-PPDU power save for non-AP HE STAs) or in 26.8.4.4 (TWT Information frame exchange for flexible wake time); such STAs do not need to interpret the TIM elements in Beacon frames.

11.2.3.15 TIM Broadcast

Change the 3rd paragraph as follows (splitting it into two paragraphs):

A non-AP STA may activate the TIM broadcast service by including a TIM Broadcast Request element in a TIM Broadcast Request frame, Association Request frame or Reassociation Request frame that is transmitted to the AP, which specifies the requested interval between TIM frame transmissions (the TIM broadcast interval). On receipt of a properly formatted TIM Broadcast Request element in a TIM Broadcast Request frame, Association Request frame or Reassociation Request frame, the AP shall include a TIM Broadcast Response element in the corresponding TIM Broadcast Response frame, Association Response frame or Reassociation Response frame, when dot11TIMBroadcastActivated is true. A non-AP STA shall transmit a TIM Broadcast Request only if the associated AP has indicated support for TIM Broadcast by setting the TIM Broadcast field of the Extended Capabilities elements that it transmits to 1.

NOTE—An OPS AP that transmits TIM frames as described in 26.14.3 (Opportunistic power save) is expected to encode the TIM bits such that an associated non-AP STA that does not support OPS operation can use the information received in the TIM frame as it would do when receiving a TIM frame transmitted following the TIM Broadcast procedure.

When the requested TIM broadcast interval is acceptable, the AP shall include a TIM Broadcast Response element specifying the requested TIM broadcast interval and a Status field indicating “Accept” when no valid TSF timestamp is present in the TIM frames, or “Accept, valid timestamp present in TIM frames” when a valid TSF timestamp is present in the TIM frames. When the AP overrides the requested TIM broadcast interval, it shall include a TIM Broadcast Response element specifying a different TIM broadcast interval and a Status field indicating “Overridden” when no valid TSF timestamp is present in the TIM frames, or “Overridden, valid timestamp present in TIM frames” when a valid TSF timestamp is present in the TIM frames, and include in the TIM Broadcast Response element the smallest TIM broadcast interval that is currently active. Otherwise, the AP shall include a TIM Broadcast Response element with a Status field indicating “Denied.” The Status field in a TIM Broadcast Response element that is included in an Association Response frame or Reassociation Response frame has implications only for the TIM Broadcast negotiation.

Change the 11th paragraph as follows:

The AP shall increase the value (modulo 256) of the Check Beacon field in the next transmitted TIM frame(s) when a critical update occurs to any of the elements inside the Beacon frame. The following events shall classify as a critical update:

a) Inclusion of a Channel Switch Announcement element
b) Inclusion of an Extended Channel Switch Announcement element
c) Modification of the EDCA parameters element
d) Inclusion of a Quiet element
e) Modification of the DSSS Parameter Set
f) Modification of the CF Parameter Set element
g) Modification of the HT Operation element
h) Inclusion of a Wide Bandwidth Channel Switch element
i) Inclusion of a Channel Switch Wrapper element
j) Inclusion of an Operating Mode Notification element
k) Inclusion of a Quiet Channel element
l) Modification of the VHT Operation element
m) Modification of the HE Operation element
n) Insertion of a Broadcast TWT element
o) Inclusion of the BSS Color Change Announcement element

p) Modification of the MU EDCA Parameter Set element

q) Modification of the Spatial Reuse Parameter Set element

NOTE—Modification of an element means that at least one value of a field in the element is changed. Inclusion of an element means that the element is included in a Beacon frame. The Insertion of an element means that the element was not present in the previous Beacon frame and is present in the current Beacon frame will be carried in the next Beacon frame.

11.2.6 SM power save

Insert the following after the 2nd paragraph:

The basic rules for a STA are defined below. Additional rules for an HE STA that sets the HE Dynamic SM Power Save subfield to 1 in the HE MAC Capabilities Information field of the HE Capabilities element it transmits in the 2.4 GHz or 5 GHz band, or sets the SM Power Save subfield to 1 in the HE 6 GHz Band Capabilities element it transmits in the 6 GHz band is defined in 26.14.4 (HE dynamic SM power save).

Change the 4th paragraph as follows:

The STA can determine the end of the frame exchange sequence through any of the following:

— It receives an individually addressed frame addressed to another STA.

— It receives a frame with a TA that differs from the TA of the frame that started the TXOP.

— It receives a PPDU and classifies the PPDU as inter-BSS PPDU (see 26.2.2 (Intra-BSS and inter-BSS PPDU classification)).

— It receives an HE MU PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS in which the STA is associated, the RXVECTOR parameter does not have any STA_ID of an RU that identifies the STA as the recipient or one of the recipients of the RU (see 26.11.1 (STA_ID)), and the BSS Color Disabled subfield in the most recently received HE Operation element from the AP with which the STA is associated is 0.

— The CS 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)).

11.3 STA authentication and association

11.3.3 Frame filtering based on STA state

Insert a new item xiv) under item 1) under item a) in the 5th paragraph as follows:

The frame classes are defined as follows:

a) Class 1 frames

   1) Control frames

      xiv) In an HE BSS Basic Trigger frame and Multi-STA BlockAck frame

11.3.5 Association, reassociation, and disassociation

11.3.5.3 AP or PCP association receipt procedures

Insert the following list item after item h:

h1) The SME shall refuse an association request from an HE STA that does not support all of the <HE-MCS, NSS> tuples indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive.

11.3.5.5 AP or PCP reassociation receipt procedures

Insert the following list item after item h:

h1) The SME shall refuse a reassociation request from an HE STA that does not support all of the <HE-MCS, NSS> tuples indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive.

11.3.8 Neighbor report information upon rejection with suggested BSS transition

Insert the following at the end of the subclause:

An HE STA that has received from an HE AP an Authentication or (Re)Association Response frame that has the Status Code field set to REJECTED_WITH_SUGGESTED_BSS_TRANSITION and that includes one or more Neighbor Report elements for BSSs that are part of the ESS of the HE AP shall, if it re-attempts to associate with the ESS, select an AP from (one of) the Neighbor Report element(s).

11.4 TS operation

11.4.4 TS setup

11.4.4.4 TS setup procedures for both AP and non-AP STA initiation

Change the 1st paragraph as follows:

The non-AP STA's SME decides that a TS needs to be created <u>or non-AP HE STA traffic characteristics and QoS requirements needs to be provided. The mechanism to provide traffic characteristics and QoS requirements are described in 26.5.8 (Use of TSPEC by HE STAs)</u>. How it does this, and how it selects the TSPEC or DMG TSPEC parameters, is beyond the scope of this standard. The SME generates an MLMEADDTS.request primitive containing a TSPEC or DMG TSPEC. A TSPEC or DMG TSPEC may also be generated autonomously by the MAC without any initiation by the SME.

11.7 TPC procedures

Change the 1st paragraph as follows:

Regulations ~~that apply to the 5 GHz band~~ in most regulatory domains require RLANs operating in the 5 GHz band <u>and 6 GHz band</u> to use transmitter power control, involving specification of a regulatory maximum transmit power and a mitigation requirement for each allowed channel. This standard describes such a mechanism, referred to as transmit power control (TPC).

11.10 Radio measurement procedures

11.10.14 Multiple BSSID set

Change the 1st paragraph as follows:

A multiple BSSID set is characterized as follows:

— All members of the set use a common operating class, channel, Channel Access Functions, and antenna connector.

— The set has a maximum range of 2^n for at least one n, where ~~1 ≤ n ≤ 46~~

- <u>1 ≤ n ≤ 8 if dot11MultiBSSIDImplemented is true</u>

- $1 \le n \le 46$ if dot11MultiBSSIDImplemented (if present) is false and dot11RMMeasurementPilotActivated is nonzero

— Members of the set have the same 48-n bits (BSSID[0:(47-n)]) in their BSSIDs.

— All BSSIDs within the multiple BSSID set are assigned in a way that they are not available as MAC addresses for STAs using a different operating class, channel or antenna connector.

NOTE—For example, if the APs within BSSs with BSSIDs 16, 17, and 27 share the same operating class, channel and antenna connector, and the range of MAC addresses from 16–31 inclusive are not assigned to other STAs using a different antenna connector, then the BSSIDs 16, 17, and 27 are members of a multiple BSSID set. The set is described by n = 4 ($2^n = 16$) with BSSIDs in the range 16–31. The set cannot be described by n = 8 for instance since at least one of the BSSIDs in the range 0–255 might be used as a BSSID by an AP that does not share the same operating class, channel, and antenna connector.

11.21 Tunneled direct-link setup

11.21.1 General

Insert the following before the last paragraph:

The HE Operation element shall be present in a TDLS Setup Confirm frame when both STAs are HE capable.

11.22 Wireless network management procedures

11.22.2 Event request and report procedures

11.22.2.1 Event request and event report

Change the 1st paragraph as follows:

The Event Request and Event Report frames enable network real-time diagnostics. A STA whose dot11EventsActivated equal to true shall support event requests and reports and shall set to 1 the Event field of the Extended Capabilities elements that it transmits. If dot11EventsActivated is true and the Event Type field is neither BSS Color Collision nor BSS Color In Use, a STA shall log all Transition, RSNA, peer-to-peer, and WNM log events, including the corresponding TSF, UTC Offset and Event Time Error. An HE STA that has dot11EventsActivated equal to true and reports BSS color collisions shall log all BSS color collision events, including the TSF value when the STA finished logging the events that are reported (see 11.22.2.7 (BSS color collision event)).

A STA with either dot11AutonomousBSSColorCollisionReportingImplemented equal to true or dot11AutonomousBSSColorInUseReportingImplemented equal to true shall set the Event field of the Extended Capabilities elements that it transmits to 1.

Insert two new subclauses at the end of 11.22.2:

11.22.2.7 BSS color collision event

The BSS color collision event report enables a non-AP HE STA to inform its associated AP whether a BSS color collision has occurred. The report carries information about the BSS color used by OBSSs that the reporting STA is able to detect (see 26.17.3.5.2 (Autonomous reporting of BSS color collision)).

11.22.2.8 BSS color in use event

If a non-AP HE STA communicates with a peer STA with a BSS color that is different from the BSS color used by its associated AP, the non-AP HE STA may send a BSS color in use event report to its associated AP in which the Event Report field has the BSS color used in the communication with the peer STA.

A non-AP HE STA shall send a BSS color in use event report to its associated AP with the Event Report field set to 0 to cancel a previously sent BSS color in use event report.

An AP shall not transmit frames to a non-AP HE STA during a TXOP, if it has received a BSS color in use event report from that non-AP HE STA with a nonzero BSS color in the Event Report field and the AP ignores an inter-BSS PPDU with the same BSS color value as the one carried in the Event Report field to obtain a TXOP by following the procedure in 26.10.2.2 (General operation with non-SRG OBSS PD level) and 26.10.2.3 (General operation with SRG OBSS PD level).

11.22.6 Fine timing measurement (FTM) procedure

11.22.6.4 Measurement exchange

Change the 10th paragraph as follows:

For the Fine Timing Measurement frames transmitted during the FTM session:

— The responding STA shall not use a bandwidth wider than that indicated by the STA in the initial Fine Timing Measurement frame.

— The responding STA shall not use an HE format if the STA indicated VHT or HT-mixed or non-HT format in the initial Fine Timing Measurement frame.

— The responding STA shall not use a VHT format if the STA indicated HT-mixed or non-HT format in the initial Fine Timing Measurement frame.

— The responding STA shall not use an HT format if the STA indicated non-HT format in the initial Fine Timing Measurement frame.

11.22.7 BSS transition management for network load balancing

11.22.7.1 BSS transition capability

Change the 3rd paragraph as follows:

Implementation of BSS transition management is optional for a WNM STA that is not a non-AP HE STA. A STA that implements BSS transition management has dot11BSSTransitionImplemented equal to true. ~~When~~ If dot11BSSTransitionImplemented is true, dot11WirelessManagementImplemented shall be true. A STA with dot11BSSTransitionActivated equal to true shall support BSS transition management and shall set to 1 the BSS Transition field of the Extended Capabilities elements that it transmits. A non-AP HE STA shall have dot11BSSTransitionImplemented and dot11BSSTransitionActivated equal to true.

11.22.7.4 BSS transition management response

Change the 2nd paragraph as follows:

The STA's SME may include the result of its BSS transition decision in the Target BSSID field and BTM Status Code field in the MLME-BTM.response primitive. A BTM Status Code field set to a value of 0 (i.e., Accept) indicates the STA will transition from the current BSS. If a non-HE STA's SME receives an MLME-BTM.indication primitive indicating a BSS transition management request that it is unable to comply with, it may issue an MLME-BTM.response primitive with a status code indicating rejection may issue an MLME-BTM.response primitive with a valid status code not equal to a value of 0 (i.e., Accept) indicating rejection if it is unable to comply with this BSS transition management request.

Insert a new subclause at the end of 11.22.7 as follows:

11.22.7.5 Planned ESS

The AP may transmit an ESS Report element (see 9.4.2.255 (ESS Report element)) to indicate whether or not it is in a planned ESS, to assist associated STAs' roaming. If it indicates that it is in a planned ESS, it indicates whether or not it is at the physical edge of the ESS and can provide a recommendation on the RSSI level to consider for BSS transition.

If the AP transmits an ESS Report element, it shall set the Planned ESS subfield in the ESS Information field to 1 if it is part of an ESS that is planned with several BSSs in overlapping configuration, whereby an associated STA may adjust its BSS transition algorithms accordingly. Otherwise, it shall set the Planned ESS subfield to 0.

If the Planned ESS subfield is 1, then the AP shall set the Edge Of ESS subfield in the ESS Information field of the ESS Report element to 1 if the AP's BSS is at the edge of an ESS (e.g., exit of a building). Otherwise, it shall set the Edge Of ESS subfield to 0.

NOTE—A non-AP STA could then prepare for more aggressive roaming or the device the non-AP STA is in could then prepare for switching to a different system. However, how the non-AP STA uses the edge of ESS information is implementation specific and beyond the scope of this standard.

If the Planned ESS subfield is 1, then the AP shall set the Recommended BSS Transition RSSI Threshold Within ESS subfield in the ESS Information field of the ESS Report element to indicate the Beacon RSSI below which an associated STA should initiate a BSS transition. Otherwise, it shall set the Recommended BSS Transition RSSI Threshold Within ESS subfield to 0.

NOTE—A non-AP STA could then use the Recommended BSS Transition RSSI Threshold Within ESS subfield to modify when it starts scanning for a new BSS. However, how the non-AP STA adjusts its BSS transition algorithms is implementation specific and beyond the scope of this standard.

The value of the Edge Of ESS subfield and the Recommended BSS Transition RSSI Threshold Within ESS subfield may be changed by the AP if conditions in the ESS change. An AP shall not change the value of the Planned ESS subfield over the lifetime of the BSS.

11.32 Multi-band operation

11.32.5 On-channel Tunneling (OCT) operation

Change the 1st paragraph as follows:

Either of the following conditions indicates that a STA supports OCT and has dot11OCTOptionImplemented equal to true:

- A STA supports ~~the~~ OCT if the OCT Not Supported subfield within the STA's Multi-band element is 0
- A non-AP STA supports OCT if the OCT field is equal to true in the Extended Capabilities elements it transmits.
- If a reporting AP sends a frame with a Reduced Neighbor Report element with a TBTT Information field describing a reported AP that has the OCT Recommended subfield equal to 1, then both the reporting AP and the reported AP support OCT.

— If a reporting AP sends a frame with a Neighbor Report element describing a reported AP that has the OCT Supported With Reporting AP subfield equal to 1, then both the reporting AP and the reported AP support OCT.

A STA should not perform OCT with a peer STA that does not support ~~the~~ OCT. A STA that does not support ~~the~~ OCT shall ignore a received OCT MMPDU.

Change the 2nd paragraph as follows:

~~OCT allows a STA of a multi-band capable device to transmit an MMPDU that was constructed by a different STA of the same device.~~ OCT provides the following:

— allows a STA of a multi-band capable device or a STA that is in the same device as another STA to transmit or forward an MMPDU that was constructed by, addressed by or addressed to a different STA in the same device
— allows an AP to transmit or forward an MMPDU that was constructed by, addressed by, or addressed to another AP if either one of the APs sends a Reduced Neighbor Report element with a TBTT Information field describing the other AP or if either one of the APs sends a Neighbor Report element describing the other AP, and where both APs support OCT

An MMPDU transmitted this way is referred to as an *OCT MMPDU*. The MLME of the nontransmitting STA that constructs or is the destination of an OCT MMPDU is referred to as an *NT-MLME*. The MLME of the STA that transmits or receives an OCT MMPDU over the air is referred to as a *TR-MLME*. An NT-MLME that constructs an OCT MMPDU destined to a peer NT-MLME does so according to the capabilities of the STA that contains the peer NT-MLME.

NOTE—OCT can be used in conjunction with or independent from the FST setup protocol.

Change the 7th paragraph as follows:

To transmit a tunneled MMPDU, the SME of a ~~multi-band capable device~~ STA that supports OCT generates an OCT MLME request primitive that includes the peer Multi-band element and the local Multi-band element. If the OCT MLME request primitive is the MLME-SCAN.request primitive with ScanType parameter set to ACTIVE, the BSSID field within the peer Multi-band element shall be set to the value of the BSSID parameter in the MLME-SCAN.request primitive and the BSSID field within the local Multi-band element shall be set to an individual MAC address.

11.46 Fast Initial Link Setup (FILS) procedures

11.46.2 FILS Discovery frame generation and usage

11.46.2.1 FILS Discovery frame transmission

Change the 3rd and 4th paragraph as follows:

If an AP transmits a FILS Discovery frame as a non-HT duplicate PPDU in an 80+80 MHz channel bandwidth, the Channel Center Frequency Segment 1 field shall be present in the FILS Discovery frame and shall be set to the channel center frequency of the frequency segment 1 for an 80+80 MHz VHT or HE operating channel.

A FILS AP should transmit FILS Discovery frame(s) in every beacon interval. The interval between the transmission of a Beacon frame and a subsequent FILS Discovery frame shall be no less than the interval indicated in dot11FILSFDFrameBeaconMinimumInterval. The transmission interval between subsequent FILS Discovery frames by an AP in a beacon interval shall be no less than the interval indicated in dot11-

FILSFDFrameBeaconMinimumInterval. If dot11FILSFDFrameBeaconMaximumInteval is not equal to 0, and if a Beacon frame, broadcast Probe Response frame or FD frame has not been transmitted by an AP for a period that is equal to dot11FILSFDFrameBeaconMaximumInterval, that AP shall queue for transmission a FD frame, broadcast Probe Response frame or a Beacon frame unless the next TBTT is within a duration indicated by the value of dot11FILSFDFrameBeaconMinimumInterval.

Insert the following at the end of the subclause:

The Address 1 field of the FILS Discovery frame shall be set to the broadcast address.

For the APs in a multiple BSSID set, only the AP corresponding to the transmitted BSSID may transmit a FILS Discovery frame; other APs corresponding to nontransmitted BSSIDs shall not transmit a FILS Discovery frame. If dot11MultiBSSIDImplemented is true, then the following applies to the fields in the FILS Discovery frame:

— The SSID or Short SSID field shall be set to the SSID or short SSID, respectively, of the transmitted BSSID

— The FILS Capability field shall be present and the Multiple BSSIDs Presence Indicator subfield shall be set to 1

11.50 Reduced neighbor report

Change the 1st paragraph as follows:

In Beacon and Probe Response frames, a Reduced Neighbor Report element may be transmitted by an AP with dot11TVHTOptionImplemented~~, or~~ dot11FILSActivated or dot11ColocatedRNRImplemented equal to true. In FILS Discovery frames, a Reduced Neighbor Report element is optionally sent by a FILS AP. An AP that operates in the 2.4 GHz or 5 GHz band and that is in the same co-located AP set as one or more 6 GHz APs shall follow the rules in 26.17.2.4 (Out of band discovery of a 6 GHz BSS) for including a Reduced Neighbor Report element in Beacon and Probe Response frames. A Reduced Neighbor Report element contains information on neighbor APs. A Reduced Neighbor Report element might not be exhaustive either by choice or by the fact that there may be neighbor APs not known to the AP.

An AP with dot11MultiBSSIDImplemented equal to true shall not include Reduced Neighbor Report element in the Nontransmitted BSSID Profile subelement of the Multiple BSSID element.

NOTE—The Beacon, Probe Response or FILS Discovery frame of an AP with dot11MultiBSSIDImplemented equal true can carry the Reduced Neighbor Report element.

Insert the following paragraphs after the 1st paragraph

If an AP reported in a TBTT Information field in a Reduced Neighbor Report element is not part of a multiple BSSID set, then the BSS Parameters subfield, if included, shall have the Multiple BSSID subfield set to 0. If an AP reported in a TBTT Information field in a Reduced Neighbor Report element is a transmitted BSSID, then the BSS Parameters subfield, if included, shall have the Multiple BSSID subfield set to 1 and the Transmitted BSSID subfield set to 1. If an AP reported in a TBTT Information field in a Reduced Neighbor Report element is a nontransmitted BSSID, then the BSS Parameters subfield, if included, shall have the Multiple BSSID subfield set to 1 and the Transmitted BSSID subfield set to 0.

An HE AP with dot11MultiBSSIDImplemented equal to true may advertise one or more nontransmitted BSSIDs in the multiple BSSID set by including the Reduced Neighbor Report element in its Beacon, Probe Response or FILS Discovery frames with the BSS Parameters subfield of the TBTT Information field containing the Co-Located subfield set to 1, the Multiple BSSID subfield set to 1 and the Transmitted BSSID subfield set to 0 and the Operating Class and Channel Number fields of the Neighbor AP Information field set to the operating class and channel number, respectively, of the transmitting AP (i.e., the transmitted BSSID).

A reporting AP should set the OCT Recommended subfield to 1 in the BSS Parameters subfield of a TBTT Information field in a Reduced Neighbor Report element if both the reporting AP and the reported AP have dot11OCTOptionImplemented equal to true and the Co-Located AP subfield is 1 in the BSS Parameters subfield corresponding to the reported AP. A reporting AP may set the OCT Recommended subfield to 1 in the BSS Parameters subfield of a TBTT Information field in a Reduced Neighbor Report element if both the reporting AP and the reported AP have the same SSID and have dot11OCTOptionImplemented equal to true and the Co-Located AP subfield is 0 in the BSS Parameters subfield corresponding to the reported AP. If the OCT Recommended subfield is 1 and the Co-Located AP subfield is 1 in the Neighbor AP Information field describing a reported HE AP in the Reduced Neighbor Report element, then a non-AP STA that has dot11OCTOptionImplemented equal to true should use the OCT procedure described in 11.32.5 (On-channel Tunneling (OCT) operation) to perform active scanning, authentication and/or association with the reported AP through over-the-air transmissions with the AP that sent the Reduced Neighbor Report element. If the OCT Recommended subfield is 1 and the Co-Located AP subfield is 0 in the Neighbor AP Information field describing a reported HE AP in the Reduced Neighbor Report element, then a non-AP STA that has dot11OCTOptionImplemented equal to true may use the OCT procedure described in 11.32.5 (On-channel Tunneling (OCT) operation) to perform active scanning, authentication and/or association with the reported AP through over-the-air transmissions with the AP that sent the Reduced Neighbor Report element.

Change the last paragraph of the subclause as follows:

A STA that receives a Neighbor AP Information field with a recognized TBTT Information Field Type subfield but an unrecognized TBTT Information Length subfield ~~shall ignore that Neighbor AP Information field and continue to process remaining Neighbor AP Information fields.~~has two possible ways of processing the received information: (1) ignore that Neighbor AP Information field and continue to process the subsequent Neighbor AP Information fields or (2) process the first 12 octets of each TBTT Information field of the Neighbor AP Information field as if the TBTT Information Length subfield had value 12, ignore the remaining TBTT Information Length minus 12 octets of each TBTT Information field of the Neighbor AP Information field, and continue to process the subsequent Neighbor AP Information fields. If the unrecognized TBTT Information Length value is less than or equal to 12, the STA shall follow the alternative (1). If the unrecognized TBTT Information Length value is greater than 12, an HE STA shall follow the alternative (2) and a non-HE STA shall follow either the alternative (1) or (2).

12. Security

Insert the following at the end if Clause 12:

12.13 Constraints on allowed security parameters

12.13.1 Introduction

This standard defines various security mechanisms of which some are deprecated or obsolete and are not considered to meet current requirements for security. Such mechanisms enable interoperability with legacy devices, but are not suitable for new uses where legacy support is not needed. This subclause describes constraints on security parameter selection for some use cases.

12.13.2 Security constraints in the 6 GHz band

The following apply to a STA operating in the 6 GHz band:

- The STA shall not use the following pre-RSNA security methods: WEP, Open System authentication without encryption, Shared Key authentication
- The STA shall not use the following cipher suite selectors:
  - 00-0F-AC:0 (Use group cipher suite)
  - 00-0F-AC:1 (WEP-40)
  - 00-0F-AC:2 (TKIP)
  - 00-0F-AC:5 (WEP-104)
- The STA should use Opportunistic Wireless Encryption, as specified in IETF RFC 8110, when connecting in an infrastructure BSS without authentication (as a replacement for Open System authentication without encryption)
- The STA shall not use the following AKM suite selectors:
  - 00-0F-AC:2 (PSK)
  - 00-0F-AC:4 (FT authentication using PSK)
  - 00-0F-AC:6 (PSK with SHA-256)
  - 00-0F-AC:19 (FT authentication using PSK with SHA-384)
  - 00-0F-AC:20 (PSK with SHA-384)
- The STA should use SAE (AKM suite selectors 00-0F-AC:8 and/or 00-0F-AC:9) if authenticating using a password where IEEE Std 802.1X is not used (as a replacement for PSK)
- The STA shall use management frame protection (MFPR=1) when using RSN

14. MLME mesh procedures

14.2 Mesh discovery

14.2.4 Mesh STA configuration

Change as follows:

The mesh STA configuration consists of the mesh profile (see 14.2.3 (Mesh profile)), the Supported Rates and BSS Membership Selectors element, the Extended Supported Rates and BSS Membership Selectors element, the HT Operations element (if present), ~~and~~ the VHT Operations element (if present), and the HE Operation element (if present).

Mesh STA configurations are identical if the following conditions hold:

- The mesh profiles are identical.
- The BSSBasicRateSet parameter of the MLME-START.request primitive is identical to the basic rate set indicated by the Supported Rates and BSS Membership Selectors element and Extended Supported Rates and BSS Membership Selectors element, if present, received in the MLME-MESH-PEERINGMANAGEMENT.indication primitive.
- For HT mesh STAs, the Basic HT-MCS Set field of the HT Operation parameter of the MLME-START.request primitive is identical to the HT Operation element received in the MLME-MESH-PEERINGMANAGEMENT.indication primitive.
- For VHT mesh STAs, the Basic VHT-MCS and NSS fields in the VHT Operation element of the MLME-START.request primitive are identical to the Basic VHT-MCS and NSS fields in the VHT Operation element received in the MLME-MESHPEERINGMANAGEMENT.indication primitive.
- For HE mesh STAs, the Basic HE-MCS and NSS Set field in the HE Operation element of the MLME-START.request primitive are identical to the Basic HE-MCS and NSS Set field in the HE Operation element received in the MLME-MESHPEERINGMANAGEMENT.indication primitive.

14.2.7 Candidate peer mesh STA

Insert a new bullet after bullet e) in the second paragraph and reletter:

The discovered neighbor mesh STA shall be considered a candidate peer mesh STA if and only if all of the following conditions are met:

e1) If both the scanning mesh STA and the discovered neighbor STA are HE STAs, the mesh STA uses the same value for the Basic HE-MCS And NSS Set field in its HE Operation element as received in the Beacon or Probe Response frame from the neighbor mesh STA.

18. Extended Rate PHY (ERP) specification

18.2 PHY-specific service parameter list

Insert the following rows after the last row in Table 18-1:

Table 18-1—TXVECTOR parameters

Parameter	Value
CH_BANDWIDTH_IN_NON_HT	If present, CBW20 or CBW40
DYN_BANDWIDTH_IN_NON_HT	If present, Static or Dynamic

Insert the following rows after the last row in Table 18-3:

Table 18-3—RXVECTOR parameters

Parameter	Value
CH_BANDWIDTH_IN_NON_HT	If present, CBW20 or CBW40
DYN_BANDWIDTH_IN_NON_HT	If present, Static or Dynamic

Insert new Clauses 26 and 27 following Clause 25 as follows:

26. High Efficiency (HE) MAC specification

26.1 Introduction

An HE STA supports the MAC and MLME functions defined in Clause 26 in addition to the MAC functions defined in Clause 10, the MLME functions defined in Clause 11, and the security functions defined in Clause 12 except when the functions in Clause 26 supersede the functions in Clause 10 or Clause 11. A successfully acknowledged frame transmitted by a non-AP STA in response to a Basic Trigger frame is a successful frame exchange initiated by the STA as referred to in Clause 11 and Clause 12.

26.2 HE channel access

26.2.1 TXOP duration-based RTS/CTS

In an HE BSS, the use of RTS/CTS can be TXOP duration-based or PSDU length-based. An HE AP can configure a non-AP HE STA to use the TXOP duration-based RTS/CTS exchanges to help mitigate interference in dense environments.

An HE AP may set the TXOP Duration RTS Threshold subfield in the HE Operation Parameters field in the HE Operation element it transmits to a value between 1 and 1022 to enable TXOP duration-based RTS/CTS exchanges of its associated STAs. The AP may set the TXOP Duration RTS Threshold field to 1023 to disable TXOP duration-based RTS/CTS exchanges of its associated STAs. The AP may in Beacon and Probe Response frames set the TXOP Duration RTS Threshold field to 0 to make no changes to TXOP duration-based RTS/CTS exchanges of its associated STAs.

If the TXOP Duration RTS Threshold subfield in the HE Operation Parameters field in the most recently received HE Operation element sent by the AP with which a non-AP HE STA is associated is equal to a non-zero value, then the non-AP HE STA shall set dot11TXOPDurationRTSThreshold to the value of the TXOP Duration RTS Threshold subfield. Otherwise, the non-AP HE STA shall not update dot11TXOPDurationRTSThreshold.

The TXOP duration-based RTS/CTS exchange is disabled at a non-AP HE STA if dot11TXOPDurationRTSThreshold is 1023. The TXOP duration-based RTS/CTS exchange is enabled at a non-AP HE STA when dot11TXOPDurationRTSThreshold is less than 1023.

A non-AP HE STA shall use an RTS/CTS exchange to initiate a TXOP if TXOP duration-based RTS/CTS exchange is enabled at a non-AP HE STA and the following conditions are met:

- The STA intends to transmit individually addressed frames to the HE AP or to a TDLS peer STA
- The TXOP duration is greater than or equal to 32 μs × dot11TXOPDurationRTSThreshold

Otherwise, the non-AP HE STA follows the rules defined in 10.3.1 (General).

26.2.2 Intra-BSS and inter-BSS PPDU classification

A STA shall classify a received PPDU as an inter-BSS PPDU if at least one of the following conditions is true:

- The RXVECTOR parameter BSS_COLOR is not 0 and is not the BSS color of the BSS of which the STA is a member.

- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID not equal to the BSSID[39:47] of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs and the RXVECTOR parameter GROUP_ID is 0.
- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID[5:8] not equal to the 4 LSBs of the BSS color announced by the BSS of which the STA whose dot11PartialBSSColorImplemented is equal to true is a member and RXVECTOR parameter GROUP_ID equal to 63 when the Partial BSS Color field in the most recent HE Operation element is 1.
- The PPDU is either a VHT MU PPDU or an HE MU PPDU with the RXVECTOR parameter UPLINK_FLAG equal to 0 and the STA is an AP.
- The PPDU carries a frame that has a BSSID field, the value of which is not the BSSID of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs or the wildcard BSSID.
- The PPDU carries a frame that does not have a BSSID field but has both an RA field and TA field, neither value of which is equal to the BSSID of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs. The Individual/Group bit in the TA field value is forced to 0 prior to comparison.

A STA shall classify the received PPDU as an intra-BSS PPDU if at least one of the following conditions is true:

- The RXVECTOR parameter BSS_COLOR of the PPDU carrying the frame is the BSS color of the BSS of which the STA is a member or the BSS color of any TDLS links to which the STA belongs if the STA is an HE STA associated with a non-HE AP.
- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID equal to the BSSID[39:47] of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs and the RXVECTOR parameter GROUP_ID equal to 0.
- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID[5:8] equal to the 4 LSBs of the BSS color announced by of the BSS of which the STA whose dot11PartialBSSColorImplemented is equal to true is a member, the RXVECTOR parameter GROUP_ID is equal to 63 and the Partial BSS Color field in the most recent HE Operation element is 1.
- The PPDU carries a frame that has an RA, TA or BSSID field value that is equal to the BSSID of the BSS or the BSSID of any BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs. The Individual/Group bit in the TA field value is forced to the value 0 prior to the comparison.
- The PPDU carries a Control frame that does not have a TA field and that has an RA field value that matches the saved TXOP holder address of the BSS or any BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs.

NOTE—See 10.19 (Group ID and partial AID in VHT and CMMG PPDUs) for the definition of PARTIAL_AID[5:8] and BSSID[39:47].

Otherwise, the PPDU cannot be determined as an intra-BSS or inter-BSS PPDU.

If, based on the MAC address information of a frame carried in a received PPDU, the received PPDU satisfies both intra-BSS and inter-BSS conditions, then the received PPDU is classified as an intra-BSS PPDU.

If the received PPDU satisfies the intra-BSS conditions using the RXVECTOR parameter BSS_COLOR and also satisfies the inter-BSS conditions using MAC address information of a frame carried in the PPDU, then the classification made using the MAC address information takes precedence.

A frame carried in a PPDU identified as an intra-BSS PPDU is an intra-BSS frame. A frame carried in a PPDU identified as an inter-BSS PPDU is an inter-BSS frame.

If a STA determines that the BSS color is temporarily disabled (see 26.17.3.3 (Disabling BSS color)), then the RXVECTOR parameter BSS_COLOR of a PPDU shall not be used to classify the PPDU.

26.2.3 SRG PPDU identification

Identification of SRG and non-SRG PPDUs is used during SRG OBSS PD spatial reuse operation as described in 26.10 (Spatial reuse operation).

A non-AP HE STA that has received a Spatial Reuse Parameter Set element from its associated AP with a value of 1 in the SRG Information Present subfield shall use information provided in the Spatial Reuse Parameter Set element to identify BSSs that are members of the STA's SRG to determine if a received inter-BSS PPDU is an SRG PPDU. An HE AP may use an SRG that is different from the SRG that it transmits to other STAs in Spatial Reuse Parameter Set elements to determine whether or not a received inter- BSS PPDU is an SRG PPDU.

A received HE PPDU that is an inter-BSS PPDU is an SRG PPDU if the bit in the SRG BSS Color Bitmap field indexed by the value of the RXVECTOR parameter BSS_COLOR is 1 (see 9.4.2.251 (Spatial Reuse Parameter Set element)). A received VHT PPDU that is an inter-BSS PPDU is an SRG PPDU if the GROUP_ID parameter of the RXVECTOR has a value of 0 and the bit in the SRG Partial BSSID Bitmap field that corresponds to the numerical value of PARTIAL_AID[0:5] of the RXVECTOR is 1 (see 9.4.2.251 (Spatial Reuse Parameter Set element)).

A received PPDU that is an inter-BSS PPDU is an SRG PPDU if BSSID information from a frame carried in the PPDU is correctly received and the bit in the SRG Partial BSSID Bitmap field that corresponds to the numerical value of BSSID[39:44] is 1.

A VHT PPDU that is an inter-BSS PPDU and that is received with RXVECTOR parameter GROUP_ID equal to 0 is an SRG PPDU if the bit in the SRG Partial BSSID Bitmap field that corresponds to the numerical value of bits [39:44] of the RA field of any correctly received frame from the PPDU is 1.

A VHT PPDU that is an inter-BSS PPDU and that is received with RXVECTOR parameter GROUP_ID equal to 63 is an SRG PPDU if the bit in the SRG Partial BSSID Bitmap field that corresponds to the numerical value of bits [39:44] of the TA field of any correctly received frame from the PPDU is 1.

An HE SU PPDU, HE ER SU PPDU or HE MU PPDU that is an inter-BSS PPDU and that is received with the RXVECTOR parameter UPLINK_FLAG equal to 1 is an SRG PPDU if the bit in the SRG Partial BSSID Bitmap field that corresponds to the numerical value of bits [39:44] of the RA field of any correctly received frame from the PPDU is 1.

Otherwise, the PPDU is not determined to be an SRG PPDU. A non-AP HE STA that has not received a Spatial Reuse Parameter Set element from its associated AP with a value of 1 in the SRG Information Present subfield shall not classify any received PPDUs as an SRG PPDU. An HE AP that has not transmitted a Spatial Reuse Parameter Set element with a value of 1 in the SRG Information Present subfield may classify received PPDUs as SRG PPDUs using information that it has not transmitted.

26.2.4 Updating two NAVs

A non-AP HE STA shall maintain two NAVs and an HE AP may maintain two NAVs: an intra-BSS NAV and a basic NAV. The intra-BSS NAV is updated by an intra-BSS PPDU. The basic NAV is updated by an inter-BSS PPDU or a PPDU that cannot be classified as intra-BSS or inter-BSS. The mechanism by which a

PPDU is classified intra-BSS or inter-BSS is defined in 26.2.2 (Intra-BSS and inter-BSS PPDU classification).

Maintaining two NAVs is beneficial in dense deployment scenarios in which a STA requires protection from frames transmitted by STAs within its BSS, i.e., intra-BSS, and avoid interference from frames transmitted by STAs in a neighboring BSS, i.e., inter-BSS. For example, in a TXOP initiated by the AP with which a STA is associated for an HE TB PPDU transmission, the intra-BSS NAV of the STA is set by the AP to prevent the STA from contending for the channel. The basic NAV of the STA is not updated by transmissions from the AP during the TXOP so that if the basic NAV of the STA is nonzero and the STA receives, from the AP, a Trigger frame with the CS Required subfield equal to 1, the STA will not respond (see 26.5.2.5 (UL MU CS mechanism)).

The requirements in 10.3.2.1 (CS mechanism) apply to an HE STA maintaining two NAVs with the exception of the virtual CS indication of medium. For an HE STA maintaining two NAVs, if both the NAV timers are 0, the virtual CS indication is that the medium is idle; if at least one of the two NAV timers is nonzero, the virtual CS indication is that the medium is busy.

The procedure in 10.3.2.9 (CTS and DMG CTS procedure) applies to an HE STA maintaining two NAVs, and the NAV referred by the description in 10.3.2.4 (Setting and resetting the NAV) is the basic NAV.

The duration information is indicated by a frame as follows:

- If there is a Duration field in the frame, then the duration information is indicated by the Duration field.
- If the frame is a PS-Poll, then the duration information is equal to the time, in microseconds, required to transmit one Ack frame plus one SIFS under the data rate selection rules. If the calculated duration information includes a fractional microsecond, that duration information is rounded up to the next higher integer.

A STA shall update the intra-BSS NAV with the duration information indicated by the received frame in a PSDU if and only if all the following conditions are met:

- The frame is identified as intra-BSS according to the rule described in 26.2.2 (Intra-BSS and inter-BSS PPDU classification).
- The indicated duration is greater than the current intra-BSS NAV value.
- The RA of the received frame is not the STA's MAC address, or the STA is not a TXOP holder and the PPDU carrying the frame does not contain a frame that solicits an immediate response from the STA, or the STA is not a TXOP holder and the received frame is a Trigger frame.

A STA shall update the basic NAV with the duration information indicated by the received frame in a PSDU if and only if all the following conditions are met:

- The frame is identified as inter-BSS or cannot be identified as intra-BSS or inter-BSS according to the rule described in 26.2.2 (Intra-BSS and inter-BSS PPDU classification).
- The indicated duration is greater than the current basic NAV value.
- The RA of the received frame is not the STA's MAC address.

A STA that is a TXOP holder shall not update the intra-BSS NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION.

A STA that is not a TXOP holder shall update the intra-BSS NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION for an HE PPDU if and only if all the following conditions are met:

- The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.

- The PPDU that carried information of the RXVECTOR parameter is identified as intra-BSS according to the rule described in 26.2.2 (Intra-BSS and inter-BSS PPDU classification).
- The STA does not receive a frame with a Duration field in the PPDU.
- The duration information indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current intra-BSS NAV of the STA.

A STA shall update the basic NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION for an HE PPDU if and only if all the following conditions are met:

- The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.
- The PPDU that carried information for the RXVECTOR parameter is identified as inter-BSS or cannot be identified as intra-BSS or inter-BSS according to the rule described in 26.2.2 (Intra-BSS and inter-BSS PPDU classification).
- The STA does not receive a frame with a Duration field in the PPDU.
- The duration information indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current basic NAV of the STA.

NOTE 1—If a PS-Poll frame is received in an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, then the RXVECTOR parameter TXOP_DURATION does not indicate duration information (see 26.11.5 (TXOP_DURATION).

NOTE 2—If a STA receives an HE PPDU with the duration information indicated by both a frame with a Duration field and the RXVECTOR parameter TXOP_DURATION, then the duration information indicated by the RXVECTOR parameter TXOP_DURATION is ignored.

NOTE 3—The additional rules of NAV consideration for a STA that is solicited for an immediate response are described in 10.3.2.9 (CTS and DMG CTS procedure), 10.3.2.11 (Acknowledgment procedure), and 26.5.2.5 (UL MU CS mechanism).

A PHY-CCARESET.request primitive shall be issued if one of the following condition is met:

- One NAV is reset, and the other NAV timer is 0.
- Both NAVs are reset simultaneously.

The NAVs (if any) are updated at the expected end of the PPDU as defined in 10.3.2.4 (Setting and resetting the NAV).

An HE STA that used information from an RTS or MU-RTS Trigger frame as the most recent basis to update its NAV is permitted to reset the NAV that is updated by the RTS or MU-RTS Trigger frame if no PHY-RXSTART.indication primitive is received from the PHY during a period with a duration of 2 × aSIFSTime + CTS_Time + aRxPHYStartDelay + 2 × aSlotTime starting when the MAC receives a PHY-RXEND.indication primitive corresponding to the detection of the RTS or MU-RTS Trigger frame (see 10.3.2.4 (Setting and resetting the NAV) for the definition of CTS_Time).

26.2.5 Truncation of TXOP

A non-AP HE STA that is not associated with an HE AP shall interpret the reception of a CF-End frame as a NAV reset, i.e., it reset its maintained NAV to 0 at the end of the PPDU containing this frame.

An HE AP that maintains one NAV (see 10.3.2.1 (CS mechanism)) and receives a CF-End frame should reset the NAV unless either of following conditions are met:

- The received CF-End frame is an inter-BSS frame and the most recently updated NAV was due to an intra-BSS frame (see 26.2.2 (Intra-BSS and inter-BSS PPDU classification)).
- The received CF-End frame is an intra-BSS frame and the most recently updated NAV was due to an inter-BSS frame (see 26.2.2 (Intra-BSS and inter-BSS PPDU classification)).

An HE STA that maintains two NAVs (see 26.2.4 (Updating two NAVs)) and receives a CF-End frame should reset the basic NAV if the received CF-End frame is an inter-BSS frame and reset the intra-BSS NAV if the received CF-End frame is an intra-BSS frame.

An HE STA that maintains two NAVs may reset both NAVs if the received CF-End frame is an intra-BSS frame and the basic NAV was updated due to a frame that cannot be identified as either inter-BSS frame or intra-BSS frame.

An HE STA that receives a CF-End frame and resets all its maintained NAV(s) can start contending for the medium without further delay.

26.2.6 MU-RTS Trigger/CTS frame exchange procedure

26.2.6.1 General

The MU-RTS Trigger/CTS frame exchange procedure allows an AP to initiate a TXOP and protect the TXOP frame exchanges. An AP may transmit an MU-RTS Trigger frame to solicit simultaneous CTS frame responses from one or more non-AP STAs.

Figure 26-1 (Example of MU-RTS/CTS/DL MU PPDU/Acknowledgment Response and NAV setting) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the DL MU PPDU and the acknowledgment responses.

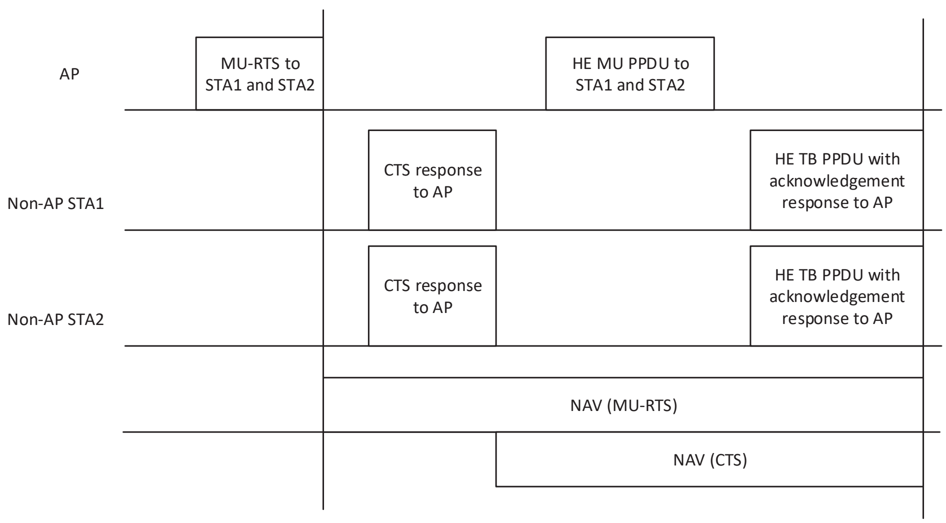

Figure 26-1—Example of MU-RTS/CTS/DL MU PPDU/Acknowledgment Response and NAV setting

Figure 26-2 (Example of MU-RTS/CTS/Trigger/HE TB PPDU/Multi-STA BlockAck and NAV setting) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the HE TB PPDU and Multi-STA BlockAck frame.

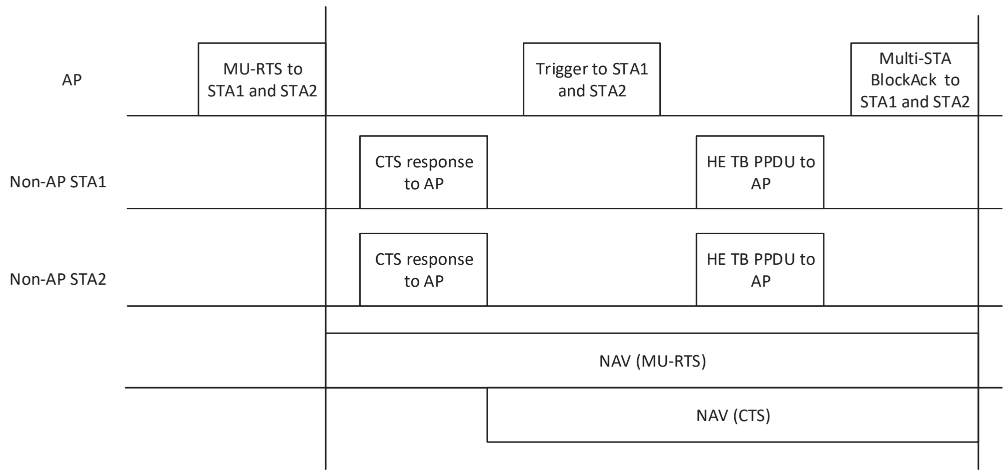

Figure 26-2—Example of MU-RTS/CTS/Trigger/HE TB PPDU/Multi-STA BlockAck and NAV setting

26.2.6.2 MU-RTS Trigger frame transmission

In each 20 MHz channel occupied by the PPDU that contains an MU-RTS Trigger frame, the transmitter of the MU-RTS Trigger frame shall request at least one non-AP STA to send a CTS frame response that occupies the 20 MHz channel. The transmitter of an MU-RTS Trigger frame shall not request a non-AP STA to send a CTS frame response in a 20 MHz channel that is not occupied by the PPDU that contains the MU-RTS Trigger frame.

After transmitting an MU-RTS Trigger frame, the AP shall wait for a CTSTimeout interval of aSIFSTime + aSlotTime + aRxPHYStartDelay that begins when the MAC receives the PHY-TXEND.confirm primitive for the transmitted MU-RTS Trigger frame. If the MAC does not receive a PHY-RXSTART.indication primitive during the CTSTimeout interval, the AP shall conclude that the transmission of the MU-RTS Trigger frame has failed, and, if the MU-RTS Trigger frame initiated a TXOP, the AP shall invoke its backoff procedure. If the MAC receives a PHY-RXSTART.indication primitive during the CTSTimeout interval, then the MAC shall wait for the corresponding PHY-RXEND.indication primitive to determine whether the MU-RTS Trigger frame transmission was successful. The receipt of a CTS frame from any non-AP STA addressed by the MU-RTS Trigger frame before the PHY-RXEND.indication primitive shall be interpreted as the successful transmission of the MU-RTS Trigger frame, permitting the frame exchange sequence to continue. The receipt of any other type of frame shall be interpreted as a failure of the MU-RTS Trigger frame transmission. In this instance, the AP may process the received frame and, if the MU-RTS Trigger frame initiated a TXOP, shall invoke its backoff procedure at the PHY-RXEND.indication primitive.

NOTE—If an AP transmits an MU-RTS Trigger frame in an already initiated TXOP and the MU-RTS Trigger frame transmission fails, then the AP might perform a PIFS recovery as described in 10.23.2.8 (Multiple frame transmission in an EDCA TXOP) or invoke the backoff procedure described in 10.23.2.2 (EDCA backoff procedure).

An MU-RTS Trigger frame shall not be carried in a VHT MU PPDU or an HE MU PPDU.

26.2.6.3 CTS frame response to an MU-RTS Trigger frame

If a non-AP STA receives an MU-RTS Trigger frame, the non-AP STA shall commence the transmission of a CTS frame response at the SIFS time boundary after the end of a received PPDU when all the following conditions are met:

- The MU-RTS Trigger frame has one of the User Info fields addressed to the non-AP STA. The User Info field is addressed to a non-AP STA if the AID12 subfield is equal to the 12 LSBs of the AID of the STA and the MU-RTS Trigger frame is sent by the AP with which the non-AP STA is associated or by the AP corresponding to the transmitted BSSID if the non-AP STA is associated with a non-transmitted BSSID and has indicated support for receiving Control frames with TA field set to the transmitted BSSID by setting the Rx Control Frame To MultiBSS subfield to 1 in the HE Capabilities element that the non-AP STA transmits.
- The UL MU CS condition indicates that the medium is idle (see 26.5.2.5 (UL MU CS mechanism)).

Otherwise, the non-AP STA shall not send a CTS frame response.

NOTE 1—The RU Allocation subfield in the User Info field addressed to the non-AP STA indicates whether the CTS frame response is to be sent on the primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel as described in 9.3.1.22.5 (MU-RTS variant).

NOTE 2—A combination of virtual CS and ED-based CCA during the SIFS after the PPDU containing the MU-RTS Trigger frame is used to determine the state of the medium (see 26.5.2.5 (UL MU CS mechanism)).

The CTS frame sent in response to an MU-RTS Trigger frame shall be carried in a non-HT or non-HT duplicate PPDU (see Clause 17) with a 6 Mb/s rate and with the TXVECTOR parameter SCRAMBLER_INITIAL_VALUE set to the same value as the RXVECTOR parameter SCRAMBLER_INITIAL_VALUE of the PPDU carrying the MU-RTS Trigger frame. The PPDU carrying the CTS frame shall be transmitted on the 20 MHz channels indicated in the RU Allocation subfield of the User Info field of the MU-RTS Trigger frame.

NOTE—A bandwidth signaling TA is not used in an MU-RTS Trigger frame or a CTS frame response to an MU-RTS Trigger frame (see 9.3.1.22 (Trigger frame format) and 9.3.1.3 (CTS frame format)). As a result, the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT is not present when transmitting an MU-RTS Trigger frame or CTS frame response to an MU-RTS Trigger frame. In Figure 17-7 (Data scrambler) the first 7 bits of scrambling sequence of an MU-RTS Trigger frame or CTS frame response to an MU-RTS Trigger frame are not defined by Table 17-7 (Contents of the first 7 bits of the scrambling sequence).

The Power Management and More Data subfields in a CTS frame sent in response to an MU-RTS Trigger frame shall be set to 0.

NOTE—Other subfields of the Frame Control field of the CTS frames sent in response to an MU-RTS Trigger frame are set as described in Figure 9-26 ((Frame Control field subfield values within Control frames carried in a non-S1G PPDU)).

Figure 26-3 (An example of an MU-RTS Trigger frame soliciting CTS frame responses on the primary 40 MHz channel) shows an example of the exchange of an MU-RTS Trigger frame and simultaneous CTS frame responses on the primary 40 MHz channel. In this example, MU-RTS Trigger frame is transmitted in a 40 MHz non-HT duplicate PPDU on the primary 40 MHz channel. Further, the MU-RTS Trigger frame requests non-AP STA1 to transmit a CTS frame response in a non-HT PPDU on the primary 20 MHz channel and non-AP STA2 to transmit a CTS frame response in a 40 MHz non-HT duplicate PPDU on the primary 40 MHz channel.

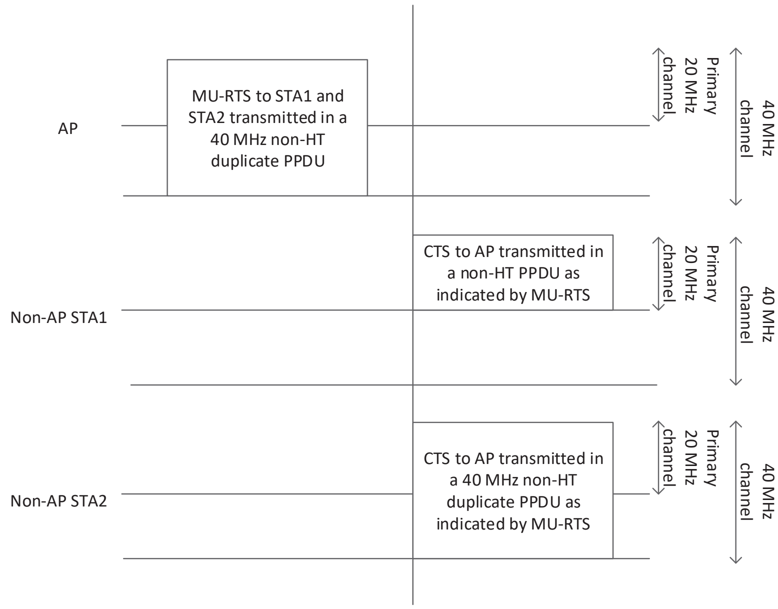

Figure 26-3—An example of an MU-RTS Trigger frame soliciting CTS frame responses on the primary 40 MHz channel

A non-AP STA that transmits a CTS frame in response to an MU-RTS Trigger frame shall follow the synchronization requirement defined in 27.3.15.3 (Pre-correction accuracy requirements).

26.2.7 EDCA operation using MU EDCA parameters

A non-AP STA that receives an MU EDCA Parameter Set element from the AP with which it is associated follows the procedure defined in this subclause.

An HE AP that has dot11MUEDCAParametersActivated equal to true includes the MU EDCA Parameter Set element in the Management frames it transmits that include the EDCA Parameter Set element. An HE AP shall set the QoS Info field of an MU EDCA Parameter Set element (if present) to the same value as the QoS Info field of an EDCA Parameter Set element (if present). An HE AP may change the MU EDCA parameters by including the MU EDCA Parameter Set element with updated MU EDCA parameters in the Beacon frames and Probe Response frames it transmits. The EDCA Parameter Set Update Count subfield in the QoS Info field of the EDCA Parameter Set element and MU EDCA Parameter Set element is incremented every time any of the EDCA parameters or the MU EDCA parameters change.

An HE STA shall update the dot11EDCATable and dot11MUEDCATable that correspond to fields in an EDCA Parameter Set element or an MU EDCA Parameter Set element within an interval of time equal to one beacon interval after receiving an updated EDCA or MU EDCA parameter set. When updating its MIB attributes, an HE STA stores the value of the EDCA Parameter Set Update Count subfield in the QoS Info field of the received EDCA Parameter Set element or MU EDCA Parameter Set element.

An HE STA shall check the EDCA Parameter Set Update Count subfield value in the QoS Info field of the QoS Capability element in the most recently received Beacon frame against the stored value to determine if the HE STA is using the current EDCA and MU EDCA parameters. If the EDCA Parameter Set Update

Count subfield value is different from the stored value, then the HE STA shall send a Probe Request frame to the AP to solicit an update.

NOTE—If the QoS Capability element is present in a Beacon frame, the EDCA Parameter Set element and the MU EDCA Parameter Set element are not present. In this case, the only way for an HE STA to obtain the updated parameters is to send a Probe Request frame to the AP.

A non-AP HE STA that receives a Basic Trigger frame that contains a User Info field addressed to the STA shall update its CWmin[AC], CWmax[AC], AIFSN[AC] and MUEDCATimer[AC] state variables to the values contained in the most recently received MU EDCA Parameter Set element sent by the AP with which the STA is associated, for all the ACs from which at least one QoS Data frame was transmitted successfully in an HE TB PPDU in response to the Trigger frame. A QoS Data frame is transmitted successfully by the STA in an HE TB PPDU for an AC if it requires immediate acknowledgment and the STA receives an immediate acknowledgment for that frame, or if the QoS Data frame does not require immediate acknowledgment.

The MUEDCATimer[AC] state variable is updated with the value contained in the MU EDCA Timer subfield of the MU EDCA Parameter Set element. The backoff counter maintenance corresponding to the updated state variables shall follow the rules in 10.23.2.2 (EDCA backoff procedure) except that if AIFSN[AC] is 0 then the EDCAF corresponding to that AC shall be suspended until the MUEDCATimer[AC] reaches 0 or is reset to 0. The updated MUEDCATimer[AC] shall start at the end of the immediate response if the transmitted HE TB PPDU contains at least one QoS Data frame for that AC that requires immediate acknowledgment, and shall start at the end of the HE TB PPDU if the transmitted HE TB PPDU does not contain any QoS Data frames for that AC that require immediate acknowledgment.

In a non-AP HE STA, each MUEDCATimer[AC] shall uniformly count down without suspension to 0 when its value is nonzero.

NOTE 1—A non-AP STA that sends a frame to the AP with an OM Control subfield containing a value of 1 in the UL MU Disable subfield or a value of 0 in the UL MU Disable subfield and a value of 1 in the UL MU Data Disable subfield does not participate in UL MU operation. As such it is exempt from updating its EDCA access parameters to the values contained in the MU EDCA Parameter Set element as defined in this subclause.

NOTE 2—A non-AP STA does not update its state variables to the values contained in the MU EDCA Parameter Set element if any of the following apply:

- The Trigger frame addressed to the STA is not a Basic Trigger frame
- The STA does not include QoS Data frames in the HE TB PPDU response sent in response to the Basic Trigger frame
- The STA transmits the HE TB PPDU in response to a Basic Trigger frame following the rules defined in 26.5.4 (UL OFDMA-based random access (UORA))

NOTE 3—The TXOP limits are not updated by the procedure defined in this subclause, but by that in 10.23.2.9 (TXOP limits).

A non-AP STA that sends frames that are not addressed to its associated AP may use the EDCA parameters values that are contained in the most recently received EDCA Parameter Set element sent by the AP with which the STA is associated, or to the default EDCA parameter values (see Table 9-137 (Default EDCA Parameter Set element parameter values if dot11OCBActivated is false)), following the rules in 10.2.3.2 (HCF contention based channel access (EDCA)).

If the MUEDCATimer[AC] of a non-AP HE STA reaches 0, either by counting down or due to a reset following the reception of an MU EDCA Control frame, the STA shall update CWmin[AC], CWmax[AC] and AIFSN[AC] to the values that are contained in the most recently received EDCA Parameter Set element sent by the AP with which the STA is associated.

A non-AP HE STA that sends a frame with an OM Control subfield with the UL MU Disable subfield set to 1 or with the UL MU Disable subfield set to 0 and the UL MU Data Disable subfield set to 1 as defined in

26.9.3 (Transmit operating mode (TOM) indication) may set the MUEDCATimer[AC] for all ACs to 0 on receiving an immediate acknowledgment from the OMI responder. The STA continues the current EDCA backoff procedure without modifying the QSRC[AC], QLRC[AC] or the backoff counter for the associated EDCAF, regardless of whether the MUEDCATimer[AC] has reached zero, until the STA invokes a new EDCA backoff procedure. The STA follows the rules defined in 10.23.2.2 (EDCA backoff procedure) for updating CWmin, CWmax and AIFSN for that AC.

A non-AP HE STA that receives an individually addressed MU EDCA Control frame from its associated AP may reset the MUEDCATimer[AC] to 0 for an AC if the bit corresponding to that AC in the Affected ACs subfield is equal to 1 when the MUEDCATimer[AC] of the STA is not equal to 0. The STA may invoke a new EDCA backoff procedure after the MUEDCATimer[AC] is reset for that AC and after CWmin[AC], CWmax[AC] and AIFSN[AC] are updated for that AC, as per this subclause, in response to the MUEDCA-Timer[AC] reset.

26.2.8 Multiple frame transmission in an EDCA TXOP in the 6 GHz band

A STA that operates in the 6 GHz band and transmits multiple frames shall follow the rules defined in 10.23.2.7 (Sharing an EDCA TXOP) with the exceptions listed below.

NOTE—In the 6 GHz band, the TXOP field in the HE-SIG-A field can be understood by all STAs. The TXOP field provides TXOP protection equivalent to non-HT duplicate RTS/CTS.

In a TXOP without non-HT duplicate PPDUs, if the TXOP is protected by the TXOP field in the HE-SIG-A field of the first HE PPDU in the TXOP, i.e., the TXOP field is not set to UNSPECIFIED, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of the subsequent PPDUs in the TXOP to indicate a bandwidth that is the same or narrower than the bandwidth indicated by the CH_BANDWIDTH parameter of the first HE PPDU in the TXOP.

NOTE—Frame exchanges in a TXOP that is protected by RTS/CTS follow the rules in 10.23.2.8 (Multiple frame transmission in an EDCA TXOP).

Additionally, if the first HE PPDU whose TXOP field in HE-SIG-A is not set to UNSPECIFIED is a DL HE MU PPDU with preamble puncture, then the TXOP holder shall use the 20 MHz channels for the non-initial PPDU that are within the set of 20 MHz channels where pre-HE modulated fields of the first HE PPDU whose TXOP field in HE-SIG-A is not set to UNSPECIFIED are located.

Within an obtained TXOP that does not include HE PPDUs whose TXOP field in HE-SIG-A is not UNSPECIFIED nor non-HT duplicate PPDUs, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a non-initial PPDU to be the equal to or less than the TXVECTOR parameter CH_BANDWIDTH of the preceding PPDU that was transmitted in the same TXOP, subject to the following constraints:

— If the preceding PPDU is a DL HE MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of the non-initial PPDU to a value whose corresponding 20 MHz channels are within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.

— If the non-initial PPDU is a DL HE MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter RU_ALLOCATION of the non-initial PPDU to a value whose corresponding RU is within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.

26.3 Fragmentation and defragmentation

26.3.1 General

An HE STA shall follow the fragmentation procedures defined in 10.2.6 (Fragmentation/defragmentation overview), 10.4 (MSDU, A-MSDU, and MMPDU fragmentation), and 10.5 (MSDU, A-MSDU, and MMPDU defragmentation) except that some of the rules are relaxed as defined in the subclauses below. Dynamic fragmentation provides further flexibility in aggregating data to fit in a constrained PPDU duration (see 26.5 (MU operation)).

Subclauses 10.2.6 (Fragmentation/defragmentation overview) and 10.4 (MSDU, A-MSDU, and MMPDU fragmentation) define the procedure to generate uniformly fragmented MSDU or MMPDU, where the length of each fragment is the same, except for the last fragment. These fragments are not included in an A-MPDU under HT-immediate block ack agreements.

An HE STA can negotiate the use of different levels of dynamic fragmentation:

— Level 1: support for one dynamic fragment that is a non-A-MPDU, no support for dynamic fragments in an A-MPDU that is does not contain an S-MPDU.

— Level 2: support for up to one dynamic fragment for each MSDU, each A-MSDU (if supported by the recipient) and one MMPDU (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) in an A-MPDU that does not contain an S-MPDU, where the A-MPDU contains at least one dynamic fragment and is sent under an HT-immediate block ack agreement.

— Level 3: support for up to 4 dynamic fragments for each MSDU and each A-MSDU (if supported by the recipient) in an A-MPDU and up to one dynamic fragment for one MMPDU (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) in an A-MPDU that does not contain an S-MPDU, where the A-MPDU contains at least one dynamic fragment and is sent under an HT-immediate block ack agreement that has enabled dynamic level 3 fragmentation.

NOTE—An HE STA that is operating in Level 2 or Level 3 can still transmit and receive the dynamic fragments under Level 1.

This subclause defines the procedure for generating nonuniformly fragmented MSDUs, A-MSDUs or MMPDUs, where the length of each fragment is not necessarily the same. The length of the first fragment shall be greater than or equal to the minimum fragment size indicated in the Minimum Fragment Size subfield of the HE Capabilities Information field in the HE Capabilities element sent by the recipient STA. If the length of the MSDU, A-MSDU or MMPDU is less than the minimum fragment size, then the MSDU, A-MSDU or MMPDU shall not be fragmented. The fragments generated with dynamic fragmentation are referred to as dynamic fragments.

These procedures allow the inclusion of one dynamic fragment that is a non-A-MPDU in level 1, level 2 and level 3, and allow the inclusion of one or more dynamic fragments within an A-MPDU that contains one or more MPDUs in level 2 and level 3.

An HE STA follows the rules defined in 26.3.2 (Dynamic fragmentation) for generating these fragments and the rules defined in 26.3.3 (Dynamic defragmentation) for defragmenting of the received dynamic fragments. In the subclauses 26.3.2 (Dynamic fragmentation) and 26.3.3 (Dynamic defragmentation), the HE STA follows the fragmentation level that is indicated in the Dynamic Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits unless an ADDBA Extension element is included in the ADDBA Request and ADDBA Response frames exchanged during the block ack setup procedure, in which case the HE STA follows the fragmentation level that is indicated in an ADDBA Extension element in the ADDBA Response frame it receives (see the subclause 26.3.3.1 (General)) during the block ack setup procedure.

An HE STA shall set the HE Fragmentation Operation subfield in the ADDBA Extension element, if present, in the ADDBA Request or ADDBA Response frame to a value that is less than or equal to the value of the Dynamic Fragmentation Support subfield in the HE Capabilities element it transmits.

An HE STA shall set the HE Fragmentation Operation subfield in the ADDBA Extension element, if present, in the ADDBA Response frame to a value that is less than or equal to the value of HE Fragmentation Operation subfield in the ADDBA Extension element, if present, in the received ADDBA Request frame.

26.3.2 Dynamic fragmentation

26.3.2.1 General

With level 1 and level 2 dynamic fragmentation, the following apply:

- An originator STA transmitting one or more dynamic fragments shall solicit an immediate response from the recipient STA for each of the fragments.
- The originator STA shall transmit the fragments in order as defined in 10.4 (MSDU, A-MSDU, and MMPDU fragmentation).

With level 3 dynamic fragmentation, not all dynamic fragments require an immediate response and dynamic fragments are not required to be sent in order.

An HE STA may transmit dynamic fragments of an A-MSDU provided the A-MSDU Fragmentation Support subfield of the HE Capabilities element transmitted by the recipient is 1.

The originator STA shall not transmit concurrently the dynamic fragments of a number of outstanding MPDUs and A-MSDUs (if supported) to the same recipient STA that is greater than *Nmax*, where *Nmax* for MSDUs and A-MSDUs (if supported) is calculated based on the Maximum Number of Fragments Exponent subfield of the HE Capabilities element transmitted by the recipient STA. The term *outstanding* refers to an MPDU containing all or part of an MSDU or A-MSDU for which transmission has been started, and for which delivery of the MSDU or A-MSDU has not yet been completed (i.e., an acknowledgment of the final fragment has not been received and the MSDU, A-MSDU or MMPDU has not been discarded due to retries, lifetime, or for some other reason).

An originator STA may retransmit the full MSDU, A-MSDU or MMPDU if all the previously transmitted dynamic fragments of that MSDU, A-MSDU or MMPDU have explicitly failed at the receiving STA. An originator STA may retransmit a failed fragment if one or more of the previously transmitted fragments of that MSDU, A-MSDU, or MMPDU have explicitly failed at the receiving STA (see below for a definition of this term). The frame body length and contents of the retransmitted fragment shall be the same as the initially transmitted fragment and shall remain fixed for the lifetime of the MSDU, A-MSDU or MMPDU at that STA except when all the fragments preceding the initial transmitted fragment were received and all the fragments following the initial transmitted fragment have either explicitly failed or have not been transmitted, in which case the frame body length and contents of the retransmitted fragment may be different from the initially transmitted fragment.

A fragment has explicitly failed at the receiving STA if the originator STA receives an immediate response that contains:

- A valid first MPDU that is not an Ack frame, Compressed BlockAck frame or Multi-STA BlockAck frame, of which all the preceding pre-EOF MPDU delimiters are received.
- A Multi-STA BlockAck frame that does not contain a BA Information field with TID equal to that of the fragment
- A Compressed BlockAck frame or Multi-STA BlockAck frame that contains a BA Information field with TID equal to that of the fragment, but does not acknowledge receipt of the fragment

An originator STA shall not transmit to a recipient STA an MPDU that is not carried in an A-MPDU or an A-MPDU that carries dynamic fragments that do not satisfy the conditions in 26.3.2.2 (Level 1 dynamic fragmentation), 26.3.2.3 (Level 2 dynamic fragmentation) and 26.3.2.4 (Level 3 dynamic fragmentation).

26.3.2.2 Level 1 dynamic fragmentation

An originator STA may transmit one dynamic fragment of an MSDU, A-MSDU (if supported by the recipient) or MMPDU that is a non-A-MPDU and that is not sent under a block ack agreement to a recipient STA using level 1 dynamic fragmentation if the Dynamic Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element received from the recipient STA is 1, 2 or 3.

An originator STA may transmit a fragmented MSDU or A-MSDU (if supported by the recipient) under a block ack agreement to a recipient STA using level 1 dynamic fragmentation provided the following condition is met: the Dynamic Fragmentation Support subfield in the HE Capabilities element received from the recipient STA is 1, 2 or 3 and for the block ack agreement associated with the TID of the MSDU or A-MSDU, the HE Fragmentation Operation subfield is 1 if the ADDBA Extension element is present in the ADDBA Response frame received from the recipient STA.

26.3.2.3 Level 2 dynamic fragmentation

An originator STA may transmit fragmented MSDUs or A-MSDU (if supported by the recipient) under a block ack agreement to a recipient STA using level 2 dynamic fragmentation provided one of the following conditions is met:

— The Dynamic Fragmentation Support subfield in the HE Capabilities element received from the recipient STA is 2, and for the block ack agreement associated with the TID of the MSDU or A-MSDU, the HE Fragmentation Operation subfield is 2 if the ADDBA Extension element is present in the ADDBA Response frame received from the recipient STA.

— The Dynamic Fragmentation Support subfield in the HE Capabilities element received from the recipient STA is 3, and for the block ack agreement associated with the TID of the MSDU or A-MSDU, the ADDBA Extension element is present and the HE Fragmentation Operation subfield is 2 in the ADDBA Response frame received from the recipient STA.

An originator STA may transmit to a recipient STA the following:

— One dynamic fragment of an MSDU, A-MSDU (if supported by the recipient), or MMPDU that is a non-A-MPDU using level 1 dynamic fragmentation.

— Up to one dynamic fragment of an MSDU or A-MSDU (if supported by the recipient) for each MSDU or A-MSDU and up to one dynamic fragment of an MMPDU in an A-MPDU format where the A-MPDU contains at least one dynamic fragment using level 2 dynamic fragmentation under a block ack agreement.

NOTE—The originator STA follows the rules in 10.12.8 (Transport of S-MPDUs) for generating the S-MPDU, the rules in 10.25.6.7 (Originator's behavior) for generating the A-MPDU and the rules in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) for generating a multi-TID A-MPDU that can contain the fragment of the MMPDU.

26.3.2.4 Level 3 dynamic fragmentation

An originator STA may transmit fragmented MSDUs or A-MSDU (if supported by the recipient) under a block ack agreement or fragmented MMPDU to a recipient STA using level 3 dynamic fragmentation provided the following conditions are met:

— The Dynamic Fragmentation Support subfield in the HE Capabilities element received from the recipient STA is 3.

— For the block ack agreement associated with the TID of the MSDU or A-MSDU, the HE Fragmentation Operation subfield is 3 if the ADDBA Extension element is present in the ADDBA Response frame received from the recipient STA.

Level 3 fragmentation allows multiple fragments of an MSDU or A-MSDU included in the same A-MPDU, reducing the fragments' transmission delay.

An originator STA may transmit to a recipient STA the following:

— One dynamic fragment of an MSDU, A-MSDU (if supported by the recipient), or MMPDU that is a non-A-MPDU using level 1 dynamic fragmentation.
  - The originator STA shall follow the rules defined in 10.12.8 (Transport of S-MPDUs) for generating the S-MPDU.

— Up to four dynamic fragments of an MSDU or A-MSDU (if supported by the recipient) for each MSDU or A-MSDU, and up to one dynamic fragment of an MMPDU in an A-MPDU, where the A-MPDU contains at least one dynamic fragment using level 3 dynamic fragmentation under block ack agreement.
  - 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 10.25.6.7 (Originator's behavior) for generating the A-MPDU with the exception that the A-MPDU shall contain MPDUs whose range of the Sequence Number subfields does not exceed $B_L/4$, where B_L is the length of the Block Ack Bitmap field of the BlockAck or Multi-STA BlockAck frame that corresponds to a TID of a transmitted fragment (see 10.25.6 (HT-immediate block ack extensions) and 26.4 (HE acknowledgment procedure)).

26.3.3 Dynamic defragmentation

26.3.3.1 General

An HE STA shall set the Dynamic Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 0 if it does not support dynamic fragments. Otherwise, the HE STA shall set the Dynamic Fragmentation Support subfield as follows:

— Set to 1, 2 or 3 if the STA supports reception of dynamic fragments following the procedure defined in 26.3.2.2 (Level 1 dynamic fragmentation)

— Set to 2 or 3 if the STA supports reception of dynamic fragments following the procedure defined in 26.3.2.3 (Level 2 dynamic fragmentation)

— Set to 3 if the STA supports reception of dynamic fragments following the procedure defined in 26.3.2.4 (Level 3 dynamic fragmentation)

An HE STA shall set dot11HEDynamicFragmentationLevel to the value of Dynamic Fragmentation Support subfield of the HE Capabilities element it transmits if it supports reception of dynamic fragments.

If a fragment is sent under level 1, level 2 or level 3 fragmentation, it belongs to dynamic fragment.

Defragmentation of dynamic fragments shall follow the rules defined in 10.5 (MSDU, A-MSDU, and MMPDU defragmentation) with the following exceptions:

— The recipient STA shall support the concurrent reception of dynamic fragments of a number of *outstanding* MSDUs and A-MSDUs when supported from the same transmitting STA that is equal to N_{max}, where N_{max} for MSDUs and A-MSDUs (if supported) is obtained from the Maximum Number Of Fragmented MSDUs/A-MSDUs Exponent subfield of the HE Capabilities element transmitted by the STA. The term *outstanding* refers to an MPDU containing all or part of an MSDU or A-MSDU for which transmission has been started, and for which delivery of the MSDU or A-MSDU has not yet been completed (i.e., an acknowledgment of the final fragment has not been received and the MSDU, A-MSDU or MMPDU has not been discarded due to retries, lifetime, or for some other reason). The recipient STA shall support the concurrent reception of dynamic fragments of one outstanding MMPDU from a transmitting STA.

— The recipient STA may be subject to the receive timer rules for each of the MSDUs, A-MSDUs and MMPDUs defined in 10.6 (Defragmentation).

A STA that has dot11AMSDUFragmentationOptionImplemented true shall set the A-MSDU Fragmentation Support subfield in the HE Capability element to 1. Otherwise, the STA shall set the A-MSDU Fragmentation Support subfield in the HE Capability element to 0.

26.3.3.2 Level 1 dynamic defragmentation

Upon reception of a non-A-MPDU or A-MPDU that carries a dynamic fragment, the recipient STA responds with an Ack frame or a Multi-STA BlockAck frame if the received fragment is contained in an MPDU that solicits an immediate response. The receiver STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame for the soliciting dynamic fragment that is an MPDU, or carried in an S-MPDU or ack-enabled single-TID A-MPDU and the rules defined in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgment for the soliciting S-MPDU that carries one dynamic fragment and carried in an HE TB PPDU, ack-enabled single-TID A-MPDU or ack-enabled multi-TID A-MPDU.

26.3.3.3 Level 2 dynamic defragmentation

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

— An Ack frame or Multi-STA BlockAck frame if the received fragment is a non-A-MPDU or contained in an A-MPDU and solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame for the soliciting dynamic fragment that is an MPDU or carried in an S-MPDU or ack-enabled single-TID A-MPDU and the rules defined in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgment for the soliciting S-MPDU carried in an HE TB PPDU, ack-enabled single-TID A-MPDU or ack-enabled multi-TID A-MPDU.

— A Compressed BlockAck frame or Multi-STA BlockAck frame if the received fragments of an MSDU or A-MSDU (if any), up to one fragment for each MSDU or A-MSDU, are contained in an A-MPDU that contains an MPDU that solicits an immediate response. The recipient STA shall follow the rules defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) for generating the BlockAck frame and the rules in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame, except that the STA shall:

  • Set to 0 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the Compressed BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment that is sent under a block ack agreement.

  • Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield and TID subfield of a received fragment that is sent under a block ack agreement contained in the soliciting A-MPDU that is not an S-MPDU.

— The STA shall update the corresponding block acknowledgment record for an MSDU or A-MSDU for which fragments are received only if that MSDU or A-MSDU is successfully reconstructed (see 10.6 (Defragmentation)). Otherwise the STA shall not update the block ack record for that MSDU or A-MSDU.

NOTE—The recipient STA sets the bits of the Block Ack Bitmap field that correspond to a Sequence Number and TID subfield of an MPDU that is not a fragment as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA).

A recipient STA shall discard any fragments of incomplete MSDUs or A-MSDUs that have been received during an HT-immediate block ack session for a TID if it receives a BlockAckReq frame from the originator STA for that TID if the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq frame or that have a sequence number that is less than *WinStartB* (see 10.25.6.6 (Receive reordering buffer control operation)). The comparison of the two values is performed circular modulo 4096 as described in 10.25.1 (Introduction).

26.3.3.4 Level 3 dynamic defragmentation

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

— An Ack frame or a Multi-STA BlockAck frame if the received fragment is a non-A-MPDU or contained in an A-MPDU that solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.11 (Acknowledgment procedure) for generating the Ack frame for the soliciting dynamic fragment that is a MPDU, or carried in an S-MPDU or ack-enabled single-TID A-MPDU and the rules defined in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgment for the soliciting S-MPDU carried in an HE TB PPDU, ack-enabled single-TID A-MPDU or ack-enabled multi-TID A-MPDU.

— A Compressed BlockAck frame or Multi-STA BlockAck frame if the received fragments of an MSDU or A-MSDU (if any) corresponding to a TID, one or more fragments for each MSDU or A-MSDU, are contained in an A-MPDU where at least one received MPDU's Fragment Number field corresponding to the same TID as the received fragments is of nonzero value that solicits the immediate response. The recipient STA shall follow the rules in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) for generating the BlockAck frame and the rules in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame, except that the STA shall:

  - Set to 1 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the Compressed BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment that is sent under a block ack agreement.
  - Set to 1 each bit in position *B* of the Block Ack Bitmap field that corresponds to a received fragment that is sent under a block ack agreement and shall set it to 0 otherwise, with *B* calculated as: $B = 4 \times (SN - SSN) + FN$, where the operations on the sequence numbers are performed modulo 4096.
    SN is the value of the Sequence Number 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.
    FN is the value in the Fragment Number subfield.

— A Compressed BlockAck frame or Multi-STA BlockAck frame if the received fragments of an MSDU or A-MSDU (if any) corresponding to a TID, one or more fragments for each MSDU or A-MSDU, are contained in an A-MPDU where all the received MPDUs' Fragment Number fields corresponding to the same TID as the received fragments are of zero values that solicit the immediate response. The recipient STA shall follow the rules in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) for generating the BlockAck frame and the rules in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame, except that the STA shall:

  - Set to 0 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the Compressed BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment that is sent under a block ack agreement.
  - Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield and TID subfield of a received fragment that is sent under a block ack agreement contained in the soliciting A-MPDU that is not an S-MPDU.

- The STA shall update the corresponding block acknowledgment record for an MSDU or A-MSDU for which fragments are received only if that MSDU or A-MSDU is successfully reconstructed (see 10.5 (MSDU, A-MSDU, and MMPDU defragmentation)). Otherwise the STA shall not update the block ack record for that MSDU or A-MSDU.

NOTE—The recipient STA sets the bits of the Block Ack Bitmap field that correspond to a Sequence Number and TID subfield of an MPDU that is not a fragment as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA).

The recipient STA shall discard any fragments of incomplete MSDUs or A-MSDUs that have been received during an HT-immediate block ack session for a TID if it receives a BlockAckReq frame from the originator STA for that TID and the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq frame or that have a sequence number that is less than *WinStartB* (see 10.25.6.6 (Receive reordering buffer control operation)). The comparison of the two values is performed circular modulo 4096 as described in 10.25.1 (Introduction).

26.4 HE acknowledgment procedure

26.4.1 Overview

The HE acknowledgment procedure builds on the features defined for HT-immediate block ack (see 10.25.6 (HT-immediate block ack extensions)), with the following extensions:

- Support for a Multi-STA BlockAck frame
- Support for a MU-BAR Trigger frame
- Support for a Multi-TID BlockAckReq frame
- Support for BlockAck Bitmap field lengths of 32, 64, 128 and 256
- Acknowledging QoS Data frames with two or more TIDs using a Multi-STA BlockAck frame
- Acknowledging QoS Data frames with one or more TIDs, and a Management frame using a Multi-STA BlockAck frame
- Acknowledging all MPDUs in a PPDU using a variant of the Multi-STA BlockAck frame
- Acknowledging MPDUs from multiple associated STAs using a single Multi-STA BlockAck frame
- Acknowledging MPDUs from multiple unassociated STAs with a single Multi-STA BlockAck frame

An HE STA shall be able to respond with Compressed BlockAck frames if HT-immediate block ack is supported in the role of recipient (see 10.25.6.1 (Introduction)). An HE STA shall be able to respond with a Multi-STA BlockAck frame if multi-TID A-MPDU operation (26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) is supported in the role of recipient.

A non-AP HE STA that is associated with an AP and that sends a Multi-STA BlockAck frame shall set the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to 0 and the RA field to the MAC address of the intended recipient. A non-AP HE STA that is not associated with an AP shall not send a Multi-STA BlockAck frame.

An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are addressed to more than one STA shall set the RA field to the broadcast address. An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are all addressed to a single recipient STA and that is sent in response to an HE TB PPDU may set the RA field of the Multi-STA BlockAck frame to either the address of the recipient STA or to the broadcast address. An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are all addressed to a single recipient STA and that is not sent in response to an HE TB PPDU shall set the RA field of the Multi-STA BlockAck frame to the address of the recipient STA.

An HE AP that sends a Multi-STA BlockAck frame to an associated STA shall set the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to the 11 LSBs of the AID of the intended STA. An HE AP that sends a Multi-STA BlockAck frame to an unassociated STA shall set the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to 2045.

An HE STA that transmits a Multi-STA BlockAck frame shall use a rate, HT-MCS, <VHT-MCS, NSS> tuple or <HE-MCS, NSS> tuple that is supported by all recipient STAs.

An HE STA that receives a Multi-STA BlockAck frame that is a response to frames requiring acknowledgment shall examine Per AID TID Info field received in the Multi-STA BlockAck frame, and shall process each Per AID TID Info field using the procedure defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

A non-AP HE STA that receives a Multi-STA BlockAck frame that is a response to frames requiring acknowledgment but that do not belong to an established a block ack agreement shall examine each Per AID TID Info field received in the Multi-STA BlockAck frame as follows:

- If the Ack Type field is 1 and the TID field is less than 8, then the Per AID TID Info field indicates the acknowledgment of an EOF MPDU that is a QoS Data frame with the indicated TID. The BA Information field is addressed to the STA if the AID of the BA Information field contains the STA's AID, and is processed according to the procedure defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).
- If the Ack Type field is 1 and the TID field is 15, then the Per AID TID Info field indicates the acknowledgment of an EOF MPDU that is a Management frame that solicits acknowledgment or a PS-Poll frame. The BA Information field is addressed to the STA if the AID of the BA Information field contains the STA's AID, and is processed according to the procedure defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).
- If the Ack Type field is 0, and the AID field is 2045, and the TID field is 15, then Per AID TID Info field indicates the acknowledgment of an EOF MPDU that is a Management frame soliciting immediate acknowledgment. The RA field in the Per AID TID Info field is the MAC address of an unassociated STA for which the Per AID TID Info subfield is intended. The BA Information field is addressed to the STA if the RA field of the BA Information field contains the STA's MAC address, and is processed according to the procedure defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

An HE AP with dot11MultiBSSIDImplemented equal to true shall not send to a non-AP STA that is associated with a nontransmitted BSSID in the multiple BSSID set a Multi-STA BlockAck frame with the TA field set to the transmitted BSSID unless the HE AP has received from the non-AP STA an HE Capabilities element with the Rx Control Frame To MultiBSS subfield in HE MAC Capabilities Information field equal to 1.

An AP that transmits a Multi-STA BlockAck frame addressed to HE STAs shall set the TA field of the frame to the MAC address of the AP unless dot11MultiBSSIDImplemented is true and the Multi-STA BlockAck frame is directed to STAs from at least two different BSSs of the multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

NOTE—An AP sets the TA field of the Multi-STA BlockAck frame that is not carried in HE MU PPDU to the transmitted BSSID when the TXOP is obtained from the transmitted BSSID (see 10.23.2.4 (Obtaining an EDCA TXOP)).

An HE STA that transmits a Multi-TID BlockAckReq frame in a PPDU that is not an HE TB PPDU shall set the TID subfields in the Per TID Info subfields of the BAR Information field of the Multi-TID BlockAckReq frame to TIDs that correspond to ACs that have the same or higher priority as the primary AC. An HE STA that transmits a Multi-TID BlockAckReq frame in an HE TB PPDU may set the TID subfields in the Per TID Info subfields of the BAR Information field of the Multi-TID BlockAckReq frame to a TID that corresponds to any AC.

An HE STA that transmits a BlockAckReq frame in an HE TB PPDU may set the TID subfield in the AID TID Info field in the BAR Information field of the BlockAckReq frame to a TID that corresponds to any AC.

26.4.2 Acknowledgment context in a Multi-STA BlockAck frame

A recipient of an A-MPDU shall set the Ack Type subfield and TID subfield in the Per AID TID Info field of the Multi-STA BlockAck frame sent as a response depending on the acknowledgment context as follows:

— An HE AP that receives an A-MPDU that includes one MPDU, and the MPDU is an EOF MPDU that is a Management frame that solicits an acknowledgment prior to association may generate a Multi-STA BlockAck frame using the procedure described in the pre-association ack context defined below.

— An HE STA that receives an A-MPDU that does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frames with Normal Ack or Implicit BAR ack policy belonging to the same block ack agreement may generate a Multi-STA BlockAck frame as follows:
  - If all MPDUs in the A-MPDU are received successfully, then the recipient may follow the procedure described in the all ack context as defined below.
  - Otherwise, the recipient shall follow the procedure described in the BlockAck context defined below.

— If an HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1 and the A-MPDU includes an EOF MPDU that is a Management frame that solicits acknowledgment, and one or more MPDUs (either EOF MPDUs or non-EOF MPDUs) that are QoS Data frames with Normal Ack or Implicit BAR ack policy, then the recipient shall generate Multi-STA BlockAck frame as follows:
  - If all the MPDUs in the A-MPDU are received successfully, then the recipient may follow the procedure described in the all ack context.
  - Otherwise:
    - For the MPDU that is a Management frame, the recipient shall create a Per AID TID info field using the procedure described below in Ack context with the TID value set to 15.
    - For the EOF MPDUs that are QoS Data frames, the recipient shall create a Per AID TID info field using the procedure described below in Ack context with the TID set to the TID of the QoS Data frame
    - For the non-EOF MPDUs that are QoS Data frames, the recipient shall create a Per AID TID info field using the procedure described below in BlockAck context with the TID set to the TID of the QoS Data frame

— If an HE STA supports multi-TID aggregation and the A-MPDU does not include an EOF MPDU but does include non-EOF MPDUs that are QoS Data frames with Implicit BAR ack policy and are belonging to more than one block ack agreement, then the recipient shall generate a Multi-STA BlockAck frame as follows:
  - If all MPDUs in the A-MPDU are received successfully, then the recipient may follow the procedure described in the all ack context
  - Otherwise, for each TID included the received A-MPDU, the recipient shall create a per AID TID info field using the procedure described in BlockAck context with the TID set to the TID of the QoS Data frame

NOTE—A STA indicates the maximum number of Per AID TID Info fields with the same AID excluding the one for a Management frame that it can include in the Multi-STA BlockAck frame in the Multi-TID Aggregation Rx Support field in the HE Capabilities element it transmits.

The procedure for different acknowledgment contexts for generating Multi-STA BlockAck frame is defined below:

a) All ack context: if the originator had set the All Ack Support subfield in the HE Capabilities element to 1, then the recipient may set the Ack Type field to 1 and the TID subfield to 14 to indicate the reception of all the MPDUs carried in the eliciting A-MPDU or multi-TID A-MPDU. Otherwise the recipient shall not set the Ack Type field to 1 and the TID subfield to 14. The Multi-STA BlockAck frame shall contain only one Per AID TID Info field addressed to an originator in the Multi-STA BlockAck frame. The recipient determines that all the MPDUs carried in the eliciting A-MPDU were received if there were no MPDU delimiter CRC errors and no MPDU FCS errors in that A-MPDU.

b) Pre-association ack context: A recipient receiving a Management frame from an unassociated STA, that requires an acknowledgment, shall set the Ack Type field to 0, AID subfield to 2045, and the TID field to 15 in the Per AID TID Info field, and the RA field of the Per AID TID Info field to the intended recipient's MAC address to indicate the successful reception of that Management frame.

c) Ack context: A recipient that sets the Ack-Enabled Aggregation Support subfield in the HE Capabilities element to 1 and that receives an EOF MPDU soliciting acknowledgment shall set the Ack Type field to 1 and, if the EOF MPDU is a QoS Data frame, set the TID field to the TID of the QoS Data frame, or, if the EOF MPDU is a Management frame or PS-Poll frame, set the TID field to 15.

   If a received A-MPDU contains more than one EOF MPDU that solicits an immediate acknowledgment, then the Multi-STA BlockAck frame shall contain multiple Per AID TID Info fields, with Ack Type field equal to 1, one for each such received EOF MPDU requesting an acknowledgment.

   The TID field is set to the TID of the QoS Data or QoS Null frame that is being acknowledged and set to 15 for a PS Poll frame or Management frame that is being acknowledged.

d) BlockAck context: The recipient shall set the Ack Type field to 0 and the TID field of a Per AID TID Info field to the TID value of MPDUs requesting block acknowledgment that are carried in the eliciting A-MPDU or multi-TID A-MPDU.

   The Multi-STA BlockAck frame may contain multiple occurrences of these Per AID TID Info fields addressed to an originator, one for each MPDU that is requesting block acknowledgment, in which case the Block Ack Starting Sequence Control and Block Ack Bitmap fields shall be set according to 10.25.6 (HT-immediate block ack extensions) for each block ack session, and according to 26.3 (Fragmentation and defragmentation) for each block ack session with dynamic fragmentation.

   The allowed values for the TID field in this context are 0 to 7 (for indicating block acknowledgment of QoS Data frames).

   Variable bitmap lengths may be included in the Per AID TID Info field when the originator and recipient negotiate their use as defined in 26.4.3 (Negotiation of block ack bitmap lengths).

The Ack Type subfield(s) in a Multi-STA BlockAck frame shall be set to 0 if the Multi-STA BlockAck frame is sent in response to an MU-BAR Trigger frame.

Upon receipt of a Multi-STA BlockAck frame the originator shall examine each Per AID TID Info field and shall perform the following operations:

— If the AID subfield is 0 for an AP originator or the non-AP STA's AID for a non-AP STA originator, the Ack Type field is 0 and the TID field is less than 8 then the BlockAck Starting Sequence Control, TID and Block Ack Bitmap fields of the Per AID TID Info field are processed according to 10.25.6 (HT-immediate block ack extensions), 26.3 (Fragmentation and defragmentation), and as defined below.

— If the AID subfield is 2045, the Ack Type field is 0 and the TID field is 15, then the Per AID TID Info field indicates the acknowledgment of a single Management frame sent by the unassociated STA as defined by the acknowledgment context.

— If the AID subfield is 0 for an AP originator or the non-AP STA's AID for a non-AP STA originator, the Ack Type field is 1 and the TID is less than or equal to 7 or is equal to 15, then the Per AID TID

Info field indicates the acknowledgment of an EOF MPDU that is a QoS Data frame identified by the value of the TID, a Management frame or a PS-Poll frame.

— If the AID subfield is 0 for an AP originator or the non-AP STA's AID for a non-AP STA originator, the Ack Type field is 1 and the TID subfield of AID TID Info field is 14, then the Per AID TID Info field indicates the acknowledgment of all MPDUs carried in the eliciting A-MPDU as defined by the acknowledgment context.

If an associated non-AP STA that does not support the UORA procedure receives a Multi-STA BlockAck frame in response to an eliciting frame, and if the Multi-STA BlockAck frame contains a Per AID TID Info subfield with the AID11 subfield set to 2045, then the STA shall ignore the 10 octets following the AID TID Info subfield, and shall continue to parse the following Per AID TID Info subfields (if any).

26.4.3 Negotiation of block ack bitmap lengths

Both the Compressed BlockAck frame and Multi-STA BlockAck frame allow different Block Ack Bitmap subfield lengths. The length of the Block Ack Bitmap subfield is indicated in the Fragment Number subfield of the Block Ack Starting Sequence Control field as defined in 9.3.1.8 (BlockAck frame format). The allowed Block Ack Bitmap lengths for each of the negotiated buffer sizes are defined in Table 26-1 (Negotiated buffer size and Block Ack Bitmap subfield length).

Table 26-1—Negotiated buffer size and Block Ack Bitmap subfield length

Negotiated buffer size	Block Ack Bitmap subfield length (bits) in a Compressed BlockAck frame	Block Ack Bitmap subfield length (bits) in a Multi-STA BlockAck frame
1–64	64	32 or 64
65–128	64 or 256	32, 64 or 128
129–256	64 or 256	32, 64, 128 or 256
NOTE—A 32-bit Block Ack Bitmap subfield length is not allowed unless the originator has set the 32-bit BA Bitmap Support field in the HE MAC Capabilities Information field in the HE Capabilities element to 1.		

An HE STA that transmits a Compressed BlockAck frame or a Multi-STA BlockAck frame shall use a Block Ack Bitmap subfield length identified in Table 26-1 (Negotiated buffer size and Block Ack Bitmap subfield length) for the negotiated buffer size of the block ack agreement to which the BA Information field corresponds.

The recipient is allowed to respond with a Block Ack Bitmap subfield in the BA Information field that is less than the maximum allowed Block Ack Bitmap for the negotiated buffer size. The length of the Block Ack Bitmap subfield in a Compressed BlockAck frame or a Multi-STA BlockAck frame may be less than the negotiated buffer size but shall be sufficient to include the recipient's scoreboard state for MPDUs beginning with the MPDU for which the Sequence Number subfield value is *WinStartR* and ending with the MPDU for which the Sequence Number subfield is *WinEndR*.

The recipient shall not include in the Buffer Size field of an ADDBA Response frame a value that would cause the BlockAck Bitmap length of its block ack responses to exceed the BlockAck Bitmap length that is derived by the Buffer Size field of the ADDBA Request frame sent by the originator. When the Buffer Size field in the ADDBA Request frame is 0, the Buffer Size field of an ADDBA Response frame is in the range 1 to 64.

NOTE—Refer to Block Ack Bitmap subfield length identified in Table 26-1 (Negotiated buffer size and Block Ack Bitmap subfield length) for the negotiated buffer size of the block ack agreement.

A recipient shall not include in a Multi-STA BlockAck frame a Per AID TID Info field with a 32-bit BlockAck Bitmap field addressed to an originator if the 32-bit BA Bitmap Support field in the HE MAC Capabilities Information field in the HE Capabilities element received from that originator is 0.

NOTE—A Multi-STA BlockAck frame might include Per AID TID Info fields with a 32-bit BlockAck Bitmap field addressed to other originators and the nonsupporting originator needs to able to parse these fields to locate a possible Per AID TID Info field addressed to it.

The originator of a BlockAckReq frame, MU-BAR Trigger frame, GCR MU-BAR Trigger frame or a A-MPDU that includes QoS Data frames that solicits an immediate BlockAck frame response or Management frame that solicits acknowledgment shall set the Duration field accounting for the largest BlockAck Bitmap length based on negotiated buffer size.

A recipient shall not transmit a Compressed BlockAck frame or a Multi-STA BlockAck frame with the LSB of the Fragment Number subfield set to 1 unless the recipient has received from the originator an HE Capabilities element with the Dynamic Fragmentation Support subfield equal to 3. If the LSB of the Fragment Number subfield of the BlockAck frame is 1, then the Block Ack Bitmap fields are set as defined in 26.3.2.4 (Level 3 dynamic fragmentation).

26.4.4 Per-PPDU acknowledgment selection rules

26.4.4.1 General

A STA that transmits a PPDU can solicit different immediate responses for frames contained in the PPDU by using the Ack Policy Indication subfield of QoS Data or QoS Null frames, the type of the frame, PPDU format, number of TIDs in the A-MPDU and the EOF field setting of the A-MPDU delimiter.

26.4.4.2 Responding to an HE SU PPDU or HE ER SU PPDU with an SU PPDU

An HE STA that receives an HE SU PPDU or HE ER SU PPDU carrying an A-MPDU that includes MPDUs that solicits acknowledgment and that does not include a triggering frame shall respond using an SU PPDU as follows:

1) If the A-MPDU includes only one MPDU and the MPDU is an EOF MPDU that is either a QoS Data frame or QoS Null frame with Normal Ack ack policy, or a Management frame that solicits acknowledgment, then the STA shall respond with an Ack frame.
2) If the A-MPDU includes only one MPDU and the MPDU is an EOF MPD that is a PS-Poll frame the STA shall respond with an Ack frame or a QoS Data frame.
3) If the HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes more than one MPDU, only one of which solicits acknowledgment and the MPDU that solicits acknowledgment is an EOF MPDU that is a QoS Data frame or a QoS Null frame with Normal Ack ack policy, or a Management frame that solicits acknowledgment, then the HE STA shall respond with an Ack frame.
4) If the A-MPDU does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frames belonging to the same block ack agreement and with the Ack Policy Indication subfield equal to Implicit BAR for at least one MPDU, then the STA shall either respond with a Compressed BlockAck frame as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) or a Multi-STA BlockAck frame with Ack Type field set to 1 and the TID field set to 14 as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame) if the recipient has indicated sup-

port for the all ack context by setting the All Ack Support subfield in the HE MAC Capabilities Information field to 1.

5) If the HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes a Management frame that solicits an acknowledgment, and one or more QoS Data frames with ack policy Normal Ack or Implicit BAR, then the STA shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

6) If the HE STA supports multi-TID aggregation and if the A-MPDU includes two or more QoS Data frames with ack policy Implicit BAR and belonging to more than one block ack agreement, then the STA shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

26.4.4.3 Responding to an HE MU PPDU with an SU PPDU

If an AP intends to solicit an immediate response in an SU PPDU the following apply:

— An AP shall set the Ack Policy Indication subfield in the QoS Data and QoS Null frames to Normal Ack or Implicit BAR in at most one A-MPDU in the HE MU PPDU (see 10.3.3.13.1 (Acknowledgment procedure for DL MU PPDU in SU PPDU) for an example of this sequence).

— The A-MPDUs in the HE MU PPDU shall not contain a Management frame that solicits acknowledgment.

An HE STA that receives an HE MU PPDU with an A-MPDU that contains MPDUs that solicit acknowledgment and that does not include a triggering frame shall respond using an SU PPDU as follows:

1) If the A-MPDU carries only one MPDU and the MPDU is an EOF MPDU that is either a QoS Data frame or QoS Null frame with Normal Ack ack policy, then the STA shall respond with an Ack frame.

2) If the HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes more than one MPDU, only one of which solicits acknowledgment and the MPDU that solicits acknowledgment is an EOF MPDU that is a QoS Data frame or a QoS Null frame with Normal Ack ack policy, then the HE STA shall respond with an Ack frame.

3) If the A-MPDU does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frame belonging to the same block ack agreement and with the Ack Policy Indication subfield equal to Implicit BAR for at least one MPDU, then the STA shall either respond with a Compressed BlockAck frame as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) or a Multi-STA BlockAck frame with the Ack Type set to 1 and the TID field set to 14 as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame) if the recipient has indicated support for the all ack context by setting the All Ack Support subfield in the HE MAC Capabilities Information field to 1.

4) If the HE STA supports multi-TID aggregation and if the A-MPDU includes two or more QoS Data frames with Implicit BAR ack policy addressed to it and belonging to more than one block ack agreement, then the STA shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

NOTE—A control response frame carried in an SU PPDU that is an immediate response to an HE MU PPDU follows the rules defined in 10.6.6.5 (Rate selection for control response frames).

An AP that sends an HE MU PPDU shall not set the Ack Policy Indication subfield to Normal Ack or Implicit BAR for any of the MPDUs carried in the HE MU PPDU if the solicited PPDU containing a control response would occupy one or more 20 MHz channels where pre-HE modulated fields of the soliciting PPDU are not located.

26.4.4.4 Responding to an HE MU PPDU, HE SU PPDU or HE ER SU PPDU with an HE TB PPDU

An AP that sends an HE MU PPDU, HE SU PPDU or HE ER SU PPDU that contains an MPDU that solicits an immediate response carried in an HE TB PPDU shall set the Ack Policy Indication subfield to HTP Ack for each of the QoS Data frames for which it intends to solicit an immediate response (see 10.3.3.13.2 (Acknowledgment procedure for DL MU PPDU in MU format)). If a Management frame that solicits acknowledgment is carried in an HE MU PPDU, then the response is carried in an HE TB PPDU. A non-AP STA that receives an HE MU PPDU, HE SU PPDU or HE ER SU PPDU with an A-MPDU that contains a QoS Data frame addressed to it and with HTP Ack ack policy, or a Management frame that solicits an immediate acknowledgment shall not respond if it has not received the UL resource allocation information either through TRS Control subfield or a Trigger frame in the soliciting PPDU.

A non-AP STA that receives an HE MU PPDU, HE SU PPDU or HE ER SU PPDU with an A-MPDU that contains one or more MPDUs that solicits acknowledgment and includes a triggering frame shall respond with an HE TB PPDU as follows:

1) If the A-MPDU includes only one MPDU, and the MPDU is an EOF MPDU that is either a QoS Data or QoS Null frame with HTP Ack ack policy or a Management frame that solicits acknowledgment, then the STA shall respond with an Ack frame.
2) If the HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes more than one MPDU, only one of which solicits acknowledgment and the MPDU that solicits acknowledgment is an EOF MPDU that is a QoS Data or QoS Null frame with HTP Ack ack policy, or a Management frame that solicits acknowledgment, then the HE STA shall respond with an Ack frame.
3) If the A-MPDU does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frames belonging to the same block ack agreement and with the Ack Policy Indication subfield equal to HTP Ack for at least one MPDU, then the STA shall respond with a Compressed BlockAck frame as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA) or a Multi-STA BlockAck frame with the Ack Type set to 1 and the TID field set to 14 as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame) if the recipient has indicated support for the all ack context by setting the All Ack Support subfield in the HE MAC Capabilities Information field to 1.
4) If the HE STA supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes a Management frame that solicits an acknowledgment, and one or more QoS Data frames with ack policy HTP Ack or Implicit BAR, then the STA shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).
5) If the HE STA supports multi-TID aggregation and if the A-MPDU includes two or more QoS Data frames with HTP Ack ack policy and belonging to more than one block ack agreement, then the STA shall respond with a Multi-STA BlockAck frame.

26.4.4.5 Responding to an HE TB PPDU with an SU PPDU

A non-AP STA that sends an HE TB PPDU as a response to a Basic Trigger frame shall set the Ack Policy Indication subfield of the QoS Data frames or QoS Null frames to Normal Ack or Implicit BAR (see 10.3.3.13.3 (Acknowledgment procedure for an UL MU transmission) for an example of this sequence).

If the HE TB PPDU carries MPDUs only from one STA and if the HE AP intends to send the response in an SU PPDU, then the HE AP shall respond using an SU PPDU as follows:

1) If the A-MPDU includes only one MPDU, and the MPDU is an EOF MPDU that is either a QoS Data frame or QoS Null frame with Normal Ack ack policy, or a Management frame that solicits

acknowledgment then the HE AP shall respond with either an Ack frame or a Multi-STA BlockAck frame with the Ack Type field set to 1.

2) If the HE AP supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes more than one MPDU, only one of which solicits acknowledgment and the MPDU that solicits acknowledgment is an EOF MPDU that is a QoS Data or QoS Null frame with Normal Ack ack policy, or a Management frame that solicits acknowledgment, then the HE AP shall respond with an Ack frame or a Multi-STA BlockAck frame with the Ack Type field set to 1.

3) If the A-MPDU does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frames belonging to the same block ack agreement and with Ack Policy Indication subfield equal to Implicit BAR for at least one MPDU, then the HE AP shall respond with a Compressed BlockAck frame as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA), a Multi-STA BlockAck frame with the Ack Type field set to 1 and the TID field set to 14 if the recipient has indicated support for the all ack context by setting the All Ack Support subfield in the HE MAC Capabilities Information field to 1 or a Multi-STA BlockAck frame with the Ack Type field set to 0 as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

4) If the HE AP supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU carries a Management frame that solicits acknowledgment, and one or more QoS Data frames with Implicit BAR ack policy, then the HE AP shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

5) If the HE AP supports multi-TID aggregation and if the A-MPDU includes two or more QoS Data frames with Normal Ack or Implicit BAR ack policy and belonging to more than one block ack agreement, then the HE AP shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

If the AP receives HE TB PPDUs from more than one STA, and if the AP intends to send the response in an SU PPDU, then the AP shall respond with a Multi-STA BlockAck frame carried in an SU PPDU that contains the appropriate settings in each Per AID TID Info field addressed to each STA as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

26.4.4.6 Responding to an HE TB PPDU with an HE MU PPDU

A non-AP STA that sends an HE TB PPDU as a response to a Basic Trigger frame that solicits an immediate response shall set the Ack Policy Indication subfield to Normal Ack or Implicit BAR for each of the QoS Data frames carried in the A-MPDU (see 10.3.3.13.3 (Acknowledgment procedure for an UL MU transmission) for an example of this sequence).

If an HE AP sends response to an HE TB PPDU that it received using an HE MU PPDU, then the AP shall respond to each A-MPDU that it received using the following procedure:

1) If the A-MPDU received from a STA includes only one MPDU, and the MPDU is an EOF MPDU that is either a QoS Data frame or QoS Null frame with Normal Ack ack policy, or a Management frame that solicits acknowledgment, then the STA shall respond with an Ack frame or a Multi-STA BlockAck frame with the Ack Type field set to 1 carried in the HE MU PPDU.

2) If the HE AP supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1, and if the A-MPDU includes more than one MPDU, only one of which solicits acknowledgment and the MPDU that solicits acknowledgment is an EOF MPDU that is a QoS Data frame with Normal Ack ack policy, or a Management frame that solicits acknowledgment, then the HE AP shall respond with an Ack frame or a Multi-STA BlockAck frame with the Ack Type field set to 1 carried in the HE MU PPDU.

3) If the A-MPDU does not include an EOF MPDU but does include one or more non-EOF MPDUs that are QoS Data frames belonging to the same block ack agreement and with the Ack Policy Indication subfield equal to Implicit BAR for at least one MPDU, then the HE AP shall respond with a Compressed BlockAck frame as defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA, DMG STA, or S1G STA), a Multi-STA BlockAck frame with the Ack Type field set to 1 and the TID field set to 14 or a Multi-STA BlockAck frame with the Ack Type field set to 0 as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame) carried in the HE MU PPDU.

4) If the HE AP supports ack-enabled aggregation by setting the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field to 1 and the A-MPDU carries a Management frame that solicits acknowledgment and one or more QoS Data frames with Implicit BAR ack policy, then the HE AP shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame), carried in the HE MU PPDU.

5) If the HE AP supports multi-TID aggregation and if the A-MPDU includes two or more QoS Data frames with Implicit BAR ack policy and are belonging to more than one block ack agreement, then the HE AP shall respond with a Multi-STA BlockAck frame as defined in 26.4.2 (Acknowledgment context in a Multi-STA BlockAck frame).

In addition, an AP with dot11MultiBSSIDImplemented equal to true may do one of the following:

— For each BSS belonging to the multiple BSSID set for which the AP has received an HE TB PPDU, the AP responds with a Multi-STA BlockAck frame with RA field set to the broadcast address and carried in a DL HE MU PPDU. The Ack Type field and AID11 field of the Multi-STA BlockAck frame are set as described in 9.3.1.8.7 (Multi-STA BlockAck variant). The AP shall set the TXVECTOR parameter STA_ID for the RU carrying the Multi-STA BlockAck frame to the value of the BSSID Index field as defined in 26.11.1 (STA_ID).
— The AP may respond with a Multi-STA BlockAck frame with the TA field set to the transmitted BSSID and carried in a DL HE MU PPDU to acknowledge the STA's transmission, if the recipient non-AP STA is associated with a nontransmitted BSSID of the multiple BSSID set and the AP has received an HE Capabilities element from the STA with the Rx Control Frame To MultiBSS subfield equal to 1. The Ack Type field and AID11 field of the Multi-STA BlockAck frame are set as described in 9.3.1.8.7 (Multi-STA BlockAck variant). The AP shall set the TXVECTOR parameter STA_ID for the RU carrying the Multi-STA BlockAck frame to 2047.

NOTE—An AP includes at most one Ack or BlockAck frame (group addressed Multi-STA BlockAck frame included) in an A-MPDU as specified in Table 9.7.3 (A-MPDU contents).

26.4.5 HE block acknowledgment request and response rules

An HE AP may solicit BlockAck frame responses from multiple HE STAs using an MU-BAR Trigger frame or GCR MU-BAR Trigger frame. An HE AP shall not send a Multi-TID BlockAckReq (neither as part of a User Info field addressed to the STA in an MU-BAR Trigger frame nor as a BlockAckReq frame) to a STA that has not indicated support for multi-TID A-MPDU. The Block Ack Bitmap length of the block ack sent in response to an eliciting Multi-TID BlockAckReq frame, BlockAckReq frame, GCR MU-BAR Trigger frame, or MU-BAR Trigger frame is determined as defined in 26.4.3 (Negotiation of block ack bitmap lengths).

An HE STA that receives a BlockAckReq frame or an MU-BAR Trigger frame that contains a Compressed BlockAckReq variant in the User Info field addressed to the STA, or a GCR MU-BAR Trigger frame that contains a Compressed BlockAckReq variant in the Common Info field shall respond with a Compressed BlockAck frame as defined in 10.25.6 (HT-immediate block ack extensions) or a Multi-STA BlockAck frame as defined in 26.4 (HE acknowledgment procedure), with Starting Sequence Number subfield set to the Starting Sequence Number subfield of the Block Ack Request Starting Sequence Control subfield and the length of the Block Ack Bitmap subfield calculated as defined in 26.4.3 (Negotiation of block ack bitmap lengths).

An HE STA that receives a Multi-TID BlockAckReq frame or an MU-BAR Trigger frame that contains a Multi-TID BlockAckReq variant in the User Info field addressed to the STA or a GCR MU-BAR Trigger frame that contains a Multi-TID BlockAckReq variant in the Common Info field shall respond with a Multi-STA BlockAck frame that contains a Per AID TID Info field with a Block Ack Bitmap subfield for each of the TIDs (with values less than 8) contained in the BlockAckReq frame, with Starting Sequence Number subfield set to the Starting Sequence Number subfield of the Block Ack Request Starting Sequence Control subfield and the length of the Block Ack Bitmap subfield calculated as defined in 26.4.3 (Negotiation of block ack bitmap lengths).

A non-AP HE STA that responds to a Compressed BlockAckReq frame, Multi-TID BlockAckReq frame, MU-BAR Trigger frame, or GCR MU-BAR Trigger frame with a Multi-STA BlockAck frame shall set the Ack Type subfield of the Multi-STA BlockAck frame to 0.

26.5 MU operation

26.5.1 HE DL MU operation

26.5.1.1 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.

The PSDU on each RU in an HE MU PPDU shall be padded to end at the same time, indicated by the L-SIG field as described in 27.3.11.5 (L-SIG).

The padding procedure for each A-MPDU in an HE MU PPDU is defined in 26.6.2.2 (A-MPDU padding in an HE SU PPDU, HE ER SU PPDU and HE MU PPDU).

An AP shall not transmit an HE MU PPDU with an RU that is narrower than the PPDU bandwidth and that is allocated to more than one STA (DL MU-MIMO) unless the AP has received from each STA an HE Capabilities element with the Partial Bandwidth DL MU-MIMO subfield in the HE PHY Capabilities Information field equal to 1.

An AP shall not send to a STA an A-MPDU contained in an HE MU PPDU that contains one of the following combinations of frames unless the AP has received from the STA an HE Capabilities element with the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field equal to 1:

- A QoS Data frame with HTP Ack ack policy carried in an A-MPDU subframe with the EOF field set to 1 and a Trigger frame.
- A Management frame carried in an A-MPDU subframe with the EOF field set to 1 where the Management frame is a Disassociation frame, (Re)Association Response frame, Authentication frame or Action frame, and a Trigger frame.

The AP shall follow the EDCA procedure defined in 10.23 (HCF) and the following additional rules:

- If at least one of the frame exchanges in HE DL MU operation requires an immediate response (i.e., the AP includes at least one Trigger frame or frame carrying a TRS Control subfield) and if the AP receives an immediate response with at least one correct MPDU from at least one of the solicited STAs, the frame exchange is successful.
- If at least one of the frame exchanges in HE DL MU operation requires an immediate response (i.e., the AP includes at least one Trigger frame or frame carrying a TRS Control subfield) and if the AP receives no immediate response, the frame exchange is not successful.
- The AP follows the MPDU aggregation rules in 26.6 (A-MPDU operation in an HE PPDU), that supersede the rules in 10.23.2.7 (Sharing an EDCA TXOP).

An AP shall not transmit an HE MU PPDU where the number of OFDM symbols in the HE-SIG-B field is greater than 16 to a non-AP STA with a 20 MHz operating channel width.

26.5.1.2 RU addressing in an HE MU PPDU

The Type and Subtype subfields in the Frame Control field and address type (individually addressed or group addressed) of MPDUs may be different across A-MPDUs in different PSDUs within the same HE MU PPDU.

An AP includes in the TXVECTOR for an HE MU PPDU at least one parameter STA_ID for each RU in the HE MU PPDU as defined in 26.11.1 (STA_ID). The AP shall not include in the TXVECTOR more than one parameter STA_ID with the same value unless the value is 2046 (indicating an unallocated RU).

A non-AP STA that receives an HE MU PPDU where the RXVECTOR includes a parameter STA_ID that matches the 11 LSBs of the non-AP STA's AID may disregard any broadcast RU in the HE MU PPDU. A non-AP STA that receives an HE MU PPDU where the RXVECTOR includes a parameter STA_ID that is equal to the BSSID Index of the BSSID of the AP with which the STA is associated (see 9.4.2.73 (Multiple BSSID-Index element)) may disregard a broadcast RU (parameter STA_ID equal to 2047).

An MPDU of an HE MU PPDU sent in a broadcast RU shall not include information intended for a STA that is identified as the recipient of another RU in the same HE MU PPDU.

26.5.1.3 RU allocation in an HE MU PPDU

An AP shall not transmit a 40 MHz HE MU PPDU in the 2.4 GHz band with an RU allocated to a 20 MHz operating non-AP HE STA unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with the 20 MHz In 40 MHz HE PPDU In 2.4 GHz Band subfield in the HE PHY Capabilities Information field equal to 1.

An AP shall not transmit a 160 MHz or 80+80 MHz HE MU PPDU with an RU allocated to a 20 MHz operating non-AP HE STA unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with the 20 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field equal to 1.

An AP shall not transmit a 160 MHz or 80+80 MHz HE MU PPDU with an RU allocated to an 80 MHz operating non-AP HE STA unless the AP has received from the 80 MHz operating non-AP HE STA an HE Capabilities element with the 80 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field equal to 1.

An AP shall follow the RU restriction rules defined in 27.3.2.8 (RU restrictions for 20 MHz operation) when assigning an RU to a 20 MHz operating non-AP STA in a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE MU PPDU. An AP shall follow the rules in 27.3.2.7 (20 MHz operating non-AP HE STAs), and 27.3.2.9 (80 MHz operating non-AP HE STAs) or the SST subchannel (if applicable) in which the STA is operating (see 26.8.7 (HE subchannel selective transmission)) if allocating RUs to a non-AP STA.

An AP shall not transmit a 40 MHz HE MU PPDU in the 2.4 GHz band with a 242-tone RU allocated to a 20 MHz operating non-AP HE STA unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with B4 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field equal to 1.

An AP shall not transmit a 40 MHz, 80 MHz, 160 MHz or 80+80 MHz HE MU PPDU in the 5 GHz band with a 242-tone RU allocated to a 20 MHz operating non-AP HE STA unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with B5 of the Supported Channel Width Set subfield of the HE PHY Capabilities Information field equal to 1.

An HE MU PPDU shall have a sufficient number of RUs allocated to users such that all of the following conditions are satisfied:

— At least $N \times 4 \times 26$ subcarriers are modulated by the allocated RUs within the entire PPDU, where N is the number of 20 MHz subchannels that are not preamble punctured in the PPDU.

— For each 20 MHz subchannel S within the bandwidth of the HE MU PPDU, at least 2×26 subcarriers are modulated by the allocated RUs in the 20 MHz subchannel S if all of the following are true:
  - At least one RU is allocated in the 20 MHz subchannel S.
  - Transmitter is an AP.
  - The AP is operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior.
  - The AP has received at least one Beacon frame from OBSS B within the past dot11ObssNbRuToleranceTime in the current operating channel in which any of the following are true:
    - The Extended Capabilities element is not present.
    - The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is not present.
    - The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is 0.
  - The 20 MHz subchannel S overlaps with the operating bandwidth of the OBSS B.

— At least one RU is allocated in the primary 20 MHz.

26.5.2 UL MU operation

26.5.2.1 General

UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response frames in an HE TB PPDU unless the Trigger frame is an MU-RTS Trigger frame, in which case the response is a CTS frame sent in a non-HT PPDU (see 26.2.6 (MU-RTS Trigger/CTS frame exchange procedure)).

A non-AP STA shall not send a triggering frame.

A non-AP HE STA shall set the TRS Support subfield of the HE Capabilities element it transmits to 1 if its dot11TRSOptionImplemented is true; otherwise the STA shall set it to 0.

A non-AP HE STA shall set the UL 2×996-tone RU Support subfield in HE Capabilities element to 1 if it supports receiving a frame that carries a TRS Control subfield that allocates a 2×996-tone RU or a Trigger frame with User Info field addressed to the STA with RU Allocation subfield indicating a 2×996-tone RU.

If a non-AP HE STA supports transmitting an HE TB PPDU that uses UL MU-MIMO within an RU that spans the entire PPDU bandwidth, then the STA shall set dot11HEFullBWULMUMIMOImplemented to true and the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field of the HE Capabilities element it transmits to 1. Otherwise, the HE STA shall set dot11HEFullBWULMUMIMOImplemented to false and the Full Bandwidth UL MU-MIMO subfield to 0.

If a non-AP HE STA with dot11HEFullBWULMUMIMOImplemented equal to true also supports transmitting an HE TB PPDU that uses UL MU-MIMO within an RU that does not span the entire PPDU bandwidth, then the STA shall set dot11HEPartialBWULMUMIMOImplemented to true and the Partial Bandwidth UL MU-MIMO subfield in the HE PHY Capabilities Information field of the HE Capabilities element it transmits to 1. Otherwise, the non-AP HE STA shall set dot11HEPartialBWULMUMIMOImplemented to false and the Partial Bandwidth UL MU-MIMO subfield to 0.

If a non-AP STA indicates Class A in the Device Class subfield of the HE PHY Capabilities Information field of the HE Capabilities element then the HE TB PPDU transmitted by the non-AP STA shall meet the Class A requirements in 27.3.15 (Transmit requirements for PPDUs sent in response to a triggering frame). Otherwise, the HE TB PPDU transmitted by the non-AP STA shall meet the Class B requirements in 27.3.15 (Transmit requirements for PPDUs sent in response to a triggering frame).

A non-AP HE STA with dot11HTVHTTriggerOptionImplemented equal to true shall set the HT And VHT Trigger Frame Rx Support field to 1 in the HE MAC Capabilities Information field in HE Capabilities elements that it transmits. A non-AP HE STA with dot11HTVHTTriggerOptionImplemented equal to false shall set the HT And VHT Trigger Frame Rx Support field to 0.

26.5.2.2 Rules for soliciting UL MU frames

26.5.2.2.1 General

An HE AP shall not allocate an RU for a 40 MHz HE TB PPDU to a 20 MHz operating non-AP HE STA in the 2.4 GHz band unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with the 20 MHz In 40 MHz HE PPDU In 2.4 GHz Band subfield in the HE PHY Capabilities Information field in its HE Capabilities element equal to 1.

An HE AP shall not allocate an RU for an 160 MHz or 80+80 MHz HE TB PPDU to a 20 MHz operating non-AP HE STA unless the AP has received from the 20 MHz operating non-AP HE STA an HE Capabilities element with the 20 MHz In 160/80+80 MHz HE PPDU in the HE PHY Capabilities Information field equal to 1.

An AP shall not allocate to a 20 MHz operating non-AP HE STA a 242-tone RU for a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE TB PPDU transmission.

An AP shall not transmit a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that does not span the entire PPDU bandwidth to a non-AP STA from which it has not received an HE Capabilities element with the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field equal to 1.

An AP shall not transmit a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that spans the full bandwidth to a non-AP STA from which it has not received an HE Capabilities element with the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field equal to 1.

An AP shall not send a frame that carries a TRS Control subfield to a non-AP STA that has not set the TRS Support subfield to 1 in the HE MAC Capabilities Information field of the HE Capabilities element it transmits.

An AP shall not send a frame that carries a TRS Control subfield that allocates a 2×996-tone RU to a non-AP STA or a Trigger frame with a User Info field that allocates a 2×996-tone RU to a non-AP STA unless the AP has received from the non-AP STA an HE MAC Capabilities element with the UL 2×996-tone RU Support subfield in the MAC Capabilities Information field equal to 1.

NOTE—An AP does not send a Trigger frame containing a User Info field with AID12 subfield carrying the 12 LSBs of the AID of a non-AP STA or a frame addressed to a non-AP STA that carries a TRS Control subfield if the AP has received from the non-AP STA an OM Control subfield with UL MU Disabled subfield set to 1 and UL MU Data Disable subfield set to 0 (see 26.9.3 (Transmit operating mode (TOM) indication)).

An AP that transmits a PPDU may solicit an HE TB PPDU from one or more non-AP STAs through one of the following mechanisms:

— Including in the PPDU one or more Trigger frames that include one or more User Info fields with one of the following AID12 subfield settings:

- The AID12 subfield is set to the 12 LSBs of the AID of the non-AP STA if the User Info field is addressed to a STA that is associated with the AP.
- The AID12 subfield is set to the 12 LSBs of the AID of the non-AP STA if the User Info field is addressed to a STA that is associated with a nontransmitted BSSID in a multiple BSSID set to which the AP belongs, the TA field of the Trigger frame is set to the transmitted BSSID and the non-AP STA has set the Rx Control Frame To MultiBSS subfield in the HE Capabilities element it transmits to 1.
- The AID12 subfield is set to 0 if the User Info field is addressed to non-AP STAs that are associated with the AP and that support the UORA procedure (see 26.5.4 (UL OFDMA-based random access (UORA)).
- The AID12 subfield is set to 2045 if the User Info field is addressed to non-AP STAs that are not associated with the AP and that support the UORA procedure (see 26.5.4 (UL OFDMA-based random access (UORA)).

— Including in the PPDU one or more individually addressed frames that include a TRS Control subfield and that:

- Are carried in an S-MPDU format that solicits an immediate Ack frame (see 10.12.8 (Transport of S-MPDUs))
- Are carried in an A-MPDU format that solicits an immediate BlockAck frame (see 10.25.6.7 (Originator's behavior))
- Are carried in a multi-TID A-MPDU format that solicits an immediate Multi-STA BlockAck frame (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU))

The AP shall follow the rules in 26.3.2 (Dynamic fragmentation) if any of the MPDUs are fragments.

More than one Trigger frame may be aggregated in an A-MPDU. If more than one Trigger frame is aggregated in an A-MPDU, all of them shall have the same content. An AP may include a frame carrying a TRS Control subfield in an HE MU PPDU, HE SU PPDU or HE ER SU PPDU.

NOTE—The TRS Control subfields within MPDUs carried in an A-MPDU have the same value (see 10.8 (HT Control field operation)).

An A-MPDU shall not include both a Trigger frame and a frame carrying a TRS Control subfield.

An AP shall not transmit a triggering frame if all of the following conditions are satisfied:

— The AP is operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior (see Table E-1)

— The AP has received at least one Beacon frame from OBSS *B* within the past dot11ObssNbRuToleranceTime in the current operating channel in which any of the following are true:

- The Extended Capabilities element is not present.
- The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is not present.
- The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is 0.

— The Trigger frame or the frame containing a TRS Control subfield allocates at least one 26-tone RU whose location in frequency overlaps with the operating bandwidth of the OBSS *B*.

If a non-AP HE STA operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior does not respond to a triggering frame in which the non-AP HE STA is allocated a 26-tone RU, then the AP should not allocate a 26-tone RU to the non-AP HE STA in the next triggering frame.

An AP shall not transmit a Trigger frame with a User Info field addressed to a non-AP STA in an HT or VHT PPDU unless the AP has received from the non-AP STA an HE Capabilities element with the HT And VHT Trigger Frame Rx Support subfield in HE MAC Capabilities Information field equal to 1.

An AP shall not use the short guard interval for an HT or VHT PPDU that carries a Trigger frame. A Trigger frame shall not be carried in a DSSS or HR/DSSS PPDU. An AP shall not use STBC encoding for a PPDU that carries a triggering frame.

26.5.2.2.2 Requirements for allocating resources

An AP that sends a Basic Trigger frame, a BQRP Trigger frame or a BSRP Trigger frame that is not aggregated with a QoS Data frame with HTP Ack ack policy or with a Management frame that solicits acknowledgment shall allocate sufficient resources for the responding STA indicated by each User Info field for the solicited associated non-AP STA or the UORA response from an associated non-AP STA to send at least one QoS Null frame that carries an HT Control field.

NOTE—An AP that sends a Basic Trigger frame uses an implementation specific method to decide the amount of resources indicated for UORA allocations.

An AP that solicits an Ack or BlockAck frame carried in an HE TB PPDU from a non-AP STA shall allocate sufficient resources for the non-AP STA to send the expected acknowledgment. If the AP solicits a BlockAck frame, the allocated resource shall be sufficient for the non-AP STA to send the BlockAck frame with Block Ack Bitmap subfields that are the negotiated block ack bitmap length (see 26.4.3 (Negotiation of block ack bitmap lengths)).

An AP that sends a BFRP Trigger frame shall allocate sufficient resources for the HE TB PPDU response form each HE beamformee to include all the solicited feedback, including feedback that is segmented and including an HT Control field in each frame.

26.5.2.2.3 Padding for Trigger frame or frame containing TRS Control subfield

An AP transmitting a PPDU that contains a BCC encoded Trigger frame or frame containing a TRS Control subfield soliciting a response from a non-AP STA shall ensure that the number of bits in the PSDU following the last bit of SCH is at least $L_{PAD,MAC}$ as defined in Equation (26-1), which is based on the *MinTrigProcTime* indicated by the non-AP STA (see Table 9-321a (Subfields of the HE MAC Capabilities Information field)), where

SCH is either:

- the User Info field addressed to the STA of the last or only Trigger frame, or
- the last TRS Control subfield in the PSDU.

$$L_{PAD,MAC} = N_{DBPS} m_{PAD} \tag{26-1}$$

where

N_{DBPS} is defined in Table 17-4 (Modulation-dependent parameters) for a non-HT PPDU, Table 19-7 (Frequently used parameters) for an HT PPDU, Table 21-6 (Frequently used parameters) for a VHT PPDU and Table 27-15 (Frequently used parameters) for an HE PPDU. If the Trigger frame or TRS Control subfield is carried in HE MU PPDU, N_{DBPS} is replaced by $N_{DBPS,u}$ of the target user in Equation (26-1).

For a non-HT PPDU, HT PPDU and VHT PPDU:

$$m_{PAD} = \begin{cases} 0, \text{ if } MinTrigProcTime \text{ is } 0 \\ 2, \text{ if } MinTrigProcTime \text{ is } 8\ \mu\text{s} \\ 4, \text{ if } MinTrigProcTime \text{ is } 16\ \mu\text{s} \end{cases}$$

For an HE PPDU:

$$m_{PAD} = \begin{cases} 0, \text{ if } MinTrigProcTime \text{ is } 0 \\ 1, \text{ if } MinTrigProcTime \text{ is } 8 \text{ or } 16\ \mu\text{s} \end{cases}$$

An AP transmitting a Trigger frame that contains at least one User Info field with AID12 subfield set to 0 (i.e., an RA-RU for associated STAs) shall ensure that the number of bits following the last bit of SCH is at least $L_{PAD,MAC}$ as defined in Equation (26-1), which is based on the largest *MinTrigProcTime* of all associated non-AP STAs, where *SCH* is the last User Info field with AID12 subfield equal to either 0 or 2046.

An AP transmitting a Trigger frame that contains at least one User Info field with AID12 subfield set to 2045 (i.e., an RA-RU for unassociated non-AP STAs) should ensure that the number of bits following the last bit of SCH is at least $4 \times N_{DBPS}$ for a non-HT PPDU, HT PPDU or VHT PPDU, or N_{DBPS} for an HE PPDU, where S*CH* is the last User Info field with AID12 subfield equal to either 2045 or 2046.

An AP transmitting an NFRP Trigger frame shall ensure that the number of bits following the last User Info field with the AID12 not equal to 4095 is at least $4 \times N_{DBPS}$ for a non-HT PPDU, HT PPDU or VHT PPDU, or N_{DBPS} for an HE PPDU.

An AP may use any type of padding to satisfy the *MinTrigProcTime* requirement of a non-AP STA, such as using the Padding field in a Trigger frame, post-EOF A-MPDU padding, or aggregating other MPDUs in the A-MPDU.

If a Trigger frame or frame containing a TRS Control subfield is LDPC encoded, then the transmitting AP ensures that $T_{TrigProc}$ meets the following requirements:

- $T_{TrigProc}$ shall be greater than or equal to the *MinTrigProcTime* specified by the non-AP STAs that are the recipients of the Trigger frame.
- For Trigger frame that contains at least one User Info field with AID12 subfield set to 0, $T_{TrigProc}$ shall be greater than or equal to the largest MinTrigProcTime of all associated non-AP STAs.
- For Trigger frame that contains at least one User Info field with AID12 subfield set to 2045, $T_{TrigProc}$ should be at least 16 µs.
- For NFRP Trigger frame, $T_{TrigProc}$ shall be at least 16 µs.

$T_{TrigProc}$ is defined as the duration of PPDU that is after the OFDM symbol containing the last coded bit of the LDPC codeword that encodes the last bit of SCH minus $T_{PE,nominal}$ defined in 27.3.13 (Packet extension).

26.5.2.2.4 Allowed settings of the Trigger frame fields and TRS Control subfield

An AP with dot11MultiBSSIDImplemented equal to true shall not send a Trigger frame (other than an NFRP Trigger frame) with the TA field set to the transmitted BSSID to a non-AP STA that is associated with a nontransmitted BSSID in the multiple BSSID set unless the AP has received an HE Capabilities element from non-AP STA with the Rx Control Frame To MultiBSS subfield in the HE MAC Capabilities Information field equal to 1. An AP with dot11MultiBSSIDImplemented equal to true may send an NFRP Trigger frame with the TA field set to the transmitted BSSID to a non-AP STA that is associated with a nontransmitted BSSID in a multiple BSSID set.

An AP that transmits a Trigger frame shall set the TA field of the frame to the MAC address of the AP, except if dot11MultiBSSIDImplemented is true and the Trigger frame is directed to non-AP STAs from at least two different BSSs of a multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

An AP shall not set any subfields of the Common Info field of a Trigger frame to a value that is not supported by all the recipient non-AP STAs of the Trigger frame and the AP.

The AP shall set the UL Length subfield of a Trigger frame to the value given by Equation (27-11) with $m = 2$.

If an AP transmits a Trigger frame that allocates an RU that spans the entire HE TB PPDU bandwidth and assigns the RU to more than one non-AP STA (i.e., for UL MU-MIMO) and with the GI And HE-LTF Type subfield of the Common Info field set to indicate either 2x HE-LTF + 1.6 µs GI or 4x HE-LTF + 3.2 µs GI, the AP may set the MU-MIMO HE-LTF Mode subfield in the Common Info field of the Trigger frame to indicate either HE single stream pilot HE-LTF mode or HE masked HE-LTF sequence mode. Otherwise, the AP shall set the MU-MIMO HE-LTF Mode subfield in the Common Info field to indicate HE single stream pilot HE-LTF mode.

An AP that transmits Trigger frames in more than one A-MPDU in an HE MU PPDU shall set each subfield, except the Trigger Type, More TF, CS Required and Trigger Dependent Common Info subfields, in the Common Info field of the Trigger frame in one A-MPDU to the same value as the corresponding subfield in the Common Info field of the Trigger frames in the other A-MPDUs.

An AP that transmits frames carrying a TRS Control subfield in more than one A-MPDU in an HE MU PPDU shall set the UL Data Symbols and AP Tx Power subfields of the TRS Control subfield in the frames of one A-MPDU to the same value as the corresponding subfields of the TRS Control subfield in the frames of the other A-MPDUs.

An AP that transmits one or more Trigger frames in one or more A-MPDUs and frames carrying a TRS Control subfield in one or more other A-MPDUs in an HE MU PPDU shall set the Common Info field of the Trigger frames and the TRS Control subfields in each A-MPDU as follows:

- The UL Length subfield in the Common Info field of the Trigger frames and the UL Data Symbols subfield in the TRS Control subfields indicate the same HE TB PPDU duration
- The AP Tx Power subfield in the Common Info field of the Trigger frames and the AP Tx Power subfield in the TRS Control subfields indicate the same transmit power
- In the Common Info field of the Trigger frames:
  - The MU-MIMO HE-LTF Mode and UL STBC subfields are set to 0
  - The Number Of HE-LTF Symbols And Midamble Periodicity subfield is set to 0
  - The Doppler subfield is set to 0
  - The Pre-FEC Padding Factor subfield is set to the default PE duration value, which is indicated by the AP in the Default PE Duration subfield of the HE Operation element it transmits and the pre-FEC padding factor is set to 4
  - The UL Spatial Reuse subfield is set to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED
  - If the TXVECTOR parameters HE_LTF_TYPE and GI_TYPE of the HE PPDU carrying the Trigger frame are either 4xHE-LTF and 3u2s_GI, respectively, or 2xHE-LTF and 1u6s_GI, respectively, then the GI And HE-LTF Type subfield is set to 2. Otherwise, the GI And HE-LTF Type subfield is set to 1.
  - The other remaining subfields are set to any valid value

NOTE—A non-AP STA obtains the information required to prepare an HE TB PPDU explicitly and implicitly. Explicit information is obtained in the Common Info field of a Trigger frame, or in the UL Data Symbols and AP Tx Power subfields of the TRS Control subfield contained in the soliciting PPDU. Implicit information is obtained in previously exchanged frames with the AP, e.g., in the BSS Color and the Default PE Duration subfields of the HE Operation element, or from default values specified in 26.5.2.3 (Non-AP STA behavior for UL MU operation).

An AP shall not set any subfields of the User Info field of a Trigger frame to a value that is not supported by the recipient non-AP STA of the User Info field and the AP. An AP shall not set any subfields of a TRS Control subfield to a value that is not supported by the recipient non-AP STA of the TRS Control subfield and the AP. If an RU is allocated to only one non-AP STA the Starting Spatial Stream subfield for that non-AP STA shall be set to 0.

An AP shall follow the RU restriction rules defined in 27.3.2.8 (RU restrictions for 20 MHz operation) when assigning an RU to a 20 MHz operating non-AP STA for a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE TB PPDU. An AP shall not set the RU Allocation subfield of the User Info field of a Trigger frame or TRS Control subfield that is addressed to a non-AP STA to a value such that the RU allocated to the STA lies outside the channel in which the STA is operating (see 27.3.2.6 (Resource allocation for an HE TB PPDU), and 27.3.2.9 (80 MHz operating non-AP HE STAs)) or outside the SST subchannel (if applicable) in which the STA is operating (see 26.8.7 (HE subchannel selective transmission)).

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

A TRS Control subfield shall not be included in a group addressed frame.

If an AP transmits one or more Trigger frames or frames carrying a TRS Control subfield, then the frames shall collectively elicit HE TB PPDU responses such that at least one scheduled RU is allocated for each 20 MHz channel occupied by the eliciting PPDU. An AP shall not allocate an RU in any 20 MHz channel that is not occupied by the immediately preceding DL PPDU.

An AP may indicate an unallocated RU in a Trigger frame by including a User Info field with the AID12 subfield set to 2046. The AP shall place any User Info fields with the AID12 subfield set to 2046 after User Info fields with the AID12 subfield set to a value less than 2046.

An AP shall not transmit a Trigger frame that contains more than one User Info field with the same value in the AID12 subfield unless the value in the AID12 subfield is 0 or greater than 2007. The AP shall place User Info fields with the same value in the AID12 subfield together as a contiguous block in the Trigger frame. The AP shall place User Info fields with the AID12 subfield set to 0 or a value greater than 2007 after User Info fields with the AID12 subfield set to a value in the range 1 to 2007 (if any present).

An AP that transmits an individually addressed Trigger frame shall include only one User Info field in the Trigger frame with the AID12 subfield set to the 12 LSBs of the AID of the non-AP STA addressed by the RA field.

An example of User Info field ordering in a Trigger frame and the relationship to RU locations is shown in Figure 26-4 (Example of User Info field ordering and RU location mapping).

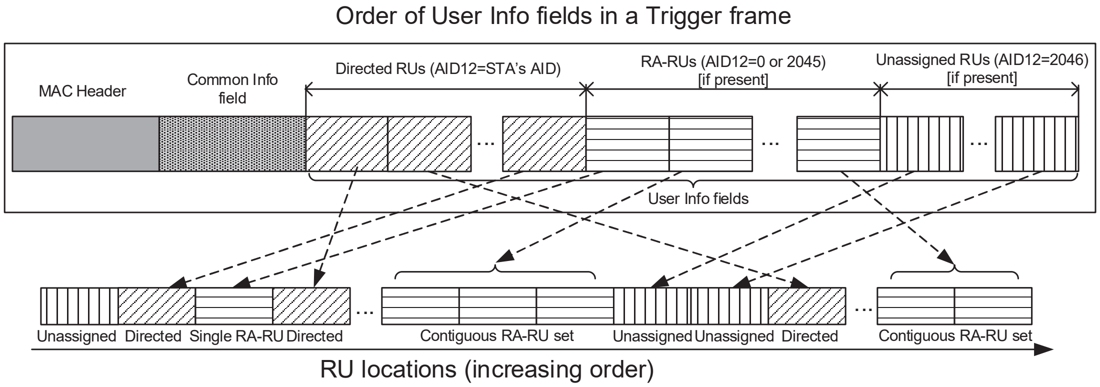

Figure 26-4—Example of User Info field ordering and RU location mapping

An AP that sends a Basic Trigger frame shall set the TID Aggregation Limit subfield of a User Info field that is addressed to a non-AP STA to a value between 0 and 1 plus the value of the Multi-TID Aggregation Tx Support subfield in the HE Capabilities element most recently received from the non-AP STA. A value 0 in the TID Aggregation Limit subfield indicates to the non-AP STA that it shall not solicit any immediate response for the MPDUs that the non-AP STA aggregates in the HE TB PPDU. A value of 7 in the TID Aggregation Limit subfield indicates to the non-AP STA that it may aggregate QoS Data frames from any number of different TID values in the multi-TID A-MPDU. Table 26-2 (Relation between TID Aggregation Limit field, Multi-TID Aggregation Tx Support field and solicited immediate response) provides a summary of the possible combinations.

Table 26-2—Relation between TID Aggregation Limit field, Multi-TID Aggregation Tx Support field and solicited immediate response

AP: TID Aggregation Limit field	Non-AP STA: Multi-TID Aggregation Tx Support field	Non-AP STA: Solicited immediate response?
0	Any value	No
1	Any value	Yes for at most 1 TID and/or 1 Management frame
tal (0 to *mta* + 1)	*mta*	Yes at most *tal* TIDs and/or at most one Management frame
where *tal* is the value in the TID Aggregation Limit field *mta* is the value in the Multi-TID Aggregation Tx Support field		

The AP may assign any ACI value defined in Table 9-154 (ACI-to-AC encoding) in the Preferred AC subfield in the Trigger Dependent User Info field for an HE STA and identified by the AID12 subfield of the User Info field of a Basic Trigger frame. If the AP does not have a recommendation then it shall set the Preferred AC subfield to the value 0 (AC_BE).

When transmitting a PPDU carrying a triggering frame, an AP should not apply transmit beamforming to:

- Non-HT PPDUs
- Fields prior to the HT-STF field of an HT mixed format PPDU
- Pre-VHT modulated fields of an VHT PPDU
- Pre-HE modulated fields of an HE PPDU

An AP shall transmit an HE PPDU that carries a Trigger frame or frame that includes a TRS Control subfield with the TXVECTOR parameter BEAM_CHANGE set to 1.

An AP should set the TID Aggregation Limit subfield in the User Info fields of a Basic Trigger frame to 0 if the CS Required subfield in the Common Info field of the Basic Trigger frame is 0.

An AP shall set the TID Aggregation Limit subfield in the User info fields of a Basic Trigger frame to 0 if the solicited HE TB PPDU is the last PPDU of the TXOP.

NOTE—An HE TB PPDU is the last PPDU if the Duration/ID field is equal to 0 in the MPDU(s) contained in the HE TB PPDU.

26.5.2.2.5 AP access procedures for UL MU operation

The AP shall follow the EDCA procedure defined in 10.23 (HCF) and the additional rules in this subclause.

If an AP receives an immediate response with at least one frame from at least one non-AP STA solicited by a Trigger frame or frame carrying a TRS Control subfield, the frame exchange is successful.

If an AP does not receive an immediate response with at least one frame from at least one non-AP STA solicited by a PPDU that contains at least one Trigger frame, then the frame exchange is not successful and the AP shall follow the backoff procedure in 10.23.2.2 (EDCA backoff procedure).

An AP may use any AC for sending a PPDU that contains only Trigger frames.

If the PPDU contains frames that are not Trigger frames in addition to a Trigger frame, then the AP follows the MPDU aggregation rules in 26.6 (A-MPDU operation in an HE PPDU), which supersedes the rules in 10.23.2.7 (Sharing an EDCA TXOP).

26.5.2.3 Non-AP STA behavior for UL MU operation

26.5.2.3.1 General

A non-AP STA shall not send an HE TB PPDU unless it is explicitly triggered by an AP in one of the operation modes described in this subclause.

The inter-frame space between a PPDU that contains a Trigger frame or frame that includes a TRS Control subfield and the HE TB PPDU is a SIFS.

A non-AP STA shall not transmit an HE TB PPDU if all of the conditions in 26.5.2.3.2 (Conditions for not responding with an HE TB PPDU) are satisfied. Otherwise, a non-AP STA shall transmit an HE TB PPDU a SIFS after a received PPDU if all of the following conditions are met:

- The received PPDU contains either a Trigger frame (that is not an MU-RTS variant) with a User Info field addressed to the non-AP STA, or a frame addressed to the non-AP STA that contains an TRS Control subfield. A User Info field in the Trigger frame is addressed to a non-AP STA if one of the following conditions are met:

- The AID12 subfield is equal to the 12 LSBs of the AID of the non-AP STA and the Trigger frame is sent by the AP with which the non-AP STA is associated with or by the AP corresponding to the transmitted BSSID if the non-AP STA is associated with a nontransmitted BSSID and has indicated support for receiving Control frames with TA field set to the transmitted BSSID by setting the Rx Control Frame To MultiBSS subfield to 1 in the HE Capabilities element that the STA transmits.
- The AID12 subfield is 0, the non-AP STA is associated with the AP that sent the Trigger frame, the non-AP STA supports the UORA procedure, and the conditions the conditions in 26.5.4 (UL OFDMA-based random access (UORA)) are satisfied.
- The AID12 subfield is 2045, the non-AP STA is not associated with the AP that sent the Trigger frame, the non-AP STA supports the UORA procedure, the conditions in 26.5.4 (UL OFDMA-based random access (UORA)) are satisfied, and the resource that the non-AP STA gains access to is sufficient for the non-AP STA to include the pending frame.

— The CS Required subfield in the Trigger frame is 1 and the UL MU CS condition described in 26.5.2.5 (UL MU CS mechanism) indicates the medium is idle, or the CS Required subfield in a Trigger frame is 0 or the response was solicited by a frame containing a TRS Control subfield.

— The UL MU Disable subfield is 0 and the UL MU Data Disable subfield is 0 in the most recent OM Control subfield (if any) sent by the non-AP STA to the AP or the UL MU Disable subfield is 0 and the UL MU Data Disable subfield is 1 in the most recent OM Control subfield (if any) sent by the non-AP STA to the AP and the frame that is being triggered is an acknowledgment (see 26.9.3 (Transmit operating mode (TOM) indication)).

A non-AP STA addressed by a User Info field in a Trigger frame (i.e., the AID12 subfield is equal to the 12 LSBs of the AID of the non-AP STA) may ignore the remainder of User Info fields in the Trigger frame.

A non-AP STA generates the A-MPDU carried in the HE TB PPDU as defined in 26.5.2.4 (A-MPDU contents in an HE TB PPDU).

26.5.2.3.2 Conditions for not responding with an HE TB PPDU

A non-AP STA shall not transmit an HE TB PPDU that is not an HE TB feedback NDP if all the following conditions are satisfied:

— The non-AP STA is operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior (see Table E-1).

— The HE TB PPDU would be in response to one of the following:

- A Trigger frame containing a User Info field with AID12 subfield carrying the 12 LSBs of the AID of the STA.
- A frame addressed to the non-AP STA that includes a TRS Control subfield.
- A Trigger frame that allocates at least one RA-RU.

— The RU is a 26-tone RU.

— If the non-AP STA has received at least one Beacon frame within the past dot11ObssNbRuToleranceTime from an AP with which the non-AP STA is not associated and the Beacon frame meets any of the following conditions:

- The Extended Capabilities element is not present.
- The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is not present.
- The OBSS Narrow Bandwidth RU In OFDMA Tolerance Support field in the Extended Capabilities element is 0.

A non-AP STA may choose to not respond to a Trigger frame that contains one or more subfields in the Common Info field or in the User Info field addressed to or selected by the non-AP STA with values that are not recognized, not supported or cannot be satisfied by the non-AP STA.

NOTE—The User Info field in this context corresponds to the one directed to the non-AP STA (i.e., value in the AID12 subfield matches the STA's AID) or the one allocating an RA-RU (single or within a contiguous set) that is selected by the non-AP STA.

A non-AP STA may choose to not respond a TRS Control subfield in a frame addressed to the non-AP STA if the TRS Control subfield contains one or more subfields with values that are not recognized, not supported or cannot be satisfied by the non-AP STA. A non-AP STA shall update the intra-BSS NAV (see 26.2.4 (Updating two NAVs)) based on the duration information of the Trigger frame or frame containing TRS Control subfield even if it decides to not respond to the frame.

26.5.2.3.3 TXVECTOR parameters for HE TB PPDU response to Trigger frame

A non-AP STA transmitting an HE TB PPDU in response to a Trigger frame shall set the TXVECTOR parameters as follows:

- The FORMAT parameter is set to HE_TB.
- The TRIGGER_METHOD parameter is set to TRIGGER_FRAME.
- The TXOP_DURATION parameter is set as defined in 26.11.5 (TXOP_DURATION).
- The BSS_COLOR parameter is set as follows:
  - If the Trigger frame was received in an HE PPDU, then set to the value of the RXVECTOR parameter BSS_COLOR of the HE PPDU.
  - If the Trigger frame was received in a non-HE PPDU, then set to the value of the active BSS color as defined in 26.11.4 (BSS_COLOR).
- The L_LENGTH parameter is set to the value indicated by the UL Length subfield in the Common Info field of the Trigger frame.
- The GI_TYPE and HE_LTF_TYPE parameters are set to the value indicated by the GI and HE-LTF Type subfield of the Common Info field of the Trigger frame.
- The NUM_STS parameter is set to the number of space-time streams indicated by the Number Of Spatial Streams subfield of the SS Allocation field of the User Info field and UL STBC subfield in the Common Info field of the Trigger frame. The NUM_STS parameter is set to 1 if the HE TB PPDU is sent on an RA-RU following the UORA procedure.
- The CH_BANDWIDTH parameter is set to the value of the UL BW subfield in the Common Info field of the Trigger frame.
- The HE_LTF_MODE parameter is set to the value indicated by the MU-MIMO HE-LTF Mode subfield of the Common Info field of the Trigger frame.
- The NUM_HE_LTF parameter is set to the value indicated by the Number Of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field of the Trigger frame.
- The STBC parameter is set to the value indicated by the UL STBC subfield of the Common Info field of the Trigger frame.
- The LDPC_EXTRA_SYMBOL parameter is set to the value indicated by the LDPC Extra Symbol Segment subfield of the Common Info field of the Trigger frame.
- The SPATIAL_REUSE parameter is set to the value of the UL Spatial Reuse subfield in the Common Info field of the eliciting Trigger frame.
- The DOPPLER parameter is set to the value of the Doppler subfield in the Common Info field of the Trigger frame.
- The MIDAMBLE_PERIODICITY parameter is present if the Doppler subfield in the Common Info field of the Trigger frame is 1. If present, it is set to the value indicated by the Number Of HE-LTF Symbols And Midamble Periodicity subfield in the Common Info field of the Trigger frame.
- The HE_SIG_A2_RESERVED parameter is set to the value of the UL HE-SIG-A2 Reserved subfield in the Common Info field of the Trigger frame.

— The MCS parameter is set to the value of the UL HE-MCS subfield in the User Info field of the Trigger frame.
— The DCM parameter is set to the value indicated by the UL DCM subfield of the User Info field of the Trigger frame.
— The STARTING_STS_NUM parameter is set to the value of the Starting Spatial Stream subfield in the SS Allocation field in the User Info field of the Trigger frame. The STARTING_STS_NUM parameter is set to 0 if the HE TB PPDU is sent on an RA-RU following the UORA procedure.
— The FEC_CODING parameter is set to the value indicated by the UL FEC Coding Type subfield of the User Info field of the Trigger frame.
— The RU_ALLOCATION parameter is set as follows:
  • If the RU is not an RA-RU or an RA-RU with Number Of RA-RU subfield of the User Info subfield of the Trigger frame set to 0, it is set to the value indicated by the RU Allocation subfield of the User Info subfield of the Trigger frame.
  • If the RU is the *k*-th RU of a set of contiguous RA-RUs starting with an RA-RU with Number Of RA-RU subfield of the User Info subfield of the Trigger frame set to a nonzero value, it is set to the value indicated by the RU Allocation subfield of the corresponding User Info subfield of the Trigger frame plus *k* minus 1.
— The TXPWR_LEVEL_INDEX parameter is set to a value based on the computed transmission power (see 27.3.15.2 (Power pre-correction)) for an HE TB PPDU and the value of the AP Tx Power subfield in the Common Info field and the UL Target RSSI subfield in the User Info field of the Trigger frame.
— The HE_TB_PE_DISAMBIGUITY parameter is set to the value indicated by the PE Disambiguity subfield in the Common Info field in the Trigger frame.

26.5.2.3.4 TXVECTOR parameters for HE TB PPDU response to TRS Control subfield

A non-AP STA transmitting an HE TB PPDU in response to a frame containing a TRS Control subfield shall set the TXVECTOR parameters as follows:
— The FORMAT parameter is set to HE_TB
— The TRIGGER_METHOD parameter is set to TRS
— The L_LENGTH parameter is computed as described in Equation (27-11) using the TXTIME value. The TXTIME is defined by Equation (27-136) where N_{SYM} is set to F_{VAL} + 1, where F_{VAL} is the value of the UL Data Symbols subfield of the TRS Control subfield
— The RU_ALLOCATION and MCS parameters are set to the values of the RU Allocation and UL HE-MCS subfields of the TRS Control subfield, respectively.
— The CH_BANDWITDTH parameter is set to the value of the RXVECTOR parameter CH_BANDWIDTH of the soliciting DL HE PPDU (see Table 27-1 (TXVECTOR and RXVECTOR parameters))
— The BSS_COLOR and DCM parameters are set to the values of the RXVECTOR parameters BSS_COLOR and DCM of the soliciting DL HE PPDU, respectively
— The DOPPLER parameter is set to 0 and the MIDAMBLE_PERIODICITY parameter is absent
— The NUM_HE_LTF parameter is set to 1
— The STARTING_STS_NUM parameter is set to 0
— The HE_LTF_MODE and STBC parameters are set to 0, and the NUM_STS parameter is set to 1
— The FEC_CODING parameter is set to 0 if the RU Allocation subfield indicates an RU that is smaller than a 484-tone RU; otherwise set to 1
— The LDPC_EXTRA_SYMBOL parameter is not present if the RU Allocation subfield indicates less than a 484-tone RU; otherwise set to 1
— The SPATIAL_REUSE parameter is set to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED

— The DEFAULT_PE_DURATION parameter is set to the default PE duration value for UL MU response scheduling, which is indicated by the AP in the Default PE Duration subfield of the HE Operation element it transmits

— The TXOP_DURATION parameter is set as defined in 26.11.5 (TXOP_DURATION)

— The HE_SIG_A2_RESERVED parameter is set to 511 (all 1s)

— If the RXVECTOR parameters HE_LTF_TYPE and GI_TYPE of HE MU PPDU carrying the frame with the TRS Control subfield are either 4xHE-LTF and 3u2s_GI, respectively, or 2xHE-LTF and 1u6s_GI, respectively, then the HE_LTF_TYPE and GI_TYPE parameters are set to 4xHE-LTF and 3u2s_GI, respectively. Otherwise, the HE_LTF_TYPE and GI_TYPE parameters are set to 2xHE-LTF and 1u6s_GI, respectively.

— The TXPWR_LEVEL_INDEX parameter is set to a value based on the computed transmission power (see 27.3.15.2 (Power pre-correction)) for an HE TB PPDU and the value of the AP Tx Power subfield of the TRS Control subfield and the UL Target RSSI subfield of the TRS Control subfield.

NOTE 1—A non-AP STA transmitting an HE TB PPDU in response to a frame carrying a TRS Control subfield considers both physical CS and virtual CS to be 0 (see 26.5.2.5 (UL MU CS mechanism)).

NOTE 2—The only permissible values for CH_BANDWIDTH are CBW20, CBW40, CBW80, CBW80+80, and CBW160 if the soliciting PPDU is an HE SU PPDU or HE MU PPDU. The only permissible value for CH_BANDWIDTH is CBW20 if the soliciting PPDU is an HE ER SU PPDU.

26.5.2.3.5 RA field for frames carried in an HE TB PPDU

The RA field of the frames sent in response to a MU-RTS Trigger frame is set as defined in 9.3.1.3 (CTS frame format). The RA field of the frames sent in response of a GCR MU-BAR Trigger frame or MU-BAR Trigger frame is set as defined in 9.3.1.8 (BlockAck frame format). The RA field of the QoS Null frames, QoS Data frames and Management frames sent in response to a Trigger frame shall be set to the MAC address of the destination AP (see 9.3.2.1 (Format of Data frames) and 9.3.3.2 (Format of Management frames)). The RA field of a QoS Null frame or Action No Ack frame sent in response to a frame carrying TRS Control subfield shall be the MAC address of the destination AP (see 9.3.2.1 (Format of Data frames) and 9.3.3.2 (Format of Management frames)).

NOTE 1—If dot11MultiBSSIDImplemented is true and the TA field of the soliciting Trigger frame contains the transmitted BSSID, the destination AP is the BSSID to which the non-AP STA intends to send the frame.

NOTE 2—All MPDUs within an A-MPDU carried in an HE TB PPDU have the same RA (see 9.7.3 (A-MPDU contents)). The settings of the address fields of MPDUs within the A-MPDU depend on the type and subtype of the MPDU as defined in 9.3 (Format of individual frame types).

26.5.2.4 A-MPDU contents in an HE TB PPDU

A non-AP STA that receives a triggering frame other than an MU-RTS Trigger frame or an NFRP Trigger frame and that transmits an HE TB PPDU response shall follow the A-MPDU padding procedure described in 26.6.2.3 (A-MPDU padding in an HE TB PPDU) and construct the A-MPDU carried in the HE TB PPDU as described below provided the AP allocates sufficient resources for the non-AP STA to include MPDU(s) in the A-MPDU. Otherwise, the non-AP STA is not required to include MPDUs in the A-MPDU and includes only padding in the A-MPDU.

NOTE—The responses to a MU-RTS Trigger frame and a NFRP Trigger frame are exempt from these construction rules since the MU-RTS Trigger frame does not solicit an HE TB PPDU and the NFRP Trigger frame solicits an HE TB PPDU that does not carry an A-MPDU.

A non-AP STA shall follow the rules in 26.5.4.5 (Additional considerations for unassociated STAs) to construct an HE TB PPDU in response to a Trigger frame from an AP with which it is not associated and that allocates RA-RUs for unassociated STAs.

A non-AP STA that responds to a DL MU PPDU containing one or more frames addressed to it that include a TRS Control subfield follows the rules defined in 10.3.2.11 (Acknowledgment procedure) for generating the Ack frame, the rules defined in 10.25.6.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, and the rules defined in 26.4 (HE acknowledgment procedure) for generating the Multi-STA BlockAck frame if at least one of the received MPDUs solicits an immediate acknowledgment. The contents of the A-MPDU carried in the HE TB PPDU shall be as defined in:

— Table 9-532 (A-MPDU contents in the control response context) if at least one of the received MPDUs solicits an immediate acknowledgment.

— Table 9-531 (A-MPDU contents in the data enabled no immediate response context) with the exception that the A-MPDU does not contain QoS Data frames, if none of the received MPDUs solicit an immediate acknowledgment.

NOTE 1—The non-AP STA additionally follows the rules in 26.3.2 (Dynamic fragmentation) if fragments are present in the soliciting A-MPDU.

NOTE 2—An AP might transmit an HE MU PPDU with an RU allocated to STA-ID 2045 with an A-MPDU that includes a Management frame addressed to an unassociated non-AP STA, that solicits an acknowledgment and that carries a TRS Control subfield. The TRS Control subfield allocates resources for the unassociated non-AP STA to respond with an HE TB PPDU that carries the acknowledgment.

An associated non-AP STA that responds to a Basic Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in the following:

— Table 9-532 (A-MPDU contents in the control response context), if the Trigger frame is contained in an A-MPDU and the non-AP STA received in the same A-MPDU at least one MPDU that solicits an immediate acknowledgment. The TID Aggregation Limit field of the User Info field addressed to the non-AP STA may have any value.

— Table 9-531 (A-MPDU contents in the data enabled no immediate response context) with the exception that the A-MPDU does not contain QoS Data frames, if the Trigger frame is either not carried in an A-MPDU or is carried in an A-MPDU but the non-AP STA receives no other MPDUs that solicit an immediate acknowledgment. The TID Aggregation Limit field of the User Info field addressed to the non-AP STA may have any value.

— Table 9-429 (A-MPDU contents in the S-MPDU context) with the following restrictions:

  - The S-MPDU shall be a control response frame if the non-AP STA received in the same A-MPDU at least one MPDU that solicits an immediate acknowledgment. The TID Aggregation Limit field of the User Info field addressed to the non-AP STA may have any value.
  - The S-MPDU may be a Multi-TID BlockAckReq frame provided that the number of TIDs present in the Multi-TID BlockAckReq frame does not exceed the TID aggregation limit indicated by the TID Aggregation Limit field of the User Info field addressed to the non-AP STA.
  - The S-MPDU may be a QoS Data, QoS Null, Management, BlockAckReq or PS-Poll frame if the TID Aggregation Limit field of the User Info field addressed to the non-AP STA is greater than 0.
  - Otherwise the S-MPDU shall be a QoS Data, QoS Null, or Management frame that does not solicit an immediate acknowledgment.

— Table 9-532a (A-MPDU contents in the HE non-ack-enabled single-TID immediate response context) or Table 9-532c (A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context) if the TID Aggregation Limit field of the User Info field addressed to the non-AP STA in the Trigger frame is greater than 0 and the non-AP STA intends to carry one or more non-EOF MPDUs (see 10.12 (A-MPDU operation) and 26.6.3.3 (Non-ack-enabled multi-TID A-MPDU operation)). The A-MPDU is subject to the following restrictions:

  - It shall contain a control response frame if the non-AP STA received in the same A-MPDU at least one MPDU that solicits an immediate acknowledgment.

  - The number of TIDs present in the A-MPDU shall count towards reaching the TID aggregation limit indicated by the TID Aggregation Limit field of the User Info field addressed to the non-AP STA in the Trigger frame.

— Table 9-532b (A-MPDU contents in the HE ack-enabled single-TID immediate response context) or Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context) if the TID Aggregation Limit field of the User Info field addressed to the non-AP STA in the Trigger frame is greater than 0 and the non-AP STA intends to carry an ack-enabled single-TID A-MPDU (see 26.6.3.1 (General) and 26.6.3.4 (Ack-enabled multi-TID A-MPDU operation). The A-MPDU is subject to the following restrictions:

  - It shall contain a control response frame if the non-AP STA receives at least another MPDU that solicits an immediate acknowledgment.
  - The number of TIDs present in the A-MPDU, in either QoS Data or BlockAckReq frames, shall count towards reaching the TID aggregation limit that is obtained from the TID Aggregation Limit field of the User Info field addressed to the non-AP STA in the Trigger frame.

A non-AP STA shall follow the rules in 26.5.4.5 (Additional considerations for unassociated STAs) to construct an HE TB PPDU in response to a Trigger frame from an AP with which it is not associated and that allocates RA-RUs for unassociated STAs.

If the associated non-AP STA has no frames pending or is unable to include pending frames in response to a Basic Trigger frame because the allocated resource is insufficient, then the associated non-AP STA shall include in the A-MPDU at least one QoS Null frame if the allocated resource is sufficient for containing a QoS Null frame.

NOTE—The non-AP STA can transmit one QoS Null frame as defined in Table 9-533 (A-MPDU contents in the S-MPDU context) or one or more QoS Null frames as defined in Table 9-531 (A-MPDU contents in the data enabled no immediate response context).

A non-AP STA that responds to a BFRP Trigger frame addressed to it shall construct an A-MPDU carried in the HE TB PPDU with one or more HE Compressed Beamforming/CQI frames (see 26.7 (HE sounding protocol)); other frames shall not be allowed in the A-MPDU.

NOTE—It is not always possible to fragment an HE compressed beamforming/CQI report (see 26.7.4 (Rules for generating segmented feedback)). If the length is insufficient to contain the HE compressed beamforming/CQI report requested by a BFRP Trigger frame, no feedback is sent.

A non-AP STA that responds to an MU-BAR Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-532 (A-MPDU contents in the control response context). The non-AP STA includes either a BlockAck frame or a Multi-STA BlockAck frame in the A-MPDU as defined in 26.4 (HE acknowledgment procedure).

A non-AP STA that responds to a GCR MU-BAR Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-532 (A-MPDU contents in the control response context). The non-AP STA includes a GCR BlockAck frame in the A-MPDU as defined in 10.25.9 (GCR and GLK-GCR block ack).

A non-AP STA that responds to a BSRP or BQRP Trigger frame addressed to it and that is not aggregated with any MPDUs that solicit an immediate acknowledgment shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-531 (A-MPDU contents in the data enabled no immediate response context) with the exception that the A-MPDU does not contain QoS Data frames. The non-AP STA shall include in the A-MPDU at least one QoS Null frame. A non-AP STA that responds to a BSRP or BQRP Trigger frame addressed to it and that is aggregated with at least one MPDU that solicits an immediate acknowledgment, shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-532 (A-MPDU contents in the control response context).

NOTE 1—The frame type of MPDUs may be different across A-MPDUs within the same HE TB PPDU subject to A-MPDU context.

NOTE 2—A non-AP STA follows the rules in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) for aggregating the QoS Data frames with multiple TIDs in HE TB PPDUs.

A non-AP STA may set dot11HEUPHControlActivated to false if the most recent OM Control field sent (if any) to the AP had the UL MU Disable field equal to 1; otherwise, the non-AP STA shall set dot11HEUPHControlActivated to true.

A STA that transmits an HE TB PPDU transmits the dB value of its UL power headroom, HR_{STA}, in the UPH Control subfield of frames (that can carry an HE-variant HT Control field) carried in the HE TB PPDU, to assist in the AP's HE-MCS selection. The UL power headroom for the assigned HE-MCS is defined in Equation (26-2).

$$HR_{STA} = Tx_{pwr}^{Max} - Tx_{pwr}^{STA} \tag{26-2}$$

where

Tx_{pwr}^{Max} represents the maximum UL transmit power of an HE TB PPDU with the assigned HE-MCS after considering hardware capability, regulatory requirements and local maximum transmit power levels (see 11.8.5 (Specification of regulatory and local maximum transmit power levels)), as well as non-802.11 in-device coexistence requirements

Tx_{pwr}^{STA} represents the current UL transmit power of the HE TB PPDU for the assigned HE-MCS, which is determined by power control and subject to the non-AP STA's capabilities and other requirements as defined in 27.3.15.2 (Power pre-correction)

HR_{STA} is the UL power headroom, in dB, of the HE TB PPDU, the encoding of which is specified in 9.2.4.6a.5 (UPH Control).

NOTE—If the Minimum Transmit Power Flag subfield in the UPH Control subfield is 1, then the non-AP STA is transmitting the HE TB PPDU at its minimum Tx_{pwr}^{STA} for the assigned HE-MCS. The UL power headroom is calculated for the assigned HE-MCS and is independent of TOM parameters provided in any OM Control field contained in the same A-Control field (see 26.9.3 (Transmit operating mode (TOM) indication)).

A non-AP STA shall include an HE variant HT Control field containing the UPH Control subfield in the frames carried in the A-MPDU of the HE TB PPDU with the following exceptions:

- A UPH Control subfield is not included in any frame if the remaining space in the A-MPDU, after inclusion of solicited frames that cannot contain an HE variant HT Control field, is not sufficient to contain frame(s) that contain an HE variant HT Control field.
- A UPH Control subfield is not included in a frame if the other Control subfields in the HE variant HT Control field and the available space in the HE variant HT Control field, other than Control subfields with a Control ID subfield equal to 15, are included in the HE variant HT Control field of the frame, is not sufficient to contain an additional UPH Control subfield as well.
- A UPH Control subfield is not included in a frame that is a Control frame.

A non-AP STA shall not include a Control subfield with a Control ID subfield set to 15 in the HE variant HT Control field of the frames carried in an HE TB PPDU.

26.5.2.5 UL MU CS mechanism

The ED-based CCA and virtual CS functions are used to determine the state of the medium if CS is required before responding to a received Trigger frame. ED-based CCA for the UL MU CS mechanism is defined in

27.3.20.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel) and virtual CS is defined in 10.3.2.1 (CS mechanism).

If the CS Required subfield in a received Trigger frame is 0 or a frame that includes a TRS Control subfield and solicits a response is received, then the non-AP STA may respond without regard to the busy/idle state of the medium.

NOTE—Responding without regard to the busy/idle state of the medium means that a non-AP STA can respond without the need to check the medium indication from physical CS and virtual CS (i.e., basic NAV and intra-BSS NAV).

The intra-BSS NAV is not considered in virtual CS by a non-AP STA in determining whether to respond to a Trigger frame sent by the AP with which the non-AP STA is associated.

The basic NAV is considered in virtual CS by a non-AP STA in determining whether to respond to a Trigger frame sent by the AP with which the non-AP STA is associated if the counter of the basic NAV is not 0.

A NAV is considered in virtual CS by a non-AP STA in determining whether to respond to a Trigger frame sent by an AP with which the non-AP STA is not associated, through the UORA procedure (see 26.5.4 (UL OFDMA-based random access (UORA))) unless one of the following conditions is met:

— The NAV was set by a frame originating from the AP sending the Trigger frame
— The NAV counter is 0

NOTE 1—The intra-BSS NAV is considered in virtual CS by a non-AP STA associated with an AP in determining whether to respond to a Trigger frame with RU allocations for unassociated STAs sent by another AP.

NOTE 2—The details of how a non-AP STA is solicited by the Trigger frame for transmission are described in 26.5.2.2.4 (Allowed settings of the Trigger frame fields and TRS Control subfield).

NOTE 3—If a non-AP STA responds to a Trigger frame from an AP with which it is not associated through the UORA procedure, the method to identify that a NAV was set by a frame originating from the AP sending the Trigger frame is implementation specific. For example, the non-AP STA can save the TXOP holder address and match the saved TXOP holder address with the TA field of the Trigger frame.

For a non-AP STA that is solicited by a Trigger frame for transmission, the indication of the virtual CS is described as follows. If no NAV is considered, then the virtual CS indicates idle. Otherwise, the virtual CS indicates busy.

If the CS Required subfield in a Trigger frame is 1, then the non-AP STA shall consider the status of the CCA (using Energy Detect defined in 27.3.20.6.5 (Per 20 MHz CCA sensitivity) and the virtual carrier sense (NAV)) during the SIFS between the Trigger frame and the PPDU sent in response to the Trigger frame. In this case, the non-AP STA shall sense the medium using energy-detect (ED) after receiving the PPDU that contains the Trigger frame (i.e., during the SIFS), and it shall perform the energy-detect (ED) at least in the subchannel that contains the non-AP STA's UL allocation, where the sensed subchannel consists of one or more 20 MHz channels. The non-AP STA may transmit the solicited PPDU if the 20 MHz channels containing the RUs allocated in the Trigger frame are considered idle. If the non-AP STA detects that the 20 MHz channels containing the allocated RUs are not all idle, then the non-AP STA shall not transmit.

NOTE—The solicited PPDU is a non-HT or non-HT duplicate PPDU if the Trigger frame is an MU-RTS Trigger frame (see 26.2.6 (MU-RTS Trigger/CTS frame exchange procedure)); otherwise, the solicited PPDU is an HE TB PPDU (see 26.5.2.3 (Non-AP STA behavior for UL MU operation)).

The CS Required subfield in the MU-RTS Trigger frame shall be set to 1.

An AP that transmits a BFRP Trigger frame with the UL Length subfield in the Common Info field set to a value greater than 76 shall set the CS Required subfield in the Common Info field to 1.

An AP that transmits a Basic, BSRP, MU-BAR, BQRP or GCR MU-BAR Trigger frame shall set the CS Required subfield to 1 unless one of the following conditions is met:

— The RA of the Trigger frame is an individually addressed non-AP STA's MAC address and a QoS Data frame with HTP Ack ack policy and/or a Management frame that solicits an acknowledgment are aggregated with the Trigger frame in an A-MPDU, and the UL Length subfield in the Common Info field of the Trigger frame is less than or equal to 418.

— The Trigger frame is either an MU-BAR or GCR MU-BAR Trigger frame and the UL Length subfield in the Common Info field of the Trigger frame is less than or equal to 418.

— The UL Length subfield in the Common Info field of the Trigger frame is less than or equal to 76.

NOTE 1—The threshold value 418 of the UL Length subfield in the Common Info field of the Trigger frame is obtained from the maximum HE TB PPDU duration, 584 µs, that can be solicited by the TRS Control subfield based on Equation (27-16). This duration is the sum of 20 µs for the L-STF, L-LTF and L-SIG fields, 20 µs for the RL-SIG, HE-SIG-A and HE-STF fields, 16 µs for the 4x HE-LTF field with 3.2 µs GI, 512 µs for 32 OFDM symbols in the Data field with 3.2 µs GI, and 16 µs PE field (see 9.2.4.6a.1 (TRS Control), 26.5.2.3 (Non-AP STA behavior for UL MU operation), and 27.3.4 (HE PPDU formats)).

NOTE 2—The UL Length subfield value 76 is derived from the duration 128 µs, which is the duration of an HE TB PPDU with 4 HE-LTF symbols and a PE field.

An AP may transmit an NFRP Trigger frame with the CS Required subfield set to 0 or 1.

26.5.3 MU cascading sequence

An MU cascading sequence is a frame exchange sequence between an AP and one or more non-AP STAs carried in an HE MU PPDU in the downlink and HE TB PPDU in the uplink and characterized by the exchange of Control, Data and/or Management frames in both directions. An example of an MU cascading sequence is shown in Figure 26-5 (An example of an MU cascading sequence).

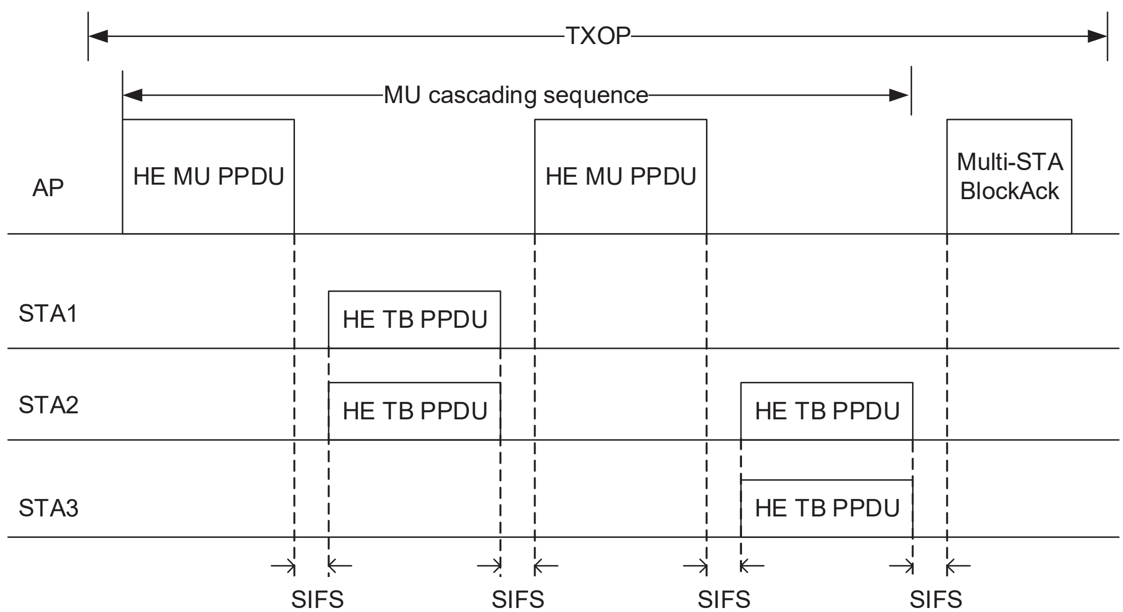

Figure 26-5—An example of an MU cascading sequence

An AP shall not transmit an A-MPDU to a non-AP STA that includes an Ack or BlockAck frame together with a triggering frame unless both the AP and the non-AP STA have indicated support by setting the MU Cascading Support subfield to 1 in the MAC Capabilities Information field in the HE Capabilities element they transmit. The A-MPDU may additionally contain one or more MPDUs and is constructed following the rules in 26.6 (A-MPDU operation in an HE PPDU).

The MU cascading sequence may have a different set of transmitters in HE TB PPDUs as compared to the receivers of the HE MU PPDU that immediately follows the HE TB PPDUs within the same TXOP. The MU cascading sequence may have a different set of receivers in the HE MU PPDU as compared to the set of transmitters of HE TB PPDUs that immediately follow the HE MU PPDU within the same TXOP.

An AP follows the procedure in 26.5.2.2.5 (AP access procedures for UL MU operation).

26.5.4 UL OFDMA-based random access (UORA)

26.5.4.1 General

An HE STA with dot11OFDMARandomAccessOptionImplemented equal to true shall set the OFDMA RA Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1. Otherwise, it shall set the OFDMA RA Support subfield to 0.

NOTE—A non-AP STA that does not support UORA can contend for the WM using EDCA for sending UL frames to the AP with which it intends to communicate.

A non-AP STA with dot11OFDMARandomAccessOptionImplemented set to true shall follow the procedure defined in 26.5.4.3 (Transmission procedure for UORA) and 26.5.4.5 (Additional considerations for unassociated STAs) to contend for an eligible RA-RU.

An HE AP that transmits a Trigger frame for random access shall set the AID12 subfield of a User Info field in the Trigger frame to 0 to indicate that one or more RA-RUs are available for non-AP STAs associated with it, and shall set the AID12 subfield in a User Info field in the Trigger frame to 2045 to indicate that one or more RA-RUs are available for non-AP STAs not associated with it.

An HE AP may transmit a Basic Trigger frame, BQRP Trigger frame or BSRP Trigger frame that contains one or more RUs for random access. An AP that transmits a Basic Trigger frame may set the AID12 subfield of any User Info field of the frame to 2045. An AP that transmits a Trigger frame that is not a Basic Trigger frame, BQRP Trigger frame or BSRP Trigger frame shall not set the AID12 subfield of any User Info field of the frame to 0.

NOTE—An non-AP HE STA that changes the maximum number of receiving spatial streams to 1 and sets the OFDMA RA Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1 cannot receive a Trigger frame sent with more than one spatial stream. As a result, if the Trigger frame indicates eligible RA-RUs for associated non-AP STAs, the non-AP HE STA cannot perform UORA defined in 26.5.4 (UL OFDMA-based random access (UORA))). An AP might take this behavior into consideration when sending a Trigger frame indicating eligible RA-RUs for associated non-AP STAs.

An HE AP that transmits a Basic Trigger frame should set the TID Aggregation Limit subfield in the User Info field indicating an RA-RU to 0 or 1.

An AP shall set the More RA-RU subfield in the User Info field to 1 if it intends to transmit additional Trigger frames in the current broadcast TWT SP that allocate RA-RUs matching the AID12 subfield value in the User Info field (see Table 9-31g (AID12 subfield encoding)).

A non-AP HE STA shall ignore the More RA-RU subfield if the More TF field in the Trigger frame is equal to 0.

The HE AP may include the UORA Parameter Set element (see 9.4.2.249 (UORA Parameter Set element) in Management frames that it transmits. The AP shall indicate the range of OFDMA contention window (OCW) in the UORA Parameter Set element for non-AP STAs to initiate random access following the Trigger frame transmission. An AP corresponding to a nontransmitted BSSID in a multiple BSSID set shall follow the rules in 11.1.3.8.4 (Inheritance of element values).

NOTE—An AP with dot11MultiBSSIDImplemented equal to true can allocate RA-RUs for non-AP STAs associated with different BSSIDs in a multiple BSSID set by transmitting a DL MU PPDU carrying broadcast RUs, one per BSS in the set (see 26.5.1.2 (RU addressing in an HE MU PPDU)), with an A-MPDU in each broadcast RU carrying a Trigger frame with at least one User Info field with the AID12 subfield set to 0.

A non-AP HE STA shall maintain an internal OCW and an internal OBO counter. OCW is an integer in the range *OCWmin* to *OCWmax*. A non-AP HE STA shall obtain *OCWmin* and *OCWmax* from the most recently received UORA Parameter Set element carried in a Beacon, Probe Response or (Re)Association Response frame transmitted by its associated AP unless the non-AP HE STA is associated with a nontransmitted BSSID of a multiple BSSID set, in which case it shall determine *OCWmin* and *OCWmax* by following the rules in 11.1.3.8.4 (Inheritance of element values).

A non-AP HE STA that has not received a UORA Parameter Set element from the AP with which it intends to communicate shall use the default values *OCWmin* = 7 and *OCWmax* = 31 if contending for RA-RUs allocated by that AP.

Each time a non-AP HE STA associates with a different AP (or a different BSSID for non-AP STA with dot11MultiBSSIDImplemented set to true), and prior to the initial attempt of RA-RU transmission towards it, the non-AP STA shall set the value of OCW to the *OCWmin* value, and shall initialize its OBO counter in the range 0 to OCW as defined in 26.5.4.3 (Transmission procedure for UORA).

26.5.4.2 Eligible RA-RUs

A non-AP STA that is the intended receiver of a User Info field in a Trigger frame (i.e., the AID12 subfield equal to the 12 LSBs of the AID of the non-AP STA) shall not contend for an RA-RU that is indicated by a Trigger frame contained in the same PPDU and shall not decrement its OBO counter.

A non-AP STA shall consider an RU as an eligible RA-RU if it supports all the transmit parameters indicated in the Common Info field and in the User Info field that allocates that RU (as described in 26.5.2.3 (Non-AP STA behavior for UL MU operation)), the non-AP STA is associated with the BSS whose BSSID is the value in the TA field of the Trigger frame and the RA-RU is allocated for associated STAs.

A non-AP STA may consider an RU as an eligible RA-RU if it supports all the transmit parameters indicated in the Common Info field and in the User Info field that allocates that RU (as described in 26.5.2.3 (Non-AP STA behavior for UL MU operation)), the non-AP STA is not associated with the BSS and the RA-RU is allocated for unassociated STAs.

An HE AP may allocate a contiguous set of RUs for random access by setting the Number Of RA-RU subfield in the User Info field of the Trigger frame to a value greater than 1. The RA-RU indicated by the RU Allocation subfield in the User Info field shall represent the starting RU of the set.The size of all RA-RUs in the set shall be the same and equal to the size of the RA-RU indicated by the RU Allocation subfield in the User Info field. The remaining subfields of the User Info field apply to each RA-RU in the set. An AP allocating a contiguous set of RA-RUs in a Trigger frame with an UL BW subfield that indicates 80+80 MHz or 160 MHz shall set the Number Of RA-RUs subfield such that all the RA-RUs in the set lie in one 80 MHz frequency segment.

NOTE—An AP can transmit a Trigger frame carrying more than one User Info field, each allocating a single or a contiguous set of RA-RUs, to ensure that an RA-RU set does not overlap with other RUs allocated by the frame.

A non-AP HE STA shall determine the number of eligible RA-RUs in a contiguous set by adding the value carried in the Number Of RA-RU subfields plus one for the User Info field corresponding to an eligible RA-RU.

A non-AP HE STA may consider as eligible RA-RUs all or a subset of the RA-RUs indicated by the User Info fields in a Trigger frame that carries more than one User Info field that allocates RA-RUs. The number of eligible RA-RUs that the non-AP STA considers for OBO countdown and transmission (see 26.5.4.3 (Transmission procedure for UORA)) shall be the total number of eligible RA-RUs indicated by the selected subset of User Info fields.

NOTE—A STA that considers only a subset of User Info fields, can randomly select User Info fields from the available set of User Info fields that allocate RA-RUs so that the UORA contention is not concentrated at the RA-RU set indicated by the first User Info field.

26.5.4.3 Transmission procedure for UORA

In this subclause, the transmit procedure using RA-RUs is described with respect to UORA parameters. The procedure is also illustrated in Figure 26-6 (Illustration of the UORA procedure).

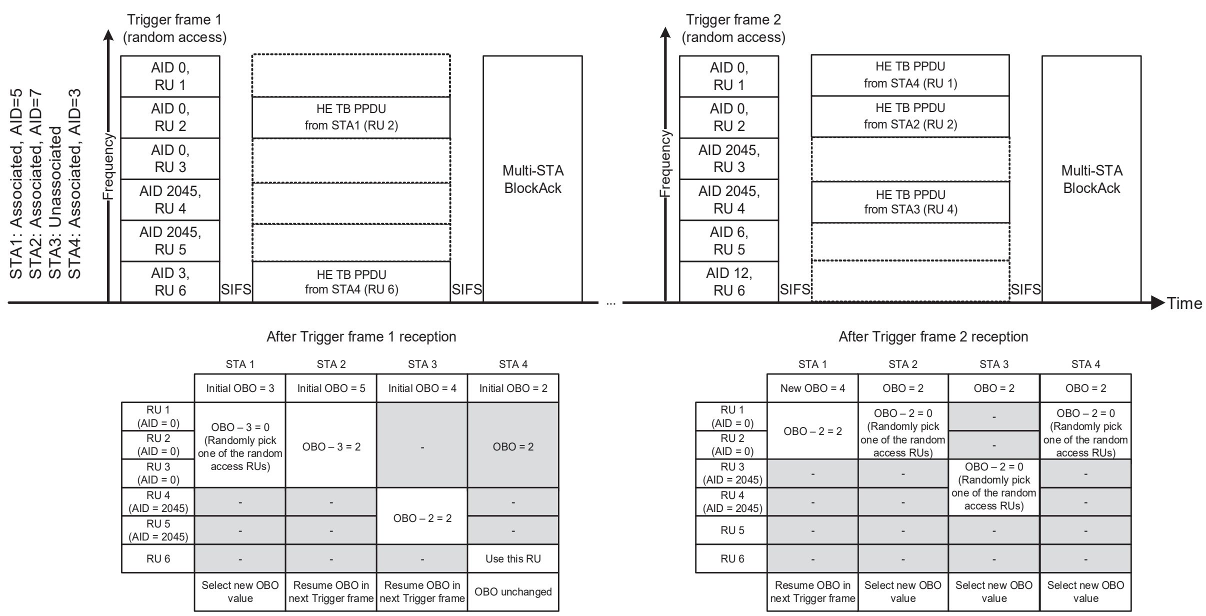

Figure 26-6—Illustration of the UORA procedure

A non-AP STA shall not contend for an eligible RA-RU or decrement its OBO counter if it does not have pending frames for the AP.

An HE STA that has a pending frame for the AP, upon the reception of a Trigger frame containing at least one eligible RA-RU, if the OBO counter of an HE STA is not greater than the number of eligible RA-RUs in a Trigger frame from that AP, then the HE STA shall set its OBO counter to zero and randomly select one of the eligible RA-RUs to be considered for transmission. Otherwise, the HE STA decrements its OBO counter by the number of eligible RA-RUs in the Trigger frame.

In the example in Figure 26-6 (Illustration of the UORA procedure):

— Before Trigger frame 1 was sent by the AP, HE STA 1, STA 2, STA 3 and STA 4 had initial OBO values of 3, 5, 4 and 2 respectively.

— Upon receiving Trigger frame 1:

- STA 4, which is associated with the AP and has pending frames for the AP, is allocated a dedicated RU (RU6). The STA does not contend for RA-RUs and instead transmits its pending frames on RU6.
- STA 1 and STA 2, both associated with the AP and having pending frames for the AP, decrement their respective OBO counters by the number of eligible RA-RUs indicated in the Trigger frame

  - (i.e., three RA-RUs for associated STAs). Since STA 1's OBO counter decrements to 0, it transmits its pending frames on RU2 that it randomly selects from the eligible set of RUs (i.e., RU1, RU2, and RU3). Since STA 2's OBO counter decrements to a nonzero value, it maintains the new OBO value (2) until it receives a later Trigger frame carrying RA-RUs for associated STAs.
  - STA 3, which is not associated with the AP but has a pending frame for the AP, decrements its OBO counter by the number of eligible RA-RUs indicated in the Trigger frame (i.e., two RA-RUs for unassociated STAs). Since STA 3's OBO counter decrements to a nonzero value, it maintains the new OBO value (2) until it receives a later Trigger frame carrying RA-RUs for unassociated STAs.
- After transmission of HE TB PPDU in response to Trigger frame 1:
  - STA 4 has additional frames pending for the AP. Therefore, it maintains its initial OBO value (2) until it receives a later Trigger frame carrying RA-RUs for associated STAs.
  - STA 1 has additional frames pending for the AP and randomly selects a new OBO value (4).
- Upon receiving Trigger frame 2:
  - STA 1, STA 2 and STA 4 decrement their respective OBO counters by number of eligible RA-RUs (two in this case). Since STA 2 and STA 4's OBO counters decrements to 0, they both transmit their pending frames on a randomly selected RU (RU2 in the case of STA 2 and RU1 in the case of STA 4). If either STAs have additional frames pending for the AP, each would randomly select a new OBO value. Since STA 1's OBO decrements to a nonzero value, it maintains the new OBO value (2) until it receives a later Trigger frame carrying RA-RUs for associated STAs.
  - STA 3 decrements its OBO counter by the number of eligible RA-RUs (two in this case). Since the STA's OBO counter decrements to 0, it transmits its pending frame on a randomly selected RU (RU4 in this case).

A non-AP STA shall follow the rules in 26.5.2.3 (Non-AP STA behavior for UL MU operation) to construct an HE TB PPDU and shall follow the rules as defined in 26.5.2.5 (UL MU CS mechanism) to determine the state of the medium before transmitting the HE TB PPDU. If CS is required and the selected RU is considered busy, then the non-AP STA shall not transmit the HE TB PPDU and the non-AP STA shall set its OBO counter to a random value drawn from a uniform distribution in the range 0 to OCW.

The MU acknowledgment procedure for UORA follows the procedure as defined in 10.3.3.13.3 (Acknowledgment procedure for an UL MU transmission).

If a non-AP STA transmits an HE TB PPDU that contains a frame that solicits an immediate response in an RA-RU and the expected response is not received, the transmission is considered unsuccessful. Otherwise, the transmission is considered successful. After each successful HE TB PPDU transmission in an RA-RU, a non-AP HE STA shall set the value of OCW to the *OCWmin* obtained from the most recent *OCWmin* indicated in the UORA Parameter Set element from the HE AP or the default (if UORA Parameter Set element was not received) and shall initialize its OBO counter to an integer value randomly selected from a uniform distribution in the range 0 to OCW. The non-AP STA shall follow the retransmission procedure defined in 26.5.4.4 (Retransmission procedure for UORA) if the transmission is not successful.

NOTE—A non-AP STA that transmits an HE TB PPDU in response to a Trigger frame that allocates RA-RU(s) by following the UORA procedure does not update its state variables to the values contained in the MU EDCA Parameter Set element (see 26.2.7 (EDCA operation using MU EDCA parameters)).

26.5.4.4 Retransmission procedure for UORA

A non-AP STA whose HE TB PPDU transmission sent in an RA-RU of a Trigger frame is unsuccessful, may attempt to retransmit the failed PPDU using EDCA or as a response to a Trigger frame.

If the HE TB PPDU is not successfully transmitted in the selected RA-RU, then the non-AP STA shall update its OCW to $2 \times \text{OCW} + 1$ when the OCW is less than the value of *OCWmax*, and shall randomly select its OBO counter in the range of 0 and OCW. Once the OCW reaches *OCWmax* for successive retransmission attempts, the OCW shall remain at the value of *OCWmax* until the OCW is reset as described in 26.5.4.3 (Transmission procedure for UORA).

A non-AP STA shall update its OCW value under the condition that the updated OCW remains in the range *OCWmin* to *OCWmax* obtained from the most recently received UORA Parameter Set element (see 9.4.2.249 (UORA Parameter Set element)). If the updated OCW becomes greater than *OCWmax* as consequence of receiving a modified UORA Parameter Set element, then the non-AP STA shall set the value of OCW to the new *OCWmax* value.

26.5.4.5 Additional considerations for unassociated STAs

An AP transmitting a Trigger frame that allocates one or more RA-RUs for unassociated STAs shall transmit the Trigger frame in an HE PPDU so that an unassociated non-AP STA can determine the AP's BSS color.

An HE AP that supports the UORA procedure and broadcast TWT operation and that intends to transmit Trigger frames that allocate one or more RA-RUs for unassociated STAs shall schedule the transmission of at least one such Trigger frame within each TWT SP corresponding to a Broadcast TWT Parameter Set field in a TWT element with a Broadcast TWT ID subfield equal to 0, Flow Type subfield equal to 0, Trigger subfield equal to 1 and Broadcast TWT Recommendation subfield equal to 2.

An AP that receives an Authentication frame within an RA-RU should schedule for transmission at a time no less than 3 TUs and no greater than 5 TUs subsequent to the transmission of the Authentication frame that is a response to that reception, a Trigger frame that allocates one or more RA-RUs for unassociated STAs.

NOTE—This Trigger frame provides a potential opportunity for an unassociated STA that transmitted the Authentication frame to transmit another Authentication frame or an Association Request frame.

An AP that supports the UORA procedure and broadcasts TWT operation and that operates a BSS with a width of 80 MHz or greater and transmitting a Trigger frame that allocates one or more RA-RUs for unassociated STAs shall include at least 2 RA-RUs for unassociated STAs for at least one transmission of such a Trigger frame within a Broadcast TWT SP that meets the conditions described above.

An AP that intends to transmit Trigger frames that allocates one or more RA-RUs for unassociated STAs should transmit FILS Discovery frames as described in 11.46.2.1 (FILS Discovery frame transmission) at regular intervals within a beacon period to assist unassociated STA discovery of the BSS and its operating parameters.

The TWT scheduling AP (see 26.8.3.1 (General)) that supports the UORA procedure may include a broadcast TWT element in FILS Discovery frames and in broadcast Probe Response frames to indicate the TWT SPs during which the AP intends to schedule for transmission at least one Trigger frame allocating one or more RA-RUs for STAs not associated with the AP. The broadcast TWT element shall carry only a broadcast TWT parameter set with the Broadcast TWT Recommendation subfield set to 2, the Trigger subfield set to 1, the Flow Type subfield set to 0, and the Broadcast TWT ID subfield set to 0. The AP transmits broadcast Probe Response frames if it has dot11FILSOmitReplicateProbeResponses equal to true.

A non-AP STA that receives a FILS Discovery frame from an AP with which it is not associated, may use the values carried in the frame to determine the operating parameters for that AP and may use the information when responding to a Trigger frame from the AP containing RA-RUs for unassociated non-AP STAs.

An unassociated non-AP STA that has not received an UORA Parameter Set element from the AP with which it intends to communicate shall use the default OCW values as defined in 26.5.4.1 (General). Each time an unassociated non-AP STA communicates with a different AP using random access it shall initialize its OCW using the default values or the parameters from the UORA Parameter Set element received from that AP and shall initialize its OBO counter as defined in 26.5.4.3 (Transmission procedure for UORA).

An unassociated non-AP STA that supports the UORA and TWT procedure may begin listening for Trigger frames at the start of a particular broadcast TWT SP after receiving a Beacon frame, a broadcast Probe Response frame or a FILS Discovery frame containing a TWT element with a Broadcast TWT Parameter Set field that has the Broadcast TWT ID subfield equal to 0, the Flow Type subfield equal to 0, the Trigger subfield equal to 1, and the Broadcast TWT Recommendation subfield equal to 2.

A non-AP STA shall include at most one Management frame in S-MPDU format when it transmits an HE TB PPDU in response to a Trigger frame sent by an AP with which the non-AP STA is not associated.

An AP that receives Management frames from one or more unassociated non-AP STAs carried in HE TB PPDUs transmitted on RA-RUs shall respond with a Multi-STA BlockAck frame carried either in an SU PPDU or in a DL HE MU PPDU on a broadcast RU with STA-ID 2045.

An AP with dot11FILSOmitReplicateProbeResponses equal to true shall follow the procedure defined in 11.1.4.3.4 (Criteria for sending a response) to respond with a broadcast Probe Response frame or the next Beacon frame if it receives one or more Probe Request frames via the UORA procedure.

26.5.5 Buffer status report operation

A non-AP STA delivers buffer status reports (BSRs) to assist its AP in allocating UL MU resources. The non-AP STA can either implicitly deliver BSRs in the QoS Control field or BSR Control subfield of any frame transmitted to the AP (unsolicited BSR) or explicitly deliver BSRs in any frame sent to the AP in response to a BSRP Trigger frame (solicited BSR). The buffer status reported in the QoS Control field consists of a queue size value for a given TID (see 9.2.4.5.6 (Queue Size subfield)). The buffer status reported in the BSR Control field consists of an ACI bitmap, delta TID, a high priority AC, and two queue sizes (see 9.2.4.6a.4 (BSR Control)).

An HE STA shall set the BSR Support subfield of the HE Capabilities element it transmits to 1 if dot11HEBSRControlImplemented is true; otherwise the HE STA shall set the BSR Support subfield to 0.

A non-AP STA reports its buffer status (unsolicited BSR) to the AP with which it is associated in the QoS Control field in QoS Null and QoS Data frames and in the BSR Control subfield (if present) in QoS Null, QoS Data and Management frames as defined below:

- The HE STA shall report the queue size for a given TID in the Queue Size subfield of the QoS Control field in QoS Data or QoS Null frames it transmits; the STA may set the Queue Size subfield to 255 to indicate an unknown/unspecified queue size for that TID.
  - The HE STA may aggregate multiple QoS Data frames or QoS Null frames in an A-MPDU to report the queue size for different TIDs. The HE STA shall follow the A-MPDU aggregation rules defined in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) for aggregating QoS Data frames with multiple TIDs. The HE STA does not follow the rules defined in 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU) for QoS Null frames with No Ack ack policy.
- The HE STA may report the buffer status in the BSR Control subfield of frames it transmits if the AP has indicated its support in the BSR Support subfield of its HE Capabilities element; otherwise the STA shall not report the buffer status in the BSR Control subfield.
  - The HE STA shall report the queue size for its preferred AC, indicated by the ACI High subfield, in the Queue Size High subfield of the BSR Control subfield; the STA may set the Queue Size High subfield to 255 to indicate an unknown/unspecified queue size for that AC.
  - The HE STA shall report the queue size for the ACs, indicated by the ACI Bitmap subfield, in the Queue Size All subfield of the BSR Control subfield; the STA may set the Queue Size All subfield to 255 to indicate an unknown/unspecified BSR for those ACs.
  - The HE STA shall set the Delta TID subfield according to Table 9-24d (Delta TID subfield encoding), and the Scaling Factor subfield as defined in 9.2.4.6a.4 (BSR Control).

NOTE 1—The STA can send an unsolicited BSR in response to certain Trigger frames except MU-RTS and BSRP (with or without RA-RUs, as defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation) and in 26.5.4 (UL OFDMA-based random access (UORA))) or it can send the unsolicited BSR after accessing the WM using EDCA.

NOTE 2—The STA might include a BSR Control subfield in a QoS Data or QoS Null frame. In this case the Queue Size subfield in the QoS Control field and the Queue Size High and Queue Size All subfields in the BSR Control subfield might differ, and any of the three subfields might be set to 255 to indicate unspecified or unknown queue size. The STA might include only the BSR Control subfield in a Management frame.

An AP can also solicit one or more associated non-AP STAs for their BSR(s) by sending a BSRP Trigger frame (see 9.3.1.22.6 (Buffer Status Report Poll (BSRP) variant)). The non-AP STA responds (solicited BSR) as defined below:

— The non-AP STA that receives a BSRP Trigger frame shall follow the rules defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation) to generate the HE TB PPDU if the Trigger frame contains the 12 LSBs of the non-AP STA's AID in any of the User Info fields; otherwise if the non-AP STA's buffers are not empty and the non-AP STA supports the UORA procedure, it may follow the rules defined in 26.5.4 (UL OFDMA-based random access (UORA)) to gain access to an RA-RU and generate the HE TB PPDU when the Trigger frame contains one or more RA-RUs.
— The non-AP STA shall include in the HE TB PPDU one or more QoS Null frames containing one or more of the following:
  • The QoS Control field(s) with Queue Size subfields for each of the TIDs for which the non-AP STA has queue size to report to the AP.
  • The BSR Control subfield with the Queue Size All subfield indicating the queue size for the ACs, indicated by the ACI Bitmap subfield, for which the non-AP STA has queue size to report to the AP if the AP has indicated its support in the BSR Support subfield of its HE Capabilities element. The non-AP STA shall set Delta TID, SF, ACI High and Queue Size High subfields of the BSR Control subfield as defined in 9.2.4.6a.4 (BSR Control).
— The non-AP STA shall not solicit an immediate response for the frames carried in the HE TB PPDU (e.g., the Ack Policy Indication subfield of a QoS Null frame shall not be set to Normal Ack or Implicit BAR).

NOTE 1—As with unsolicited BSR, the STA might include a BSR Control subfield in a QoS Null frame that is sent in response to the BSRP Trigger frame. In this case, the Queue Size subfield in the QoS Control field and the Queue Size High and Queue Size All subfields in the BSR Control subfield might differ, and any of the three subfields might be set to 255 to indicate an unspecified or unknown queue size.

NOTE 2—An AP does not send a BSRP Trigger frame containing the 12 LSBs of the AID of the non-AP STA that sets the UL MU Disable field to 1.

An AP may include a BSRP Trigger frame together with other Control, Data and Management frames in one A-MPDU to a non-AP STA if the HE Capabilities element received from the non-AP STA has the BSRP BQRP A-MPDU Aggregation field equal to 1. A non-AP STA constructs the A-MPDU contained in the HE TB PPDU sent in response to a BSRP Trigger frame as described in 26.5.2.4 (A-MPDU contents in an HE TB PPDU).

The NDP feedback report procedure described in 26.5.7 (NDP feedback report procedure) can be used for buffer status feedback operation. An AP that sent an NFRP Trigger frame to one or more non-AP STAs may send a BSRP Trigger frame to those non-AP STAs to get more precise buffer status information.

26.5.6 Bandwidth query report operation

A non-AP STA may send bandwidth query reports (BQRs) to assist its AP in allocating DL MU and UL MU resources. The non-AP STA may either implicitly deliver BQRs in the BQR Control subfield of a frame transmitted to the AP (unsolicited BQR) or explicitly deliver BQRs in a frame sent to the AP in response to a BQRP Trigger frame (solicited BQR).

An HE STA shall set the BQR Support subfield of the HE Capabilities element it transmits to 1 if dot11HEBQRControlImplemented is true; otherwise the HE STA shall set the BQR Support subfield to 0.

The HE STA may report the channel availability information as specified in 27.3.20.6.5 (Per 20 MHz CCA sensitivity) in the BQR Control subfield of frames it transmits if the AP has indicated its support in the BQR Support subfield of its HE Capabilities element; otherwise the STA shall not report the channel availability information in the BQR Control subfield.

NOTE—The STA can send an unsolicited BQR in response to certain Trigger frames except NFRP, MU-RTS and BQRP (with or without RA-RUs, as defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation) and in 26.5.4 (UL OFDMA-based random access (UORA))) or it can send the unsolicited BQR after accessing the WM using EDCA.

An AP may solicit BQRs from a non-AP STA only if the non-AP STA has indicated support by setting the BQR Support field in the HE Capabilities element it transmits to 1; otherwise the AP shall not solicit BQRs from the non-AP STA. An AP may solicit BQRs from one or more non-AP HE STAs that support generating BQRs, by sending a BQRP Trigger frame (see 9.3.1.22.8 (Bandwidth Query Report Poll (BQRP) variant)). A non-AP STA that supports generating a BQR responds (solicited BQR) as defined below:

- The STA that receives a BQRP Trigger frame shall follow the rules defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation) to generate the HE TB PPDU if the Trigger frame contains the STA’s AID in any of the User Info fields; otherwise the STA shall follow the rules defined in 26.5.4 (UL OFDMA-based random access (UORA)) to gain access to an RA-RU and generate the HE TB PPDU if the Trigger frame contains one or more RA-RUs.
- The STA shall include in the HE TB PPDU one or more QoS Null frames containing the BQR Control subfield with the channel availability information of the STA. The HE STA shall not solicit an immediate response for the frames carried in the HE TB PPDU. The Ack Policy Indication subfield of the frame shall be set to No Ack.

NOTE—An AP does not send a BQRP Trigger frame addressed to a STA that has set the UL MU Disable field to 1.

An AP may include a BQRP Trigger frame together with other Control, Data and Management frames in one A-MPDU to a STA if the HE Capabilities element received from the STA has the BSRP BQRP A-MPDU Aggregation field equal to 1. A non-AP STA constructs the A-MPDU contained in the HE TB PPDU sent in response to a BQRP Trigger frame as described in 26.5.2.4 (A-MPDU contents in an HE TB PPDU).

26.5.7 NDP feedback report procedure

26.5.7.1 General

The NDP feedback report procedure allows an HE AP to collect feedback that is not channel sounding from multiple non-AP HE STAs.

An HE AP sends an NFRP Trigger frame to solicit NDP feedback report response from many non-AP STAs that are identified by a range of scheduled AIDs in the Trigger frame. The NDP feedback report response from a non-AP STA is an HE TB feedback NDP (see 27.3.18 (HE TB feedback NDP)). A non-AP STA uses the information carried in the NFRP Trigger frame to know if it is scheduled, and in this case, to derive the parameters for the transmission of the response.

In this subclause, the NDP feedback report procedure is described.

26.5.7.2 STA behavior

A non-AP STA shall set the NDP Feedback Report Support subfield in the HE Capabilities element to 1 if it supports NDP feedback report and set it 0, otherwise.

A non-AP STA shall not transmit an NDP feedback report response unless it is explicitly enabled by an AP in one of the operation modes described in this subclause. The inter frame space between a PPDU that contains an NFRP Trigger frame and the NDP feedback report poll response is SIFS. A non-AP STA shall commence the transmission of an NDP feedback report response at the SIFS time boundary after the end of a received PPDU, if all the following conditions are met:

— The received PPDU contains an NFRP Trigger frame
— The non-AP STA is scheduled by the NFRP Trigger frame
— The NDP feedback report support subfield in HE MAC Capabilities Information field is set to 1
— The non-AP STA intends to provide a response to the type of the NDP feedback contained in the NFRP Trigger frame, as described in 26.5.7.4 (NDP feedback report for a resource request).

A non-AP STA that does not satisfy all of the above conditions shall not respond to the NFRP Trigger frame.

A non-AP STA is scheduled to respond to the NFRP Trigger frame if all the following conditions are met:

— The non-AP STA is associated with the BSSID indicated in the TA field of the NFRP Trigger frame or the non-AP STA is associated with a nontransmitted BSSID of a multiple BSSID set and the TA field of the NFRP Trigger frame is set to the transmitted BSSID of that multiple BSSID set.
— The non-AP STA's AID is greater than or equal to the starting AID and less than starting AID + N_{STA}, using the Starting AID subfield in the eliciting Trigger frame, and with N_{STA} the total number of non-AP STAs that are scheduled to respond to the NFRP Trigger frame. N_{STA} is calculated by the following equation, with UL BW subfield and Multiplexing Flag subfield from the eliciting Trigger frame:
$N_{STA} = 18 \times 2^{BW} \times (Multiplexing\ Flag + 1)$

A non-AP STA shall obtain NDP feedback report parameter values from the most recently received NDP Feedback Report Parameter Set element carried in a Beacon, Probe Response, or (Re)Association Response frame from its associated AP unless the non-AP STA is associated with a nontransmitted BSSID of a multiple BSSID set, in which case it shall follow the rules in 11.1.3.8.4 (Inheritance of element values) to determine the NDP feedback parameter values. If the NDP Feedback Report Parameter Set element is not received in a Management frame with a TA equal to the BSSID of the associated AP or to the transmitted BSSID of the multiple BSSID set, the non-AP STA shall use default values for the NDP Feedback Report parameters.

An NDP feedback report response is an HE TB feedback NDP as defined in 27.3.4 (HE PPDU formats).

A non-AP STA transmitting an NDP feedback report shall set the TXVECTOR parameter as for transmitting an HE TB PPDU in response to a Trigger frame as described in 26.5.2.3 (Non-AP STA behavior for UL MU operation), except for the following parameters:

— The FORMAT parameter shall be set to HE_TB
— The APEP_LENGTH parameter shall be set to 0
— The RU_ALLOCATION parameter shall be set to be maximum RU size for the BW
— The RU_TONE_SET_INDEX parameter shall be set with the following equation, with the value of the Starting AID subfield in the User Info field of the eliciting Trigger frame:
  - RU_TONE_SET_INDEX = 1 + ((AID – Starting AID) mod (18×2^{BW}))
— The NUM_STS parameter shall be set to 1
— The SPATIAL_REUSE parameter shall be set to PSR_DISALLOW
— The STARTING_STS_NUM parameter shall be set with the following equation, with the values of the Starting AID subfield in the User Info field of the eliciting Trigger frame:
  - STARTING_STS_NUM = $\lfloor (\text{AID} - \text{Starting AID}) / 18 / 2^{BW} \rfloor$

- The MCS parameter shall be set to 0
- The DCM parameter shall be set to 0
- The FEC_CODING parameter shall be set to 0
- The TXPWR_LEVEL_INDEX parameter shall be set to the value based on the Transmit Power Control for an HE TB PPDU and based on the value of the AP Tx Power subfield and the UL Target RSSI subfield in the User Info field of the eliciting Trigger frame (see 27.3.15.2 (Power pre-correction))

NOTE—The subcarriers for each RU_TONE_SET index are contained in a 20 MHz channel and can be transmitted by a 20 MHz operating STA.

26.5.7.3 AP behavior

An AP shall set the NDP Feedback Report Support subfield in the HE Capabilities element to 1 if it supports NDP feedback report and set it 0 otherwise.

An AP may include the NDP Feedback Report Parameter Set element in Beacon frames, Probe Response frames and (Re)Association Response frames in order to modify parameters for NDP Feedback Report operation. The procedure of NDP Feedback report described in this subclause allows operation even if the NDP Feedback Report Parameter Set element is not sent by the AP.

The NFRP Trigger frame shall be transmitted in a non-HT PPDU or HT PPDU, or as an EOF MPDU in a VHT, HE ER SU PPDU or HE SU PPDU.

An AP that transmits an NFRP Trigger frame shall set the TA field of the frame to the MAC address of the AP, unless dot11MultiBSSIDImplemented is true and the Trigger frame is directed to STAs from at least two different BSSs of a multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

Following the transmission from an AP of an NFRP Trigger frame, multiple STAs may simultaneously send NDP feedback report responses to the AP. Based on the RXVECTOR parameter NDP_REPORT, which provides the detected status array for the resources of each spatial stream and tone set assigned by the Trigger frame, the AP can derive the list of AIDs from the resources of which an NDP feedback report response was sent, and their response.

The AP shall not send any acknowledgment in response to the reception of NDP feedback report responses.

26.5.7.4 NDP feedback report for a resource request

If the Feedback Type subfield in the User Info field of the NFRP Trigger frame is 0, a STA that is scheduled may send an NDP feedback report response in order to signal to the AP that it is in the awake state and that it might have frames in its queues for UL MU. If the STA does not satisfy either of the conditions in Table 26-3 (FEEDBACK_STATUS description), then the STA shall not respond to the NFRP Trigger frame.

Each STA that is scheduled is assigned a STARTING_STS_NUM and an RU_TONE_SET_INDEX to transmit a FEEDBACK_STATUS bit.

The meaning of the FEEDBACK_STATUS bit is defined in Table 26-3 (FEEDBACK_STATUS description):

Table 26-3—FEEDBACK_STATUS description

FEEDBACK_STATUS	Condition
0	The STA is in the awake state and reports buffered octets for transmission not exceeding the resource request buffer threshold. NOTE—The STA can use this value to indicate that it is in the awake state even if it does not have any buffered octets for transmission, for example to solicit delivery of BUs known to be buffered at the AP.
1	The STA is in the awake state and reports buffered octets for transmission exceeding the resource request buffer threshold.

The resource request buffer threshold is equal to $2^{(\text{Resource request buffer threshold exponent})}$ octets, using the Resource Request Buffer Threshold Exponent subfield in the most recently received NDP Feedback Report Parameter Set element sent by the AP with which the STA is associated. The resource request buffer threshold is equal to 256 octets if the STA did not receive an NDP Feedback Report Parameter Set element from the AP with which the STA is associated.

26.5.7.5 Power save operation with NDP feedback report procedure

An HE AP that sends an NFRP Trigger frame to a non-AP STA in PS mode and receives an NDP feedback report response from the STA shall assume the STA to be or to have transitioned to the awake state and:

— follow the rules defined in 11.2.3.5 (Power management with APSD) to deliver BUs to the STA as if the STA had sent a U-APSD trigger frame, if the STA is using U-APSD

— follow the rules defined in 11.2.3.1 (General) to deliver BUs to the STA as if the STA had sent a PS-Poll frame, if the STA is not using U-APSD

— in addition, the AP shall follow the rules defined in 26.8 (TWT operation) for delivery of BUs during the TWT SP if the STA operates with TWT.

NOTE—As the AP does not send an acknowledgment in response to the NDP Feedback Report response, a STA that sends an NDP Feedback Report response and indicates that it is in the awake state might still schedule for transmission a PS-Poll or U-APSD trigger frame in order to indicate that it is in the awake state.

26.5.8 Use of TSPEC by HE STAs

In addition to the TS Setup operations as described in 11.4.4 (TS setup), a non-AP HE STA may use a TSPEC contained in a Basic ADDTS Request frame to provide its traffic characteristics and QoS requirements to an HE AP that supports the reception of Basic ADDTS Request frame in order to facilitate efficient scheduling for HE AP's UL and DL MU operations. A TSPEC provided by a non-AP HE STA is used by a receiving HE AP to facilitate the creation of a schedule for contention based channel access (EDCA) or MU operation. How the HE AP uses the information provided by the non-AP HE STA is beyond the scope of the specification.

A non-AP HE STA transmits an ADDTS Request with Schedule and APSD subfields in the TSPEC element set to 0 to signal its traffic characteristics and QoS requirements. An HE AP transmits an ADDTS Response frame as a response to ADDTS Request frame as described in 11.4.4 (TS setup).

A non-AP HE STA should send a DELTS frame with the corresponding TSID if the traffic associated with the TSID has been terminated. When receiving a DELTS from a non-AP HE STA, the HE AP shall consider the information provided in the TSPEC as no longer valid.

26.5.9 UL MU transmit power capabilities

A non-AP HE STA may use the UL MU Power Capabilities element in an (Re)Association Request frame in order to inform an HE AP of the relative maximum transmit power at which the non-AP HE STA is capable of transmitting an HE TB PPDU for each HE-MCS in the current operating channel width when using an RU size greater than or equal to 242 subcarriers.

An HE AP might use this information as an input into the algorithm used to schedule the non-AP HE STA for UL MU transmission. The specification of the algorithm is beyond the scope of this standard.

26.6 A-MPDU operation in an HE PPDU

26.6.1 General

A-MPDU operation for an HE PPDU follows the procedures defined in 10.12 (A-MPDU operation) and, additionally, the procedures defined in this subclause.

An HE STA that sends a Class 1 frame or a Class 2 frame in an HE PPDU shall send the frame as an S-MPDU (see Table 9-533 (A-MPDU contents in the S-MPDU context)).

An HE STA that sends a VHT Capabilities element, an HT Capabilities element, or an HE 6 GHz Band Capabilities element and an HE Capabilities element with Maximum A-MPDU Length Exponent Extension field of 0 shall support in reception an A-MPDU pre-EOF padding with maximum length defined in 10.12.2 (A-MPDU length limit rules).

An HE STA that sends a VHT Capabilities element and an HE Capabilities element with Maximum A-MPDU Length Exponent Extension subfield greater than 0 shall support reception of an HE PPDU with an A-MPDU pre-EOF padding as defined in 10.12.2 (A-MPDU length limit rules) except that the maximum length for the A-MPDU pre-EOF padding shall be equal to $min(2^{(20 + \text{Maximum A-MPDU Length Exponent Extension})} - 1, 6\,500\,631)$. An HE STA that sets the Maximum A-MPDU Length Exponent Extension subfield of the HE Capabilities element to a value greater than 0 shall set the Maximum A-MPDU Length Exponent subfield of the VHT Capabilities element to 7.

NOTE—6 500 631 is defined in Table 9-25 (Maximum data unit sizes (in octets) and durations (in microseconds)) as the upper bound of A-MPDU size.

An HE STA that does not send a VHT Capabilities element but sends an HT Capabilities element and an HE Capabilities element with Maximum A-MPDU Length Exponent Extension subfield greater than 0 shall support in reception an A-MPDU pre-EOF padding in an HE PPDU as defined in 10.13.2 (A-MPDU length limit rules) except that the maximum length for the A-MPDU pre-EOF padding shall be equal to $2^{(16 + \text{Maximum A-MPDU Length Exponent Extension})} - 1$. An HE STA that sets the Maximum A-MPDU Length Exponent Extension subfield of the HE Capabilities element to a value greater than 0 shall set the Maximum A-MPDU Length Exponent subfield of the HT Capabilities element to 3.

NOTE—An HE STA that is a VHT STA sends a VHT Capabilities element. An HE STA that is not a VHT STA does not send a VHT Capabilities element.

An HE STA that sends an HE 6 GHz Band Capabilities element and an HE Capabilities element with Maximum A-MPDU Length Exponent Extension subfield greater than 0 shall support in reception an A-MPDU pre-EOF padding in an HE PPDU as defined in 10.12.2 (A-MPDU length limit rules) except that the maximum length for the A-MPDU pre-EOF padding shall be equal to

$min(2^{(20 + \text{Maximum A-MPDU Length Exponent Extension})} - 1, 6\,500\,631)$. An HE STA that sets the Maximum A-MPDU Length Exponent Extension subfield of the HE Capabilities element to a value greater than 0 shall set the Maximum A-MPDU Length Exponent subfield of the HE 6 GHz Band Capabilities element to 7.

An HE STA shall not transmit an A-MPDU in an HE PPDU to a STA that exceeds the maximum A-MPDU length capability indicated in the HE Capabilities, VHT Capabilities, and HT Capabilities elements received from the recipient STA. If a VHT Capabilities element is received from the recipient STA, then the maximum A-MPDU length capability is derived from the Maximum A-MPDU Length Exponent Extension subfield in the HE Capabilities and the Maximum A-MPDU Length Exponent subfield in the VHT Capabilities element. Otherwise the maximum A-MPDU length capability is derived from the Maximum A-MPDU Length Exponent subfields in the HE Capabilities element and the Maximum A-MPDU Length Exponent subfield in the HT Capabilities element or in the HE 6 GHz Band Capabilities element.

An HE STA may transmit an HE SU PPDU or HE MU PPDU that carries an A-MPDU with contents defined in Table 9-531 (A-MPDU contents in the data enabled no immediate response context) or Table 9-532a (A-MPDU contents in the HE non-ack-enabled single-TID immediate response context).

An A-MPDU with any number of QoS Null frames with any TID and with No Ack ack policy and aggregated with or without other frames may be transmitted to a recipient STA in an HE PPDU that is not an HE TB PPDU regardless of the value of the Multi-TID Aggregation Rx/Tx Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element received from the recipient STA.

An A-MPDU with any number of QoS Null frames with any TID and with No Ack ack policy and aggregated with or without other frames in an A-MPDU may be transmitted in the HE TB PPDU regardless of the value of the TID Aggregation Limit subfield and the value of the Preferred AC subfield in the Basic Trigger frame, and the value of the Multi-TID Aggregation Rx Support of the AP that solicits the A-MPDU.

NOTE—A QoS Null frame with Normal Ack or Implicit BAR ack policy is not allowed to be sent in an A-MPDU, except for a QoS Null frame with Normal Ack ack policy in an S-MPDU (as defined in Table 9-532a (A-MPDU contents in the HE non-ack-enabled single-TID immediate response context) in HE PPDU context), Table 9-532b (A-MPDU contents in the HE ack-enabled single-TID immediate response context), Table 9-532c (A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context), Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context), Table 9-426 (A-MPDU contents in the data enabled no immediate response context) and Table 9-532 (A-MPDU contents in the control response context)).

26.6.2 A-MPDU padding in an HE PPDU

26.6.2.1 General

In an HE PPDU, a STA shall not add an A-MPDU subframe with the EOF field set to 1 and with the MPDU Length field set to 0 before an A-MPDU subframe with a nonzero MPDU Length field.

26.6.2.2 A-MPDU padding in an HE SU PPDU, HE ER SU PPDU and HE MU PPDU

An HE STA that transmits a DL HE MU PPDU that contains one or more PSDUs, each of which carries an A-MPDU, shall construct the A-MPDUs as described in 10.12.6 (A-MPDU padding for VHT PPDU) except that one or more A-MPDU subframes with a nonzero MPDU Length field and with an EOF field equal to 1 may be added if the A-MPDU is an ack-enabled single-TID A-MPDU (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)).

An HE STA that transmits an HE SU PPDU, HE ER SU PPDU or UL HE MU PPDU that contains one A-MPDU shall construct the A-MPDU as described in 10.12.6 (A-MPDU padding for VHT PPDU) except that one or more A-MPDU subframes with a nonzero MPDU Length field and with an EOF field equal to 1 may be added if the A-MPDU is an ack-enabled single-TID A-MPDU (see 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)).

26.6.2.3 A-MPDU padding in an HE TB PPDU

A non-AP STA that transmits an HE TB PPDU shall construct the PSDU carried in the HE TB PPDU as described in this subclause.

The STA calculates the PSDU_LENGTH as defined in 6.5 (PLME SAP interface) and initializes A-MPDU_Length to 0.

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

— The A-MPDU content constraints (see 10.12.1 (A-MPDU contents) and 26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)) for the intended recipient
— The Length limit constraints (see 9.7.1 (A-MPDU format) and 10.12.2 (A-MPDU length limit rules)) for the intended recipient
— The MPDU start spacing constraints (see 10.12.3 (Minimum MPDU Start Spacing field)) for the intended recipient

provided that the following conditions are met:

— The A-MPDU subframes have a value greater than 0 in the MPDU Length field, or have a value 0 in the MPDU Length field and a value 0 in the EOF field.
— After incrementing the A-MPDU_Length with the length of each such added A-MPDU subframe, the relationship A-MPDU_Length ≤ PSDU_LENGTH is true.

Padding is then 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.

An A-MPDU pre-EOF padding is constructed from each user from any of the following:

— A-MPDU subframes constructed from the MPDUs available for transmission from any AC that is selected by the STA
— A-MPDU subframes with 0 in the MPDU Length field and 0 in the EOF field

26.6.3 Multi-TID A-MPDU and ack-enabled single-TID A-MPDU

26.6.3.1 General

A non-ack-enabled multi-TID A-MPDU is an A-MPDU that does not contain an EOF MPDU but does contain non-EOF MPDUs from at least two TIDs (see Table 9-532c (A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context)).

An ack-enabled multi-TID A-MPDU is an A-MPDU that contains at least one EOF MPDU that solicits acknowledgment and one or more MPDUs from at least one TID (see Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context)).

An ack-enabled single TID A-MPDU is an A-MPDU that contains one EOF MPDU that solicits acknowledgment and one or more non-EOF MPDUs that do not solicit an immediate response (see Table 9-532b (A-MPDU contents in the HE ack-enabled single-TID immediate response context)).

An HE STA with dot11HEAMPDUwithMultipleTIDOptionImplemented equal to true shall set the Multi-TID Aggregation Rx Support subfield to a nonzero value in the HE MAC Capabilities Information field in the HE Capabilities element it transmits. An HE STA with dot11HEAMPDUwithMultipleTIDOptionImplemented equal to false shall set the Multi-TID Aggregation Rx Support subfield to 0.

An HE STA with dot11AckEnabledAMPDUOptionImplemented equal to true shall set the Ack-Enabled Aggregation Support subfield to 1 in the HE MAC Capabilities Information field in the HE Capabilities element it transmits. An HE STA with dot11AckEnabledAMPDUOptionImplemented equal to false shall set the Ack-Enabled Aggregation Support subfield to 0.

A multi-TID A-MPDU is either a non-ack-enabled multi-TID A-MPDU or an ack-enabled multi-TID A-MPDU. A first HE STA may transmit a non-ack-enabled multi-TID A-MPDU to a second HE STA if the first HE STA has received from the second STA an HE Capabilities element where the Multi-TID Aggregation Rx Support subfield is nonzero. A first HE STA may transmit an ack-enabled multi-TID A-MPDU or a non-ack-enabled multi-TID A-MPDU to a second HE STA if the first HE STA has received from the second HE STA an HE Capabilities element where the Multi-TID Aggregation Rx Support subfield is nonzero and where the Ack-Enabled Aggregation Support subfield is 1. Otherwise the first HE STA shall not transmit a multi-TID A-MPDU to the second HE STA.

An HE STA shall not transmit a multi-TID A-MPDU or ack-enabled single-TID A-MPDU in a VHT PPDU or a HT PPDU.

A non-AP STA shall not send a non-ack-enabled multi-TID A-MPDU in an HE TB PPDU unless it is in response to a Basic Trigger frame where the TID Aggregation Limit field of the User Info field addressed to the STA is greater than 1. A non-AP STA shall not send an ack-enabled multi-TID A-MPDU in an HE TB PPDU unless it is in response to a Basic Trigger frame where the TID Aggregation Limit field of the User Info field addressed to the STA is greater than 0.

NOTE—An ack-enabled multi-TID A-MPDU solicited by a Basic Trigger frame with TID Aggregation Limit field equal to 1 can contain one Management frame that solicits acknowledgment and one or more QoS Data frames from the same TID if the AP supports reception of ack-enabled multi-TID A-MPDUs.

A multi-TID A-MPDU shall not be transmitted in an HE SU PPDU, HE ER SU PPDU or HE MU PPDU, unless the TXOP limit is greater than 0 for the AC that is used to gain access to the medium. The AC used to gain access to the medium is the primary AC (see 10.23.2.9 (TXOP limits)). If the TXOP limit of the primary AC is greater than 0, then the STA may aggregate QoS Data frames from one or more TIDs in the A-MPDU under the following conditions:

- The A-MPDU shall be carried in either an HE SU PPDU or an HE ER SU PPDU transmitted by the STA within the obtained TXOP or an HE MU PPDU transmitted by a non-AP STA within the obtained TXOP
- The A-MPDU shall contain one or more MPDUs with any of the TIDs that correspond to the primary AC
- If no more MPDUs can be aggregated in the A-MPDU from any of the TIDs that correspond to the primary AC then the A-MPDU may additionally contain one or more MPDUs with TIDs that do not correspond to the primary AC if the TIDs correspond to any AC that has a higher priority with respect to the primary AC and the addition of these MPDUs does not cause the STA to exceed the current TXOP duration

An HE AP may aggregate MPDUs from any TIDs in multi-TID A-MPDU for DL HE MU PPDU transmission and the number of TIDs in multi-TID A-MPDU shall not be more than the Multi-TID Aggregation Rx Support announced by the recipient.

The Multi-STA BlockAck frame is used to acknowledge the MPDUs in a multi-TID A-MPDU as defined in 26.4 (HE acknowledgment procedure).

In a multi-TID A-MPDU, MPDUs with the same TID are not necessarily contiguous.

If the AP specifies a value defined in Table 9-154 (ACI-to-AC encoding) in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then an HE STA that transmits a multi-TID A-MPDU to the AP should aggregate QoS Data frames with TIDs that are from the same AC as or a higher priority AC than indicated in the Preferred AC subfield of the Trigger Dependent User Info field that is addressed to the STA in the Trigger frame. The number of TIDs from which QoS Data frames and the Management frame that solicits Ack frame are aggregated in an HE TB PPDU by a STA shall follow the restriction defined in Table 26-2 (Relation between TID Aggregation Limit field, Multi-TID Aggregation Tx Support field and solicited immediate response).

NOTE—While it is recommended that the STA transmit QoS Data from the AC that has the same or a higher priority than the preferred AC, the STA might still to aggregate QoS Data from an AC that has lower priority than the preferred AC.

The STA may aggregate MPDUs from TIDs in other ACs within the remaining time to the HE TB PPDU duration value indicated in the UL Length subfield in the Common Info field of the received Trigger frame, up to the limit indicated in the TID Aggregation Limit subfield in Trigger Dependent User Info field of the Trigger frame.

NOTE—If the AP indicates AC_BK in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then an HE STA that transmits a multi-TID A-MPDU to the AP might aggregate MPDUs from any AC/TID or combination of TIDs, up to the limit indicated in the TID Aggregation Limit subfield in Trigger Dependent User Info field of the Trigger frame.

An HE STA that intends to send QoS Data frames from a single TID should select a TID that is from the AC indicated in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame or from a higher priority AC. If the HE STA has no buffered MPDU for TIDs belonging to the same AC as or a higher priority AC than indicated in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then the HE STA may include MPDUs for a TID belonging to any other AC in that A-MPDU carried in the HE TB PPDU.

NOTE—A multi-TID A-MPDU allows the aggregation of a Management frame regardless of the value indicated in the Multi-TID Aggregation Rx Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element as long as the indicated in the value of the TID Aggregation Limit subfield in the Trigger Dependent User Info field of a the Basic Trigger frame is nonzero.

26.6.3.2 Ack-enabled single-TID A-MPDU operation

An ack-enabled single-TID A-MPDU is an A-MPDU with contents defined in Table 9-532b (A-MPDU contents in the HE ack-enabled single-TID immediate response context).

NOTE—An ack-enabled single-TID A-MPDU does not contain more than one of the following frames: QoS Data frames, Management frame that solicits acknowledgment. In this case the Management frame that solicits acknowledgment is treated as if it were a QoS Data frame with TID equal to 15.

An HE STA shall not transmit an ack-enabled single-TID A-MPDU to a recipient STA unless it has received from the recipient STA an HE Capabilities element with the Ack-Enabled Aggregation Support subfield equal to 1.

26.6.3.3 Non-ack-enabled multi-TID A-MPDU operation

A non-ack-enabled multi-TID A-MPDU is an A-MPDU with contents defined in Table 9-532c (A-MPDU contents in the HE non-ack-enabled multi-TID immediate response context).

NOTE—A non-ack-enabled multi-TID A-MPDU might include other frames such as a Trigger frame, BlockAck frame, or QoS Null frame (see Table 9-530 (A-MPDU contents in the non-HE data enabled immediate response context))

An HE STA shall not transmit a non-ack-enabled multi-TID A-MPDU to a recipient STA unless it has received from the recipient STA an HE Capabilities element where the Multi-TID Aggregation Rx Support subfield is nonzero.

A STA that receives a non-ack-enabled multi-TID A-MPDU responds as defined in 26.4.4 (Per-PPDU acknowledgment selection rules).

26.6.3.4 Ack-enabled multi-TID A-MPDU operation

An ack-enabled multi-TID A-MPDU is an A-MPDU with contents defined in Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context).

QoS Data frames with the same TID shall have the same ack policy.

QoS Data frames with the same TID shall be carried in A-MPDU subframes with the same value in the EOF field setting.

In an ack-enabled multi-TID A-MPDU, the EOF field in the MPDU delimiter of each A-MPDU subframe carrying a frame that solicits an Ack frame as defined in Table 9-532d (A-MPDU contents in the HE ack-enabled multi-TID immediate response context) shall be set to 1. The EOF field in all other A-MPDU subframes in the A-MPDU that carry frames shall be set to 0.

An HE STA shall not transmit an ack-enabled multi-TID A-MPDU to a recipient STA unless it has received from the recipient STA an HE Capabilities element where the Multi-TID Aggregation Rx Support subfield is nonzero and the Ack-Enabled Aggregation Support subfield is 1.

A STA that receives an ack-enabled multi-TID A-MPDU responds as defined in 26.4.4 (Per-PPDU acknowledgment selection rules).

A STA that transmits an ack-enabled multi-TID A-MPDU that contains at least two EOF MPDUs shall ignore the immediate response if it is an Ack frame.

26.7 HE sounding protocol

26.7.1 General

Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.

The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report:

- SU feedback: The HE compressed beamforming/CQI report consists of an HE Compressed Beamforming Report field
- MU feedback: The HE compressed beamforming/CQI report consists of an HE Compressed Beamforming Report field and HE MU Exclusive Beamforming Report field
- CQI feedback: The HE compressed beamforming/CQI report consists of an HE CQI Report field

NOTE—Use of HE TB sounding does not necessarily imply MU feedback. HE TB sounding is also used to obtain SU feedback and CQI feedback.

The HE compressed beamforming/CQI report is carried in a single HE Compressed Beamforming/CQI frame if the resulting frame is less than or equal to 11 454 octets in length (see 26.7.3 (Rules for HE sounding protocol sequences)). Otherwise, the HE beamforming feedback is segmented and each segment is carried in an HE Compressed Beamforming/CQI frame.

An HE beamformer shall support a maximum MPDU length for the HE compressed beamforming/CQI report that is the minimum of 11 454 octets and the maximum length of the HE compressed beamforming/CQI report that the HE beamformer intends to solicit from its HE beamformees.

26.7.2 Sounding sequences and support

An SU beamformer is an HE STA that sets the SU Beamformer subfield in the HE PHY Capabilities Information field of the HE Capabilities element it transmits to 1.

An SU beamformee is an HE STA that sets the SU Beamformee subfield in the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1. A non-AP HE STA shall set the SU Beamformee subfield to 1. An HE AP may set the SU Beamformee subfield to 1.

An MU beamformer is an HE AP that sets the MU Beamformer subfield in the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1. An HE AP that indicates support for 4 or more space-time streams in the Tx HE-MCS Map ≤ 80 MHz subfield in the Supported HE-MCS And NSS field in the HE Capabilities element shall set the MU Beamformer subfield to 1. A non-AP HE STA shall set the MU Beamformer subfield to 0. An MU beamformer is also an SU beamformer and shall set the SU Beamformer subfield to 1.

A non-AP HE STA shall support operation as an MU beamformee. An HE AP does not support operation as an MU beamformee.

The term HE beamformer refers to both the SU beamformer and MU beamformer. The term HE beamformee refers to both the SU beamformee and MU beamformee.

The type of feedback (SU, MU or CQI) solicited by an HE beamformer from an HE beamformee is indicated in the Feedback Type And Ng and Codebook subfields in the STA Info field identifying the HE beamformee in the HE NDP Announcement frame as defined in Table 9-31a (Feedback Type And Ng subfield and Codebook Size subfield encoding).

The bandwidth (partial or full) of the feedback solicited by an HE beamformer from an HE beamformee depends on the Partial BW Info subfield in the STA Info field identifying the HE beamformee in the HE NDP Announcement frame, the bandwidth of the HE NDP Announcement frame and the value of the Disallowed Subchannel Bitmap subfield, if present. Full bandwidth feedback is solicited if the RU Start Index subfield in the Partial BW Info subfield is 0, the Disallowed Subchannel Bitmap subfield is absent or contains all zeroes and the RU End Index subfield in the Partial BW subfield is the value shown in Table 26-4 (Settings for BW, RU Start Index, and RU End Index fields in HE NDP Announcement frame) where partial bandwidth is not supported by the HE beamformer, for the bandwidth of the HE NDP Announcement frame.

Other settings of the Partial BW Info subfield solicit partial bandwidth feedback. Punctured sounding is indicated by the inclusion of a nonzero Disallowed Subchannel Bitmap subfield in the HE NDP Announcement frame and in such a case, the disallowed subchannels are applied to the tone information to be included in the feedback after selecting tones for feedback based on the RU Start Index and RU End Index subfield values and HE NDP Announcement frame bandwidth as described above. See Table 26-4 (Settings for BW, RU Start Index, and RU End Index fields in HE NDP Announcement frame).

The RU Start Index and RU End Index subfields shall cover at least one allowed subchannel.

An SU beamformer may solicit full bandwidth SU feedback from an SU beamformee in an HE non-TB sounding sequence. An SU beamformer shall not solicit partial bandwidth SU feedback in an HE non-TB sounding sequence. An SU beamformer may solicit partial bandwidth or full bandwidth SU feedback from an SU beamformee in an HE TB sounding sequence if the SU beamformee indicates support by setting the Triggered SU Beamforming Feedback subfield in the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1.

An MU beamformer may solicit full bandwidth MU feedback from an MU beamformee in an HE TB sounding sequence. An MU beamformer may solicit partial bandwidth MU feedback from an MU beamformee in an HE TB sounding sequence if the MU beamformee indicates support by setting the Triggered MU Beamforming Partial BW Feedback subfield to 1. An MU beamformer shall not solicit MU feedback in an HE non-TB sounding sequence.

An MU beamformer may solicit full bandwidth or partial bandwidth CQI feedback from an MU beamformee in an HE TB sounding sequence if the MU beamformee indicates support by setting the Triggered CQI Beamforming Feedback subfield to 1.

An MU beamformer may solicit full bandwidth CQI feedback from an MU beamformee in an HE non-TB sounding sequence if the MU beamformee indicates support by setting the Non-Triggered CQI Beamforming Feedback subfield to 1.

An HE beamformer may solicit punctured SU feedback from an HE beamformee in an HE TB sounding sequence if the HE beamformee indicates support for punctured sounding by setting the Punctured Sounding Support subfield in the HE Capabilities elements it transmits to 1. An HE beamformer shall indicate punctured subchannels in the HE sounding NDP of an HE TB sounding sequence by setting the appropriate bits of the Disallowed Subchannel Bitmap subfield of the STA Info field with the AID11 subfield set to 2047 in the preceding HE NDP Announcement frame. An SU beamformer that indicates punctured subchannels in an HE NDP Announcement frame in an HE TB sounding sequence shall set the TXVECTOR parameter INACTIVE_SUBCHANNELS of the non-HT duplicate PPDU carrying the HE NDP Announcement frame and the HE sounding NDP as described in 26.11.7 (INACTIVE_SUBCHANNELS and RU_ALLOCATION).

An SU beamformee that supports punctured sounding shall generate feedback corresponding to the subchannels indicated in the STA Info field addressed to it in an HE NDP Announcement frame, but excluding subcarriers that are disallowed according to the value of the Disallowed Subchannel Bitmap subfield in that frame.

An HE beamformer shall not send an HE NDP Announcement frame that initiates an HE TB sounding sequence with a STA Info field identifying an HE beamformee if the STA Info field and the PHY Capabilities Information field in the HE Capabilities element most recently received from the HE beamformee meet any of the following conditions (see Table 9-31a (Feedback Type And Ng subfield and Codebook Size subfield encoding)):

— The Feedback Type And Ng subfield in the STA Info field indicates SU and $Ng = 16$, and the Ng = 16 SU Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng subfield in the STA Info field indicates MU and $Ng = 16$, and the Ng = 16 MU Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng subfield in the STA Info field indicates SU, the Codebook Size subfield indicates codebook resolution $(\phi, \psi) = \{4, 2\}$ and the Codebook Size $(\phi, \psi) =\{4, 2\}$ SU Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng subfield in the STA Info field indicates MU, the Codebook Size subfield in the STA Info field indicates codebook resolution (ϕ, ψ) = {7, 5} and the Codebook Size (ϕ, ψ) ={7, 5} MU Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng and Codebook Size subfields in the STA Info field indicate CQI and the Triggered CQI Beamforming Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng subfield in the STA Info field indicates MU, the Partial BW Info subfield in the STA Info field indicates partial bandwidth and the Triggered MU Beamforming Partial BW Feedback subfield in the HE PHY Capabilities Information field is 0

— The Feedback Type And Ng subfield indicates SU and the Triggered SU Beamforming Feedback subfield in the HE PHY Capabilities Information field is 0

An HE beamformee indicates the maximum number of HE-LTF symbols it can receive in a 20 MHz, 40 MHz or 80 MHz HE sounding NDP in the Beamformee STS ≤ 80 MHz subfield in the PHY Capabilities Information field in the HE Capabilities element it transmits.

An HE beamformee shall set the Beamformee STS ≤ 80 MHz subfield to indicate a maximum number of HE-LTF symbols of 4 or greater.

An HE beamformee that supports 160 MHz or 80+80 MHz channel widths indicates the maximum number of HE-LTF symbols it can receive in a 160 MHz or 80+80 MHz HE sounding NDP in the Beamformee STS > 80 MHz subfield in the PHY Capabilities Information field in the HE Capabilities element it transmits.

An HE beamformer shall not transmit a 20 MHz, 40 MHz or 80 MHz HE sounding NDP with a TXVECTOR parameter NUM_STS that is greater than the maximum number of HE-LTF symbols indicated in the Beamformee STS ≤ 80 MHz subfield of any STA identified by a STA Info field in the preceding HE NDP Announcement frame.

An HE beamformer shall not transmit a 160 MHz or 80+80 MHz HE sounding NDP with a TXVECTOR parameter NUM_STS that is greater than the maximum number of HE-LTF symbols indicated in the Beamformee STS > 80 MHz subfield of any STA identified by a STA Info field in the preceding HE NDP Announcement frame.

An HE beamformer indicates the maximum number of HE-LTF symbols it might transmit in a 20 MHz, 40 MHz or 80 MHz HE sounding NDP in the Number Of Sounding Dimensions ≤ 80 MHz subfield.

An HE beamformer indicates the maximum number of HE-LTF symbols it might transmit in an 80+80 MHz or 160 MHz HE sounding NDPP in the Number Of Sounding Dimensions > 80 MHz subfield.

An HE beamformer shall not transmit a 20 MHz, 40 MHz or 80 MHz HE sounding NDP where the number of HE-LTF symbols exceeds the value indicated in the Number Of Sounding Dimensions ≤ 80 MHz subfield.

An HE beamformer shall not transmit an 80+80 MHz or 160 MHz HE sounding NDP where the number of HE-LTF symbols exceeds the value indicated in the Number Of Sounding Dimensions > 80 MHz subfield.

26.7.3 Rules for HE sounding protocol sequences

An HE non-TB sounding sequence is a sounding sequence initiated by an HE beamformer with a burst of two frames comprising an individually addressed HE NDP Announcement frame with a single STA Info field, the STA Info field having a value in the AID11 field other than 2047, followed after a SIFS by an HE sounding NDP. An example of an HE non-TB sounding protocol with a single HE beamformee is shown in Figure 26-7 (An example of the sounding protocol with a single HE beamformee).

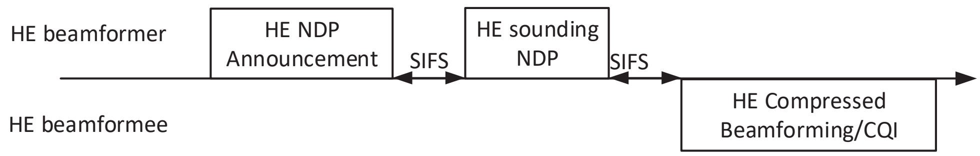

Figure 26-7—An example of the sounding protocol with a single HE beamformee

An HE beamformer that initiates the HE non-TB sounding sequence shall transmit the HE NDP Announcement frame with a single STA Info field that has a value in the AID11 field other than 2047 and with the AID11 field in that STA Info field set to the AID of the STA identified by the RA field or to 0 if the STA identified by the RA field is a mesh STA, AP or IBSS member STA.

An HE beamformer may initiate an HE non-TB sounding sequence with an HE beamformee to solicit SU feedback over full bandwidth.

An HE beamformer shall not initiate an HE non-TB sounding sequence with an HE NDP Announcement frame that has a Partial BW Info subfield that indicates less than full bandwidth (see Table 26-4 (Settings for BW, RU Start Index, and RU End Index fields in HE NDP Announcement frame)).

An HE TB sounding sequence is a sounding sequence initiated by an HE beamformer with a burst of three frames comprising a broadcast HE NDP Announcement frame with two or more STA Info fields followed after a SIFS by an HE sounding NDP followed after a SIFS by a BFRP Trigger frame. An example of an HE TB sounding protocol with more than one HE beamformee is shown in Figure 26-8 (An example of the sounding protocol with more than one HE beamformee).

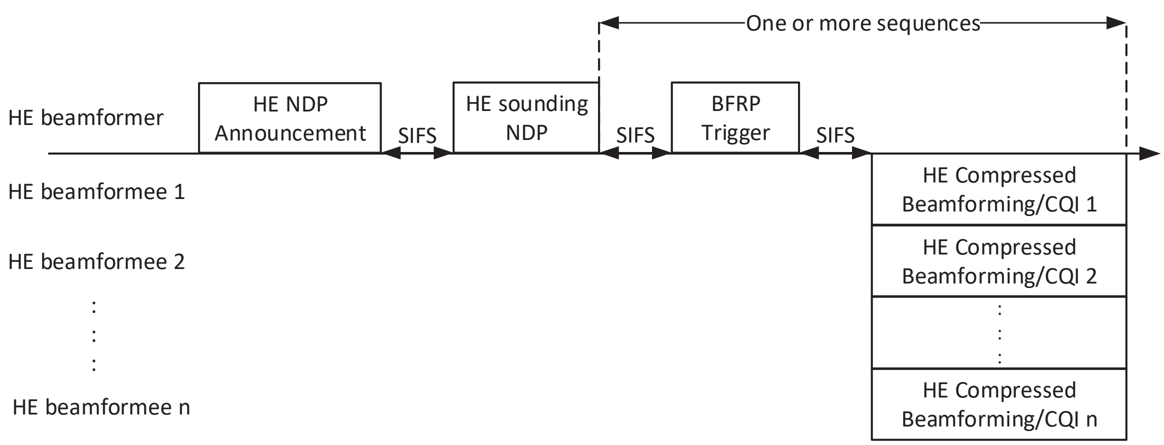

Figure 26-8—An example of the sounding protocol with more than one HE beamformee

An HE beamformer that initiates an HE TB sounding sequence shall transmit the HE NDP Announcement frame with two or more STA Info fields and the RA field set to the broadcast address.

An HE beamformer may initiate an HE TB sounding sequence to solicit MU feedback over full bandwidth.

An HE beamformer may initiate an HE TB sounding sequence to solicit a feedback variant only if the feedback variant is computed based on parameters supported by the HE beamformee; otherwise the HE beamformer shall not solicit a feedback variant computed based on parameters not supported by the HE beamformee (see 26.7.2 (Sounding sequences and support)).

An HE beamformer that initiates an HE non-TB sounding sequence or an HE TB sounding sequence shall transmit an HE sounding NDP a SIFS after the HE NDP Announcement frame.

An HE AP with dot11MultiBSSIDImplemented equal to true shall not send an HE NDP Announcement frame with the TA field set to the transmitted BSSID to a non-AP STA that is associated with a nontransmitted BSSID in the multiple BSSID set unless the AP has received from the non-AP STA an HE Capabilities element with the Rx Control Frame To MultiBSS subfield in the HE MAC Capabilities Information field equal to 1.

An AP that transmits an HE NDP Announcement frame identifying HE STAs shall set the TA field of the frame to the MAC address of the AP, unless dot11MultiBSSIDImplemented is true and the HE NDP Announcement frame identifies STAs from at least two different BSSs of the multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID. If the HE NDP Announcement frame is transmitted in a non-HT duplicate PPDU then the TA field of the HE NDP Announcement frame is a bandwidth signaling TA (see 10.6.6.6 (Channel Width selection for Control frames)).

An HE beamformer that transmits an HE NDP Announcement frame to an HE beamformee that is an AP, TDLS peer STA, mesh STA or IBSS STA, shall include one STA Info field in the HE NDP Announcement frame and shall set the AID11 field in the STA Info field of the frame to 0. An HE beamformer that is an AP and that transmits an HE NDP Announcement frame to one or more HE beamformees shall set the AID11 field in the STA Info field identifying a non-AP STA to the 11 LSBs of the AID of the non-AP STA. An HE NDP Announcement frame shall not include multiple STA Info fields that have the same value in the AID11 subfield. An HE beamformer that transmits an HE NDP Announcement frame may include a STA Info field with an AID11 subfield value of 2047 to indicate disallowed subchannels during punctured channel operation. When present, the STA Info field with AID11 value of 2047 shall be the first STA Info field in the frame. An HE beamformer that transmits an HE NDP Announcement frame shall not include more than one STA Info field with an AID11 subfield value of 2047.

In an HE TB sounding sequence, a STA Info field in the HE NDP Announcement frame that solicits SU or MU feedback indicates the subcarrier grouping, *Ng*, codebook size and the number of columns, *Nc*, to be used by the HE beamformee identified by the STA Info field for the generation of the SU or MU feedback.

In an HE non-TB sounding sequence where the STA Info field in the HE NDP Announcement frame solicits SU feedback, the subcarrier grouping, *Ng*, codebook size and the number of columns, *Nc*, used for the generation of the SU feedback are determined by the HE beamformee.

In an HE TB sounding sequence, a STA Info field in the HE NDP Announcement frame that solicits CQI feedback indicates the *Nc* to be used by the HE beamformee identified by the STA Info field for the generation of the CQI feedback.

In an HE non-TB sounding sequence where the STA Info field in the HE NDP Announcement frame solicits CQI feedback, the *Nc* used for the generation of the CQI feedback is determined by the HE beamformee.

An HE beamformer that has initiated an HE TB sounding sequence may send another BFRP Trigger frame in the same TXOP as shown in Figure 26-8 (An example of the sounding protocol with more than one HE beamformee). The HE beamformer uses the additional BFRP Trigger frames to solicit HE compressed beamforming/CQI reports from HE beamformees not addressed in a previous BFRP Trigger frame or to solicit retransmission of an HE compressed beamforming/CQI report. An HE beamformer shall not transmit a BFRP Trigger frame that identifies a STA identified in the HE NDP Announcement frame of an HE TB sounding sequence unless it is in the same TXOP as the HE TB sounding sequence.

An HE beamformer that transmits an HE NDP Announcement frame as part of an HE TB sounding sequence shall set the Nc subfield of the STA Info field to indicate a value less than or equal to the minimum of:

— The maximum number of supported spatial streams according to the corresponding HE beamformee's Rx HE-MCS Map ≤ 80 MHz, Rx HE-MCS Map 160 MHz, and Rx HE-MCS Map 80+80 MHz subfields in the Supported HE-MCS And NSS Set field of the HE Capabilities element sent by the HE beamformee.

— The maximum number of supported spatial streams according to the Rx NSS subfield value in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield equal to 0, or OM Control subfield sent by the corresponding HE beamformee (see 26.9 (Operating mode indication)).

— The maximum *Nc* indicated by the Max Nc subfield in the HE PHY Capabilities Information field of the HE Capabilities element sent by the HE beamformee.

An HE beamformer that transmits an HE NDP Announcement frame shall set the RU Start Index and RU End Index subfields in a STA Info field to indicate the starting 26-tone RU and the ending 26-tone RU, respectively, of the solicited HE compressed beamforming/CQI report (see 9.3.1.19 (VHT/HE NDP Announcement frame format)). For preamble punctured sounding, the RU Start Index and RU End Index correspond to the bandwidth before puncturing and the Disallowed Subchannel Bitmap subfield is used to indicate the subcarriers that are punctured in the HE sounding NDP and in the solicited feedback.

NOTE—In order to maximize the channel estimate quality after interpolation/extrapolation resulting from grouping, the subcarriers for which feedback is requested using the RU Start Index and RU End Index subfields do not necessarily lie within the actual RU as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU). Rather, they are defined in Table 9-93c (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 4) and Table 9-93d (Subcarrier indices scidx(0) and scidx(Ns – 1) for Ng = 16).

The bandwidth of the HE NDP Announcement frame is obtained from the RXVECTOR parameter CH_BANDWIDTH of the HE NDP Announcement frame if received in an HE, VHT or HT PPDU and from the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT if the HE NDP Announcement frame is received in a non-HT duplicate PPDU and is 20 MHz if the HE NDP Announcement frame is received in a non-HT PPDU.

In an HE non-TB sounding sequence, an HE beamformer shall solicit full bandwidth feedback. In an HE TB sounding sequence, an HE beamformer shall solicit full bandwidth feedback in a STA Info field identifying an HE beamformee that has not indicated support for partial bandwidth feedback. In an HE TB sounding sequence, an HE beamformer may solicit full bandwidth or partial bandwidth feedback in a STA Info field identifying an HE beamformee that has indicated support for partial bandwidth feedback (see 26.7.2 (Sounding sequences and support)).

For 80+80 MHz, feedback is not requested for the gap between the 80 MHz segments.

The HE beamformer shall set the TXVECTOR parameter CH_BANDWIDTH or CH_BANDWIDTH_IN_NON_HT, the RU Start Index field, and the RU End Index field of the HE NDP Announcement frame, depending on the operating channel width and partial BW support of the HE beamformee, as defined in Table 26-4 (Settings for BW, RU Start Index, and RU End Index fields in HE NDP Announcement frame). The bandwidth of the HE NDP Announcement frame is determined before applying puncturing based on disallowed subchannels.

Table 26-4—Settings for BW, RU Start Index, and RU End Index fields in HE NDP Announcement frame

Partial bandwidth supported by HE beamformer	Operating channel width of the HE beamformee (MHz)	Bandwidth of HE NDP Announcement frame	RU Start Index field	RU End Index field
No	20, 40, 80, 160/80+80	20 MHz	0	8
Yes	20, 40, 80, 160/80+80		0–8	0–8
No	40, 80, 160/80+80	40 MHz	0	17
Yes	40, 80, 160/80+80		0–17	0–17
No	80, 160/80+80	80 MHz	0	36
Yes	80, 160/80+80		0–36	0–36
No	160/80+80	160 MHz or 80+80 MHz	0	73
Yes	160/80+80		0–73	0–73
NOTE 1—The value of the RU Start Index field is always less than or equal to the value of the RU End Index field.				
NOTE 2—Partial BW feedback can only be solicited with an HE TB sounding sequence and cannot be solicited with an HE non-TB sounding sequence.				

The HE beamformer shall use a lowest 26-tone RU, which is the lower bound of the starting 26-tone in the RU Start Index subfield of a STA Info field that is equal to the maximum of:

— The minimum 26-tone RU located within the channel width indicated in the VHT Operation Information field of either the HE Operation element or the VHT Operation element, whichever is present, and within the channel width indicated in the HT Operation element

— The minimum 26-tone RU located within the channel width indicated in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield equal to 0, or OM Control subfield sent by the corresponding HE beamformee (see 26.9 (Operating mode indication))

The HE beamformer shall use a highest 26-tone RU, which is the upper bound of the ending 26-tone RU in the RU End Index subfield of a STA Info field that is equal to the minimum of:

— The maximum 26-tone RU located within the channel width indicated in the VHT Operation Information field of either the HE Operation element or the VHT Operation element, whichever is present, and within the channel width indicated in the HT Operation element

— The maximum 26-tone RU located within the channel width indicated in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield equal to 0, or OM Control field sent by the corresponding HE beamformee (see 26.9 (Operating mode indication))

An HE beamformer soliciting SU or CQI feedback in an HE non-TB sounding sequence shall set the Feedback Type And Ng, Codebook Size and Nc subfields in the HE NDP Announcement frame to 0. An HE beamformee that receives an HE NDP Announcement frame soliciting SU feedback as part of an HE non-

TB sounding sequence shall generate an HE compressed beamforming/CQI report for SU feedback with *Nc* in the range 1 to 8, $Ng = 4$ or $Ng = 16$, and codebook size $(\phi, \psi) = \{4, 2\}$ or $(\phi, \psi) = \{6, 4\}$. The HE beamformee shall transmit the HE compressed beamforming/CQI report a SIFS after the HE sounding NDP.

An HE beamformee that receives an HE NDP Announcement frame soliciting CQI feedback as part of an HE non-TB sounding sequence shall generate an HE compressed beamforming/CQI report for CQI feedback with *Nc* determined by the HE beamformee.

An HE beamformee that receives an HE NDP Announcement frame soliciting CQI feedback as part of an HE TB sounding sequence shall generate an HE compressed beamforming/CQI report for CQI feedback with *Nc* determined by the HE beamformer.

An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field (indicating a non-TB sounding sequence) and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP.

An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field identifying it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng*, codebook size, and *Nc* indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a matching STA Info field, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has the TA field set to the transmitted BSSID, and the HE beamformee is a non-AP STA associated to a nontransmitted BSSID that supports receiving Control frames with TA field set to the transmitted BSSID, then the HE compressed beamforming/CQI report sent in response shall have the RA field set to as defined in 26.5.2.3.5 (RA field for frames carried in an HE TB PPDU).

NOTE—A non-AP HE beamformee that transmits an OM Control subfield with the UL MU Disable field set to 1 does not respond to BFRP Trigger frames (see 26.9 (Operating mode indication)).

An HE beamformee that is a non-AP STA that transmits an HE Compressed Beamforming/CQI Report shall set the RU Start Index and RU End Index subfields of the HE MIMO Control field to indicate the range of tones for which compressed beamforming/CQI information is provided. If the HE NDP Announcement frame that solicited the feedback includes a Disallowed Subchannel Bitmap field with a nonzero value, then a beamformee that indicates support for punctured sounding by setting the Punctured Sounding Support subfield in the HE Capabilities elements that it transmits to 1 shall include a Disallowed Subchannel Bitmap subfield in the solicited feedback with the same value as the Disallowed Subchannel Bitmap subfield of the HE NDP Announcement frame that solicited the feedback to indicate subcarriers for which feedback information is not provided from within the range of subcarriers indicated by the RU Start Index and RU End Index subfields.

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

An HE beamformer that sends a BFRP Trigger frame shall set the Feedback Segment Retransmission Bitmap fields of the BFRP Trigger frame to all 1s except when the HE beamformer intends to solicit the retransmission of segmented feedback as defined in 26.7.4 (Rules for generating segmented feedback).

NOTE—The BFRP Trigger frame contains one or more User Info fields, each of which identifies an HE beamformee.

The SNR per subcarrier computation is recommended to be done on at least 4 subcarriers in a 26-tone RU.

26.7.4 Rules for generating segmented feedback

If the HE compressed beamforming/CQI report solicited by the HE beamformer would result in an HE Compressed Beamforming/CQI frame that exceeds 11 454 octets in length, then the HE compressed beamforming/CQI report shall be split into up to 8 feedback segments. Each feedback segment shall be included in a separate HE Compressed Beamforming/CQI frame and shall contain successive portions of the HE compressed beamforming/CQI report. Each feedback segment shall be of equal length except the last feedback segment that may be smaller. Each HE Compressed Beamforming/CQI frame that includes a feedback segment that is not the last feedback segment shall have a length of 11 454 octets. Each feedback segment is identified by the value of the Remaining Feedback Segments subfield and the First Feedback Segment subfield in the HE MIMO Control field as defined in 9.4.1.64 (HE MIMO Control field); the other nonreserved subfields of the HE MIMO Control field shall be the same for all feedback segments. All feedback segments shall be sent in a single A-MPDU contained in a PPDU and shall be included in the A-MPDU in the descending order of the Remaining Feedback Segments subfield values.

An HE beamformer that sends a BFRP Trigger frame, in its first attempt to retrieve an HE compressed beamforming/CQI report from an HE beamformee, shall solicit all possible feedback segments by setting all of the bits in the Feedback Segment Retransmission Bitmap subfield to 1 in the User Info field identifying the HE beamformee.

An HE beamformer that fails to receive some or all of the feedback segments of the HE compressed beamforming/CQI report from the HE beamformee, may solicit the selective retransmission of missing feedback segments by sending a BFRP Trigger frame that indicates in the Feedback Segment Retransmission Bitmap subfield of the User Info field identifying the HE beamformee the list of feedback segments solicited for retransmission (see 9.3.1.22.3 (Beamforming Report Poll (BFRP) variant)).

NOTE—In an HE non-TB sounding sequence, if the HE beamformer does not receive all feedback segments from the HE beamformee, the HE beamformer cannot use a BFRP Trigger frame to request retransmission of the feedback segments. In this case the HE beamformee can only repeat the entire non-TB sounding sequence.

An HE beamformer that fails to receive the first feedback segment (identified by the First Feedback Segment field set to 1), may solicit the selective retransmission of the missing feedback segments assuming the HE compressed beamforming/CQI report is split into 8 feedback segments. The HE beamformer may also solicit the retransmission of all feedback segments by setting all of the bits in the Feedback Segment Retransmission Bitmap subfield to 1 in the User Info field identifying the HE beamformee.

An HE beamformee that transmits an HE compressed beamforming/CQI report including the HE Compressed Beamforming Report information and any HE MU Exclusive Beamforming Report information in response to a BFRP Trigger frame shall either transmit only the feedback segments indicated in the Feedback Segment Retransmission Bitmap field in the User Info field of the BFRP Trigger frame identifying the HE beamformee or transmit all the feedback segments available at the HE beamformee, excluding the feedback segments that do not exist at the HE beamformee.

NOTE—If an HE beamformer solicits the missing feedback segments from a beamformee and does not receive a response from the beamformee, the HE beamformer might either initiate an HE TB sounding sequence or transmit an additional BFRP Trigger frame to the HE beamformee.

26.7.5 HE sounding NDP transmission

The TXVECTOR parameters for an HE sounding NDP shall be set as follows:

— FORMAT is set to HE_SU

— APEP_LENGTH is set to 0

— HE_LTF_TYPE is set to either 2xHE-LTF or 4xHE-LTF

— If HE_LTF_TYPE is 2xHE-LTF, then GI_TYPE is set to either 0u8s_GI or 1u6s_GI

— If HE_LTF_TYPE is 4xHE-LTF, then GI_TYPE is set to 3u2s_GI

— NUM_STS indicates two or more space-time streams if the Feedback Type field in the HE MIMO Control field of the preceding HE NDP Announcement frame indicates either SU or MU, or one or more space-time streams if the Feedback Type field in the HE MIMO Control field of the preceding HE NDP Announcement frame indicates CQI. See below for additional constraints on NUM_STS.

— CH_BANDWIDTH is set to the same value as the TXVECTOR parameter CH_BANDWIDTH in the preceding HE NDP Announcement frame

— SPATIAL_REUSE is set to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED (see 26.11.6 (SPATIAL_REUSE))

— BSS_COLOR is set to the value indicated in the BSS Color subfield of the HE Operation element received or transmitted by the HE AP

— TXOP_DURATION set to either 127 or a value defined in Equation (26-3)

$$\begin{aligned}\max(&\min\left(8\left\lfloor\frac{\lceil D_{\mathrm{HE\_NDPA}}-\mathrm{SIFS}-\mathrm{TXTIME}\rceil}{8}\right\rfloor, 504\right),\\ &\min\left(128\left\lfloor\frac{\lceil D_{\mathrm{HE\_NDPA}}-\mathrm{SIFS}-\mathrm{TXTIME}\rceil}{128}\right\rfloor, 8448\right))\end{aligned} \tag{26-3}$$

where

$D_{\mathrm{HE\_NDPA}}$ is the value of the Duration/ID field in the MAC header of the preceding HE NDP Announcement frame

TXTIME is the transmission time of an HE sounding NDP defined in Equation (27-136)

The Supported HE-MCS and NSS Set field of the HE Capabilities element transmitted by the transmitter and the receiver of the HE sounding NDP do not affect the values used for the NUM_STS parameter for the TXVECTOR of an HE sounding NDP.

The destination of an HE sounding NDP is equal to the RA of the immediately preceding HE NDP Announcement frame.

The source of an HE sounding NDP is equal to the TA of the immediately preceding HE NDP Announcement frame.

26.8 TWT operation

26.8.1 General

Target wake time (TWT) allows an AP to manage activity in the BSS in order to minimize contention between STAs and to reduce the required amount of time that a STA in PS mode needs to be awake. This is achieved by allocating STAs to operate at nonoverlapping times and/or frequencies, and concentrate the frame exchanges in predefined service periods.

An HE STA negotiates individual TWT agreements, as defined in 10.47 (Target wake time (TWT)), subject to the additional rules and restrictions that are defined in 26.8.2 (Individual TWT agreements) and 26.8.7 (HE subchannel selective transmission). A non-AP HE STA establishes membership in broadcast TWT schedules, as defined in 26.8.3 (Broadcast TWT operation), which are used as defined in 26.8.3.3 (Rules for TWT scheduled STA), 26.14.2 (Power save with UORA and TWT), and 26.14.3 (Opportunistic power save). An HE AP delivers broadcast TWT parameter sets to non-AP HE STAs as described in 26.8.3.2 (Rules for TWT scheduling AP), 26.14.2 (Power save with UORA and TWT) and 26.14.3 (Opportunistic power save).

A STA does not need to be aware of the values of TWT parameters of the TWT agreements of other STAs in the BSS of the STA or of TWT agreements of STAs in other BSSs. A STA does not need to be aware that a TWT service period (SP) is used to exchange frames with other STAs. Frames transmitted during a TWT SP are carried in any PPDU format supported by the pair of STAs that have established the TWT agreement corresponding to that TWT SP, including HE MU PPDU, HE TB PPDU, etc.

An HE STA with dot11TWTOptionImplemented equal to true shall set:

— The TWT Requester Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT requesting STA; otherwise set to 0.

— The TWT Responder Support subfield to 1 in the HE Capabilities elements that it transmits if it supports operating in the role of a TWT responding STA; otherwise set to 0.

— The Broadcast TWT Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT scheduled STA or in the role of a TWT scheduling AP; otherwise set to 0.

An HE AP shall set the TWT Responder Support subfield of the Extended Capabilities element and HE Capabilities element to 1.

An HE AP may request TWT participation by all associated STAs that have declared support for TWT. A non-AP STA declares support for the role of TWT requesting STA by setting the TWT Requester Support subfield in the Extended Capabilities element or in the HE Capabilities element to 1 and declares support for the role of TWT scheduled STA by setting the Broadcast TWT Support subfield in the HE Capabilities element to 1. The HE AP makes the request for TWT participation by setting the TWT Required subfield to 1 in HE Operation elements it transmits. A STA that supports TWT and that has received an HE Operation element with the TWT Required subfield equal to 1 from the HE AP with which it is associated shall either negotiate individual TWT agreements, as defined in 26.8.2 (Individual TWT agreements), or participate in broadcast TWT operation, as defined in 26.8.3 (Broadcast TWT operation).

NOTE—The AP sets the TWT Required subfield to 1 if it is not available outside TWT SPs (see 26.8.2 (Individual TWT agreements) and 26.8.3 (Broadcast TWT operation)). The AP might not be available outside TWT SPs if it sets the Responder PM Mode subfield to 1 (see 10.47.7 (TWT Sleep Setup)).

26.8.2 Individual TWT agreements

An HE STA may negotiate individual TWT agreements with another HE STA as defined in 10.47.1 (TWT overview), except that the STA:

— May set the Responder PM Mode subfield to 1 if it is a TWT responding STA that intends to go to doze state outside of TWT SPs.

- If the TWT responding STA is an AP then it may set the Responder PM Mode subfield to 1 only if all non-AP STAs that are associated to it indicate support of TWT and the AP has set the TWT Required subfield to 1 in the HE Operation element it transmits; otherwise it shall set the Responder PM Mode subfield to 0.
- An AP that sets the Responder PM Mode subfield to 1 follows the rules defined in 10.47.7 (TWT Sleep Setup).

— Shall set the Implicit subfield to 1 and the NDP Paging Indicator subfield to 0 in all TWT elements that it transmits during the TWT setup.

— May set the Trigger subfield to 1 in the TWT element it transmits during the TWT setup to negotiate a trigger-enabled TWT.

- A successful TWT agreement whose Trigger subfield in the TWT response sent by the AP is 1 is a trigger-enabled TWT; otherwise it is not a trigger-enabled TWT.

— Shall set the TWT Channel subfield in the TWT element it transmits to 0 unless the HE STA sets up a subchannel selective transmission operation as defined in 26.8.7 (HE subchannel selective transmission).

— May set the TWT Protection field to 1 to indicate that TXOPs within the TWT SPs shall be initiated with a NAV protection mechanism, such as (MU) RTS/CTS, or CTS-to-self frame; otherwise it shall set it to 0.

— An HE STA shall not use the RAW mechanism for protection of TWT SPs.

An HE STA that successfully sets up a TWT agreement with another HE STA shall follow the rules defined in 10.47.1 (TWT overview) and 10.47.4 (Implicit TWT operation), except that all the additional rules defined in 26.8 (TWT operation) supersede all the respective rules defined in 10.47.1 (TWT overview) and 10.47.4 (Implicit TWT operation). A TWT or TWT SP that is set up under an implicit TWT agreement is an implicit TWT or implicit TWT SP, respectively (see 10.47.1 (TWT overview)). A TWT or TWT SP that is set up under a trigger-enabled TWT agreement is a trigger-enabled TWT or trigger-enabled TWT SP, respectively.

An example of individual TWT operation is shown in Figure 26-8a (Example of individual TWT operation), where the AP is the TWT responding STA and STA 1 and STA 2 are the TWT requesting STAs.

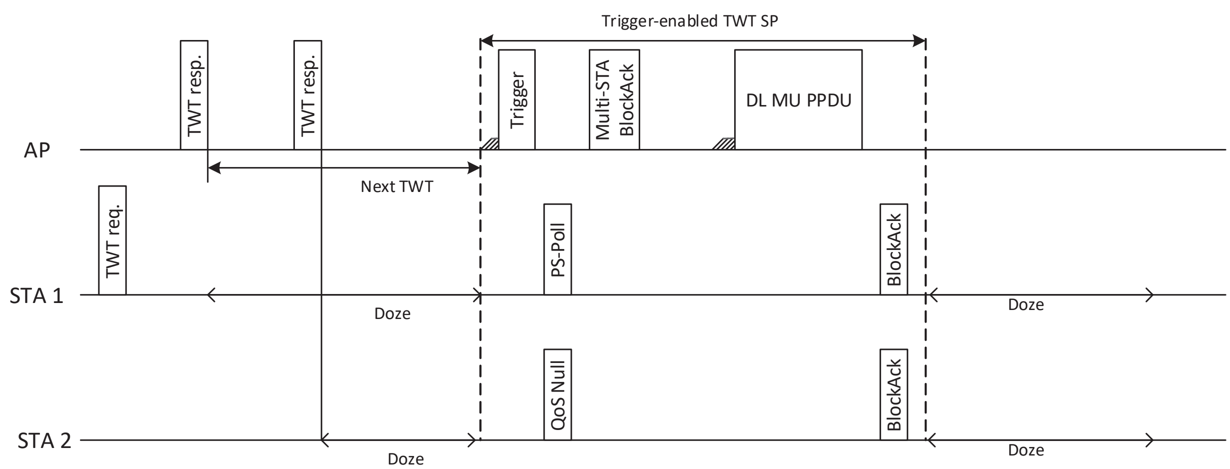

Figure 26-9—Example of individual TWT operation

In this example, STA 1 sends a TWT request to the TWT responding STA to setup a trigger-enabled TWT agreement. The TWT responding STA accepts the TWT agreement with STA 1 and confirms the acceptance in the TWT response sent to STA 1. Subsequently, the TWT responding STA sends an unsolicited TWT response to STA 2 to setup a trigger-enabled TWT agreement with STA 2. Both these TWT agreements are setup as announced TWTs. During the trigger-enabled TWT SP, the TWT responding STA sends a Trigger frame to which the TWT requesting STAs indicate that they are awake during the TWT SP. STA 1 indicates that it is awake by sending a PS-Poll frame and STA 2 indicates that it is awake by sending a QoS Null frame in response to the Trigger frame. STA 1 and STA 2 receive their DL BUs in a subsequent exchange with the TWT responding STA and go to doze state outside of this TWT SP.

An HE STA may execute the individual TWT setup exchanges defined in Table 26-5 (TWT setup exchange for unsolicited TWT and recommended broadcast TWT switch) in addition to the exchanges defined in 10.47 (Target wake time (TWT)). An HE STA that intends to set up an individual TWT shall set the Negotiation Type subfield to 0 as defined in 10.47 (Target wake time (TWT)) or as defined in Table 26-5 (TWT setup exchange for unsolicited TWT and recommended broadcast TWT switch). The HE STA may respond to the TWT request with a TWT response that has the Negotiation Type subfield equal to 3 as indicated in Table 26-5 (TWT setup exchange for unsolicited TWT and recommended broadcast TWT switch) to provide recommended broadcast TWT schedules for the requesting STA.

Table 26-5—TWT setup exchange for unsolicited TWT and recommended broadcast TWT switch

TWT Setup Command field in an initiating frame	TWT Setup Command field in a response frame	TWT condition after the completion of the exchange
Request TWT or Suggest TWT or Demand TWT with Broadcast subfield = 0	Accept TWT with Broadcast subfield = 1	This response is not allowed.
Request TWT, Suggest TWT or Demand TWT with Broadcast subfield = 0	Dictate TWT with Broadcast subfield = 1	No individual TWT agreement exists with the associated TWT Flow identifier. One or more broadcast TWT schedule exists that uses the TWT parameters identified in the response frame including a Broadcast TWT IDs. The broadcast TWT schedules are not necessarily newly created. The responding STA will not create any new individual TWT agreement with the requester at this time. The STA transmitting the initiating frame is not a member of the broadcast TWT, however the STA is recommended to join any of the broadcast TWT schedules.
Accept TWT with Broadcast subfield set to 0	No frame transmitted	The STA receiving this frame now has an individual TWT agreement with the transmitter of the frame where the parameters of the individual TWT agreement are identified by the initiating frame.
Alternate TWT or Dictate TWT with Broadcast subfield = 0	No frame transmitted	The STA receiving this frame is not, through the receipt of this frame, a member of the TWT identified by the initiating frame but can use the information provided to create a request to set up a TWT in a subsequent initiating frame that it transmits.
NOTE 1—The Negotiation Type subfield in the TWT element contained in these frames is 0 if the Broadcast subfield is 0 and is 3 if the Broadcast subfield is 1. NOTE 2—The initiating frame and response frame settings not listed in the tables in 10.47 (Target wake time (TWT)) or 26.8 (TWT operation) are not allowed. The initiating frame is a TWT request if the TWT element carried in the frame has the TWT Request field set to 1; otherwise it is a TWT response (see Table 9-297 (TWT Setup Command field values)). The response frame is a TWT response if the TWT element contained in the frame has the TWT Request field equal to 0.		

An HE STA that successfully sets up an individual TWT agreement and operates in PS mode may listen to Beacon frames, but is exempt from the requirements for receiving Beacon frames as defined in 11.2.3.1 (General). The HE STA follows the rules in 11.2.3 (Power management in a non-DMG infrastructure network) to receive group-addressed frames.

NOTE 1—An HE AP sets the bit in the TIM element of the Beacon frame that corresponds to the AID of the TWT requesting STA to 1 to indicate the presence of available buffered BUs for the STA (see 11.2.3.7 (Receive operation for STAs in PS mode)).

NOTE 2—The TWT responding STA might inform the TWT requesting STA, if it supports TIM Broadcast, of any critical update (as defined in 11.2.3.15 (TIM Broadcast)) by sending a Management frame to the TWT requesting STA when the STA is in the awake state.

An HE STA may tear down an individual TWT agreement by sending a TWT Teardown frame with the Negotiation Type subfield set to 0. An HE STA may tear down all individual TWT agreements by sending a TWT Teardown frame with the Teardown All TWT field set to 1.

An HE AP may send an unsolicited TWT response with the Trigger subfield equal to 1 to a non-AP HE STA that has set the TWT Requester Support subfield to 1 in the HE Capabilities elements that it transmits to the AP. The TWT response shall have one of these values in the TWT Setup Command field: Accept TWT, Alternate TWT or Dictate TWT. An unsolicited TWT response with TWT Setup Command field of Alternate TWT or Dictate TWT contains an advisory notification to the recipient of TWT parameters that are likely to be accepted by the AP if the recipient transmits a subsequent TWT request to the AP that includes those TWT parameters. An unsolicited TWT response with the TWT Setup Command field of Accept TWT creates a TWT agreement between the two STAs. A STA that received an unsolicited TWT response with the TWT Setup Command field of Accept TWT may transmit a TWT Teardown frame to delete the unsolicited individual TWT agreement.

NOTE—The HE AP might send an unsolicited TWT response to a non-AP HE STA with a TWT Flow Identifier that corresponds to an existing TWT agreement. The unsolicited TWT response with TWT Setup Command field of Accept TWT will indicate new TWT parameters that are different from the previously negotiated TWT parameters for that TWT agreement.

An HE STA shall not transmit BAT, TACK, or STACK frames, which are allowed in 10.47.2 (TWT acknowledgment procedure)).

A TWT requesting STA should not transmit frames to the TWT responding STA outside of negotiated TWT SPs and should not transmit frames that are not contained within HE TB PPDUs to the TWT responding STA within trigger-enabled TWT SPs.

NOTE—The TWT requesting STA decides which frames to transmit within or outside a TWT SP and while it is recommended that the TWT requesting STA not transmit using EDCA within or outside TWT SPs the TWT requesting STA might still do so. If the STA decides to transmit then the STA might contend for access to the medium as defined in 10.23.2 (HCF contention based channel access (EDCA)) and in 26.2.7 (EDCA operation using MU EDCA parameters).

The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission a Trigger frame for the TWT requesting STA, as described in 26.5.2 (UL MU operation), within each TWT SP for that TWT agreement. The TWT responding STA should solicit buffer status reports from the TWT requesting STA at the start of the TWT SP following the procedure described in 26.5.3 (MU cascading sequence) or as described in 26.5.7 (NDP feedback report procedure). The TWT responding STA that intends to schedule for transmission additional Trigger frames during a trigger-enabled TWT SP shall set the More TF subfield in the Common Info field of the Trigger frame to 1 to indicate that it will schedule for transmission another Trigger frame within the same TWT SP. The TWT responding STA shall set the More TF subfield to 0 when the Trigger frame is the last scheduled Trigger frame of the TWT SP or when the Trigger frame is scheduled for transmission outside of a TWT SP.

NOTE 1—The TWT responding STA can cancel the transmission of a scheduled Trigger frame if the STA gains access to the wireless medium outside of the TWT SP. The TWT responding STA does not schedule for transmission a Trigger frame for the TWT requesting STA when the TWT agreement is not a trigger-enabled TWT agreement or when the TWT requesting STA has sent an OM Control subfield that has the UL MU Disable subfield equal to 1 (see 26.9 (Operating mode indication).

NOTE 2—The Trigger frame can be replaced by a frame carrying a TRS Control subfield provided that the frame is carried in a DL MU PPDU and the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU. In this case, the AP is recommended to allocate enough resources in subsequent Trigger frames sent during the TWT SP so that the STA can send as much as possible of the data reported in the BSR.

A TWT requesting STA transmits an HE TB PPDU as a response to a Trigger frame that identifies it and is sent during a trigger-enabled TWT SP (see 26.5.2 (UL MU operation)). A TWT requesting STA that is in PS mode and is awake shall include a PS-Poll frame or a U-APSD trigger frame in the HE TB PPDU if the TWT is an announced TWT unless the STA has already transmitted a PS-Poll or U-APSD trigger frame or transmitted any other indication that the STA is in the awake state within that TWT SP or has, previous to the start of the TWT SP but after the end of the most recent TWT SP, indicated to the AP that it is currently in the awake state. The STA may include other frames in the HE TB PPDU when other rules do not prohibit their inclusion, see 26.5.2 (UL MU operation).

NOTE 1–A Trigger frame identifies a TWT requesting STA if it is sent by the AP with which the STA is associated and the frame contains the 12 LSBs of the STA's AID in any of its User Info fields. The Trigger frame can have multiple recipients, each of which is identified by the presence of the 12 LSBs of the recipient's AID in any of its User Info fields (see 26.5.2 (UL MU operation)), and can have in the TA field the MAC address of the AP or the transmitted BSSID under the conditions defined in 26.5.2.2.4 (Allowed settings of the Trigger frame fields and TRS Control subfield).

NOTE 2—Other indications that the STA is in the awake state are the transmission of an HE TB feedback NDP in response to an NFRP Trigger frame (see 26.5.7 (NDP feedback report procedure)) or the transmission of a frame that indicates that the STA is in active mode (see 11.2.3.2 (STA power management modes)).

A TWT responding STA that receives a PS-Poll frame or a U-APSD trigger frame or any other indication from a TWT requesting STA that is in PS mode during or before an announced TWT SP but after the end of the most recent TWT SP, that the TWT requesting STA is in the awake state during the TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) except that the TWT responding STA should deliver to the TWT requesting STA as many buffered BUs as are available at the TWT responding STA, provided that the BU delivery does not exceed the duration of the TWT SP, the TWT requesting STA has indicated that it is in the awake state for that TWT SP and as long as the TWT requesting STA has not entered the doze state (see 26.8.4.2 (TWT Information frame exchange for individual TWT) and 26.8.5 (Power save operation during TWT SPs)).

NOTE—The indication that the TWT requesting STA is in the awake state for that TWT SP might be a PS-Poll, U-APSD trigger frame, or any frame for which an immediate response is solicited and that follows the rules in 11.2.3.2 (Non-AP STA power management modes) but the corresponding immediate response frame is not received by the TWT requesting STA. Other indications that the STA is in the awake state are the transmission of an HE TB feedback NDP in response to an NFRP Trigger frame (see 26.5.7 (NDP feedback report procedure)) or the transmission of a frame that indicates that the STA is in active mode (see 11.2.3.2 (Non-AP STA power management modes)).

A TWT responding STA that sends frames to a TWT requesting STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) except that the TWT responding STA should deliver to the TWT requesting STA as many buffered BUs as are available at the TWT responding STA, provided that the BU delivery does not exceed the duration of the TWT SP and as long as the TWT requesting STA has not entered the doze state (see 26.8.4.2 (TWT Information frame exchange for individual TWT) and 26.8.5 (Power save operation during TWT SPs)).

NOTE—The TWT responding STA can deliver the buffered BUs in A-MPDUs sent under a block ack agreement if the TWT is an announced TWT and the TWT requesting STA is awake for that TWT SP, or if the TWT is an unannounced TWT (at the start of which the TWT requesting STA is assumed to already be awake). The buffered BUs can be delivered in multiple PPDUs transmitted within the TWT SP. The TWT responding STA can transmit frames to TWT requesting STA after the end of the TWT SP if the STA is in Active mode.

A TWT responding STA may transmit to a TWT requesting STA that is in Active mode at any time (see 11.2.3.2 (STA power management modes)). A TWT responding STA may transmit to a TWT requesting STA that is in PS mode and awake outside of a TWT SP following the rules in 11.2.3.6 (AP operation).

26.8.3 Broadcast TWT operation

26.8.3.1 General

A TWT scheduling AP is an HE AP with dot11TWTOptionActivated equal to true that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and that follows the rules in 26.8.3.2 (Rules for TWT scheduling AP), 26.14.2 (Power save with UORA and TWT), and those for periodic opportunistic power save defined in 26.14.3 (Opportunistic power save).

A TWT scheduling AP includes a broadcast TWT element in the Beacon frame as described in 26.8.3.2 (Rules for TWT scheduling AP). An AP corresponding to a nontransmitted BSSID in a multiple BSSID set shall follow the rules in 11.1.3.8.4 (Inheritance of element values).

A TWT scheduling AP may include a TWT element with the Negotiation Type subfield equal to 3 in an (Re)Association Response frame or in a TWT setup frame to assign the recipient STA to a broadcast TWT schedule without having received a request from the STA to become a member of the broadcast TWT schedule if that STA has set the Broadcast TWT Support field of HE Capabilities element it transmits to 1.

A non-AP HE STA shall obtain TWT parameter values from the most recently received TWT element carried in a Beacon, Probe Response, or (Re)Association Response frame from its associated AP unless the non-AP HE STA is associated with a nontransmitted BSSID of a multiple BSSID set, in which case it shall follow the rules in 11.1.3.8.4 (Inheritance of element values) to determine the TWT parameter values.

A TWT scheduled STA is a non-AP HE STA that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling AP.

A TWT scheduled STA follows the schedule provided by the TWT scheduling AP as described in 26.8.3.3 (Rules for TWT scheduled STA), and, in addition, the rules in 26.14.2 (Power save with UORA and TWT) if the STA supports the UORA procedure, and the rules in 26.14.3 (Opportunistic power save) if the STA supports OPS operation. A TWT scheduled STA can negotiate the wake TBTT and wake interval for Beacon frames it intends to receive as described in 26.8.6 (Negotiation of wake TBTT and wake interval) or can join a particular broadcast TWT as described below.

An example of broadcast TWT operation is shown in Figure 26-10 (Example of broadcast TWT operation with optional TBTT negotiation), where the AP is the TWT scheduling AP and STA 1 and STA 2 are the TWT scheduled STAs.

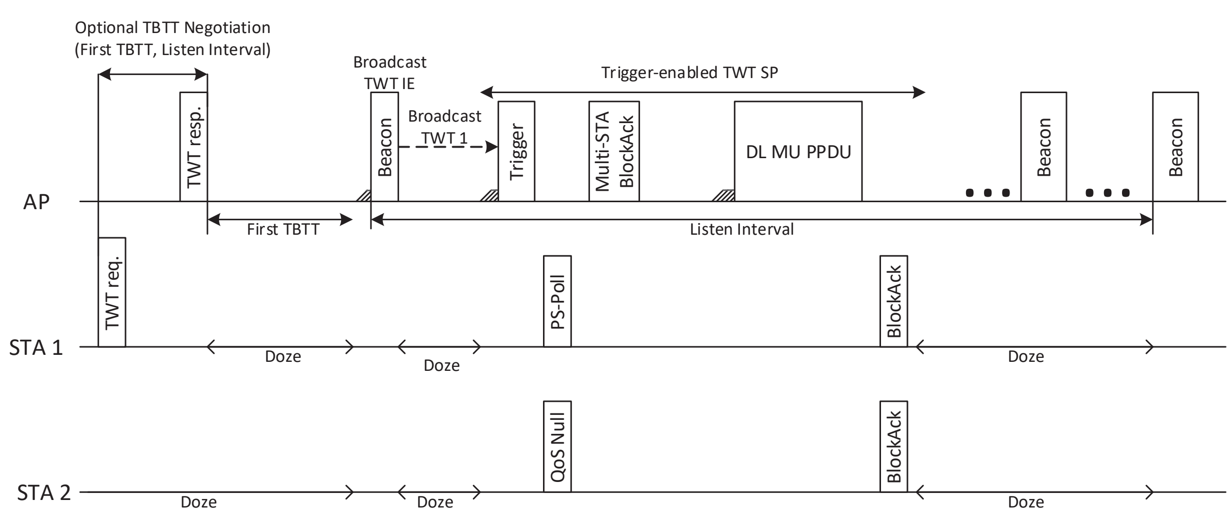

Figure 26-10—Example of broadcast TWT operation with optional TBTT negotiation

The TWT scheduling AP includes a broadcast TWT element in the Beacon frame that indicates a broadcast TWT SP during which the AP intends to send Trigger frames, or DL BUs to the TWT scheduled STAs. STA 1 and STA 2 wake to receive the Beacon frame to determine the broadcast TWT. During the trigger-enabled TWT SP the AP sends a Trigger frame to which STA 1 and STA 2 indicate that they are awake during the TWT SP. STA 1 indicates that it is awake by sending a PS-Poll and STA 2 indicates that it is awake by sending a QoS Null frame in response to the Trigger frame. STA 1 and STA 2 receive their DL BUs in a subsequent exchange with the AP and go to doze state outside of this TWT SP.

Each broadcast TWT is uniquely identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield and is greater than 0 and the MAC address is the address of the TWT scheduling AP.

Broadcast TWT schedules are advertised by the TWT scheduling AP in frames that carry TWT elements with the Negotiation Type subfield set to 2 as described in 26.8.3.2 (Rules for TWT scheduling AP). Broadcast TWT schedules that are intended for member TWT scheduled STAs are identified by a Broadcast TWT ID subfield that is greater than 0 and broadcast TWT schedules that are intended for all TWT scheduled STAs are identified by a Broadcast TWT ID subfield equal to 0.

Negotiations to become a member of or terminate membership in a broadcast TWT, identified by a Broadcast TWT ID subfield greater than 0, are performed with an exchange of frames that carry TWT elements with the Negotiation Type subfield set to 3 as described in 26.8.3.3 (Rules for TWT scheduled STA).

The TWT scheduling AP may send an unsolicited TWT response with the Trigger subfield set to 1 to a non-AP HE STA that has set the Broadcast TWT Support subfield to 1 in the HE Capabilities elements that it transmits to the AP. The TWT response shall indicate one of the following values in the TWT Setup Command field: Accept TWT, Alternate TWT, or Dictate TWT. An unsolicited TWT response with TWT Setup Command field indicating Alternate TWT or Dictate TWT contains an advisory notification to the recipient of TWT parameters that are likely to be accepted by the AP if the recipient transmits a subsequent TWT request to the AP that includes those TWT parameters. An unsolicited TWT response with a TWT Setup Command field that indicates Accept TWT allocates a broadcast TWT schedule to the receiving STA. A STA that receives an unsolicited TWT response with a TWT Setup Command field that indicates Accept TWT may transmit a TWT Teardown frame or a TWT response with TWT Setup Command field indicating Reject TWT to withdraw from the unsolicited broadcast TWT schedule.

26.8.3.2 Rules for TWT scheduling AP

A TWT scheduling AP may include a broadcast TWT element in a Beacon frame that is scheduled at a TBTT (see 11.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling AP shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. The TWT scheduling AP shall set the Last Broadcast Parameter Set subfield to 0 in each TWT parameter set except for that the last (or only) TWT parameter set of the TWT element that shall have the Last Broadcast Parameter Set subfield set to 1. The TWT scheduling AP shall set the NDP Paging Indicator subfield to 0 and the Negotiation Type subfield to 2, and may set the Responder PM Mode subfield to 0 in the TWT element (see 10.47.7 (TWT Sleep Setup)). Each TWT parameter set specifies the TWT parameters of a specific broadcast TWT that are valid within a broadcast TWT SP. Each specific broadcast TWT is identified as indicated in 26.8.3.1 (General). Individual STAs may have membership in broadcast TWTs as the result of negotiation with a TWT scheduling AP as described in 26.8.3.1 (General).

The TWT scheduling AP sets the TWT parameters of each TWT parameter set as described below.

The TWT scheduling AP shall set the TWT Request subfield to 0 and the TWT Setup Command subfield as defined in Table 26-6 (Broadcast TWT announcements) and shall include the broadcast TWT element in the Beacon frames for as long as there is at least one active broadcast TWT schedule. Broadcast TWT announcements are broadcast TWT schedules advertised in broadcast TWT elements contained in broadcast Management frames (see Table 26-6 (Broadcast TWT announcements)).

The TWT scheduling AP shall set the Broadcast TWT Persistence subfield for each broadcast TWT to the number of TBTTs for which the Broadcast TWT schedule will be in existence, counting forward from the current TBTT. The AP may change the value of the Broadcast TWT Persistence subfield for any Broadcast TWT within any transmitted TWT element. If the AP reduces the value of the subfield, it shall not reduce the value by more than one as compared to the value transmitted during the immediately preceding beacon interval. If the AP increases the value of the Broadcast TWT Persistence subfield, it may increase the value by any amount as compared to the value transmitted during the immediately preceding TBTT.

A TWT scheduling AP that sets the TWT Setup Command subfield to Reject TWT shall indicate the TBTT at which the periodic broadcast TWT will be terminated by setting the value of the Broadcast TWT Persistence subfield to indicate the number of TBTTs that remain until the broadcast TWT schedule is terminated. The broadcast TWT schedule terminates at the next TBTT that follows the TBTT at which the TWT scheduling AP transmits the broadcast TWT element with Broadcast TWT Persistence subfield for that broadcast TWT schedule equal to 0.A TWT scheduling AP may terminate the membership of a TWT scheduled STA in all broadcast TWTs by transmitting a TWT Teardown frame with the Teardown All TWT field set to 1.

A TWT scheduling AP that sets the TWT Setup Command subfield to Alternate TWT shall indicate the TBTT at which the periodic broadcast TWT parameter set will be modified by setting the Broadcast TWT Persistence subfield to indicate the number of TBTTs that remain until the broadcast TWT schedule is modified. The broadcast TWT schedule will be modified at the next TBTT, which follows the TBTT at which the TWT scheduling AP transmits the broadcast TWT element with Broadcast TWT Persistence subfield for that broadcast TWT schedule equal to 0. The AP shall include in the broadcast TWT element the future broadcast TWT parameter set that will take effect at that TBTT. The future broadcast TWT parameter set shall have the same values in the TWT Setup Command and Broadcast TWT ID subfields as the current broadcast TWT parameter set that is being modified and switch the TWT Setup Command subfield from Alternate TWT to Accept TWT at that TBTT. The future broadcast TWT parameter set shall be in a Broadcast TWT Parameter Set field that is located after the Broadcast TWT Parameter Set field that contains the current broadcast TWT parameter set.

NOTE—TWT scheduled STAs follow the broadcast TWT parameters that are included in the current broadcast TWT parameter set and only switch to following the broadcast TWT parameters in the future broadcast TWT parameter set if the TWT Setup Command field is equal to Accept TWT in the Broadcast TWT Parameter Set field that contains the future broadcast TWT parameter set.

A TWT scheduling AP should indicate Alternate TWT or Reject TWT in the TWT Setup Command field of the broadcast TWT element for as many TBTTs as needed to exceed the longest interval any STA is expected to not receive Beacon frames either when the TWT parameters of a periodic TWT will change, or when the periodic TWT specified by that TWT parameter set will be terminated.

The TWT scheduling AP shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0 (i.e., the TWT is not a trigger-enabled TWT). The AP is not expected to schedule for transmission Trigger frames during a non-trigger-enabled TWT SP and is expected to schedule Trigger frames during a trigger-enabled TWT SP as described below.

The TWT scheduling AP shall schedule for transmission of a Trigger frame addressed to one or more TWT scheduled STAs during a trigger-enabled TWT SP. A TWT scheduling AP should not include the 12 LSBs of the STA's AID in a User Info field of a Trigger frame transmitted within a broadcast TWT SP unless the STA is in the awake state, has established membership in the broadcast TWT with that Broadcast TWT ID, or has indicated to receive the Beacon frame preceding the beacon interval that contains this TWT SP (see 26.8.6 (Negotiation of wake TBTT and wake interval)).

The TWT scheduling AP that schedules for transmission additional Trigger frames during a trigger-enabled TWT SP shall set the More TF subfield in the Common Info field of the Trigger frame to 1 to indicate that it will schedule for transmission another Trigger frame within the same TWT SP. The TWT scheduling AP shall set the More TF subfield to 0 if the Trigger frame is the last scheduled Trigger frame of the TWT SP or if the Trigger frame is scheduled for transmission outside of a trigger-enabled TWT SP. The TWT scheduling AP should poll as many STAs as possible among TWT scheduled STAs that are members of that nonzero Broadcast TWT ID so that the STAs can perform a frame exchange with the TWT scheduling AP during that TWT SP.

NOTE 1—The TWT scheduling AP does not intend to schedule for transmission of a Trigger frame for the TWT scheduled STA when the broadcast TWT is not a trigger-enabled TWT or when the TWT scheduled STA has sent an OM Control subfield that has the UL MU disable bit equal to 1 (see 26.9 (Operating mode indication)).

NOTE 2—The TWT scheduling AP can cancel the transmission of a scheduled Trigger frame if the AP gains access to the wireless medium outside of the TWT SP.

NOTE 3—The Trigger frame can be replaced by a frame carrying a TRS Control subfield provided that the frame is carried in a DL MU PPDU and the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU. In this case it is recommended to allocate enough resources in subsequent Trigger frames sent during the TWT SP so that the STA can send as much as possible of the data reported in the BSR.

The TWT scheduling AP shall set the Flow Type field to 1 to indicate an unannounced TWT. Otherwise, it shall set the Flow Type field to 0 to indicate an announced TWT.

The TWT scheduling AP should schedule delivery of individually addressed DL BUs during unannounced TWT SPs with nonzero Broadcast TWT ID subfield.

The TWT scheduling AP shall set the Broadcast TWT Recommendation subfield according to Table 9-297a (Broadcast TWT Recommendation field for a broadcast TWT element). The TWT scheduling AP shall set the Trigger field to 1 if the Broadcast TWT Recommendation subfield is 1 or 2, and may set the Trigger field to any value if the Broadcast TWT Recommendation subfield is 0 or 3.

A TWT scheduling AP that has advertised a broadcast TWT with a Broadcast TWT ID equal to 0 shall schedule the following:

- The delivery of group addressed DL BUs during the broadcast TWT SPs located within the beacon interval that follows the DTIM Beacon frame if the TWT parameter set indicated non-trigger enabled unannounced TWT SP and had the Broadcast TWT Recommendation subfield equal to 0.
- The transmission of a Trigger frame that does not contain an RA-RU during the broadcast TWT SPs if the TWT parameter set indicated trigger-enabled announced TWT SP and had the Broadcast TWT Recommendation subfield equal to 1. The Trigger frame shall contain at least one User Info field addressed to a TWT scheduled STA whose TIM bit in the Beacon frame is 1 and that is not a member of any nonzero broadcast TWT during this beacon interval.
- The transmission of a Trigger frame that contains at least one RA-RU (see 26.5.4 (UL OFDMA-based random access (UORA))) during the broadcast TWT SPs if the TWT parameter set indicated a trigger enabled announced TWT SP and had the Broadcast TWT Recommendation subfield set to 2 (see 26.14.2 (Power save with UORA and TWT).
- The transmission of a TIM frame or FILS Discovery frame at the start of a broadcast TWT SP if the TWT parameter set indicated a non-trigger enabled unannounced TWT SP and had the Broadcast TWT Recommendation subfield set to 3 (see 26.14.3.2 (AP operation for opportunistic power save)).

A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the Broadcast TWT Recommendation subfield equal to 0 or 3 may contain zero or more RA-RUs (see 26.5.4 (UL OFDMA-based random access (UORA))). A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the Broadcast TWT Recommendation subfield equal to 1 shall contain no RA-RU.

The TWT scheduling AP shall set the TWT field to the TSF timer [10: 25] that corresponds to the next TWT that is scheduled for this TWT parameter set when it queues for transmission the frame that contains the TWT element. The TSF timer at which the next TWT is scheduled has bits 0 to 9 equal to 0 and bits 26 to 63 equal to the same value as the respective bits in the current TSF timer.

The TWT scheduling AP shall include a nonzero value for the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT and a zero value for an aperiodic TWT.

The TWT parameters are valid for each successive TWT of a periodic TWT and for the only TWT of an aperiodic TWT.

The TWT scheduling AP shall include a unique value in the Broadcast TWT ID subfield for each Broadcast TWT to allow identification of each Broadcast TWT unless the TWT Setup Command field is Alternate TWT or the Broadcast TWT ID subfield is zero.

NOTE—The broadcast TWT element contains two Broadcast TWT Parameter Set fields with the same Broadcast TWT ID subfield value if the TWT Setup Command field indicates Alternate TWT in one of the Broadcast TWT Parameter Set fields. The broadcast TWT element might contain multiple Broadcast TWT Parameter Set fields with the Broadcast TWT ID subfield equal to 0.

A TWT scheduling AP that receives a PS-Poll or a U-APSD trigger frame or any other indication from a TWT scheduled STA that is in PS mode during or before an announced TWT SP but after the end of the most recent TWT SP, that the TWT scheduled STA is in the awake state during the TWT SP shall follow the rules defined in 11.2.3.6 (AP operation) except that the AP should deliver to the TWT scheduled STA as many buffered BUs as are available at the AP, provided that the BU delivery does not exceed the duration of the TWT SP, the TWT scheduled STA has indicated that it is in the awake state for that TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 26.8.4.3 (TWT Information frame exchange for broadcast TWT) and 26.8.5 (Power save operation during TWT SPs)).

NOTE—The indication that the TWT scheduled STA is in the awake state for that TWT SP might be a PS-Poll, U-APSD trigger frame, or any frame for which an immediate response is solicited and that follows the rules in 11.2.3.2 (Non-AP STA power management modes) but the corresponding immediate response frame is not received by the TWT scheduled STA. Other indications that the STA is in the awake state are the transmission of an HE TB feedback NDP in response to an NFRP Trigger frame (see 26.5.7 (NDP feedback report procedure)) or the transmission of a frame that indicates that the STA is in active mode (see 11.2.3.2 (Non-AP STA power management modes)).

A TWT scheduling AP that sends frames to a TWT scheduled STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation) except that the AP should deliver to the TWT scheduled STA as many buffered BUs as available at the AP, provided that the BU delivery does not exceed the duration of the TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 26.8.4.3 (TWT Information frame exchange for broadcast TWT) and 26.8.5 (Power save operation during TWT SPs).

NOTE—The TWT scheduling AP can deliver the buffered BUs in A-MPDUs sent under a BlockAck agreement if the TWT is an announced TWT and the TWT scheduled STA is awake for that TWT SP, or if the TWT is an unannounced TWT (at the start of which the TWT scheduled STA is assumed to already be awake). The buffered BUs can be delivered in multiple PPDUs transmitted within the TWT SP. The TWT scheduling AP can exceed the duration of the TWT SP if the TWT scheduled STA is in Active mode.

A TWT scheduling AP may transmit to a TWT scheduled STA that is in Active mode at any time (see 11.2.3.2 (Non-AP STA power management modes)). A TWT scheduling AP may transmit to a TWT scheduled STA that is in PS mode and awake outside of a TWT SP following the rules in 11.2.3.6 (AP operation).

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Negotiation Type subfield equal to 3 and the TWT Setup Command field set to Suggest or Demand may respond with a frame containing a TWT element as shown in Table 26-7 (Broadcast TWT membership exchanges).

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Negotiation Type subfield equal to 3 and the TWT Setup Command field set to Reject shall delete the membership of the STA corresponding to the TA of the MMPDU that contained the TWT element from the broadcast TWT schedule that has the Broadcast TWT ID value that is equal to the value of the Broadcast TWT ID field of the TWT element.

A TWT scheduling AP may transmit a broadcast TWT announcement at any time. Valid broadcast TWT announcements are described in Table 26-6 (Broadcast TWT announcements).

Table 26-6—Broadcast TWT announcements

TWT Setup Command field in an initiating frame	TWT Setup Command field in a response frame	Condition after the completion of the exchange
Accept TWT	No frame transmitted	Only an HE AP is permitted to transmit this sequence. TWT scheduled STAs that receive this frame use the provided TWT parameters to determine the broadcast TWT schedule. The broadcast TWT schedule is identified by the broadcast TWT ID and the TA of the initiating frame.
Alternate TWT	No frame transmitted	When transmitted by a TWT scheduling AP, some of the parameters of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame will change at the TBTT that occurs after the Broadcast TWT Persistence field of that broadcast TWT parameter set reaches 0. The new parameters will be present in the first Beacon frame transmitted by the TWT scheduling AP at the TBTT, which has a broadcast TWT parameter set with the same broadcast TWT ID and same TA, but with the TWT command value set to Accept TWT.
Reject TWT	No frame transmitted	When transmitted by a TWT scheduling AP, the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame will be terminated at the TBTT that occurs after the Broadcast TWT Persistence field of that broadcast TWT parameter reaches 0. The termination occurs at the TBTT at which a Beacon frame is transmitted by the TWT scheduling AP that does not include a broadcast TWT parameter set with the same broadcast TWT ID and same TA as the initiating frame.
NOTE 1—The Negotiation Type subfield of the TWT element contained in these frames is 2. NOTE 2—The initiating frame and response frame settings not listed in the tables in 10.47 (Target wake time (TWT)) or 26.8 (TWT operation) are not allowed. The initiating frame is a TWT response. NOTE 3—MMPDUs that contain a broadcast TWT element generated by a TWT scheduling AP can be broadcast Probe Response, FILS Discovery, and Beacon frames. The TWT element has the TWT Request field equal to 0 and the Negotiation Type subfield equal to 2. The TWT scheduling AP can include a TWT parameter set with Broadcast TWT ID value 0 to indicate a TWT allocated for all STAs, and Broadcast TWT ID greater than 0 to indicate a TWT intended to TWT scheduled STAs that are members of that broadcast TWT.		

26.8.3.3 Rules for TWT scheduled STA

A TWT scheduled STA that receives a broadcast TWT element in a Beacon frame shall follow the rules defined in this subclause to interact with the TWT scheduling AP.

A TWT scheduled STA should not transmit frames to the TWT scheduling AP outside of broadcast TWT SPs and should not transmit frames that are not contained within HE TB PPDUs to the TWT scheduling AP within trigger-enabled broadcast TWT SPs, except that the STA can transmit frames within negotiated individual TWT SPs as defined in 26.8.2 (Individual TWT agreements).

NOTE—The TWT scheduled STA decides which frames to transmit within or outside a TWT SP and while it is recommended that the TWT scheduled STA not transmit using EDCA within or outside TWT SPs, the TWT scheduled STA might still do so. If the STA decides to transmit then the STA might contend for accessing the medium as defined in 10.23.2 (HCF contention based channel access (EDCA)) and in 26.2.7 (EDCA operation using MU EDCA parameters).

A TWT scheduled STA may request to become a member of a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Negotiation Type subfield set to 3 and the TWT Setup Command field set to Request TWT or Suggest TWT or Demand TWT. The TWT Parameter set indicates the Broadcast TWT ID of the broadcast TWT that the STA is requesting to join. See Table 26-7 (Broadcast TWT membership exchanges).

A TWT scheduled STA may terminate membership in a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Negotiation Type subfield set to 3 and the TWT Setup Command field set to Reject TWT or by transmitting a TWT Teardown frame that has the Negotiation Type subfield set to 3. A TWT scheduled STA may terminate membership in all broadcast TWTs by transmitting a TWT Teardown frame with the Teardown All TWT field set to 1.

A TWT scheduled STA that receives a TWT element with the TWT Request field equal to 0, the Negotiation Type subfield equal to 3 and the TWT Setup Command field indicating Accept TWT is a member of the broadcast TWT identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield in the TWT element and the MAC address that is the TA of the MMPDU that contained the TWT element is equal to the MAC address of the AP with which the STA is associated, regardless of whether the TWT scheduled STA had previously transmitted a corresponding TWT element to the AP with the TWT Setup Command field indicating Request TWT, Suggest TWT or Demand TWT.

Valid broadcast TWT membership exchanges are described in Table 26-7 (Broadcast TWT membership exchanges).

Table 26-7—Broadcast TWT membership exchanges

TWT Setup Command field in an initiating frame	TWT Setup Command field in a response frame	Condition after the completion of the exchange
Demand TWT	Accept TWT	A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the initiating frame and repeated in the responding frame. The TWT scheduled STA transmitting the initiating frame is a member of the Broadcast TWT schedule identified by the Broadcast TWT ID and the TA of the response frame.
Request TWT or Suggest TWT	Accept TWT	A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the response frame. The TWT scheduled STA transmitting the initiating frame is a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame.

Table 26-7—Broadcast TWT membership exchanges

Suggest TWT or Demand TWT	Alternate TWT	No new broadcast TWT schedule has been created with the TWT parameters indicated in the initiating frame. The TWT scheduling AP is offering an alternative set of parameters vs. those indicated in the initiating frame, as a means of negotiating TWT parameters with the TWT scheduled STA. The TWT scheduled STA can send a new request with any set of TWT parameters and the TWT scheduling AP might create a new broadcast TWT schedule using the parameters indicated in the responding frame.
Suggest TWT or Demand TWT	Dictate TWT	A broadcast TWT schedule is either created or already exists and is using the TWT parameters identified in the response frame, including a broadcast TWT ID. The TWT scheduling AP will not create any new broadcast TWT schedule with the TWT scheduled STA at this time. The TWT scheduled STA transmitting the initiating frame is not a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame. The TWT scheduled STA can send a new request, but will receive an Accept TWT only if it uses the dictated TWT parameters.
Request TWT or Suggest TWT or Demand TWT	Reject TWT	The TWT scheduled STA transmitting the initiating frame is a not a member of a broadcast TWT identified by the broadcast TWT ID and the TA of the response frame, if such a broadcast TWT exists. The TWT scheduling AP will not accept any new request from the TWT scheduled STA to join or create a broadcast TWT at this time.
Accept TWT	No frame transmitted	Not permitted to be transmitted by a TWT scheduled STA. When transmitted by a TWT scheduling AP, the recipient STA’s membership in the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame is established.
Alternate TWT or Dictate TWT	No frame transmitted	Not permitted to be transmitted by a TWT scheduled STA. When transmitted by a TWT scheduling AP, the TWT scheduled STA receiving this frame is not, through the receipt of this frame, a member of the broadcast TWT identified by the initiating frame. The TWT scheduled STA can use the information provided to create a request to join a TWT in a subsequent initiating frame that it transmits.

Table 26-7—Broadcast TWT membership exchanges

Reject TWT	No frame transmitted	When transmitted by a TWT scheduled STA, the transmitting STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the RA of the initiating frame is terminated. When transmitted by a TWT scheduling AP, the receiving STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame is terminated.

NOTE 1—The Negotiation Type subfield of the TWT element contained in these frames is 3.

NOTE 2—The initiating frame and response frame settings not listed in the tables in 10.47 (Target wake time (TWT)) or 26.8 (TWT operation) are not allowed. The initiating frame is a TWT request if the TWT element contained in the frame has the TWT Request field equal to 1 (see Table 9-297 (TWT Setup Command field values)); otherwise it is a TWT response. The response frame is a TWT response.

NOTE 3—In addition to these exchanges, the TWT scheduling AP might respond to an initiating frame that solicits membership in a broadcast TWT schedule with an indication or solicitation of the establishment of an individual TWT agreement.

NOTE 4—MMPDUs that contain a broadcast TWT element generated by a TWT scheduled STA can be (Re)Association Request, and TWT Setup frames with TWT Request field equal to 1. The TWT element has the Negotiation Type subfield equal to 3 and the Broadcast TWT ID(s) that the STA intends to join or withdraw. MMPDUs that contain a broadcast TWT element generated by a TWT scheduled AP can be (Re)Association Response, and TWT Setup frames with TWT Request field equal to 0. The TWT element has the Negotiation Type subfield equal to 3 and the Broadcast TWT ID(s) to which the STA is assigned or from which the STA is withdrawn.

A TWT scheduled STA that is in PS mode may enter the doze state after receiving a Beacon frame with a TWT element indicating the existence of a broadcast TWT and shall be in the awake state at the broadcast TWT start times for which the STA has indicated it will be awake by any of the following means:

- Establishing a membership for the unannounced broadcast TWT with those broadcast TWT IDs
- Negotiating a wake TBTT and wake interval between Beacon frames that the STA receives, as defined in 26.8.6 (Negotiation of wake TBTT and wake interval)
- Having sent a PS-Poll or U-APSD trigger frame during the beacon interval
- Having sent another indication that it is in the awake state during that beacon interval

NOTE 1—Other indications that the STA is in the awake state are the transmission of an HE TB feedback NDP in response to an NFRP Trigger frame (see 26.5.7 (NDP feedback report procedure)) or the transmission of a frame that indicates that the STA is in active mode (see 11.2.3.2 (Non-AP STA power management modes)).

NOTE 2—The STA might indicate that it will not be awake at certain broadcast TWT start times by sending a TWT Information frame. The AP might indicate to a STA that it need not be awake at certain broadcast TWT start times by sending a TWT information frame (see 26.8.4 (Use of TWT Information frames)).

A TWT scheduled STA is not required to be in the awake state at broadcast TWT SP start times corresponding to the broadcast TWT that has the broadcast TWT ID value of 0.

A TWT scheduled STA that did not receive a Beacon frame at a TBTT shall act as if it had received the expected Beacon frame containing a TWT element for a broadcast TWT, if the missed beacon corresponds to a TBTT that is within the next n TBTTs beyond the most recently received Beacon frame that included a TWT element for that broadcast TWT, where n is equal to one plus the value obtained from the Broadcast TWT Persistence subfield of the corresponding Broadcast TWT, except that n is infinite if the Broadcast TWT Persistence subfield is 255.

A TWT scheduled STA transmits an HE TB PPDU as a response to a Trigger frame that is addressed to it and is sent during a trigger-enabled TWT SP (see 26.5.2 (UL MU operation)). A TWT scheduled STA that is in PS mode and is awake during an announced TWT SP shall include a PS-Poll frame or a U-APSD trigger frame in the HE TB PPDU if it intends to solicit buffered BUs from the TWT scheduling AP (see 11.2.3.7 (Receive operation for STAs in PS mode)) unless the STA has already transmitted within that TWT SP a PS-Poll or U-APSD trigger frame or has transmitted any other indication that the STA is in the awake state within that TWT SP, or has, previous to the start of the TWT SP but after the end of the most recent TWT SP, indicated to the AP that it is currently in the awake state. A TWT scheduled STA that is in PS mode shall transition to the awake state at the start of an unannounced TWT SP of which it is a member. The STA may include other frames in the HE TB PPDU when other rules do not prohibit their inclusion (see 26.5.2 (UL MU operation))

NOTE 1—A TWT scheduling AP sets the bit in the TIM element of the Beacon frame that corresponds to the AID of the TWT scheduled STA to 1 to indicate that it expects the TWT scheduled STA to solicit available buffered BUs (see 11.2.3.7 (Receive operation for STAs in PS mode)).

NOTE 2—Other indications that the STA is in the awake state are the transmission of an HE TB feedback NDP in response to an NFRP Trigger frame (see 26.5.7 (NDP feedback report procedure)) or the transmission of a frame that indicates that the STA is in active mode (see 11.2.3.2 (Non-AP STA power management modes)).

A TWT scheduled STA should not send frames that do not satisfy the Broadcast TWT Recommendation subfield recommendations in Table 9-297a (Broadcast TWT Recommendation field for a broadcast TWT element) during the corresponding TWT SP(s). Frames sent as a response to a Trigger frame are subject to further restrictions as defined in 26.5.2 (UL MU operation).

26.8.4 Use of TWT Information frames

26.8.4.1 General

An HE STA may transmit a TWT Information frame to its peer STA during an individual TWT agreement, broadcast TWT schedule, or at any time as defined in 26.8.4.2 (TWT Information frame exchange for individual TWT), 26.8.4.3 (TWT Information frame exchange for broadcast TWT) and 26.8.4.4 (TWT Information frame exchange for flexible wake time), respectively.

NOTE—An HE AP might include multiple TWT Information frames, each addressed to a different peer STA, in an HE MU PPDU (see 26.5.1 (HE DL MU operation)).

The TWT Information frame shall have the Response Requested subfield equal to 0, the Next TWT Request subfield equal to 0, and one of the following:

- A nonzero value in the Next TWT subfield if the frame is transmitted by a TWT responding STA, a TWT scheduling AP, or by any HE STA to a peer STA that has set the Flexible TWT Schedule Support field to 1 in the HE Capabilities element it transmits.
  - The value of the Next TWT subfield shall be selected from existing TWT values for an individual TWT agreement if the Flexible TWT Schedule Support field in the HE Capabilities element received from the peer STA is 0 and shall be selected from existing TWT values for a broadcast TWT schedule regardless of the value of the Flexible TWT Schedule Support field received from the peer STA.
  - The Next TWT subfield may contain any nonzero value if Flexible TWT Schedule Support field in the HE Capabilities element received from the peer STA is 1.
  - The All TWT field is 1 if the resumption applies to all broadcast TWT schedules followed by the TWT scheduled STA and/or to all individual TWT agreements followed by the TWT responding STA.
- A Next TWT subfield that is present if the frame is transmitted by a TWT requesting STA, a TWT scheduled STA, or if the frame is transmitted by any HE STA to a peer STA that has set the Flexible TWT Schedule Support field to 1 in the HE Capabilities element it transmits.

- The Next TWT subfield indicates the earliest TWT at which the individual TWT agreement or broadcast TWT schedule is resumed and shall be selected from existing TWT values for that TWT agreement or broadcast TWT schedule if the Flexible TWT Schedule Support field in the HE Capabilities element received from the peer STA is 0.
- The All TWT field is 1 if the resumption applies to all broadcast TWT schedules followed by the TWT scheduled STA and/or to all individual TWT agreements followed by the TWT requesting STA.
- The Next TWT subfield may contain any nonzero value if Flexible TWT Schedule Support field in the HE Capabilities element received from the peer STA is 1.

— A Next TWT subfield that is not present if the frame is transmitted by a TWT requesting STA or a TWT scheduled STA to indicate suspension of the individual TWT agreement or broadcast TWT schedule.

- The All TWT subfield is 1 if the suspension applies to all broadcast TWT schedules followed by the TWT scheduled STA and/or to all individual TWT agreements followed by the TWT requesting STA.

NOTE—Information exchanged with TWT Information frames does not modify the TWT parameters of any existing TWT session except if the TWT Information frame is sent under flexible TWT (see 26.8.4.4 (TWT Information frame exchange for flexible wake time)).

The use of TWT Information frames for suspending and/or resuming existing individual TWT agreements is described in 26.8.4.2 (TWT Information frame exchange for individual TWT). The use of TWT Information frames for suspending and/or resuming existing broadcast TWT schedules is described in 26.8.4.3 (TWT Information frame exchange for broadcast TWT). The use of TWT Information frames for providing a flexible TWT that is independent of any existing TWT agreements or TWT schedules is described in 26.8.4.4 (TWT Information frame exchange for flexible wake time).

26.8.4.2 TWT Information frame exchange for individual TWT

An HE STA that has an individual TWT agreement may transmit a TWT Information frame to a peer STA with which it has the agreement if the peer STA has set the TWT Information Frame Disabled field to 0 in the TWT element sent during TWT setup; otherwise the HE STA shall not transmit a TWT Information frame to the peer STA. The HE STA sets the fields of the TWT Information frame as defined in 26.8.4.1 (General).

A TWT requesting STA that receives a TWT Information frame containing a Next TWT subfield follows the rules in 10.47.4 (Implicit TWT operation) and the rules below.

A TWT requesting STA that receives an acknowledgment in response to a TWT Information frame transmitted by the STA:

— That does not contain a Next TWT subfield shall consider the corresponding TWT agreement suspended until the TWT session is resumed.

— That contains a Next TWT subfield shall consider the corresponding TWT agreement suspended and shall resume the TWT agreement starting from the value indicated in the Next TWT subfield of the transmitted TWT Information frame.

— Assumes that any other individual TWT agreements, broadcast TWT schedules (see 26.8.3 (Broadcast TWT operation)), are not affected by the transmission of this frame except when the All TWT subfield of the TWT Information frame is equal to 1. Other default PS procedures are not affected by the transmission of this frame (see 11.2 (Power management)).

NOTE—The TWT Flow Identifier, together with the MAC addresses of the TWT requesting STA and TWT responding STA identifies the TWT agreement for which the TWT Information frame is sent (see 10.47.1 (TWT overview)).

If the TWT Information frame contains an All TWT subfield equal to 1 then the above rules apply to all individual TWT agreements, except that the resumptions of the respective TWTs shall occur at the first TWT of the respective TWT agreement that occurs not earlier than the Next TWT value contained in the TWT Information frame, regardless of the value of the Flexible TWT Schedule Support field in the HE Capabilities element exchanged between the two STAs.

A TWT requesting STA that is in PS mode and that transmits a TWT Information frame to a TWT responding STA shall suspend the corresponding TWT agreement and may transition to doze state after receiving the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger frame and has not yet received the expected frames from the AP in response and shall resume TWT operation for the corresponding TWT agreement at the specified TWT indicated (if any) in the TWT Information frame. A TWT requesting STA that is in PS mode and that receives a TWT Information frame from a TWT responding STA shall suspend the TWT agreement and may go to doze state after transmitting the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger frame and has not yet received the expected frames from the TWT responding STA in response and shall resume TWT operation for the corresponding TWT agreement at the specified TWT indicated (if any) in the TWT Information frame.

26.8.4.3 TWT Information frame exchange for broadcast TWT

An HE STA that is a TWT scheduling AP may transmit a TWT Information frame to any of the members of a broadcast TWT schedule if the member has set the TWT Information Frame Disabled field to 0 in the TWT element sent when joining the broadcast TWT schedule. An HE STA that is a TWT scheduled STA may transmit a TWT Information frame to the TWT scheduling AP corresponding to a broadcast TWT schedule established by that STA if the AP has set the TWT Information Frame Disabled field to 0 in the broadcast TWT element it transmits. The HE STA sets the fields of the TWT Information frame as defined in 26.8.4.1 (General).

A TWT scheduled STA that receives a TWT Information frame that contains an All TWT subfield equal to 1 follows the rules defined in 26.8.3.3 (Rules for TWT scheduled STA), except that the TWT scheduled STA shall consider all the broadcast TWT schedules as suspended and shall resume each broadcast TWT schedule at the first TWT that occurs not earlier than the Next TWT subfield value contained in the received TWT Information frame.

A TWT scheduled STA that receives an acknowledgment in response to a TWT Information frame transmitted by the STA that contains an All TWT subfield equal to 1 and that does not contain a Next TWT subfield shall consider all broadcast TWT schedules suspended, and can follow the default PS procedure defined in 11.2 (Power management) until the broadcast TWT schedules are resumed.

A TWT scheduled STA that receives an acknowledgment in response to a TWT Information frame transmitted by the STA that contains an All TWT subfield equal to 1 and that contains a Next TWT subfield shall suspend all broadcast TWT schedules and shall resume the broadcast TWT schedules at the first scheduled TWT for each respective broadcast TWT schedule that occurs not earlier than the value indicated in the Next TWT subfield contained in the transmitted TWT Information frame, regardless of the values of the Flexible TWT Schedule Support field in the HE Capabilities element exchanged between the two STAs.

NOTE—TWT suspension and resumption as indicated by a TWT Information frame with the All TWT subfield equal to 1 applies to all broadcast TWT schedules of the TWT scheduling AP.

A TWT scheduled STA that is in PS mode and that transmits a TWT Information frame to a TWT scheduling AP shall suspend the corresponding broadcast TWT schedule and may transition to doze state after receiving the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger frame and has not yet received the expected frames from the TWT scheduling AP in response, and shall resume TWT operation for the corresponding broadcast TWT schedule at the specified TWT indicated (if any) in the TWT Information frame. A TWT scheduled STA that is in PS mode and that receives a TWT Information frame from a TWT scheduling AP shall suspend the corresponding broadcast TWT schedule and may transition to doze state after transmitting the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger frame and has not yet received the expected frames from the TWT scheduling AP in response, and shall resume TWT operation for the corresponding broadcast TWT schedule at the specified TWT indicated (if any) in the TWT Information frame.

26.8.4.4 TWT Information frame exchange for flexible wake time

An HE STA may transmit a TWT Information frame that contains a flexible TWT to a peer STA if the peer STA has set the Flexible TWT Schedule Support field of the HE Capabilities it transmits to 1; otherwise the HE STA shall not transmit a TWT Information frame that contains a flexible TWT to the peer STA.

A flexible TWT is a nonzero value indicated in the Next TWT subfield of a TWT Information frame with All TWT subfield equal to 0, which is independent from any existing TWT values of TWT agreements that the HE STA might be following (if any). The HE STA sets the fields of the transmitted TWT Information frame as defined in 26.8.4.1 (General).

NOTE—Flexible TWT support does not depend on the STA's TWT capabilities, i.e., the STA can use flexible TWT without being required to set up an individual TWT agreement or broadcast TWT schedule.

An HE STA that receives acknowledgment for a TWT Information frame with flexible TWT and that contains a TWT Flow Identifier that identifies an existing individual TWT agreement shall replace the next TWT SP start time for that TWT agreement with the value contained in the Next TWT subfield of the TWT Information frame.

A non-AP HE STA that receives acknowledgment for a TWT Information frame with flexible TWT and that contains a TWT Flow Identifier that does not identify any existing individual TWT agreement preserves the PM mode from the time the TWT Information frame was sent to the time indicated in the Next TWT subfield of the TWT Information frame as described below.

NOTE—If the TWT Information frame has the All TWT field equal to 1 then the TWTs are suspended and resumed as described in 26.8.4.2 (TWT Information frame exchange for individual TWT) and 26.8.4.3 (TWT Information frame exchange for broadcast TWT).

A non-AP HE STA that transmits a TWT Information frame that contains a flexible TWT to a peer STA may go to doze state after receiving the acknowledgment sent in response to the TWT Information frame if it is in PS mode (i.e., the PM subfield of the Frame Control field of the TWT Information frame is 1) and may be unavailable if it is in active mode (i.e., the PM subfield of the Frame Control field of the TWT Information frame is 0) and shall be in the awake state at the time it indicated in the Next TWT subfield of the TWT Information frame and shall be in the PS mode if the PM subfield of the TWT Information frame was 1 and in active mode if the PM subfield of the TWT Information frame was 0. The STA, once in the awake state, shall follow the rules that correspond to the power management mode of the STA, which are defined in 11.2.3 (Power management in a non-DMG infrastructure network) for the Active and PS mode, and in 26.8 (TWT operation) when the STA operates within TWT SPs.

NOTE—An HE AP delivers DL BUs to the STA at or after the flexible TWT indicated in the flexible TWT by following the rules in 11.2.3.6 (AP operation) if the STA does not follow TWT, and by following the rules in 26.8 (TWT operation) if the STA follows TWT and the delivery falls within a TWT SP. The STA is not required to send a frame at or after the flexible TWT to indicate its awake state to the AP. If the STA is following U-APSD then the operation is resumed at a time that occurs at the flexible TWT and if the STA is following an APSD schedule then the operation is resumed at a time that occurs at or after the flexible TWT.

A non-AP HE STA that receives a TWT Information frame that contains a flexible TWT from a peer STA may go to doze state after transmitting the acknowledgment if it is in PS mode and may be unavailable if it is in active mode and shall be in the awake state at the time it indicated in the Next TWT subfield of the TWT Information frame and shall be in the PS mode if the STA was in PS mode when it received the TWT Information frame and in active mode if the STA was in active mode when it received the TWT Information frame. The STA, once in the awake state, shall follow the rules that correspond to the power management mode of the STA, which are defined in 11.2.3 (Power management in a non-DMG infrastructure network) for the Active and PS mode, and in 26.8 (TWT operation) when the STA operates within TWT SPs.

26.8.5 Power save operation during TWT SPs

The following rules apply to TWT SPs for both broadcast TWT schedules and individual TWT agreements where the TWT SP of a broadcast TWT is uniquely identified by the <broadcast TWT ID, MAC address of TWT scheduling AP> tuple and the TWT SP of an individual TWT is uniquely identified by the <TWT flow identifier, MAC address of TWT requesting STA, MAC address of TWT responding STA> triple.

A TWT requesting STA or a TWT scheduled STA that is not in PS mode and that transmits a frame with the Power Management subfield set to 1 during a TWT SP shall remain in the awake state until the Adjusted-MinimumTWTWakeDuration time has elapsed from the TWT SP start time or until a TWT SP termination event is detected, whichever occurs first for that particular TWT SP.

A TWT requesting STA or a TWT scheduled STA in PS mode that is in the awake state for a TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time even if it has previously transmitted a PS-Poll frame or U-APSD trigger frame and has not yet received the expected frames from the AP in response. For a trigger-enabled TWT SP, if the AdjustedMinimumTWTWakeDuration time has elapsed from the scheduled TWT SP start time and no Trigger frames are received by the STA, the HE STA may enter doze state if no other condition requires the STA to remain awake.

When a TWT SP termination event is detected within a TWT SP by a STA in PS mode that is participating in the TWT SP, the STA may transition to the doze state without waiting for the expiration of the Adjusted-MinimumTWTWakeDuration time as described in 10.47.1 (TWT overview), even if it has previously transmitted a PS-Poll frame or U-APSD trigger frame and has not yet received the expected frames from the AP in response.

A TWT requesting STA or a TWT scheduled STA shall classify any of the following events as a TWT SP termination event:

1) The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgment in response to an individually addressed QoS Data or QoS Null frame sent by the TWT responding STA or TWT scheduling AP, respectively, that had the EOSP subfield equal to 1.
2) The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgment in response to an individually addressed frame that is neither a QoS Data frame nor a QoS Null frame, sent by the TWT responding STA or TWT scheduling AP, respectively, with the More Data field equal to 0.
3) The reception of an individually addressed or broadcast QoS Data or QoS Null frame sent by the TWT responding STA or TWT scheduling AP, that does not solicit an immediate response and with the EOSP subfield equal to 1.
4) The reception of an individually addressed frame that is neither a QoS Data frame nor a QoS Null frame, sent by the TWT responding STA or TWT scheduling AP, that does not solicit an immediate response and with the More Data field equal to 0.
5) The reception of a Trigger frame sent by the TWT responding STA or TWT scheduling AP that has the More TF field equal to 0 and is not addressed to the TWT requesting STA or TWT scheduled STA provided that the TWT requesting STA or TWT scheduled STA is either awake for an announced trigger-enabled TWT SP but did not transmit an indication that it is in the awake state to the TWT responding STA or TWT scheduling AP or is awake for an unannounced trigger-enabled TWT SP.

The classification of a More Data field equal to 0 in an Ack, BlockAck and individually addressed Multi-STA BlockAck frame as an event that terminates a TWT SP is only possible when both STAs have indicated support of transmitting or receiving the frame with a nonzero More Data subfield, which is indicated in the More Data Ack subfield of the QoS Info field of frames they transmit (see 11.2.3 (Power management in a non-DMG infrastructure network)).

NOTE 1—A STA participating in multiple TWT SPs that overlap in time stays in the awake state until the latest AdjustedMinimumTWTWakeDuration time of all of the TWT SPs expires, except that a TWT SP termination event causes all of the overlapping TWT SPs to terminate.

NOTE 2—A Trigger frame is addressed to the STA if the Trigger frame contains the AID of the STA in one of its User Info fields (see 26.5.2 (UL MU operation)), and has in its TA field either the MAC address of its associated AP or the transmitted BSSID (see 26.5.2.2.4 (Allowed settings of the Trigger frame fields and TRS Control subfield)). Otherwise, the Trigger frame is not addressed to the STA. If the Trigger frame contains one or more RA-RUs for which the STA can gain access according to 26.5.4 (UL OFDMA-based random access (UORA)) then the STA can follow the rules defined in 26.14.2 (Power save with UORA and TWT) to determine an early TWT SP termination event.

Additional TWT SP termination events for a TWT requesting STA occur after the acknowledgment of a TWT Information frame as defined in 26.8.4.2 (TWT Information frame exchange for individual TWT) and in 26.8.4.4 (TWT Information frame exchange for flexible wake time).

Additional TWT SP termination events for a TWT scheduled STA occur after the acknowledgment of a TWT Information frame as defined in 26.8.4.3 (TWT Information frame exchange for broadcast TWT) and in 26.8.4.4 (TWT Information frame exchange for flexible wake time).

26.8.6 Negotiation of wake TBTT and wake interval

A TBTT scheduled STA that intends to operate in power save mode (see 11.2.3.2 (Non-AP STA power management modes)) may transmit a TWT request to the TBTT scheduling AP that identifies the wake TBTT of the first Beacon frame and the wake interval between subsequent Beacon frames it intends to receive. The TWT request shall contain:

- The Negotiation Type subfield equal to 1 and the TWT Setup Command field to Suggest TWT or Demand TWT
- The requested first wake TBTT in the Target Wake Time field
- The requested wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields
- The requested TBTT wake duration in the Nominal Minimum TWT Wake Duration field
- All other fields in the TWT element are reserved.

A TBTT scheduling AP that receives a TWT request from a STA whose value of the Negotiation Type subfield is 1 shall respond with a TWT response that contains either Accept TWT, Alternate TWT, or Reject TWT in the TWT Setup Command field and, in the case of an Accept TWT, it shall also contain:

- The Negotiation Type subfield equal to 1
- The allocated first wake TBTT in the Target Wake Time field
- The allocated wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields
- The allocated TBTT wake duration in the Nominal Minimum TWT Wake Duration field
- All other fields in the TWT element are reserved

After successfully completing the negotiation, the TBTT scheduled STA may go to doze state until its TSF matches the next negotiated wake TBTT provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TBTT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated wake TBTTs and shall operate as described in 26.8.3.3 (Rules for TWT scheduled STA).

If the TBTT scheduled STA receives a Beacon frame from the TBTT scheduling AP at or after TBTT, the TBTT scheduled STA may go to doze state until the next wake TBTT if no other condition requires the STA to remain awake. The TBTT scheduled STA may go to doze state after a nominal minimum TBTT wake duration time has elapsed from the TBTT start time if no other condition requires the STA to remain awake.

Either STA that is a party to an established wake TBTT agreement can tear down the wake TBTT agreement by following the tear down procedure described in 10.47.8 (TWT Teardown) and by setting the Negotiation Type subfield to 1 in the TWT Teardown frame.

Table 26-8 (Wake TBTT negotiation exchanges) summarizes the interactions between devices that negotiate a Wake TBTT agreement.

Table 26-8—Wake TBTT negotiation exchanges

TWT Setup Command field in an initiating frame	TWT Setup Command field in a response frame	Condition after the completion of the exchange
Request TWT	Accept TWT or Alternate TWT or Dictate TWT or Reject TWT or no response	This exchange is not allowed.
Demand TWT or Suggest TWT	Accept TWT	A Wake TBTT agreement has been created with the Wake TBTT parameters indicated in the initiating frame.
Demand TWT or Suggest TWT	Reject TWT	No Wake TBTT agreement has been created.
Demand TWT or Suggest TWT	Alternate TWT	No Wake TBTT agreement has been created. The TBTT scheduling AP is offering an alternative set of parameters vs. those indicated in the initiating frame. The TBTT scheduled STA can send a new request with any set of Wake TBTT parameters and the responder might create a Wake TBTT agreement using those parameters. The TBTT scheduled STA is unlikely to send a new request if the TWT Setup Command is Demand TWT and is very likely to send a new request if the TWT Setup Command is Suggest TWT.
NOTE 1—The Negotiation Type subfield of the TWT element contained in these frames is equal to 1. NOTE 2—The initiating frame and response frame settings not listed in the tables in 10.47 (Target wake time (TWT)) or 26.8 (TWT operation) are not allowed. The initiating frame is a TWT request and the response frame is a TWT response.		

26.8.7 HE subchannel selective transmission

26.8.7.1 General

An HE STA that supports HE subchannel selective transmission (SST) operation shall set dot11HESubchannelSelectiveTransmissionImplemented to true and shall set the HE Subchannel Selective Transmission Support field in the HE Capabilities element it transmits to 1. An HE STA that does not support HE SST operation shall set the HE Subchannel Selective Transmission Support field in the HE Capabilities element it transmits to 0.

A non-AP HE STA with dot11HESubchannelSelectiveTransmissionImplemented to true is a HE SST non-AP STA.

An HE AP with dot11HESubchannelSelectiveTransmissionImplemented to true is an HE SST AP.

An HE SST STA may set up SST operation by negotiating a trigger-enabled TWT as defined in 26.8.2 (Individual TWT agreements) except that:

— The TWT request may have a TWT Channel field with up to one bit set to 1 to indicate the secondary channel requested to contain the RU allocations addressed to the HE SST non-AP STA that is a 20 MHz operating STA
— The TWT request may have a TWT Channel field with all the four LSBs or all the four MSBs set to 1 to indicate whether the primary 80 MHz channel or the secondary 80 MHz channel is requested to contain the RU allocations addressed to the HE SST non-AP STA that is an 80 MHz operating STA
— The TWT response shall have a TWT Channel field with up to one bit set to 1 to indicate the secondary channel that will contain the RU allocations addressed to the HE SST non-AP STA that is a 20 MHz operating STA
— The TWT response shall have a TWT Channel field with all the 4 LSBs or all the 4 MSBs to indicate whether the primary 80 MHz channel or the secondary 80 MHz channel will contain the RU allocations addressed to the HE SST non-AP STA that is a 80 MHz operating STA.

26.8.7.2 SST operation

An HE SST non-AP STA and HE SST AP that successfully sets up SST operation shall follow the rules defined in this subclause.

If an HE SST AP causes its operating channel or channel width to change and if any secondary channel of a trigger-enabled TWT is not within the new operating channel or channel width, then the HE SST AP and the HE SST STA implicitly terminate the trigger-enabled TWT.

The HE SST AP follows the rules in 26.8.2 (Individual TWT agreements) to exchange frames with the HE SST non-AP STA during trigger-enabled TWT SPs, except that the AP shall ensure the following:

— The individually addressed RUs allocated in DL MU PPDUs and in Trigger frames addressed to the HE SST non-AP STA are within the subchannel indicated in the TWT Channel field of the TWT response and follows the RU restriction rules defined in 27.3.2.8 (RU restrictions for 20 MHz operation) if the HE SST STA is a 20 MHz operating STA and in 27.3.2.9 (80 MHz operating non-AP HE STAs) if the HE SST non-AP STA is an 80 MHz operating STA.
— The trigger-enabled TWT SPs do not overlap with TBTTs at which DTIM Beacon frames are sent.
— The same subchannel is used for all trigger-enabled TWT SPs with the same HE SST non-AP STA that overlap in time.

An HE SST non-AP STA operating on the secondary channel shall not conduct OMI operation as defined in 26.9 (Operating mode indication) or OMN operation as defined in 11.41 (Notification of operating mode changes) to change the operating bandwidth.

The HE SST non-AP STA follows the rules in 26.8.2 (Individual TWT agreements) to exchange frames with the HE SST AP during trigger-enabled TWT SPs, except that the STA:

— Shall be available in the subchannel indicated in the TWT Channel field of the TWT response at TWT start times
— Shall not access the medium in the subchannel using DCF or EDCAF

— Shall not respond to Trigger frames addressed to it (see 26.5 (MU operation) and 26.8.2 (Individual TWT agreements)) unless it has performed CCA until a frame is detected by which it can set its NAV, or until a period equal to NAVSyncDelay has transpired, whichever is earlier.

— Shall update its NAV according to 26.2.4 (Updating two NAVs) if it receives a PPDU in the subchannel

An HE SST non-AP STA may include a Channel Switch Timing element in (Re-)Association Request frames it transmits to an HE SST AP to indicate the time required by the STA to switch between different subchannels. The received channel switch time informs the HE SST AP of the duration of time that the HE SST non-AP STA might not be available to receive frames before the TWT start time and after the end of the trigger-enabled TWT SP.

NOTE—An HE SST STA in PS mode is not required to move to the primary channel after the end of the trigger-enabled TWT SP.

26.9 Operating mode indication

26.9.1 General

OMI is a procedure used between an OMI initiator and an OMI responder. An HE STA that transmits a frame including an OM Control subfield is defined as an OMI initiator. An HE STA with dot11OMIOptionImplemented equal to true that receives a frame including an OM Control subfield is defined as an OMI responder.

An HE STA with dot11OMIOptionImplemented equal to true shall set the OM Control Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1; otherwise the HE STA shall set the OM Control Support subfield to 0. An HE AP shall set dot11OMIOptionImplemented to true and the HE AP shall implement the reception of the OM Control subfield.

An OMI initiator may send to an OMI responder an individually addressed QoS Data, QoS Null or Class 3 Management frame after association that contains the OM Control subfield and that solicits an immediate acknowledgment to indicate a change in its receive operating mode (ROM) as defined in 26.9.2 (Receive operating mode (ROM) indication) and/or transmit operating parameters (TOM) as defined in 26.9.3 (Transmit operating mode (TOM) indication). An OMI responder implements the reception of an individually addressed QoS Data, QoS Null or Class 3 Management frame that contains the OM Control subfield that indicates a change in ROM and/or TOM parameters.

The OMI initiator shall indicate a change in its ROM parameters by including the OM Control subfield in a QoS Data, QoS Null or Class 3 Management frame that solicits acknowledgment and is addressed to the OMI responder as defined in 26.9.2 (Receive operating mode (ROM) indication).

NOTE—Frames that solicit an immediate acknowledgment are, for example, QoS Null frames and QoS Data frames with Normal Ack or Implicit BAR ack policy and Action frames.

An HE STA can change its operating mode setting using either operating mode notification as described in 11.42 (Notification of operating mode changes), or the operating mode indication (OMI) procedure described in this subclause. An HE STA should not transmit an OM Control subfield and an Operating Mode field in the same PPDU. If a STA transmits both an OM Control subfield and Operating Mode field in the same PPDU, then the OMI responder shall use the channel width and the maximum number of spatial streams indicated by the most recently received OM Control subfield or Operating Mode field from the OMI initiator.

NOTE—An OM Control field is transmitted before an Operating Mode field in the same frame.

The OMI initiator supports receiving PPDUs with a bandwidth up to the value indicated by the Channel Width subfield and with a number of spatial streams, *Nss*, as indicated in the Rx NSS subfield of the OM Control subfield and calculated in the Equation (26-4).

If the operating channel width of the STA is greater than 80 MHz, then the maximum number of spatial streams that the STA supports in reception for a given HE-MCS as a function of the received HE PPDU bandwidth *BW* at an HE STA transmitting an OM Control subfield is defined in Equation (26-4).

$$\mathrm{floor}\,(\mathit{Rx\text{-}NSS\text{-}from\text{-}OMI} \times (\mathit{Max\text{-}HE\text{-}NSS\text{-}at\text{-}BW} / \mathit{Max\text{-}HE\text{-}NSS\text{-}at\text{-}80})) \tag{26-4}$$

where

Rx-NSS-from-OMI is Rx NSS from the OM Control subfield transmitted by the STA

Max-HE-NSS-at-BW is the maximum NSS among all HE-MCS at *BW* MHz from the Supported HE-MCS And NSS Set field transmitted by the STA as described in 26.15.4 (Rate selection constraints for HE STAs)

Max-HE-NSS-at-80 is the maximum NSS among all HE-MCS at 80 MHz from the Supported HE-MCS And NSS Set field transmitted by the STA

NOTE—If the operating channel width of the STA is greater than 80 MHz, then the Rx NSS subfield indicates the maximum number of spatial streams for PPDU bandwidths that are equal to or less than 80 MHz. If the operating channel width of the STA is less than or equal to 80 MHz, then the Rx NSS subfield indicates the maximum number of spatial streams, N_{SS}, that the STA supports in reception.

The VHT channel width and the VHT NSS allowed at an HE STA transmitting an OM Control subfield are defined in Table 26-9 (Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield) to determine the allowed NSS when operating as HE STA using channel bandwidth of 160 MHz or 80+80 MHz.

Table 26-9—Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield

OM Control subfield	VHT capabilities of STA transmitting OM Control subfield		VHT NSS support of STA transmitting the OM Control subfield as a function of the PPDU bandwidth (× Max VHT NSS) (see requirements R1 and R2)					Location of 160 MHz center frequency if BSS bandwidth is 160 MHz	Location of secondary 80 MHz center frequency if BSS bandwidth is 80+80 MHz
Channel Width	Supported Channel Width	Extended NSS BW Support	20 MHz	40 MHz	80 MHz	160 MHz	80+80 MHz		
0	0-2	0-3	1						
1	0-2	0-3	1	1					
2	0-2	0-3	1	1	1				
3	0	1	1	1	1	1/2		CCFS2	
3	0	2	1	1	1	1/2	1/2	CCFS2	CCFS2
3	0	3	1	1	1	3/4	3/4	CCFS2	CCFS2
3	1	0	1	1	1	1		CCFS1	
3	1	1	1	1	1	1	1/2	CCFS1	CCFS2
3	1	2	1	1	1	1	3/4	CCFS1	CCFS2
3	1	3	2	2	2	2	1	CCFS1	CCFS1

Table 26-9—Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield *(continued)*

OM Control subfield	VHT capabilities of STA transmitting OM Control subfield		VHT NSS support of STA transmitting the OM Control subfield as a function of the PPDU bandwidth (× Max VHT NSS) (see requirements R1 and R2)					Location of 160 MHz center frequency if BSS bandwidth is 160 MHz	Location of secondary 80 MHz center frequency if BSS bandwidth is 80+80 MHz
Channel Width	Supported Channel Width	Extended NSS BW Support	20 MHz	40 MHz	80 MHz	160 MHz	80+80 MHz		
3	2	0	1	1	1	1	1	CCFS1	CCFS1
3	2	3	2	2	2	1	1	CCFS1	CCFS1

R1: NSS support shall be rounded down to the nearest integer.
R2: The maximum NSS support shall be 8.

NOTE 1—Max VHT NSS as indicated by the value of the Rx NSS field. The Rx NSS field indicates the same Max HE NSS and Max VHT NSS. Max VHT NSS is at the bandwidth indicated in the VHT Capabilities element. For all allowed MCS values, the Max VHT NSS values are same, but the supported NSS can be different.

NOTE 2—1/2 × or 3/4 × Max VHT NSS support might end up being 0, indicating no support.

NOTE 3—Any other combination than the ones listed in this table is reserved.

NOTE 4—CCFS1 refers to the value of the Channel Center Frequency Segment 1 field of the most recently transmitted VHT Operation element (if any) or HE Operation element.

NOTE 5—CCFS2 refers to the value of the Channel Center Frequency Segment 2 field of the most recently transmitted HT Operation element.

NOTE 6—CCFS1 is nonzero when the current BSS bandwidth is 160 MHz or 80+80 MHz and the NSS support is at least Max VHT NSS. CCFS2 is zero in this case.

NOTE 7—CCFS2 is nonzero when the current BSS bandwidth is 160 MHz or 80+80 MHz and the NSS support is less than Max VHT NSS. CCFS1 is zero in this case.

NOTE 8—At most one of CCFS1 and CCFS2 is nonzero.

NOTE 9—A supported multiple of Max VHT NSS applies to both transmit and receive. A supported multiple of Max HE NSS applies to receive

NOTE 10—Some combinations of Supported Channel Width Set and Extended NSS BW support might not occur in practice.

The OMI initiator shall indicate a change in its TOM parameters by including the OM Control subfield in a QoS Data, QoS Null or Class 3 Management frame that solicits an immediate acknowledgment frame and is addressed to the OMI responder as defined in 26.9.3 (Transmit operating mode (TOM) indication).

A non-AP STA OMI initiator that sends an OM Control subfield with UL MU Disable subfield equal to 0, supports transmitting an HE TB PPDU with an RU allocation that is within the operating channel width indicated in the Channel Width subfield and with a number of space-time streams, N_{STS}, that is up to the value indicated by the Tx NSTS subfield of the OM Control subfield as defined in 27.8.3 (Transmit operating mode (TOM) indication).

NOTE 1—To avoid possible frame loss, an OMI initiator can continue with its current operating channel width and active receive chains and active transmit chains in HE TB PPDUs and not suspend HE TB PPDUs or Data frames in HE TB PPDUs until it infers that the OMI responder has processed an OM Control subfield from the OMI initiator indicating any of the following changes:

- Reduced operating channel width
- Reduction in the number of active receive chains

— Reduction in the number of active transmit chains in HE TB PPDUs
— Suspension of UL MU operation

The OMI initiator might make this inference from any combination of the following:

— By receiving a frame addressed to itself from the second HE STA in a PPDU with a bandwidth and NSS that are less than or equal to the channel width and NSS, respectively, indicated in the OM Control subfield
— Based on the passage of time in some implementation dependent way, which is outside the scope of this Standard

NOTE 2—It might take a long time for a STA to change its operating mode following the transmission of the OM Control subfield and during that time the STA might not be able to receive frames resulting in frame loss. If a non-AP STA cannot tolerate frame loss during that period it can set the Power Management subfield of the Frame Control field of the frame that carries the OM Control subfield to 1 to indicate that the STA has entered power save. When the non-AP STA has completed its operating mode change, it can send another frame (such as a QoS Null) with the Frame Control field Power Management subfield set to 0 to indicate that the STA has exited power save.

26.9.2 Receive operating mode (ROM) indication

ROM indication allows the OMI initiator to adapt the maximum operating channel width and/or the maximum number of spatial streams, *Nss*, it can receive from the OMI responder.

An OMI initiator that sends a frame that includes an OM Control subfield should change its OMI parameters, Rx NSS and Channel Width, as follows:

— When the OMI initiator changes a ROM parameter from higher to lower, it should make the change for that parameter only after the TXOP in which it received the immediate acknowledgment from the OMI responder.
— When the OMI initiator changes a ROM parameter from lower to higher, it should make the change for that parameter only after the TXOP in which it expects to receive acknowledgment from the OMI responder.

An OMI initiator that is an HE AP should be capable of receiving within an operating channel width and with N_{SS} that are up to the values of the most recently transmitted Channel Width subfield and Rx NSS subfield that the OMI initiator has successfully indicated in the OM Control subfield or in the Operating Mode field sent to any associated STA.

NOTE—In the event of transmission failure of the frame containing the OM Control subfield, the OMI initiator attempts the recovery procedure defined in 10.23.2.8 (Multiple frame transmission in an EDCA TXOP).

The OMI responder shall update the operating channel width and the maximum N_{SS} values as obtained from the Channel Width and Rx NSS subfields, respectively, of the most recently received OM Control subfield sent by the OMI initiator to send SU PPDUs and to assign an RU allocation in sent MU PPDUs, subject to restrictions defined in 27.3.1.2 (OFDMA), addressed to the OMI initiator in subsequent TXOPs. The OMI responder shall update the maximum N_{SS} value to a value determined from the Rx NSS subfield and Table 26-9 (Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield) if the Channel Width subfield of the OM Control field indicates 160 MHz or 80+80 MHz.

After transmitting the acknowledgment for the frame containing the OM Control subfield, the OMI responder may transmit subsequent SU PPDUs or MU PPDUs that are addressed to the OMI initiator.

NOTE—The acknowledgment is transmitted a SIFS after the frame. A subsequent PPDU is a PPDU that is intended for the OMI initiator and need not be the PPDU immediately following the acknowledgment.

An OMI initiator that is a non-AP STA may set the DL MU-MIMO Resound Recommendation subfield to 1 in the OM Control field in frames addressed to an OMI responder that is an AP to indicate that the non-AP STA suggests that the AP resound the channel with the non-AP STA. An OMI initiator that is a non-AP STA and that has no recommendation on the AP’s DL MU-MIMO operation shall set DL MU-MIMO Resound Recommendation subfield to 0.

An OMI responder that receives a frame that carries an OM Control field with the DL MU-MIMO Resound Recommendation field equal to 1 from an OMI initiator may resound the channel or increase the frequency of the channel sounding with the OMI initiator if the OMI responder sends a DL MU-MIMO PPDU addressed to the OMI initiator.

26.9.3 Transmit operating mode (TOM) indication

TOM indication allows the OMI initiator to suspend and resume responding to variants of the Trigger frame and TRS Control subfields per the UL MU Disable and UL MU Data Disable subfields settings as indicated in Table 9-24a (UL MU Disable and UL MU Data Disable subfields encoding), or to adapt the maximum operating channel width and/or the maximum number of space-time streams, N_{STS}, that it can transmit in response to a triggering frame sent by the OMI responder

NOTE—TOM indication does not relate to transmissions in PPDUs other than HE TB PPDUs. An AP does not perform TOM indication as an OMI initiator.

An OMI initiator that is a non-AP STA may indicate changes in its transmit parameters by sending a frame that contains the OM Control subfield to the OMI responder. The OMI initiator shall set:

- The UL MU Disable subfield to 1 to indicate suspension to response to a triggering frame (see 26.5.2 (UL MU operation).
  - An AP that is an OMI initiator shall set the UL MU Disable subfield to 0.
- The Tx NSTS subfield to the maximum N_{STS} that the STA will use for an HE TB PPDU sent in response to a Trigger frame or frame carrying a TRS Control subfield.
- The Channel Width subfield to the maximum operating channel width that the STA will use for an HE TB PPDU sent in response to a Trigger frame or frame carrying a TRS Control subfield.

If a non-AP HE STA has received the OM Control UL MU Data Disable RX Support field in the HE Capabilities element set to 1, then the non-AP HE STA, acting as an OMI initiator, may set the UL MU Disable subfield to 0 and the UL MU Data Disable subfield to 1 to indicate that only UL MU Data frame transmission is suspended but UL MU control response frame transmissions in response to a Basic Trigger frame is not suspended (see 26.5.2 (UL MU operation)) Responses to other Trigger frame variants are not suspended. management frame transmissions are not suspended.

An OMI initiator shall set the UL MU Disable subfield to 0 and the UL MU Data Disable subfield to 0 to indicate resumption or continuation of participation in all triggered UL MU operations.

If an HE AP has set the OM Control UL MU Data Disable RX Support field in the HE Capabilities element it transmits to 0, an associated STA shall not set the UL MU Data Disable subfield in the OM Control field to 1.

An OMI initiator that sent a frame including the OM Control subfield should change its TOM parameters, Tx NSTS, UL MU Disable, UL MU Data Disable and Channel Width, as follows:

- If the OMI initiator changes a TOM parameter from higher to lower, it should make the change for that parameter only after the TXOP in which it received the immediate acknowledgment from the OMI responder.
- If the OMI initiator changes a TOM parameter from lower to higher, it should make the change for that parameter only after the TXOP in which it expects to receive acknowledgment from the OMI responder.

The TOM parameters UL MU Disable and UL MU Data Disable changes from higher to lower if its value changes from 0 to 1. The change of UL MU Disable from 1 to 0 and UL MU Data Disable from 0 to 1 is a change from lower to higher.

An OMI responder that receives a frame containing an OM Control subfield from an OMI initiator performs the following operations.

An AP OMI responder shall not send any Trigger frames or frames carrying a TRS Control subfield to a non-AP STA OMI initiator for subsequent TXOPs (see 26.5.2 (UL MU operation)) if the UL MU Disable subfield is 1 in the most recently received OM Control subfield sent by the STA.

NOTE—A device might have multiple radios that can create difficult in-device coexistence challenges. The device might set UL MU Disable subfield to 1 and the UL MU Data Disable subfield to 0 if it has trouble responding to a triggering frame because the timing or high transmit power would cause interference with another radio in the device.

An OMI responder shall consider the OMI initiator as participating in UL MU operation for subsequent TXOPs if the UL MU Disable subfield is 0 in the most recently received OM Control subfield with the following restrictions:

— The maximum N_{STS} that the OMI initiator can transmit in an HE TB PPDU is indicated in the Tx NSTS subfield of the OM Control subfield
— The maximum operating channel width over which the OMI initiator can transmit in an HE TB PPDU is indicated in the Channel Width subfield of the OM Control subfield

An OMI responder that has transmitted the OM Control UL MU Data Disable RX Support subfield set to 1 shall regard an OMI initiator as capable of participating in UL MU operation only for the purpose of transmission of acknowledgments if the UL MU Disable subfield is equal to 0 and the UL MU Data Disable subfield is equal to 1 in the most recently received OM Control subfield from that OMI initiator.

The OMI responder shall indicate a number of spatial streams, N_{SS}, in the User Info field of a Trigger frame, which contains the AID of the OMI initiator, that is less than or equal to the N_{STS} that is calculated from the Tx NSTS subfield of the OM Control subfield received from the OMI initiator.

The OMI responder shall indicate an RU allocation in the RU Allocation subfield of the User Info field of a Trigger frame or TRS Control subfield addressed to the OMI initiator, that is within the operating channel width specified in the Channel Width subfield of the OM Control subfield received from the OMI initiator and subject to the restrictions defined in 27.3.1.2 (OFDMA).

26.10 Spatial reuse operation

26.10.1 General

The objective of HE spatial reuse operation is to allow the medium to be reused more often between OBSSs in dense deployment scenarios by the early identification of signals from overlapping basic service sets (OBSSs) and interference management.

There are two independent spatial reuse modes: OBSS PD-based spatial reuse and PSR-based spatial reuse.

An HE AP participating in spatial reuse may request an associated non-AP HE STA to gather information regarding the neighborhood by sending a Beacon request (see 9.4.2.21.7 (Beacon request)) by following the procedure described in 11.11 (Radio measurement procedures). An HE AP shall not set a measurement mode in a Beacon request to an associated STA to a mode for which the STA has not explicitly indicated support via the RM Enabled Capabilities element (see 9.4.2.45 (RM Enabled Capabilities element)). An HE AP that sends a Beacon request for this purpose:

— May request that the non-AP HE STA gather information of BSSs matching a particular BSSID and/or SSID
— May request that the non-AP HE STA generate a report that is only for the channel on which the requesting AP is operating or to which the requesting AP is considering switching

— Shall request that the non-AP HE STA include the HE Operation element of neighboring HE APs in order to help determine the BSS color information of the neighboring APs

A non-AP HE STA that performs spatial reuse operation shall have dot11RadioMeasurementActivated set to true and shall respond to a Beacon request from its associated AP with a Beacon report as described in 11.11 (Radio measurement procedures).

Class B device as defined in 27.3.15.3 (Pre-correction accuracy requirements) shall not operate with the procedures defined in this subclause.

26.10.2 OBSS PD-based spatial reuse operation

26.10.2.1 General

OBSS PD-based spatial reuse operation comprises two types of operation. The first type is defined in 26.10.2.2 (General operation with non-SRG OBSS PD level), and allows a STA, under specific conditions, to ignore an inter-BSS PPDU using a non-SRG OBSS PD level. The second type is defined in 26.10.2.3 (General operation with SRG OBSS PD level) and allows a STA, under specific conditions, to ignore inter-BSS PPDUs that are identified as being SRG PPDUs, using an SRG OBSS PD level. In addition to these differences between the two types, Non-SRG OBSS PD Min offset is fixed and defined in the specification while the SRG OBSS PD Min offset can be defined by the AP. A STA may operate using one of the two types, neither type, or both types simultaneously.

26.10.2.2 General operation with non-SRG OBSS PD level

If the PHY of a STA issues a PHY-CCA.indication(BUSY) followed by a PHY-RXSTART.indication due to a PPDU reception then the STA's MAC sublayer may a) issue a PHY-CCARESET.request primitive before the end of the PPDU and not update its basic NAV timer based on the PPDU or may b) not update its basic NAV timer based on the PPDU if all the following conditions are met:

— The STA has not set the TXVECTOR parameter SPATIAL_REUSE to the value PSR_AND_NON_SRG_OBSS_PD_PROHIBITED in any HE PPDU it has transmitted in the current beacon period and in the previous beacon period.

— The most recently received Spatial Reuse Parameter Set element from its associated AP had the Non-SRG OBSS PD SR Disallowed subfield equal to 0 or the non-AP STA has not received a Spatial Reuse Parameter Set element from its associated AP or the STA is an AP and its most recently transmitted Spatial Reuse Parameter Set element had the Non-SRG OBSS PD SR Disallowed subfield equal to 0 or the STA is an AP and has not transmitted a Spatial Reuse Parameter Set element.

— The received PPDU is an inter-BSS PPDU (see 26.2.2 (Intra-BSS and inter-BSS PPDU classification)) and the received PPDU is not a non-HT PPDU carrying a response frame (Ack, BlockAck or CTS frame), or the received PPDU contains a CTS and a PHY-CCA.indication transition from BUSY to IDLE occurred within the PIFS time immediately preceding the received CTS and that transition corresponded to the end of an inter-BSS PPDU that contained an RTS that was ignored following this procedure.

— The STA is operating with an SRG OBSS PD level as described in 26.10.2.3 (General operation with SRG OBSS PD level) and the received PPDU is not an SRG PPDU, or the STA is not operating with an SRG OBSS PD level.

— The SPATIAL_REUSE subfield in the HE-SIG-A (if present) of the received PPDU is not set to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED.

— The received signal strength level, which is measured from the L-STF or L-LTF fields of the PPDU and which is used to determine PHY-CCA.indication, is below the non-SRG OBSS PD level. The non-SRG OBSS PD level is defined in 26.10.2.4 (Adjustment of OBSS PD and transmit power). If the STA has dot11HEPSROptionImplemented set to true, it also follows the rules defined in 26.10.4 (Interaction of OBSS PD and PSR-based spatial reuse) to determine non-SRG OBSS PD level.

- The PPDU is not one of the following:
  - A non-HE PPDU that carries a frame where the RA field is equal to the STA MAC address
  - A non-HE PPDU that carries a Public Action frame
  - A non-HE PPDU that carries a VHT/HE NDP Announcement frame or Fine Timing Measurement frame
  - A non-HE NDP

NOTE—A STA cannot perform SR over an HE sounding NDP or HE TB feedback NDP (see 26.11.6 (SPATIAL_REUSE)).

If the inter-BSS frame is carried in an HE ER SU PPDU (where power of the L-STF/L-LTF symbols is boosted 3 dB), the received signal strength, which is measured from the L-STF or L-LTF fields of the PPDU and which is used to determine PHY-CCA.indication, shall be decreased by 3 dB to compensate for the power difference.

NOTE—In the case of a received CF-End frame that satisfies the conditions above, either the issuance of a PHY-CCARESET.request or the choice to not update the basic NAV timer both result in the NAV not being canceled as would normally occur following the successful reception of a CF-End frame.

The PHY-CCARESET.request primitive shall be issued at the end of the PPDU if the PPDU is an HE SU PPDU or an HE ER SU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_DELAYED.

NOTE 1—A STA sets the TXVECTOR parameter SPATIAL_REUSE to SR_DELAYED in a PPDU if it allows OBSS PD-based spatial reuse operation, but only after the end of the PPDU.

NOTE 2—An AP can get protection equivalent to SR_DELAYED by transmitting the Trigger frame in a non-HT PPDU or HT PPDU with the TXVECTOR parameter AGGREGATION set to 0 instead of in a VHT PPDU.

If the PHY-CCARESET.request primitive is issued before the end of the received PPDU, and a TXOP is initiated within the duration of the received PPDU, then the TXOP and the duration of the transmitted PPDU within that TXOP shall be limited to the duration of the received PPDU if the received PPDU is an HE MU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_RESTRICTED.

NOTE—A STA sets the TXVECTOR parameter SPATIAL_REUSE to SR_RESTRICTED in a PPDU if it allows OBSS PD-based spatial reuse operation, but only before the end of the PPDU.

A STA that ignores a PPDU following the procedure described in this subclause is deemed to perform non-SRG OBSS PD-based spatial reuse.

26.10.2.3 General operation with SRG OBSS PD level

If the PHY of a STA issues a PHY-CCA.indication(BUSY) followed by a PHY-RXSTART.indication due to a PPDU reception then the STA’s MAC sublayer may a) issue a PHY-CCARESET.request primitive before the end of the PPDU and not update its basic NAV timer based on the PPDU or may b) not update its basic NAV timer based on the PPDU if all the following conditions are met:

- The received PPDU is an SRG PPDU (see 26.2.3 (SRG PPDU identification))
- The received signal strength level, which is measured from the L-STF or L-LTF fields of the PPDU and which is used to determine PHY-CCA.indication, is below the SRG OBSS PD level. The SRG OBSS PD level is defined in 26.10.2.4 (Adjustment of OBSS PD and transmit power). If the STA has dot11HEPSROptionImplemented set to true, it also follows the rules defined in 26.10.4 (Interaction of OBSS PD and PSR-based spatial reuse) to determine SRG OBSS PD level.
- The PPDU is not one of the following:
  - A non-HE PPDU that carries a frame where the RA field is equal to the STA MAC address
  - A non-HE PPDU that carries a Public Action frame

- A non-HE PPDU that carries a VHT/HE NDP Announcement frame or Fine Timing Measurement frame
- A non-HE NDP

NOTE—A STA cannot perform SR over an HE sounding NDP or HE TB feedback NDP (see 26.11.6 (SPATIAL_REUSE)).

If the inter-BSS frame is carried in an HE ER SU PPDU (where power of the L-STF/L-LTF symbols is boosted 3 dB), the received signal strength, which is measured from the L-STF or L-LTF fields of the PPDU and which is used to determine PHY-CCA.indication, shall be decreased by 3 dB to compensate for the power difference when compared to the OBSS PD level.

NOTE—In the case of a received CF-End frame that satisfies the conditions above, either the issuance of a PHY-CCA-RESET.request or the choice to not update the basic NAV timer both result in the NAV not being canceled as would normally occur following the successful reception of a CF-End frame.

The PHY-CCARESET.request primitive shall be issued at the end of the PPDU if the PPDU is an HE SU PPDU or an HE ER SU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_DELAYED.

NOTE—An AP can get protection equivalent to SR_DELAYED by transmitting the Trigger frame in a non-HT PPDU or HT PPDU with the TXVECTOR parameter AGGREGATION set to 0 instead of in a VHT PPDU.

If the PHY-CCARESET.request primitive is issued before the end of the received PPDU, and a TXOP is initiated within the duration of the received PPDU, then the TXOP and the duration of the transmitted PPDU within that TXOP shall be limited to the duration of the received PPDU if the received PPDU is an HE MU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_RESTRICTED.

NOTE—The restriction, in addition to the TXOP limit, of the PPDU duration within the TXOP is included in the above paragraph related to SR_RESTRICTED as there are conditions where the TXOP limit can be exceeded (see 10.23.2.9 (TXOP limits)).

An AP that sends a Spatial Reuse Parameter Set element with the SRG Information Present subfield in the SR Control field set to 1 shall set the SRG BSS Color Bitmap and SRG Partial BSSID Bitmap fields as follows:

— If the transmitting AP is in the same ESS as another AP (i.e., with the same SSID and connected by a DS), or is controlled by the same external management entity as another AP (irrespective of SSID), then the transmitting AP may set the SRG BSS Color Bitmap and/or SRG Partial BSSID Bitmap fields that correspond to that other AP to 1

— Else, the AP shall set the bits in the SRG BSS Color Bitmap and/or SRG Partial BSSID Bitmap to 0.

If an HE AP determines values for dot11SRGAPBSSColorBitmap and dot11SRGAPBSSIDBitmap (i.e., the SRG for the AP’s own transmissions), then the values shall be determined according to the above rules.

26.10.2.4 Adjustment of OBSS PD and transmit power

If using OBSS PD-based spatial reuse, an HE STA shall maintain an OBSS PD level and may adjust this OBSS PD level in conjunction with its transmit power and this adjustment shall be made in accordance with Equation (26-5).

$$OBSS\_PD_{level} \le max(OBSS\_PD_{min}, min(OBSS\_PD_{max}, OBSS\_PD_{min} + (TX\_PWR_{ref} - TX\_PWR))) \quad (26\text{-}5)$$

The adjustment rule is illustrated in Figure 26-11 (Illustration of the adjustment rules for OBSS PD and TX_PWR).

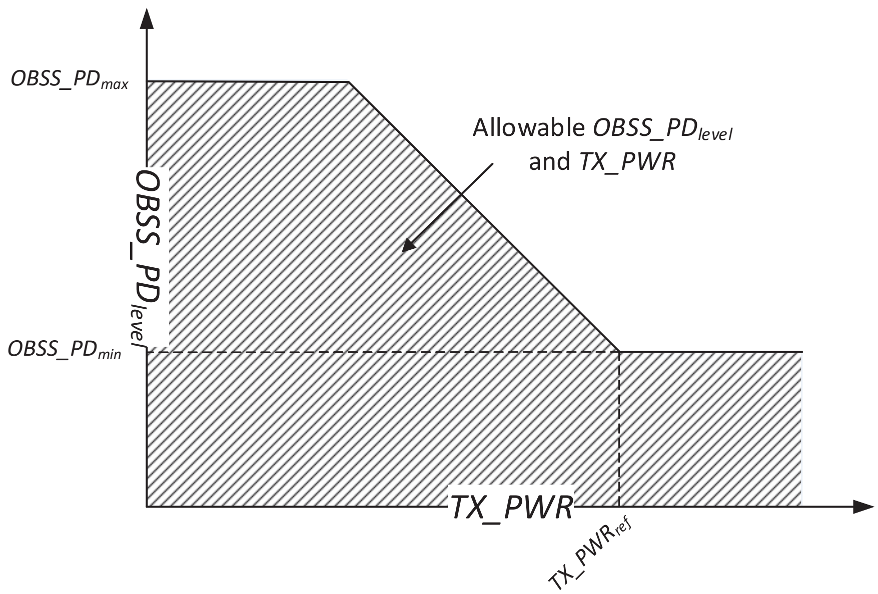

Figure 26-11—Illustration of the adjustment rules for OBSS PD and TX_PWR

The value of the $OBSS\_PD_{level}$ is applicable to the start of a 20 MHz PPDU received on the primary 20 MHz channel. If the bandwidth of the received PPDU differs from 20 MHz, then the value of the $OBSS\_PD_{level}$ is increased by 10 log (bandwidth/20 MHz), using the bandwidth in MHz indicated by the value of RXVECTOR parameter CH_BANDWIDTH or CH_BANDWIDTH_IN_NON_HT if present.

TX_PWR_{ref} = 21 dBm for non-AP STAs.

TX_PWR_{ref} = 21 dBm for an AP with the Max HE-MCS For 3 SS subfield in the Tx HE-MCS Map ≤ 80 MHz subfield in the Supported HE-MCS and NSS Set field of its HE Capabilities element field set to 3.

TX_PWR_{ref} = 25 dBm for an AP with the Max HE-MCS For 3 SS subfield in the Tx HE-MCS Map ≤ 80 MHz subfield in the Supported HE-MCS and NSS Set field of its HE Capabilities element field set to a value other than 3.

TX_PWR is the STA transmission power in dBm at the output of the antenna connector and is set following the rules in 11.8.6 (Transmit power selection) and, for transmission of HE TB PPDU, also following the rules in 27.3.15.2 (Power pre-correction).

NOTE—The TX_PWR_{ref} is 4 dB higher for APs with more than 2 spatial streams as those APs typically have higher transmit power than other devices, and as the OBSS PD procedure is based on a relative reduction of power.

An AP may define SRG OBSS PD Min Offset and SRG OBSS PD Max Offset values that are used by its associated STAs to derive an SRG OBSS PD level for determining reception behavior for inter-BSS PPDUs that are determined to be SRG PPDUs. An AP may define a non-SRG OBSS PD Max Offset value that is used by its associated STAs to derive a non-SRG OBSS PD level for determining reception behavior for inter-BSS PPDUs that are not determined to be SRG PPDUs. The values of SRG OBSS PD Min Offset, SRG OBSS PD Max Offset and Non-SRG OBSS PD Max Offset are transmitted to associated STAs within the Spatial Reuse Parameter Set element.

An AP transmitting a Spatial Reuse Parameter Set element shall respect the following constraints:

- $-82 \leq -82$ + SRG OBSS PD Min Offset ≤ -62
- SRG OBSS PD Min Offset ≤ SRG OBSS PD Max Offset
- -82 + SRG OBSS PD Max Offset ≤ -62
- -82 + Non-SRG OBSS PD Max Offset ≤ -62

An HE STA shall maintain a non-SRG OBSS PD level, with its value selected by respecting the OBSS PD level condition in Equation (26-5) but with Non-SRG OBSS PD Min and Non-SRG OBSS PD Max in place of $OBSS\_PD_{min}$ and $OBSS\_PD_{max}$, respectively. A non-AP STA shall determine Non-SRG OBSS PD Min and Non-SRG OBSS PD Max according to Table 26-10 (Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values for non-AP STAs). An HE AP shall set Non-SRG OBSS PD Min to –82 dBm and Non-SRG OBSS PD Max to –82 dBm + dot11NonSRGAPOBSSPDMaxOffset.

Table 26-10—Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values for non-AP STAs

Non-SRG OBSS PD SR Disallowed field in Spatial Reuse Parameter Set element	Non-SRG Offset Present field in Spatial Reuse Parameter Set element	Value of Non-SRG OBSS PD Min (dBm)	Value of Non-SRG OBSS PD Max (dBm)
Not applicable if the Spatial Reuse Parameter Set element is not received	Not applicable if the Spatial Reuse Parameter Set element is not received	–82	–62
0	0	–82	–62
0	1	–82	–82 + Non-SRG OBSS PD Max Offset
1	N/A	–82	–82

An HE STA shall maintain an SRG OBSS PD level, with its value selected by respecting the OBSS PD level condition in Equation (26-5) but with SRG OBSS PD Min and SRG OBSS PD Max in place of $OBSS\_PD_{min}$ and $OBSS\_PD_{max}$, respectively. A non-AP STA shall determine SRG OBSS PD Min and SRG OBSS PD Max to Table 26-11 (SRG OBSS PD Min and SRG OBSS PD Max values for non-AP STAs). An HE AP shall set SRG OBSS PD Min to –82 + dot11SRGAPOBSSPDMinOffset dBm and SRG OBSS PD Max to –82 + dot11SRGAPOBSSPDMaxOffset dBm. An HE AP may transmit SRG OBSS PD Min and SRG OBSS PD Max offset values that are different from the ones that it uses.

Table 26-11—SRG OBSS PD Min and SRG OBSS PD Max values for non-AP STAs

SRG Information Present field in Spatial Reuse Parameter Set element	Value of SRG OBSS PD Min (dBm)	Value of SRG OBSS PD Max (dBm)
Not applicable if the Spatial Reuse Parameter Set element is not received	N/A see NOTE	N/A see NOTE
0	N/A see NOTE	N/A see NOTE
1	–82 + SRG OBSS PD Min Offset	–82 + SRG OBSS PD Max Offset
NOTE—If SRG Information is not present, a STA cannot determine a PPDU to be SRG and so will not use SRG OBSS PD Min or SRG OBSS PD Max values.		

The Spatial Reuse Parameter Set element is optionally present in Beacon frames, Probe Response frames and (Re)Association Response frames.

26.10.2.5 OBSS PD SR transmit power restriction period

If a STA ignores an inter-BSS PPDU following the procedure in 26.10.2.3 (General operation with SRG OBSS PD level), using a chosen SRG OBSS PD level, or following the procedure in 26.10.2.2 (General operation with non-SRG OBSS PD level) using a chosen non-SRG OBSS PD level, then the STA shall start an OBSS PD SR transmit power restriction period. This OBSS PD SR transmit power restriction period shall be terminated at the end of the TXOP that the STA gains once its backoff reaches zero.

If a STA starts an OBSS PD SR transmit power restriction period with a chosen non-SRG OBSS PD level, the STA's transmit power as measured at the output of the antenna connector shall be equal or lower than the TX_PWR_{max}, calculated with this chosen non-SRG OBSS PD level with Equation (26-6), with the appropriate non-SRG parameters according to Table 26-10 (Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values for non-AP STAs), for the transmissions of any PPDU that is not carrying a frame that is allowed to be sent without regard to the busy/idle state of the medium until the end of the OBSS PD SR transmit power restriction period.

If a STA starts an OBSS PD SR transmit power restriction period with a chosen SRG OBSS PD level, the STA's transmit power as measured at the output of the antenna connector shall be equal or lower than the TX_PWR_{max}, calculated with this chosen SRG OBSS PD level with Equation (26-6), with the appropriate SRG parameters according to Table 26-11 (SRG OBSS PD Min and SRG OBSS PD Max values for non-AP STAs), for the transmissions of any PPDU that is not carrying a response frame that is allowed to be sent without regard to the busy/idle state of the medium until the end of the OBSS PD SR transmit power restriction period.

NOTE—Examples of frames that are transmitted without regard to the busy/idle state of the medium include but are not limited to a frame contained in an HE TB PPDU that is a response to a Trigger frame with the CS Required subfield set to 0 and an Ack or BlockAck frame sent as an immediate response.

A STA may have multiple ongoing OBSS PD SR transmit power restriction periods that overlap in time.

NOTE 1—The STA's transmit power is always equal or lower than the minimum TX_PWR_{max} among all TX_PWR_{max} from ongoing OBSS PD SR transmit power restriction periods.

$$TX\_PWR_{max} = \begin{cases} \text{unconstrained, if } OBSS\_PD_{level} \le OBSS\_PD_{min} \\ TXPWR_{ref} - (OBSS\_PD_{level} - OBSS\_PD_{min}), \text{ if } OBSS\_PD_{max} \ge OBSS\_PD_{level} > OBSS\_PD_{min} \end{cases} \tag{26-6}$$

NOTE 2—Equation (26-6) is equivalent to the condition defined in Equation (26-5). The STA can derive $OBSS\_PD_{level}$ from its transmit power or can derive TX_PWR_{max} from $OBSS\_PD_{level}$.

NOTE 3—Anytime, even if TX_PWR_{max} is unconstrained, the STA has to respect the transmit power restrictions defined in 11.8.6 (Transmit power selection).

An example of OBSS PD SR operation is shown in Figure 26-12 (Example of OBSS PD SR operation).

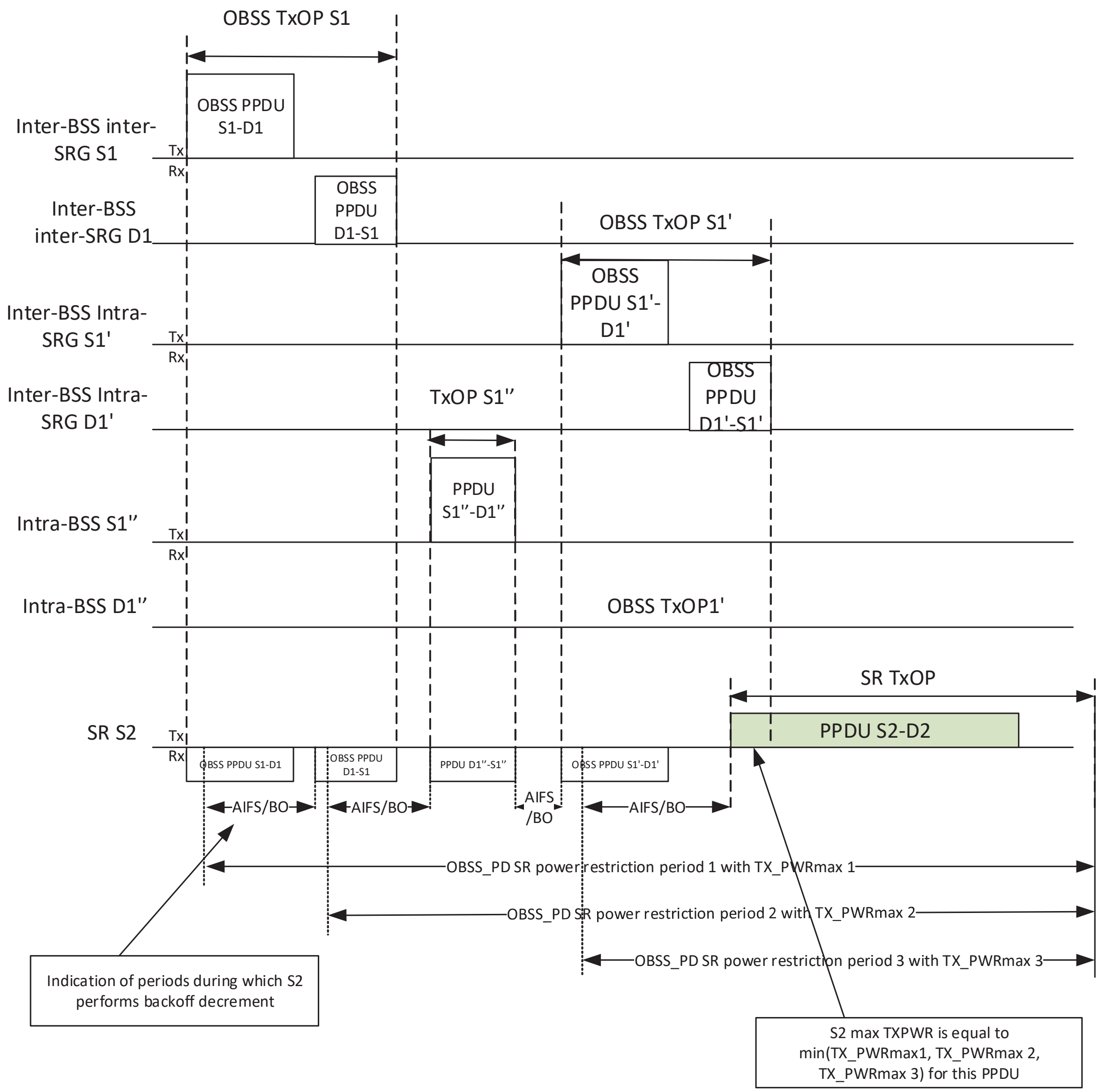

Figure 26-12—Example of OBSS PD SR operation

In this example:

— STA SR S2 receives the PPDU from S1 and, if it classifies it as inter-BSS PPDU, ignores it using OBSS PD-based spatial reuse with non-SRG OBSS PD, starts the OBSS PD SR transmit power restriction period 1 with TX_PWRmax 1 and decrements its backoff counter until the reception of the PPDU from D1.

— If it classifies the PPDU from D1 as inter-BSS PPDU, it ignores it if it chooses to do so using OBSS PD-based spatial reuse with non-SRG OBSS PD, starts the OBSS PD SR transmit power restriction period 2 with TX_PWRmax 2 and decrements its backoff counter until the reception of the PPDU from S1".

— It defers during the TXOP S1" set by the intra-BSS PPDU from S1" that belongs to its own BSS. At the end of the TXOP S1", it resumes its backoff decrement until the reception of the PPDU from S1'.

— If it classifies the PPDU from S1' as SRG PPDU, it ignores it if it chooses to do so using OBSS PD-based spatial reuse with SRG OBSS PD, starts the OBSS PD SR transmit power restriction period 3 with TX_PWRmax 3 and decrements its backoff counter until it reaches zero, as it does not receive the PPDU from D1'.

— It starts transmitting a PPDU with a TX_PWRmax equal to min(TX_PWRmax 1, TX_PWRmax 2, TX_PWRmax 3) and respect this transmit power restriction until the end of the SR TXOP.

26.10.2.6 OBSS PD-based spatial reuse backoff procedure

If an HE STA ignores an inter-BSS PPDU following the procedure in 26.10.2.2 (General operation with non-SRG OBSS PD level), the HE STA may resume EDCAF procedures after the PHY-CCARESET.request primitive is sent, provided that the medium condition is not otherwise indicated as BUSY.

26.10.3 PSR-based spatial reuse operation

26.10.3.1 General

An HE STA supporting PSR-based PSRT PPDU transmission indicates this by setting the PSR-based SR Support subfield to 1 in the HE PHY Capabilities Information field of the HE Capabilities element (see Table 9-321b (Subfields of the HE PHY Capabilities Information field)). An HE-STA supporting PSR-based PSRT PPDU reception indicates this by setting the PSR Responder subfield to 1 in the HE MAC Capabilities Information field of the HE Capabilities element (see Table 9-321a (Subfields of the HE MAC Capabilities Information field)).

An HE STA shall set the PSR-based SR Support field to 1 in the HE Capabilities element it transmits if it supports transmitting an PSRT PPDU under the conditions specified in this subclause; otherwise the STA shall set the PSR-based SR Support field to 0.

STAs that receive a Spatial Reuse Parameter Set element from their associated AP that has a value of 1 in the PSR Disallowed subfield shall not perform PSR-based SR transmissions.

An PSR opportunity is identified from the value of the RXVECTOR parameter SPATIAL_REUSE of an HE TB PPDU and/or the contents of a Trigger frame. An HE STA may initiate an SR transmission during an PSR opportunity for the duration of an ongoing PPDU when certain conditions, designed to avoid interfering with the reception of the ongoing PPDU at the recipient, are met. If the RXVECTOR parameter SPATIAL_REUSE of the ongoing PPDU has the value PSR_DISALLOW or PSR_AND_NON_SRG_OBSS_PD_PROHIBITED, no PSR-based SR transmission is allowed for the duration of that PPDU.

An AP sending a Trigger frame may set the Spatial Reuse *n* field(s) in the UL Spatial Reuse subfield in the Common Info field of the Trigger frame to PSR_DISALLOW or, if permitted by the rules in 26.11.6 (SPATIAL_REUSE), to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED to disallow OBSS STAs from performing PSR-based SR transmission during the ensuing uplink PPDU duration. An AP sending a Trigger frame shall not set the SR field in the Common Info field of the Trigger frame to SR_DELAYED or SR_RESTRICTED.

An HE STA shall set the SR Responder subfield of the HE Capabilities element it transmits to 1 if dot11SRResponderOptionImplemented is true; otherwise the HE STA shall set the SR Responder subfield to 0.

26.10.3.2 PSR-based spatial reuse initiation

An HE STA identifies an PSR opportunity if the following two conditions are met:

1) The STA receives a PHY-RXSTART.indication corresponding to the reception of a PSRR PPDU that is identified as an inter-BSS PPDU (see 26.2.2 (Intra-BSS and inter-BSS PPDU classification))
2) An PSRT PPDU is queued for transmission and the intended transmit power of the PSRT PPDU, after normalization to 20 MHz bandwidth (i.e., the transmit power in dBm minus the value, in dB of the intended transmit bandwidth divided by 20 MHz), is below the value of PSR minus RPL, where PSR is the value obtained from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) based on at least one of:
    a) The value of the UL Spatial Reuse field in the Common Info field of the Trigger frame of the PSRR PPDU
    b) The value of the RXVECTOR parameter Spatial Reuse of the HE TB PPDU that follows the PSRR PPDU

The value of RPL is equal to the RSSI at the antenna connector(s), over the PSRR PPDU bandwidth, during the non-HE portion of the HE PPDU preamble of the triggering PPDU, averaged over all antennas used to receive the PPDU.

An HE STA that identifies an PSR opportunity may choose not to perform NAV update operations normally executed based on the receipt of the RXVECTOR parameter TXOP_DURATION and the Trigger frame Duration field. See Figure 26-13 (PSRR PPDU spatial reuse). A STA that identifies an PSR opportunity may issue a PHY-CCARESET.request to ignore the associated HE TB PPDU(s) that are triggered by the Trigger frame of the PSRR PPDU and that occurs within aSIFSTime + aRxPHYStartDelay + 2 × aSlotTime of the end of the last symbol on the air of the PPDU that contained the Trigger frame, provided that the value of the RXVECTOR parameter BSS_COLOR of the HE TB PPDU matches the BSS color of the PSRR PPDU. A STA that identifies an PSR opportunity shall not transmit an PSRT PPDU that terminates beyond the PPDU duration of the HE TB PPDU that is triggered by the Trigger frame of the PSRR PPDU.

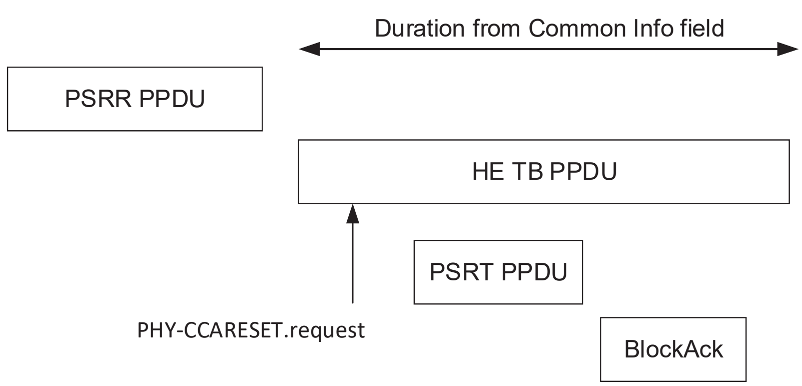

Figure 26-13—PSRR PPDU spatial reuse

26.10.3.3 PSR-based spatial reuse backoff procedure

If an HE STA identifies an PSR opportunity as allowed in 26.10.3.2 (PSR-based spatial reuse initiation), the HE STA may continue the countdown of an existing backoff procedure provided that the medium condition is not otherwise indicated as BUSY. If the HE STA receives another PPDU during the backoff procedure, it shall suspend its back-off and subsequently, if an PSR opportunity is identified based on the identification of the new PPDU as an PSRR PPDU, then the STA may resume its backoff procedure. The TXOP that the HE STA gains once its backoff reaches zero shall not extend beyond the PSR opportunity endpoint that is the earliest ending of all of the durations of all of the PSRR PPDUs that were used to confirm the PSR opportunity and all of the durations indicated in the Common Info fields of Trigger frames within all PSRR PPDUs that were used to confirm the PSR opportunity.

If the HE STA is employing $OBSS\_PD_{level}$ as a threshold for determination of an IDLE medium condition prior to the reception of an PSRR PPDU per the rules specified in 26.10.2 (OBSS PD-based spatial reuse operation), the intended transmit power of the next PSRT PPDU in the transmission queue as measured at the output of the antenna connector shall be equal to or lower than the TX_PWR_{max}, calculated with this specific $OBSS\_PD_{level}$ using Equation (26-6).

After a STA has identified the start of an PSR opportunity, and until the PSR opportunity endpoint is reached, the transmission of any PPDU by the STA shall be limited by the transmit power restrictions identified in 26.10.3 (PSR-based spatial reuse operation).

26.10.3.4 UL Spatial Reuse subfield of Trigger frame

An AP with dot11HEPSROptionImplemented set to true that transmits a Trigger frame may determine the value of the UL Spatial Reuse subfield of the Common Info field of the Trigger frame in each 20 MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU by selecting the row in Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) that has a numerical value in the column labeled "Meaning" that is the highest value that is equal to or below the value of the computed MAC parameter PSR_INPUT as follows:

$$\mathrm{PSR\_INPUT} = TX\_PWR_{AP} + \text{Acceptable Receiver Interference Level}_{\mathrm{AP}} \tag{26-7}$$

where

TX_PWR_{AP} is the total power at the antenna connector(s), in dBm per 20 MHz bandwidth, over all antennas used to transmit the PSRR PPDU containing the Trigger frame for each 20 MHz transmit bandwidth for 20 MHz, 40 MHz, and 80 MHz PPDU or in each of the 40 MHz transmit bandwidths for an 80+80 MHz or 160 MHz PPDU.

Acceptable Receiver Interference Level$_{\mathrm{AP}}$ is a value in dBm normalized to a 20 MHz bandwidth (i.e., minus transmit bandwidth divided by 20 MHz bandwidth in dB) for each 20 MHz transmit bandwidth for 20 MHz, 40 MHz, and 80 MHz PPDU or in each of the 40 MHz transmit bandwidths for an 80+80 MHz or 160 MHz PPDU and should be set to value of the UL target RSSI indicated in the Trigger frame minus the minimum SNR value that yields ≤ 10% PER for the highest HE-MCS of the ensuing uplink HE TB PPDU, minus a safety margin value not to exceed 5 dB as determined by the AP.

An AP with dot11HEPSROptionImplemented set to true that transmits a Trigger frame may set the value of the UL Spatial Reuse subfield value of the Common Info field of the Trigger frame in each 20 MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU to PSR_DISALLOW.

An AP with dot11HEPSROptionImplemented set to false that transmits a Trigger frame shall set the value of the UL Spatial Reuse subfield value of the Common Info field of the Trigger frame in each 20 MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU to PSR_DISALLOW.

26.10.3.5 PSRT PPDU transmission requirements

An HE STA that identifies an PSR opportunity shall not transmit a frame during the PSR opportunity that elicits a response transmission from a STA from which it has not received an HE Capabilities element with the PSR Responder subfield equal to 1. An HE STA that identifies an PSR opportunity shall not transmit a frame that does not include a CAS Control subfield with the PSRT PPDU subfield set to 1 and that solicits a response transmission during that PSR opportunity.

26.10.3.6 PSRT PPDU reception and response transmission requirements

An HE STA that receives a PPDU that contains at least one frame with a CAS Control subfield with an PSRT PPDU subfield equal to 1 shall not transmit a response PPDU elicited by the received PPDU if all outstanding PSR and OBSS PD transmit power requirements are not met by the response transmission.

26.10.4 Interaction of OBSS PD and PSR-based spatial reuse

An HE STA with dot11HEPSROptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than PSR_DISALLOW or PSR_AND_NON_SRG_OBSS_PD_PROHIBITED for the RXVECTOR parameter SPATIAL_REUSE and fails to identify an PSR opportunity based on the receipt of the PPDU shall disable OBSS PD SR operation on this PPDU.

An HE STA with dot11HEPSROptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than PSR_DISALLOW, SR_DELAYED or PSR_AND_NON_SRG_OBSS_PD_PROHIBITED for the RXVECTOR parameter SPATIAL_REUSE and identifies an PSR opportunity based on the receipt of the PPDU may disable OBSS PD SR operation on this PPDU.

An HE STA with dot11HEPSROptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than PSR_DISALLOW or PSR_AND_NON_SRG_OBSS_PD_PROHIBITED in the Common Info Field SPATIAL_REUSE of a Trigger frame and fails to identify an PSR opportunity based on the receipt of the PPDU shall disable OBSS PD SR operation on the HE TB PPDU that is elicited by the Trigger frame.

An HE STA with dot11HEPSROptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than PSR_DISALLOW in the Common Info Field SPATIAL_REUSE of a Trigger frame and identifies an PSR opportunity based on the receipt of the PPDU may disable OBSS PD SR operation on the Data field of the HE TB PPDU that is elicited by the Trigger frame.

26.11 Setting TXVECTOR parameters for an HE PPDU

26.11.1 STA_ID

Each parameter STA_ID in the TXVECTOR identifies the STA or group of STAs that is the recipient of an RU in the HE MU PPDU transmitted with the TXVECTOR parameter UPLINK_FLAG set to 0. An individually addressed RU is an RU addressed to either an associated non-AP STA or a TDLS peer STA and the parameter STA_ID for that RU is set to the 11 LSBs of the AID of the STA receiving the PSDU contained in that RU. If an RU is intended for one or more unassociated non-AP STAs, then the parameter STA_ID for that RU is set to 2045. If an RU is intended for no user, then the parameter STA_ID for that RU is set to 2046. If an RU is intended for an AP (i.e., the TXVECTOR parameter UPLINK_FLAG is 1), then the parameter STA_ID contains only one element that is set to the 11 LSBs of the AID of the non-AP STA transmitting the PPDU. If an RU is intended for multiple STAs for MU-MIMO then multiple STAs identified by STA-IDs in the parameter STA_IDs will use the same resource unit (see 26.5.2 (UL MU operation)). If an RU is intended for multiple associated STAs and carries a single A-MPDU then the parameter STA_ID is set as follows:

— For an AP with dot11MultiBSSIDImplemented equal to false, if the RU is intended for more than one associated STA in the BSS that is not a recipient of an individually addressed RU, the parameter STA_ID is set to 0.
— For an AP with dot11MultiBSSIDImplemented equal to true, if the RU is intended for more than one associated STA in any of its BSSs that is not a recipient of an individually addressed RU, the param-

eter STA_ID is set to 0 for transmitted BSSID or to the value of the BSSID Index field corresponding to that BSS (see 9.4.2.73 (Multiple BSSID-Index element)) for a nontransmitted BSSID. The number of such elements shall not exceed the maximum number of BSSs of the multiple BSSID set.

— For an AP with dot11MultiBSSIDImplemented equal to true, if the RU is intended for more than one associated STA on any of its BSSs, the parameter STA_ID is set to 2047.

The parameter STA_ID values between 2008 and 2044 are reserved.

A non-AP STA shall not transmit an HE MU PPDU where the TXVECTOR parameter STA_ID includes more than one entry in the range 1 to 2007.

26.11.2 UPLINK_FLAG

An HE STA transmitting an HE SU PPDU, HE ER SU PPDU or HE MU PPDU sets the TXVECTOR parameter UPLINK_FLAG as follows:

— A STA transmitting an HE PPDU containing frames that are addressed to an AP shall set the TXVECTOR parameter UPLINK_FLAG to 1 unless the HE PPDU is an HE ER SU PPDU with the TXVECTOR parameter TXOP_DURATION set to UNSPECIFIED and contains an RTS or CTS frame in which case the STA may set the TXVECTOR parameter UPLINK_FLAG to 0.

— Otherwise, the HE STA shall set the TXVECTOR parameter UPLINK_FLAG to 0.

26.11.3 BEAM_CHANGE

An HE STA uses the TXVECTOR parameter BEAM_CHANGE to indicate a change in the spatial mapping of the pre-HE-STF portion of the PPDU and the first symbol of HE-LTF (see Table 27-1 (TXVECTOR and RXVECTOR parameters)).

An HE STA that transmits an HE SU PPDU or an HE ER SU PPDU shall set the TXVECTOR parameter BEAM_CHANGE to 1 if one or more of the following conditions are met:

— The number of spatial streams is greater than 2

— The PPDU is the first PPDU in a TXOP

— The PPDU carries a Trigger frame

26.11.4 BSS_COLOR

An HE STA that transmits HE Operation element shall select and advertise a BSS color as described in 26.17.3 (BSS color).

An HE STA that transmitted an HE Operation element shall set the TXVECTOR parameter BSS_COLOR as follows:

— For an HE SU PPDU, HE ER SU PPDU or DL HE MU PPDU, the parameter BSS_COLOR is set to the value indicated in the BSS Color subfield of the HE Operation element if all the recipient STAs are members of the HE STA's HE BSS or the PPDU carries at least one triggering frame.

— For an HE SU PPDU, HE ER SU PPDU or DL HE MU PPDU, the parameter BSS_COLOR is set to 0 if the HE STA expects that at least one intended recipient STA is not a member of the HE STA's HE BSS and the PPDU does not carry a triggering frame.

A non-AP HE STA that transmits an HE SU PPDU or HE ER SU PPDU to a STA that is not a member of the transmitting STA's HE BSS shall set the TXVECTOR parameter BSS_COLOR to 0.

The active BSS color is one of the following:

— The value of the BSS Color field in the most recently received HE Operation element if an HE STA receives an HE Operation element from a peer HE STA.
— The value of the New BSS Color field in the most recently received BSS Color Change Announcement element if an HE STA receives a BSS Color Change Announcement element from a peer HE STA and the BSS color change TBTT has passed (see 26.17.3.4 (Selecting and advertising a new BSS color)).

An HE STA shall set the TXVECTOR parameter BSS_COLOR for an HE SU PPDU, HE ER SU PPDU or UL HE MU PPDU that is addressed to a peer STA to the active BSS color value, if the HE STA has established any of the following:
— An association with the peer STA
— A TDLS link with the peer STA
— An IBSS membership with the peer STA

NOTE 1—A non-AP HE STA sets the TXVECTOR parameter BSS_COLOR for an HE TB PPDU to the active color (see 26.5.2.3 (Non-AP STA behavior for UL MU operation)).

NOTE 2—An HE mesh STA sets the TXVECTOR parameter BSS_COLOR for an HE PPDU that it transmits to a peer HE mesh STA to the value in the BSS Color subfield of its transmitted HE Operation element.

An HE STA that receives an HE PPDU with RXVECTOR parameter BSS_COLOR with a value between 1 and 63 follows the spatial reuse rule described in 26.10 (Spatial reuse operation).

NOTE—An HE STA that received an HE PPDU with the RXVECTOR parameter BSS_COLOR equal to 0 does not follow the spatial reuse rule described in 26.10 (Spatial reuse operation).

An HE STA that received an HE SU PPDU, HE ER SU PPDU or HE MU PPDU with the RXVECTOR parameter BSS_COLOR equal to 0 shall not discard the HE PPDU.

While the BSS Color Disabled subfield is 1, an HE STA shall continue to advertise a nonzero value (same as before the color was disabled) in the BSS Color subfield of HE Operation element and in the TXVECTOR parameter BSS_COLOR of an HE PPDU that it transmits.

NOTE—A non-AP HE STA sets the TXVECTOR parameter BSS_COLOR of an HE PPDU that it transmits to the value advertised by the AP it intends to communicate with even if the AP has temporarily disabled BSS color.

If the value of TXVECTOR parameter PARTIAL_AID [5:8] for VHT PPDUs transmitted from an HE AP to all associated VHT and HE STAs with the TXVECTOR parameter GROUP_ID equal to 63 would not be consistent with the partial BSS color (i.e., *BCB*(0:3) described in 26.17.4 (AID assignment)) announced by the HE AP, then the HE AP shall set the Partial BSS Color field in the HE Operation element to 0. Otherwise, the HE AP may set the Partial BSS Color subfield in the HE Operation element to 1 (see 26.17.4 (AID assignment)).

26.11.5 TXOP_DURATION

The TXVECTOR parameter TXOP_DURATION of an HE PPDU indicates duration information for NAV setting and protection of the TXOP except that the TXVECTOR parameter TXOP_DURATION is set to UNSPECIFIED to indicate no duration information.

NOTE—The value of TXVECTOR parameter TXOP_DURATION is converted to an indication in the TXOP field of HE-SIG-A as described in Table 27-18 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU), Table 27-20 (HE-SIG-A field of an HE MU PPDU), and Table 27-21 (HE-SIG-A field of an HE TB PPDU). The indication in the TXOP field of HE-SIG-A is converted to the RXVECTOR parameter TXOP_DURATION as described in Table 27-1 (TXVECTOR and RXVECTOR parameters).

A STA that is not a TXOP responder and that transmits an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU may set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED.

A STA that transmits an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU that carries a PS-Poll frame shall set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED.

A STA that is a TXOP responder that transmits an HE SU PPDU, HE ER SU PPDU, or HE TB PPDU shall set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED if the RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is UNSPECIFIED.

An HE AP that has set the BSS Color Disabled field in the HE Operation element to 1 shall set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED for an HE PPDU that it transmits to non-AP STAs associated to it.

If the BSS Color Disabled field is 1 in the HE Operation element most recently received from an AP by a non-AP STA, then the non-AP STA should set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED for an HE PPDU that is not an HE TB PPDU sent to that AP.

A STA that transmits an HE TB PPDU shall not set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED if any one of the following condition is met:

— The RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is not UNSPECIFIED
— The soliciting PPDU is not an HE PPDU

A STA that transmits a frame with a Duration field in an HE PPDU with the TXVECTOR parameter TXOP_DURATION not set to UNSPECIFIED shall set the TXVECTOR parameter TXOP_DURATION to the duration information indicated by the Duration field if the value of the Duration field is smaller than 8448. Otherwise, the STA shall set the TXVECTOR parameter TXOP_DURATION to 8448.

NOTE—For a TXOP responder, the Duration field in a frame carried in a response PPDU is set based on the Duration field in a frame carried in the soliciting PPDU as described in 9.2.5.7 (Setting for control response frames) or 9.2.5.8 (Setting for other response frames).

If a STA transmits either an HE TB feedback NDP or an HE TB PPDU carrying a PS-Poll frame with the TXVECTOR parameter TXOP_DURATION not set to UNSPECIFIED, it shall calculate the duration information and set the TXVECTOR parameter TXOP_DURATION for the HE TB feedback NDP or HE TB PPDU to the value of the computed duration information. The TXOP responder shall calculate duration information equal to the duration information indicated by the Duration field of the frame that solicits the response minus the time, in microseconds, between the end of the PPDU carrying the frame that soliciting the HE TB PPDU and the end of the HE TB PPDU. If the calculated duration information includes a fractional microsecond, the duration information is rounded up to the next higher integer. If the calculated duration information is smaller than 8448 μs, the TXVECTOR parameter TXOP_DURATION shall be set to the calculated duration information. Otherwise, the TXVECTOR parameter TXOP_DURATION shall be set to 8448.

NOTE—The time is equal to SIFS plus the duration of the HE TB PPDU, where the duration of the HE TB PPDU is defined in Equation (27-134).

In the 6 GHz band, a TXOP holder shall not set the TXVECTOR parameter TXOP_DURATION for a transmitted HE PPDU to UNSPECIFIED unless at least one of the following conditions is true:

— The BSS Color Disabled field is 1 in the HE Operation element transmitted within the BSS of which the TXOP holder is a member
— The HE PPDU carries a PS-Poll frame

26.11.6 SPATIAL_REUSE

The contents of the Spatial Reuse fields are carried in the TXVECTOR parameter SPATIAL_REUSE for an HE PPDU indicating spatial reuse information. The behavior of STAs upon reception of an HE PPDU with different SPATIAL_REUSE values is described in 26.10.2 (OBSS PD-based spatial reuse operation) and

26.10.3 (PSR-based spatial reuse operation). The different values that may be indicated in the SPATIAL_REUSE parameter of the TXVECTOR are listed in Table 27-22 (Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) and Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU). The value PSR_DISALLOW is used to prohibit PSR-based spatial reuse during the transmission of the corresponding PPDU. The value PSR_AND_NON_SRG_ OBSS_PD_PROHIBITED is used to prohibit both PSR-based spatial reuse and non-SRG OBSS PD-based spatial reuse during the transmission of the corresponding PPDU. The interpretation of other values are described in this subclause and in 26.10 (Spatial reuse operation). The conditions for a STA to set the SPATIAL_REUSE parameter to its different values are described in this subclause.

For a PPDU with a value of HE_TB for the TXVECTOR parameter FORMAT, the SPATIAL_REUSE parameter contains an array of four values. The first value in the array is the SPATIAL_REUSE parameter that applies to the lowest frequency 20 MHz subband, the second value in the array applies to the second lowest frequency 20 MHz subband, the third value in the array applies to the third lowest frequency 20 MHz subband and the fourth value in the array applies to the highest frequency 20 MHz subband if the CH_BANDWIDTH parameter has the value of CBW20, CBW40 or CBW80. The first value in the array applies to the lowest frequency 40 MHz subband, the second value in the array applies to the second lowest frequency 40 MHz subband, the third value in the array applies to the third lowest frequency 40 MHz subband and the fourth value in the array applies to the highest frequency 40 MHz subband if the CH_BANDWIDTH parameter has the value of CBW160 or CBW80+80. If the SPATIAL_REUSE parameter is an array, each value in the array shall individually conform to the rules in this subclause.

An HE STA that transmits an HE TB PPDU sets the TXVECTOR parameter SPATIAL_REUSE as defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation).

An AP with dot11HEPSROptionImplemented set to true that transmits an HE ER SU PPDU that does not contain a Trigger frame should set the TXVECTOR parameter SPATIAL_REUSE to PSR_DISALLOW.

A non-AP STA with dot11HEPSROptionImplemented set to true that transmits an HE SU PPDU, HE ER SU PPDU or HE MU PPDU may set the TXVECTOR parameter SPATIAL_REUSE, when permitted by other conditions, to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED if the HESIGA_Spatial_reuse_value15_allowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 1. Otherwise, the non-AP STA shall set it to PSR_DISALLOW.

An HE STA that transmits an HE TB PPDU determines the value of the TXVECTOR parameter SPATIAL_REUSE according to 26.5.2.3 (Non-AP STA behavior for UL MU operation).

An HE AP with dot11HEPSROptionImplemented set to true that transmits an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU may set the TXVECTOR parameter SPATIAL_REUSE to PSR_DISALLOW to disallow OBSS STAs from performing PSR-based SR transmission during the duration of the corresponding PPDU.

An HE STA with dot11HEPSROptionImplemented set to false may set the TXVECTOR parameter SPATIAL_REUSE to PSR_DISALLOW for any PPDU that is not an HE TB PPDU, an HE NDP PPDU, a PPDU containing an HE NDP Announcement frame, or a PPDU containing a response to an HE NDP Announcement frame.

A STA shall set the TXVECTOR parameter SPATIAL_REUSE of an HE PPDU to PSR_DISALLOW or, if permitted by the other rules in this subclause, to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED, if the STA is a non-AP HE STA and the PSR Disallowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 1.

An HE STA shall set the TXVECTOR parameter SPATIAL_REUSE to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED for an HE NDP PPDU.

An HE STA shall set the TXVECTOR parameter SPATIAL_REUSE to PSR_AND_NON_SRG_OBSS_P-D_PROHIBITED for a PPDU containing an NDP Announcement frame and in any frame that is transmitted as a response to an NDP Announcement frame.

A non-AP HE STA may set the TXVECTOR parameter SPATIAL_REUSE of an HE PPDU to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED if the HESIGA_Spatial_reuse_value15_allowed sub-field of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 1. If the HESIGA_Spatial_reuse_value15_allowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 0, or if STA has not received a Spatial Reuse Parameter Set element from its associated AP, the STA shall not set the TXVECTOR parameter SPATIAL_REUSE of any HE PPDU to PSR_AND_NON_SRG_OBSS_P-D_PROHIBITED, unless the HE PPDU contains an NDP, an NDP Announcement frame or is a frame that is transmitted as a response to an NDP Announcement frame.

An AP HE STA may set the TXVECTOR parameter SPATIAL_REUSE of an HE PPDU to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED if the HESIGA_Spatial_reuse_value15_allowed sub-field of the SR Control field of the most recently transmitted Spatial Reuse Parameter Set element is equal to 1. If the HESIGA_Spatial_reuse_value15_allowed subfield of the SR Control field of the most recently transmitted Spatial Reuse Parameter Set element is equal to 0, or if the AP has not transmitted a Spatial Reuse Parameter Set element, the AP shall not set the TXVECTOR parameter SPATIAL_REUSE of any HE PPDU to PSR_AND_NON_SRG_OBSS_PD_PROHIBITED.

An HE AP that transmits an HE SU PPDU or an HE ER SU PPDU that contains a Trigger frame should set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAYED. An HE STA that transmits an HE MU PPDU shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAYED.

An HE STA that transmits an HE SU PPDU or HE ER SU PPDU shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_RESTRICTED.

An HE AP that transmits an HE MU PPDU that contains a Trigger frame should set the TXVECTOR parameter SPATIAL_REUSE to SR_RESTRICTED.

An HE STA that transmits a PPDU that does not contain a Trigger frame shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAYED or SR_RESTRICTED.

26.11.7 INACTIVE_SUBCHANNELS and RU_ALLOCATION

The indication of which subchannels are punctured in an HE sounding NDP or in an HE NDP Announcement frame that is carried in a non-HT Duplicate PPDU is conveyed from the MAC to the PHY through the TXVECTOR parameters INACTIVE_SUBCHANNELS and RU_ALLOCATION. The parameter INACTIVE_SUBCHANNELS may be present in the TXVECTOR of a non-HT duplicate PPDU that carries an HE NDP Announcement frame or of an HE sounding PPDU. The parameter INACTIVE_SUBCHANNELS shall not be present otherwise. The setting of the RU_ALLOCATION parameter for other PPDUs is specified in 26.5.2.3.3 (TXVECTOR parameters for HE TB PPDU response to Trigger frame), 26.5.2.3.4 (TXVECTOR parameters for HE TB PPDU response to TRS Control subfield) and 26.5.7.2 (STA behavior).

INACTIVE_SUBCHANNELS is an eight-bit bitmap with an encoding that is the same as the encoding for the Disallowed Subchannel Bitmap subfield defined in 9.3.1.19 (VHT/HE NDP Announcement frame format). A bit in the INACTIVE_SUBCHANNELS bitmap is set to 1 to indicate that no energy is transmitted on the corresponding subchannel for the corresponding PPDU. The RU_ALLOCATION parameter is set to a value that corresponds to the puncturing signaled by the INACTIVE_SUBCHANNELS bitmap.

A STA transmitting an HE sounding NDP may set the TXVECTOR parameter INACTIVE_SUBCHANNELS to any value provided that the bit representing the primary 20 MHz channel is set to 0.

If an HE AP transmits an HE NDP Announcement frame in a PPDU with punctured channels, then the TXVECTOR parameters FORMAT, NON_HT_MODULATION, CH_BANDWIDTH and INACTIVE_-SUBCHANNELS shall be set as follows:

— The TXVECTOR parameter FORMAT shall be set to NON_HT
— The TXVECTOR parameter NON_HT_MODULATION shall be set to NON_HT_DUP_OFDM.
— The INACTIVE_SUBCHANNELS parameter may have any value, except that the bit in the bitmap representing the primary 20 MHz subchannel shall be set to 0.
— The CH_BANDWIDTH parameter value shall be set to CBW80 if there are no bits set to 0 in the INACTIVE_SUBCHANNELS bitmap that correspond to any 20 MHz subchannel of the secondary 80 MHz and at least one bit set to 0 that corresponds to any 20 MHz subchannel of the secondary 40 MHz
— The CH_BANDWIDTH parameter value shall be set to CBW160 if there is at least one bit set to 0 in the INACTIVE_SUBCHANNELS bitmap that corresponds to any 20 MHz subchannel of the secondary 80 MHz

Each 8 bits of the RU_ALLOCATION are set to 113 (01110001 in binary representation) for the 242-tone RU that is most closely aligned in frequency with the 20 MHz subchannel that is indicated as disallowed by the value 1 in the INACTIVE_SUBCHANNELS parameter. Each 8 bits of the RU_ALLOCATION are set to 192 (11000000 in binary representation) for the 242-tone RU that is most closely aligned in frequency with the 20 MHz subchannel that is indicated as not disallowed by the value 0 in the INACTIVE_SUBCHANNELS parameter.

26.11.8 STBC and DCM

An HE STA shall not transmit an HE SU PPDU or HE ER SU PPDU with the TXVECTOR parameter STBC set to 1 if any of the following conditions are met:

— TXVECTOR parameter DCM is set to 1
— TXVECTOR parameter NUM_STS is not equal to 2
— TXVECTOR parameters HE_LTF_TYPE and GI_TYPE are set to 4x HE-LTF and 0u8s_GI, respectively

An HE STA shall not transmit an HE TB PPDU with the TXVECTOR parameter STBC set to 1 if any of the following conditions are met:

— TXVECTOR parameter DCM is set to 1
— TXVECTOR parameter NUM_STS is not equal to 2

An HE STA shall not transmit an HE MU PPDU with the TXVECTOR parameter STBC set to 1 if any of the following conditions are met:

— At least one element in the TXVECTOR parameter DCM is set to 1
— At least one element in the TXVECTOR parameter NUM_STS is not equal to 2
— There are two or more STA_ID parameters in the TXVECTOR using the same RU

NOTE—Two or more STA_ID parameters in the TXVECTOR using the same RU means that DL MU-MIMO is used.

An HE STA shall not transmit an HE SU PPDU or HE ER SU PPDU with the TXVECTOR parameters STBC or DCM set to 1 if the TXVECTOR parameters HE_LTF_TYPE and GI_TYPE are set to 4x HE-LTF and 0u8s_GI, respectively.

26.12 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 to 0 and the Nominal Packet Padding subfield to 0 in HE Capabilities elements that it transmits has as a nominal packet padding of 0 µs for all constellations, NSS and RU allocations that it supports.

A STA that sets the PPE Thresholds Present subfield to 0 and the Nominal Packet Padding subfield to 1 in the HE Capabilities elements that it transmits has a nominal packet padding of 8 µs for all constellations, NSS and RU allocations that it supports.

A STA that sets the PPE Thresholds Present subfield to 0 and the Nominal Packet Padding subfield to 2 in the HE Capabilities elements that it transmits has nominal packet padding of 16 µs for all constellations, NSS and RU allocations that it supports.

A STA that sets the PPE Thresholds Present subfield to 1 in the HE Capabilities elements that it transmits shall indicate its nominal packet padding per constellation, NSS and RU allocation by setting the subfields of the PPE Thresholds field according to 9.4.2.247 (HE Capabilities element) and using the corresponding values from dot11PPEThresholdsMappingTable.

After receiving the PPE Thresholds field from a second STA, the first STA uses the combination of the PPET8 NSTS*n* RU*b* subfield and PPET16 NSTS*n* RU*b* subfield values to determine the nominal packet padding for HE PPDUs that are transmitted to the second STA using NSTS = *n* and an RU allocation corresponding to RU Allocation Index b, for each value of NSTS and RU specified by the field. The nominal packet padding is used in computing the PE field duration (see 27.3.13 (Packet extension)).

NOTE—If the pre-FEC padding factor is 4, then the value of nominal T_{PE} is equal to the nominal packet padding (see Table 27-46 (Nominal TPE values)).

For all values of *n* and *b* for which PPET8 and PPET16 are not present, the nominal packet padding is 0 for HE PPDUs that are transmitted to the STA using NSTS = *n* and an RU allocation corresponding to RU allocation index *b*. The nominal packet padding as a function of the PPE thresholds, the number of spatial streams and the RU allocation index is described in Table 26-12 (PPE thresholds per PPET8 and PPET16).

Table 26-12—PPE thresholds per PPET8 and PPET16

Result of comparison of the constellation index *x* of an HE PPDU with NSTS value *n* and RU allocation size that corresponds to the RU Allocation index = (*b* + DCM) to the value in the PPET8 NSTS*n* RU (*b* + DCM) subfield	Result of comparison of the constellation index *x* of an HE PPDU with NSTS value *n* and RU allocation size that corresponds to the RU Allocation index = value (*b* + DCM) to the value in the PPET16 NSTS*n* RU(*b* + DCM) subfield	Nominal packet padding for an HE PPDU transmitted to this STA using the constellation index = *x*, NSTS = *n* and RU allocation size that corresponds to the RU Allocation index = (*b* + DCM)
x greater than or equal to PPET8	*x* less than PPET16 or PPET16 equal to None	8 µs
x greater than PPET8 or PPET8 equal to None	*x* greater than or equal to PPET16	16 µs
All other combinations not otherwise listed in this table		0
NOTE—DCM = 1 if the HE PPDU uses DCM; DCM = 0 otherwise.		

In Table 26-12 (PPE thresholds per PPET8 and PPET16), "RU Allocation index = (*b* + DCM)" means the following. With the exception of a 2×996-tone RU, if DCM is applied in a given RU, the nominal packet padding value is based on the next larger RU size (RU index + 1). For example, if DCM is applied to a 242-tone RU then the nominal packet padding value for a 484-tone RU is used. If DCM is applied to 106-tone RU then the nominal packet padding value for a 242-tone RU is used. If DCM is applied to a 2×996-tone RU then the nominal packet padding value for a 2×996-tone RU is used.

The nominal packet padding value shall be 0 for all RU less than 242 unless the RU size is 106 and DCM is enabled.

A STA transmitting an HE PPDU provides the nominal packet padding in the TXVECTOR parameter NOMINAL_PACKET_PADDING for the minimal PE calculation (see 27.3.13 (Packet extension)).

A STA transmitting an HE PPDU that carries a broadcast frame shall set the value of the TXVECTOR parameter NOMINAL_PACKET_PADDING to 16 µs. A STA transmitting an HE PPDU that carries a group addressed, but not broadcast, frame shall not set the value of the TXVECTOR parameter NOMINAL_PACKET_PADDING to a value that is less than that required for any of the recipients in the group.

A STA transmitting an HE PPDU to a receiving STA shall include post-FEC padding determined by the pre-FEC padding factor (see 27.3.12 (Data field)) and after including the post-FEC padding, the transmitting STA shall include a packet extension with a duration indicated by the TXVECTOR parameter NOMINAL_PACKET_PADDING (see 27.3.13 (Packet extension)).

26.13 Link adaptation using the HLA Control subfield

This subclause applies to frame exchange sequences that include PPDUs containing an HE variant HT Control field.

An HE STA shall set the HE Link Adaptation Support subfield in the HE Capabilities Information field in the HE Capabilities element it transmits to the value of dot11HEMCSFeedbackOptionImplemented.

A STA that supports HE link adaptation using the HLA Control subfield shall set the HE Link Adaptation Support subfield in the HE Capabilities Information field in the HE Capabilities element to 2 or 3, depending on its own link adaptation feedback capability. A STA shall not send an MRQ to a STA that has not set the HE Link Adaptation Support subfield to 3 in the HE Capabilities Information field of the HE Capabilities element. A STA shall not send an unsolicited MFB in any frame that contains an HLA Control subfield to a STA that has not set the HE Link Adaptation Support subfield to either 2 or 3 in the HE Capabilities Information field of the HE Capabilities element.

The MFB requester may set the MRQ subfield to 1 and Unsolicited MFB subfield to 0 in the HLA Control subfield of a frame to request a STA to provide link adaptation feedback. In each request, the MFB requester shall set the MSI field to a value ranging from 0 to 6. For the MFB requester, how to choose the MSI value is implementation dependent.

The appearance of more than one instance of an HLA Control subfield with the MRQ field equal to 1 within a single PPDU shall be interpreted by the receiver as a single request for link adaptation feedback.

The MFB requester shall specify the RU index and BW requesting the link adaptation feedback.

On receipt of an HLA Control subfield with the MRQ subfield equal to 1, an MFB responder computes the HE-MCS, NSS, and DCM of the RU and BW specified in the MRQ and these estimates are based on the same RU of the PPDU carrying the MRQ. The PPDU carrying MRQ shall include the RU requested for MFB. The MFB responder labels the result of this computation with the MSI value from the HLA Control subfield in the received frame carrying the MRQ. The MFB responder may include the received MSI value in the MSI field of the corresponding response frame. In the case of a delayed response, this allows the MFB requester to associate the MFB with the soliciting MRQ.

An MFB responder that sends a solicited MFB shall set the Unsolicited MFB subfield to 0 and MRQ subfield to 0 in the HLA Control subfield.

The STA receiving MFB may use the received MFB to compute the appropriate HE-MCS, DCM and NSS.

The MFB responder may send a solicited response frame with any of the following combinations of HE-MCS, NSS, and MSI:

- HE-MCS = 15, NSS = 7, MSI = 0–6: the responder will not provide feedback for the request that had the MSI value.
- HE-MCS = valid value, NSS = valid value, MSI = 0–6: the responder is providing feedback for the request that had the MSI value. The MSI value in the response frame matches the MSI value of the MRQ request.

A STA sending unsolicited MFB using the HLA Control subfield shall set the Unsolicited MFB subfield to 1.

Unsolicited HE-MCS, NSS, DCM, BW, and RU estimates reported in an HLA Control subfield sent by a STA are computed based on the most recent PPDU received by the STA that matches the description indicated by the PPDU format, Tx Beamforming, and Coding Type subfields in the same HLA Control subfield.

In an unsolicited MFB response the PPDU Formats, Coding Type, and Tx Beamforming subfields are set according to the RXVECTOR parameters of the received PPDU from which the HE-MCS, RU, BW, and NSS are estimated, as follows:

- The PPDU format subfield is set and encoded as follows:

- 0 if the parameter FORMAT is equal to HE_SU
- 1 if the parameter FORMAT is equal to HE_MU
- 2 if the parameter FORMAT is equal to HE_ER_SU
- 3 if the parameter FORMAT is equal to HE_TB

— The Coding Type subfield is set to 0 if the parameter FEC_CODING is equal to BCC_CODING and set to 1 if equal to LDPC_CODING.

— The Tx Beamforming subfield is set to 1 if the parameter BEAMFORMED is equal to 1 and set to 0 if equal to 0.

— The BW subfield shall indicate a bandwidth less than or equal to the bandwidth indicated by the parameter CH_BANDWIDTH.

— The RU subfield indicates the RU at which the recommended HE-MCS is applied. The recommended RU shall be within an RU or a bandwidth in which the received HE PPDU is located.

For either a solicited or an unsolicited response, the recommended HE-MCS and NSS subfields of HLA Control subfield shall be selected from the HE-MCS and NSS set supported by the recipient STA.

The HE-MCS subfield of HLA Control subfield is the recommended data rate, for given transmission properties carried in the RXVECTOR of the PPDU used for MFB estimation, which results in an estimated frame error rate of 10% or lower for an MPDU length of 3895 octets.

NOTE—Some HE PPDU might not be able to carry 3895 octets due to PPDU duration limitations.

If the MFB requester sets the MRQ subfield to 1 and sets the MSI subfield to a value that matches the MSI subfield value of a previous request for which the responder has not yet provided feedback, the responder shall discard or abandon the computation for the MRQ that corresponds to the previous use of that MSI subfield value and start a new computation based on the new request.

A STA may respond immediately to a current request for MFB with a frame containing an MSI field value and NSS, HE-MCS, and DCM subfields that correspond to a request that precedes the current request.

A non-AP HE STA may set the UL HE TB PPDU MFB to 1 in the HLA Control field it transmits to the AP to indicate that the NSS, HE-MCS, DCM, BW and RU Allocation in the HLA Control field represent the recommended MFB for the HE TB PPDU sent from the non-AP HE STA. The AP should not exceed the recommended RU size indicated in the most recently received RU Allocation field of the HLA Control field when it sends a Trigger frame or a TRS Control field addressed to the STA.

26.14 Power management

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

Intra-PPDU power save is the power save mechanism for an HE STA to enter the doze state or become unavailable until the end of a received PPDU that is identified as an intra-BSS PPDU. The STA can enter the doze state if it is in PS mode and can become unavailable if it is in Active mode (see 11.2.3.2 (Non-AP STA power management modes)).

A non-AP HE STA that has dot11IntraPPDUPowerSaveOptionActivated equal to true operates in intra-PPDU power save mode.

A non-AP HE STA that is in intra-PPDU power save mode may enter the doze state or become unavailable until the end of a PPDU currently being received if one of the following conditions is met:

— The PPDU is an HE MU PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS in which the STA is associated, the RXVECTOR parameter UPLINK_FLAG is 0 and the RXVECTOR parameters STA_ID do not include the identifier of the STA or the broadcast identifier(s) intended for the STA and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP with which it is associated.

— The PPDU is an HE MU PPDU, HE SU PPDU or HE ER SU PPDU and one of the following conditions are true:

- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS in which the STA is associated, the RXVECTOR parameter UPLINK_FLAG is 1 and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP with which it is associated.
- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS in which the STA is associated, the RXVECTOR parameter UPLINK_FLAG is 0 and a PHY-RXEND.indication(UnsupportedRate) primitive was received and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP with which it is associated.

— The PPDU is an HE TB PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS in which the STA is associated and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP with which it is associated.

— The PPDU is a VHT PPDU where the RXVECTOR parameter PARTIAL_AID is the BSSID[39:47] of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs and the RXVECTOR parameter GROUP_ID is 0.

— The PPDU is a PPDU with:

- An A-MPDU including TA or RA equal to either the BSSID of the BSS in which the STA is associated or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs and,
- The RA is not the individual MAC address of the STA or the group address(es) of the STA.

— The PPDU is either an HE MU PPDU with the RXVECTOR parameter UPLINK_FLAG set to 0 or a VHT MU PPDU containing an A-MPDU with

- The RA(s) in the A-MPDU is (are) equal to the STA's individual address and,
- The STA has received in the A-MPDU at least one MPDU delimiter with EOF equal to 1 and with MPDU length field equal to 0.

A non-AP HE STA that is in intra-PPDU power save mode and has entered doze state or has become unavailable shall continue to operate its NAV timers and consider the medium busy and shall transition to the awake state at the end of the PPDU.

A non-AP HE STA that is in intra-PPDU power save mode may discard a PPDU identified as an inter-BSS PPDU as defined in 26.2.2 (Intra-BSS and inter-BSS PPDU classification) until the end of the PPDU.

NOTE—The STA can contend for access to the medium immediately on the expiry of the NAV timers.

26.14.2 Power save with UORA and TWT

This subclause defines the power save mechanisms for a non-AP HE STA that is operating in PS mode and is UORA and TWT capable.

An HE AP may indicate start times for one or more broadcast TWT SPs containing Trigger frames with random access allocations in the broadcast TWT element that is included in a Management frame as described in 26.8.3.2 (Rules for TWT scheduling AP). An example of power save operation is shown in Figure 26-14 (Example of power save operation with UORA and TWT).

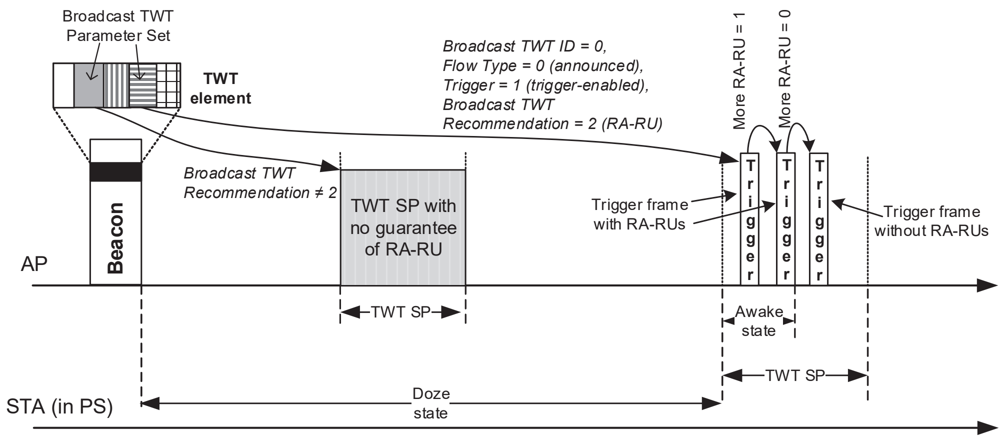

Figure 26-14—Example of power save operation with UORA and TWT

A TWT SP with RA-RU is a TWT SP corresponding to a Broadcast TWT Parameter Set field in a TWT element that has a Broadcast TWT ID subfield equal to 0, Flow Type subfield equal to 0, Trigger subfield equal to 1, and a Broadcast TWT Recommendation subfield equal to 2. An associated HE STA that supports the TWT and UORA procedure when operating in PS mode, upon receiving a Beacon frame from its associated AP carrying a TWT element indicating a schedule for TWT SP(s) with RA-RU, may enter the doze state if no other condition requires it to be awake. The STA may transition to awake state at the start of a TWT SP with RA-RU and follow the procedure in 26.5.4 (UL OFDMA-based random access (UORA))) to send an HE TB PPDU to its associated AP.

An HE STA shall follow the procedure described in 26.8.5 (Power save operation during TWT SPs) to determine if TWT SP termination event has occurred and may enter doze state if no other condition requires the STA to remain awake.

A non-AP HE STA shall decrement its OBO counter by following the procedure in 26.5.4.3 (Transmission procedure for UORA). If the OBO counter decrements to a nonzero value, then the STA may enter the doze state until the end of the current TWT SP if the STA has not declared to the AP that it is in awake state (as described in 26.8.3.3 (Rules for TWT scheduled STA)), no other condition requires it to remain awake and one of the following conditions is met:

- The More TF subfield in the Common Info field of the Trigger frame is equal to 0.
- The More TF subfield in the Common Info field of the Trigger frame is equal to 1 and the More RA-RU subfield in the User Info field is equal to 0 indicating that subsequent Trigger frames in the current broadcast TWT SP will not include RA-RUs matching the value in AID12 subfield (see Table 9-31g (AID12 subfield encoding)).

26.14.3 Opportunistic power save

26.14.3.1 General

An OPS non-AP STA is a non-AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1.

An OPS AP is an AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field in HE Capabilities element to 1.

The objective of the opportunistic power save mechanism is to allow OPS non-AP STAs that are in active mode to be unavailable and to allow OPS non-AP STAs that are in PS mode and have to be in the awake state because of the power management mode they use to be in doze state to save power for a defined period. The opportunistic power save mechanism has two modes: aperiodic and periodic.

In the aperiodic mode, an OPS AP sends an OPS frame or a FILS Discovery frame at any time to provide the scheduling information for all OPS non-AP STAs for the OPS period that follows the transmission of the OPS frame or FILS Discovery frame. Based on this information, the OPS non-AP STAs that are in active mode may be unavailable during the OPS period and the OPS non-AP STAs that are in PS mode may be in doze state during the OPS period.

In the scheduled mode, an OPS AP splits a beacon interval into several periodic broadcast TWT SPs and provides, at the beginning of each SP, the scheduling information for all OPS non-AP STAs. Based on this information, the OPS non-AP STAs that are in active mode may be unavailable until the next TWT SP and the OPS non-AP STAs that are in PS mode may be in doze state until the next TWT SP.

26.14.3.2 AP operation for opportunistic power save

To enable aperiodic opportunistic power save, an OPS AP shall schedule for transmission an OPS frame or a FILS Discovery frame with the RA field set to the broadcast address that includes a TIM element (see 9.4.2.5 (TIM element)) and an OPS element (see 9.4.2.256 (OPS element)). The AP should transmit a FILS Discovery frame instead of an OPS frame if the target transmission time closely aligns with the transmission time of a FILS Discovery frame. The OPS Duration field in the OPS element shall be set to the duration of the OPS period that immediately follows the transmission of the OPS frame or FILS Discovery frame. The TIM element is encoded specifically as defined in 9.4.2.5 (TIM element) in order to provide the information of which STAs are not scheduled during the OPS period. If the OPS AP sets the bit corresponding to an OPS non-AP STA in the traffic indication virtual bitmap field carried by the Partial Virtual Bitmap of the TIM element of the OPS frame or FILS Discovery frame to 0, the AP should send neither individually addressed frames to the STA nor Trigger frames with a User Info field that addresses the STA during the OPS period.

To enable periodic opportunistic power save, an OPS AP shall include a TWT element in beacons to set a periodic Broadcast TWT SP with the following information:

- The Broadcast TWT Recommendation field set to 3
- The Broadcast TWT ID subfield is set to 0

At the beginning of these periodic TWT SPs with the Broadcast TWT Recommendation field set to 3, the AP shall schedule for transmission a TIM frame or a FILS Discovery frame with the RA field set to the broadcast address that includes a TIM element (see 9.4.2.5 (TIM element)). The FILS Discovery frame may include an OPS element. The AP should transmit a FILS Discovery frame instead of a TIM frame if the TWT SP start time closely aligns with the transmission time of a FILS Discovery frame. If the OPS AP also operates with TIM Broadcast and uses TIM frames for opportunistic power save, the OPS AP should align the transmission time of a TIM frame for TIM Broadcast, with the start time of the broadcast TWT SP with the Broadcast TWT Recommendation field set to 3. If the OPS AP sets the bit corresponding to an OPS non-AP STA in the traffic indication virtual bitmap carried in the Partial Virtual Bitmap field of the TIM element of the TIM frame or FILS Discovery frame to 0, the AP should send neither individually addressed frames to the STA nor Trigger frames with a User Info field that addresses the STA during the TWT SP and until the next TWT SP with the Broadcast TWT Recommendation field set to 3.

26.14.3.3 STA operation for opportunistic power save

With aperiodic opportunistic power save, if an OPS non-AP STA with AID *N* that is in the awake state receives a TIM element and an OPS element in an OPS frame or a FILS Discovery frame from the associated OPS AP, then the STA may be unavailable if the STA is in active mode or may be in doze state if the

STA is in PS mode until the end of the OPS period indicated in the OPS element, if the bit *N* in the traffic indication virtual bitmap carried in the Partial Virtual Bitmap field of the current TIM element is 0, unless other conditions not related to operation with the OPS AP require the STA to be in the awake state. At the end of the OPS period, the STA shall be in the awake state, unless determined otherwise by other power save protocols.

With periodic opportunistic power save, if an OPS non-AP STA with AID *N* that is in the awake state receives from the OPS AP with which it associated a TIM element with bit *N* of the traffic indication virtual bitmap field equal to 0 in a TIM frame or FILS Discovery frame within a broadcast TWT SP with the Broadcast TWT Recommendation field set to 3, then the STA may be unavailable if the STA is in active mode or may be in doze state if the STA is in PS mode during the TWT SP and until the next TWT SP with the Broadcast TWT Recommendation field set to 3, unless other conditions not related to operation with the OPS AP require the STA to be in the awake state.

An OPS non-AP STA shall not operate with TIM broadcast procedure if its associated AP is an OPS AP.

26.14.4 HE dynamic SM power save

A STA that supports HE dynamic SM power save has dot11HEDynamicSMPowerSaveOptionImplemented set to true and shall set the HE Dynamic SM Power Save subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits in the 2.4 GHz or 5 GHz band to 1 and sets the SM Power Save subfield in the HE 6 GHz Band Capabilities element it transmits in the 6 GHz band to 1.

In dynamic SM power save mode (see 11.2.6 (SM power save)), a non-AP HE STA that sets the HE Dynamic SM Power Save subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1 or that sets the SM Power Save subfield in the HE 6 GHz Band Capabilities element it transmits to 1 shall follow the dynamic SM power save procedures defined in 11.2.6 (SM power save) except that the non-AP HE STA may enable its multiple receive chains if it receives a Trigger frame as described below.

The non-AP HE STA enables its multiple receive chains if it receives a Trigger frame that starts a frame exchange sequence. Such a frame exchange sequence shall satisfy the following conditions:

- The starting Trigger frame is transmitted with a single-spatial stream.
- The starting Trigger frame is from the associated AP or from the AP corresponding to the transmitted BSSID if the non-AP HE STA is associated with a nontransmitted BSSID and has indicated support for receiving Control frames with TA set to the transmitted BSSID by setting the Rx Control Frame To MultiBSS subfield to 1 in the HE Capabilities element that the non-AP HE STA transmits.
- The starting Trigger frame is an MU-RTS Trigger frame, BSRP Trigger frame or BQRP Trigger frame that includes a User Info field with the AID12 subfield equal to the 12 LSBs of the AID of the non-AP HE STA (see 26.5.2.2.1 (General)) in dynamic SM power save mode.

The non-AP HE STA shall, subject to its spatial stream capabilities (see 9.4.2.55.4 (Supported MCS Set field), 9.4.2.157.3 (Supported VHT-MCS and NSS Set field) and 9.4.2.247 (HE Capabilities element)) and operating mode (see 11.41 (Notification of operating mode changes) and 26.9 (Operating mode indication)), be capable of receiving a PPDU that is sent using more than one spatial stream a SIFS after the end of its response frame transmission. The STA switches to the multiple receive chain mode if it receives the Trigger frame addressed to it as defined above and switches back immediately after the frame exchange sequence ends.

NOTE 1—A Trigger frame always solicits an immediate response.

NOTE 2—A non-AP HE STA that is in dynamic SM power save mode and that sets the HE Dynamic SM Power Save subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1 or that sets the SM Power Save subfield in the HE 6 GHz Band Capabilities element it transmits to 1 cannot distinguish between a Trigger frames that precedes a MIMO transmission and a Trigger frames that does not precede a MIMO transmission and, therefore, always enables its multiple receive chains if it receives an MU-RTS Trigger frame, BSRP Trigger frame, or BQRP Trigger frame that has a User Info field addressed to it.

26.15 PPDU format, BW, MCS, NSS, and DCM selection rules

26.15.1 General

An HE STA can transmit different PPDUs formats, with different transmit parameters, such as channel width, MCS, NSS, DCM. This subclause defines the rules followed by an HE STA for selecting these parameters depending on the capabilities of the intended receiver(s) and other considerations.

26.15.2 PPDU format selection

An HE STA that transmits non-HT, HT, or VHT PPDUs shall follow the rules in 10.6 (Multirate support). An HE STA may transmit an HE SU PPDU to a peer HE STA subject to the restrictions defined below.

An HE AP may transmit an HE MU PPDU as defined in 26.5.1 (HE DL MU operation). A non-AP HE STA transmits HE TB PPDUs as defined in 26.5.2 (UL MU operation).

A STA shall not transmit a 242-tone HE ER SU PPDU to a peer non-AP STA if the most recently received OM Control field from that peer non-AP STA, if any, has the ER SU Disable subfield equal to 1.

A STA shall not transmit a 242-tone HE ER SU PPDU to an AP if the most recently received HE Operation element from that AP has the ER SU Disable subfield equal to 1.

A STA shall not transmit a 106-tone HE ER SU PPDU to a peer STA if the HE Capabilities element received from that peer STA has the Partial Bandwidth Extended Range field equal to 0.

A non-AP STA, TDLS STA or IBSS STA shall not transmit a 20 MHz HE MU PPDU with just a 106-tone RU to a peer STA unless it has received from the peer STA an HE Capabilities element with the Rx Partial BW SU In 20 MHz HE MU PPDU subfield in the HE PHY Capabilities Information field equal to 1.

NOTE—A non-AP STA transmitting an HE MU PPDU sets the TXVECTOR parameter UPLINK_FLAG to 1 if the PPDU is sent to the AP and to 0 if the PPDU is sent to a TDLS STA (see 26.11.2 (UPLINK_FLAG)). The HE MU PPDU format enables the non-AP STA to include its AID (i.e., transmitter's AID if the UPLINK_FLAG is 1 and the receiver's AID if the UPLINK_FLAG is 0) in the PHY header of the PPDU and its use is out of scope of the standard.

An HE STA shall not transmit an HE MU PPDU with a single user being allocated an RU occupying the entire PPDU bandwidth and a compressed HE-SIG-B to a peer STA unless the HE STA has received from the peer STA an HE Capabilities element with the Rx Full BW SU Using HE MU PPDU With Compressed HE-SIG-B subfield in the HE PHY Capabilities Information field equal to 1.

An HE STA shall not transmit an HE MU PPDU with a single user being allocated an RU occupying the entire PPDU bandwidth and a noncompressed HE-SIG-B to a peer STA unless the PPDU bandwidth is less than or equal to 80 MHz and the HE STA has received from the peer STA an HE Capabilities element with the Rx Full BW SU Using HE MU PPDU With Non-Compressed HE-SIG-B subfield in the HE PHY Capabilities Information field equal to 1.

An HE STA shall send Control frames following the rules defined in 10.6.6 (Rate selection for Control frames) with the following exceptions:

- A Control frame shall be carried in an HT PPDU, VHT PPDU, HE ER SU PPDU or HE SU PPDU when the Control frame is sent using an STBC frame.
- A Control frame sent by the AP as a response to an HE TB PPDU may be carried in any PPDU format that is supported by the intended receivers.

- A Trigger frame that is not an MU-RTS Trigger frame may be carried in any PPDU format that is supported by the intended receivers subject to the restrictions in 26.5.2 (UL MU operation).
- A Control frame is carried in an HE TB PPDU if it is sent as a response to a PPDU that contains a Trigger frame that is not an MU-RTS Trigger frame or if it is sent as a response to a PPDU that contains a frame containing a TRS Control subfield (see 26.5.2 (UL MU operation)).
- A Control frame sent by an HE STA as a response to an HE ER SU PPDU that does not contain a Trigger frame or frame carrying a TRS Control field should be carried in an HE ER SU PPDU unless the most recently received PPDU sent by a recipient of the HE ER SU PPDU to the HE STA after association was not an HE ER SU PPDU in which case the Control frame should be carried in non-HT PPDU.
- A Control frame sent by an HE STA as a response to an HE SU PPDU or a non-HT PPDU that does not contain a Trigger frame or frame carrying a TRS Control field should be carried in a non-HT PPDU unless the most recently received PPDU sent by a recipient of the HE SU PPDU to the HE STA after association was an HE ER SU PPDU in which case the Control frame should be carried in an HE ER SU PPDU.
- A Control frame shall not be sent in an HE ER SU PPDU if the channel bandwidth of the soliciting PPDU is greater than 20 MHz.
- A Control frame that is not solicited by another frame and is not a Trigger frame may be carried in an HE ER SU PPDU.
- A Control frame sent in the 6 GHz band as a response to an HE SU PPDU or HE MU PPDU, and that is not carried in HE TB PPDU, may be carried in an HE SU PPDU if the transmit time of HE SU PPDU is less than or equal to the PPDU duration of a non-HT PPDU containing the Control frame sent at the primary rate (see 10.6.6.5.2 (Selection of a rate or MCS)).

NOTE 1—A change in the format of the PPDU containing the control response frame (between non-HT and HE ER SU PPDU) occurs in subsequent TXOPs. A STA that solicits a control response frame from a responding STA accounts for the PPDU format of the control response frame to calculate the expected duration of the TXOP. The responding STA determines that the most recent PPDU sent to the soliciting STA is received if it receives an immediate acknowledgment by the soliciting STA in response to the PPDU.

NOTE 2—A STA does not transmit a Control frame in an HE ER SU PPDU to a receiving STA unless the receiving STA indicates that HE ER SU PPDU reception is enabled.

An HE STA should send an Ack frame in the same PPDU format as the soliciting PPDU if the soliciting PPDU is a VHT PPDU or HT PPDU containing a Fine Timing Measurement frame.

26.15.3 MCS, NSS, BW and DCM selection

An HE STA shall follow the rules defined in 10.6 (Multirate support) and 26.15.4 (Rate selection constraints for HE STAs) for selecting the rate, MCS, NSS, and the rules defined in 10.3.2.8 (VHT and S1G RTS procedure), 10.3.2.9 (CTS and DMG CTS procedure), 10.6.6.6 (Channel Width selection for Control frames) and 10.6.12 (Channel Width in non-HT and non-HT duplicate PPDUs) for selecting the channel width (BW) of transmitted PPDUs with the following exceptions:

- HE-MCS, NSS, and BW selection for an HE TB PPDU are defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation).
- Rate and BW selection for a CTS sent in response to an MU-RTS Trigger frame are defined in 26.2.6 (MU-RTS Trigger/CTS frame exchange procedure).
- A STA that transmits a Control frame carried in a non-HT PPDU that is a response to a frame received in an HE ER SU PPDU shall set the rate of the non-HT PPDU to 6 Mb/s.
- A STA that transmits a Control frame that is an S-MPDU carried in an HE ER SU PPDU and that is a response to a frame received in an HE ER SU PPDU shall use the <HE-MCS, NSS> tuple <HE-MCS 0, 1>.

— NSS and BW selection is further constrained as defined in 26.9 (Operating mode indication), 11.42 (Notification of operating mode changes), 26.15.2 (PPDU format selection), 26.17 (HE BSS operation) and in the remaining subclauses of 26.15 (PPDU format, BW, MCS, NSS, and DCM selection rules).

An HE STA that transmits an HE PPDU to a receiving STA shall use an <HE-MCS, NSS> tuple that is supported by the receiving STA as indicated by the Supported HE-MCS And NSS Set field in the HE Capabilities element that the receiving STA transmits. If the Supported HE-MCS and NSS set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a <HE-MCS, NSS> tuple in the basic HE-MCS and NSS set if the basic HE-MCS and NSS set is not empty, otherwise the transmitting STA shall transmit using a <HE-MCS, NSS> tuple in the mandatory HE-MCS and NSS Set. An HE STA is subject to all of the rules for HT STAs and VHT STAs that apply to its operating band (see 10.27 (Protection mechanisms)).

An HE STA may transmit an HE PPDU with 1024-QAM on a 26-, 52-, and 106-tone RU to a recipient STA if it has received from the recipient STA an HE Capabilities element with the Rx 1024-QAM < 242-tone RU Support subfield in the HE PHY Capabilities Information field equal to 1; otherwise the HE STA shall not transmit an HE PPDU with 1024-QAM on a 26-, 52-, and 106-tone RU.

An HE AP shall not set the UL HE-MCS subfield of a User Info field in a Trigger frame to 10 or 11 for a 26-, 52-, or 106-tone RU allocation unless the User Info field is addressed to a non-AP HE STA from which the HE AP has received an HE Capabilities element with the Tx 1024-QAM < 242-tone RU Support subfield in the HE PHY Capabilities Information field equal to 1.

An HE STA that sends a Control frame in response to a frame carried in an HE SU PPDU or an HE ER SU PPDU or an HE MU PPDU that carries a frame with the Normal Ack or Implicit BAR ack policy shall set the TXVECTOR parameter CH_BANDWIDTH to indicate a channel width that is the same as the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response. If the most recently received PPDU sent by the responding STA to the soliciting STA after association was an HE ER SU PPDU, the soliciting STA shall set the TXVECTOR parameter CH_BANDWIDTH to CBW20 for an HE SU PPDU and to ER-RU-242 or ER-RU-H-106 for an HE ER SU PPDU.

NOTE—A preamble punctured HE MU PPDU cannot carry a frame with Normal Ack or Implicit BAR ack policy if the solicited PPDU containing a control response occupies one ore more punctured 20 MHz channels of the preamble punctured HE MU PPDU (see 26.4.4.3 (Responding to an HE MU PPDU with an SU PPDU)).

If a control response frame is transmitted in an HE SU PPDU or HE MU PPDU, the channel width (CH_BANDWIDTH parameter of the TXVECTOR) shall be selected first according to 10.6.6.6 (Channel Width selection for Control frames), and then the <HE-MCS, NSS> tuple shall be selected from a set of <HE-MCS, NSS> tuples called the *CandidateMCSSet*. The *CandidateMCSSet* is defined in 10.6.6.5.3 (Control response frame MCS computation) except that the set additionally contains the <HE-MCS, NSS> tuples for an HE STA.

An HE STA may transmit an HE SU PPDU or HE ER SU PPDU with DCM applied to the Data field to a recipient STA if it has received from the recipient STA an HE Capabilities element with the DCM Max Constellation Rx subfield in the HE PHY Capabilities Information field greater than 0; otherwise the HE STA shall not transmit an HE SU PPDU or HE ER SU PPDU with DCM applied to the Data field to the recipient STA.

An HE STA may transmit to a recipient STA an HE MU PPDU with DCM applied to the HE-SIG-B field and/or an RU in the Data field addressed to the STA if it has received from the recipient STA an HE Capabilities element with the DCM Max Constellation Rx subfield in the HE PHY Capabilities Information field greater than 0; otherwise the HE STA shall not transmit to the recipient STA an HE MU PPDU with DCM applied to the HE-SIG-B field and/or an RU in the Data field addressed to the STA.

An HE STA transmits an HE TB PPDU with DCM as defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation). An HE AP shall not set the DCM subfield of a User Info field in a Trigger frame to 1 if it has not received from the recipient STA an HE Capabilities element with the DCM Max Constellation Tx subfield in the HE PHY Capabilities Information field greater than 0.

An HE STA that transmits an HE PPDU with DCM applied to the Data field to a recipient STA shall use an RU size that is less than or equal to the maximum RU size indicated in the DCM Max RU subfield in the HE PHY Capabilities Information field in the HE Capabilities element received from the recipient STA.

An HE AP that transmits a Trigger frame addressed to a recipient STA that solicits an HE TB PPDU with DCM shall set the RU Allocation subfield in the Trigger frame to indicate an RU size that is less than or equal to the maximum RU size indicated in the DCM Max RU subfield in HE PHY Capabilities Information field in the HE Capabilities element received from the recipient STA.

An HE STA that transmits an HE PPDU with DCM applied to the Data field to a recipient STA shall use an NSS that is less than or equal to the value indicated in the DCM Max NSS Rx subfield in the HE PHY Capabilities Information field in the HE Capabilities element received from the recipient STA.

An HE AP that transmits a Trigger frame with a User Info field addressed to a recipient STA and with the UL DCM subfield in the User Info field set to 1 shall set the Number Of Spatial Streams subfield in the SS Allocation subfield in the User Info field to less than or equal to the DCM Max NSS Tx subfield in HE PHY Capabilities Information field in the HE Capabilities element received from the recipient STA.

An HE AP shall not transmit a Trigger frame with the UL STBC subfield set to 1 and the UL BW subfield set to indicate a bandwidth less than or equal to 80 MHz if at least one User Info field is addressed to a non-AP HE STA from which the HE AP has received an HE Capabilities element with the STBC Tx ≤ 80 MHz subfield in HE PHY Capabilities Information field equal to 0.

An HE AP shall not transmit a Trigger frame with the UL STBC subfield set to 1 and the UL BW subfield set to indicate 80+80 MHz or 160 MHz if at least one User Info field is addressed to a non-AP HE STA from which the HE AP has received an HE Capabilities element with the STBC Tx > 80 MHz subfield in HE PHY Capabilities Information field equal to 0.

An HE STA that sends a Control frame in an HE ER SU PPDU format should use:

- DCM encoding if the most recently received PPDU sent by the HE STA, after association, to the STA soliciting the Control frame used DCM; otherwise the STA should not use DCM for the Control frame.
- 106-tone HE ER SU PPDU if the most recently received PPDU sent by the HE STA, after association, to the STA soliciting the Control frame was a 106-tone HE ER SU PPDU; otherwise the STA should not use a 106-tone HE ER SU PPDU for the Control frame.

NOTE—Transmit parameter switching occurs in subsequent TXOPs. A STA that solicits a Control frame from a peer STA accounts for the transmit parameter of the Control frame to calculate the expected duration of the TXOP. The responding STA determines that the most recent PPDU sent to the soliciting STA is received if it receives an immediate acknowledgment by the soliciting STA in response to the PPDU.

26.15.4 Rate selection constraints for HE STAs

26.15.4.1 Receive HE-MCS and NSS Set

The receive HE-MCS and NSS set is the set of <HE-MCS, NSS> tuples for PPDU bandwidths less than or equal to 80 MHz, 160 MHz PPDUs or 80+80 MHz PPDUs that a STA is capable of receiving. The receive HE-MCS and NSS set for a first STA is determined by a second HE STA for each <HE-MCS, NSS> tuple NSS = 1, …, 8 and PPDU bandwidth (less than or equal to 80 MHz, and 160 MHz or 80+80 MHz) from the

Supported HE-MCS And NSS Set field of the HE Capabilities element received from the first STA as follows:

— If support for the HE-MCS for NSS spatial streams at that PPDU bandwidth is mandatory (see 27.1.1 (Introduction to the HE PHY)), then the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on receive.

— Otherwise, if the Max HE-MCS For *n* SS subfield (*n* = NSS) in each Rx HE-MCS Map *b* subfield for $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$ indicates support and neither the Operating Mode field nor the OM Control subfield is received from the first HE STA, then the <HE-MCS, NSS> tuple at PPDU bandwidth *b* for a given operating channel width is supported by the first STA on receive as defined in 9.4.2.247.4 (Supported HE-MCS And NSS Set field).

— Otherwise,

- If the Operating Mode field is received from the first HE STA, the <HE-MCS, NSS> tuple at that PPDU bandwidth for a given operating channel width is supported by the first STA on receive as defined in 9.4.2.247.4 (Supported HE-MCS And NSS Set field) and by Equation (9-2a).
- If the OM Control subfield is received from the first HE STA, the <HE-MCS, NSS> tuple at that PPDU bandwidth for a given operating channel width is supported by the first STA on receive as defined in 9.4.2.247.4 (Supported HE-MCS And NSS Set field) and by Equation (26-4).

— Otherwise, the <HE-MCS, NSS> tuple at that PPDU bandwidth is not supported by the first STA on receive.

The <HE-MCS, NSS> tuples excluded by 26.15.4.3 (Additional rate selection constraints for HE PPDUs) can also be eliminated from the receive HE-MCS and NSS set.

An HE STA shall not, unless explicitly stated otherwise, transmit an HE PPDU unless the <HE-MCS, NSS> tuple and bandwidth used are in the receive HE-MCS and NSS set of the receiving STA(s).

26.15.4.2 Transmit HE-MCS and NSS Set

The transmit HE-MCS and NSS set is the set of <HE-MCS, NSS> tuples for PPDU bandwidth less than or equal to 80 MHz, 106 MHz PPDUs or 80+80 MHz PPDUs that a STA is capable of transmitting. The transmit HE-MCS and NSS set of a first STA is determined by a second STA for each <HE-MCS, NSS> tuple NSS = 1, …, 8 and PPDU bandwidth (less than or equal to 80 MHz, and 160 MHz or 80+80 MHz) from the Supported HE-MCS And NSS Set field received from the first STA as follows:

— If support for the <HE-MCS, NSS> tuple at that bandwidth is mandatory (see 27.1.1 (Introduction to the HE PHY)), then the <HE-MCS, NSS> tuple at that PPDU bandwidth is supported by the first STA on transmit.

— Otherwise, if the Max HE-MCS For *n* SS subfield (*n* = NSS) in each Tx HE-MCS Map *b* subfield for $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$ indicates support, then the <HE-MCS, NSS> tuple at PPDU bandwidth *b* for a given operating channel width is supported by the first STA on transmit as defined in 9.4.2.247.4 (Supported HE-MCS And NSS Set field).

— Otherwise, the <HE-MCS, NSS> tuple at that PPDU bandwidth is not supported by the first STA on transmit.

A non-AP STA may exclude certain numbers of space-time streams, N_{STS}, as defined in 26.9.3 (Transmit operating mode (TOM) indication) from its transmit HE-MCS and NSS set.

26.15.4.3 Additional rate selection constraints for HE PPDUs

A STA shall not transmit a 20 MHz or 40 MHz HE PPDU with an <HE-MCS, NSS> tuple that has HE-MCS 0, 1, 2 or 3 and NSS less than or equal to 4 to a receiver STA that has marked as unsupported the HT-MCS with value HE-MCS + 8 × (NSS – 1) in the Rx MCS Bitmask subfield in the Supported MCS Set field in the

HT Capabilities element it transmits. The transmission of a 20 MHz or 40 MHz HE PPDU with HE-MCS greater than 3 is not subject to this constraint.

A STA shall not transmit an 80 MHz, 160 MHz or 80+80 MHz HE PPDU with an <HE-MCS, NSS> tuple that has HE-MCS 0 or 1 and NSS less than or equal to 4 to a receiver STA that has marked as unsupported the HT-MCS values of both 2 × HE-MCS + 8 × (NSS – 1) and 2 × HE-MCS + 1 + 8 × (NSS – 1) in the Rx MCS Bitmask subfield in the Supported MCS Set field in the HT Capabilities element it transmits. The transmission of an 80 MHz, 160 MHz or 80+80 MHz HE PPDU with HE-MCS greater than 1 is not subject to this constraint.

An example tabulation of this behavior is given in Table 26-13 (Example of rate selection for HE PPDUs).

Table 26-13—Example of rate selection for HE PPDUs

HT-MCSs that are marked as unsupported	<HE-MCS, NSS> tuples that are not used for CBW20 and CBW40	<HE-MCS, NSS> tuples that are not used for CBW80, CBW160, and CBW80+80
0, 8, 16	<0, 1>, <0, 2>, <0, 3>	-
1, 9	<1, 1>, <1, 2>	-
10	<2, 2>	-
3	<3, 1>	-
0, 1	<0, 1>, <1, 1>	<0, 1>
2, 3	<2, 1>, <3, 1>	<1, 1>
0, 1, 8, 9	<0, 1>, <1, 1>, <0, 2>, <1, 2>	<0, 1>, <0, 2>

26.15.4.4 Rx Supported VHT-MCS and NSS Set

For each <VHT-MCS, NSS> tuple, NSS = 1, …, 8, and bandwidth (20 MHz, 40 MHz, 80 MHz, and 160 MHz or 80+80 MHz) from the Supported VHT-MCS and NSS Set field received from a first STA, a second HE STA shall follow the rules in subclause 10.6.13.1 (Rx Supported VHT-MCS and NSS Set) to determine the Rx Supported VHT-MCS and NSS Set of the first HE STA with the following exception:

— If the second HE STA receives OM Control subfield from the first HE STA, the receive HE-MCS and NSS Set of a first HE STA is determined by a second HE STA according to 9.4.2.157.3 (Supported VHT-MCS and NSS Set field) and Table 26-9 (Setting of the VHT Channel Width and VHT NSS at an HE STA transmitting the OM Control subfield).

NOTE—If the second STA receives both an Operating Mode field and an OM Control subfield from the first STA, the rules in 26.9.1 (General) apply.

26.15.5 Additional rules for ER beacons and group addressed frames

An AP that transmits a Beacon frame or group addressed frames in an HE ER SU PPDU shall transmit the HE ER SU PPDU with an <HE-MCS, NSS> tuple where the HE-MCS is a mandatory HE-MCS and NSS = 1.

A Beacon frame or a group addressed frame transmitted in an HE ER SU PPDU shall be sent as an S-MPDU (see Table 9-532 (A-MPDU contents in the S-MPDU context)), except for group addressed Data frames, which are not required to be sent as an S-MPDU, but are required to follow the rules in 10.12.4 (A-MPDU aggregation of group addressed Data frames).

The HE AP transmitting the HE ER SU PPDU shall set the TXVECTOR parameters as follows:

- CH_BANDWIDTH to ER-RU-242
- HE_LTF_TYPE to 2xHE-LTF and GI_TYPE to 0u8s_GI or 1u6s_GI, or HE_LTF_TYPE to 4xHE-LTF and GI_TYPE to 3u2s_GI
- FEC_CODING to BCC_CODING
- STBC to 0
- DCM to 0
- DOPPLER to 0
- BEAMFORMED to 0
- NUM_STS to 1
- NOMINAL_PACKET_PADDING to 16 µs
- NO_SIG_EXTN to false in the 2.4 GHz band and true otherwise
- BEAM_CHANGE as defined in 26.11.3 (BEAM_CHANGE)

26.15.6 Additional rules for HE beacons and group addressed frames

An AP that transmits a Beacon frame or group addressed frames in an HE SU PPDU shall transmit the HE SU PPDU with an <HE-MCS, NSS> tuple where the HE-MCS is a mandatory HE-MCS and NSS = 1.

NOTE—An AP might send a Beacon frame in an HE SU PPDU only when operating in the 6 GHz band (see 26.17.2.2 (Beacons in the 6 GHz band)).

A Beacon frame or a group addressed frame transmitted in an HE SU PPDU shall be sent as an S-MPDU (see Table 9-532 (A-MPDU contents in the S-MPDU context)), except for group addressed Data frames, which are not required to be sent as an S-MPDU, but are required to follow 10.12.4 (A-MPDU aggregation of group addressed Data frames).

If the HE SU PPDU contains a group addressed frame intended for at least one STA that is not associated to the AP, then the HE AP shall set the TXVECTOR parameters for the HE PPDU as follows:

- CH_BANDWIDTH to CBW20
- HE_LTF_TYPE to 2xHE-LTF and GI_TYPE to 0u8s_GI or 1u6s_GI, or HE_LTF_TYPE to 4xHE-LTF and GI_TYPE to 3u2s_GI
- FEC_CODING to BCC_CODING
- STBC to 0
- DCM to 0
- DOPPLER to 0
- BEAMFORMED to 0
- NOMINAL_PACKET_PADDING to 16 µs
- NO_SIG_EXTN to false in the 2.4 GHz band and true otherwise
- BEAM_CHANGE as defined in 26.11.3 (BEAM_CHANGE)

Otherwise, if the HE SU PPDU contains group addressed frames intended only for associated STAs then the AP shall set the TXVECTOR parameters listed above to values that are indicated as supported by all the intended STAs, except that the CH_BANDWIDTH shall be set to CBW20 if at least one of the intended STAs is currently not in the awake state.

26.15.7 Additional rules for group addressed frames in an HE MU PPDU

An HE AP may include group addressed frames in an HE MU PPDU subject to the rules defined in this subclause.

An HE AP shall not include a Beacon frame in an HE MU PPDU.

An HE AP that includes a group addressed frame in an HE MU PPDU shall ensure that the frame is included in a broadcast RU in the HE MU PPDU. The HE AP shall additionally ensure that the following conditions are satisfied for the broadcast RU:

- The RU allocation shall comply with the rules in 26.5.1.3 (RU allocation in an HE MU PPDU) and 27.3.2.8 (RU restrictions for 20 MHz operation)
- The <HE-MCS, NSS> tuple shall have a mandatory HE-MCS and NSS = 1
- The broadcast RU shall be located within:
  - The primary 20 MHz channel if the group addressed frame is a FILS Discovery or a Probe Response frame, except when the primary 20 MHz channel does not coincide with a PSC and the AP is a 6 GHz-only AP, in which case the broadcast RU may be in a PSC that is within the BSS operating channel width (see 26.17.2.3 (Scanning in the 6 GHz band)). The broadcast RU size shall not exceed 106 subcarriers if the MU PPDU has a bandwidth that is greater than 20 MHz.
  - The primary 20 MHz channel if the group addressed frame is addressed to at least one associated non-AP STA that has not declared to be in the awake state. The broadcast RU size shall not exceed 106 subcarriers if the MU PPDU has a bandwidth that is greater than 20 MHz.
  - A bandwidth that is indicated as supported in reception by one or more associated non-AP STAs, if the group addressed frame is addressed only to those non-AP STAs and the STAs have declared to be in the awake state. The broadcast RU size shall not exceed the minimum common bandwidth that is supported in reception by all STAs in the HE Capabilities element they transmit or in the most recently sent OM Control or OMN frames.
  - The SST subchannel if the group addressed frame is addressed to one or more HE SST STAs, the primary 20 MHz channel does not coincide with the subchannel assigned to the HE SST STAs and the frame is not addressed to any STAs other than the HE SST STAs in that subchannel (see 26.8.7.2 (SST operation)). The broadcast RU size shall not exceed 106 subcarriers if the SST subchannel is 20 MHz.
- The TXVECTOR parameters listed below shall be set as follows:
  - HE_LTF_TYPE to 2xHE-LTF and GI_TYPE to 0u8s_GI or 1u6s_GI, or HE_LTF_TYPE to 4xHE-LTF and GI_TYPE to 3u2s_GI
  - FEC_CODING to BCC_CODING
  - STBC to 0
  - DCM to 0
  - DOPPLER to 0
  - BEAMFORMED to 0
  - NOMINAL_PACKET_PADDING to 16 μs
  - NO_SIG_EXTN to false in the 2.4 GHz band and true otherwise
  - BEAM_CHANGE as defined in 26.11.3 (BEAM_CHANGE)
  - STA_ID as defined in 26.11.1 (STA_ID)

Group addressed frames transmitted in an HE MU PPDU shall be sent as an S-MPDU (see Table 9-532 (A-MPDU contents in the S-MPDU context)) except for group addressed Data frames, which may also be sent within an A-MPDU subject to the rules in 10.12.4 (A-MPDU aggregation of group addressed Data frames).

26.15.8 Additional rules for PPDUs sent in the 6 GHz band

An HE STA that transmits a PPDU that is not sent in response to a Trigger frame in the 6 GHz band and that contains a frame that is not a control response frame with the Address 1 field set to the MAC address of an HE AP with which it is not associated and from which it has received a FILS Discovery frame or an HE Operation element shall ensure that the PPDU meets the following conditions:

— The bandwidth of the PPDU is less than or equal to the operating bandwidth of the HE BSS as indicated in the BSS Operating Channel Width subfield of the FILS Discovery frame or in the Channel Width subfield of the HE Operation element sent by the AP

— The PPDU is transmitted with a number of spatial streams that is less than or equal to the maximum number of spatial streams of the HE BSS as indicated in the Maximum Number of Spatial Stream subfield of the FILS Discovery frame or in the Basic HE-MCS and NSS Set field of the HE Operation element sent by the AP

— If the PPDU is an HE PPDU, then the PPDU is transmitted with an <HE-MCS, NSS> tuple providing a data rate that is greater than or equal to the minimum rate indicated in the FILS Minimum Rate field (if present) of the FILS Discovery frame or in the Minimum Rate field of the HE Operation element sent by the AP.

— If the PPDU is a non-HT PPDU then the PPDU is transmitted with a data rate that is greater than or equal to the minimum of <R, 54 Mb/s>, where R is the minimum rate indicated in the FILS Minimum Rate field (if present) of the FILS Discovery frame or in the Minimum Rate field of the HE Operation element sent by the AP

An HE STA that transmits a PPDU that is not sent in response to a Trigger frame in the 6 GHz band and that contains a frame that is not a control response frame with Address 1 field set to the MAC address of the AP with which it is associated shall ensure that the PPDU meets the following conditions:

— If the PPDU is a non-HT (duplicate) PPDU then the PPDU is transmitted with a data rate that is greater than or equal to the minimum of <R, 54 Mb/s>, where R is the minimum rate indicated in the Minimum Rate field of the HE Operation element sent by the AP.

— If the PPDU is an HE PPDU then the PPDU is transmitted with an <HE-MCS, NSS> tuple providing a data rate that is not less than the data rate indicated in the Minimum Rate field of the HE Operation element sent by the AP.

An HE STA that transmits a PPDU that is not an HE TB PPDU in the 6 GHz band and that contains a frame that is not a control response frame with Address 1 field set to the MAC address of an AP with which it is not associated shall determine a local maximum transmit power for that transmission following the rules in 11.7.5 (Specification of regulatory and local maximum transmit power levels), if the local maximum transmit power is received in Transmit Power Envelope elements and combinations of Country elements and Power Constraint elements in the most recent Beacon or Probe Response frame, on the channel from that AP.

26.16 Midamble parameter setting rules

A STA shall not set the TXVECTOR parameter DOPPLER to 1 for an HE SU PPDU, HE ER SU PPDU or HE MU PPDU unless the STA has received from each of the intended recipient STAs an HE Capabilities element with the Doppler Rx subfield in the HE PHY Capabilities Information field equal to 1.

A STA shall not send a Trigger frame with the Doppler subfield in the Common Info field set to 1 unless the STA has received from each of the intended recipient STAs of the Trigger frame an HE Capabilities element with the Doppler Tx subfield in the HE PHY Capabilities Information field equal to 1.

A STA shall not set the TXVECTOR parameter HE_LTF_TYPE to 1xHE-LTF and the parameter DOPPLER to 1 for an HE SU PPDU unless the STA has received an HE Capabilities element from each of the intended recipient STAs where the HE PHY Capabilities Information field meets the following conditions:

- The Midamble Tx/Rx 2x And 1x HE-LTF subfield is 1
- The HE SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1

A STA shall not set the TXVECTOR parameter HE_LTF_TYPE to 1xHE-LTF and the parameter DOPPLER to 1 for an HE ER SU PPDU unless the HE STA has received from each of the intended recipient STAs an HE Capabilities element in which the HE PHY Capabilities Information field meets the following conditions:

- The Midamble Tx/Rx 2x And 1x HE-LTF subfield is 1
- The HE ER SU PPDU With 1x HE-LTF And 0.8 µs GI subfield is 1

A STA shall not set the TXVECTOR parameter HE_LTF_TYPE to 2xHE-LTF and the parameter DOPPLER to 1 for an HE SU PPDU, HE ER SU PPDU or HE MU PPDU unless the HE STA has received an HE Capabilities element with the Midamble Tx/Rx 2x And 1x HE-LTF subfield in the HE PHY Capabilities Information field equal to 1.

A non-AP STA shall not transmit an HE Capabilities element with the Doppler Tx subfield in the HE PHY Capabilities Information field set to 1 unless the non-AP STA meets all of the following conditions:

- The non-AP STA is capable of transmitting an HE TB PPDU with midambles and a 4x HE-LTF
- If non-AP STA has set the Midamble Tx/Rx 2x And 1x HE-LTF subfield in the HE PHY Capabilities Information field to 1, the non-AP STA is capable of transmitting an HE TB PPDU with midambles and a 2x HE-LTF
- If the non-AP STA has set both the Midamble Tx/Rx 2x And 1x HE-LTF and the Full Bandwidth UL MU-MIMO subfields in the HE PHY Capabilities Information field to 1, the non-AP STA is capable of transmitting an HE TB PPDU with midambles, using full bandwidth UL MU-MIMO, and a 1x HE-LTF

A STA that transmits an HE SU PPDU or HE ER SU PPDU with the TXVECTOR parameter DOPPLER set to 1 shall not set the TXVECTOR parameter NUM_STS to indicated a number of space-time streams that is greater than indicated in the Midamble Tx/Rx Max NSTS subfield in the HE PHY Capabilities Information subfield of the HE Capabilities element received from any of the intended recipient STAs.

A STA transmitting an HE MU PPDU with the TXVECTOR parameter DOPPLER set to 1 shall not set the TXVECTOR parameter NUM_STS[*u*] to indicate a number of space-time streams that is greater than indicated in the Midamble Tx/Rx Max NSTS subfield in the HE PHY Capabilities Information subfield of the HE Capabilities element received from the intended recipient STA *u*.

An AP transmitting a Trigger frame with the Doppler subfield in the Common Info field set to 1 shall not set the Number Of Spatial Streams subfield in a User Info field in the Trigger frame to indicate a number of space-time streams that is greater than indicated in the Midamble Tx/Rx Max NSTS subfield in the HE PHY Capabilities Information subfield of the HE Capabilities element received from the STA addressed by the User Info field.

26.17 HE BSS operation

26.17.1 Basic HE BSS operation

The Beacon frames generated within an HE BSS contain an HE Operation element.

An HE STA has dot11HEOptionImplemented equal to true.

A STA that is operating in an HE BSS shall be able to receive and transmit at each of the <HE-MCS, NSS> tuple values indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter of the MLME-START.request primitive and shall be able to receive at each of the <HE-MCS, NSS> tuple values indicated by the Supported HE-MCS and NSS Set field of the HE Capabilities parameter of the MLME-START.request primitive.

The basic HE-MCS and NSS set is the set of <HE-MCS, NSS> tuples that are supported by all HE STAs that are members of an HE BSS. It is established by the STA that starts the HE BSS, indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive. Other HE STAs determine the basic HE-MCS and NSS set from the Basic HE-MCS And NSS Set field of the HE Operation element in the BSSDescription derived through the scan mechanism (see 11.1.4.1 (General)).

An HE STA shall not attempt to join (MLME-JOIN.request primitive) a BSS unless it supports (i.e., is able to both transmit and receive using) all of the <HE-MCS, NSS> tuples in the basic HE-MCS and NSS set.

NOTE—An HE STA does not attempt to (re)associate with an HE AP unless the STA supports (i.e., is able to both transmit and receive using) all of the <HE-MCS, NSS> tuples in the Basic HE-MCS And NSS Set field in the HE Operation element transmitted by the AP because the MLME-JOIN.request primitive is a necessary precursor to (re)association.

A STA operating in the 2.4 GHz band that sets dot11HEOptionImplemented to true shall set dot11HighThroughputOptionImplemented to true. A STA operating in the 5 GHz or 6 GHz band that sets dot11HEOptionImplemented to true shall set both dot11VHTOptionImplemented and dot11HighThroughputOptionImplemented to true. A non-AP STA that sets dot11HEOptionImplemented to true shall set dot11MultiBSSIDImplemented to true.

An HE STA operating in the 6 GHz band shall inherit the functionalities of a VHT STA except that it is exempt from following VHT and HT functionalities and/or requirements that are unavailable or superseded by equivalent HE functionalities and/or requirements (see Clauses 26 (High Efficiency (HE) MAC specification)and 27 (High Efficiency (HE) PHY specification)), and that it shall use the HE format instead of the VHT, HT_GF, or HT_MF format for PPDUs transmitted in the 6 GHz band. Additional HE functionalities and/or requirements for the 6 GHz band are defined in 26.17.2 (HE BSS operation in the 6 GHz band).

A STA that is an HE AP or an HE mesh STA declares the channel widths at which it is capable of operating in the PHY Capabilities Information field of the HE Capabilities element that it transmits (see Table 9-321b (Subfields of the HE PHY Capabilities Information field)).

An HE AP operating in the 5 GHz or 6 GHz bands shall set B1 in the Supported Channel Width Set field in the PHY Capabilities Information field in the HE Capabilities element to indicate support for 40 MHz and 80 MHz channel width.

A STA transmitting an HT Capabilities element and HE Capabilities element shall set the Supported Channel Width Set subfield of the HT Capabilities element to 1 if either B0 or B1 of the Supported Channel Width Set subfield of the HE Capabilities element is 1 unless the STA is a 20 MHz-only non-AP HE STA, in which case the Supported Channel Width Set subfield of the HT Capabilities element is set to 0.

A STA transmitting a VHT Capabilities element and HE Capabilities element shall set the Supported Channel Width Set subfield of the VHT Capabilities element to indicate the same channel width as indicated in the HE Capabilities element unless the STA is a 20 MHz-only non-AP HE STA, in which case the Supported Channel Width Set subfield of the VHT Capabilities element is reserved.

At a minimum, an HE STA sets the Rx MCS Bitmask subfield of the Supported MCS Set field of its HT Capabilities element according to the setting of each Rx HE-MCS Map b subfield, $b \in \{\leq 80$ MHz, 160

MHz, 80+80 MHz}, of the Supported HE-MCS And NSS Set field of its HE Capabilities element as follows: for each Max HE-MCS For n SS subfield, $1 \leq n \leq 4$, of each Rx HE-MCS Map b subfield, $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz}, with a value other than 3 (no support for that number of spatial streams), the STA shall indicate support for HT MCSs $8 \times (n - 1)$ to $8 \times (n - 1) + 7$ in the Rx MCS Bitmask subfield, where n is the number of spatial streams, except for those HT-MCSs marked as unsupported as described in 26.15.4.3 (Additional rate selection constraints for HE PPDUs).

An HE AP or an HE mesh STA shall set the VHT Operation Information Present field in the HE Operation element to 0 if a VHT Operation element is present in the frame that carries the HE Operation element or if the frame that carries the HE Operation element is sent in the 2.4 GHz band. An HE AP or HE mesh STA shall set the VHT Operation Information Present field in the HE Operation element to 1 if a VHT Operation element is not present in the frame that carries the HE Operation element and the frame is sent in the 5 GHz band.

An HE AP or an HE mesh STA that transmits an HE Operation element that has the VHT Operation Information Present field set to 1 shall do one of the following to set the BSS operating channel:

- Set the STA Channel Width subfield and Channel Center Frequency Segment 2 subfield in the HT Operation Information field in the HT Operation element, the Channel Width subfield in the VHT Operation Information field in the HE Operation element, the Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the VHT Operation Information field in the HE Operation element to indicate the BSS bandwidth as defined in Table 11-24 (VHT BSS bandwidth) and Table 11-26 (Extended NSS channel width) respectively based on the Extended NSS BW Support and Supported Channel Width Set fields.
- Set the STA Channel Width subfield and Channel Center Frequency Segment 2 subfield in the HT Operation Information field in the HT Operation element, the Channel Width subfield in the VHT Operation Information field in the HE Operation element, the Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the VHT Operation Information field in the HE Operation element to indicate the BSS bandwidth as defined in Table 11-24 (VHT BSS bandwidth) and Table 11-26 (Extended NSS channel width) respectively based on the Rx HE-MCS Map ≤ 80 MHz, Rx HE-MCS Map 160 MHz, and Rx HE-MCS Map 80+80 MHz fields.

NOTE 1—The Channel Center Frequency Segment 2 is 0 if Table 11-24 (VHT BSS bandwidth) is applied.

NOTE 2—These two methods give the same result.

The setting of the Channel Center Frequency Segment 0, Channel Center Frequency Segment 1 and Channel Center Frequency Segment 2 subfields is defined in Table 11-25 (Setting of Channel Center Frequency Segment 0, Channel Center Frequency Segment 1 and Channel Center Frequency Segment 2 subfields), except that the Max NSS support is provided by the HE STA in frames that contain an HE Capabilities element (see 9.4.2.247 (HE Capabilities element)) and an Operating Mode field (see 9.2.4.6.4.3 (Operating Mode) and 9.4.1.53 (Operating Mode field)), where in the table the maximum NSS support refers to the HE maximum NSS support instead of the VHT maximum NSS support for an HE STA.

An HE STA shall determine the channelization using the information in the Primary Channel field of the HT Operation element when operating in 2.4 GHz and the combination of the information in the Primary Channel field in the HT Operation element and the Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the VHT Operation Information field in the VHT Operation element if operating in the 5 GHz band (see 21.3.14 (Channelization)). An HE STA determines the channelization as defined in 26.17.2 (HE BSS operation in the 6 GHz band) if operating in the 6 GHz band.

An HE AP or an HE mesh STA shall set the Secondary Channel Offset subfield in the HT Operation Information field in the HT Operation element to indicate the secondary 20 MHz channel as defined in Table 9-168 (HT Operation element fields and subfields), if the BSS bandwidth is more than 20 MHz.

An HE STA that is a member of an HE BSS shall follow the rules in 11.40.1 (Basic VHT BSS functionality) when transmitting a 20 MHz, 40 MHz, 80 MHz, 160 MHz or 80+80 MHz HE PPDUs with the following exceptions:

— An HE TB PPDU sent in response to a triggering frame follows the rules defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation).

— An 80 MHz, 160 MHz or 80+80 MHz DL HE MU PPDU with preamble puncturing may be transmitted if the primary 20 MHz or the primary 40 MHz are occupied by the transmission and certain 20 MHz subchannels of the secondary channel are idle (see Table 27-20 (HE-SIG-A field of an HE MU PPDU) and 10.23.2.5 (EDCA channel access in VHT, HE, or TVHT BSS)).

An HE STA shall not transmit to a recipient HE STA using a channel width that is not indicated as supported in the Supported Channel Width Set subfield in the HE Capabilities element received from that HE STA.

An HE STA shall not transmit to a recipient HE STA using a channel width that exceeds the BSS channel width in the Channel Width field that is contained in:

— The HE Operation element most recently exchanged with the recipient STA, if any, and if the Channel Width field is present

— Otherwise, the VHT Operation element most recently exchanged with the recipient STA, if any

— Otherwise, the HT Operation element most recently exchanged with the recipient STA, if any.

A STA shall not transmit an HE PPDU to a recipient STA that carries a frame that is not an HE Compressed Beamforming/CQI frame (see 26.7.3 (Rules for HE sounding protocol sequences)) and that exceeds the maximum MPDU length capability indicated in the VHT Capabilities element last received from the recipient STA in the 2.4 GHz or 5 GHz band or, if a VHT Capabilities element has not been received from the recipient STA, that exceeds the maximum A-MSDU length indicated in the HT Capabilities element last received from the recipient STA in the 2.4 GHz or 5 GHz band.

A STA shall not transmit an HE PPDU to a recipient STA that carries a frame that is not an HE Compressed Beamforming/CQI frame (see 26.7.3 (Rules for HE sounding protocol sequences)) and that exceeds the maximum MPDU length capability indicated in the HE 6 GHz Band Capabilities element last received from the recipient STA in the 6 GHz band.

An HE AP shall set the RIFS Mode field in the HT Operation element to 0.

An HE STA follows the rules in 11.40 (VHT BSS operation) for channel selection, determining scanning requirements, channel switching, NAV assertion and antenna indication when operating in the 5 GHz or 6 GHz band unless explicitly stated otherwise in Clause 26. An HE STA shall additionally follow the rules in 26.17.2 (HE BSS operation in the 6 GHz band) for scanning and operation in the 6 GHz band.

An HE STA shall follow the rules in 11.16 (20/40 MHz BSS operation) for channel selection, determining scanning requirements, channel switching, NAV assertion when operating in 2.4 GHz unless explicitly stated otherwise in Clause 26.

The AP of an ER BSS shall not transmit a Probe Response or (Re)Association Response frame in response to a Probe Request or (Re)Association Request frame, respectively, sent by a non-HT STA, or that includes an HE Capabilities element where the Partial Bandwidth Extended Range subfield in the HE PHY Capabilities Information field is equal to 0 if the HE AP transmits an ER beacon in an HE ER SU PPDU with a 106-tone RU. An HE AP that is not operating an ER BSS may set the ER SU Disable subfield in the HE Operation element it transmits to 1.

A STA shall have the same value of maximum VHT NSS defined by its Rx HE-MCS Map ≤ 80 MHz subfield in the HE Capabilities element as the maximum NSS value indicated by its Rx VHT-MCS Map field in the VHT Capabilities element. If a STA supports 160 MHz, the Maximum NSS defined by its Rx VHT-MCS Map field and Extended NSS BW Support field in the VHT Capabilities element at 160 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map 160 MHz subfield in the HE Capabilities element at 160 MHz. If a STA supports 80+80 MHz, the maximum NSS defined by its Rx VHT-MCS Map field and Extended NSS BW Support field in the VHT Capabilities element at 80+80 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map 80+80 MHz subfield in the HE Capabilities element at 80+80 MHz. For every NSS in VHT Capabilities elements and HE Capabilities elements transmitted by a STA, if the maximum HE-MCS is 9 or more, the maximal VHT-MCS shall be 9. Otherwise the maximal VHT-MCS shall be the same as the HE-MCS. An HE STA shall not transmit a VHT Capabilities element with the Supported Channel Width Set field equal to 1 and the Extended NSS BW Support field equal to 3 or with the Supported Channel Width Set field equal to 2 and the Extended NSS BW Support field equal to 3.

If an HE STA supports 160 MHz, the maximum NSS defined by its Rx HE-MCS Map 160 MHz subfield for an HE-MCS in the HE Capabilities element at 160 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map ≤ 80 MHz subfield for the HE-MCS in the HE Capabilities element at 80 MHz.

If an HE STA supports 80+80 MHz, the maximum NSS defined by its Rx HE-MCS Map 80+80 MHz subfield for an HE-MCS in the HE Capabilities element at 80+80 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map ≤ 80 MHz subfield for the HE-MCS in the HE Capabilities element at 80 MHz.

26.17.2 HE BSS operation in the 6 GHz band

26.17.2.1 General

An HE STA that supports operation in the 6 GHz band sets dot11HE6GOptionImplemented to true.

An HE STA with dot11HE6GOptionImplemented equal to true and operating in the 6 GHz band is a 6 GHz HE STA.

A STA with dot11HE6GOptionImplemented equal to true shall have dot11ExtendedChannelSwitchActivated, dot11MultiDomainCapabilityActivated and dot11OperatingClassesRequired equal to true and shall set to 1 the value of the Extended Channel Switching field in the Extended Capabilities elements it transmits.

A 6 GHz HE STA shall meet the Class A requirements in 27.3.15 (Transmit requirements for PPDUs sent in response to a triggering frame).

An HE AP operating in the 6 GHz band shall indicate support for at least 80 MHz channel width.

An HE AP operating in the 6 GHz band shall set the Co-Hosted BSS subfield in HE Operation element to 0.

A 6 GHz HE STA shall not transmit an HT Capabilities element, VHT Capabilities element, HT Operation element, VHT Operation element or an HE Operation element that contains a VHT Operation Information field.

A 6 GHz HE STA shall not transmit in an HE PPDU a frame other than an HE Compressed Beamforming/CQI frame (see 26.7.3 (Rules for HE sounding protocol sequences)) that exceeds the maximum MPDU length capability indicated in the HE 6 GHz Band Capabilities element received from the recipient HE STA 6G.

An AP or mesh STA operating in the 6 GHz band shall include the 6 GHz Operation Information field in the HE Operation elements it transmits. The AP or mesh STA shall set the Channel Width subfield, the Channel

Center Frequency Segment 0, and the Channel Center Frequency Segment 1 subfields of the 6 GHz Operation Information field as defined in Table 26-14 (6 GHz BSS channel width), based on the Rx HE-MCS Map ≤ 80 MHz, Rx HE-MCS Map 160 MHz, and Rx HE-MCS Map 80+80 MHz subfields of the Supported HE MCS And NSS Set field of the HE Capabilities element transmitted by the AP.

Table 26-14—6 GHz BSS channel width

Channel Width field	Center Frequency Segment 1 field	BSS channel width
0	0	20 MHz
1	0	40 MHz
2	0	80 MHz
3	CCFS1 > 0 and |CCFS1 – CCFS0| = 8	160 MHz
3	CCFS1 > 0 and |CCFS1 – CCFS0| > 16	80+80 MHz
NOTE 1—CCFS0 represents the value of the Channel Center Frequency Segment 0 field and CCFS1 represents the value of the Channel Center Frequency Segment 1 field.		

A 6 GHz HE STA shall determine the BSS channelization using the Primary Channel, Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the 6 GHz Operation Information field in the HE Operation element when operating in 6 GHz band (see 21.3.14 (Channelization) for the channelization and 27.3.23.2 (Channel allocation in the 6 GHz band) for the equation defining the channel center frequencies in the 6 GHz band).

A STA shall not transmit an HT PPDU in the 6 GHz band. A STA shall not transmit a VHT PPDU in the 6 GHz band. A STA shall not transmit a DSSS, HR/DSSS, or ERP-OFDM PPDU in the 6 GHz band.

A 6 GHz HE STA shall set dot11SpectrumManagementRequired to true and operate as defined in 11.7 (TPC procedures).

A 6 GHz AP shall set dot11FILSOmitReplicateProbeResponses to true.

A 6 GHz HE AP may respond with a (Re)Association Response frame with the Status Code field indicating DENIED_POOR_CHANNEL_CONDITIONS if it receives a (Re)Association Request frame from a non-AP STA below a minimum RSSI threshold value. A 6 GHz HE AP may send a Disassociation frame with the Reason Code field indicating POOR_RSSI_CONDITIONS to an associated non-AP STA if it receives frames from the STA below a minimum RSSI threshold value for a sufficiently long period of time. How an AP selects a minimum RSSI threshold value or sufficient interval of time is out of scope of this specification.

A 6 GHz non-AP HE STA that receives a (Re)Association Response frame with the Status Code field indicating DENIED_POOR_CHANNEL_CONDITIONS or a Disassociation frame with the Reason Code field indicating POOR_RSSI_CONDITIONS from a 6 GHz HE AP should not transmit a (Re)Association Request frame or a Probe Request frame to the AP until one of the following condition is met:

— Sufficient time has passed since it received the (Re)Association Response frame or Disassociation frame from the AP.

— The STA has determined that a (Re)Association Request frame or Probe Request frame that it transmits will be received by the AP at a sufficiently high RSSI level and in sufficiently good conditions compared with its previous transmission to the AP.

How a non-AP STA determines sufficient time has passed or a suitable RSSI threshold is out of scope of the standard.

26.17.2.2 Beacons in the 6 GHz band

An HE AP 6G transmits Beacon frames as defined in 11.1 (Synchronization), which may be contained in a non-HT PPDU, non-HT duplicate PPDU, or HE SU PPDU.

An HE AP 6G that transmits a Beacon frame in a non-HT PPDU follows the rules in 10.6.5.1 (Rate selection for non-STBC Beacon and non-STBC PSMP frames).

An HE AP 6G that transmits a Beacon frame in a non-HT duplicate PPDU shall follow the rules in 10.6.5.1 (Rate selection for non-STBC beacon and non-STBC PSMP frames) and shall set the TXVECTOR parameter CH_BANDWIDTH of the PPDU to a value that is up to the operating channel width of the BSS.

If an HE AP 6G schedules a Beacon frame for transmission in a non-HT duplicate PPDU then it shall set the Duplicate Beacon subfield to 1 in the 6 GHz Operation Information field of the HE Operation element it transmits; otherwise the AP shall set the Duplicate Beacon subfield to 0.

An HE AP 6G that transmits a Beacon frame in an HE SU PPDU shall follow the rules defined in 26.15.6 (Additional rules for HE beacons and group addressed frames).

An AP shall not transmit a Beacon frame in an HE SU PPDU or non-HT duplicate PPDU in the 2.4 GHz or 5 GHz bands.

26.17.2.3 Scanning in the 6 GHz band

26.17.2.3.1 General

A 6 GHz AP may set dot11ColocatedRNRImplemented to true and shall set dot11ShortSSIDListImplemented to true. An AP that is in the same co-located AP set as a 6 GHz AP shall set dot11ColocatedRNRImplemented to true and dot11ShortSSIDListImplemented to true.

In the 6 GHz band, a STA shall not transmit a Probe Request frame to the broadcast destination address that includes a Short SSID List element with more than one Short SSID field.

NOTE—In bands other than the 6 GHz band, there might be more than one Short SSID field in a Short SSID List element in a Probe Request frame to the broadcast destination address. A Probe Request frame does not contain more than one Short SSID List element (see Table 9-40 (Probe Request frame body)).

26.17.2.3.2 AP behavior for fast passive scanning

A 6 GHz AP that does not share the same co-located AP set as an AP operating in the 2.4 GHz band or 5 GHz band is referred to as a 6 GHz-only AP.

A 6 GHz-only AP shall, unless it does not intend to be efficiently discovered by STAs using scanning in the 6 GHz band, set dot11FILSFDFrameBeaconMaximumInterval to a nonzero value that is less than or equal to 20 TUs.

A 6 GHz AP that has dot11FILSFDFrameBeaconMaximumInterval equal to a nonzero value shall schedule for transmission FILS Discovery frames as described in 11.46.2.1 (FILS Discovery frame transmission), except that the following apply:

- If the FILS Discovery frame is contained in a DL HE MU PPDU then it shall be included in the broadcast RU of the DL HE MU PPDU as defined in 26.15.7 (Additional rules for group addressed frames in an HE MU PPDU).
- If dot11UnsolicitedProbeResponseOptionActivated is true, all FILS Discovery frames shall be omitted and an unsolicited broadcast Probe Response frame shall be scheduled for transmission at the target transmit time instead of each FILS Discovery frame.
- If dot11UnsolicitedProbeResponseOptionActivated is false, then a FILS Discovery frame may be omitted and an unsolicited broadcast Probe Response frame shall be scheduled for transmission at the target transmit time instead of that FILS Discovery frame.

An AP with dot11UnsolicitedProbeResponseOptionActivated equal to true shall set dot11FILSFDFrameBeaconMaximumInterval to a nonzero value that is less than or equal to 20 TUs.

An AP operating in the 6 GHz band may set dot11FILSFDFrameBeaconMaximumInterval to a nonzero value.

An AP operating in the 6 GHz band may send an unsolicited broadcast Probe Response frame. The Probe Response frame may be included in the broadcast RU of a DL HE MU PPDU as defined in 26.15.7 (Additional rules for group addressed frames in an HE MU PPDU). The Probe Response may be carried in a non-HT duplicate PPDU in which case the PPDU shall have the TXVECTOR parameter CH_BANDWIDTH set to a value that is up to the operating channel width of the BSS.

An HE AP operating in the 6 GHz band that transmits a FILS Discovery frame carrying an FD Capability field shall set the PHY Index subfield to 4.

An AP that corresponds to a nontransmitted BSSID does not schedule for transmission FILS Discovery frames (see 11.46.2.1 (FILS Discovery frame transmission)) or unsolicited broadcast Probe Response frames (see 11.1.4.3.4 (Criteria for sending a response)).

If a 6 GHz-only EMA AP transmits a FILS Discovery frame, then the AP shall include in the FILS Discovery frame a Reduced Neighbor Report element carrying information on all nontransmitted BSSIDs in the multiple BSSID set that are discoverable (see 11.50 (Reduced neighbor report)).

NOTE—A FILS Discovery frame received from a 6 GHz AP with the Multiple BSSIDs Presence Indicator subfield equal to 1 and not carrying a Reduced Neighbor Report element implies that the AP's Beacon frame at the advertised TBTT carries a complete list of nontransmitted BSSID profiles or that the information of the nontransmitted BSSID(s) is advertised in the 2.4 GHz or 5 GHz band by a co-located AP.

If a 6 GHz-only EMA AP transmits a Beacon or broadcast Probe Response frame carrying a partial list of nontransmitted BSSID profiles, then the AP shall include in the frame a Reduced Neighbor Report element with information on all nontransmitted BSSIDs in the multiple BSSID set that are discoverable and not carried in that frame (see 11.50 (Reduced neighbor report)).

A 6 GHz-only AP should set up the BSS with a primary 20 MHz channel that coincides with a preferred scanning channel (PSC) (see 26.17.2.3.3 (Non-AP STA scanning behavior)).

NOTE—An AP might initiate a BSS with a primary channel that coincides with a PSC in order to assist STAs that are scanning the 6 GHz band to discover the BSS. The AP might subsequently switch its operating channel to a non-PSC (e.g., using a CSA mechanism) if it does not expect additional (not yet associated) STAs will need to discover the BSS.

A 6 GHz AP shall not respond to a Probe Request frame if the frame carries a FILS Request Parameters element and the AP is unable to satisfy the response time constraint specified in the Max Channel Time field in the element (see 11.1.4.3.4 (Criteria for sending a response)). If a 6 GHz AP receives a Probe Request frame and responds with a Probe Response frame (per 11.1.4.3.4 (Criteria for sending a response)), the Address 1 field of the Probe Response frame shall be set to the broadcast address unless the AP is not indicating its actual SSID in the SSID element of its Beacon frames.

26.17.2.3.3 Non-AP STA scanning behavior

The set of 20 MHz channels in the 6 GHz band, with channel center frequency, ch_a = Channel starting frequency – 55 + 80 × n (MHz) are referred to as preferred scanning channels (PSCs). Channel starting frequency is defined in 27.3.23.2 (Channel allocation in the 6 GHz band), and n = 1, …, 15.

NOTE—PSCs might not all be available in a specific location due to regulatory restrictions. A STA scanning the 6 GHz band knows where these PSCs are located since their position is fixed.

A non-AP STA that is actively scanning a channel in the 6 GHz band shall operate as defined in 11.1.4.3.2 (Active scanning procedure for a non-DMG STA), unless a given rule is superseded by the rules defined in 26.17.2.3 (Scanning in the 6 GHz band).

The non-AP STA shall not transmit a Probe Request frame to the broadcast destination address with the Address 3 field set to the wildcard BSSID, and the SSID set to the wildcard SSID.

The non-AP STA shall not send a Probe Request frame to the broadcast destination address with the Address 3 field (BSSID) set to the BSSID of an AP from which it has already received a Probe Response or a Beacon frame since the start of its scanning on that channel.

The non-AP STA shall not send a Probe Request frame to the broadcast destination address with the Address 3 field (BSSID) set to the BSSID of a nontransmitted BSSID if it has already received the nontransmitted BSSID profile for that BSSID via a Beacon frame or Probe Response frame sent by the transmitted BSSID since the start of its scanning on that channel.

The non-AP STA shall not send a Probe Request frame to the broadcast destination address with the SSID field and/or the Address 3 field set to the SSID and/or BSSID, respectively, of an AP for which it has received a Reduced Neighbor Report or Neighbor Report element with the Unsolicited Probe Responses Active subfield corresponding to that AP set to 1 and that indicates that the AP is operating in that channel until the FILSProbeTimer reaches dot11FILSProbeDelay.

The non-AP STA shall not transmit more than one Probe Request frame to the broadcast destination address with the Address 3 field set to the wildcard BSSID and the SSID field not set to the wildcard SSID during each 20 TU period scanning the channel. The non-AP STA shall not transmit more than three Probe Request frames to the broadcast destination address with Address 3 field set to a non-wildcard BSSID during each 20 TU period scanning the channel.

The non-AP STA shall set dot11FILSProbeDelay to a value equal to or greater than 20 TU.

NOTE—A non-AP STA waits for at least 20 TU so that it maximizes the probability of receiving FILS Discovery or broadcast Probe Response frames, if any, sent by an AP in that channel (see 26.17.2.3.2 (AP behavior for fast passive scanning)).

If the non-AP STA is scanning a channel, then the following apply:

— If the STA has received a FILS Discovery frame indicating that an AP is operating in that channel, or if the STA has received a Reduced Neighbor Report or Neighbor Report element indicating that an AP is operating in that channel then the STA may, subject to the other rules in this clause, send a Probe Request frame to the broadcast destination address in that channel, with the SSID field set to the SSID that corresponds to that AP or with the Short SSID field of the Short SSID List element set to the short SSID that corresponds to that AP and/or with the Address 3 field set to the BSSID of that AP, starting from step c) of 11.1.4.3.2 (Active scanning procedure for a non-DMG STA)

— Otherwise, if the channel is a PSC and the STA has determined the medium to be idle for a continuous period of at least dot11MinPSCProbeDelay from the start of the scan on the channel then the STA may, subject to other rules in this subclause, send a Probe Request frame to the broadcast destination address in that channel, with the SSID field set to the SSID that corresponds to an AP or with the Short SSID field of the Short SSID List element set to the short SSID that corresponds to an AP, and/or with the Address 3 field set to the BSSID of an AP, after invoking the backoff procedure, described in 10.23.2.2 (EDCA backoff procedure) and starting from step c) of 11.1.4.3.2 (Active scanning procedure for a non-DMG STA)

— Otherwise, if the STA has discovered the presence of an AP in that channel through means that are out of scope of the standard and the AP might be detected by the STA, then the STA may send a Probe Request frame to the broadcast destination address in that channel, with the Address 3 field set to the BSSID of that AP starting from step c) of 11.1.4.3.2 (Active scanning procedure for a non-DMG STA)

— Otherwise, if the FILSProbeTimer reaches dot11FILSProbeDelay and the channel is a PSC, then the STA may, subject to the other rules in this subclause, send a Probe Request to the broadcast destination address in that channel, starting from step c) of 11.1.4.3.2 (Active scanning procedure for a non-DMG STA),

— Otherwise, the STA shall not send a Probe Request frame to the broadcast destination address in that channel.

NOTE 1—The STA might send an individually addressed Probe Request frame to an AP for reasons other than active scan (e.g. to obtain an updated EDCA parameter set) even if it has already received a FILS Discovery, Probe Response or Beacon frame from that AP.

NOTE 2—An AP might be detected by a STA if the STA and the AP are on the same channel and in range.

If a non-AP STA sends a Probe Request frame in the 6 GHz band that includes a FILS Request Parameters element, then the non-AP STA shall set the value of PHY Support Criterion subfield in the element to either 0 or 3.

26.17.2.4 Out of band discovery of a 6 GHz BSS

An AP that operates in the 2.4 GHz or 5 GHz band and that is in the same co-located AP set as one or more 6 GHz APs shall include in Beacon and Probe Response frames that it transmits a Reduced Neighbor Report element with the Co-Located AP subfield in the BSS Parameters subfield in the TBTT Information field set to 1 to provide at least the operating channels and operating classes of those 6 GHz APs.

NOTE—The Reduced Neighbor Report element might contain information on 6 GHz APs that are not in the same co-located AP set as the transmitting AP. In this case the Co-Located AP subfield is set to 0.

An AP responds to a probe request by following the rules defined in 11.1.4.3.4 (Criteria for sending a response).

If neither of the following conditions is met:

— the AP transmits an individually addressed Probe Response frame to a STA that has signaled that it does not support operating in the 6 GHz band (see 9.4.2.53 (Supported Operating Classes element))

— the AP operating in the 6 GHz band does not intend to be discovered by STAs

then the following applies:

— If an AP operating in the 2.4 GHz or 5 GHz band is in the same co-located AP set as one or more 6 GHz APs and has the same SSID as those 6 GHz APs, then the Beacon and Probe Response frames transmitted by the AP or by the transmitted BSSID of the same Multiple BSSID set as the AP shall include, for each of these 6 GHz APs, a TBTT Information field in a Reduced Neighbor Report element with the BSSID field set to the BSSID of the 6 GHz AP, and with either the Short SSID field set to the short SSID of the 6 GHz AP or the Same SSID subfield in the BSS Parameters subfield set to 1

— If an AP operating in the 2.4 GHz or 5 GHz band is in the same co-located AP set as a 6 GHz AP and has a different SSID, and no other AP in the same co-located AP set and operating in the 2.4 GHz or 5 GHz band is indicating the 6 GHz AP in a Reduced Neighbor Report element of the Beacon and Probe Response frames they transmit, then Beacon and Probe Response frames transmitted by the AP (or by the transmitted BSSID of the same Multiple BSSID set as the AP) shall include a TBTT Information field in a Reduced Neighbor Report element with the BSSID field and the Short SSID field set to the BSSID and short SSID of the 6 GHz AP, respectively.

If the AP reported in the TBTT Information field in the Reduced Neighbor Report element is a 6 GHz AP, the reporting AP shall include the BSS Parameters subfield in the TBTT Information field and shall follow the rules in 11.50 (Reduced neighbor report) to set the Multiple BSSID subfield, the Transmitted BSSID subfield, the Co-Located AP subfield and the OCT Recommended subfield.

A STA receiving a frame containing a Reduced Neighbor Report element describing a reported AP operating at 6 GHz with the OCT Recommended subfield set to 1 in the BSS Parameters subfield shall follow the rules in 11.50 (Reduced neighbor report) to perform active scanning, authentication and/or association with the reported AP.

An AP that operates in the 2.4 GHz or 5 GHz band and that is in the same co-located AP set as one or more 6 GHz APs shall include the Advertisement Protocol element in Beacon and Probe Response frames that it transmits and shall support responding with a Neighbor Report ANQP element (9.4.5.19 Neighbor Report ANQP element) carrying one or more Neighbor Report elements (see 9.4.2.36 (Neighbor Report element)) that include at least the SSID information of all the 6 GHz APs in the same co-located AP set, except the 6 GHz APs that do not intend to be discovered.

NOTE 1—The Neighbor Report ANQP-element can also carry Neighbor Report elements containing information on 6 GHz APs that are not in the same co-located AP set.

NOTE 2—It is recommended that the AP responds with a GAS comeback delay of zero.

NOTE 3—If the Same SSID subfield is set to 0 in the BSS Parameters of a reported 6 GHz AP, a non-AP STA that does not know the short SSID of the reported 6 GHz AP and that intends to discover the SSID of the reported 6 GHz AP might:

— Use the OCT procedure described in 11.32.5 (On-channel Tunneling (OCT) operation) to send a Probe Request frame to the reported AP through over-the-air transmissions with the reporting AP, if the OCT Recommended subfield is 1 in the Neighbor AP Information field describing the reported AP.
— Use the ANQP procedure described in 11.23.3.3 (ANQP Procedure) to send an ANQP request with a Query ID corresponding to Neighbor Report to the reporting AP to retrieve the SSID of the 6 GHz APs, including the reported AP.
— Send a Probe Request frame to the reported AP including the BSSID of the reported AP.
— Send a Probe Request frame to the reported AP including the short SSID of the reported AP.
— Perform passive scanning in the operating channel of the reported AP.

An AP may set the Unsolicited Probe Responses Active subfield to 1 for a reported AP in a Reduced Neighbor Report element or Neighbor Report element in a frame it transmits if all 6 GHz APs of the same ESS as the reported AP that operate in the same channel as the reported AP and that might be detected by a STA receiving this frame have dot11UnsolicitedProbeResponseOptionActivated equal to true and so are transmitting unsolicited Probe Response frames every 20 TUs (see 26.17.2.3.2 (AP behavior for fast passive scanning)). Otherwise, the AP shall set the Unsolicited Probe Responses Active subfield to 0.

NOTE—An AP might be detected by a STA if the STA and the AP are on the same channel and in range.

An AP may set the Member Of ESS With 2.4/5 GHz Co-Located AP subfield to 1 in a Reduced Neighbor Report element in a frame it transmits, if the reported AP operates in the 6 GHz band and is part of an ESS where each AP in the ESS that is operating in the same band as the reported AP and that might be detected by a STA receiving this frame (irrespective of the operating channel), has dot11MemberOfColocated6GHzESSOptionActivated equal to true and also has a corresponding AP operating in the 2.4 GHz or 5 GHz band that is in the same co-located AP set as that AP.

NOTE—This subfield indicates that the reported AP is part of an ESS that has no 6 GHz-only APs that might be detected by a STA receiving this frame. This means that all APs operating in the 6 GHz band that are part of that ESS that might be detected by a STA receiving this frame can be discovered in the 2.4 GHz and/or 5 GHz bands.

26.17.2.5 HE STA antenna indication

A 6 GHz HE STA that does not change its receive antenna pattern after association shall set the Rx Antenna Pattern Consistency subfield in the HE 6 GHz Band Capabilities element to 1; otherwise, the STA shall set the Rx Antenna Pattern Consistency subfield in the HE 6 GHz Band Capabilities element to 0.

A 6 GHz HE STA that does not change its transmit antenna pattern after association shall set the Tx Antenna Pattern Consistency subfield in the HE 6 GHz Band Capabilities element to 1; otherwise, the STA shall set the Tx Antenna Pattern Consistency subfield in the HE 6 GHz Band Capabilities element to 0.

26.17.3 BSS color

26.17.3.1 General

BSS color identifies a BSS and assists a STA receiving a PPDU that carries BSS color in identifying the BSS from which the PPDU originates so that the STA can use the channel access rules in 26.10 (Spatial reuse operation), reduce power consumption as described in 26.14.1 (Intra-PPDU power save for non-AP HE STAs) or update its NAV as described in 26.2.4 (Updating two NAVs).

All APs that are members of a multiple BSSID set or co-hosted BSSID set shall use the same BSS color.

A non-AP HE STA associated with an HE AP that is transmitting an HE PPDU in a direct path to a TDLS peer STA shall set the BSS Color subfield of the HE Operation element it transmits to the peer STA to the value indicated in the BSS Color subfield of the HE Operation element received from the HE AP. An HE STA associated with a non-HE AP that is the initiating STA of the TDLS link shall use the same active BSS color for all its TDLS links by setting the BSS Color subfield of the HE Operation element it transmits to the TDLS peer HE STA to the value of dec(BSSID[39:44]) of the non-HE AP or the dec(transmitted BSSID[39:44]) of the non-HE AP if the AP indicates the support of multiple BSSID in its Extended Capabilities element.

An HE STA that transmits an HE Operation element shall select an initial BSS color by following the procedure in 26.17.3.2 (Initial BSS color).

An HE STA that transmits an HE Operation element may disable BSS color by follow the procedure in 26.17.3.3 (Disabling BSS color).

An HE STA that transmits an HE Operation element may determine that a BSS color collision has occurred by following the procedure in 26.17.3.5 (Detecting and reporting BSS color collision).

An HE AP may follow the procedure in 26.17.3.4 (Selecting and advertising a new BSS color) to select and advertise a new BSS color.

A non-AP HE STA may following the procedure in 26.17.3.5 (Detecting and reporting BSS color collision) to determine and report a BSS color collision to the AP with which is associated.

26.17.3.2 Initial BSS color

An HE STA shall set the BSS Color subfield of the first HE Operation element it transmits to a value in the range 1 to 63 and shall maintain that value in subsequent HE Operation elements it transmits for the lifetime of the BSS or until the BSS color is changed as described in 26.17.3.4 (Selecting and advertising a new BSS color).

26.17.3.3 Disabling BSS color

An HE STA that transmits an HE Operation element and that decides to temporarily disable the use of BSS color in the BSS to which it belongs, for example, after detecting a BSS color collision with an OBSS (see 26.17.3.5 (Detecting and reporting BSS color collision)), shall set the value of BSS Color Disabled subfield in the HE Operation element to 1 to inform its associated peer HE STAs that the BSS color is disabled; otherwise the HE STA shall set the BSS Color Disabled subfield to 0.

If the most recently received HE Operation element from the AP with which it is associated contained a value of 1 in the BSS Color Disabled subfield then:

- A non-AP HE STA should use the Address 1, Address 2 and Duration/ID fields of the frames contained in the received HE PPDUs instead of the RXVECTOR parameters BSS_COLOR and TXOP_DURATION to determine whether the STA should update the intra-BSS NAV.
- A non-AP HE STA should use the Address 1, Address 2 fields of the frames contained in the received HE PPDUs instead of the RXVECTOR parameters BSS_COLOR and STA_ID to determine whether the STA may go to doze state for the duration of that PPDU (see 26.14.1 (Intra-PPDU power save for non-AP HE STAs)).

A non-AP HE STA may use the RXVECTOR parameter BSS_COLOR of an HE PPDU to determine whether it should update the intra-BSS NAV (see 26.2.4 (Updating two NAVs)) and/or the STA may go to doze state for the duration of the PPDU (see 26.14.1 (Intra-PPDU power save for non-AP HE STAs)) if the most recently received HE Operation element from the AP with which it is associated contained a value of 0 in the BSS Color Disabled subfield.

26.17.3.4 Selecting and advertising a new BSS color

An HE STA that transmits an HE Operation element shall select a BSS color as defined in 26.17.3.2 (Initial BSS color) for its BSS. An HE AP may change the BSS color under certain conditions, for example if it detects that an OBSS is using the same color. When selecting or changing the BSS color, the HE AP may consider the BSS colors of OBSSs that the HE AP has identified by itself or via the autonomous collision reports received from associated non-AP HE STAs (see 26.17.3.5 (Detecting and reporting BSS color collision)).

An HE AP shall announce an upcoming BSS color change using the BSS Color Change Announcement element. The BSS Color Change Announcement element may be carried in the Beacon, Probe Response, (Re)Association Response, and HE BSS Color Change Announcement frames transmitted by the AP. An HE AP should announce an upcoming BSS color change for a period of time that is sufficiently long for all STAs in the BSS, including STAs in PS mode, to have an opportunity to receive at least one frame carrying a BSS Color Change Announcement element before the BSS color change.

If the Color Switch Countdown field in BSS Color Change Announcement element has a value greater than 0, then at the next TBTT the AP shall decrement the Color Switch Countdown field value by 1 until it reaches 0. BSS color change TBTT is the one at which the Color Switch Countdown field value has decremented to 0. An HE AP shall not alter the BSS color change TBTT after it has announced a pending BSS color change. An AP belonging to a co-hosted BSSID set (see 26.17.7 (Co-hosted BSSID set)) should select the value of Color Switch Countdown field such that the BSS color change TBTT interval between the BSSs in the set shall not be greater than one beacon interval of the BSS with largest beacon interval in the set.

During the time leading up to the BSS color change TBTT:

— An HE AP shall set the BSS Color Disabled subfield to 1 and shall continue to advertise the existing BSS color via the BSS Color subfield in the HE Operation element.
— An HE AP shall not change the value it advertises in the New BSS Color subfield of the BSS Color Change Announcement element.
— An HE AP shall set the TXVECTOR parameter BSS_COLOR of an HE PPDU to the existing BSS color.

At the BSS color change TBTT, an HE AP shall:

— Set the BSS Color Disabled subfield in the HE Operation element that it transmits to 0 unless the HE AP belongs to a co-hosted BSSID set, in which case it shall continue to set the BSS Color Disabled subfield to 1 until all the BSSs in the co-hosted BSSID set have passed their respective BSS color change TBTT
— Start advertising the new BSS color in the BSS Color subfield in the HE Operation element
— Start using the new BSS color for all frames that it transmits after the TBTT

A co-hosted AP should not transmit an HE PPDU during the transition period until all the BSSs in the co-hosted set have completed their switch to the new color.

A non-AP HE STA that receives a BSS Color Change Announcement element from an AP shall use the value specified in the New BSS Color field of the element as the BSS color when communicating with that AP following the BSS color change TBTT.

A non-AP HE STA in an infrastructure BSS shall not transmit the BSS Color Change Announcement element. An HE STA belonging to an IBSS or a mesh BSS shall not transmit a BSS Color Change Announcement element. An HE STA participating in an IBSS or a mesh BSS may temporarily disable the use of BSS color if the HE STA determines that a BSS color collision has occurred (see 26.17.3.3 (Disabling BSS color)).

NOTE—The color change mechanism described in this subclause does not apply to an IBSS or a mesh BSS since these BSSs do not have a single coordinator.

26.17.3.5 Detecting and reporting BSS color collision

26.17.3.5.1 General

An HE AP may determine that a BSS color collision has occurred if it receives frames on its primary channel from an OBSS STA containing the same BSS color as the one it has selected for its BSS or if it receives autonomous BSS color collision event reports from its associated STAs. The HE AP shall set the BSS Color Disabled subfield to 1 in the HE Operation element that it transmits if the BSS color collision persists for a duration of at least dot11BSSColorCollisionAPPeriod.

26.17.3.5.2 Autonomous reporting of BSS color collision

A STA that supports autonomous reporting of BSS color collision shall set dot11AutonomousBSSColorCollisionReportingImplemented to true.

A non-AP HE STA that supports autonomous reporting of BSS color collision may send a color collision report to its associated AP when it detects that color collision has occurred. The STA shall declare that a color collision has occurred if it receives, on its associated AP's primary channel, a frame with at least three Address fields in the MAC header and with the same color as its associated BSS in which none of the Address fields match the BSSID of the BSS that the STA is associated with, or any of the other BSSs in the same multiple BSSID set or co-hosted BSSID set to which its BSS belongs.

The HE STA's autonomous report shall include BSS color information of all OBSSs that the STA is able to detect frames from in order to help its associated AP select a new nonoverlapping BSS color when the AP decides to switch to a different BSS color.

A non-AP HE STA that is autonomously reporting a BSS color collision shall transmit an Event Report frame (see 9.6.14.3 (Event Report frame format)) containing a single Event Report element (see 9.4.2.68 (Event Report element)). The Event Report element shall carry Event Token field value set to 0 (autonomous report) and Event Type field value set to 4 (BSS Color Collision). The Event Report Status field shall be set to 0 (Successful) and the Event Report field shall carry information about the BSS color used by OBSSs that the reporting STA is able to detect.

A non-AP HE STA that intends to autonomously report a BSS color collision to its associated HE AP shall do so by scheduling for transmission a BSS color collision Event Report frame every dot11BSSColorCollisionSTAPeriod unless the BSS color collision no longer exists or if the associated HE AP has set the BSS Color Disabled field to 1 in HE Operation element that it transmits or if the non-AP STA has transmitted several such reports to its associated HE AP.

NOTE—The maximum number of BSS color collision event reports a non-AP STA transmits is out of scope of this standard.

26.17.4 AID assignment

An HE AP that transmits an HE Operation element with the Partial BSS Color subfield in the BSS Color Information field set to 1 shall allocate AIDs that meet the constraint in Equation (26-8).

$$\mathrm{AID}(5{:}8) = bin[(BCB(0{:}3) - (BSSID[44{:}47] \oplus BSSID[40{:}43]))\ mod\ 2^4, 4] \quad (26\text{-}8)$$

where $BCB(0{:}3)$ represents bits 0 to 3 inclusive of the BSS color in the transmitted HE Operation element with bit 0 being the first transmitted and AID(5:8) represents bits 5 to 8 inclusive of the allocated AID with bit 5 being the first transmitted.

NOTE—See 1.5 for the behavior of the mod operator with a negative first operand.

26.17.5 Quiet HE STAs in an HE BSS

26.17.5.1 General

Quiet time period (QTP) is an optional feature that defines a period of time (QTP period) that is intended to be used primarily for the exchange of specific frames between a STA requesting a QTP and its peers using peer-to-peer links. The particular frames to be exchanged using peer-to-peer links during the QTP period are identified by a service specific identifier. The determination of which frames are associated with the service specific identifier is beyond the scope of the standard. The method for selection of the service specific identifier by the peer-to-peer operation is beyond the scope of the standard.

An AP that supports QTP is a QTP AP and shall set the QTP Support field to 1 in HE Capabilities elements that it transmits and shall set the QTP Support field to 0 otherwise. A non-AP HE STA that supports QTP is a QTP non-AP STA and shall set the QTP Support field to 1 in HE Capabilities elements that it transmits and shall set the QTP Support field to 0 otherwise.

A QTP non-AP STA may request its QTP AP to set up a QTP and if successful, the QTP AP informs other associated QTP non-AP STAs of the QTP and of the service specific identifier associated with that QTP.

The QTP mechanism informs other HE STAs of the period and the intended peer-to-peer operation, and requests that during the QTP, the QTP non-AP STAs should not exchange frames that are not associated with the service specific identifier.

A QTP non-AP STA may ignore the QTP. A QTP non-AP STA that decides to stay quiet during a QTP period suspends the decrementing of its backoff counters at the start time of the QTP period and resumes them when the QTP period ends.

NOTE—Otherwise, a STA that does not stay quiet does not suspend the decrementing of its backoff counters.

26.17.5.2 QTP Requesting STA procedure

A QTP requesting STA is a QTP non-AP STA that requests a QTP.

Upon the reception of an MLME-QTP.request primitive, a QTP requesting STA shall perform the following procedure (Figure 26-15 (Quiet time period operation)):

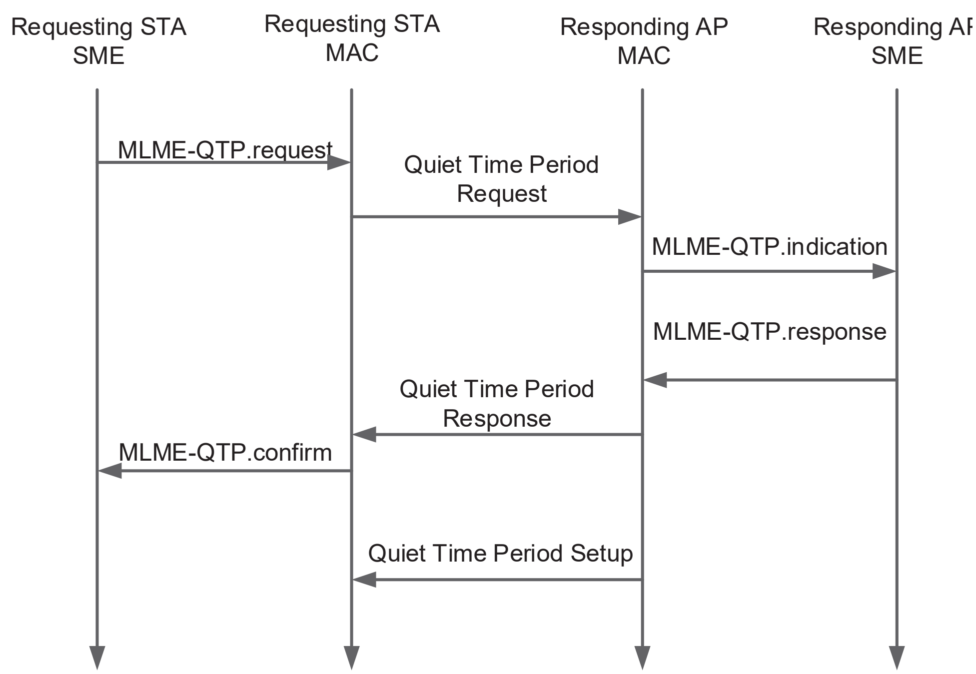

Figure 26-15—Quiet time period operation

a) If a QTP requesting STA is associated with a QTP AP, the QTP requesting STA sends a QTP Request frame which is a Quiet Time Period Action frame (9.6.31.3 (Quiet Time Period Action frame details)) with the Control field of the Quiet Time Period element indicating the Quiet Time Period Request subtype. The QTP Request frame indicates the duration, interval, and type of operation (indicated by Service Specific Identifier). The QTP requesting STA may include multiple Quiet Time Period elements with Request subtype in one QTP Request frame for multiple types of frames associated with different service specific identifiers.

b) A QTP Response frame is a Quiet Time Period Action frame (9.6.31.3 (Quiet Time Period Action frame details)) with the Control field of the Quiet Time Period element indicating Quiet Time Period Response subtype. If a QTP Response frame is received with the dialog token matching the request token with a status code set to a value of SUCCESS, the QTP AP has confirmed the reception of the QTP Request frame, and the MLME shall issue an MLME-QTP.confirm primitive indicating the success of the procedure. A QTP Setup frame is a Quiet Time Period Action frame (9.6.31.3 (Quiet Time Period Action frame details)) with the Control field of the Quiet Time Period element indicating Quiet Time Period Setup subtype. If a QTP Setup frame is received, at the start time for a QTP period, the QTP requesting STA may schedule frames for transmission that are associated with the service specific identifier indicated in the QTP Setup frame and should not transmit frames that are not associated with the service specific identifier.

26.17.5.3 Responding AP procedure

Upon receipt of a QTP request, a QTP AP shall operate as follows (Figure 26-15 (Quiet time period operation)):

a) The MLME of the AP shall issue an MLME-QTP.indication primitive.

b) Upon receipt of the MLME-QTP.response primitive, the AP may respond by sending a broadcast QTP Response frame.

   1) If the status code in the broadcast QTP Response frame is SUCCESS, the AP accepts the request. The AP shall schedule the quiet period(s) according to the accepted request. Contained in the transmitted QTP Response frame is a copy of the dialog token from the QTP requesting STA. The QTP procedure shall be terminated if the number of quiet periods exceeds the value of the Repetition Count field specified.

   2) If the status code in the broadcast QTP Response frame is REJECTED, the AP indicates that the request cannot be fulfilled.

   3) If the status code in the broadcast QTP Response frame is COUNTERED, the AP counters the request with recommended values and the current request is rejected. Upon receiving the counter-proposal, a QTP STA can send a QTP Request frame to set up another QTP period.

c) When the scheduled quiet time periods arrive, the AP may transmit a Quiet Time Period Action frame including a Quiet Time Period Setup element. The AP shall set the Quiet Period Duration field of the Quiet Time Period Setup frame to a value no larger than indicated in the Quiet Period Duration field of the Quiet Time Period Request element sent by the requesting STA.

d) At the start time for a quiet time period, the AP may schedule for transmission a QTP Setup frame. The AP shall set the Quiet Period Duration field of the QTP Setup frame to a value no larger than indicated in the Quiet Period Duration field of the QTP Request frame sent by the QTP requesting STA.

NOTE—The AP is not required to transmit a QTP Setup frame when a scheduled QTP period arrives. The interference mitigation protocol is to provide an AP a tool to manage and avoid interference. How or whether the AP will transmit QTP Setup frame when a scheduled QTP periods arrives is not in the scope of this specification.

26.17.6 ER beacon generation in an ER BSS

An ER beacon is a Beacon frame carried in an HE ER SU PPDU using a 242-tone RU and transmitted in the primary 20 MHz channel. An ER beacon provides additional link budget for downlink transmissions to compensate for the link budget imbalance between downlink and uplink due to introduction of UL OFDMA transmission. An HE AP shall operate an ER BSS in addition to a non-ER BSS operated by another AP that is in the same co-located AP set. An ER BSS, if present, shall operate independently of the collocated non-ER BSS that is in the same co-located AP set and the AP operating the ER BSS shall have a BSSID different from the AP operating the non-ER BSS.

NOTE—An AP that uses ER Beacon frames can balance the link budget by allocating narrow RUs to STAs. An ER BSS is expected to have a larger coverage area than a non-ER BSS.

The HE AP of an ER BSS shall not set the ER SU Disable subfield to 1 in HE Operation elements it transmits.

The HE AP of an ER BSS shall transmit Beacon frames and group addressed frames in HE ER SU PPDUs following the rules in 26.15.5 (Additional rules for ER beacons and group addressed frames).

26.17.7 Co-hosted BSSID set

HE BSSs that are not part of a multiple BSSID set (i.e., dot11MultiBSSIDImplemented is false) but share the same operating class, channel and antenna connectors belong to a co-hosted BSSID set.

A STA that supports co-hosted BSSID capability shall have dot11CoHostedBSSIDImplemented equal to true.

An AP that belongs to a co-hosted BSSID set shall perform the following operations:

— Set the Co-Hosted BSS subfield in the HE Operation element that it transmits to 1.

— Set the Max Co-Hosted BSSID Indicator field in the HE Operation element that it transmits to a non-zero value n, where $1 \leq n \leq 8$, such that 2^n indicates the maximum number of BSSIDs in the co-hosted set.

Members of the co-hosted BSSID set have the same $48 - n$ bits (BSSID[0:($47 - n$)]) in their BSSIDs.

If its associated AP has set the Co-Hosted BSS subfield in the HE Operation Parameters field to 1, a non-AP STA shall identify a BSS as a co-hosted BSS, if the $48 - n$ bits (BSSID[0:($47 - n$)]) of the BSSID of the BSS are the same as the $48 - n$ bits (BSSID[0:($47 - n$)]) of the BSSID of its associated AP, where n is the value carried in the Max Co-Hosted BSSID Indicator field of the HE Operation element transmitted by the associated AP.

27. High Efficiency (HE) PHY specification

27.1 Introduction

27.1.1 Introduction to the HE PHY

Clause 27 (High Efficiency (HE) PHY specification) specifies the PHY entity for a high efficiency (HE) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 27 (High Efficiency (HE) PHY specification), an HE STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory requirements of the following PHY specifications:

— Clause 19 (High Throughput (HT) PHY specification) and Clause 21 (Very High Throughput (VHT) PHY specification) if the HE STA supports an operating channel width greater than or equal to 80 MHz and is operating in the 5 GHz band.

— Clause 19 (High Throughput (HT) PHY specification) and Clause 21 (Very High Throughput (VHT) PHY specification) transmission and reception on 20 MHz channel width (see 26.17.1 (Basic HE BSS operation)) if the HE STA is a 20 MHz-only non-AP HE STA and is operating in the 5 GHz band.

— Clause 19 (High Throughput (HT) PHY specification) if the HE STA is operating in the 2.4 GHz band.

— Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) if the HE STA is operating in the 6 GHz band.

For 2.4 GHz band operation, the HE PHY is based on HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), which in turn is based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 5 GHz band operation, the HE PHY is based on the VHT PHY defined in Clause 21 (Very High Throughput (VHT) PHY specification), which in turn is based on the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), which in turn is further based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 6 GHz band operation, the HE PHY is based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

The HE PHY extends the maximum number of users supported for DL MU-MIMO transmissions to 8 users per resource unit (RU) and provides support for DL and UL orthogonal frequency division multiple access (OFDMA) as well as for UL MU-MIMO. Both DL and UL MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones). In an MU-MIMO resource unit, there is support for up to 8 users with up to 4 space-time streams per user with the total across all users not exceeding 8 space-time streams.

The HE PHY provides support for 20 MHz, 40 MHz, 80 MHz and 160 MHz contiguous channel widths and support for 80+80 MHz noncontiguous channel width, depending on the frequency band and capability. For PPDU bandwidths greater than or equal to 80 MHz, the HE PHY supports preamble punctured HE MU PPDU transmissions where pre-HE modulated fields (see Figure 27-23 (Timing boundaries for HE PPDU fields if midamble is not present)) are not transmitted in one or more of the nonprimary 20 MHz channels, and RUs associated with those punctured 20 MHz channels as defined in 27.3.11.8.3 (Common field) are not allocated.

The HE PHY provides support for 0.8 μs, 1.6 μs and 3.2 μs guard interval durations.

The HE PHY provides support for 3.2 μs (1x), 6.4 μs (2x), and 12.8 μs (4x) HE-LTF symbol durations, excluding the GI duration. The HE PHY supports a DFT period of 3.2 μs and 12.8 μs for the pre-HE modulated fields and the HE modulated fields in an HE PPDU, respectively. The HE PHY data subcarrier frequency spacing is a quarter of VHT PHY and HT PHY subcarrier frequency spacing defined in Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 19 (High Throughput (HT) PHY specification), respectively.

The HE PHY data subcarriers are modulated using BPSK, BPSK DCM, QPSK, QPSK DCM, 16-QAM, 16-QAM DCM, 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.

The HE PHY provides support for midambles. Midambles facilitate updating of the channel estimate during HE PPDU reception and might be of use in high mobility scenarios that often result in significant variations of the wireless channel over the duration of a PPDU.

An HE STA shall support the following features:

— Transmission and reception of an HE SU PPDU that consists of a single RU spanning the entire PPDU bandwidth.
— Transmission and reception of an HE ER SU PPDU that consists of a 242-tone RU spanning the entire primary 20 MHz PPDU bandwidth.
— BCC coding (transmit and receive). BCC coding is not used in the following cases:
  - An HE SU PPDU with a bandwidth greater than 20 MHz
  - An RU of size greater than 242 subcarriers in an HE MU PPDU or an HE TB PPDU
  - An HE SU PPDU with number of spatial streams greater than 4
  - An RU allocated to a single user in an HE MU PPDU or for an HE TB PPDU with a number of spatial streams greater than 4
  - An HE SU PPDU using HE-MCSs 10 or 11
  - An RU in an HE MU PPDU or an HE TB PPDU using HE-MCSs 10 or 11
— LDPC coding (transmit and receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA supports transmitting and receiving in channel bandwidths greater than 20 MHz.
— LDPC coding (transmit and receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA declares support for transmitting or receiving more than 4 spatial streams.
— LDPC coding (transmit and receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA declares support for HE-MCSs 10 and 11 (transmit and receive).
— Single spatial stream HE-MCSs 0 to 7 (transmit and receive) in all supported channel widths for HE SU PPDUs.
— HE SU PPDUs and HE ER SU PPDUs with a 2x HE-LTF and 0.8 μs GI duration on the HE-LTF and Data field OFDM symbols (transmit and receive).
— HE SU PPDUs and HE ER SU PPDUs with a 2x HE-LTF and 1.6 μs GI duration on the HE-LTF and Data field OFDM symbols (transmit and receive).
— HE SU PPDU and HE ER SU PPDUs with a 4x HE-LTF and 3.2 μs GI duration on the HE-LTF and Data field OFDM symbols (transmit and receive).
— Full bandwidth UL MU-MIMO with a 1x HE-LTF and 1.6 μs GI duration on the HE-LTF and Data field OFDM symbols if the STA supports UL MU-MIMO.
— HE SU PPDUs with a 4x HE-LTF and 0.8 μs GI duration on the HE-LTF and Data field OFDM symbols if the STA supports HE ER SU PPDUs with a 4x HE-LTF and 0.8 μs GI duration on the HE-LTF and Data field OFDM symbols (transmit and receive).
— Single spatial stream HE-MCSs 0 to 2 in primary 20 MHz channel for HE ER SU PPDUs.
— HE ER SU PPDU is not used in the following cases:

  - Number of spatial streams greater than 1
  - HE-MCS greater than 2 when 242 subcarriers are used in the Data field OFDM symbols
  - HE-MCS greater than 0 when 106 subcarriers are used in the Data field OFDM symbols
  - Bandwidth greater than 20 MHz
- 20 MHz channel width and all RU sizes and locations applicable to the 20 MHz channel width in 2.4 GHz, 5 GHz and 6 GHz bands (transmit and receive).

An HE STA may support the following features:

- HE-MCSs 8 to 11 (transmit and receive).
- Two or more spatial streams (transmit and receive).
- DCM (transmit and receive).
- HE SU PPDUs and HE ER SU PPDUs with a 1x HE_LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols (transmit and receive).
- HE SU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols if the STA does not support HE ER SU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on both the HE-LTF and Data field OFDM symbols (transmit and receive).
- HE ER SU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on both the HE-LTF and Data field OFDM symbols (transmit and receive).
- LDPC coding (transmit and receive) if the maximum number of spatial streams the STA is capable of transmitting or receiving in an HE SU PPDU is less than or equal to 4.
- Single spatial stream HE-MCS 0 in the higher frequency 106-tone RU of the primary 20 MHz channel for an HE ER SU PPDU.
- STBC (transmit and receive).

An HE AP shall support the following features:

- Transmission of an HE MU PPDU where none of the RUs utilize MU-MIMO (DL OFDMA).
- Reception of an HE TB PPDU where none of the RUs utilize MU-MIMO (UL OFDMA).
- Transmission of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO), provided the AP is capable of transmitting 4 or more spatial streams.
- Transmission of the HE-SIG-B field in an HE MU PPDU at HE-MCSs 0 to 5.
- Single spatial stream HE-MCSs 0 to 7 in all supported channel widths and RU sizes for HE MU PPDUs (transmit) or HE TB PPDUs (receive).
- 40 MHz and 80 MHz channel widths and all RU sizes and locations applicable to the 40 MHz and 80 MHz channel width in 5 GHz and 6 GHz bands (transmit and receive).
- HE MU PPDUs with a 2x HE-LTF and 0.8 µs and 1.6 µs GI duration on the HE-LTF and Data field OFDM symbols (transmit).
- Reception of an HE TB PPDU with a 2x HE-LTF and 1.6 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Reception of an HE TB PPDU with a 4x HE-LTF and 3.2 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Transmission of an HE MU PPDU with a 4x HE-LTF and 3.2 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Transmission of an HE MU PPDU with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols if the HE AP supports HE ER SU PPDUs with the same HE-LTF and GI combinations.

An HE AP may support the following features:

- MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (DL MU-MIMO within OFDMA).
- MU-MIMO reception on an RU in an HE TB PPDU where the RU spans the entire PPDU bandwidth (UL MU-MIMO).
- MU-MIMO reception on an RU in an HE TB PPDU where the RU does not span the entire PPDU bandwidth (UL MU-MIMO within OFDMA).
- Reception of the payload on an RU in an HE MU PPDU where RU spans the entire PPDU bandwidth or a 106-tone RU within 20 MHz PPDU bandwidth.
- 40 MHz channel width in the 2.4 GHz band (transmit and receive). If it is supported then all RU sizes and locations applicable to 40 MHz channel width are supported in 2.4 GHz band (transmit and receive).
- 160 MHz and 80+80 MHz channel widths and 2×996-tone RU size applicable to the 160/80+80 MHz channel width in the 5 GHz and 6 GHz bands (transmit and receive).
- Transmission of an HE MU PPDU with preamble puncturing.
- HE MU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols if the STA does not support HE ER SU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols (transmit).
- Punctured sounding operation.

A non-AP HE STA shall support the following features:

- Reception of an HE MU PPDU where the RU allocated to the non-AP STA is not utilizing MU-MIMO (DL OFDMA).
- Transmission of an HE TB PPDU where the RU allocated to the non-AP STA is not utilizing MU-MIMO (UL OFDMA).
- Reception of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO). The maximum number of spatial streams per user the non-AP STA can receive in the DL MU-MIMO transmission shall be equal to the minimum of 4 and the maximum number of spatial streams supported for reception of HE SU PPDUs. The non-AP STA shall be able to receive its intended spatial streams in a DL MU-MIMO transmission with a total number of spatial streams across all users of at least 4.
- Responding with the requested beamforming feedback in an HE sounding procedure with the maximum number of space-time streams in the HE sounding NDP that the non-AP STA can respond to being at least 4.
- Reception of the HE-SIG-B field in an HE MU PPDU at HE-MCSs 0 to 5.
- Single spatial stream HE-MCSs 0 to 7 in all supported channel widths and RU sizes for HE MU PPDUs (receive) or HE TB PPDUs (transmit).
- 40 MHz and 80 MHz channel widths and all RU sizes and locations applicable to the 40 MHz and 80 MHz channel widths in the 5 GHz band (transmit and receive) except for a 20 MHz-only non-AP HE STA in which case the 40 MHz and 80 MHz channel widths, 996-tone RU, and 484-tone RU sizes in the 5 GHz and 6 GHz bands are not applicable.
- Reception of an HE MU PPDU with a 2x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Reception of an HE MU PPDU with a 2x HE-LTF and 1.6 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Transmission of an HE TB PPDU with a 2x HE-LTF and 1.6 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Reception of an HE MU PPDU with a 4x HE-LTF and 3.2 µs GI duration on the HE-LTF and Data field OFDM symbols.

- Transmission of an HE TB PPDU with a 4x HE-LTF and 3.2 µs GI duration on the HE-LTF and Data field OFDM symbols.
- Reception of an HE MU PPDU with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and the Data field OFDM symbols if the non-AP HE STA supports HE ER SU PPDUs with the same HE-LTF and GI combinations.

A 20 MHz operating non-AP HE STA shall support 26-, 52-, and 106-tone RU sizes on locations allowed in 27.3.2.8 (RU restrictions for 20 MHz operation) in the primary 20 MHz channel within 40 MHz and the primary 20 MHz channel within 80 MHz channel widths in the 5 GHz and 6 GHz bands (transmit and receive).

A non-AP HE STA may support the following:

- Transmission of an HE MU PPDU with a single RU spanning the entire PPDU bandwidth or a 20 MHz HE MU PPDU with a single 106-tone RU in the primary 20 MHz channel.
- 40 MHz channel width in the 2.4 GHz band (transmit and receive). If 40 MHz channel width in the 2.4 GHz band is supported then all RU sizes and locations applicable to 40 MHz channel width are supported except for a 20 MHz-only non-AP HE STA in which case the 40 MHz channel width and all RU sizes and locations of 40 MHz channel width in 2.4 GHz band are not applicable.
- 160 MHz and 80+80 MHz channel width and 2×996-tone RU size applicable to the 160 MHz and 80+80 MHz channel width in the 5 GHz and 6 GHz bands (transmit and receive) except for a 20 MHz-only non-AP HE STA in which case the 160 MHz and 80+80 MHz channel width and 2×996-tone RU size in the 5 GHz and 6 GHz bands are not applicable.
- MU-MIMO reception on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (DL MU-MIMO within OFDMA). The maximum number of spatial streams per user in the DL MU-MIMO within OFDMA transmission that the non-AP STA can receive shall be a minimum of 4 and the maximum number of spatial streams supported for reception of HE SU PPDUs. The total number of spatial streams (across all users) in the DL MU-MIMO within OFDMA transmission that the non-AP STA can receive shall be at least 4.
- MU-MIMO transmission on an RU in an HE TB PPDU where the RU spans the entire PPDU bandwidth (UL MU-MIMO). If supported, then the non-AP HE STA shall support transmitting UL MU-MIMO where the total space-time streams summed across all users is less than or equal to 8.
- MU-MIMO transmission on an RU in an HE TB PPDU where the RU does not span the entire PPDU bandwidth (UL MU-MIMO within OFDMA). If supported, then the non-AP HE STA shall support transmitting UL MU-MIMO where the total space-time streams summed across all users is less than or equal to 8.
- The reception of a 160 MHz or 80+80 MHz HE MU PPDU, or the transmission of a 160 MHz or 80+80 MHz HE TB PPDU where the assigned RU is in the primary 80 MHz channel if the non-AP HE STA is capable of up to 80 MHz channel width and operating with 80 MHz channel width.
- HE MU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols if the non-AP HE STA does not support HE ER SU PPDUs with a 4x HE-LTF and 0.8 µs GI duration on the HE-LTF and Data field OFDM symbols (receive).
- Punctured sounding operation

A 20 MHz-only non-AP HE STA may support the following:

- 26-, 52-, 106-, and 242-tone RU sizes on locations allowed in 27.3.2.8 (RU restrictions for 20 MHz operation) in the primary 20 MHz channel within 40 MHz channel width in the 2.4 GHz band if the 20 MHz-only non-AP HE STA does not support the HE subchannel selective transmission operation described in 26.8.7 (HE subchannel selective transmission).
- 26-, 52-, 106-, and 242-tone RU sizes on locations allowed in 27.3.2.8 (RU restrictions for 20 MHz operation) in any 20 MHz channel within 40 MHz channel width in the 2.4 GHz band if the 20 MHz-only non-AP HE STA supports the HE subchannel selective transmission operation as described in 26.8.7 (HE subchannel selective transmission).

— 26-, 52-, 106-, and 242-tone RU sizes on locations allowed in 27.3.2.8 (RU restrictions for 20 MHz operation) in any 20 MHz channel within 40 MHz, 80 MHz, 160 MHz, and 80+80 MHz channel widths in the 5 GHz and 6 GHz bands if the 20 MHz-only non-AP HE STA supports the HE subchannel selective transmission operation as described in 26.8.7 (HE subchannel selective transmission).

A 20 MHz operating non-AP HE STA may support 26-, 52-, 106-, and 242-tone RU sizes on locations allowed in 27.3.2.8 (RU restrictions for 20 MHz operation) in the primary 20 MHz channel within 160 MHz and 80+80 MHz channel widths in the 5 GHz and 6 GHz bands.

27.1.2 Scope

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

a) A function that maps the PSDU received from the MAC into a PPDU for transmission to one or more receiving STAs.

b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of HE, Clause 21 (Very High Throughput (VHT) PHY specification), Clause 19 (High Throughput (HT) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), and Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) PHYs. A 20 MHz-only non-AP HE STA supports a mixture of HE, Clause 19 and Clause 17 PHYs, and also supports transmission and reception of VHT PPDUs of 20 MHz PPDU bandwidth.

27.1.3 HE PHY functions

27.1.3.1 General

The HE PHY contains two functional entities: the PHY function, and the physical layer management function (i.e., the PLME). These functions are described in detail in 27.3 (HE PHY) and 27.4 (HE PLME). The HE PHY service is provided to the MAC through the PHY service primitives defined in Clause 8 (PHY service specification). The HE PHY service interface is described in 27.2 (HE PHY service interface).

27.1.3.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

27.1.3.3 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 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.

27.1.4 PPDU formats

The structure of the PPDU transmitted by an HE STA is determined by the TXVECTOR parameters as defined in Table 27-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU and can take on one of the following values:

— Non-HT format (NON_HT), based on Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or Clause 18 (Extended Rate PHY (ERP) specification), and including non-HT duplicate format.
— HT-mixed format (HT_MF) as specified in Clause 19 (High Throughput (HT) PHY specification).
— HT-greenfield format (HT_GF) as specified in Clause 19 (High Throughput (HT) PHY specification).
— VHT format (VHT) as defined in Clause 21 (Very High Throughput (VHT) PHY specification).
— HE SU PPDU format (HE_SU) carries a single PSDU. With this format the HE-SIG-A field is not repeated.
— HE ER SU PPDU format (HE_ER_SU) carries a single PSDU. It is similar to the HE SU PPDU format, except that the HE-SIG-A field is repeated.
— HE MU PPDU format (HE_MU) carries one or more PSDUs to one or more users.
— HE TB PPDU format (HE_TB) carries a single PSDU and is sent in response to a PPDU that carries a triggering frame. The preamble format prior to the HE-STF field is identical to the HE SU PPDU.

27.2 HE PHY service interface

27.2.1 Introduction

The PHY provides an interface to the MAC through an extension of the generic PHY service interface defined in 8.3.4 (Basic service and options). The interface includes TXVECTOR, RXVECTOR, PHYCONFIG_VECTOR and TRIG_VECTOR.

The MAC uses the TXVECTOR to supply the PHY with per-PPDU transmit parameters. The PHY uses the RXVECTOR to inform the MAC of the received PPDU parameters. The MAC uses the PHYCONFIG_VECTOR to configure the PHY for operation that is independent of frame transmission or reception. The MAC uses the TRIG_VECTOR to configure the PHY to receive HE TB PPDUs over each assigned RU.

27.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 27-1 (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 and PHY-RXEND.indication primitives.

Table 27-1—TXVECTOR and RXVECTOR parameters

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 15, Clause 16, Clause 17, Clause 18 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_ER_SU indicates HE ER SU PPDU format. HE_TB indicates HE TB PPDU format.	Y	Y
NON_HT_MODULATION	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters).			
L_LENGTH	FORMAT is HE_SU, HE_MU or HE_ER_SU	Not present. NOTE—The LENGTH field of the L-SIG field for HE PPDU is defined in Equation (27-11) using the TXTIME value defined in 27.4.3 (TXTIME and PSDU_LENGTH calculation), which in turn depend on other parameters including the TXVECTOR parameter APEP_LENGTH.	N	N
	FORMAT is HE_TB	Indicates the value in the LENGTH field of the L-SIG field in the range of 1 to 4095. The value is obtained from the Trigger frame or the TRS Control subfield in the frame to which the HE TB PPDU is a response.	Y	N
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		
N_TX	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the number of transmit chains.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
EXPANSION_MAT	FORMAT is HE_SU, HE_ER_SU or HE_TB	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 27.3.16.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE sounding NDPs or VHT NDPs.	Y	N
	FORMAT is HE_MU	For each user, contains a vector in the number of all the subcarriers in the RU that is assigned to this user. The vector for each subcarrier contains feedback matrices as defined in 27.3.16.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE sounding NDPs or VHT NDPs.	MU	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CHAN_MAT	FORMAT is HE_SU and PSDU_LENGTH is 0	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 27.3.16.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE sounding NDP.	N	Y
	FORMAT is HE_MU, HE_ER_SU or HE_TB. FORMAT is HE_SU and PSDU_LENGTH is greater than 0.	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DELTA_SNR	FORMAT is HE_MU	Contains an array of delta SNR values as defined in 9.4.1.66 (HE MU Exclusive Beamforming Report field) based on the channel measured during the training symbols of the received HE sounding NDP.	MU	N
	FORMAT is HE_SU and PSDU_LENGTH greater than 0, or FORMAT is HE_ER_SU or HE_TB		O	N
	FORMAT is HE_SU and PSDU_LENGTH is 0		N	Y
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RCPI	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).			

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
SNR	FORMAT is HE_SU and PSDU_LENGTH is 0	Contains an array of average values of received SNR measurements for each spatial stream. SNR indications of 8 bits are supported. Average value of SNR shall be the sum of the decibel values of SNR per subcarrier divided by the number of subcarriers represented in each stream as described in 9.4.1.65 (HE Compressed Beamforming Report field).	N	Y
	FORMAT is HE_MU, HE_ER_SU or HE_TB, or FORMAT is HE_SU and PSDU_LENGTH is greater than 0	Not present.	N	N
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CQI	FORMAT is HE_SU and PSDU_LENGTH is 0	Contains an array of received per-RU average SNRs for each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU as described in 9.4.1.67 (HE CQI Report field).	N	Y
	Otherwise	Not present.	N	N
NO_SIG_EXTN	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates whether signal extension needs to be applied at the end of transmission. Boolean: true indicates that no signal extension is present. false indicates that a signal extension is present.	Y	N
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		
FEC_CODING	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the FEC encoding used. Enumerated type: BCC_CODING indicates BCC coding. LDPC_CODING indicates LDPC coding.	MU	MU
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LDPC_EXTRA_SYMBOL	FORMAT is HE_TB	Indicates the presence of the extra OFDM symbol segment for LDPC in an HE TB PPDU. Integer: 1 indicates that an extra OFDM symbol segment for LDPC is present. 0 indicates that an extra OFDM symbol segment for LDPC is not present.	Y	N
	Otherwise	Not present.	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
STBC	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates if STBC is used. For an HE MU PPDU and HE TB PPDU where each RU includes no more than 1 user: Set to 1 to indicate that for all RUs the Data field is STBC encoded Set to 0 to indicate that in no RU is the Data field STBC encoded For an HE SU PPDU or HE ER SU PPDU: Set to 1 to indicate that the Data field is STBC encoded Set to 0 to indicate that the Data field is not STBC encoded	Y	Y
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		
GI_TYPE	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the length of the GI for the HE-LTF and Data fields. Enumerated type: 0u8s_GI indicates 0.8 µs 1u6s_GI indicates 1.6 µs 3u2s_GI indicates 3.2 µs NOTE—the length of GI for pre-HE modulated fields is 0.8 µs.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TXPWR_LEVEL_INDEX	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	The allowed values for the TXPWR_LEVEL_INDEX parameter are in the range from 1 to numberOfOctets (dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RSSI	FORMAT is HE_SU, HE_ER_SU, HE_MU or HE_TB	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the HE-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
RSSI_LEGACY	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	The allowed values for the RSSI_LEGACY parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of non-HE portion of the HE PPDU preamble. RSSI_LEGACY is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	Otherwise	Not present	N	N
MCS	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the modulation and coding schemes used in the transmission of the PPDU. Integer: range 0 to 11	MU	MU
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DCM	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Set to 1 to indicate that DCM is used for the Data field. Set to 0 to indicate that DCM is not used for the Data field. NOTE—DCM is applicable to only HE-MCSs 0, 1, 3 and 4. DCM is applicable to only 1 and 2 spatial streams.	MU	MU
	Otherwise	Not present.		
MCS_SIG_B	FORMAT is HE_MU	Indicates the modulation and coding scheme used for HE-SIG-B field. Integer: 0 indicates HE-MCS 0 1 indicates HE-MCS 1 2 indicates HE-MCS 2 3 indicates HE-MCS 3 4 indicates HE-MCS 4 5 indicates HE-MCS 5	Y	Y
	Otherwise	Not present.	N	N
DCM_SIG_B	FORMAT is HE_ MU	Set to 1 to indicate that DCM is used for the HE-SIG-B field. Set to 0 to indicate that DCM is not used for the HE-SIG-B field.	Y	Y
	Otherwise	Not present.	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
SIG_B_COMPRESSION_MODE	FORMAT is HE_MU	Indicates whether or not the Common field is present in the HE-SIG-B field. Integer: 0 indicates that the Common field is present 1 indicates that the Common field is not present	Y	N
	Otherwise	Not present.	N	N
REC_MCS	FORMAT is HE_SU, HE_MU or HE_ER_SU	Indicates the HE-MCS that the receiver recommends	N	O
	FORMAT is HE_TB	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
CH_BANDWIDTH	FORMAT is HE_SU	Indicates the channel width of the PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz	Y	Y
	FORMAT is HE_ER_SU	Indicates the channel width of the PPDU. Enumerated type: ER-RU-242 for the 242-tone RU in the primary 20 MHz channel ER-RU-H-106 for the higher frequency 106-tone RU in the primary 20 MHz channel	Y	Y
	FORMAT is HE_MU	Indicates the channel width of the PPDU. Enumerated type: CBW20 for full 20 MHz CBW40 for full 40 MHz CBW80 for full 80 MHz CBW160 for full 160 MHz CBW80+80 for 80+80 MHz HE-CBW-PUNC80-PRI for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured. HE-CBW-PUNC80-SEC for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz subchannels in secondary 40 MHz is punctured. HE-CBW-PUNC160-PRI20 for preamble puncturing in 160 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz channel is punctured. HE-CBW-PUNC80+80-PRI20 for preamble puncturing in 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz channel is punctured. HE-CBW-PUNC160-SEC40 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present, and at least one 20 MHz subchannel that is not in the primary 40 MHz is punctured. HE-CBW-PUNC80+80-SEC40 for preamble puncturing in 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present, and at least one 20 MHz subchannel that is not in the primary 40 MHz is punctured.	Y	Y
	FORMAT is HE_TB	Indicates the Bandwidth field of the HE-SIG-A in the transmitted or received PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz NOTE—The TXVECTOR parameter CH_BANDWIDTH does not represent the channel width of the transmitted PPDU.	Y	Y

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
INACTIVE_SUBCHANNELS	FORMAT is HE_MU and CH_BANDWIDTH is any value for preamble punctur-ing, or FORMAT is NON_HT and NON_HT_MODULA-TION is NON_HT_DUP_OFDM, or FORMAT is HE_SU and PSDU_LENGTH is 0	Indicates the 20 MHz subchannels that are punctured. A bitmap indexed by the 20 MHz subchannels in ascending order with the LSB indicating the lowest frequency 20 MHz subchannel. A bit is set to 1 to indicate that the corresponding 20 MHz subchannel is punctured and set to 0 to indicate the corresponding 20 MHz subchannel is not punctured.	Y	N
	Otherwise	Not present.	N	N
DYN_BANDWIDTH_IN_NON_HT	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CH_BANDWIDTH_IN_NON_HT	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LENGTH	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
APEP_LENGTH	FORMAT is HE_SU or HE_ER_SU	Integer. If 0 and FORMAT is HE_SU, indicates an HE sounding NDP. Otherwise, indicates the number of octets in the range 1 to *aPSDUMaxLength* in the A-MPDU pre-EOF padding (see Table 27-55 (HE PHY characteristics)) that is carried in the PSDU.	Y	O
	FORMAT is HE_MU or HE_TB		MU	O
	Otherwise	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters) or Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
PSDU_LENGTH	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the number of octets in the PSDU in the range of 0 to *aPSDUMaxLength* octets (see Table 27-55 (HE PHY characteristics)). A value of 0 indicates an HE sounding NDP.	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
USER_POSITION	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
NUM_STS	FORMAT is HE_SU	Indicates the number of space-time streams. Integer in the range 1-8.	Y	Y
	FORMAT is HE_ER_SU	Indicates the number of space-time streams. Integer in the range 1-2.	Y	Y
	FORMAT is HE_MU	Indicates the number of space-time streams. Integer in the range: 1-4 per user per MU-MIMO RU in the TXVECTOR 1-4 per MU-MIMO RU in the RXVECTOR 1-8 per RU assigned to no more than 1 user in the TXVECTOR and RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	MU	Y
	FORMAT is HE_TB	Indicates the number of space-time streams. Integer in the range: 1-4 for a MU-MIMO RU in the TXVECTOR 1-4 per user per MU-MIMO RU in the RXVECTOR 1-8 for an RU assigned to no more than 1 user in the TXVECTOR and RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
GROUP_ID	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
PARTIAL_AID	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TXOP_DURATION	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Provide the duration of TXOP. Enumerated type or integer: UNSPECIFIED indicates no NAV duration information (see 26.11.5 (TXOP_DURATION)). 0 – 8448 indicates a duration in units of 1 µs that is used to update the NAV for this TXOP (see 26.2.4 (Updating two NAVs)). When the value of the TXOP field in the HE-SIG-A of a received HE PPDU is less than 127, if B0 of the TXOP field is 0, the RXVECTOR parameter TXOP_DURATION is set to (8 × value of B1 to B6 of the TXOP field). Otherwise, the RXVECTOR parameter TXOP_DURATION is set to (512 + 128 × value of B1 to B6 of the TXOP field). See 26.11.5 (TXOP_DURATION) for more details.	Y	Y
	Otherwise	Not present.	N	N
SPATIAL_REUSE	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the spatial reuse parameter value. There is one value of the parameter for each of an HE SU PPDU, HE ER SU PPDU and HE MU PPDU. There are one to four values of the parameter present for an HE TB PPDU, with the number of values present dependent on the bandwidth of the PPDU. See the Spatial Reuse field definition in 27.3.11.7.2 (Content). See 26.5.2.3 (Non-AP STA behavior for UL MU operation) and 26.11.6 (SPATIAL_REUSE).	Y	Y
	Otherwise	Not present	N	N
DOPPLER	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Set to 1 to indicate that either the midamble is present for the PPDU or that the channel is with high Doppler. Set to 0 otherwise.	Y	Y
	Otherwise	Not present	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
NUM_USERS	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present. NOTE—The number of users for an HE SU PPDU, HE ER SU PPDU or HE TB PPDU is always 1. The number of users in an RU in an HE MU PPDU is determined by RU_ALLOCATION and STA_ID parameters for that RU.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RU_ALLOCATION	FORMAT is HE_MU and SIG_B_COMPRESSION_MODE is 0	For the TXVECTOR, indicates the RU Allocation subfield of Common field in the HE-SIG-B of the transmitted PPDU. 8 bits for a 20 MHz PPDU; 16 bits for a 40 MHz PPDU; 32 bits for an 80 MHz PPDU 64 bits for a 160 MHz or 80+80 MHz PPDU. See 27.3.11.8.3 (Common field) for details. For the RXVECTOR, 8 bits are used to indicate the RU allocated in the whole bandwidth. See 9.3.1.22 (Trigger frame format) for details.	Y	Y
	FORMAT is HE_TB	8 bits are used to indicate the RU allocated in the whole bandwidth per user. See 9.3.1.22 (Trigger frame format) for details.	Y	N
	FORMAT is HE_SU, APEP_LENGTH is 0, and CH_BANDWIDTH is not CBW20 or CBW40 FORMAT is NON_HT, NON_HT_MODULATION is NON_HT_DUP_OFDM, and CH_BANDWIDTH is not CBW20 or CBW40	For the TXVECTOR, indicates the active RUs. 32 bits for 80 MHz PPDU 64 bits for 160 MHz and 80+80 MHz PPDU For each 8 bits, only the following values are allowed: 113 (01110001 in binary representation) 192 (11000000 in binary representation) See 27.3.11.8.3 (Common field) for details.	Y	N
	Otherwise	Not present	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
BEAMFORMED	FORMAT is HE_SU or HE_ER_SU	Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise.	Y	Y
	FORMAT is HE_MU or HE_TB	For an RU assigned to no more than 1 user, set to 1 if a beamforming steering matrix is applied and set to 0 otherwise. For each user in an RU assigned to more than 1 user, always set to 0.	MU	O
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CENTER_26_TONE_RU	FORMAT is HE_MU and CH_BANDWIDTH is CBW80, CBW160, CBW80+80, HE-CBW-PUNC80-PRI, HE-CBW-PUNC80-SEC, HE-CBW-PUNC160-PRI20, HE-CBW-PUNC80+80-PRI20, HE-CBW-PUNC160-SEC40, or HE-CBW-PUNC80+80-SEC40.	Indicate the presence of the center 26-tone RU with regard to bandwidth. If the CH_BANDWIDTH parameter is CBW80, HE-CBW-PUNC80-PRI or HE-CBW-PUNC80-SEC: Set to 1 to indicate that a user is allocated to the center 26-tone RU (see Figure 27-7 (RU locations in an 80 MHz HE PPDU)) Set to 0 to indicate that no user is allocated to the center 26-tone RU If the CH_BANDWIDTH parameter is CBW160, CBW80+80, HE-CBW-PUNC160-PRI20, HE-CBW-PUNC80+80-PRI20, HE-CBW-PUNC160-SEC40, or HE-CBW-PUNC80+80-SEC40: Set to 0 to indicate that no user is allocated to either the center 26-tone RU of the lower frequency 80 MHz or that of the higher frequency 80 MHz Set to 1 to indicate that a user is allocated to the center 26-tone RU of the lower frequency 80 MHz Set to 2 to indicate that a user is allocated to the center 26-tone RU of the higher frequency 80 MHz Set to 3 to indicate that a user is allocated to each of the center 26-tone RU of the lower frequency 80 MHz and that of the higher frequency 80 MHz individually See 27.3.11.8.3 (Common field).	Y	N
	Otherwise	Not present	N	N
HE_LTF_TYPE	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Indicates the type of HE-LTF. Enumerated type: 1xHE-LTF indicates a 1x HE-LTF 2xHE-LTF indicates a 2x HE-LTF 4xHE-LTF indicates a 4x HE-LTF See 27.3.11.10 (HE-LTF).	Y	Y
	Otherwise	Not present.	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
HE_LTF_MODE	FORMAT is HE_TB	Integer: Set to 0 to indicate that the transmitted PPDU uses HE single stream pilot HE-LTF mode. Set to 1 to indicate the transmitted PPDU uses HE masked HE-LTF sequence mode. Present for full bandwidth MU-MIMO not using 1x HE-LTF and not present otherwise. See 27.3.11.10 (HE-LTF).	O	N
	Otherwise	Not present.	N	N
NUM_HE_LTF	FORMAT is HE_MU or HE_TB	Indicates the number of OFDM symbols in the HE-LTF field. See 26.5.2.3 (Non-AP STA behavior for UL MU operation) and 27.3.11.7.2 (Content).	Y	N
	Otherwise	Not present.	N	N
HE_SIG_A2_RESERVED	FORMAT is HE_TB	Indicates the Reserved field setting for HE-SIG-A2 of HE TB PPDU. See 26.5.2.3 (Non-AP STA behavior for UL MU operation) and Table 27-21 (HE-SIG-A field of an HE TB PPDU) for details.	Y	N
	Otherwise	Not present.	N	N
STARTING_STS_NUM	FORMAT is HE_TB	Set to the starting spatial stream number minus 1 (spatial streams are globally numbered starting from 1)	Y	N
	Otherwise	Not present.	N	N
TXOP_PS_NOT_ALLOWED	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
RX_START_OF_FRAME_OFFSET	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
PREAMBLE_TYPE	FORMAT is NON_HT and NON_HT_MODULATION is one of ERP-DSSS ERP-CCK	Enumerated type: SHORTPREAMBLE LONGPREAMBLE	Y	Y
	Otherwise	Not present	N	N
NOMINAL_PACKET_PADDING	FORMAT is HE_SU, HE_MU or HE_ER_SU	The nominal packet padding as defined in 9.4.2.247.5 (PPE Thresholds field). Possible values are 0 µs, 8 µs and 16 µs.	MU	N
	Otherwise	Not present	N	N
TRIGGER_METHOD	FORMAT is HE_TB	Indicates the method used to trigger this HE TB PPDU transmission. Enumerated type: TRIGGER_FRAME for Trigger frame TRS for TRS Control subfield	Y	N
	Otherwise	Not present	N	N
DEFAULT_PE_DURATION	FORMAT is HE_TB and TRIGGER_METHOD is TRS	Duration of the PE field to be transmitted (see 26.5.2.3 (Non-AP STA behavior for UL MU operation)). A value 0, 4, 8, 12 or 16 indicating the PE field duration in µs.	Y	N
	Otherwise	Not present	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
BEAM_CHANGE	FORMAT is HE_SU or HE_ER_SU	Integer: Set to 0 to indicate that the spatial mapping of the pre-HE modulated fields are the same as the first symbol of HE-LTF field. Set to 1 to indicate that the spatial mapping of the pre-HE modulated fields are different from the first symbol of HE-LTF field.	Y	Y
	Otherwise	Not present	N	N
BSS_COLOR	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB	Set to a value in the range 0 to 63 (see 26.11 (Setting TXVECTOR parameters for an HE PPDU)).	Y	Y
	Otherwise	Not present	N	N
UPLINK_FLAG	FORMAT is HE_SU or HE_MU	Set to 1 if the PPDU is addressed to an AP Set to 0 otherwise.	Y	Y
	FORMAT is HE_ER_SU	Set to 0 if the PPDU is not addressed to an AP, or if the PPDU is addressed to an AP and meets the exception in 26.11.2 (UPLINK_FLAG). Set to 1 otherwise.	Y	Y
	Otherwise	Not present	N	N
STA_ID	FORMAT is HE_MU	Indicates the list of STA-IDs for an HE MU PPDU (see 26.11 (Setting TXVECTOR parameters for an HE PPDU)).	MU	MU
	Otherwise	Not present	N	N
SCRAMBLER_INITIAL_VALUE	FORMAT is NON_HT	In TXVECTOR, if present, indicates the value of the Scrambler Initialization field in the SERVICE field, after scrambling. In RXVECTOR, indicates the value of the Scrambler Initialization field in the SERVICE field, prior to descrambling.	O	Y
	FORMAT is HE_MU or HE_TB	Not present.	N	N
	FORMAT is VHT and GROUP_ID is neither 0 nor 63	Not present.	N	N
	Otherwise	Indicates the value in the Scrambler Initialization field in the SERVICE field prior to descrambling.	N	Y

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
TRIGGER_RESPONDING	FORMAT is NON_HT	Boolean value: true indicates that the MAC entity requests that the PHY entity do synchronization as defined in 27.3.15.3 (Pre-correction accuracy requirements). false indicates that the MAC entity does not request that the PHY entity do synchronization as defined in 27.3.15.3 (Pre-correction accuracy requirements). Set to true if the non-HT or non-HT duplicate PPDU is sent in response to an MU-RTS Trigger frame. Set to false otherwise.	Y	N
	Otherwise	Not present	N	N
NDP_REPORT	FORMAT is HE_TB and PSDU_LENGTH = 0	Provides the detected status array on the resources assigned by the Trigger frame. The array has N_{STA} entries (N_{STA} is defined in 26.5.7.2 (STA behavior)) where each entry takes on the value: 1 if transmission is detected on the first group of the tone set 0 if transmission is detected on the second group of the tone set NONE if transmission is not detected on either group of the tone set.	N	Y
	Otherwise	Not present	N	N
FEEDBACK_STATUS	FORMAT is HE_TB and APEP_LENGTH = 0	Indicates the value of the one bit used to modulate the tones in each tone set. See 27.3.4 (HE PPDU formats) and 26.5.7 (NDP feedback report procedure).	Y	N
	Otherwise	Not present	N	N
RU_TONE_SET_INDEX	FORMAT is HE_TB and APEP_LENGTH = 0	Indicates the RU tone set used for an HE TB feedback NDP. See 27.3.18 (HE TB feedback NDP).	Y	N
	Otherwise	Not present	N	N

Table 27-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
MIDAMBLE_PERIODICITY	FORMAT is HE_SU, HE_MU, HE_ER_SU or HE_TB, and DOPPLER is 1	Indicates the midamble periodicity in number of OFDM symbols in the Data field. Set to 10 or 20.	Y	N
	Otherwise	Not present.	N	N
HE_TB_PE_DISAMBIGUITY	FORMAT is HE_TB and TRIGGER_METHOD is TRIGGER_FRAME	Indicates PE disambiguity for the HE TB PPDU transmission. Set to 0 to indicate no PE disambiguity Set to 1 to indicate PE disambiguity	Y	N
	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 and HE ER SU PPDU and present per user for an HE MU PPDU. For an HE TB PPDU, MU in the TXVECTOR column indicates that the parameter is present once and MU in the RXVECTOR column indicates the parameter is not present. 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.

NOTE 2—Refer to Clause 15, 16, 17, 18, 19 and 21 for the TXVECTOR/RXVECTOR parameters that are not present in this table when FORMAT is not HE_SU, HE_MU, HE_ER_SU or HE_TB.

27.2.3 TRIGVECTOR parameters

The TRIGVECTOR is carried in a PHY-TRIGGER.request primitive and provides the PHY of the AP with the parameters needed to receive an HE TB PPDU over each assigned RU. The parameters in Table 27-2

(TRIGVECTOR parameters) are defined as part of the TRIGVECTOR parameter list in the PHY-TRIGGER.request primitive.

Table 27-2—TRIGVECTOR parameters

Parameter	Value
CH_BANDWIDTH	Indicates the bandwidth in the HE-SIG-A of the expected HE TB PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz
UL_LENGTH	Indicates the value of the L-SIG LENGTH field of the expected HE TB PPDU.
GI_AND_HE_LTF_TYPE	Indicates the GI and HE-LTF type of the expected HE TB PPDU. Enumerated type: 1x HE-LTF + 1.6 μs GI 2x HE-LTF + 1.6 μs GI 4x HE-LTF + 3.2 μs GI
MU_MIMO_HE_LTF_MODE	Indicates the HE-LTF mode of the expected UL MU-MIMO HE TB PPDU, if it uses full bandwidth MU-MIMO and does not use 1x HE-LTF. Set to 0 to indicate that HE single stream pilot HE-LTF mode is used. Set to 1 to indicate that HE masked HE-LTF sequence mode is used.
NUMBER_OF_HE_LTF_SYMBOLS	Indicates the number of HE-LTF symbols present in the expected HE TB PPDU. If the parameter DOPPLER is 0: Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols If the parameter DOPPLER is 1: Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols
MIDAMBLE_PREIODICITY	Indicates the midamble periodicity. Present only if the parameter DOPPLER is 1. Integer value: Set to 10 to indicate a 10 symbol midamble periodicity Set to 20 to indicate a 20 symbol midamble periodicity
STBC	Indicates the status of STBC encoding in the expected HE TB PPDU. Set to 1 if STBC encoding is used. Set to 0 otherwise.
LDPC_EXTRA_SYMBOL	Indicates the status of the LDPC extra symbol segment in the expected HE TB PPDU. Set to 1 if LDPC extra symbol segment is present. Set to 0 otherwise.

Table 27-2—TRIGVECTOR parameters *(continued)*

Parameter	Value
PRE_FEC_FACTOR	Indicates the pre-FEC padding factor for the expected HE TB PPDU. Set to 0 to indicate a pre-FEC padding factor of 4. Set to 1 to indicate a pre-FEC padding factor of 1. Set to 2 to indicate a pre-FEC padding factor of 2. Set to 3 to indicate a pre-FEC padding factor of 3.
PE_DISAMBIGUITY	Indicates the PE disambiguity for the expected HE TB PPDU. Set to 0 to indicate no PE disambiguity. Set to 1 to indicate PE disambiguity.
DOPPLER	Indicates a high Doppler mode for the expected HE TB PPDU. Set to 1 to indicate that midambles are present. Set to 0 otherwise.
AID12_LIST	Carries the 12 LSBs of the AID of each triggered STA. NOTE—Each entry of AID12_LIST is (12-bit) AID of the corresponding HE TB PPDU. See the AID12 subfield in 9.3.1.22 (Trigger frame format).
RU_ALLOCATION_LIST	8 bits are used per STA to indicate the RU allocated in the whole bandwidth. See 9.3.1.22 (Trigger frame format).
FEC_CODING_LIST	Indicates the coding type for each expected HE TB PPDU. NOTE—Each entry indicates the coding type of the corresponding HE TB PPDU. See the UL FEC Coding Type subfield description in 9.3.1.22 (Trigger frame format).
HE_MCS_LIST	Indicates the HE-MCS for each expected HE TB PPDU. NOTE—Each entry of HE_MCS_LIST indicates the HE-MCS of the corresponding HE TB PPDU. See the UL HE-MCS subfield in 9.3.1.22 (Trigger frame format) for more information of each entry.
UL_DCM_LIST	Indicates whether or not DCM is applied for each expected HE TB PPDU. NOTE—Each entry indicates 1-bit UL DCM of the corresponding HE TB PPDU. See the UL DCM subfield description in 9.3.1.22 (Trigger frame format) for details.
SS_ALLOCATION_LIST	Indicates the spatial streams of each expected HE TB PPDU. NOTE—Each entry indicates the spatial streams of the corresponding HE TB PPDU. See the SS Allocation subfield description in 9.3.1.22 (Trigger frame format).

27.2.4 PHYCONFIG_VECTOR parameters

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for an HE PHY contains an OPERATING_CHANNEL parameter, which identifies the operating or primary channel. The PHY shall set dot11CurrentPrimaryChannel to the value of this parameter.

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for an HE PHY contains a CHANNEL_WIDTH parameter, which identifies the operating channel width and takes one of the values 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 80+80 MHz. The PHY shall set dot11CurrentChannelWidth to the value of this parameter. The PHY shall set dot11HECurrentChannelWidthSet to a value that is obtained from the Supported Channel Width Set subfield of a transmitted HE Capabilities element.

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for an HE PHY contains a CENTER_FREQUENCY_SEGMENT_0 parameter, which identifies the center frequency of the channel (or of segment 0 if the CHANNEL_WIDTH parameter indicates 80+80 MHz) and takes a value between 1 and 255. The PHY shall set dot11CurrentChannelCenterFrequencyIndex0 to the value of this parameter. The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for an HE PHY contains a CENTER_FREQUENCY_SEGMENT_1 parameter, which takes the value 0 if the CHANNEL_WIDTH parameter does not indicate 80+80 MHz, and otherwise identifies the center frequency of segment 1 and takes a value between 1 and 200. The PHY shall set dot11CurrentChannelCenterFrequencyIndex1 to the value of this parameter.

27.2.5 Effects of CH_BANDWIDTH parameter on PPDU format

Table 27-3 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters) shows the valid combinations of the FORMAT, NON_HT MODULATION and CH_BANDWIDTH parameters and the corresponding PPDU format and value of CH_OFFSET (if applicable). Other combinations are reserved.

Table 27-3— Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters

FORMAT	NON_HT_ MODULATION	CH_BANDWIDTH	CH_OFFSET	PPDU format
HE	N/A	CBW20	N/A	The STA transmits an HE PPDU of 20 MHz bandwidth. If the BSS bandwidth is wider than 20 MHz, then the transmission shall use the primary 20 MHz channel.
HE	N/A	CBW40	N/A	The STA transmits an HE PPDU of 40 MHz bandwidth. If the BSS bandwidth is wider than 40 MHz, then the transmission shall use the primary 40 MHz channel.
HE	N/A	CBW80	N/A	The STA transmits an HE PPDU of 80 MHz bandwidth. If the BSS bandwidth is wider than 80 MHz, then the transmission shall use the primary 80 MHz channel.
HE	N/A	CBW160	N/A	The STA transmits an HE PPDU of 160 MHz bandwidth.
HE	N/A	CBW80+80	N/A	The STA transmits an HE PPDU of 80+80 MHz bandwidth.
HE	N/A	HE-CBW-PUNC80-PRI	N/A	The STA transmits an HE PPDU on the punctured 80 MHz bandwidth where only the secondary 20 MHz is punctured.
HE	N/A	HE-CBW-PUNC80-SEC	N/A	The STA transmits an HE PPDU on the punctured 80 MHz bandwidth where only one of the two 20 MHz subchannels in secondary 40 MHz is punctured.

Table 27-3— Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters *(continued)*

FORMAT	NON_HT_ MODULATION	CH_BANDWIDTH	CH_OFFSET	PPDU format
HE	N/A	HE-CBW-PUNC160-PRI20	N/A	The STA transmits an HE PPDU on the punctured 160 MHz bandwidth where only the secondary 20 MHz in the primary 80 MHz is punctured.
HE	N/A	HE-CBW-PUNC80+80-PRI20	N/A	The STA transmits an HE PPDU on the punctured 80+80 MHz bandwidth where only the secondary 20 MHz in the primary 80 MHz is punctured.
HE	N/A	HE-CBW-PUNC160-SEC40	N/A	The STA transmits an HE PPDU on the punctured 160 MHz bandwidth where the primary 40 MHz in the primary 80 MHz is present, and at least one 20 MHz subchannel that is not in the primary 40 MHz is punctured.
HE	N/A	HE-CBW-PUNC80+80-SEC40	N/A	The STA transmits an HE PPDU on the punctured 80+80 MHz bandwidth where the primary 40 MHz in the primary 80 MHz is present, and at least one 20 MHz subchannel that is not in the primary 40 MHz is punctured.
HT_MF, HT_GF, VHT	See Table 21-2 (Interpretation of FORMAT, NON_HT_MODULATION, CH_BANDWIDTH, and CH_OFFSET parameters) and Table 19-2 (Interpretation of FORMAT, CH_BANDWIDTH and CH_OFFSET parameters)			
NON_HT	If INACTIVE_SUBCHANNELS is not present, see Table 21-2 (Interpretation of FORMAT, NON_HT_MODULATION, CH_BANDWIDTH, and CH_OFFSET parameters) and Table 19-2 (Interpretation of FORMAT, CH_BANDWIDTH and CH_OFFSET parameters)			
NON_HT	If INACTIVE_SUBCHANNELS is present, see Table 27-4 (Interpretation of CH_BANDWIDTH and INACTIVE_SUBCHANNELS parameters when FORMAT is equal to NON_HT and NON_HT_MODULATION is equal to NON_HT_DUP_OFDM)			

Valid combinations of the CH_BANDWIDTH and INACTIVE_SUBCHANNELS parameters when FORMAT is NON_HT and the corresponding PPDU and CH_OFFSET (if applicable) are shown in Table 27-4 (Interpretation of CH_BANDWIDTH and INACTIVE_SUBCHANNELS parameters when FORMAT is equal to NON_HT and NON_HT_MODULATION is equal to NON_HT_DUP_OFDM). Other combinations are reserved.

27.2.6 Support for non-HT, HT and VHT formats

27.2.6.1 General

An HE STA logically contains Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 19 (High Throughput (HT) PHY specification), Clause 21 (Very

Table 27-4— Interpretation of CH_BANDWIDTH and INACTIVE_SUBCHANNELS parameters when FORMAT is equal to NON_HT and NON_HT_MODULATION is equal to NON_HT_DUP_OFDM

CH_BANDWIDTH	INACTIVE_SUBCHANNELS	CH_OFFSET	PPDU format
CBW80	All bits set to 1 except for the four bits corresponding to the primary 80 MHz channel, which are set to 0	N/A	The STA transmits a NON_HT PPDU of 80 MHz bandwidth. If the BSS bandwidth is wider than 80 MHz, then the transmission shall use the primary 80 MHz channel.
CBW80	The bit corresponding to the primary 20 MHz channel set to 0 and one or two other bits set to 0 that correspond to any other subchannels in the primary 80 MHz, all other bits set to 1	N/A	The STA transmits a punctured NON_HT PPDU of 80 MHz bandwidth. If the BSS bandwidth is wider than 80 MHz, then the transmission shall use the primary 80 MHz channel.
CBW160	All eight bits set to 0	N/A	The STA transmits a NON_HT PPDU of 160 MHz bandwidth.
CBW160	The bit corresponding to the primary 20 MHz channel set to 0 and one to six other bits set to 0 that correspond to any other subchannels in the 160 MHz, all other bits set to 1	N/A	The STA transmits a punctured NON_HT PPDU of 160 MHz bandwidth.
CBW80+80	All eight bits set to 0	N/A	The STA transmits a NON_HT PPDU of 80+80 MHz bandwidth.
CBW80+80	The bit corresponding to the primary 20 MHz channel set to 0 and one to six other bits set to 0 that correspond to any other subchannels in the 80+80 MHz, all other bits set to 1	N/A	The STA transmits a punctured NON_HT PPDU of 80+80 MHz bandwidth.

High Throughput (VHT) PHY specification) and Clause 27 (High Efficiency (HE) PHY specification) PHYs. The MAC interacts with the PHYs via the Clause 27 (High Efficiency (HE) PHY specification) PHY service interface, which in turn interacts with the Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 19 (High Throughput (HT) PHY specification) PHY service interfaces and Clause 21 (Very High Throughput (VHT) PHY specification) as shown in Figure 27-

1 (PHY interaction on transmit for various PPDU formats), Figure 27-2 (PHY interaction on receive for various PPDU formats), and Figure 27-3 (PHY-CONFIG and CCA interaction with various PPDU formats).

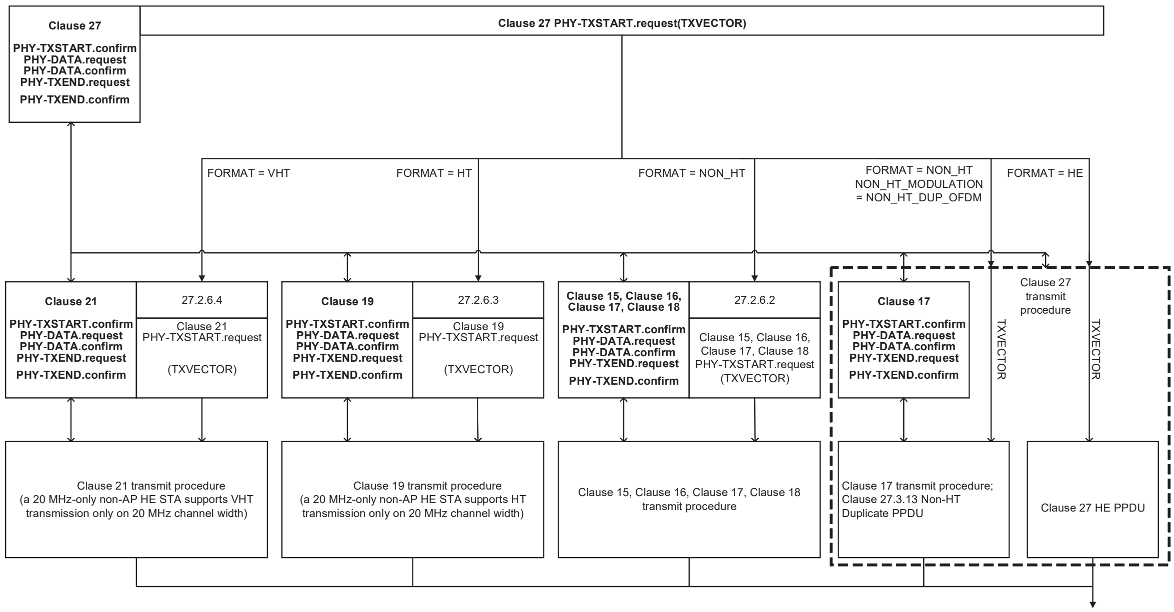

Figure 27-1—PHY interaction on transmit for various PPDU formats

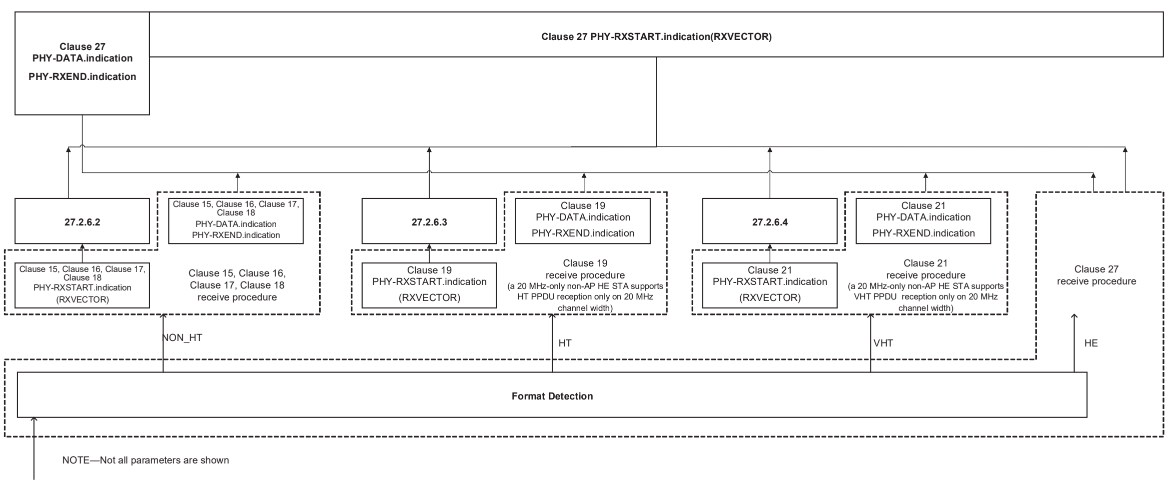

Figure 27-2—PHY interaction on receive for various PPDU formats

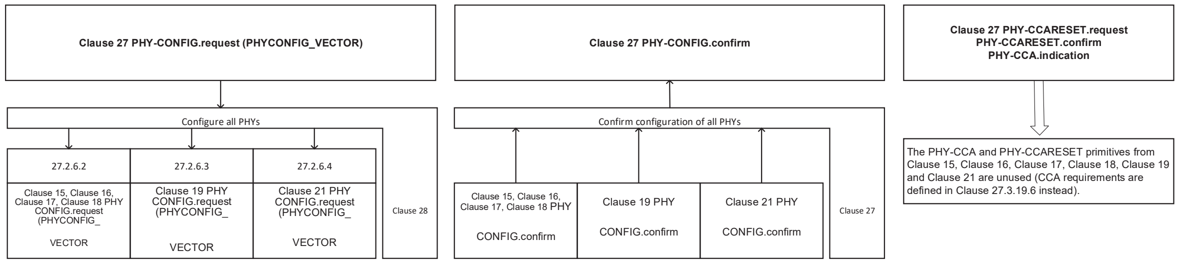

Figure 27-3—PHY-CONFIG and CCA interaction with various PPDU formats

27.2.6.2 Support for non-HT format

The behavior of the HE PHY on receipt of a PHY-TXSTART.request(TXVECTOR) primitive with the FORMAT parameter equal to NON_HT and the NON_HT_MODULATION parameter not equal to NON_HT_DUP_OFDM is defined in Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), and Clause 18 (Extended Rate PHY (ERP) specification) and depends on the parameter NON_HT_MODULATION. If the parameter NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM, then the following additional requirements apply:

— The requirements in 21.3.9.1 (Transmission of 20 MHz NON_HT PPDUs with more than one transmit chain)
— The requirements in 21.3.17.1 (Transmit spectrum mask) instead of the requirements in 17.3.9.3 (Transmit spectrum mask)
— The requirements in 27.3.19.3 (Transmit center frequency and symbol clock frequency tolerance)) instead of the requirements in 17.3.9.7.2 (Transmitter center frequency leakage)

The modulation equation for non-HT duplicate transmission is defined in 27.3.14 (Non-HT duplicate transmission).

The HE PHY TXVECTOR parameters in Table 27-1 (TXVECTOR and RXVECTOR parameters) are mapped to Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), and Clause 18 (Extended Rate PHY

(ERP) specification) TXVECTOR parameters according to Table 27-5 (Mapping of the HE PHY parameters for non-HT operation). The HE PHY parameters not listed in the table are not present.

Table 27-5—Mapping of the HE PHY parameters for non-HT operation

HE PHY Parameter	2.4 GHz operation defined by Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications)	2.4 GHz operation defined by Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification)	2.4 GHz operation defined by Clause 18 (Extended Rate PHY (ERP) specification)	5 GHz and 6 GHz operation defined by Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification)	Parameter List
L_LENGTH	LENGTH	LENGTH	LENGTH	LENGTH	TXVECTOR/ RXVECTOR
L_DATARATE	DATARATE	DATARATE	DATARATE	DATARATE	TXVECTOR/ RXVECTOR
TXPWR_ LEVEL_ INDEX	TXPWR_ LEVEL_INDEX	TXPWR_ LEVEL_INDEX	TXPWR_ LEVEL_INDEX	TXPWR_ LEVEL_INDEX	TXVECTOR
RSSI	RSSI	RSSI	RSSI	RSSI	RXVECTOR
SERVICE	SERVICE	SERVICE	SERVICE	SERVICE	TXVECTOR/ RXVECTOR
RCPI	RCPI	RCPI	RCPI	RCPI	RXVECTOR
CH_ BANDWIDTH _IN_NON_HT	discarded	discarded	CH_ BANDWIDTH_ IN_NON_HT	CH_ BANDWIDTH_ IN_NON_HT	TXVECTOR/ RXVECTOR
DYN_ BANDWIDTH _IN_NON_HT	discarded	discarded	DYN_ BANDWIDTH_ IN_NON_HT	DYN_ BANDWIDTH_ IN_NON_HT	TXVECTOR/ RXVECTOR
OPERATING_ CHANNEL	discarded	discarded	discarded	OPERATING_ CHANNEL	PHYCONFIG _VECTOR

The behavior of the HE PHY on receipt of a PHY-TXSTART.request(TXVECTOR) primitive with the FORMAT parameter equal to NON-HT and the NON_HT_MODULATION parameter equal to NON_HT_ DUP_OFDM is defined in 27.3.14 (Non-HT duplicate transmission).

To support the non-HT format, the HE PHY, on receipt of a PHY-CONFIG.request(PHYCONFIG_VEC-TOR) primitive, behaves as if it were a Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specifica-tion), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or Clause 18 (Extended Rate PHY (ERP) specification) PHY that had received a PHY-CONFIG.request(PHYCONFIG_ VECTOR) primitive but without the PHYCONFIG_VECTOR parameters CHANNEL_WIDTH, CENTER_ FREQUENCY_SEGMENT_0, and CENTER_FREQUENCY_SEGMENT_1.

As defined in 27.3.22 (HE receive procedure), once a PPDU is received and detected as a non-HT PPDU, the behavior of the HE PHY is defined in Clause 15 (DSSS PHY specification for the 2.4 GHz band desig-nated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specifi-cation), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), or Clause 18

(Extended Rate PHY (ERP) specification) depending on the PPDU format. The RXVECTOR parameters from the Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification) are mapped to the HE PHY RXVECTOR parameters as defined in Table 27-5 (Mapping of the HE PHY parameters for non-HT operation). The HE PHY parameters not listed in the table are not present.

27.2.6.3 Support for HT format

The behavior of an HE PHY on receipt of a PHY-TXSTART.request(TXVECTOR) primitive with the TXVECTOR parameter FORMAT equal to HT_MF or HT_GF is defined in Clause 19 (High Throughput (HT) PHY specification) with the following additional requirements:

- The requirements in 21.3.9.2 (Transmission of HT PPDUs with more than four transmit chains)
- The requirements in 27.3.19.3 (Transmit center frequency and symbol clock frequency tolerance) instead of the requirements in 19.3.18.4 (Transmit center frequency tolerance)

The HE PHY TXVECTOR parameters in Table 27-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to Clause 19 (High Throughput (HT) PHY specification) TXVECTOR parameters in Table 19-1 (TXVECTOR and RXVECTOR parameters). The HE PHY parameters not listed in Table 19-1 are not present. The PHY shall use a value of CH_OFFSET in the Clause 19 (High Throughput (HT) PHY specification) TXVECTOR that is consistent with Table 27-3 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters). A 20 MHz-only non-AP HE STA supports HT transmission only on 20 MHz channel width.

On receipt of a PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive, the HE PHY behaves, for the purposes of HT PPDU transmission and reception, as if it were a Clause 19 (High Throughput (HT) PHY specification) PHY that had received PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive but without the PHYCONFIG_VECTOR parameters CHANNEL_WIDTH, CENTER_FREQUENCY_SEGMENT_0, and CENTER_FREQUENCY_SEGMENT_1 and with the PHYCONFIG_VECTOR parameter SECONDARY_CHANNEL_OFFSET set to SECONDARY_CHANNEL_NONE if dot11CurrentChannelWidth indicates 20 MHz, to SECONDARY_CHANNEL_ABOVE if $f_{P20,idx} < f_{S20,idx}$, or to SECONDARY_CHANNEL_BELOW otherwise.

As defined in 27.3.22 (HE receive procedure), once a PPDU is received and detected as an HT PPDU, the behavior of the HE PHY is defined in Clause 19 (High Throughput (HT) PHY specification). The RXVECTOR parameters in Table 19-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to the RXVECTOR parameters in Table 27-1 (TXVECTOR and RXVECTOR parameters). The HE PHY parameters not listed in Table 19-1 are not present. A 20 MHz-only non-AP HE STA supports HT reception only on 20 MHz channel width.

27.2.6.4 Support for VHT format

The behavior of an HE PHY on receipt of a PHY-TXSTART.request(TXVECTOR) primitive with the TXVECTOR parameter FORMAT equal to VHT is defined in Clause 21 (Very High Throughput (VHT) PHY specification) except that the requirements in 27.3.19.3 (Transmit center frequency and symbol clock frequency tolerance) apply instead of the requirements in 21.3.17.4.2 (Transmit center frequency tolerance).

The HE PHY TXVECTOR parameters in Table 27-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to the Clause 21 (Very High Throughput (VHT) PHY specification) TXVECTOR parameters in Table 21-1 (TXVECTOR and RXVECTOR parameters). The HE PHY parameters not listed in Table 21-1 are not present. The 20 MHz-only non-AP HE STA supports VHT transmission only on 20 MHz channel width.

On receipt of a PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive, the HE PHY behaves, for the purposes of VHT PPDU transmission and reception, as if it were a Clause 21 (Very High Throughput (VHT) PHY specification) PHY that received the PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive.

As defined in 27.3.22 (HE receive procedure), once a PPDU is received and detected as an VHT PPDU, the behavior of the HE PHY is defined in Clause 21 (Very High Throughput (VHT) PHY specification). The RXVECTOR parameters in Table 21-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to the RXVECTOR parameters in Table 27-1 (TXVECTOR and RXVECTOR parameters). The HE PHY parameters not listed in Table 21-1 are not present. A 20 MHz-only non-AP HE STA supports VHT reception only on 20 MHz channel width.

27.3 HE PHY

27.3.1 Introduction

This subclause provides the procedure by which PSDUs are converted to and from transmissions on the wireless medium.

During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU. At the receiver, the PHY preamble is processed to aid in the detection, demodulation, and delivery of the PSDU.

27.3.1.1 MU transmission

The MU transmissions include DL MU transmissions and UL MU transmissions.

DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. UL MU transmission allows an AP to simultaneously receive information from more than one non-AP STA. UL MU transmissions are preceded by a triggering frame from the AP. The non-AP STAs transmit using the HE TB PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both.

The HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 27.3.10 (Mathematical description of signals)). The transmission within an RU in a PPDU may be a single stream to one user, spatially multiplexed to one user (SU-MIMO), or spatially multiplexed to multiple users (MU-MIMO).

NOTE—The VHT PHY supports only full bandwidth DL MU-MIMO as described in 21.3.11 (SU-MIMO and DL-MU-MIMO Beamforming).

The HE PHY supports DL MU-MIMO and UL MU-MIMO, for both the full bandwidth case as well as for the partial bandwidth case where MU-MIMO is used only on certain RUs in the PPDU. The combination of SU transmissions and MU-MIMO transmissions on different RUs in one PPDU is also supported.

27.3.1.2 OFDMA

OFDMA is an OFDM-based multiple access scheme where different subsets of subcarriers are allocated to different users, allowing simultaneous data transmission to or from one or more users. In OFDMA, users are allocated different subsets of subcarriers that can change from one PPDU to the next. The difference between OFDM and OFDMA is illustrated in Figure 27-4 (Illustration of OFDM and OFDMA concepts). Similar to OFDM, OFDMA employs multiple subcarriers, but the subcarriers are divided into several groups where each group is referred to as an RU. With OFDMA, different transmit powers may be applied to different RUs.

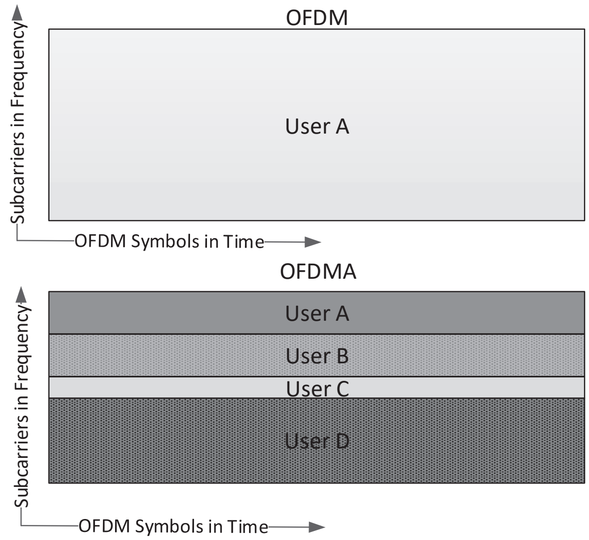

Figure 27-4—Illustration of OFDM and OFDMA concepts

27.3.2 Subcarrier and resource allocation

27.3.2.1 General

An OFDM symbol is constructed of subcarriers, the number of which is a function of the PPDU bandwidth. There are several subcarrier types:

1) Data subcarriers, which are used for data transmission (see 27.3.2.2 (Resource unit, guard and DC subcarriers))
2) Pilot subcarriers, which are used for phase information and parameter tracking (see 27.3.2.4 (Pilot subcarriers))
3) Unused subcarriers, which are not used for either data or pilot transmission. The unused subcarriers are the DC subcarrier (see 27.3.2.2 (Resource unit, guard and DC subcarriers)), the Guard band subcarriers at the band edges (see 27.3.2.2 (Resource unit, guard and DC subcarriers)), and the Null subcarriers (see 27.3.2.3 (Null subcarriers)).

The following notation is used to describe the indices for a set of subcarriers:

— [$x1$:$y1$] represents the set of subcarriers with index k that satisfies $x1 \le k \le y1$
— [$x1$:$y1$, $x2$:$y2$] represents the set of subcarriers with index k that satisfies either $x1 \le k \le y1$ or $x2 \le k \le y2$

27.3.2.2 Resource unit, guard and DC subcarriers

The RUs defined for DL and UL transmission are as follows: 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU, 484-tone RU, 996-tone RU and 2×996-tone RU.

The 26-tone RU, 52-tone RU, 106-tone RU and 242-tone RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU format. The 52-tone RU, 106-tone RU and 242-tone RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE TB PPDU format. The 26-tone RU is used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE TB PPDU format unless a STA is operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_ Behavior (see 26.5.2.2.1 (General) and 26.5.2.3 (Non-AP STA behavior for UL MU operation)). The 106-tone RU is used in the HE ER SU PPDU format.

The 484-tone RU is used in the 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU and HE TB PPDU formats. The 996-tone RU is used in the 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU and HE TB PPDU formats. The 2×996-tone RU is used in the 160 MHz and 80+80 MHz HE MU PPDU format and 160 MHz and 80+80 MHz HE TB PPDU format.

The 242-tone and larger RUs are used in the HE SU PPDU format. The 242-tone RU is used in the 20 MHz HE SU PPDU and HE ER SU PPDU formats. The 484-tone RU is used in the 40 MHz HE SU PPDU format. The 996-tone RU is used in the 80 MHz HE SU PPDU format. The 2×996-tone RU is used in the 160 MHz and 80+80 MHz HE SU PPDU formats.

The maximum number of RUs in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE PPDU formats are defined in Table 27-6 (Maximum number of RUs for each channel width).

Table 27-6—Maximum number of RUs for each channel width

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

An HE MU PPDU using OFDMA transmission can carry a mixture of 26-, 52-, 106-, 242-, 484-, and 996-tone RUs.

A 26-tone RU consists of 24 data subcarriers and 2 pilot subcarriers. The positions of the pilots for the 26-tone RU are defined in 27.3.2.4 (Pilot subcarriers). The location of the 26-tone RUs are fixed as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU).

Table 27-7—Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	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-tone RU	RU 1 [–121: –70]	RU 2 [–68: –17]	RU 3 [17: 68]	RU 4 [70: 121]	
106-tone RU	RU 1 [–122: –17]		RU 2 [17: 122]		
242-tone RU	RU 1 [–122: –2, 2:122]				
The subcarrier index of 0 corresponds to the DC tone. Negative subcarrier indices correspond to subcarries with frequency lower than the DC tone, and positive subcarrier indices correspond to subcarriers with frequency higher than the DC tone. RU 5 is the middle 26-tone RU.					

Table 27-8—Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	RU 1 [–243: –218]	RU 2 [–217: –192]	RU 3 [–189: –164]	RU 4 [–163: –138]	RU 5 [–136: –111]
	RU 6 [–109: –84]	RU 7 [–83: –58]	RU 8 [–55: –30]	RU 9 [–29: –4]	
	RU 10 [4: 29]	RU 11 [30: 55]	RU 12 [58: 83]	RU 13 [84: 109]	RU 14 [111: 136]
	RU 15 [138: 163]	RU 16 [164: 189]	RU 17 [192: 217]	RU 18 [218: 243]	
52-tone RU	RU 1 [–243: –192]	RU 2 [–189: –138]	RU 3 [–109: –58]	RU 4 [–55: –4]	
	RU 5 [4: 55]	RU 6 [58: 109]	RU 7 [138: 189]	RU 8 [192: 243]	
106-tone RU	RU 1 [–243: –138]	RU 2 [–109: –4]	RU 3 [4: 109]	RU 4 [138: 243]	
242-tone RU	RU 1 [–244: –3]		RU 2 [3: 244]		
484-tone RU	RU 1 [–244: –3, 3: 244]				

Table 27-8—Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU *(continued)*

RU type	RU index and subcarrier range
The subcarrier index of 0 corresponds to the DC tone. Negative subcarrier indices correspond to subcarries with frequency lower than the DC tone, and positive subcarrier indices correspond to subcarriers with frequency higher than the DC tone.	

Table 27-9—Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	RU 1 [–499: –474]	RU 2 [–473: –448]	RU 3 [–445: –420]	RU 4 [–419: –394]	RU 5 [–392: –367]
	RU 6 [–365: –340]	RU 7 [–339: –314]	RU 8 [–311: –286]	RU 9 [–285: –260]	
	RU 10 [–257: –232]	RU 11 [–231: –206]	RU 12 [–203: –178]	RU 13 [–177: –152]	RU 14 [–150: –125]
	RU 15 [–123: –98]	RU 16 [–97: –72]	RU 17 [–69: –44]	RU 18 [–43: –18]	RU 19 [–16: –4, 4: 16]
	RU 20 [18: 43]	RU 21 [44: 69]	RU 22 [72: 97]	RU 23 [98: 123]	RU 24 [125: 150]
	RU 25 [152: 177]	RU 26 [178: 203]	RU 27 [206: 231]	RU28 [232: 257]	
	RU 29 [260: 285]	RU 30 [286: 311]	RU 31 [314: 339]	RU 32 [340: 365]	RU 33 [367: 392]
	RU 34 [394: 419]	RU 35 [420: 445]	RU 36 [448: 473]	RU37 [474: 499]	
52-tone RU	RU 1 [–499: –448]	RU 2 [–445: –394]	RU 3 [–365: –314]	RU 4 [–311: –260]	
	RU 5 [–257: –206]	RU 6 [–203: –152]	RU 7 [–123: –72]	RU 8 [–69: –18]	
	RU 9 [18: 69]	RU 10 [72: 123]	RU 11 [152: 203]	RU 12 [206: 257]	
	RU 13 [260: 311]	RU 14 [314: 365]	RU 15 [394: 445]	RU 16 [448: 499]	
106-tone RU	RU 1 [–499: –394]	RU 2 [–365: –260]	RU 3 [–257: –152]	RU 4 [–123: –18]	
	RU 5 [18: 123]	RU 6 [152: 257]	RU 7 [260: 365]	RU 8 [394: 499]	
242-tone RU	RU 1 [–500: –259]	RU 2 [–258: –17]	RU 3 [17: 258]	RU 4 [259: 500]	
484-tone RU	RU 1 [–500: –17]		RU 2 [17: 500]		

Table 27-9—Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU *(continued)*

RU type	RU index and subcarrier range	
996-tone RU	RU 1 [–500: –3, 3: 500]	
The subcarrier index of 0 corresponds to the DC tone. Negative subcarrier indices correspond to subcarries with frequency lower than the DC tone, and positive subcarrier indices correspond to subcarriers with frequency higher than the DC tone. RU 19 is the center 26-tone RU.		

The data and pilot subcarrier indices for a non-OFDMA 80 MHz HE PPDU are the same as those for a 996-tone RU.

The location of the 26-tone RUs are shown in Figure 27-5 (RU locations in a 20 MHz HE PPDU), Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used for the 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE MU PPDU or HE TB PPDU formats using OFDMA transmission.

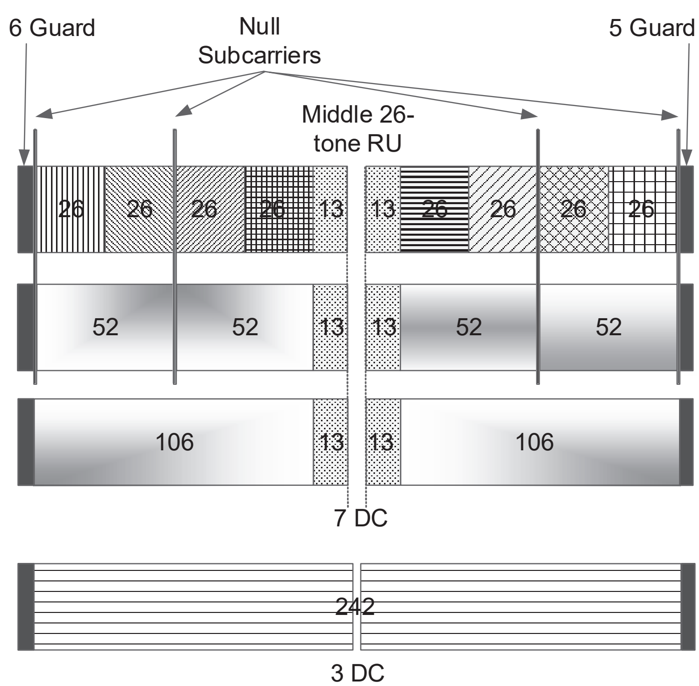

Figure 27-5—RU locations in a 20 MHz HE PPDU

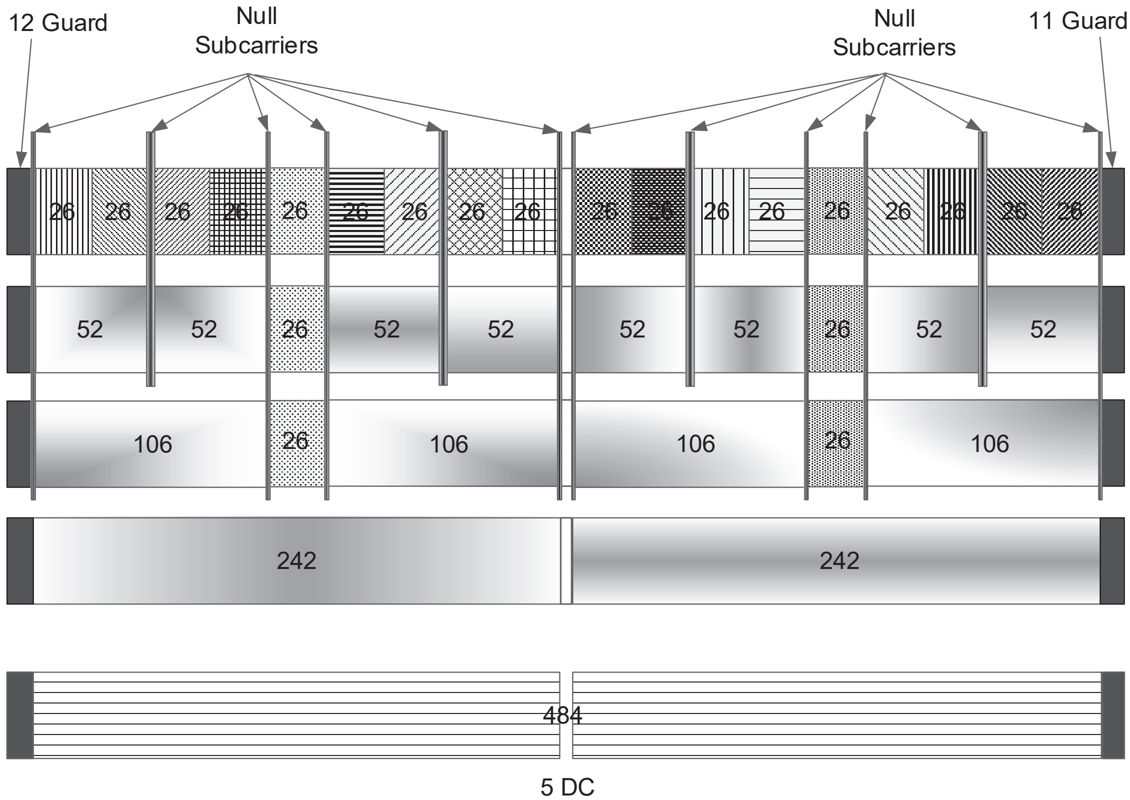

Figure 27-6—RU locations in a 40 MHz HE PPDU

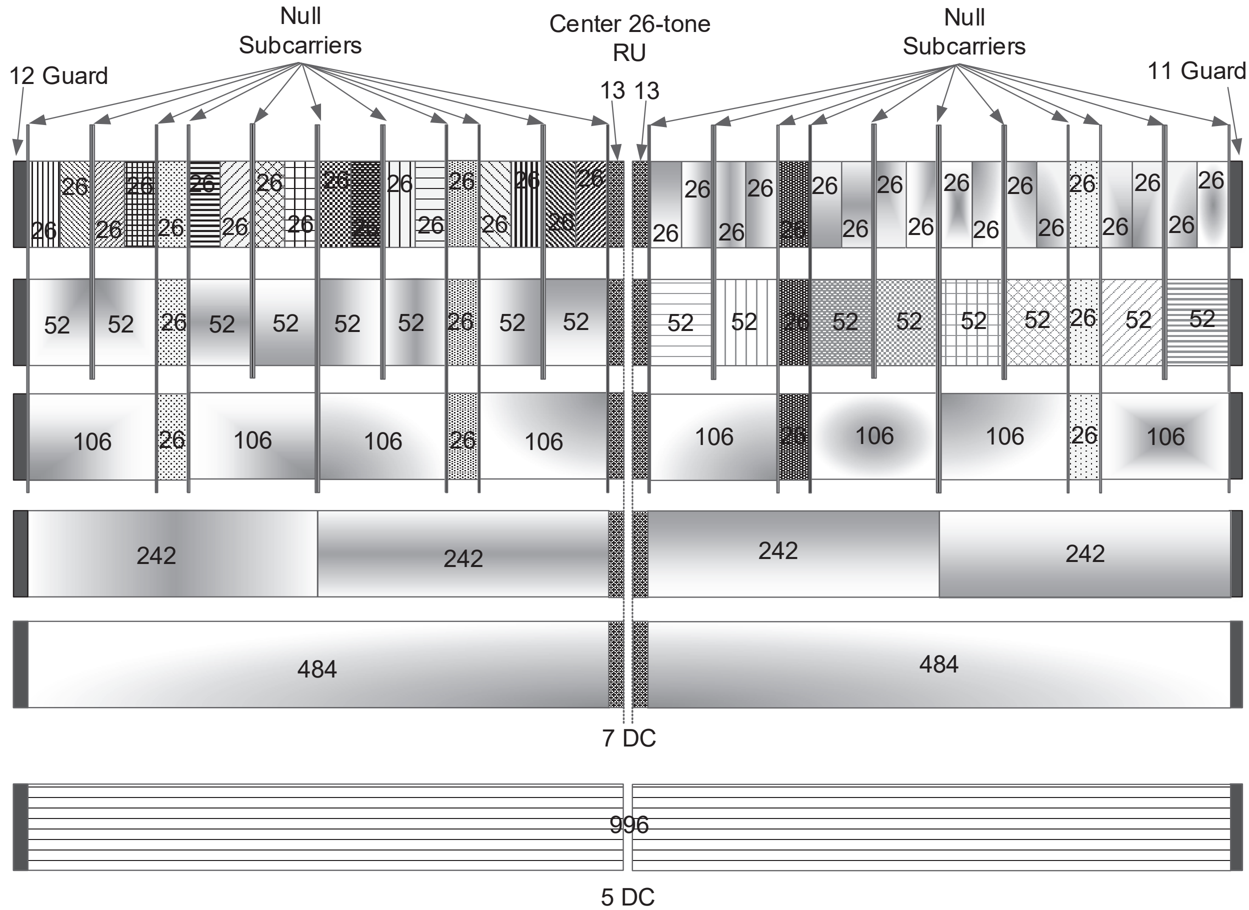

Figure 27-7—RU locations in an 80 MHz HE PPDU

A 52-tone RU consists of 48 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 52-tone RU are defined in 27.3.2.4 (Pilot subcarriers). The locations of the 52-tone RUs are fixed as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU) and illustrated in Figure 27-5 (RU locations in a 20 MHz HE PPDU), Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU format or HE TB PPDU formats using OFDMA transmission is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission.

A 106-tone RU consists of 102 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 106-tone RU are defined in 27.3.2.4 (Pilot subcarriers). The locations of the 106-tone RUs are fixed as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU) and illustrated in Figure 27-5 (RU locations in a 20 MHz HE PPDU), Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission.

A 242-tone RU consists of 234 data subcarriers and 8 pilot subcarriers. The positions of pilots for the 242-tone RU are defined in 27.3.2.4 (Pilot subcarriers). The locations of the 242-tone RUs are fixed as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU) and illustrated in Figure 27-5 (RU locations in a 20 MHz HE PPDU), Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE PPDU formats, respectively. The same structure as used in the 80 MHz HE PPDU formats is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE PPDU formats.

A 484-tone RU consists of 468 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 484-tone RU is defined in 27.3.2.4 (Pilot subcarriers). The locations of the 484-tone RUs are fixed as defined in Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU) and illustrated in Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU) for the 40 MHz and 80 MHz HE PPDU formats. The same structure as used for the 80 MHz HE PPDU formats is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE PPDU formats.

A 996-tone RU consists of 980 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 996-tone RU is defined in 27.3.2.4 (Pilot subcarriers). The locations of the 996-tone 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 MHz and 80+80 MHz HE PPDU formats.

A 2×996-tone RU consists of two 996-tone RUs, one RU in each of the 80 MHz channels for 160 MHz and 80+80 MHz HE PPDU formats.

The 20 MHz HE MU PPDU and HE TB PPDU with one or more RUs smaller than 242 tones have 7 DC subcarriers located at [–3: 3]. The 20 MHz HE SU PPDU, HE MU PPDU and HE TB PPDU with a 242-tone RU have 3 DC subcarriers located at [–1: 1]. The 40 MHz HE PPDU has 5 DC subcarriers located at [–2: 2]. The 80 MHz HE MU PPDU and HE TB PPDU with one or more RUs smaller than 996 tones have 7 DC subcarriers located at [–3: 3]. The 80 MHz HE SU PPDU, HE MU PPDU and HE TB PPDU with a 996-tone RU have 5 DC subcarriers located at [–2: 2]. The structure used in the 80 MHz HE PPDU is used for both the Primary 80 MHz and Secondary 80 MHz channels in the 160 MHz and 80+80 MHz HE PPDU. The DC subcarriers are located on subcarriers [–11: 11].

The 20 MHz HE PPDU has 11 guard subcarriers: the 6 lowest frequency subcarriers [–128: –123] and 5 highest frequency subcarriers [123: 127] as shown in Figure 27-5 (RU locations in a 20 MHz HE PPDU). The 40 MHz HE PPDU has 23 guard subcarriers: the 12 lowest frequency subcarriers [–256: –245] and the 11 highest frequency subcarriers [245: 255] as shown in Figure 27-6 (RU locations in a 40 MHz HE PPDU). The 80 MHz HE PPDU has 23 guard subcarriers: the 12 lowest frequency subcarriers [–512: –501] and the 11 highest frequency subcarriers [501: 511] as shown in Figure 27-7 (RU locations in an 80 MHz HE PPDU). For the 160 MHz and 80+80 MHz HE PPDU, the same number of lowest frequency and highest frequency guard subcarriers as 80 MHz are defined at each edge of the 160 MHz and 80+80 MHz.

27.3.2.3 Null subcarriers

There are null subcarriers between the 26-, 52- and 106-tone RU locations as illustrated in Figure 27-5 (RU locations in a 20 MHz HE PPDU), Figure 27-6 (RU locations in a 40 MHz HE PPDU) and Figure 27-7 (RU locations in an 80 MHz HE PPDU). The null subcarriers are located near the DC or edge tones to provide protection from transmit center frequency leakage, receiver DC offset, and interference from neighboring RUs. The null subcarriers have zero energy. The indices of the null subcarrier are enumerated in Table 27-10 (Null subcarrier indices).

Table 27-10— 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
160 MHz	26, 52, 106	{null subcarrier indices in 80 MHz – 512, null subcarrier indices in 80 MHz + 512}
	242, 484, 996, 2×996	none

The null subcarriers locations for each 80 MHz frequency segment of an 80+80 MHz HE PPDU shall follow the locations of an 80 MHz HE PPDU.

27.3.2.4 Pilot subcarriers

Within the HE modulated fields (see 27.3.10 (Mathematical description of signals)) of an HE PPDU, pilot subcarriers are present in the Data field, and may be present in the HE-LTF field (see 27.3.11.10 (HE-LTF)). The pilot subcarrier indices for the Data field OFDM symbols are defined in 27.3.12.13 (Pilot subcarriers).

One of three HE-LTF types is used in the HE-LTF field of an HE PPDU: 1x HE-LTF, 2x HE-LTF and 4x HE-LTF (see 27.3.11.10 (HE-LTF)). If pilot subcarriers are present in the HE-LTF field of an HE PPDU, then, for a 4x HE-LTF and 2x HE-LTF, the pilot subcarrier locations in the HE-LTF field are the same as the pilot subcarrier locations in the Data field. For a 1x HE-LTF, the pilot subcarrier locations in the HE-LTF field are the pilot subcarriers locations in the Data field that are multiples of 4.

27.3.2.5 Resource indication and User identification in an HE MU PPDU

An AP that transmits an HE MU PPDU shall set the UL/DL field in the HE-SIG-A field to 0.

The HE-SIG-B field consists of one or two HE-SIG-B content channels, with each HE-SIG-B content channel conveying user allocation for one or more 20 MHz subchannels. A 20 MHz HE MU PPDU has one HE-SIG-B content channel, while an HE MU PPDU with greater than 20 MHz PPDU bandwidth has two HE-SIG-B content channels.

A full bandwidth MU-MIMO transmission using the HE MU PPDU format shall have a value of 1 for the HE-SIG-B Compression field in HE-SIG-A, where the Common field in HE-SIG-B is not present, the HE modulated fields of the PPDU consist of one RU that spans the entire PPDU bandwidth and the preamble is not punctured. The number of users in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in HE-SIG-A. The allocated spatial streams for each user and the total number of spatial streams are indicated in the Spatial Configuration field of the User field in HE-SIG-B containing the STA-ID of the designated MU-MIMO STA as defined in Table 27-30 (Spatial Configuration subfield encoding).

If the value of HE-SIG-B Compression field in HE-SIG-A is 0, then the RU Allocation subfield in the Common field in each HE-SIG-B content channel indicates the combination of RUs in the current PPDU and the number of User fields included in the corresponding HE-SIG-B content channel for each RU. See 27.3.11.8.2 (HE-SIG-B content channels) for a description of the HE-SIG-B content channels.

If there is only one User field (see Table 27-28 (User field format for a non-MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of spatial streams for the user in the RU is indicated by the NSTS field in the User field.

If there is more than one User field (see Table 27-29 (User field format for a MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of allocated spatial streams for each user in the RU is indicated by the Spatial Configuration field of the User field in HE-SIG-B. Note that, if the value of HE-SIG-B Compression field in HE-SIG-A is 0, for an RU with 484 or more subcarriers and having two or more intended users, the User fields corresponding to the RU may be split between two HE-SIG-B content channels. In this case, the total number of users and the total number of spatial streams in the RU are the sum of the number of users and number of spatial streams per user, respectively, indicated in both HE-SIG-B content channels. For PPDU bandwidths greater than 20 MHz, the split is an equitable split in the case of full bandwidth DL MU-MIMO (see 27.3.11.8.4 (User Specific field)), or a dynamic split in the case where the HE-SIG-B Compression field in the HE-SIG-A field is equal to 0 (see 27.3.11.8.3 (Common field)).

In each HE-SIG-B content channel, the User fields are ordered such that, together with the HE-SIG-B Compression field in the HE-SIG-A and the Common field in the HE-SIG-B (if present), the RU location and spatial streams allocated to each user can be identified (see 27.3.11.8.4 (User Specific field)). If the UL/DL field in the HE-SIG-A field is set to 0, the STA-ID field in each User field indicates the intended recipient user of the corresponding spatial streams and the RU. Otherwise, the STA-ID field indicates the STA that transmits the PPDU in the corresponding spatial streams and the RU.

HE-LTF symbols in the DL HE MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, it is recommended that the STA uses the channel knowledge for all space-time streams to reduce the effect of space-time streams allocated to other users.

If a STA is included as a member of the MU-MIMO group in RU r, its corresponding $N_{STS,r,u}$ contained in the User field in HE-SIG-B for user u shall not be zero. If a STA determines that it is not a member of the MU-MIMO group in RU r, then the STA may elect not to process RU r in the remainder of the PPDU.

27.3.2.6 Resource allocation for an HE TB PPDU

UL MU transmissions are preceded by a Trigger frame or frame carrying a TRS Control subfield from the AP. The Trigger frame or frame carrying the TRS Control subfield indicates the parameters, such as the duration of the HE TB PPDU, RU allocation, target RSSI and HE-MCS (see 9.3.1.22 (Trigger frame format), 9.2.4.6a.1 (TRS Control) and 26.5.2.3 (Non-AP STA behavior for UL MU operation)), required to transmit an HE TB PPDU.

The Trigger frame indicates whether the UL MU transmission following it uses HE single stream pilot HE-LTF mode or HE masked HE-LTF sequence mode if the HE-LTF type of the HE TB PPDU is 2x HE-LTF or 4x HE-LTF. HE no pilot HE-LTF mode is used if the HE-LTF type of the HE TB PPDU is 1x HE-LTF. If HE single stream pilot HE-LTF mode is used, no masking is applied to the HE-LTF. HE single stream pilot HE-LTF mode is used for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmissions.

27.3.2.7 20 MHz operating non-AP HE STAs

A 20 MHz-only non-AP HE STA is a non-AP HE STA that indicates in the Supported Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element that it transmits (see 9.4.2.247.3 (HE PHY Capabilities Information field)) support for only 20 MHz channel width for the frequency band in which it is operating. A 20 MHz operating non-AP HE STA is a non-AP HE STA that is operating in 20 MHz channel width mode, such as a 20 MHz-only non-AP HE STA or an HE STA that reduced its operating channel width to 20 MHz using operating mode indication (OMI).

A 20 MHz operating non-AP HE STA shall operate in the primary 20 MHz channel except when the 20 MHz operating non-AP HE STA sets dot11HESubchannelSelectiveTransmissionImplemented equal to true. In this case, the 20 MHz operating non-AP HE STA may operate in any 20 MHz channel within the BSS bandwidth by following the procedure in 26.8.7 (HE subchannel selective transmission).

An HE AP operating in the 5 GHz or 6 GHz band shall be able to interoperate with non-AP HE STAs, regardless of the indicated value of B1 in the Supported Channel Width Set subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.247.3 (HE PHY Capabilities Information field)).

A 20 MHz operating non-AP HE STA shall support tone mapping of 26-tone RU, 52-tone RU, 106-tone RU and 242-tone RU for a 20 MHz HE PPDU (see Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU)) in the 2.4 GHz, 5 GHz and 6 GHz frequency bands.

A 20 MHz operating non-AP HE STA indicates support of tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU for a 40 MHz HE PPDU (see Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU)) in the 2.4 GHz band using the 20 MHz In 40 MHz HE PPDU In 2.4 GHz Band subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.247.3 (HE PHY Capabilities Information field)) with the exception of RUs that are restricted from operation as specified in 27.3.2.8 (RU restrictions for 20 MHz operation).

A 20 MHz operating non-AP HE STA shall support tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU for 40 MHz HE PPDU (see Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU)) in the 5 GHz frequency band, and for 80 MHz HE PPDU (see Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU)) in the 5 GHz and 6 GHz bands with the exception of RUs that are restricted from operation as specified in 27.3.2.8 (RU restrictions for 20 MHz operation).

A 20 MHz operating non-AP HE STA indicates support of tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU for 80+80 MHz and 160 MHz HE PPDU using the 20 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.247.3 (HE PHY Capabilities Information field)) with the exception of RUs that are restricted from operation as specified in 27.3.2.8 (RU restrictions for 20 MHz operation).

A 20 MHz operating non-AP HE STA may support tone mapping of 242-tone RU for the reception of 40 MHz HE MU PPDU (see Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU)) in the 2.4 GHz, 5 GHz and 6 GHz bands, and 80 MHz, 80+80 MHz and 160 MHz HE MU PPDU (see Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU)) in the 5 GHz and 6 GHz bands. This support is indicated in the Supported Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element (see 9.4.2.247.3 (HE PHY Capabilities Information field)).

27.3.2.8 RU restrictions for 20 MHz operation

If a 20 MHz operating non-AP HE STA is the receiver of a 40 MHz, 80 MHz, 80+80 MHz or 160 MHz HE MU PPDU, or the transmitter of a 40 MHz, 80 MHz, 80+80 MHz or 160 MHz HE TB PPDU, then the RU tone mapping in 20 MHz is not aligned with the 40 MHz, 80 MHz, 80+80 MHz or 160 MHz RU tone mapping (see 27.3.2.2 (Resource unit, guard and DC subcarriers)).

An AP shall not assign the following RUs to a 20 MHz operating non-AP HE STA where the RU index is defined in Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU):

— 26-tone RU 5 and 14 of a 40 MHz HE MU PPDU and HE TB PPDU

An AP shall not assign the following RUs to a 20 MHz operating non-AP HE STA where the RU index is defined in Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU):

— 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of an 80 MHz HE MU PPDU and HE TB PPDU

— 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of the lower 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU and HE TB PPDU

— 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of the upper 80 MHz of an 80+80 MHz HE MU PPDU and HE TB PPDU

— 52-tone RU 5 and 12 of an 80 MHz HE MU PPDU and HE TB PPDU

— 52-tone RU 5 and 12 of the lower 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU and HE TB PPDU

— 52-tone RU 5 and 12 of the upper 80 MHz of an 80+80 MHz HE MU PPDU and HE TB PPDU

— 106-tone RU 3 and 6 of an 80 MHz HE MU PPDU and HE TB PPDU

— 106-tone RU 3 and 6 of the lower 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU and HE TB PPDU

— 106-tone RU 3 and 6 of the upper 80 MHz of an 80+80 MHz HE MU PPDU and HE TB PPDU

27.3.2.9 80 MHz operating non-AP HE STAs

An HE AP shall not allocate an RU in a 160 MHz or 80+80 MHz HE MU or HE TB PPDU to an 80 MHz operating non-AP HE STA if the non-AP STA has set the 80 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field in the HE Capabilities element to 0.

An HE AP shall not allocate an RU outside of the primary 80 MHz in a 160 MHz or 80+80 MHz HE MU or HE TB PPDU to an 80 MHz operating non-AP HE STA if the non-AP STA has set the HE Subchannel

Selective Transmission Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element to 0.

An HE AP shall not allocate an RU outside of the primary 80 MHz in a 160 MHz or 80+80 MHz HE MU or HE TB PPDU to an 80 MHz operating non-AP HE STA if the non-AP STA has set the HE Subchannel Selective Transmission Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element to 1 but has not set up SST operation on the secondary 80 MHz channel with the HE AP.

27.3.3 MU-MIMO

27.3.3.1 DL MU-MIMO

27.3.3.1.1 Supported RU sizes in DL MU-MIMO

A STA that sets the Partial Bandwidth DL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element that it transmits to 1 shall support receiving an RU in an HE MU PPDU where MU-MIMO is employed in the RU, the RU size is greater than or equal to 106-tones, and the RU does not span the entire PPDU bandwidth.

27.3.3.1.2 Maximum number of spatial streams in an HE MU PPDU

An HE STA shall support the reception of DL MU-MIMO transmissions on full bandwidth with a maximum number of space-time streams (per user) that is the minimum of 4 and the maximum number of space-time streams supported for reception of HE SU PPDUs. The maximum number of space-time streams supported for reception of HE SU PPDUs is indicated for various bandwidths in the Supported HE-MCS and NSS Set field in the HE Capabilities element.

For transmissions using bandwidth less than or equal to 80 MHz, an HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with the total number of space-time streams (across all users) up to the value indicated by the Beamformee STS ≤ 80 MHz subfield in the HE PHY Capabilities Information field in the HE Capabilities element. For transmissions using bandwidth greater than 80 MHz, an HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with the total number of space-time streams (across all users) up to the value indicated by the Beamformee STS > 80 MHz subfield in the HE PHY Capabilities Information field in the HE Capabilities element.

An HE AP that is capable of transmitting 4 or more space-time streams shall support DL MU-MIMO transmissions on full bandwidth.

All of the aforementioned requirements in this subclause on the per user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

27.3.3.2 UL MU-MIMO

27.3.3.2.1 Introduction

UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs.

27.3.3.2.2 Supported RU sizes in UL MU-MIMO

An AP that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element that it transmits to 1 shall support receiving an RU in an HE TB PPDU where MU-MIMO is employed in the RU, the RU size is greater than or equal to 106-tones, and the RU does not span the entire PPDU bandwidth.

A non-AP STA that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element that it transmits to 1 shall support transmitting an RU in an HE TB PPDU where UL MU-MIMO is employed in the RU, the RU size is greater than or equal to 106-tones, and the RU does not span the entire PPDU bandwidth.

A STA that sets the Partial Bandwidth UL MU-MIMO subfield to 1 shall set the Full Bandwidth UL MU-MIMO subfield in the HE PHY Capabilities Information field to 1.

27.3.3.2.3 MU-MIMO HE-LTF Mode

A non-AP STA that sets the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1 shall support both the HE single stream pilot HE-LTF mode and the HE masked HE-LTF sequence mode as defined in Equation (27-59) for the transmission of an HE TB PPDU with one RU spanning the entire PPDU bandwidth, and the RU using MU-MIMO.

An AP that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1 shall support receiving HE TB PPDUs using the HE single stream pilot HE-LTF mode if the HE TB PPDUs use MU-MIMO in an RU that does not span the entire PPDU bandwidth.

A non-AP STA that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1 shall support transmitting an HE TB PPDU using the HE single stream pilot HE-LTF mode if the HE TB PPDU uses MU-MIMO in an RU that does not span the entire PPDU bandwidth.

27.3.3.2.4 Maximum number of spatial streams in UL MU-MIMO

A non-AP STA that supports UL MU-MIMO shall support transmitting an HE TB PPDU using MU-MIMO where:

- The number of spatial streams allocated to the non-AP STA ranges from 1 to N, where N is the smaller of 4 and the maximum number of spatial streams supported by the non-AP STA for transmitting HE SU PPDUs.
- The number of total spatial streams (summed over all users) is less than or equal to 8.

The maximum number of spatial streams supported by a STA for the transmission of an HE SU PPDU is indicated in the Supported HE-MCS And NSS Set field in the HE Capabilities element.

All the requirements in this subclause on the per user and total number of spatial streams are applicable to both full bandwidth and partial bandwidth MU-MIMO.

27.3.4 HE PPDU formats

Four HE PPDU formats are defined: HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU. The HE sounding NDP is a variant of the HE SU PPDU and defined in 27.3.17 (HE sounding NDP). The HE TB feedback NDP is a variant of the HE TB PPDU and defined in 27.3.18 (HE TB feedback NDP).

NOTE—The HE ER SU PPDU is not a variant of the HE SU PPDU. Requirements related to HE SU PPDUs and HE ER SU PPDUs are specified separately.

The format of the HE SU PPDU is defined as in Figure 27-8 (HE SU PPDU format). This PPDU format is used for SU transmission and, in this format, the HE-SIG-A field is not repeated.

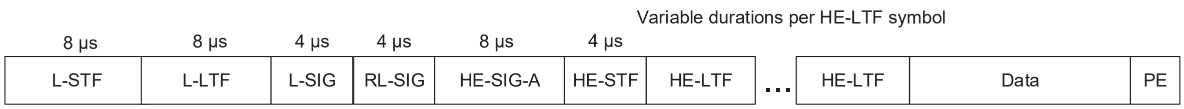

Figure 27-8—HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 27-9 (HE MU PPDU format). This format is used for transmission to one or more users if the PPDU is not a response of a Trigger frame. In the HE MU PPDU, the HE-SIG-A field is not repeated. The HE-SIG-B field is present in this format.

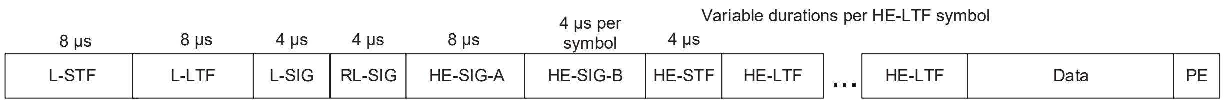

Figure 27-9—HE MU PPDU format

The format of the HE ER SU PPDU is defined as in Figure 27-10 (HE ER SU PPDU format). This format is used for SU transmission and, in this format, the HE-SIG-A field is twice as long as the HE-SIG-A field in other HE PPDU formats.

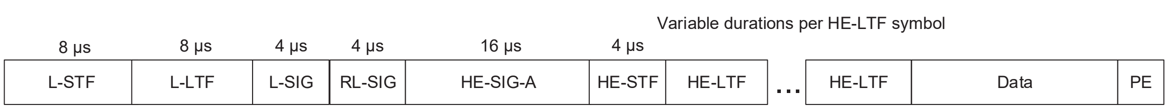

Figure 27-10—HE ER SU PPDU format

The format of the HE TB PPDU is defined as in Figure 27-11 (HE TB PPDU format). This format is used for a transmission that is a response to a triggering frame from an AP.

The format of the HE TB PPDU is the same as the HE SU PPDU except that the duration of the HE-STF field in the HE TB PPDU is twice the duration o f the HE-STF field in the HE SU PPDU.

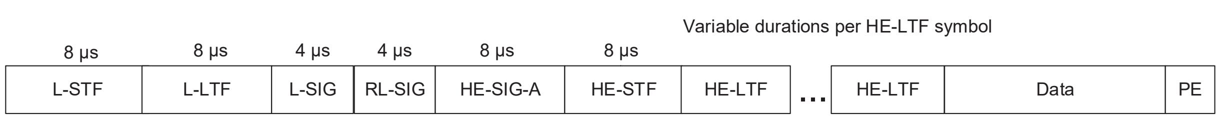

Figure 27-11—HE TB PPDU format

The fields of the HE PPDU formats are summarized in Table 27-11 (HE PPDU fields).

Table 27-11—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
HE-STF	HE Short Training field
HE-LTF	HE Long Training field
Data	The Data field carrying the PSDU(s)
PE	Packet extension field

The RL-SIG, HE-SIG-A, HE-STF, HE-LTF, and PE fields are present in all HE PPDU formats. The HE-SIG-B field is present only in the HE MU PPDU. The PE field is defined in 27.3.13 (Packet extension).

The L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, and HE-SIG-B fields are referred to as pre-HE modulated fields, while the HE-STF, HE-LTF and Data fields are referred to as the HE modulated fields.

In the HE TB PPDU, the pre-HE modulated fields, which include L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields, are sent only on the 20 MHz channels where the STA's HE modulated fields are located. If the HE modulated fields are located in more than one 20 MHz channel, the pre-HE modulated fields are duplicated over the multiple 20 MHz channels, as shown in Figure 27-12 (Number of 20 MHz channels occupied by the pre-HE modulated fields in an HE TB PPDU).

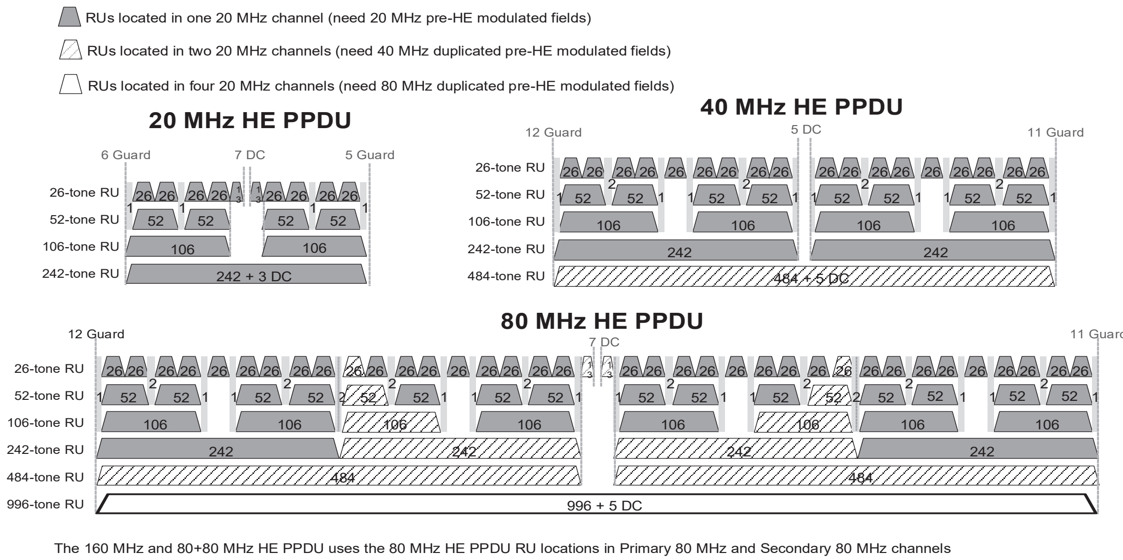

Figure 27-12—Number of 20 MHz channels occupied by the pre-HE modulated fields in an HE TB PPDU

A PPDU transmitted with the TXVECTOR parameter NO_SIG_EXTN set to false is followed by a period of duration aSignalExtension without transmission. See 10.3.8 (Signal extension).

A signal extension shall be present in a transmitted PPDU if the TXVECTOR parameter NO_SIG_EXTN is false and one of the following conditions apply:

— The TXVECVTOR parameter FORMAT is HE, HT_MF or HT_GF
— The TXVECTOR parameter FORMAT is NON_HT and the TXVECTOR parameter NON_HT_MODULATION is ERP-OFDM or NON_HT_DUP_OFDM

A signal extension shall be assumed to be present (for the purpose of timing of PHY-RXEND.indication and PHY-CCA.indication primitives, as described below and in 27.3.22 (HE receive procedure)) in a received PPDU if one of the following conditions apply:

— The RXVECTOR parameter FORMAT is HE, HT_MF or HT_GF
— The RXVECTOR parameter FORMAT is NON_HT and the RXVECTOR parameter NON_HT_MODULATION is ERP-OFDM or NON_HT_DUP_OFDM

A PPDU containing a signal extension is called a signal extended PPDU. When transmitting a signal extended PPDU, the PHY-TXEND.indication primitive shall be emitted a period of aSignalExtension after the end of the actual ending time of the PPDU. When receiving a signal extended PPDU, the PHY-RXEND.indication primitive shall be emitted a period of aSignalExtension after the end of the actual ending time of the PPDU.

27.3.5 Transmitter block diagram

The generation of each field in an 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) Replication over multiple 20 MHz (for BW > 20 MHz)
l) Multiplication by 1st column of $P_{HE\text{-}LTF}$
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder for one spatial stream
p) Cyclic shift diversity (CSD) per STS insertion
q) Spatial mapper
r) Frequency mapping
s) Inverse discrete Fourier transform (IDFT)
t) Cyclic shift diversity (CSD) per chain insertion
u) Guard interval (GI) insertion
v) Windowing

Figure 27-13 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU if the Beam Change subfield is 1) to Figure 27-22 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) show example transmitter block diagrams. The actual structure of the transmitter is implementation dependent.

In particular, Figure 27-13 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU if the Beam Change subfield is 1) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is 1. These transmit blocks are also used to generate the L-STF and L-LTF fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is 1, with the following exceptions:

— The BCC encoder and interleaver as well as constellation mapper are not used when generating the L-STF and L-LTF fields.

— The BCC interleaver is not applied in the 2nd and the 4th OFDM symbols of HE-SIG-A field in the HE ER SU PPDU.

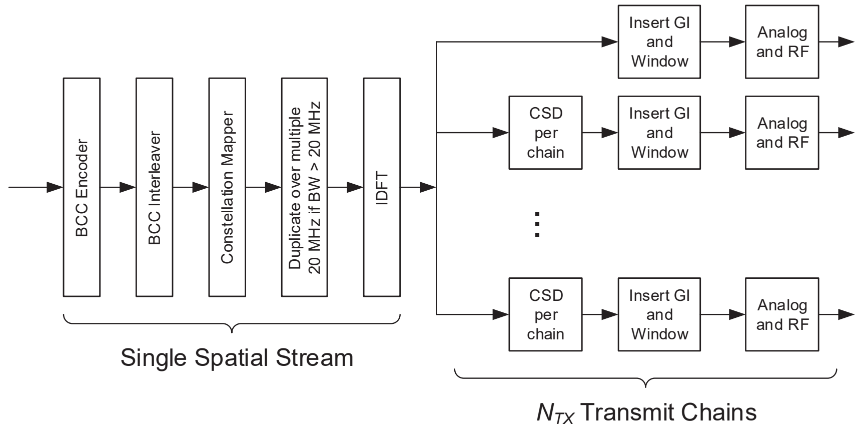

Figure 27-13—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU if the Beam Change subfield is 1

Figure 27-14 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU if the Beam Change subfield is 0) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is 0. These transmit blocks are also used to generate the L-STF and L-LTF fields of the HE PPDU if the Beam Change subfield in HE-SIG-A field is 0, with the following exceptions:

— The BCC encoder and interleaver as well as constellation mapper are not used when generating the L-STF and L-LTF fields.

— The BCC interleaver is not applied in the 2nd and the 4th OFDM symbols of HE-SIG-A field in the HE ER SU PPDU.

NOTE—For an HE MU PPDU, the duplication on 20 MHz channels is subject to the availability of 20 MHz channels in the case of preamble puncturing.

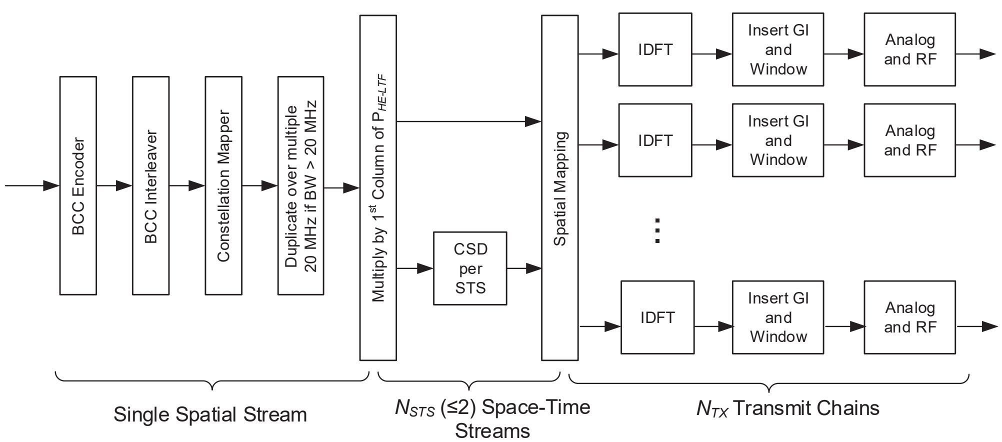

Figure 27-14—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU if the Beam Change subfield is 0

Figure 27-15 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU) shows the transmit process for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU using one frequency segment. In the HE TB PPDU, the transmission of the pre-HE modulated fields refer to the description in 27.3.4 (HE PPDU formats) and also shown in Figure 27-15 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU). The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.

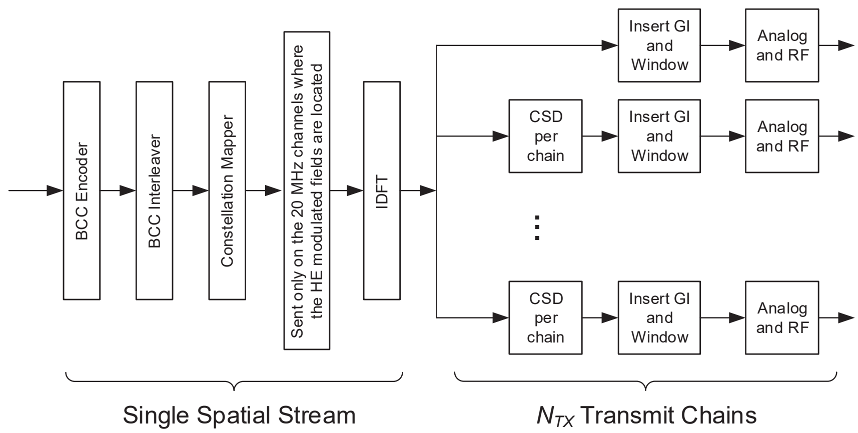

Figure 27-15—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU

Figure 27-16 (Transmitter block diagram for the HE-SIG-B field) shows the transmit process for the HE-SIG-B field of an HE MU PPDU using one frequency segment. This block diagram is for transmitting HE-SIG-B in one 20 MHz subchannel. Refer to 27.3.11.8.2 (HE-SIG-B content channels) for the methods of transmitting HE-SIG-B in 40 MHz, 80 MHz and 160 MHz. The DCM tone mapper, which is defined in 27.3.12.9 (Constellation mapping), is applied only if the HE-SIG-B DCM field in the HE-SIG-A field is 1.

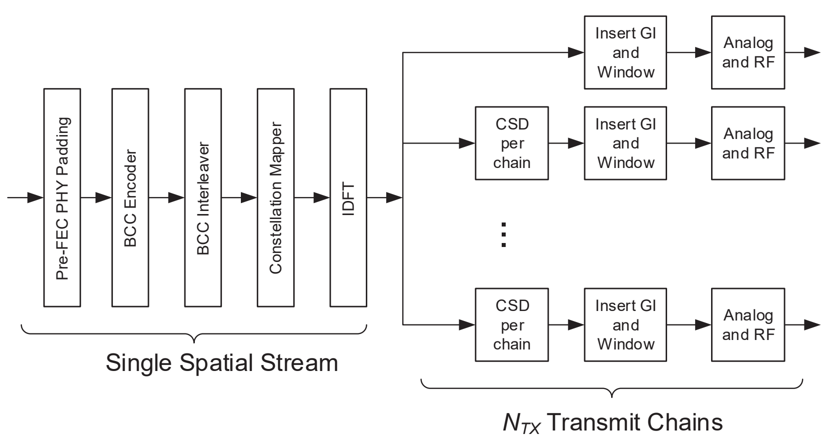

Figure 27-16—Transmitter block diagram for the HE-SIG-B field

Figure 27-17 (Transmitter block diagram for the UL transmission or DL non-MU-MIMO transmission of a Data field with BCC encoding on a 26-, 52-, 106- or 242-tone RU) shows the transmitter blocks for the UL transmission or DL non-MU-MIMO transmission of a Data field with BCC encoding on a 26-, 52-, 106-, or 242-tone RU for a single frequency segment if the number of spatial streams is less than or equal to 4. Figure

27-17 applies to the Data field of an HE MU PPDU that is transmitted on an RU allocated to a single user, the Data field of an HE SU PPDU, and the Data field of an HE TB PPDU (whether or not it is spatially multiplexed with other users).

The DCM tone mapper, which is part of the constellation mapper, is applied only if DCM is indicated for the RU. 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 27-32 (Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, and HE ER SU PPDU). A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial and frequency mapping block of Figure 27-17 (Transmitter block diagram for the UL transmission or DL non-MU-MIMO transmission of a Data field with BCC encoding on a 26-, 52-, 106- or 242-tone RU), are also used to generate the HE-STF field. This figure also applies to the Data field with BCC encoding in an HE TB PPDU.

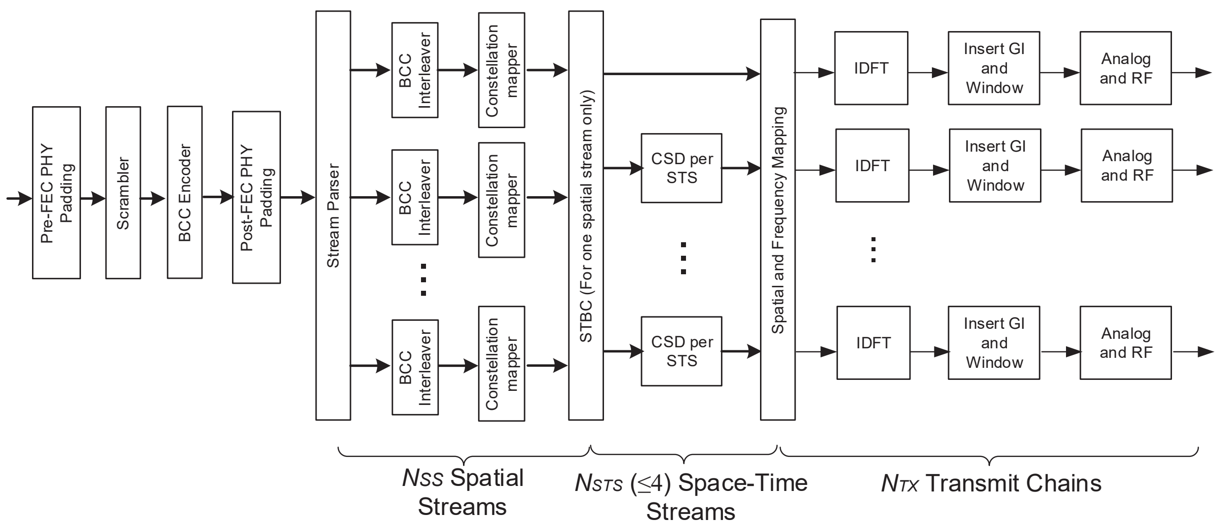

Figure 27-17—Transmitter block diagram for the UL transmission or DL non-MU-MIMO transmission of a Data field with BCC encoding on a 26-, 52-, 106- or 242-tone RU

Figure 27-18 (Transmitter block diagram for the UL transmission or DL non-MU-MIMO transmission of a Data field with LDPC encoding on a 26-, 52-, 106-, 242-, 484- or 996-tone RU) shows the transmitter blocks for the UL transmission or DL non-MU-MIMO transmission of a Data field with LDPC encoding on a 26-, 52-, 106-, 242-, 484-, or 996-tone RU for a single frequency segment. Figure 27-18 applies to the Data field of an HE MU PPDU that is transmitted on an RU allocated to a single user, the Data field of an HE SU PPDU, and the Data field of an HE TB PPDU (whether or not it is spatially multiplexed with other users). This figure also applies to the data field with LDPC encoding in an HE TB PPDU.

The DCM tone mapper, which is part of the constellation mapper, is applied only if DCM is indicated for the RU. This figure also applies to the data field with LDPC encoding in an HE TB PPDU.

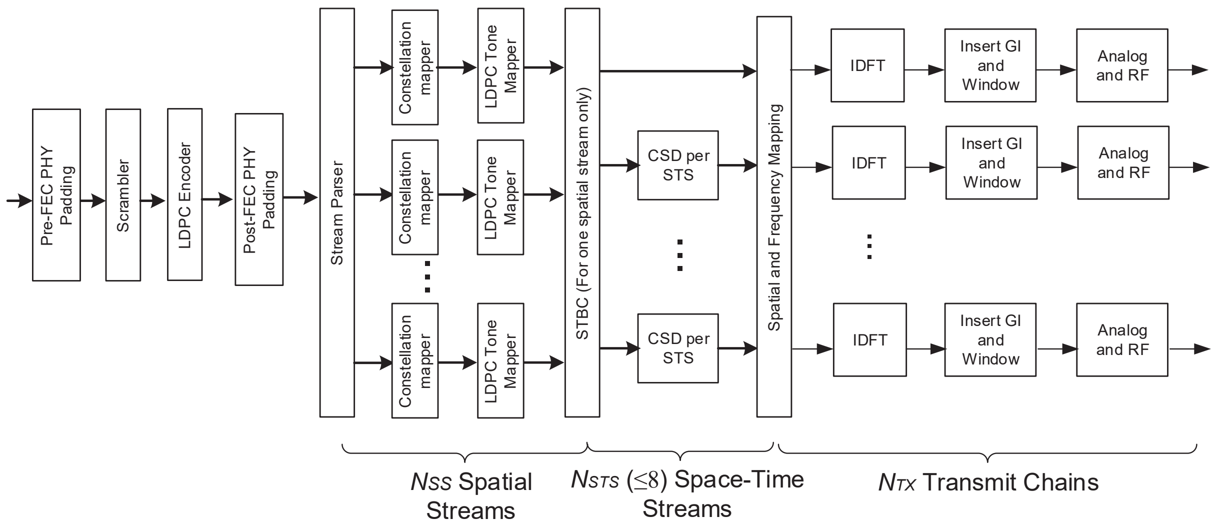

Figure 27-18—Transmitter block diagram for the UL transmission or DL non-MU-MIMO transmission of a Data field with LDPC encoding on a 26-, 52-, 106-, 242-, 484- or 996-tone RU

Figure 27-19 (Transmitter block diagram for the DL MU-MIMO transmission of a Data field with BCC encoding on a 106- or 242-tone RU) shows the transmitter blocks for the transmission, in an HE MU PPDU, of the Data field with BCC encoding on a 106- or 242-tone RU allocated to more than one user.

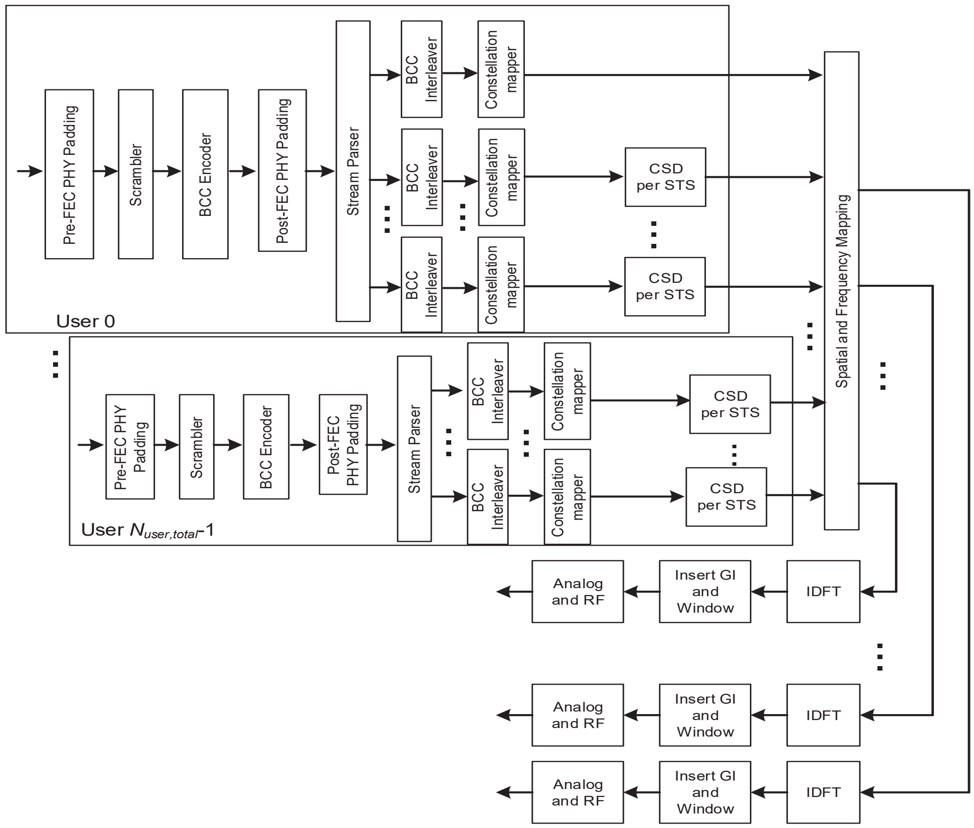

Figure 27-19—Transmitter block diagram for the DL MU-MIMO transmission of a Data field with BCC encoding on a 106- or 242-tone RU

Figure 27-20 (Transmitter block diagram for the DL MU-MIMO transmission of a Data field with LDPC encoding on a 106-, 242-, 484- or 996-tone RU) shows the transmitter blocks for the transmission, in an HE

MU PPDU, of the Data field with LDPC encoding on a 106-, 242-, 484-, or 996-tone RU allocated to more than one user.

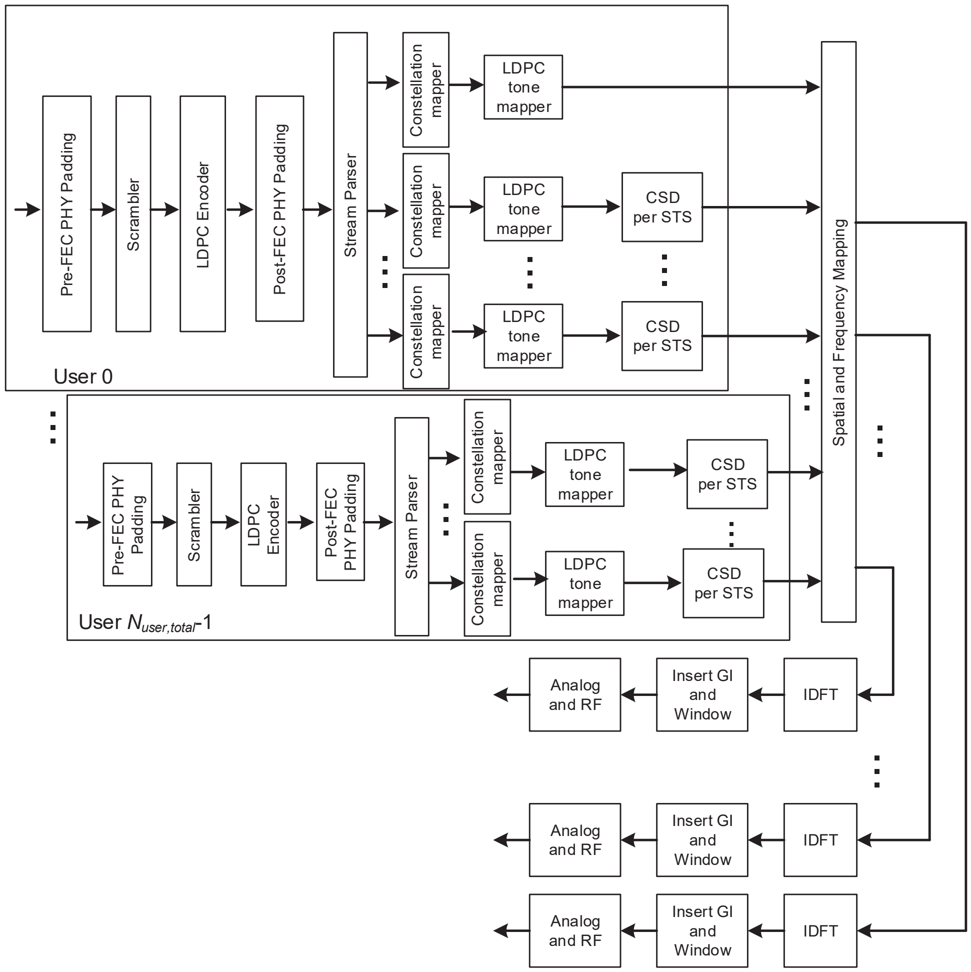

Figure 27-20—Transmitter block diagram for the DL MU-MIMO transmission of a Data field with LDPC encoding on a 106-, 242-, 484- or 996-tone RU

Figure 27-21 (Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 160 MHz with LDPC encoding.

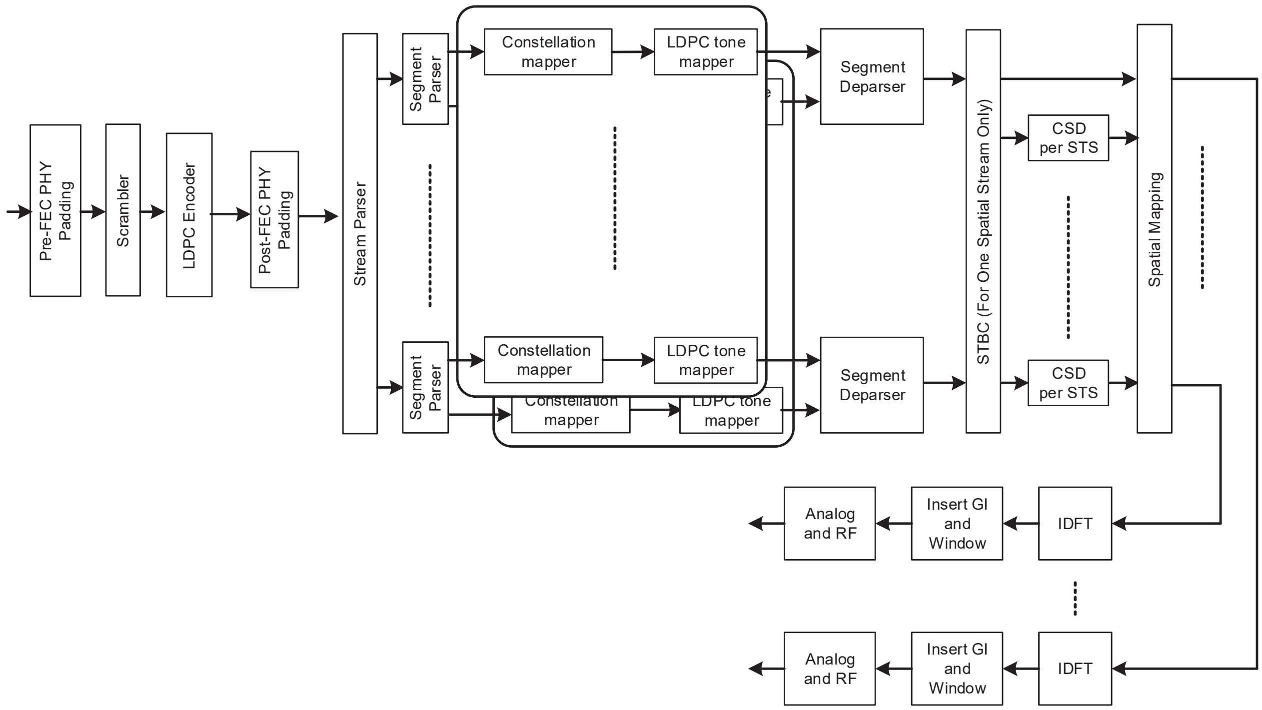

Figure 27-21—Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding

Figure 27-22 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 80+80 MHz with LDPC encoding.

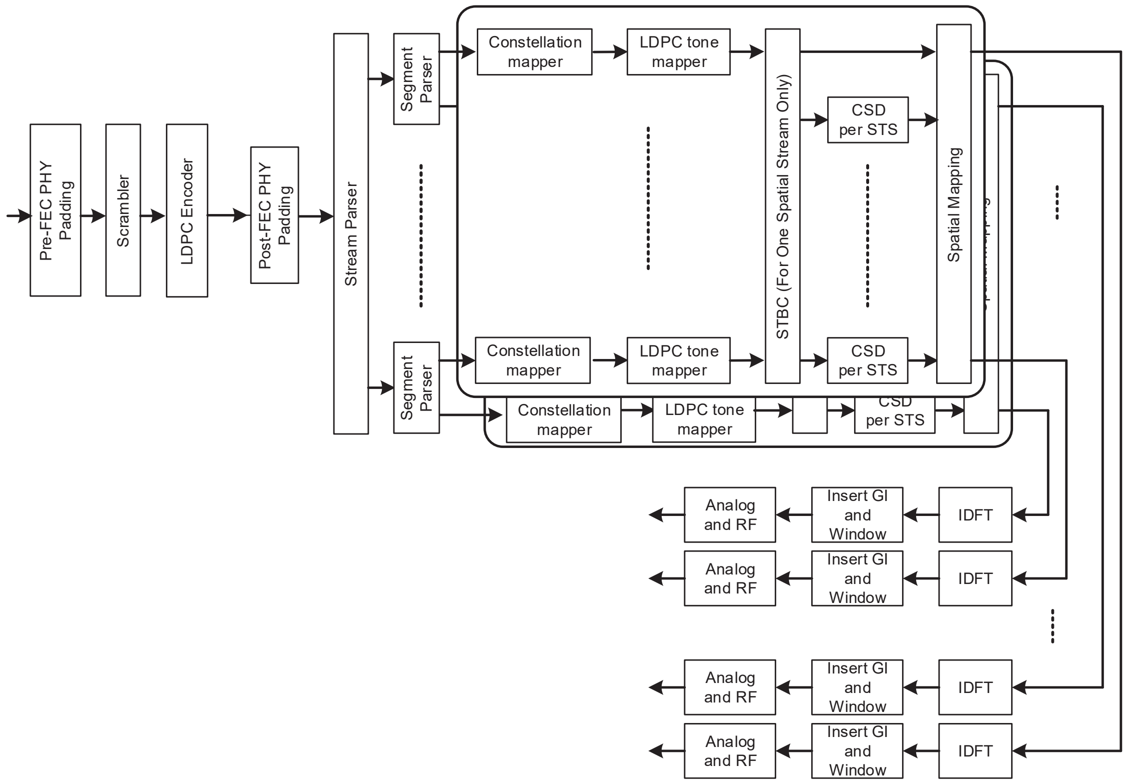

Figure 27-22—Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding

27.3.6 Overview of the PPDU encoding process

27.3.6.1 General

This subclause provides an overview of the HE PPDU encoding process.

27.3.6.2 Construction of L-STF

Construct the L-STF field as defined in 27.3.11.3 (L-STF) with the following highlights:

a) Determine the channel bandwidth from the TXVECTOR parameter CH_BANDWIDTH.

b) Sequence generation: Generate the L-STF sequence over the channel bandwidth as described in 27.3.11.3 (L-STF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 27.3.11.3 (L-STF).

c) Phase rotation: Apply appropriate phase rotation for each 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

d) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

e) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 27.3.11.3 (L-STF).

f) IDFT: Compute the inverse discrete Fourier transform.

g) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

h) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

i) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.3 Construction of L-LTF

Construct the L-LTF field as defined in 27.3.11.4 (L-LTF) with the following highlights:

a) Determine the channel bandwidth from the TXVECTOR parameter CH_BANDWIDTH.

b) Sequence generation: Generate the L-LTF sequence over the channel bandwidth as described in 27.3.11.4 (L-LTF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 27.3.11.4 (L-LTF).

c) Phase rotation: Apply appropriate phase rotation for each 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

d) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

e) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 27.3.11.4 (L-LTF).

f) IDFT: Compute the inverse discrete Fourier transform.

g) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

h) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{L-LTF}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

i) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the carrier frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.4 Construction of L-SIG

Construct the L-SIG field as the SIGNAL field defined in 27.3.11.5 (L-SIG) with the following highlights:

a) Set the RATE subfield in the SIGNAL field to 6 Mb/s. Set the LENGTH, Parity, and Tail fields in the SIGNAL field as described in 27.3.11.5 (L-SIG).

b) BCC encoder: Encode the SIGNAL field by a convolutional encoder at the rate of $R = 1/2$ as described in 27.3.12.5.1 (BCC coding and puncturing).

c) BCC interleaver: Interleave as described in 17.3.5.7 (BCC interleavers).

d) Constellation Mapper: BPSK modulate as described in 27.3.12.9 (Constellation mapping).

e) Pilot insertion: Insert pilots as described in 27.3.11.5 (L-SIG).

f) Extra subcarrier insertion: Four extra subcarriers are inserted at $k \in \{-28, -27, 27, 28\}$ for channel estimation purpose and the values on these four extra subcarriers are $\{-1, -1, -1, 1\}$, respectively.

Apply a 3 dB power boost to the four extra subcarriers if transmitting an HE ER SU PPDU as described in 27.3.11.5 (L-SIG).

g) Duplication and phase rotation: Duplicate the L-SIG field over each occupied 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

h) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

i) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the *A* matrix and *Q* matrix as described in 27.3.11.5 (L-SIG).

j) IDFT: Compute the inverse discrete Fourier transform.

k) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

l) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

m) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.5 Construction of RL-SIG

Construct the RL-SIG field as the repeat SIGNAL field defined in 27.3.11.6 (RL-SIG) with the following highlights:

a) Set the RATE subfield in the repeat SIGNAL field to 6 Mb/s. Set the LENGTH Parity, and Tail fields in the repeat SIGNAL field as described in 27.3.11.6 (RL-SIG).

b) BCC encoder: Encode the repeat SIGNAL field by a convolutional encoder at the rate of $R = 1/2$ as described in 27.3.12.5.1 (BCC coding and puncturing).

c) BCC interleaver: Interleave as described in 17.3.5.7 (BCC interleavers).

d) Constellation Mapper: BPSK modulate as described in 27.3.12.9 (Constellation mapping).

e) Pilot insertion: Insert pilots as described in 27.3.11.6 (RL-SIG).

f) Extra subcarrier insertion: Four extra subcarriers are inserted at $k \in \{-28, -27, 27, 28\}$ for channel estimation purpose and the values on these four extra subcarriers are {–1, –1, –1, 1}, respectively. Apply a 3 dB power boost to the four extra subcarriers if transmitting an HE ER SU PPDU as described in 27.3.11.6 (RL-SIG).

g) Duplication and phase rotation: Duplicate the RL-SIG field over each occupied 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

h) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

i) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the *A* matrix and the *Q* matrix as described in 27.3.11.6 (RL-SIG).

j) IDFT: Compute the inverse discrete Fourier transform.

k) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

l) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

m) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.6 Construction of HE-SIG-A

For an HE SU PPDU, HE MU PPDU, and HE TB PPDU, the HE-SIG-A field consists of two parts, HE-SIG-A1 and HE-SIG-A2 as defined in 27.3.11.7 (HE-SIG-A) and is constructed as follows:

a) Obtain the HE-SIG-A field values from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 27.3.11.7 (HE-SIG-A). This results in 52 uncoded bits.

b) BCC encoder: Encode the data by a convolutional encoder at the rate of $R = 1/2$ as described in 17.3.5.6 (Convolutional encoder).

c) BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers).

d) Constellation mapper: BPSK modulate the first 52 interleaved bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the first OFDM symbol of HE-SIG-A. BPSK modulate the second 52 interleaved bits to form the second OFDM symbol of HE-SIG-A.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) Duplicate and phase rotation: Duplicate the HE-SIG-A OFDM symbols over each occupied 20 MHz subchannel of the channel width. Apply the appropriate phase rotation for each occupied 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

g) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

h) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 27.3.11.7.4 (Encoding and modulation).

i) IDFT: Compute the inverse discrete Fourier transform.

j) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

k) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

l) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

For an HE ER SU PPDU, the HE-SIG-A field consists of four parts, HE-SIG-A1, HE-SIG-A2, HE-SIG-A3, and HE-SIG-A4. HE-SIG-A1 and HE-SIG-A2 have the same data bits while HE-SIG-A3 and HE-SIG-A4 have the same data bits as defined in 27.3.11.7 (HE-SIG-A). The HE-SIG-A field is constructed as follows:

a) Obtain the HE-SIG-A fields from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 27.3.11.7 (HE-SIG-A). This results in 52 uncoded bits.

b) BCC encoder: Encode the data by a convolutional encoder at the rate of $R = 1/2$ as described in 17.3.5.6 (Convolutional encoder).

c) BCC interleaver: Interleave the data bits of HE-SIG-A1 and HE-SIG-A3 as described in 27.3.12.8 (BCC interleavers). The data bits of HE-SIG-A2 and HE-SIG-A4 are not interleaved.

d) Constellation mapper: BPSK modulate the HE-SIG-A1, HE-SIG-A3, and HE-SIG-A4 data bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the first, third, and fourth OFDM symbol of HE-SIG-A, respectively. QBPSK modulate the HE-SIG-A2 encoded data bits to form the second OFDM symbol of HE-SIG-A.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) Duplication and phase rotation: Duplicate the HE-SIG-A field over each occupied 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

g) CSD per STS: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD per STS for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

h) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 27.3.11.7.4 (Encoding and modulation).

i) IDFT: Compute the inverse Fourier transform.

j) CSD per chain: If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, apply CSD per chain for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

k) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

l) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.7 Construction of HE-SIG-B

For an HE MU PPDU, the HE-SIG-B field consists of a Common field followed by a User Specific field as defined in 27.3.11.8 (HE-SIG-B) and is constructed as follows:

a) Obtain the HE-SIG-B field values from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 27.3.11.8 (HE-SIG-B).

b) BCC encoder: Encode the Common field data and each User Block field data individually by a convolutional encoder as described in 27.3.12.5.1 (BCC coding and puncturing).

c) BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers).

d) Constellation mapper: Obtain MCS_SIG_B from the TXVECTOR and use it to modulate the interleaved bits as described in 27.3.12.9 (Constellation mapping) to form the HE-SIG-B OFDM symbols.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) Duplicate and phase rotation: Duplicate HE-SIG-B OFDM symbols as described in 27.3.11.8.5 (Encoding and modulation). Apply the appropriate phase rotation for each 20 MHz subchannel as described in 27.3.10 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

g) CSD: Apply CSD for each transmit chain and frequency segment as described in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

h) IDFT: Compute the inverse Fourier transform.

i) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 27.3.10 (Mathematical description of signals).

j) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.8 Construction of HE-STF

The HE-STF field is defined in 27.3.11.9 (HE-STF) and is constructed as follows:

a) Sequence generation: Generate the HE-STF in the frequency domain over the bandwidth indicated by the TXVECTOR parameter CH_BANDWIDTH as described in 27.3.11.9 (HE-STF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 27.3.11.9 (HE-STF).

b) CSD: Apply CSD for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

c) Spatial mapping: Apply the Q matrix as described in 27.3.11.9 (HE-STF).

d) IDFT: Compute the inverse discrete Fourier transform.

e) Insert GI and apply windowing: Prepend a GI; 0.8 µs GI for HE SU PPDU, HE ER SU PPDU, and HE MU PPDU and 1.6 µs GI for an HE TB PPDU. Apply windowing as described in 27.3.10 (Mathematical description of signals).

f) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.9 Construction of HE-LTF

The HE-LTF field is defined in 27.3.11.10 (HE-LTF) and is constructed as follows:

a) Sequence generation: Generate the HE-LTF sequence in frequency domain over the bandwidth indicated by CH_BANDWIDTH as described in 27.3.11.10 (HE-LTF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 27.3.11.10 (HE-LTF).

b) $A_{\text{HE-LTF}}$ matrix mapping: Apply the $P_{\text{HE-LTF}}$ matrix to the data tones of the HE-LTF sequence and apply the $R_{\text{HE-LTF}}$ matrix to pilot subcarriers of the HE-LTF sequence except the UL MU-MIMO transmission not using HE single stream pilot HE-LTF mode as described in 27.3.11.10 (HE-LTF). There is no pilot mapping for an HE TB feedback NDP.

c) CSD: Apply CSD for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

d) Spatial mapping: Apply the Q matrix as described in 27.3.11.10 (HE-LTF).

e) IDFT: Compute the inverse discrete Fourier transform.

f) Insert GI and apply windowing: Prepend a GI indicated by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.10 (Mathematical description of signals).

g) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.10 Construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU

27.3.6.10.1 Using BCC

The construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU with BCC encoding proceeds as follows:

a) Construct the SERVICE field as described in 27.3.12.3 (SERVICE field) and append the PSDU to the SERVICE field.

b) Pre-FEC padding: Append the pre-FEC pad bits and tail bits as described in 27.3.12 (Data field).

c) Scrambler: Scramble the pre-FEC padded data.

d) BCC encoder: BCC encode as described in 27.3.12.5.1 (BCC coding and puncturing).

e) Post-FEC padding: Append the post-FEC pad bits and PE field as described in 27.3.12 (Data field).

f) Stream parser: Rearrange the output of BCC encoder into blocks as described in 27.3.12.6 (Stream parser).

g) BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers).

h) Constellation mapper: Map to BPSK, BPSK DCM, QPSK, QPSK DCM, 16-QAM, 16-QAM DCM, 64-QAM, or 256-QAM constellation points as described in 27.3.12.9 (Constellation mapping).

i) STBC: Apply STBC as described in 27.3.12.12 (Space-time block coding).

j) Pilot insertion: Insert pilots following the steps described in 27.3.12.13 (Pilot subcarriers).

k) CSD: Apply CSD for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

l) Spatial mapping: Apply the Q matrix as described in 27.3.12.14 (OFDM modulation).

m) IDFT: In an 80+80 MHz transmission, map each frequency subblock to a separate IDFT. Compute the inverse discrete Fourier transform.

n) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.10 (Mathematical description of signals).

o) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.10.2 Using LDPC

The construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU with LDPC encoding proceeds as follows:

a) Construct the SERVICE field as described in 27.3.12.3 (SERVICE field) and append the PSDU to the SERVICE field.

b) Pre-FEC padding: Append the pre-FEC padding bits as described in 27.3.12 (Data field). There are no tail bits.

c) Scrambler: Scramble the pre-FEC padded data.

d) LDPC encoder: LDPC encode as described in 27.3.12.5.2 (LDPC coding).

e) Post-FEC padding: Append the post-FEC pad bits and PE field as described in 27.3.12 (Data field).

f) Stream parser: Rearrange the output of LDPC encoder into blocks as described in 27.3.12.6 (Stream parser).

g) Segment parser (if needed): In a 160 MHz or 80+80 MHz transmission with a 2×996-tone RU, divide the output of each stream parser into two frequency subblocks as described in 27.3.12.6 (Stream parser). This block is bypassed for 20 MHz, 40 MHz, and 80 MHz transmissions.

h) Constellation mapper: Map to BPSK, BPSK DCM, QPSK, QPSK DCM, 16-QAM, 16-QAM DCM, 64-QAM, 256-QAM, or 1024-QAM constellation points as described in 27.3.12.9 (Constellation mapping).

i) LDPC tone mapper: the LDPC tone mapping shall be performed on all LDPC encoded streams as described in 27.3.12.10 (LDPC tone mapper).

j) Segment deparser (if needed): In 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 27.3.12.11 (Segment deparser). This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz transmissions.

k) STBC: Apply STBC as described in 27.3.12.12 (Space-time block coding).

l) Pilot insertion: Insert pilots following the steps described in 27.3.12.13 (Pilot subcarriers).

m) CSD: Apply CSD for each space-time stream and frequency segment as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

n) Spatial mapping: Apply the Q matrix as described in 27.3.12.14 (OFDM modulation).

o) IDFT: In an 80+80 MHz transmission, map each frequency subblock to a separate IDFT. Compute the inverse discrete Fourier transform.

p) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.10 (Mathematical description of signals).

q) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.6.11 Construction of the Data field in an HE MU PPDU

27.3.6.11.1 General

In an HE MU transmission, the PPDU encoding process is performed independently in an RU on a per user basis up to the input of the spatial mapping block, except that CSD is performed with knowledge of the space-time streams starting index for that user. All user data in an RU is combined and mapped to the transmit chains in the spatial mapping block.

27.3.6.11.2 Using BCC

A Data field with BCC encoding is constructed using steps (a) to (l) in 27.3.6.10.1 (Using BCC), then applying CSD for an HE MU PPDU as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

27.3.6.11.3 Using LDPC

A Data field with LDPC encoding is constructed using steps (a) to (l) in 27.3.6.10.2 (Using LDPC), then applying CSD for an HE MU PPDU as described in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

27.3.6.11.4 Combining to form an HE MU PPDU

The per user data is combined as follows:

a) Spatial mapping: The Q matrix is applied as described in 27.3.12.14 (OFDM modulation). The combining of all user data of an RU is done in this block.

b) IDFT: Compute the inverse discrete Fourier transform.

c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.10 (Mathematical description of signals).

d) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.10 (Mathematical description of signals) and 27.3.11 (HE preamble) for details.

27.3.7 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a compact representation of the modulation and coding used in the Data field of the PPDU. For an HE SU PPDU and an HE ER SU PPDU it is carried in the HE-SIG-A field. For an HE MU PPDU it is carried per user in the User Specific field of the HE-SIG-B field. For an HE TB PPDU, it is carried in the User Info field of the Trigger frame soliciting the HE TB PPDU.

Rate dependent parameters for the full set of HE-MCSs are shown in Table 27-56 (HE-MCSs for 26-tone RU, NSS = 1) to Table 27-111 (HE-MCSs for 2×996-tone RU, NSS = 8) (in 27.5 (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 RU, 52-tone RU, 106-tone RU, 242-tone RU, 484-tone RU and 996-tone RU, and bandwidth options of 20 MHz, 40 MHz, 80 MHz, and either 160 MHz or 80+80 MHz.

The HE ER SU PPDU supports only a single 242-tone or 106-tone RU. An HE ER SU PPDU with a 242-tone RU shall only be transmitted with the <HE-MCS, NSS> tuples <HE-MCS 0, 1>, <HE-MCS 1, 1> and <HE-MCS 2, 1>. An HE ER SU PPDU with a 106-tone RU shall only be transmitted with the <HE-MCS, NSS> tuple <HE-MCS 0, 1>. The 106-tone RU location within the 20 MHz tone plan is fixed as the one that is higher in frequency.

DCM is an optional modulation scheme used for the HE-SIG-B field and the Data field in an HE PPDU. The use of DCM for the HE-SIG-B field in an HE MU PPDU is indicated in the HE-SIG-A field. For the HE-SIG-B field, DCM is applicable to only the HE-SIG-B-MCSs 0, 1, 3 and 4. The use of DCM on the Data field of an HE SU PPDU and HE ER SU PPDU is indicated in the HE-SIG-A field. The use of DCM in the Data field of an HE MU PPDU is indicated in the HE-SIG-B field. For the Data field, DCM is applicable to only the HE-MCSs 0, 1, 3 and 4.

The pre-HE modulated fields (see Figure 27-23 (Timing boundaries for HE PPDU fields if midamble is not present)) are not transmitted in 20 MHz subchannels in which the preamble is punctured as described in 27.3.11.3 (L-STF).

27.3.8 HE-SIG-B modulation and coding schemes (HE-SIG-B-MCSs)

The HE-SIG-B-MCS is a compact representation of the modulation and coding used in the HE-SIG-B field of the HE MU PPDU. The HE-SIG-B modulation and coding schemes is carried in the HE-SIG-B-MCS subfield of the HE-SIG-A field in the HE MU PPDU and indicates an HE-SIG-B-MCS in the range 0 to 5.

27.3.9 Timing-related parameters

Refer to Table 19-6 (Timing-related constants) and Table 21-5 (Timing-related constants) for timing-related parameters for non-HE PPDU formats.

Table 27-12 (Timing-related constants) defines the timing-related parameters for HE PPDU formats.

Table 27-12—Timing-related constants

Parameter	Values	Description
$\Delta_{F,\ \mathrm{Pre\text{-}HE}}$	312.5 kHz	Subcarrier frequency spacing for the pre-HE modulated fields
$\Delta_{F,\ \mathrm{HE}}$	78.125 kHz	Subcarrier frequency spacing for the HE modulated fields
$T_{DFT,\mathrm{Pre\text{-}HE}}$	3.2 µs	IDFT/DFT period for the pre-HE modulated fields
$T_{DFT,\mathrm{HE}}$	12.8 µs	IDFT/DFT period for the Data field.
$T_{GI,\mathrm{Pre\text{-}HE}}$	0.8 µs	Guard interval duration for the pre-HE modulated fields
$T_{GI,\mathrm{L\text{-}LTF}}$	1.6 µs	Guard interval duration for the L-LTF field.
$T_{GI1,Data}$	0.8 µs	Base guard interval duration for the Data field
$T_{GI2,Data}$	1.6 µs	Double guard interval duration for the Data field
$T_{GI4,Data}$	3.2 µs	Quadruple guard interval duration for the Data field.

Table 27-12—Timing-related constants *(continued)*

Parameter	Values	Description
$T_{GI,\text{HE-LTF}}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-LTF field, same as $T_{GI,Data}$
$T_{GI,Data}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the Data field.
T_{SYM1}	13.6 µs = $T_{DFT,\text{HE}} + T_{GI1,Data} = 1.0625 \times T_{DFT,HE}$	OFDM symbol duration with base GI
T_{SYM2}	14.4 µs = $T_{DFT,\text{HE}} + T_{GI2,Data} = 1.125 \times T_{DFT,HE}$	OFDM symbol duration with double GI
T_{SYM4}	16 µs = $T_{DFT,\text{HE}} + T_{GI4,Data} = 1.25 \times T_{DFT,\text{HE}}$	OFDM symbol duration with quadruple GI
T_{SYM}	T_{SYM1}, T_{SYM2}, or T_{SYM4} depending on the GI used for data	OFDM symbol interval for HE PPDU fields. See Table 27-16 (Number of modulated sub-carriers and guard interval duration values for HE PPDU fields).
$T_{\text{L-STF}}$	8 µs = 10 × $T_{DFT,\text{Pre-HE}}$ /4	Non-HT Short Training field duration
$T_{\text{L-LTF}}$	8 µs = 2 × $T_{DFT,\text{Pre-HE}} + T_{GI,\text{L-LTF}}$	Non-HT Long Training field duration
$T_{\text{L-SIG}}$	4 µs	Non-HT SIGNAL field duration
$T_{\text{RL-SIG}}$	4 µs	Repeated non-HT SIGNAL field duration
$T_{\text{HE-SIG-A}}$	8 µs = 2 × 4 µs	HE-SIG-A field duration in an HE SU PPDU, HE MU PPDU and HE TB PPDU
$T_{\text{HE-SIG-A-R}}$	16 µs = 4 × 4 µs	HE-SIG-A field duration in an HE ER SU PPDU
$T_{\text{HE-SIG-B}}$	4 µs = $T_{DFT,\text{Pre-HE}} + T_{GI,\text{Pre-HE}}$	Duration of each OFDM symbol in the HE-SIG-B field
$T_{\text{HE-STF-T}}$	8 µs = 5 × 1.6 µs	HE-STF field duration for an HE TB PPDU
$T_{\text{HE-STF-NT}}$	4 µs = 5 × 0.8 µs	HE-STF field duration for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU
$T_{\text{HE-LTF-1X}}$	3.2 µs	Duration of each 1x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-2X}}$	6.4 µs	Duration of each 2x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-4X}}$	12.8 µs	Duration of each 4x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF}}$	$T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$ or $T_{\text{HE-LTF-4X}}$ depending upon the HE-LTF duration used	Duration of each OFDM symbol without GI in the HE-LTF field
$T_{\text{HE-LTF-SYM}}$	$T_{\text{HE-LTF}} + T_{GI,\text{HE-LTF}}$	Duration of each OFDM symbol including GI in the HE-LTF field
$N_{service}$	16	Number of bits in the SERVICE field
N_{tail}, $N_{tail,u}$	6 for BCC encoder, 0 for LDPC encoder	Number of tail bits per encoder (for user *u*)
T_{SYML}	4 µs	OFDM symbol duration including GI prior to the HE-STF field
T_{PE}	0, 4 µs, 8 µs, 12 µs or 16 µs depending on the actual extension duration used	Duration of the PE field

Table 27-13 (Subcarrier allocation related constants for the HE-modulated fields in a non-OFDMA HE PPDU) defines tone allocation related parameters for a non-OFDMA HE PPDU.

Table 27-13—Subcarrier allocation related constants for the HE-modulated fields in a non-OFDMA HE PPDU

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description
N_{SD}	234	468	980	980	1960	Number of data subcarriers per frequency segment
N_{SP}	8	16	16	16	32	Number of pilot subcarriers 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 subcarriers at DC per segment
$N_{Guard,Left}$	6	12	12	12	12	Number of low frequency guard subcarriers
$N_{Guard,Right}$	5	11	11	11	11	Number of high frequency guard subcarriers
NOTE: $N_{ST} = N_{SD} + N_{SP}$						

Table 27-14 (Subcarrier allocation related constants for RUs in an OFDMA HE PPDU) defines tone allocation related parameters for an OFDMA HE PPDU.

Table 27-14—Subcarrier allocation related constants for RUs in an OFDMA HE PPDU

Parameter	RU Size (subcarriers)							Description
	26	52	106	242	484	996	2×996	
N_{SD}	24	48	102	234	468	980	1960	Number of data subcarriers per RU
N_{SP}	2	4	4	8	16	16	32	Number of pilot subcarriers per RU
N_{ST}	26	52	106	242	484	996	1992	Total number of subcarriers per RU
NOTE: $N_{ST} = N_{SD} + N_{SP}$								

Table 27-15 (Frequently used parameters) defines parameters used frequently in Clause 27 (High Efficiency (HE) PHY specification).

Table 27-15—Frequently used parameters

Symbol	Explanation
N_{RU}	For pre-HE modulated fields, $N_{RU} = 1$. For HE modulated fields, N_{RU} represents the number of occupied RUs in the transmission.
$N_{user,r}$	For pre-HE modulated fields, $N_{user,r} = 1$. For HE modulated fields, $N_{user,r}$ represents the total number of users in the r-th occupied RU of the transmission.
$N_{user,total}$	Total number of users in all occupied RUs of an HE transmission, i.e., $N_{user,total} = \sum_{r=0}^{N_{RU}-1} N_{user,r}$
N_{CBPS}, $N_{CBPS,u}$	Number of coded bits per OFDM symbol for user u, $u = 0, \ldots, N_{user,total} - 1$ For an HE SU PPDU and HE ER SU PPDU, $N_{CBPS} = N_{CBPS,0}$ For an HE MU PPDU, N_{CBPS} is undefined
N_{CBPSS}, $N_{CBPSS,u}$	Number of coded bits per OFDM symbol per spatial stream for user u, $u = 0, \ldots, N_{user,total} - 1$. For the Data field of an HE SU PPDU and HE ER SU PPDU, $N_{CBPSS} = N_{CBPSS,0}$ For the Data field of an HE MU PPDU, N_{CBPSS} is undefined
N_{DBPS}, $N_{DBPS,u}$	Number of data bits per OFDM symbol for user u, $u = 0, \ldots, N_{user,total} - 1$. For an HE SU PPDU and HE ER SU PPDU, $N_{DBPS} = N_{DBPS,0}$ For an HE MU PPDU, N_{DBPS} is undefined

Table 27-15—Frequently used parameters *(continued)*

Symbol	Explanation
N_{BPSCS}, $N_{BPSCS,u}$	Number of coded bits per subcarrier per spatial stream for user u, $u = 0, \ldots, N_{user,total} - 1$. For an HE SU PPDU and HE ER SU PPDU, $N_{BPSCS} = N_{BPSCS,0}$ For an HE MU PPDU, N_{BPSCS} is undefined
N_{RX}	Number of receive chains
N_{STS}, $N_{STS,r,u}$	For HE modulated fields, $N_{STS,r,u}$ represents the number of space-time streams in the r-th occupied RU for user u, $u = 0, \ldots, N_{user,r} - 1$. For STBC, $N_{STS,r,u} = 2$. For an HE SU PPDU and HE ER SU PPDU, $N_{STS} = N_{STS,0,0}$ For an HE MU PPDU, N_{STS} is undefined if any one of the RUs is assigned to more than one user, and $N_{STS} = 2$ if all RUs are assigned to no more than one user and the STBC field is set to 1.
$N_{STS,r,total}$	For HE modulated fields, $N_{STS,r,total}$ is the total number of space-time streams over all the users in the r-th occupied RU. $$N_{STS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{STS,r,u}$$ For pre-HE modulated fields, $N_{STS,r,total}$ is undefined if the TXVECTOR parameter BEAM_CHANGE is 1 or not present, and $N_{STS,r,total} = N_{STS}$ if BEAM_CHANGE is 0. NOTE—$N_{STS,r,total} = N_{STS}$ for an HE SU PPDU and HE ER SU PPDU.
N_{SS}, $N_{SS,r,u}$, $N_{SS,u}$	Number of spatial streams. For the Data field, $N_{SS,r,u}$ is the number of spatial streams at r-th RU for user u, $u = 0, \ldots, N_{user,r} - 1$ and $N_{SS,u}$ is the number of spatial streams for user u, $u = 0, \ldots, N_{user,total} - 1$. For the Data field of an HE SU PPDU and HE ER 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—$N_{SS,r,total} = N_{SS}$ for an HE SU PPDU and HE ER SU PPDU.
N_{TX}	Number of transmit chains
$N_{HE\text{-}LTF}$	The number of OFDM symbols in the HE-LTF field (see 27.3.11.10 (HE-LTF))
$N_{HE\text{-}SIG\text{-}B}$	The number of OFDM symbols in the HE-SIG-B field (see 27.3.11.8 (HE-SIG-B))
K_r	Set of used subcarrier indices in the r-th occupied RU

Table 27-15—Frequently used parameters *(continued)*

Symbol	Explanation
R, R_u	R_u is the coding rate for user u, $u = 0, \ldots, N_{user,total} - 1$. For an HE SU PPDU, $R = R_0$ For an HE MU PPDU, R is undefined
$M_{r,u}$	The sum of the number of space-time streams of users prior to user u in RU r. 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 $u = 1, \ldots, N_{user,r} - 1$.

27.3.10 Mathematical description of signals

For a description of the conventions used for the mathematical description of the signals, see 17.3.2.5 (Mathematical conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 27 (High Efficiency (HE) PHY specification):

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

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 21.3.7 (Mathematical description of signals).

For a 20 MHz non-OFDMA HE PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on all or a subset of subcarriers –122 to –2 and 2 to 122, with 0 being the center (DC) subcarrier.

For a 20 MHz OFDMA HE PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on all or a subset of the subcarriers –122 to –4 and 4 to 122, with 0 being the center (DC) subcarrier.

For a 40 MHz non-OFDMA HE PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on subcarriers –244 to –3 and 3 to 244, with 0 being the center (DC) subcarrier.

For a 40 MHz OFDMA HE PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on all or a subset of subcarriers –244 to –3 and 3 to 244, with 0 being the center (DC) subcarrier.

For an 80 MHz non-OFDMA HE PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –3 and 3 to 500, with 0 being the center (DC) subcarrier.

For an 80 MHz OFDMA HE PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on all or a subset of the subcarriers –500 to –4 and 4 to 500, with 0 being the center (DC) subcarrier.

For a 160 MHz HE PPDU transmission or a noncontiguous 80+80 MHz transmission, each half 80 MHz bandwidth is divided into 1024 subcarriers, and the subcarriers on which the signal is transmitted in each 80 MHz bandwidth is identical to an 80 MHz HE PPDU transmission, depending on non-OFDMA or OFDMA transmission within the corresponding 80 MHz.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal on transmit chain i_{TX} and frequency segment i_{Seg} is related to the complex baseband signal by the relation shown in Equation (27-1).

$$r_{RF}^{(i_{Seg},\, i_{TX})}(t) = \mathrm{Re}\left\{ \frac{1}{\sqrt{N_{Seg}}} r_{PPDU}^{(i_{Seg},\, i_{TX})}(t) \exp\left(j 2\pi f_c^{(i_{Seg})} t\right) \right\}, \quad i_{Seg} = 0, \ldots, N_{Seg} - 1; \; i_{TX} = 1, \ldots, N_{TX} \qquad (27\text{-}1)$$

where

N_{Seg} represents the number of frequency segments in the transmit signal as defined in Table 27-13 (Subcarrier allocation related constants for the HE-modulated fields in a non-OFDMA HE PPDU)

$r_{PPDU}^{(i_{Seg},\, i_{TX})}$ 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}. Table 21-7 (Center frequency of the portion of the PPDU transmitted in frequency segment iSeg) shows $f_c^{(i_{Seg})}$ as a function of the channel starting frequency, dot11CurrentChannelWidth (see Table 21-22 (Fields to specify VHT channels)) and CH_BANDWIDTH where $f_{CH,\, start}$, $f_{P20,\, idx}$, $f_{P40,\, idx}$, and $f_{P80,\, idx}$ are given in Equation (21-4), Equation (21-5), Equation (21-7), and Equation (21-9), respectively. For an HE STA operating in the 6 GHz band, see 27.3.23.2 (Channel allocation in the 6 GHz band) for the value of channel starting frequency and the valid range of dot11CurrentChannelCenterFrequencyIndex0 and dot11CurrentChannelCenterFrequencyIndex1.

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 when the midamble is not present are shown in Figure 27-23 (Timing boundaries for HE PPDU fields if midamble is not present), where $N_{\text{HE-LTF}}$ is the number of HE-LTF symbols and is defined in Table 27-15 (Frequently used parameters), $N_{\text{HE-SIG-B}}$ is the number of OFDM symbols in the HE-SIG-B field present in an HE MU PPDU, and N_{SYM} is the number of data OFDM symbols.

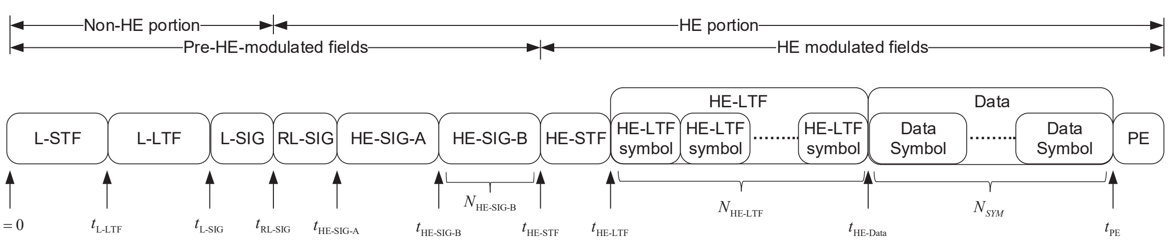

Figure 27-23—Timing boundaries for HE PPDU fields if midamble is not present

NOTE—Data OFDM symbols are OFDM symbols in the Data field of an HE PPDU that are not midamble symbols.

The time offset, t_{Field}, determines the starting time of the corresponding field relative to the start of L-STF ($t = 0$).

The signal transmitted on frequency segment i_{Seg} and transmit chain i_{TX} shall be as shown in Equation (27-2) if midamble is not present.

$$r_{PPDU}^{(i_{Seg},\, i_{TX})}(t) = r_{\text{L-STF}}^{(i_{Seg},\, i_{TX})}(t) + r_{\text{L-LTF}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{L-LTF}}) + r_{\text{L-SIG}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{L-SIG}}) + r_{\text{RL-SIG}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{RL-SIG}}) + r_{\text{HE-SIG-A}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-SIG-A}}) + r_{\text{HE-SIG-B}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-SIG-B}}) + r_{\text{HE-STF}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-STF}}) + r_{\text{HE-LTF}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-LTF}}) + r_{\text{HE-Data}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-Data}}) + r_{\text{HE-PE}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-PE}}) \tag{27-2}$$

where

$r_{\text{HE-SIG-B}}^{(i_{Seg},\, i_{TX})}(t - t_{\text{HE-SIG-B}})$ is only applicable to an HE MU PPDU

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

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

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

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

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

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

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

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

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

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

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

In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, for each field excluding the PE field, $r_{Field}^{(i_{Seg},\, i_{TX})}(t)$ is defined as the summation of one or more subfields. Each subfield, $r_{Subfield}^{(i_{Seg},\, i_{TX})}(t)$, is defined to be an inverse discrete Fourier transform in Equation (27-3).

$$r_{Subfield}^{(i_{Seg},\, i_{TX})}(t) = w_{T_{Subfield}}(t) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r^{Field}}{\sqrt{N_{Norm,\, r}}} \sum_{k \in K_r} \eta_{Field,\, k} \sum_{u=0}^{N_{user,\, r}-1} \sum_{m=1}^{N_{STS,\, r,\, u}} \left[Q_k^{(i_{Seg})}\right]_{i_{TX},\, (M_{r,\, u}+m)} \Upsilon_{k,\, BW} X_{k,\, r,\, u}^{i_{Seg},\, m} \exp(j2\pi k \Delta_{F,\, Field}(t - T_{GI,\, Field} - T_{CS,\, \text{HE}}(M_{r,\, u} + m))) \tag{27-3}$$

In an HE TB PPDU, transmitted by user u in the r-th occupied RU, each subfield, $r_{Subfield,\, r,\, u}^{(i_{Seg},\, i_{TX})}(t)$, is defined in Equation (27-4).

$$r_{Subfield,\, r,\, u}^{(i_{Seg},\, i_{TX})}(t) = \frac{\beta_r^{Field}}{\sqrt{N_{Norm,\, r}}} w_{T_{Subfield}}(t) \sum_{k \in K_r} \eta_{Field,\, k} \sum_{m=1}^{N_{STS,\, r,\, u}} \left[Q_{k,\, u}^{(i_{Seg})}\right]_{i_{TX},\, m} \Upsilon_{k,\, BW} X_{k,\, r,\, u}^{(i_{Seg},\, m)} \exp(j2\pi k \Delta_{F,\, Field}(t - T_{GI,\, Field} - T_{CS,\, \text{HE}}(M_{r,\, u} + m))) \tag{27-4}$$

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 and Data fields, as shown in Figure 27-23 (Timing boundaries for HE PPDU fields if midamble is not present).

For an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, 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 if the TXVECTOR parameter BEAM_CHANGE is 1 or not present and power boost in HE modulated fields is not present.

For an HE TB PPDU, the total power of the time domain HE modulated field signals summed over all transmit chains may exceed the total power of the time domain pre-HE modulated field signals summed over all transmit chains by up to 3 dB.

For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (27-3) and Equation (27-4) the following notations are used:

$N_{Norm,r}$ If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, then for pre-HE modulated fields, $N_{Norm,r} = N_{TX}$. If the TXVECTOR parameter BEAM_CHANGE is 0, then for pre-HE modulated fields $N_{Norm,r} = N_{STS,r,total}$, where $N_{STS,r,total}$ is given in Table 27-15 (Frequently used parameters). For HE modulated fields $N_{Norm,r} = N_{STS,r,total}$.

$w_{Subfield}(t)$ is a windowing function. An example function, $w_{Subfield}(t)$, is given in 17.3.2.5 (Mathematical conventions in the signal descriptions).

K_r For pre-HE modulated fields, K_r is the set of subcarriers indices in the allocated 20 MHz channels. For HE modulated fields in a non-OFDMA HE PPDU, K_r is the set of subcarriers indices from $-N_{SR}$ to N_{SR} as defined in Table 27-13 (Subcarrier allocation related constants for the HE-modulated fields in a non-OFDMA HE PPDU) excluding DC subcarriers. 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 as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU).

$\eta_{Field,k}$ is the power scale factor of the k-th subcarrier of a given field within an OFDM symbol, which is $\sqrt{2}$ for all the subcarriers of the L-STF, L-LTF, HE-STF and HE-LTF fields in the HE ER SU PPDU. For the L-SIG and RL-SIG fields of an HE ER SU PPDU,

$$\eta_{Field,k} = \begin{cases} \sqrt{2}, k = -28, -27, 27, 28 \\ 1, \quad \text{otherwise} \end{cases}$$

For the HE-SIG-A and Data fields in an HE ER SU PPDU, $\eta_{Field,k} = 1$. For the pre-HE portion of the HE TB PPDU, $\eta_{Field,k} = \left[\frac{1}{\sqrt{2}}, 1\right]$, meaning in the range $\frac{1}{\sqrt{2}}$ to 1. For all other fields in other HE PPDUs $\eta_{Field,k} = 1$.

α_r is the power boost factor in the range [0.5, 2] of the r-th occupied RU in an HE PPDU. For a DL HE MU PPDU, an AP shall limit the ratio between the maximum value of α_r and the minimum value of α_r to 2 unless the Power Boost Factor Support subfield of the HE PHY Capabilities Information field in the HE Capabilities element from all recipient STAs is 1, in which case the AP can use a ratio of up to 4. For an HE SU PPDU and HE ER SU PPDU, α_r is always set to 1.

β_r^{Field} is the power normalization factor and is defined in Equation (27-5)

$$\beta_r^{Field} = \begin{cases} \dfrac{\varepsilon_{Field}}{\sqrt{N_{Field}^{\text{Tone}}}}, \text{ for pre-HE modulated fields} \\ \dfrac{1}{\sqrt{\left|K_r^{Field}\right|}}, \text{ for HE modulated fields in an HE TB PPDU} \\ \sqrt{\dfrac{|K_r|}{\left|K_r^{Field}\right|}} \Big/ \sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}, \text{ otherwise} \end{cases} \quad (27\text{-}5)$$

$|K_r|$ is the cardinality of the set of subcarriers K_r.

$\left|K_r^{Field}\right|$ is the cardinality of the set of modulated subcarriers within K_r for the HE-STF and Data fields. For the HE-LTF field,

$$\left|K_r^{\text{HE-LTF}}\right| = \begin{cases} |K_r|, \text{ for a 4x HE-LTF} \\ |K_r|/2, \text{ for a 2x HE-LTF} \\ |K_r|/4, \text{ for a 1x HE-LTF} \end{cases}$$

N_{Field}^{Tone} Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields) summarizes the various values of N_{Field}^{Tone} as a function of bandwidth per frequency segment.

Table 27-16—Number of modulated subcarriers 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	$T_{GI,\text{L-LTF}}$
L-SIG in an HE PPDU	56	112	224	448	$T_{GI,\text{Pre-HE}}$
L-SIG in a non-HT duplicate PPDU	-	104	208	416	
RL-SIG	56	112	224	448	$T_{GI,\text{Pre-HE}}$
HE-SIG-A	56	112	224	448	$T_{GI,\text{Pre-HE}}$
HE-SIG-B	56	112	224	448	$T_{GI,\text{Pre-HE}}$

N_{RU} is defined in Table 27-15 (Frequently used parameters)

$$\varepsilon_{Field} = \begin{cases} \sqrt{\dfrac{N_{\text{L-LTF}}^{\text{Tone}}}{N_{\text{L-SIG}}^{\text{Tone}}}}, & \text{for the L-STF and L-LTF fields} \\ 1, & \text{otherwise} \end{cases}$$

$Q_k^{(i_{Seg})}$ 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 $N_{STS,r,total}$ columns. If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, then for pre-HE modulated fields $Q_k^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{ Pre-HE}}T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are defined in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields); otherwise it is identical to the spatial mapping $Q_k^{(i_{Seg})}$ for HE modulated fields.

$Q_{k,u}^{(i_{Seg})}$ is the spatial mapping matrix for user u on subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,r,u}$ columns. For pre-HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{ Pre-HE}}T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are defined in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

$\Delta_{F,Field}$ is the subcarrier frequency spacing. For pre-HE modulated fields, $\Delta_{F,Field} = \Delta_{F,\text{ Pre-HE}}$ given in Table 27-12 (Timing-related constants). For HE modulated fields, $\Delta_{F,Field} = \Delta_{F,\text{ HE}}$ given in Table 27-12 (Timing-related constants).

$M_{r,u}$ is given in Table 27-15 (Frequently used parameters).

$X_{k,r,u}^{(i_{Seg},m)}$ is the frequency-domain symbol in subcarrier k of user u in the r-th RU for frequency segment i_{Seg} of space-time stream m. Some of the $X_{k,r,u}^{(i_{Seg},m)}$ within $-N_{SR} \le k \le N_{SR}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the null subcarriers in an HE OFDMA PPDU, as well as the unmodulated tones of L-STF, HE-STF, and HE-LTF fields.

$T_{GI,Field}$ is the guard interval duration used for each OFDM symbol in the field. The value for each field is defined in Table 27-12 (Timing-related constants).

$T_{CS,\text{ HE}}(l)$ For pre-HE modulated fields, if the TXVECTOR parameter BEAM_CHANGE is 1 or not present, $T_{CS,\text{ HE}}(l) = 0$. For HE modulated fields and pre-HE modulated fields if the TXVECTOR parameter BEAM_CHANGE is 0, $T_{CS,\text{ HE}}(l)$ represents the cyclic shift per space-time stream, whose value is defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

$\Upsilon_{k,BW}$ is used to represent tone rotation. BW in $\Upsilon_{k,BW}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 27-17 (CH_BANDWIDTH and for pre-HE modulated fields). In HE modulated fields, $\Upsilon_{k,BW} = 1$ for all the subcarriers. In pre-HE modulated fields, $\Upsilon_{k,BW}$ is defined as in 21.3.7.5 (Definition of tone rotation) if TXVECTOR parameter BEAM_CHANGE is 1 and $\Upsilon_{k,BW} = 1$ for all the subcarriers if TXVECTOR parameter

BEAM_CHANGE is 0. If the TXVECTOR parameter BEAM_CHANGE is not present (such as in an HE MU PPDU and HE TB PPDU), BEAM_CHANGE is assumed to be 1.

Table 27-17—CH_BANDWIDTH and $\Upsilon_{k,BW}$ for pre-HE modulated fields

CH_BANDWIDTH	$\Upsilon_{k,\mathrm{BW}}$
CBW20	$\Upsilon_{k,20}$
CBW40	$\Upsilon_{k,40}$
CBW80	$\Upsilon_{k,80}$
CBW160	$\Upsilon_{k,160}$
CBW80+80	$\Upsilon_{k,80}$ per frequency segment
HE-CBW-PUNC80-PRI	$\Upsilon_{k,80}$
HE-CBW-PUNC80-SEC	$\Upsilon_{k,80}$
HE-CBW-PUNC160-PRI20	$\Upsilon_{k,160}$
HE-CBW-PUNC80+80-PRI20	$\Upsilon_{k,80}$ per frequency segment
HE-CBW-PUNC160-SEC40	$\Upsilon_{k,160}$
HE-CBW-PUNC80+80-SEC40	$\Upsilon_{k,80}$ per frequency segment

27.3.11 HE preamble

27.3.11.1 Introduction

The HE preamble consists of pre-HE modulated fields and HE modulated fields. The pre-HE modulated fields for the various HE PPDU formats are the following:

- L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields of an HE SU PPDU, HE ER SU PPDU and HE TB PPDU
- L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A and HE-SIG-B fields of an HE MU PPDU

The HE modulated fields in the preamble for all HE PPDU formats are the HE-STF and HE-LTF fields.

27.3.11.2 Cyclic shift

27.3.11.2.1 Cyclic shift for pre-HE modulated fields

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, then the cyclic shift value $T_{CS}^{i_{TX}}$ for the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A and HE-SIG-B fields of the PPDU for transmit chain i_{TX} out of a total of N_{TX} are defined in Table 21-10 (Cyclic shift values for L-STF, L-LTF, L-SIG, and VHT-SIG-A fields of the PPDU). In UL MU transmission the cyclic shift value $T_{CS}^{i_{TX}}$ is based on the local transmit chain indices at each STA.

If the TXVECTOR parameter BEAM_CHANGE is 0, then the cyclic shift value $T_{CS,\mathrm{HE}}(n)$ for the L-STF, L-LTF, L-SIG, RL-SIG, and HE-SIG-A fields is specified in 27.3.11.2.2 (Cyclic shift for HE modulated fields).

27.3.11.2.2 Cyclic shift for HE modulated fields

The cyclic shift values defined in this subclause apply to the HE-STF, HE-LTF and Data fields of the HE PPDU if the TXVECTOR parameter BEAM_CHANGE is 1 or not present, and apply to the entire PPDU if the TXVECTOR parameter BEAM_CHANGE is 0.

Throughout the HE modulated fields of the preamble, cyclic shifts are applied to prevent unintended beamforming when correlated signals are transmitted in multiple space-time streams. The same cyclic shifts are also applied to these streams during the transmission of the Data field of the HE PPDU. For the *r*-th RU, the cyclic shift value $T_{CS,\mathrm{HE}}(n)$ for the HE modulated fields for space-time stream n out of $N_{STS,r,total}$ total space-time streams is shown in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU).

27.3.11.3 L-STF

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain representation of the L-STF field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as specified in Equation (27-6). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg},\, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-26}^{26} \eta_{\text{L-STF},k} \begin{pmatrix} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} S_{k,20} \\ \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t-T_{CS}^{i_{TX}})) \end{pmatrix} \quad (27\text{-}6)$$

where

ε is a power scaling factor with the value $\varepsilon = \sqrt{\dfrac{N_{\text{L-LTF}}^{\text{Tone}}}{N_{\text{L-SIG}}^{\text{Tone}}}}$

$\eta_{\text{L-STF},k}$ is a PPDU format dependent scaling factor for the L-STF field on subcarrier index k with the following value

$$\eta_{\text{L-STF},k} = \begin{cases} \sqrt{2}, & \text{for an HE ER SU PPDU} \\ \left[\frac{1}{\sqrt{2}}, 1\right], & \text{for an HE TB PPDU} \\ 1, & \text{otherwise} \end{cases} \quad (27\text{-}7)$$

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

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

$N_{\text{L-STF}}^{\text{Tone}}$ has the value given in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields).

$\Omega_{20\text{MHz}}$ is a set of 20 MHz channels where pre-HE modulated fields are located. The set of 20 MHz channels contains one or more values in the range 0 to $N_{20\text{MHz}} - 1$ for an HE TB PPDU, HE sounding NDP or HE MU PPDU with preamble puncturing, and it contains all values in the range 0 to $N_{20\text{MHz}} - 1$ for other HE PPDU formats.

$$N_{20\mathrm{MHz}} = \begin{cases} 1, \text{ if CH\_BANDWIDTH is CBW20} \\ 2, \text{ if CH\_BANDWIDTH is CBW40} \\ 4, \text{ if CH\_BANDWIDTH is CBW80, HE-CBW-PUNC80-PRI,} \\ \quad \text{HE-CBW-PUNC80-SEC, CBW80+80, HE-CBW-PUNC80+80-PRI20,} \\ \quad \text{or HE-CBW-PUNC80+80-SEC40} \\ 8, \text{ if CH\_BANDWIDTH is CBW160, HE-CBW-PUNC160-PRI20,} \\ \quad \text{or HE-CBW-PUNC160-SEC40} \end{cases}$$

$S_{k,20}$ is defined as $S_{-26,26}$ in Equation (19-8).

i_{BW} is the index of 20 MHz channels, $0 \le i_{BW} \le N_{20\mathrm{MHz}} - 1$.

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-STF field shall be as specified in Equation (27-8). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20\mathrm{MHz}}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS}} \eta_{\text{L-STF},k} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,1} S_{k,20} \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t-T_{CS,\text{HE}}(m))) \right) \tag{27-8}$$

where

$T_{CS,\text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is the spatial mapping/steering matrix for subcarrier k, in frequency segment i_{Seg} on the data OFDM symbols over subcarrier spacing $\Delta_{F,\text{HE}}$ as defined in Table 27-12 (Timing-related constants). Refer to the descriptions in 21.3.10.11.1 (Transmission in VHT format) for examples of $Q_k^{(i_{Seg})}$.

$A_{\text{HE-LTF}}^k$ is defined in Equation (27-55)

N_{STS} is the number of space-time streams of the HE-modulated fields in an HE SU PPDU or HE ER SU PPDU as defined in Table 27-15 (Frequently used parameters)

27.3.11.4 L-LTF

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain representation of the L-LTF field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as specified in Equation (27-9). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW} \in \Omega_{20\mathrm{MHz}}} \sum_{k=-26}^{26} \eta_{\text{L-LTF},k} \left(\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} L_{k,20} \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - T_{GI,\text{L-LTF}} - T_{CS}^{i_{TX}})) \right) \tag{27-9}$$

$\eta_{\text{L-LTF},k}$ is a PPDU format dependent scaling factor for the L-LTF field on subcarrier index k with the same value as $\eta_{\text{L-STF},k}$.

ε is a power scaling factor with the value $\varepsilon = \sqrt{\dfrac{N_{\text{L-LTF}}^{\text{Tone}}}{N_{\text{L-SIG}}^{\text{Tone}}}}$

$T_{GI,\text{L-LTF}}$ is given in Table 27-12 (Timing-related constants)

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

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

$N_{\text{L-LTF}}^{\text{Tone}}$ has the value given in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields).

$L_{k,20}$ is defined as $L_{-26,26}$ in Equation (17-8).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-LTF field shall be as specified in Equation (27-10). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg},\, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS}} \eta_{\text{L-LTF},k} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})}\right]_{i_{TX},m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1} L_{k,20} \\ \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{ Pre-HE}}(t-T_{GI,\text{ L-LTF}}-T_{CS,\text{ HE}}(m))) \end{array} \right) \tag{27-10}$$

where

$T_{CS,\text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (27-55)

27.3.11.5 L-SIG

The L-SIG field is used to communicate rate and length information. The structure of the L-SIG field is defined in Figure 17-5 (SIGNAL field bit assignment).

In an HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field). In a non-HT duplicate PPDU, the RATE field is defined in 17.3.4.2 (RATE field) using the L_DATARATE parameter in the TXVECTOR.

For an HE TB PPDU, the LENGTH field is set to the TXVECTOR parameter L_LENGTH. For an HE SU PPDU, HE ER SU PPDU and HE MU PPDU, the LENGTH field is set to the value given by the Equation (27-11).

$$\text{Length} = \left\lceil \frac{\text{TXTIME} - SignalExtension - 20}{4} \right\rceil \times 3 - 3 - m \tag{27-11}$$

where

TXTIME (in µs) is defined in 27.4.3 (TXTIME and PSDU_LENGTH calculation).

m is 1 for an HE MU PPDU and HE ER SU PPDU, and 2 otherwise

SignalExtension is 0 µs if the TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table 27-55 (HE PHY characteristics) if the TXVECTOR parameter NO_SIG_EXTN is false

In a non-HT duplicate PPDU, the LENGTH field is defined in 17.3.4.3 (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 17.3.5.6 (Convolutional encoder), 17.3.5.7 (Data interleaving), and 17.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by $d_k, k = 0, \ldots, 47$ and are mapped to subcarriers [–26, 26]. In addition, values [–1, –1, –1, 1] are mapped to the extra subcarriers [–28, –27, 27, 28] of the L-SIG field of a 20 MHz HE PPDU. Subcarriers [–28, –27, 27, 28] are also BPSK modulated. Pilots shall be inserted as described in 17.3.5.9 (Pilot subcarriers).

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain waveform of the L-SIG field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as given by Equation (27-12).

$$r_{\text{L-SIG}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \begin{pmatrix} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}} \eta_{\text{L-SIG},\,k} (D_{k,\,20} + p_0 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{pmatrix} \tag{27-12}$$

where

$\eta_{\text{L-SIG},\,k}$ is a PPDU dependent scaling factor for the L-SIG field on the subcarrier *k* defined as follows:

$$\eta_{\text{L-SIG},\,k} = \begin{cases} \sqrt{2}, \ k = \pm 28, \pm 27 \text{ for an HE ER SU PPDU} \\ \left[\frac{1}{\sqrt{2}}, 1\right], \text{ for an HE TB PPDU} \\ 1, \text{ otherwise} \end{cases}$$

$T_{GI,\text{Pre-HE}}$ is given in Table 27-12 (Timing-related constants)

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

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

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

P_k is defined in 17.3.5.10 (OFDM modulation)

p_0 is the first pilot value in the sequence defined in 17.3.5.10 (OFDM modulation)

$N_{\text{L-SIG}}^{\text{Tone}}$ is defined in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

NOTE—$M_{20}^{r}(k)$ is a "reverse" function of the function $M(k)$ defined in 17.3.5.10 (OFDM modulation).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the L-SIG field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as given by Equation (27-13).

$$r_{\text{L-SIG}}^{(i_{Seg},\, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\, m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} \eta_{\text{L-SIG},\,k} (D_{k,\,20} + p_0 P_k) \cdot \exp(j 2\pi (k - K_{\text{Shift}}(i_{\text{BW}})) \Delta_{F,\,\text{Pre-HE}} (t - T_{GI,\,\text{Pre-HE}} - T_{CS,\,\text{HE}}(m))) \right) \tag{27-13}$$

where

$T_{CS,\,\text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (27-55)

27.3.11.6 RL-SIG

The RL-SIG field is a repeat of the L-SIG field and is used to differentiate an HE PPDU from a non-HT PPDU, HT PPDU, and VHT PPDU.

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain waveform of the RL-SIG field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as given by Equation (27-14).

$$r_{\text{RL-SIG}}^{(i_{Seg},\, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{RL-SIG}}^{\text{Tone}}}} w_{T_{\text{RL-SIG}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \begin{pmatrix} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\,\text{BW}} \eta_{\text{L-SIG},\,k}(D_{k,\,20} + p_1 P_k) \\ \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{pmatrix} \tag{27-14}$$

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the RL-SIG field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as given by Equation (27-15).

$$r_{\text{RL-SIG}}^{(i_{Seg},\, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{RL-SIG}}^{\text{Tone}}}} w_{T_{\text{RL-SIG}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \begin{pmatrix} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})}\right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,\,1} \eta_{\text{L-SIG},\,k}(D_{k,\,20} + p_1 P_k) \\ \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - T_{GI,\,\text{Pre-HE}} - T_{CS,\,\text{HE}}(m))) \end{pmatrix} \tag{27-15}$$

where

p_1 is the second pilot value in the sequence defined in 17.3.5.10 (OFDM modulation)

Other variables are defined below Equation (27-1), Equation (27-3), Equation (27-4), Equation (27-6), Equation (27-8) and Equation (27-12)

27.3.11.7 HE-SIG-A

27.3.11.7.1 General

The HE-SIG-A field carries information necessary to interpret HE PPDUs. The integer fields of the HE-SIG-A field are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

27.3.11.7.2 Content

The HE-SIG-A field for an HE SU PPDU or an HE ER SU PPDU contains the fields listed in Table 27-18 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU).

Table 27-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	Format	1	Differentiate an HE SU PPDU and HE ER SU PPDU from an HE TB PPDU: Set to 1 for an HE SU PPDU and HE ER SU PPDU

Table 27-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B1	Beam Change	1	Set to 1 to indicate that the pre-HE modulated fields of the PPDU may be spatially mapped differently from the first symbol of the HE-LTF. Equation (27-6), Equation (27-9), Equation (27-12), Equation (27-14), Equation (27-16) and Equation (27-18) apply if the Beam Change field is 1. Set to 0 to indicate that the pre-HE modulated fields of the PPDU are spatially mapped the same way as the first symbol of the HE-LTF on each subcarrier. Equation (27-8), Equation (27-10), Equation (27-13), Equation (27-15), Equation (27-17) and Equation (27-19) apply if the Beam Change field is 0.
	B2	UL/DL	1	Indicates whether the PPDU is sent UL or DL. Set to 1 if the PPDU is addressed to an AP. Set to 0 otherwise. See the TXVECTOR parameter UPLINK_FLAG.
	B3-B6	HE-MCS	4	For an HE SU PPDU: Set to *n* for HE-MCS *n*, where *n* = 0, 1, 2, …, 11 Values 12-15 are reserved For an HE ER SU PPDU with Bandwidth field set to 0 (242-tone RU): Set to *n* for HE-MCS *n*, where *n* = 0, 1, 2 Values 3-15 are reserved For an HE ER SU PPDU with Bandwidth field set to 1 (upper frequency 106-tone RU): Set to 0 for HE-MCS 0 Values 1-15 are reserved
	B7	DCM	1	Indicates whether or not DCM is applied to the Data field for the HE-MCS indicated. See Table 27-19 (Interpretation of DCM, STBC and GI+HE-LTF Size subfields) for the interpretation of this field. NOTE—DCM is applicable to only HE-MCSs 0, 1, 3 and 4. DCM is applicable to only1 and 2 spatial streams.
	B8-B13	BSS Color	6	The BSS Color field is an identifier of the BSS. Set to the value of the TXVECTOR parameter BSS_COLOR.
	B14	Reserved	1	Reserved and set to 1
	B15-B18	Spatial Reuse	4	Indicates whether or not spatial reuse modes are allowed during the transmission of this PPDU and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. Set to a value from Table 27-22 (Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU), see 26.11.6 (SPATIAL_REUSE) and 26.10 (Spatial reuse operation).

Table 27-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B19-B20	Bandwidth	2	For an HE SU PPDU: Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz For an HE ER SU PPDU: Set to 0 for 242-tone RU Set to 1 for upper frequency 106-tone RU within the primary 20 MHz Values 2 and 3 are reserved
	B21-B22	GI+HE-LTF Size	2	Indicates the GI duration and HE-LTF size. See Table 27-19 (Interpretation of DCM, STBC and GI+HE-LTF Size subfields) for the interpretation of this field.
	B23-B25	NSTS And Midamble Periodicity	3	If the Doppler field is 0, indicates the number of space-time streams. Set to the number of space-time streams minus 1 For an HE ER SU PPDU, values 2-7 are reserved If the Doppler field is 1, then B23-B24 indicates the number of space time streams, up to 4, and B25 indicates the midamble periodicity. B23-B24 is set to the number of space time streams minus 1. For an HE ER SU PPDU, values 2 and 3 are reserved B25 is set to 0 if TXVECTOR parameter MIDAMBLE_PERIODICITY is 10 and set to 1 if TXVECTOR parameter MIDAMBLE_PERIODICITY is 20.
HE-SIG-A2 (HE SU PPDU) or HE-SIG-A3 (HE ER SU PPDU)	B0-B6	TXOP	7	Set to 127 to indicate no duration information if TXVECTOR parameter TXOP_DURATION is set to UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1-B6 is set to floor(TXOP_DURATION/8). Otherwise, B0 is set to 1 and B1-B6 is set to floor ((TXOP_DURATION – 512) / 128). where B0 indicates the TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs. B1-B6 indicates the scaled value of the TXOP_DURATION
	B7	Coding	1	Indicates whether BCC or LDPC is used: Set to 0 to indicate BCC Set to 1 to indicate LDPC

Table 27-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B8	LDPC Extra Symbol Segment	1	Indicates the presence of the extra OFDM symbol segment for LDPC: Set to 1 if an extra OFDM symbol segment for LDPC is present Set to 0 if an extra OFDM symbol segment for LDPC is not present Reserved and set to 1 if the Coding field is 0.
	B9	STBC	1	Indicates whether or not STBC is applied to the Data field. See Table 27-19 (Interpretation of DCM, STBC and GI+HE-LTF Size subfields) for the interpretation of this field.
	B10	Beamformed	1	Set to 1 if a beamforming steering matrix is applied to the portion of the waveform contributed by the RU that contains this user's allocation and the RU contains no more than one user. Set to 0 otherwise.
	B11-B12	Pre-FEC Padding Factor	2	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
	B13	PE Disambiguity	1	Indicates PE disambiguity as defined in 27.3.13 (Packet extension).
	B14	Reserved	1	Reserved and set to 1
	B15	Doppler	1	Set to 1 if one of the following applies: — The number of OFDM symbols in the Data field is larger than the signaled midamble periodicity plus 1 and the midamble is present — The number of OFDM symbols in the Data field is less than or equal to the signaled midamble periodicity plus 1 (see 27.3.12.16 (Midambles), the midamble is not present, but the channel is fast varying. It recommends that midamble may be used for the PPDUs of the reverse link. Set to 0 otherwise.
	B16-B19	CRC	4	CRC for bits 0–41 of the HE-SIG-A field (see 27.3.11.7.3 (CRC computation)). Bits 0–41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

For an HE SU PPDU and HE ER SU PPDU, the DCM, STBC and GI+HE-LTF Size subfields in the HE-SIG-A field are interpreted as defined in Table 27-19 (Interpretation of DCM, STBC and GI+HE-LTF Size subfields).

Table 27-19—Interpretation of DCM, STBC and GI+HE-LTF Size subfields

Subfields in the HE-SIG-A field of an HE SU PPDU or HE ER SU PPDU (see Table 27-18 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU))			Interpretation		
DCM	**STBC**	**GI+HE-LTF Size**	**DCM Applied**	**STBC Applied**	**GI+HE-LTF size**
0	0	0	No	No	1x HE-LTF and 0.8 µs GI
		1			2x HE-LTF and 0.8 µs GI
		2			2x HE-LTF and 1.6 µs GI
		3			4x HE-LTF and 3.2 µs GI
1	0	0	Yes	No	1x HE-LTF and 0.8 µs GI
		1			2x HE-LTF and 0.8 µs GI
		2			2x HE-LTF and 1.6 µs GI
		3			4x HE-LTF and 3.2 µs GI
0	1	0	No	Yes	1x HE-LTF and 0.8 µs GI
		1			2x HE-LTF and 0.8 µs GI
		2			2x HE-LTF and 1.6 µs GI
		3			4x HE-LTF and 3.2 µs GI
1	1	0–2	Reserved		
		3	No	No	4x HE-LTF and 0.8 µs GI

The HE-SIG-A field of an HE MU PPDU contains the fields listed in Table 27-20 (HE-SIG-A field of an HE MU PPDU).

Table 27-20—HE-SIG-A field of an HE MU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	UL/DL	1	Indicates whether the PPDU is sent UL or DL. Set to 1 if the PPDU is addressed to an AP. Set to 0 otherwise. See the TXVECTOR parameter UPLINK_FLAG. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the frame.
	B1-B3	HE-SIG-B-MCS	3	Indicates the HE-MCS of the HE-SIG-B field: Set to 0 for HE-SIG-B-MCS 0 Set to 1 for HE-SIG-B-MCS 1 Set to 2 for HE-SIG-B-MCS 2 Set to 3 for HE-SIG-B-MCS 3 Set to 4 for HE-SIG-B-MCS 4 Set to 5 for HE-SIG-B-MCS 5 Values 6 and 7 are reserved
	B4	HE-SIG-B DCM	1	Set to 1 indicates that the HE-SIG-B is modulated with DCM for the HE-MCS. Set to 0 indicates that the HE-SIG-B is not modulated with DCM for the HE-MCS. NOTE—DCM is only applicable to HE-SIG-B-MCS 0, 1, 3, and 4.
	B5-B10	BSS Color	6	The BSS Color field is an identifier of the BSS. Set to the value of the TXVECTOR parameter BSS_COLOR.
	B11-B14	Spatial Reuse	4	Indicates whether or not spatial reuse modes are allowed during the transmission of this PPDU and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. Set to the value of the SPATIAL_REUSE parameter of the TXVECTOR, which contains a value from Table 27-22 (Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) (see 26.11.6 (SPATIAL_REUSE)) and 26.10 (Spatial reuse operation).

Table 27-20—HE-SIG-A field of an HE MU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B15-B17	Bandwidth	3	Set to 0 for 20 MHz. Set to 1 for 40 MHz. Set to 2 for 80 MHz non-preamble puncturing mode. Set to 3 for 160 MHz and 80+80 MHz non-preamble puncturing mode. If the HE-SIG-B Compression field is 0: Set to 4 for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured. Set to 5 for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz subchannels in secondary 40 MHz is punctured. Set to 6 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured. Set to 7 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present, and at least one 20 MHz subchannel that is not in the primary 40 MHz is punctured. If the HE-SIG-B Compression field is 1 then values 4-7 are reserved.
	B18-B21	Number Of HE-SIG-B Symbols Or MU-MIMO Users	4	If the HE-SIG-B Compression field is 0, indicates the number of OFDM symbols in the HE-SIG-B field: Set to the number of OFDM symbols in the HE-SIG-B field minus 1 if the number of OFDM symbols in the HE-SIG-B field is less than 16; Set to 15 to indicate that the number of OFDM symbols in the HE-SIG-B field is equal to 16 if Longer Than 16 HE-SIG-B OFDM Symbols Support subfield of the HE Capabilities element transmitted by at least one recipient STA is 0; Set to 15 to indicate that the number of OFDM symbols in the HE-SIG-B field is greater than or equal to 16 if the Longer Than 16 HE-SIG-B OFDM Symbols Support subfield of the HE Capabilities element transmitted by all the recipient STAs are 1 and if the HE-SIG-B-MCS field is set to 0, 1, 2, or 3 regardless of the value of the HE-SIG-B DCM field, or the HE-SIG-B-MCS field is set to 4 and the HE-SIG-B DCM field is set to 1. The exact number of OFDM symbols in the HE-SIG-B field is calculated based on the number of User fields in the HE-SIG-B content channel, which is indicated by HE-SIG-B Common field in this case. If the HE-SIG-B Compression field is 1, indicates the number of MU-MIMO users and is set to the number of MU-MIMO users minus 1.
	B22	HE-SIG-B Compression	1	Set to 0 if the Common field in HE-SIG-B is present. Set to 1 if the Common field in HE-SIG-B is not present.

Table 27-20—HE-SIG-A field of an HE MU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B23-B24	GI+HE-LTF Size	2	Indicates the GI duration and HE-LTF size: Set to 0 to indicate a 4x HE-LTF and 0.8 µs GI Set to 1 to indicate a 2x HE-LTF and 0.8 µs GI Set to 2 to indicate a 2x HE-LTF and 1.6 µs GI Set to 3 to indicate a 4x HE-LTF and 3.2 µs GI
	B25	Doppler	1	Set to 1 if one of the following applies: — The number of OFDM symbols in the Data field is larger than the signaled midamble periodicity plus 1 and the midamble is present — The number of OFDM symbols in the Data field is less than or equal to the signaled midamble periodicity plus 1 (see 27.3.12.16 (Midambles), the midamble is not present, but the channel is fast varying. It recommends that midamble may be used for the PPDUs of the reverse link. Set to 0 otherwise.
HE-SIG-A2	B0-B6	TXOP	7	Set to 127 to indicate no duration information if TXVECTOR parameter TXOP_DURATION is UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1–B6 is set to floor(TXOP_DURATION/8). Otherwise, B0 is set to 1 and B1–B6 is set to floor ((TXOP_DURATION – 512) / 128). where B0 indicates the TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs. B1-B6 indicates the scaled value of the TXOP_ DURATION
	B7	Reserved	1	Reserved and set to 1

Table 27-20—HE-SIG-A field of an HE MU PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B8-B10	Number of HE-LTF Symbols And Midamble Periodicity	3	If the Doppler field is 0, indicates the number of HE-LTF symbols: Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols Other values are reserved. If the Doppler field is 1, B8–B9 indicates the number of HE-LTF symbols and B10 indicates midamble periodicity: B8-B9 is encoded as follows: 0 indicates 1 HE-LTF symbol 1 indicates 2 HE-LTF symbols 2 indicates 4 HE-LTF symbols 3 is reserved B10 is set to 0 to indicate 10 symbols midamble periodicity and set to 1 to indicate 20 symbols midamble periodicity.
	B11	LDPC Extra Symbol Segment	1	Indication of the presence of the extra OFDM symbol segment for LDPC. Set to 1 if an extra OFDM symbol segment for LDPC is present. Set to 0 otherwise.
	B12	STBC	1	In an HE MU PPDU where each RU includes no more than 1 user, set to 1 to indicate all RUs are STBC encoded in the payload, set to 0 to indicate all RUs are not STBC encoded in the payload. STBC does not apply to HE-SIG-B.
	B13-B14	Pre-FEC Padding Factor	2	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
	B15	PE Disambiguity	1	Indicates PE disambiguity as defined in 27.3.13 (Packet extension).
	B16-B19	CRC	4	CRC for bits 0-41 of the HE-SIG-A field (see 27.3.11.7.3 (CRC computation)). Bits 0-41 of the HE-SIG-A field correspond to bits 0-25 of HE-SIG-A1 followed by bits 0-15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

It is optional for an HE STA to receive a preamble punctured HE MU PPDU with the Bandwidth field in HE-SIG-A in the range of 4 to 7. An HE STA indicates that it is capable of receiving a preamble punctured HE MU PPDU with the Bandwidth field of HE-SIG-A field in the range of 4 to 7 using the Punctured Preamble Rx subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.247 (HE Capabilities element)).

The HE-SIG-A field for an HE TB PPDU contains the fields listed in Table 27-21 (HE-SIG-A field of an HE TB PPDU).

Table 27-21—HE-SIG-A field of an HE TB PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	Format	1	Differentiate an HE SU PPDU and HE ER SU PPDU from an HE TB PPDU: Set to 0 for an HE TB PPDU
	B1-B6	BSS Color	6	The BSS Color field is an identifier of the BSS. Set to the value of the TXVECTOR parameter BSS_COLOR.
	B7-B10	Spatial Reuse 1	4	Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. If the Bandwidth field indicates 20 MHz, 40 MHz, or 80 MHz then this Spatial Reuse field applies to the first 20 MHz subband. If the Bandwidth field indicates 160/80+80 MHz then this Spatial Reuse field applies to the first 40 MHz subband of the 160 MHz operating band. Set to the value of the SPATIAL_REUSE(1) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL_REUSE) and 26.10 (Spatial reuse operation)).

Table 27-21—HE-SIG-A field of an HE TB PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B11-B14	Spatial Reuse 2	4	Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. If the Bandwidth field indicates 40 MHz or 80 MHz: This Spatial Reuse field applies to the second 20 MHz subband. If the STA operating channel width is 20 MHz, then this field is set to the same value as the Spatial Reuse 1 field. If the STA operating channel width is 40 MHz in the 2.4 GHz band, this field is set to the same value as the Spatial Reuse 1 field. If the Bandwidth field indicates 160/80+80 MHz the this Spatial Reuse field applies to the second 40 MHz subband of the 160 MHz operating band. Set to the value of the SPATIAL_REUSE(2) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL_REUSE) and 26.10 (Spatial reuse operation)).
	B15-B18	Spatial Reuse 3	4	Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. If the Bandwidth field indicates 80 MHz: This Spatial Reuse field applies to the third 20 MHz subband. If the STA operating channel width is 20 MHz or 40 MHz, this field is set to the same value as the Spatial Reuse 1 field. If the Bandwidth field indicates 160/80+80 MHz: This Spatial Reuse field applies to the third 40 MHz subband of the 160 MHz operating band. If the STA operating channel width is 80+80 MHz, this field is set to the same value as the Spatial Reuse 1 field. Set to the value of the SPATIAL_REUSE(3) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL_REUSE) and 26.10 (Spatial reuse operation)).

Table 27-21—HE-SIG-A field of an HE TB PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B19-B22	Spatial Reuse 4	4	Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU. If the Bandwidth field indicates 80 MHz: This Spatial Reuse field applies to the fourth 20 MHz subband. If the STA operating channel width is 20 MHz, then this field is set to the same value as the Spatial Reuse 1 field. If the STA operating channel width is 40 MHz, then this field is set to the same value as the Spatial Reuse 2 field. If the Bandwidth field indicates 160/80+80 MHz: This Spatial Reuse field applies to the fourth 40 MHz subband of the 160 MHz operating band. If the STA operating channel width is 80+80 MHz, then this field is set to same value as the Spatial Reuse 2 field. Set to the value of the SPATIAL_REUSE(4) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL_REUSE) and 26.10 (Spatial reuse operation)).
	B23	Reserved	1	Reserved and set to 1. NOTE—Unlike other Reserved fields in HE-SIG-A of the HE TB PPDU, B23 does not have a corresponding bit in the Trigger frame.
	B24-B25	Bandwidth	2	Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz
HE-SIG-A2	B0-B6	TXOP	7	Set to 127 to indicate no duration information if TXVECTOR parameter TXOP_DURATION is UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1–B6 is set to floor(TXOP_DURATION/8). Otherwise, B0 is set to 1 and B1-B6 is set to floor ((TXOP_DURATION – 512) / 128). where B0 indicates the TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs. B1–B6 indicates the scaled value of the TXOP_DURATION

Table 27-21—HE-SIG-A field of an HE TB PPDU *(continued)*

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
	B7-B15	Reserved	9	Reserved and set to value indicated in the UL HE-SIG-A2 Reserved subfield in the Trigger frame.
	B16-B19	CRC	4	CRC of bits 0–41 of the HE-SIG-A field. See 27.3.11.7.3 (CRC computation). Bits 0–41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

The four Spatial Reuse fields, 1, 2, 3, and 4, are arranged in increasing order of frequency and correspond to:

— For 20 MHz one Spatial Reuse field corresponding to the entire 20 MHz (other 3 fields indicate identical values). The Spatial Reuse fields only apply to the 20 MHz used for the transmission.

— For 40 MHz two Spatial Reuse fields with Spatial Reuse 3 field identical in value to the Spatial Reuse 1 field and Spatial Reuse 4 field identical in value to Spatial Reuse 2 field. The Spatial Reuse fields only apply to the 20 MHz used for the transmission.

— For 80 MHz four Spatial Reuse fields, one for each 20 MHz subchannel

- For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 20 MHz sub-band is also applicable to the 242-tone RU that is most closely aligned in frequency (in the tone plan for that BW) with the aforementioned 20 MHz sub-band. The correspondence from an Spatial Reuse field to a 242-tone RU also holds for any RU within the 242-tone RU. The above also implies that a 20 MHz OBSS STA uses the Spatial Reuse field corresponding to its 20 MHz channel, a 40 MHz OBSS STA located on the lower frequency half of the 80 MHz BSS uses Spatial Reuse 1 field, Spatial Reuse 2 field values and a 40 MHz OBSS STA located on the upper frequency half of the 80 MHz BSS uses Spatial Reuse 3 field, Spatial Reuse 4 field values

— For 160 MHz and 80+80 MHz four Spatial Reuse fields, one for each 40 MHz subchannel

- For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 40 MHz sub-band is also applicable to the 484-tone RU that is most closely aligned in frequency (in the tone-plan of that BW) with the aforementioned 40 MHz sub-band. The correspondence from an Spatial Reuse field to a 484-tone RU also holds for any RU within the 484-tone RU.

Table 27-22 (Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) defines the encoding for the Spatial Reuse field for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU.

Table 27-22—Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU

Value	Meaning
0	PSR_DISALLOW
1-12	Reserved

Table 27-22—Spatial Reuse field encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU *(continued)*

Value	Meaning
13	SR_RESTRICTED
14	SR_DELAYED
15	PSR_AND_NON_SRG_OBSS_PD_PROHIBITED

Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) defines the encoding for the Spatial Reuse 1, Spatial Reuse 2, Spatial Reuse 3 and Spatial Reuse 4 fields for an HE TB PPDU

Table 27-23—Spatial Reuse field encoding for an HE TB PPDU

Value	Meaning
0	PSR_DISALLOW
1	PSR = –80 dBm
2	PSR = –74 dBm
3	PSR = –68 dBm
4	PSR = –62 dBm
5	PSR = –56 dBm
6	PSR = –50 dBm
7	PSR = –47 dBm
8	PSR = –44 dBm
9	PSR = –41 dBm
10	PSR = –38 dBm
11	PSR = –35 dBm
12	PSR = –32 dBm
13	PSR = –29 dBm
14	PSR ≥ –26 dBm
15	PSR_AND_NON_SRG_OBSS_PD_PROHIBITED

27.3.11.7.3 CRC computation

The CRC computation defined in this subclause applies to HE-SIG-A, the Common field of HE-SIG-B, and the User Block field of HE-SIG-B.

The CRC is calculated over bits 0 to 41 of the HE-SIG-A field and over bits 0 to L of the HE-SIG-B field ($L = x$ for each Common field where $x = N \times 8$ if the Center 26-tone RU field is present, and $x = N \times 8 - 1$ otherwise, and $L = 20$ for an User Block field that contains one User field and $L = 41$ for an User Block field that contains two User fields). Bits 0 to 41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2). Refer to Table 27-24 (Common field) for N and the conditions under which the Center 26-tone RU field is present.

The value of the CRC field shall be the 1s complement of

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

where

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

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

$G(D)$ is defined in 19.3.9.4.4 (CRC calculation for HT-SIG)

$crc(D) = c_0 D^7 + c_1 D^6 + \ldots + c_6 D + c_7$

m_L is the serial input shown in Figure 27-24 (CRC calculation)

The CRC field is transmitted from $c4$ to $c7$ with $c7$ first.

Figure 27-24 (CRC calculation) shows the operation of the CRC. First, the shift register is reset to all 1s. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, $c7$ first, through an inverter.

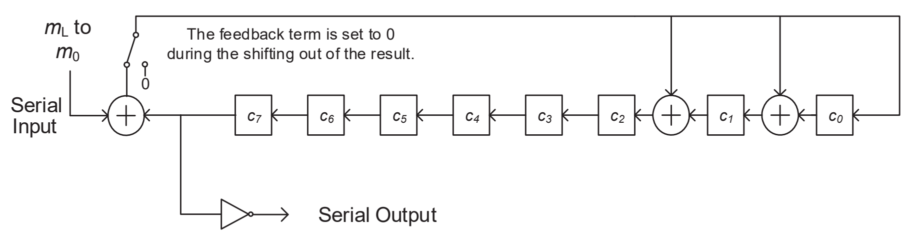

Figure 27-24—CRC calculation

As an example, if bits $\{m_0 \ldots m_{41}\}$ are given by {1 1 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 1 0}, the output bits $\{B_7 \ldots B_4\}$, where B_7 is output first, are {0 1 1 1}.

27.3.11.7.4 Encoding and modulation

For an HE SU PPDU, HE MU PPDU and HE TB 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 data bits of the HE-SIG-A OFDM symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 17.3.5.6 (Convolutional encoder), 27.3.12.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively. The constellation mappings of HE-SIG-A in HE SU PPDU, HE MU PPDU and HE TB PPDU are shown in Figure 27-25 (Data subcarrier constellation of HE-SIG-A symbols). 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 OFDM symbol of HE-SIG-A and the second 52 complex numbers form the second OFDM symbol of HE-SIG-A.

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain waveform for the HE-SIG-A field of an HE SU PPDU, HE MU PPDU and HE TB PPDU, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as specified in Equation (27-16).

$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \eta_{\text{HE-SIG-A},k} \begin{pmatrix} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}(D_{k,n,20} + p_{n+2}P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{pmatrix} \tag{27-16}$$

where

T_{SYML} is given in Table 27-12 (Timing-related constants)

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

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

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

$$\eta_{\text{HE-SIG-A},k} = \begin{cases} \left[\frac{1}{\sqrt{2}}, 1\right], \text{ for an HE TB PPDU} \\ 1, \text{ otherwise} \end{cases}$$

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)

$N_{\text{HE-SIG-A}}^{\text{Tone}}$ is defined in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 27.3.11.2.1 (Cyclic shift for pre-HE modulated fields).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the HE-SIG-A field shall be as given by Equation (27-17).

$$r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \begin{pmatrix} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})}\right]_{i_{TX},m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1} (D_{k,n,20} + p_{n+2}P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - nT_{SYML} - T_{\text{GI,Pre-HE}} - T_{CS,HE}(m))) \end{pmatrix} \tag{27-17}$$

where

$T_{CS,\,\mathrm{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals)

$A^k_{\text{HE-LTF}}$ is defined in Equation (27-55)

For an HE ER 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. 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 has the same encoded bits as HE-SIG-A1 and the encoded bits shall be mapped to a QBPSK constellation without interleaving and have pilots inserted. The constellation mappings of the HE-SIG-A field in an HE ER SU PPDU is shown in Figure 27-25 (Data subcarrier constellation of HE-SIG-A symbols). The QBPSK constellation on HE-SIG-A2 is used to differentiate between an HE ER SU PPDU and an HE MU PPDU when $m = 1$ in Equation (27-11). HE-SIG-A4 has the same encoded bits as HE-SIG-A3 and the encoded bits shall be mapped to a BPSK constellation without interleaving and have pilots inserted. BCC encoding, data interleaving, constellation mapping and pilot insertion follow the steps described in 17.3.5.6 (Convolutional encoder), 27.3.12.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively.

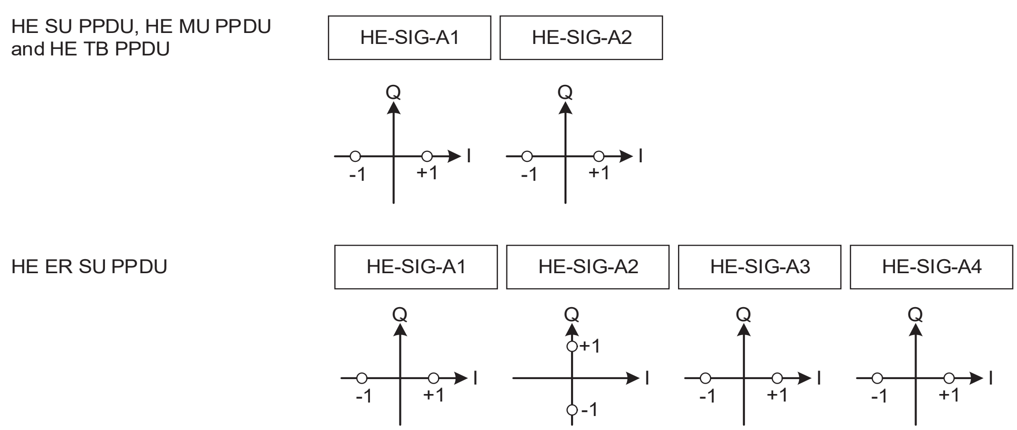

Figure 27-25—Data subcarrier constellation of HE-SIG-A symbols

If the TXVECTOR parameter BEAM_CHANGE is 1 or not present, the time domain waveform for the HE-SIG-A field in an HE ER SU PPDU shall be as specified in Equation (27-18).

$$r^{(i_{Seg},\, i_{TX})}_{\text{HE-SIG-A}}(t) = \frac{1}{\sqrt{N_{TX} \cdot N^{\text{Tone}}_{\text{HE-SIG-A}}}} \sum_{n=0}^{3} w_{T_{\text{SYML}}}(t - nT_{SYML}) \sum_{k=-28}^{28} (R_n D_{k,\,n,\,20} + p_{n+2} P_k) \cdot \exp(j2\pi k \cdot \Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \tag{27-18}$$

where

R_n 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 ER SU PPDU shall be as specified in Equation (27-19).

$$\begin{aligned} r^{(i_{Seg}, i_{TX})}_{\text{HE-SIG-A}}(t) = {} & \frac{1}{\sqrt{N_{STS} \cdot N^{\text{Tone}}_{\text{HE-SIG-A}}}} \sum_{n=0}^{3} w_{T_{SYML}}(t - nT_{SYML}) \\ & \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q^{(i_{Seg})}_{4k}\right]_{i_{TX},m} \left[A^{4k}_{\text{HE-LTF}}\right]_{m,1} (R_n D_{k,n,20} + p_{n+2}P_k) \\ \cdot \exp(j2\pi k \cdot \Delta_{F,\text{ Pre-HE}}(t - nT_{SYML} - T_{\text{GI, Pre-HE}} - T_{CS,HE}(m))) \end{array} \right) \end{aligned} \tag{27-19}$$

27.3.11.8 HE-SIG-B

27.3.11.8.1 General

The HE-SIG-B field provides the necessary signaling, including the OFDMA and DL MU-MIMO resource allocation information, to allow the STAs to look up the corresponding resources to be used in the HE modulated fields of the PPDU. The integer fields of the HE-SIG-B field are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

Dynamic split is defined as the split of User fields across HE-SIG-B content channels according to the Common field in each HE-SIG-B content channel and used when the HE-SIG-B Compression field in the HE-SIG-A field is set to 0.

Equitable split is defined as the split of User fields across HE-SIG-B content channels used when the HE-SIG-B Compression field in the HE-SIG-A field is set to 1.

27.3.11.8.2 HE-SIG-B content channels

The HE-SIG-B field of a 20 MHz HE MU PPDU contains one HE-SIG-B content channel. The HE-SIG-B field of an HE MU PPDU that is 40 MHz or wider contains two HE-SIG-B content channels.

The HE-SIG-B content channel format is shown in Figure 27-26 (HE-SIG-B content channel format). The HE-SIG-B content channel consists of a Common field, if present, followed by a User Specific field.

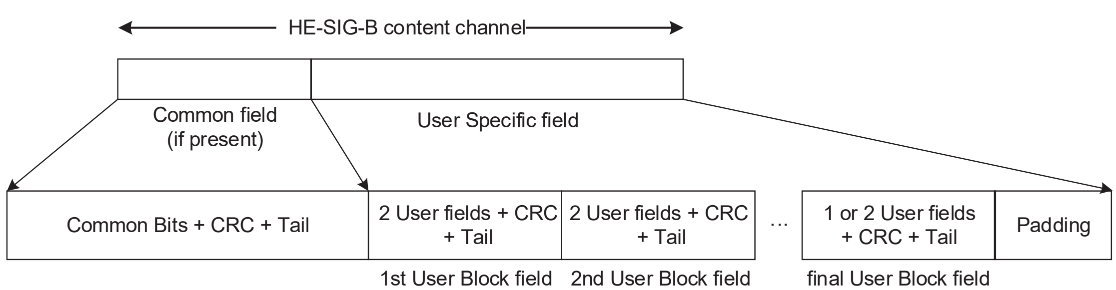

Figure 27-26—HE-SIG-B content channel format

If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1 (indicating full bandwidth MU-MIMO transmission), the Common field is not present and the HE-SIG-B content channel consists of only the User Specific field. If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 0, the Common field is present in HE-SIG-B content channel.

The Common field of an HE-SIG-B content channel contains information regarding the resource unit allocation such as the RU assignment to be used in the HE modulated fields of the PPDU, the RUs allocated for MU-MIMO and the number of users in MU-MIMO allocations. The Common field is defined in 27.3.11.8.3 (Common field).

The union of the User Specific fields in the HE-SIG-B content channels contains information for all users in the PPDU on how to decode their payload. As shown in Figure 27-26 (HE-SIG-B content channel format), the User Specific field is organized into User Block fields that in turn contain User fields. See 27.3.11.8.4 (User Specific field) for a description of the contents of the User Specific field.

See Annex Z for HE-SIG-B content examples.

27.3.11.8.3 Common field

This subclause is not applicable if the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1.

The Common field format is defined in Table 27-24 (Common field).

Table 27-24—Common field

Subfield	Number of subfields	Number of bits per subfield	Description
RU Allocation	*N*	8	*N* RU Allocation subfields are present in an HE-SIG-B content channel, where: $N = 1$ if the Bandwidth field in the HE-SIG-A field is 0 or 1 (indicating a 20 MHz or 40 MHz HE MU PPDU) $N = 2$ if the Bandwidth field in the HE-SIG-A field is 2, 4, or 5 (indicating an 80 MHz HE MU PPDU) $N = 4$ if the Bandwidth field in the HE-SIG-A field is 3, 6, or 7 (indicates a 160 MHz or 80+80 MHz HE MU PPDU) Each RU Allocation subfield in an HE-SIG-B content channel corresponding to a 20 MHz frequency segment indicates the RU assignment, including the size of the RU(s) and their placement in the frequency domain, to be used in the HE modulated fields of the HE MU PPDU in the frequency domain, also indicates information needed to compute the number of users allocated to each RU, where the subcarrier indices of the RU(s) meet the conditions in Table 27-25 (RUs associated with each RU Allocation subfield for each HE-SIG-B content channel and PPDU bandwidth).

Table 27-24—Common field *(continued)*

Subfield	Number of subfields	Number of bits per subfield	Description
Center 26-tone RU	0 or 1	1	The Center 26-tone RU field is present if the Bandwidth field in the HE-SIG-A field indicates a bandwidth greater than 40 MHz and not present otherwise. If the Bandwidth field in the HE-SIG-A field is 2, 4 or 5 (indicating 80 MHz): Set to 1 to indicate that a user is allocated to the center 26-tone RU (see Figure 27-7 (RU locations in an 80 MHz HE PPDU)) and that its User field is present in HE-SIG-B content channel 1; otherwise, set to 0. The same value is applied to both HE-SIG-B content channels. If the Bandwidth field in the HE-SIG-A field is 3, 6 or 7 (indicating 160 MHz or 80+80 MHz): For HE-SIG-B content channel 1, set to 1 to indicate that a user is allocated to the center 26-tone RU of the lower frequency 80 MHz; otherwise, set to 0. For HE-SIG-B content channel 2, set to 1 to indicate that a user is allocated to the center 26-tone RU of the higher frequency 80 MHz; otherwise, set to 0.
CRC	1	4	The CRC is calculated over bits 0 to $N \times 8$ if the Bandwidth field in the HE-SIG-A field indicates a bandwidth greater than 40 MHz, and bits 0 to $N \times 8 - 1$, otherwise. See 27.3.11.7.3 (CRC computation).
Tail	1	6	Used to terminate the trellis of the convolutional decoder. Set to 0

A 996-tone RU is referred to by two consecutive RU Allocation subfields per HE-SIG-B content channel, for both HE-SIG-B content channels. The two consecutive RU Allocation subfields per HE-SIG-B content channel are labeled the first RU Allocation subfield and the second RU Allocation subfield. A 484-tone RU is referred to by a single RU Allocation subfield per HE-SIG-B content channel, for both HE-SIG-B content channels. Smaller RUs are referred to by a single RU Allocation subfield in a single HE-SIG-B content channel. If a Common field is present in a 160 MHz or 80+80 MHz PPDU, a 2×996 tone RU is not permitted (none are defined in Table 27-26 (RU Allocation subfield)).

For an RU that is referred to by a first or only RU Allocation subfield in an HE-SIG-B content channel, the RU Allocation subfield encodes the number of User fields per RU contributed to the User Specific field in the same HE-SIG-B content channel as the RU Allocation subfield. This number is labeled $N_{user}(r, c)$ for RU r and HE-SIG-B content channel c as described in Table 27-26 (RU Allocation subfield).

For an RU that is referred to by two RU Allocation subfields in an HE-SIG-B content channel (i.e., a 996-tone RU in a 160 MHz or 80+80 MHz PPDU), the second RU Allocation subfield in the HE-SIG-B content channel encodes zero additional User fields per RU contributed to the User Specific field in the same HE-SIG-B content channel as the RU Allocation subfield.

In an HE MU PPDU, an RU that is not allocated to a user can be indicated as follows:

— The Center 26-tone RU subfield in the HE-SIG-B Common field is set to 0 (see Table 27-24 (Common field)).

- The RU Allocation subfield in the HE-SIG-B Common field is set to a value between 16 and 31 or between 96 and 113 (see Table 27-26 (RU Allocation subfield)).
- Both RU Allocation subfields at the same position in each HE-SIG-B Common field of the two HE-SIG-B content channels are set to 114 (see Table 27-26 (RU Allocation subfield)).
- The STA-ID subfield in the HE-SIG-B User field is set to 2046 (see 26.11.1 (STA_ID) and 27.3.11.8.4 (User Specific field)).

The subcarriers in the HE modulated fields of a PPDU that correspond to an unallocated RU shall not be modulated.

If an RU is an unallocated RU, zero users are allocated to it. Otherwise, the number of users allocated to RU r is determined from the RU size and $N_{user}(r, c)$ as follows:

- If RU r is a 26-tone or 52-tone RU, then one user is allocated to the RU.
- If RU r is a 106-tone or 242-tone RU, then the number of users allocated to the RU is $N_{user}(r, c)$.
- If RU r is a 484-tone or larger RU, then the number of users allocated to the RU equals the number of User fields for the RU summed across both HE-SIG-B content channels, i.e., $N_{user}(r, 1) + N_{user}(r, 2)$.

NOTE 1—The exact dynamic split of User fields between the two content channels, $N_{user}(r, 1)$ and $N_{user}(r, 2)$, is not specified and might be used to reduce any disparity in the number of User fields between content channels.

NOTE 2—If the number of users per RU is greater than one, then the users in the RU are multiplexed using MU-MIMO.

For a 996-tone RU, for each HE-SIG-B content channel, the first 8-bit RU Allocation subfield referring to the RU may use values in the range 208–215 ($11010y_2y_1y_0$ in binary representation) as in Table 27-26 (RU Allocation subfield) with $y_2y_1y_0$ indicating the number of User fields signaled in the corresponding content channel, while the second 8-bit RU Allocation subfield referring to the RU shall be set to 115 (01110011 in binary representation).

NOTE—Although there are two RU Allocation subfields per HE-SIG-B content channel for the users of a 996-tone RU, each user is described by only one User field, which is located in one HE-SIG-B content channel.

As defined in Table 27-24 (Common field) and Table 27-25 (RUs associated with each RU Allocation subfield for each HE-SIG-B content channel and PPDU bandwidth), the Center 26-tone RU field carries the same value in both HE-SIG-B content channels. The User field that corresponds to the center 26-tone RU is carried in HE-SIG-B content channel 1.

Table 27-25—RUs associated with each RU Allocation subfield for each HE-SIG-B content channel and PPDU bandwidth

PPDU bandwidth	RU Allocation subfield and Center 26-tone RU subfield (if present)	RUs in the subcarrier range, or overlapping with the subcarrier range if the RU is larger than a 242-tone RU
20 MHz	The RU Allocation subfield in a single HE-SIG-B content channel	[–122:122]
40 MHz	The RU Allocation subfield in HE-SIG-B content channel 1	[–244:–3]
	The RU Allocation subfield in HE-SIG-B content channel 2	[3:244]

Table 27-25—RUs associated with each RU Allocation subfield for each HE-SIG-B content channel and PPDU bandwidth *(continued)*

PPDU bandwidth	RU Allocation subfield and Center 26-tone RU subfield (if present)	RUs in the subcarrier range, or overlapping with the subcarrier range if the RU is larger than a 242-tone RU
80 MHz	The first RU Allocation subfield in HE-SIG-B content channel 1	[–500:–259]
	The first RU Allocation subfield in HE-SIG-B content channel 2	[–258:–17]
	Center 26-tone RU subfield in HE-SIG-B content channel 1 and 2	[–16:–4, 4:16]
	The second RU Allocation subfield in HE-SIG-B content channel 1	[17:258]
	The second RU Allocation subfield in HE-SIG-B content channel 2	[259:500]
160 MHz or 80+80 MHz	The first RU Allocation subfield in HE-SIG-B content channel 1	[–1012:–771]
	The first RU Allocation subfield in HE-SIG-B content channel 2	[–770:–529]
	Center 26-tone RU subfield for lower frequency 80 MHz in HE-SIG-B content channel 1	[–528:–516, –508:–496]
	The second RU Allocation subfield in HE-SIG-B content channel 1	[–495:–254]
	The second RU Allocation subfield in HE-SIG-B content channel 2	[–253:–12]
	The third RU Allocation subfield in HE-SIG-B content channel 1	[12:253]
	The third RU Allocation subfield in HE-SIG-B content channel 2	[254:495]
	Center 26-tone RU subfield for higher frequency 80 MHz in HE-SIG-B content channel 2	[496:508, 516:528]
	The fourth RU Allocation subfield in HE-SIG-B content channel 1	[529:770]
	The fourth RU Allocation subfield in HE-SIG-B content channel 2	[771:1012]

The mapping from the 8-bit RU Allocation subfield to the RU assignment and the number of User fields per RU contributed to the User Specific field in the same HE-SIG-B content channel as the RU Allocation subfield is defined in the Table 27-26 (RU Allocation subfield).

Table 27-26—RU Allocation subfield

<table>
<tr><th>RU Allocation subfield (B7 B6 B5 B4 B3 B2 B1 B0)</th><th>#1</th><th>#2</th><th>#3</th><th>#4</th><th>#5</th><th>#6</th><th>#7</th><th>#8</th><th>#9</th><th>Number of entries</th></tr>
<tr><td>0 (00000000)</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>1 (00000001)</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>2 (00000010)</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>3 (00000011)</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>4 (00000100)</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>5 (00000101)</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>6 (00000110)</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>7 (00000111)</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td colspan="2">52</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>8 (00001000)</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>9 (00001001)</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>10 (00001010)</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>11 (00001011)</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>12 (00001100)</td><td colspan="2">52</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>13 (00001101)</td><td colspan="2">52</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>14 (00001110)</td><td colspan="2">52</td><td colspan="2">52</td><td>26</td><td colspan="2">52</td><td>26</td><td>26</td><td>1</td></tr>
<tr><td>15 (00001111)</td><td colspan="2">52</td><td colspan="2">52</td><td>26</td><td colspan="2">52</td><td colspan="2">52</td><td>1</td></tr>
<tr><td>16-23 (00010$y_2y_1y_0$)</td><td colspan="2">52</td><td colspan="2">52</td><td>-</td><td colspan="4">106</td><td>8</td></tr>
<tr><td>24-31 (00011$y_2y_1y_0$)</td><td colspan="4">106</td><td>-</td><td colspan="2">52</td><td colspan="2">52</td><td>8</td></tr>
<tr><td>32-39 (00100$y_2y_1y_0$)</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td><td colspan="4">106</td><td>8</td></tr>
<tr><td>40-47 (00101$y_2y_1y_0$)</td><td>26</td><td>26</td><td colspan="2">52</td><td>26</td><td colspan="4">106</td><td>8</td></tr>
<tr><td>48-55 (00110$y_2y_1y_0$)</td><td colspan="2">52</td><td>26</td><td>26</td><td>26</td><td colspan="4">106</td><td>8</td></tr>
</table>

Table 27-26—RU Allocation subfield *(continued)*

RU Allocation subfield (B7 B6 B5 B4 B3 B2 B1 B0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
56-63 (00111$y_2y_1y_0$)	52		52		26	106				8
64-71 (01000$y_2y_1y_0$)	106				26	26	26	26	26	8
72-29 (01001$y_2y_1y_0$)	106				26	26	26	52		8
80-87 (01010$y_2y_1y_0$)	106				26	52		26	26	8
88-95 (01011$y_2y_1y_0$)	106				26	52		52		8
96-111 (0110$y_1y_0z_1z_0$)	106				-	106				16
112 (01110000)	52		52		-	52		52		1
113 (01110001)	242-tone RU empty (with zero users)									1
114 (01110010)	484-tone RU; contributes zero User fields to the User Specific field in the same HE-SIG-B content channel as this RU Allocation subfield									1
115 (01110011)	996-tone RU; contributes zero User fields to the User Specific field in the same HE-SIG-B content channel as this RU Allocation subfield									1
116-119 (011101x_1x_0)	Reserved									4
120-127 (01111$y_2y_1y_0$)	Reserved									8
128-191 (10$y_2y_1y_0z_2z_1z_0$)	106				26	106				64
192-199 (11000$y_2y_1y_0$)	242									8
200-207 (11001$y_2y_1y_0$)	484									8
208-215 (11010$y_2y_1y_0$)	996									8
216-223 (11011$y_2y_1y_0$)	Reserved									8
224-255 (111$x_4x_3x_2x_1x_0$)	Reserved									32

Table 27-26—RU Allocation subfield *(continued)*

RU Allocation subfield (B7 B6 B5 B4 B3 B2 B1 B0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
If signaling RUs of size greater than 242 subcarriers, $y_2y_1y_0$ = 000–111 indicates the number of User fields in the HE-SIG-B content channel that contains the corresponding 8-bit RU Allocation subfield. Otherwise, $y_2y_1y_0$ = 000–111 indicates the number of users multiplexed in the 106-tone RU, 242-tone RU or the lower frequency 106-tone RU if there are two 106-tone RUs and one 26-tone RU is assigned between two 106-tone RUs. The binary vector $y_2y_1y_0$ indicates $N_{user}(r, c) = 2^2 \times y_2 + 2^1 \times y_1 + y_0 + 1$ users multiplexed in the RU.										
$z_2z_1z_0$ = 000–111 indicates the number of users multiplexed in the higher frequency 106-tone RU if there are two 106-tone RUs and one 26-tone RU is assigned between two 106-tone RUs. The binary vector $z_2z_1z_0$ indicates $N_{user}(r, c) = 2^2 \times z_2 + 2^1 \times z_1 + z_0 + 1$ users multiplexed in the RU.										
Similarly, y_1y_0 = 00–11 indicates the number of users multiplexed in the lower frequency 106-tone RU. The binary vector y_1y_0 indicates $N_{user}(r, c) = 2^1 \times y_1 + y_0 + 1$ users multiplexed in the RU.										
Similarly, z_1z_0 = 00–11 indicates the number of users multiplexed in the higher frequency 106-tone RU. The binary vector z_1z_0 indicates $N_{user}(r, c) = 2^1 \times z_1 + z_0 + 1$ users multiplexed in the RU.										
#1 to #9 (from left to the right) is ordered in increasing order of the absolute frequency.										
x_1x_0 = 00-11, $x_4x_3x_2x_1x_0$ = 00000–11111.										
'-' means no user in that RU, i.e., $N_{user}(r, c) = 0$.										
For RU *r* that is a 106-tone or larger RU, $N_{user}(r, c)$ is indicated by the letters (such as $y_2y_1y_0$ or $z_2z_1z_0$) in the RU allocation subfield above if the letters are present in the RU allocation subfield; otherwise $N_{user}(r, c) = 0$.										
For RU *r* that is a 26-tone or 52-tone RU, $N_{user}(r, c) = 1$.										

If a single RU in a 40 MHz PPDU overlaps the subcarrier ranges [–244:–3] and [3:244], the corresponding RU Allocation subfields in the respective content channels shall both refer to the same RU.

If a single RU in an 80 MHz PPDU overlaps more than one of the subcarrier ranges [–500:–259], [–258:–17], [17:258] or [259:500], the corresponding RU Allocation subfields in the respective content channels shall all refer to the same RU.

If a single RU in a 160 MHz or 80+80 MHz PPDU overlaps more than one of the subcarrier ranges [–1012:–771], [–770:–529], [–495:–254], [–253:–12], [12:253], [254:495], [529:770] or [771:1012], the corresponding RU Allocation subfields in the respective content channels shall all refer to the same RU.

In Table 27-26 (RU Allocation subfield), the number of entries column refers to the number of RU Allocation subfield values that refer to the same RU assignment to be used in the frequency domain but differ in the number of User fields per RU. The number of User fields per RU indicated by the RU Allocation subfields and the Center 26-tone RU subfield of an HE-SIG-B content channel indicate the number of User fields in the User Specific field of the HE-SIG-B content channel.

For an MU-MIMO allocation of RU size greater than 242 subcarriers, the dynamic split of User fields between HE-SIG-B content channel 1 and HE-SIG-B content channel 2 is decided by the AP (on a per case basis) and signaled by the AP using the RU Allocation subfields in each HE-SIG-B content channel. See Annex Z for examples.

The pre-HE modulated fields (see Figure 27-23 (Timing boundaries for HE PPDU fields if midamble is not present)) are not transmitted in 20 MHz subchannels in which the preamble is punctured (see 27.3.7 (HE modulation and coding schemes (HE-MCSs))).

If the Bandwidth field in the HE-SIG-A field of an HE MU PPDU is 4, 5, 6 or 7, then one or more 20 MHz subchannels of the preamble are punctured, as defined in Table 27-20 (HE-SIG-A field of an HE MU PPDU). If two adjacent 20 MHz subchannels that comprise a 40 MHz subchannel in which a 484-tone RU is located are punctured, then B7–B0 of the RU Allocation subfields corresponding to the two 20 MHz subchannels shall both be set to 113 (242-tone RU is empty) or shall both be set to 114 (see Table 27-26 (RU Allocation subfield)) to indicate that the preamble is punctured in both the 20 MHz subchannels. Each punctured 20 MHz subchannel that does not have B7–B0 of its corresponding RU Allocation subfield set to 114 shall have B7–B0 of its RU Allocation subfield set to 113.

The center 26-tone RU in a preamble punctured 80 MHz, 160 MHz or 80+80 MHz HE MU PPDU shall not be allocated to a user if either of the two 20 MHz subchannels that the center 26-tone RU straddles have the preamble punctured.

27.3.11.8.4 User Specific field

The User Specific field of an HE-SIG-B content channel consists of zero or more User Block fields followed by padding (if present) as shown in Figure 27-26 (HE-SIG-B content channel format). Each non-final User Block field is made up of two User fields that contain information for two STAs that is used to decode their payloads. The final User Block field contains information for one or two users depending on the number of users in the HE-SIG-B content channel. If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 0, then the number of User fields is indicated by the RU Allocation subfields and the Center 26-tone RU subfield in the same HE-SIG-B content channel. If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1, then the number of users is indicated by the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field.

If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1 (indicating full bandwidth MU-MIMO transmission) and the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field of an HE MU PPDU is 0 (indicating 1 user), then the User Specific field in the HE-SIG-B field consists of a single User Block field containing one User field for a non-MU-MIMO allocation as shown in Table 27-28 (User field format for a non-MU-MIMO allocation).

The User Block field is defined in Table 27-27 (User Block field).

Table 27-27—User Block field

Field	Number of fields	Number of bits per field	Description
User field	*N*	21	*N* User fields are present, where: *N* = 1 if it is the final User Block field, and if there is only one user in the final User Block field. *N* = 2 otherwise. The User field format for a non-MU-MIMO allocation is defined in Table 27-28 (User field format for a non-MU-MIMO allocation). The User field format for a MU-MIMO allocation is defined in Table 27-29 (User field format for a MU-MIMO allocation).

Table 27-27—User Block field *(continued)*

Field	Number of fields	Number of bits per field	Description
CRC	1	4	The CRC is calculated over bits 0 to 20 for a User Block field that contains one User field, and bits 0 to 41 for a User Block field that contains two User fields. See 27.3.11.7.3 (CRC computation).
Tail	1	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 0, then for an MU-MIMO allocation of RU size greater than 242 subcarriers, the AP performs a dynamic split of the User fields between HE-SIG-B content channel 1 and HE-SIG-B content channel 2 as described in 27.3.11.8.3 (Common field).

If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1, for bandwidths larger than 20 MHz, the AP performs an equitable split of the User fields between two HE-SIG-B content channels, i.e., User field k of a K user MU-MIMO PPDU is carried in HE-SIG-B content channel c, where c is defined in Equation (27-20).

$$c = \begin{cases} 1, \text{ if } k \in 1, \ldots, \lceil K/2 \rceil \\ 2, \text{ if } (k \in \lceil K/2 \rceil + 1, \ldots, K) \end{cases} \tag{27-20}$$

Since a single STA is not required to decode the data for more than one user (see 26.5.1.2 (RU addressing in an HE MU PPDU)), the signaling that enables a STA to decode its data is carried in only one User field.

The ordering of User fields in the User Specific field in an HE-SIG-B content channel is determined using the following three step procedure:

1) If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1, this first step is bypassed. Otherwise, the User fields in the User Specific field of an HE-SIG-B content channel are grouped into sets of User fields, where each set comprises the User fields indicated by one RU Allocation subfield or the Center 26-tone RU. These sets shall be ordered as follows:

    a) If the Bandwidth field in HE-SIG-A is 0 or 1, then there is only one set, so the need for ordering in this first step does not arise

    b) If the Bandwidth field in HE-SIG-A is 2, 4 or 5, then the set of User fields indicated by the first RU Allocation subfield are followed by the set of the User fields indicated by the second RU Allocation subfield; in turn, if the center 26-tone RU is assigned, then its User field is appended as the last User field to HE-SIG-B content channel 1 only.

    c) If the Bandwidth field in HE-SIG-A is 3, 6 or 7, then the set of User fields indicated by the first RU Allocation subfield are followed by the set of the User fields indicated by the second RU Allocation subfield; in turn these are followed by the set of the User fields indicated by the third RU Allocation subfield and then by the set of the User fields indicated by the fourth RU Allocation subfield. If the center 26-tone RU that spans subcarriers [–528:–516, –508:–496] is assigned, then its User field is appended to HE-SIG-B content channel 1. If the center 26-tone RU that spans subcarriers [496:508, 516:528] is assigned, then its User field is appended as the last User field to HE-SIG-B content channel 2.

2) If the HE-SIG-B Compression field in the HE-SIG-A field of an HE MU PPDU is 1, then this second step is bypassed. Otherwise, each subset of User fields indicated by an RU Allocation subfield shall be ordered by increasing frequency of RU, i.e., #1–#9 in Table 27-26 (RU Allocation subfield).

3) Without regard to the value of HE-SIG-B Compression field, the ordering of User fields in the same RU shall follow the user ordering in Table 27-30 (Spatial Configuration subfield encoding).

In this way, RU Allocation subfields, Center 26-tone RU fields (if present), and the position of a user's User field in the User Specific field of an HE-SIG-B content channel indicate the user's RU assignment.

If the Bandwidth field in the HE-SIG-A field of an HE MU PPDU (see Table 27-20 (HE-SIG-A field of an HE MU PPDU)) is 4 or 5 (preamble is punctured), the content of the HE-SIG-B content channel 1 and 2 shall be constructed as described above for an 80 MHz PPDU without preamble puncturing.

If the Bandwidth field in the HE-SIG-A field of an HE MU PPDU is 6 or 7 (preamble is punctured), the content of the HE-SIG-B content channel 1 and 2 shall be constructed as described above for an 160 MHz PPDU without preamble puncturing.

An example for the mapping of the 8-bit RU Allocation subfield and the position of the User field to a user's data is illustrated in Figure 27-27 (An example of the mapping of the 8-bit RU Allocation subfield and the position of the User field to the user's assignment for one 20 MHz channel). The RU Allocation subfield indicates an arrangement of one 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 8 User fields in the 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.

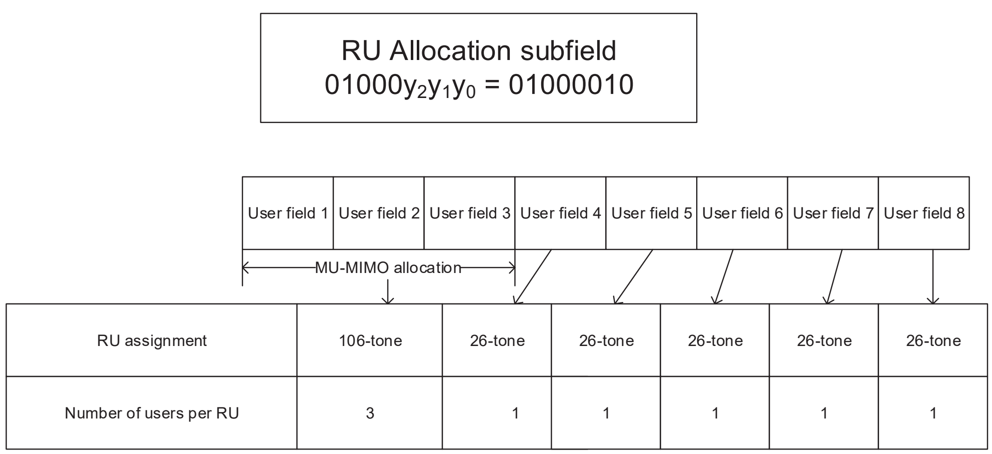

Figure 27-27—An example of the mapping of the 8-bit RU Allocation subfield and the position of the User field to the user's assignment for one 20 MHz channel

The contents of the User field differ depending on whether the field addresses a user in a non-MU-MIMO allocation in an RU or a user in an MU-MIMO allocation in an RU. Irrespective of whether the allocation is for a user in a non-MU-MIMO or an MU-MIMO allocation, the size of the User field is the same.

The User field format for a non-MU-MIMO allocation is defined in Table 27-28 (User field format for a non-MU-MIMO allocation).

Table 27-28—User field format for a non-MU-MIMO allocation

Bit	Subfield	Number of bits	Description
B0–B10	STA-ID	11	Set to a value of the TXVECTOR parameter STA_ID (see 26.11.1 (STA_ID)).
B11–B13	NSTS	3	If the STA-ID subfield is not 2046, indicates the number of space-time streams and is set to the number of space-time streams minus 1. Set to an arbitrary value if the STA-ID subfield is 2046.
B14	Beamformed	1	If the STA-ID subfield is not 2046, used in transmit beamforming: Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise. Set to an arbitrary value if the STA-ID subfield is 2046.
B15–B18	HE-MCS	4	If the STA-ID subfield is not 2046, indicates the modulation and coding scheme: Set to *n* for HE-MCS *n*, where *n* = 0, 1, 2, …, 11 Values 12-15 are reserved Set to an arbitrary value if the STA-ID subfield is 2046.
B19	DCM	1	If the STA-ID subfield is not 2046, indicates whether or not DCM is used: Set to 1 to indicate that the payload of the corresponding user of the HE MU PPDU is modulated with DCM for the HE-MCS. Set to 0 to indicate that the payload of the corresponding user of the PPDU is not modulated with DCM for the HE-MCS. Set to an arbitrary value if the STA-ID subfield is 2046.
B20	Coding	1	If the STA-ID subfield is not 2046, indicates whether BCC or LDPC is used: Set to 0 for BCC Set to 1 for LDPC Set to an arbitrary value if the STA-ID subfield is 2046.

The User field format for an MU-MIMO allocation is defined in Table 27-29 (User field format for a MU-MIMO allocation).

Table 27-29—User field format for a MU-MIMO allocation

Bit	Subfield	Number of bits	Description
B0–B10	STA-ID	11	Set to a value indicated from TXVECTOR parameter STA_ID (see 26.11.1 (STA_ID)).
B11–B14	Spatial Configuration	4	Indicates the number of spatial streams for a user in an MU-MIMO allocation (see Table 27-30 (Spatial Configuration subfield encoding)).
B15–B18	HE-MCS	4	Modulation and coding scheme. Set to n for HE-MCS n, where $n = 0, 1, 2,\ldots, 11$ Values 12-15 are reserved
B19	Reserved	1	Reserved and set to 0
B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—If the STA-ID subfield is 2046, then the other subfields can be set to arbitrary values.			

A User field for an MU-MIMO allocation includes a 4-bit Spatial Configuration subfield that indicates the number of spatial streams for each user and the total number of spatial streams in the MU-MIMO allocation. The subfield shown in Table 27-30 (Spatial Configuration subfield encoding) is constructed by using the entries corresponding to the value of number of users (N_{user}) multiplexed using MU-MIMO in an RU.

If the HE-SIG-B Compression field in the HE-SIG-A field is 0 and MU-MIMO is used in an RU of size less than or equal to 242 subcarriers, the number of users (N_{user}) in an MU-MIMO allocation is equal to the number of User fields per RU signaled for the RU in the associated RU Allocation subfield of the Common field in the same HE-SIG-B content channel.

If the HE-SIG-B Compression field in the HE-SIG-A field is 0 and MU-MIMO is used in RUs of size greater than 242 subcarriers, the AP performs a dynamic split of the User fields corresponding to the same MU-MIMO allocations as described in 27.3.11.8.3 (Common field) into two HE-SIG-B content channels and the number of users (N_{user}) is computed as the sum of the number of User fields indicated for the RU by the 8-bit RU Allocation subfield in each HE-SIG-B content channel.

If the HE-SIG-B Compression field in the HE-SIG-A field is 1, then the number of users, N_{user}, is signaled by the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field and the AP performs an equitable split of the User fields following Equation (27-20).

The User field positions within an RU are defined to be logically continuous: the last User field corresponding to an RU in HE-SIG-B content channel 1 is immediately followed by the first User field corresponding to the same RU in HE-SIG-B content channel 2.

For a given value of N_{user}, the four bits of the Spatial Configuration subfield are used as follows: A STA with a STA-ID that matches the 11-bit ID signaled in the User field for an MU-MIMO allocation derives the number of spatial streams allocated to it using the row corresponding to the signaled 4-bit Spatial Configuration subfield and the column corresponding to the User field position in the User Specific field. The starting stream index for the user is computed by summing the N_{STS} in the columns prior to the column indicated by the user's User field position.

Table 27-30—Spatial Configuration subfield encoding

N_{user}	B3…B0	N_{STS} [1]	N_{STS} [2]	N_{STS} [3]	N_{STS} [4]	N_{STS} [5]	N_{STS} [6]	N_{STS} [7]	N_{STS} [8]	Total N_{STS}	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	7
	0100–0101	2–3	2	1	1	1				7–8	
	0110	2	2	2	1	1				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

The user ordering identified by the column headers $N_{STS}[s]$, $s = 1, 2, 3, \ldots$ in Table 27-30 (Spatial Configuration subfield encoding) shall be the same as the user index u, $u = 0, 1, 2, \ldots$ in Equation (27-38), Equation (27-59) and Equation (27-108), i.e., $u = s - 1$.

The total number of spatial streams (total N_{STS}) is computed by summing all columns for the row signaled by the Spatial Configuration field and is indicated in Table 27-30 (Spatial Configuration subfield encoding) under the column Total N_{STS}.

27.3.11.8.5 Encoding and modulation

The bits in the Common field of each HE-SIG-B content channel shall be BCC encoded at rate $R = 1/2$.

In the User Specific field, each User Block field of each HE-SIG-B content channel shall be BCC encoded at rate $R = 1/2$. If the number of User fields in an HE-SIG-B content channel is odd, CRC and tail bits are added after the last User field, which is not grouped. Padding bits are appended immediately after the tail bits corresponding to the final User Block field in each HE-SIG-B content channel to round up to the next multiple of number of data bits per HE-SIG-B OFDM symbol. The padding bits may be set to any value. Further padding bits are appended to each HE-SIG-B content channel so that the number of OFDM symbols after encoding and modulation in different 20 MHz bands ends at the same OFDM symbol. For both the Common field and User Block field, the information bits, tail bits and padding bits (if present) are BCC encoded at rate $R = 1/2$ using the encoder described in 17.3.5.6 (Convolutional encoder). If the coding rate of the HE-SIG-B-MCS is not equal to 1/2, the convolutional encoder output bits for each field are concatenated, then the concatenated bit streams are punctured as described in 17.3.5.6 (Convolutional encoder).

The coded bits are interleaved as in 27.3.12.8 (BCC interleavers). The interleaved bits are mapped to constellation points from the HE-SIG-B-MCS specified in HE-SIG-A and have pilots inserted following the steps described in 17.3.5.8 (Subcarrier modulation mapping) and 17.3.5.9 (Pilot subcarriers), respectively. Each HE-SIG-B OFDM symbol shall have 52 data tones.

The guard interval used for HE-SIG-B shall be 0.8 µs.

The number of OFDM symbols in the HE-SIG-B field, denoted by $N_{SYM,\text{HE-SIG-B}}$, shall be signaled by the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field of an HE MU PPDU (see 27.3.11.7.2 (Content)).

For the HE-SIG-B content channel c ($c = 1$ or 2), denote the complex number assigned to the k-th data subcarrier of the n-th symbol by $d_{k,n,c}$. The time domain waveform for the HE-SIG-B field, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, is given by Equation (27-21).

$$
\begin{aligned}
r_{\text{HE-SIG-B}}^{(i_{Seg},\, i_{TX})}(t) = {} & \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-B}}^{\text{Tone}}}} \sum_{n=0}^{N_{SYM,\,\text{HE-SIG\_B}}-1} w_{T_{\text{HE-SIG-B}}}(t - nT_{SYML}) \\
& \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}} \left(\Gamma_{M_{20}^r(k)} D_{k,\,n,\,i_{BW}}^{i_{Seg}} + p_{n+4} P_k \right) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right)
\end{aligned}
\tag{27-21}
$$

where

$\Gamma_{M_{20}^r(k)}$ is the phase rotation value for HE-SIG-B field PAPR reduction. If the HE-SIG-B field is modulated with HE-SIG-B-MCS 0 and DCM=1, $\Gamma_{M_{20}^r(k)} = 1$. For all other modulation schemes of HE-SIG-B field,

$$\Gamma_{M^r_{20}(k)} = \begin{cases} 1 & 0 \le M^r_{20}(k) < 26 \\ (-1)^{M^r_{20}(k)} & 26 \le M^r_{20}(k) < 52 \end{cases}$$

$N^{Tone}_{\text{HE-SIG-B}}$ is given in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$K_{\text{Shift}}(i)$ is defined in 21.3.8.2.4 (L-SIG definition)

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

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

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)

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

From Equation (27-21) and 27.3.11.8.2 (HE-SIG-B content channels), a 20 MHz PPDU contains one HE-SIG-B content channel as shown in Figure 27-28 (HE-SIG-B content channel for a 20 MHz PPDU).

Figure 27-28—HE-SIG-B content channel for a 20 MHz PPDU

From Equation (27-21) and 27.3.11.8.2 (HE-SIG-B content channels), a 40 MHz PPDU contains two HE-SIG-B content channels, each occupying a 20 MHz frequency segment as shown in Figure 27-29 (HE-SIG-B content channel for a 40 MHz PPDU). HE-SIG-B content channel 1 occupies the 20 MHz frequency segment that is lower in frequency. HE-SIG-B content channel 2 occupies the 20 MHz frequency segment that is upper in frequency.

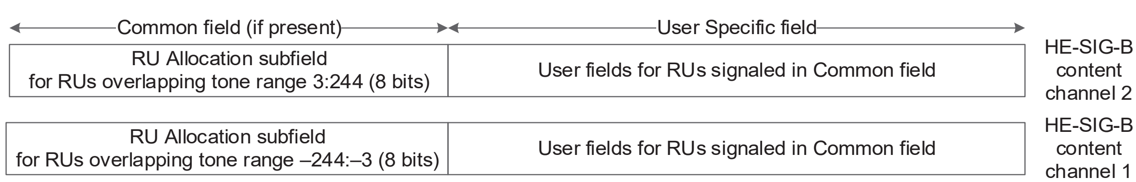

Figure 27-29—HE-SIG-B content channel for a 40 MHz PPDU

From Equation (27-21) and 27.3.11.8.2 (HE-SIG-B content channels), an 80 MHz PPDU contains two HE-SIG-B content channels each of which are duplicated once as shown in Figure 27-30 (HE-SIG-B content channels and their duplication in an 80 MHz PPDU). HE-SIG-B content channel 1 occupies the 20 MHz frequency segment that is lowest in frequency and is duplicated on the 20 MHz frequency segment that is third lowest in frequency. HE-SIG-B content channel 2 occupies the 20 MHz frequency segment that is second lowest in frequency and is duplicated on the 20 MHz frequency segment that is fourth lowest in frequency.

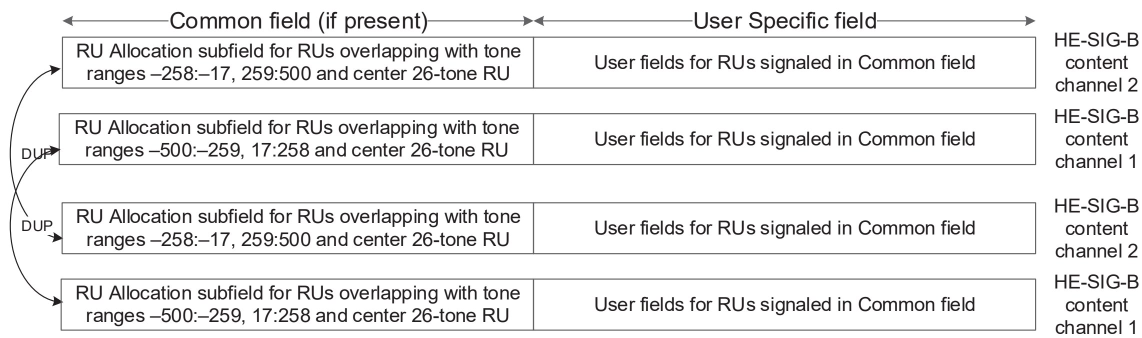

Figure 27-30—HE-SIG-B content channels and their duplication in an 80 MHz PPDU

From Equation (27-21) and 27.3.11.8.2 (HE-SIG-B content channels), a 160 MHz PPDU contains two HE-SIG-B content channels each of which are duplicated four times as shown in Figure 27-31 (HE-SIG-B content channels and their duplication in a 160 MHz PPDU). HE-SIG-B content channel 1 occupies the 20 MHz frequency segment that is lowest in frequency and is duplicated on the 20 MHz frequency segments that are third, fifth and seventh lowest in frequency. HE-SIG-B content channel 2 occupies the 20 MHz frequency segment that is second lowest in frequency and is duplicated on the 20 MHz frequency segments that are fourth, sixth and eighth lowest in frequency.

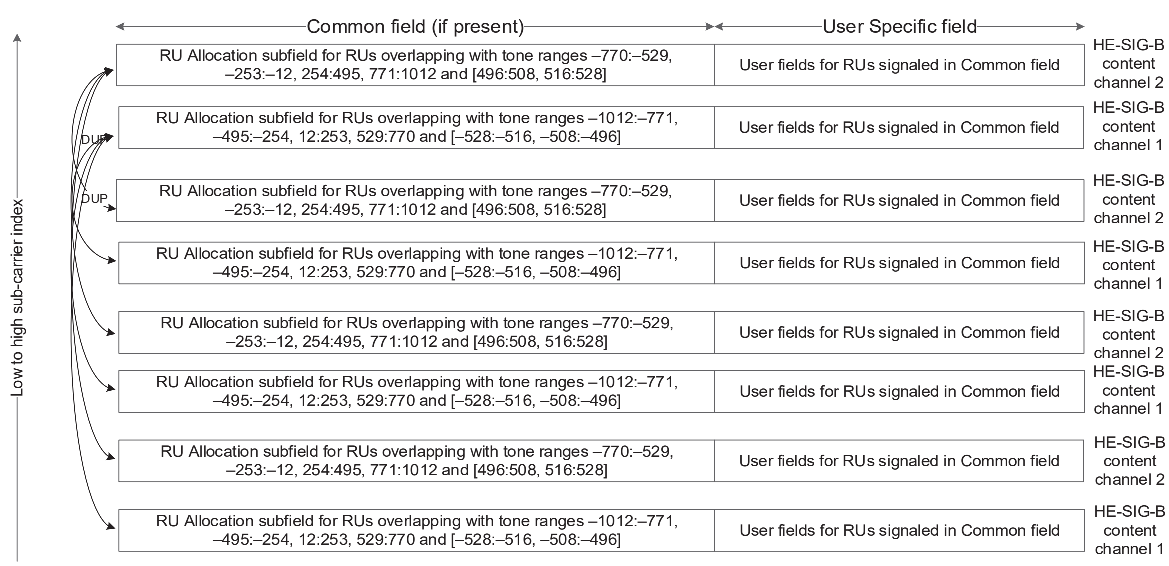

Figure 27-31—HE-SIG-B content channels and their duplication in a 160 MHz PPDU

If the Bandwidth field in the HE-SIG-A field of an HE MU PPDU (see Table 27-20 (HE-SIG-A field of an HE MU PPDU)) is 4 or 5 (preamble is punctured), the mapping of the HE-SIG-B content channels to 20 MHz segments shall be the same as for an 80 MHz PPDU (see Figure 27-30 (HE-SIG-B content channels and their duplication in an 80 MHz PPDU)), with the exception that punctured 20 MHz channels shall be excluded.

If the Bandwidth field in the HE-SIG-A field of an HE MU PPDU (see Table 27-20 (HE-SIG-A field of an HE MU PPDU)) is 6 or 7 (preamble is punctured), the mapping of the HE-SIG-B content channels to 20 MHz segments shall be the same as for an 160 MHz PPDU (see Figure 27-31 (HE-SIG-B content channels and their duplication in a 160 MHz PPDU)), with the exception that punctured 20 MHz channels shall be excluded.

27.3.11.9 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 that are not HE TB PPDUs is $T_{\text{HE-STF-NT}}$ (periodicity of 0.8 µs with 5 periods as given in Table 27-12 (Timing-related constants)) and the duration of the HE-STF field for an HE TB PPDU is $T_{\text{HE-STF-T}}$ (periodicity of 1.6 µs with 5 periods as given in Table 27-12 (Timing-related constants)).

For the HE-STF field, the M sequence is defined by Equation (27-22).

$$M = \{-1, -1, -1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, -1, 1\} \tag{27-22}$$

The HE-STF field is constructed by mapping the M sequence(s) multiplied by $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ to each 242-tone RU. For a transmission bandwidth greater than 40 MHz, $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ is assigned to subcarrier indices that are inside the center 26-tone RUs.

For a 20 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (27-23).

$$HES_{-112:16:112} = \{M\} \cdot (1+j)/\sqrt{2} \tag{27-23}$$
The value of the HE-STF sequence at null tone index 0 is $HES_0 = 0$

where $HES_{a:b:c}$ means coefficients of the HE-STF on every b subcarrier indices from a to c subcarrier indices and coefficients on other subcarrier indices are set to zero.

For a 40 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (27-24).

$$HES_{-240:16:240} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \tag{27-24}$$

For an 80 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (27-25).

$$HES_{-496:16:496} = \{M, 1, -M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \tag{27-25}$$

For a 160 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (27-26).

$$HES_{-1008:16:1008} = \{M, 1, -M, 0, -M, 1, -M, 0, -M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \tag{27-26}$$

For an 80+80 MHz transmission, the lower 80 MHz segment for HE PPDUs that are not HE TB PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (27-25).

For an 80+80 MHz transmission, the frequency domain sequence of the upper 80 MHz segment for HE PPDUs that are not HE TB PPDUs is given by Equation (27-27).

$$HES_{-496:16:496} = \{-M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (27\text{-}27)$$

For a 20 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (27-28).

$$HES_{-120:8:120} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \quad (27\text{-}28)$$

For an HE TB feedback NDP in 20 MHz channel width, the frequency domain sequence is given by Equation (27-29).

$$HES^{\text{TB NDP}}_{-120:8:120} = HES_{-120:8:120} \quad (27\text{-}29)$$

For a 40 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (27-30).

$$\begin{aligned} &HES_{-248:8:248} = \{M, -1, -M, 0, M, -1, M\} \cdot (1+j)/\sqrt{2} \\ &\text{The value of the HE-STF sequence at edge tone indices } \pm 248 \text{ is } HES_{\pm 248} = 0 \end{aligned} \quad (27\text{-}30)$$

For an HE TB feedback NDP in 40 MHz channel width, the frequency domain sequence is given by Equation (27-31).

$$\begin{aligned} &HES^{\text{TB NDP}}_{-248:8:-8} = \{M, -1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if RU\_TONE\_SET\_INDEX} \le 18 \\ &HES^{\text{TB NDP}}_{8:8:248} = \{M, -1, M\} \cdot (1+j)/\sqrt{2}, \text{ if RU\_TONE\_SET\_INDEX} > 18 \\ &HES^{\text{TB NDP}}_{\pm 248} = 0 \end{aligned} \quad (27\text{-}31)$$

For an 80 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (27-32).

$$\begin{aligned} &HES_{-504:8:504} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \\ &\text{The value of the HE-STF sequence at edge tone indices } \pm 504 \text{ is } HES_{\pm 504} = 0 \end{aligned} \quad (27\text{-}32)$$

For an HE TB feedback NDP in 80 MHz channel width, the frequency domain sequence is given by Equation (27-33).

$$\begin{aligned} &HES^{\text{TB NDP}}_{-504:8:-264} = \{M, -1, M\} \cdot (1+j)/\sqrt{2}, \text{ if RU\_TONE\_SET\_INDEX} \le 18 \\ &HES^{\text{TB NDP}}_{-248:8:-8} = \{-M, -1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 18 < \text{RU\_TONE\_SET\_INDEX} \le 36 \\ &HES^{\text{TB NDP}}_{8:8:248} = \{-M, 1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 36 < \text{RU\_TONE\_SET\_INDEX} \le 54 \\ &HES^{\text{TB NDP}}_{264:8:504} = \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 54 < \text{RU\_TONE\_SET\_INDEX} \le 72 \\ &HES^{\text{TB NDP}}_{\pm 504} = 0 \end{aligned} \quad (27\text{-}33)$$

For a 160 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (27-34).

$$HES_{-1016:8:1016} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M, 0$$
$$-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (27\text{-}34)$$

The value of the HE-STF sequence at edge tone indices ±8 and ±1016 is $HES_{\pm 8} = 0$, $HES_{\pm 1016} = 0$

For an HE TB feedback NDP in 160 MHz channel width, the frequency domain sequence is given by Equation (27-35).

$$\begin{aligned}
HES^{\mathrm{TB\ NDP}}_{-1016:8:-776} &= \{M, -1, M\} \cdot (1+j)/\sqrt{2}, \text{ if RU_TONE_SET_INDEX} \le 18 \\
HES^{\mathrm{TB\ NDP}}_{-760:8:-520} &= \{-M, -1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 18 < \text{RU_TONE_SET_INDEX} \le 36 \\
HES^{\mathrm{TB\ NDP}}_{-504:8:-264} &= \{-M, 1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 36 < \text{RU_TONE_SET_INDEX} \le 54 \\
HES^{\mathrm{TB\ NDP}}_{-248:8:-8} &= \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 54 < \text{RU_TONE_SET_INDEX} \le 72 \\
HES^{\mathrm{TB\ NDP}}_{8:8:248} &= \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 72 < \text{RU_TONE_SET_INDEX} \le 90 \\
HES^{\mathrm{TB\ NDP}}_{264:8:504} &= \{M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 90 < \text{RU_TONE_SET_INDEX} \le 108 \\
HES^{\mathrm{TB\ NDP}}_{520:8:760} &= \{-M, 1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 108 < \text{RU_TONE_SET_INDEX} \le 126 \\
HES^{\mathrm{TB\ NDP}}_{776:8:1016} &= \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 126 < \text{RU_TONE_SET_INDEX} \le 144 \\
HES^{\mathrm{TB\ NDP}}_{\pm 8} &= HES^{\mathrm{TB\ NDP}}_{\pm 1016} = 0
\end{aligned} \quad (27\text{-}35)$$

For an 80+80 MHz transmission, the lower 80 MHz segment for HE TB PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (27-32).

For an 80+80 MHz transmission, the frequency domain sequence of the upper 80 MHz segment for HE TB PPDUs is given by Equation (27-36).

$$HES_{-504:8:504} = \{-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (27\text{-}36)$$

The value of the HE-STF sequence at edge tone indices ±504 is $HES_{\pm 504} = 0$

For an HE TB feedback NDP in the lower 80 MHz segment of an 80+80 MHz channel width, the frequency domain sequence is given by Equation (27-33).

For an HE TB feedback NDP in the upper 80 MHz segment of an 80+80 MHz channel width, the frequency domain sequence is given by Equation (27-37).

$$\begin{aligned}
HES^{\mathrm{TB\ NDP}}_{-504:8:-264} &= \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if RU_TONE_SET_INDEX} \le 90 \\
HES^{\mathrm{TB\ NDP}}_{-248:8:-8} &= \{M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 90 < \text{RU_TONE_SET_INDEX} \le 108 \\
HES^{\mathrm{TB\ NDP}}_{8:8:248} &= \{-M, 1, M\} \cdot (1+j)/\sqrt{2}, \text{ if } 108 < \text{RU_TONE_SET_INDEX} \le 126 \\
HES^{\mathrm{TB\ NDP}}_{264:8:504} &= \{-M, 1, -M\} \cdot (1+j)/\sqrt{2}, \text{ if } 126 < \text{RU_TONE_SET_INDEX} \le 144 \\
HES^{\mathrm{TB\ NDP}}_{\pm 504} &= 0
\end{aligned} \quad (27\text{-}37)$$

If a 20 MHz operating non-AP STA sends an HE TB feedback NDP report response (see 26.5.7 (NDP feedback report procedure)) on a channel width greater than 20 MHz, the HE-STF subcarrier that overlaps the DC subcarrier of the 20 MHz operating non-AP STA is not transmitted.

For an OFDMA transmission, the coefficients in Equation (27-23) to Equation (27-36) are set to zero if those values are corresponding to subcarrier indices that fall within RUs that have no users assigned to them.

The time domain representation of the signal for an HE PPDU that is not an HE TB PPDU on frequency segment i_{Seg} and transmit chain i_{TX} shall be as specified in Equation (27-38).

$$r_{\text{HE-STF}}^{(i_{Seg},\, i_{TX})}(t) = w_{T_{\text{HE-STF-NT}}}(t) \cdot \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{STS,\,r,\,total}}} \sum_{k \in K_r} \eta_{\text{HE-STF},\,k} \sum_{u=0}^{N_{user,\,r}-1} \sum_{m=1}^{N_{STS,\,r,\,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX},\, M_{r,\,u}+m} HES_k \cdot \exp(j2\pi k \Delta_{F,\,\text{HE}}(t - T_{CS,\,HE}(M_{r,\,u}+m))) \right) \tag{27-38}$$

where

α_r is defined in 27.3.10 (Mathematical description of signals)

$\eta_{\text{HE-STF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-STF},\,k} = \begin{cases} \sqrt{2}, & \text{for an HE ER SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

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

$$\beta_r = \left(\sqrt{\frac{|K_r|}{\left|K_r^{\text{HE-STF}}\right|}} \right) \Big/ \left(\sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|} \right)$$

$|K_r|$ is the cardinality of the set of subcarriers K_r, as defined in 27.3.10 (Mathematical description of signals)

$K_r^{\text{HE-STF}}$ is the set of subcarriers that have nonzero values within K_r in the HE-STF field

$T_{CS,\,\text{HE}}(M_{r,\,u}+m)$ represents the cyclic shift for space-time stream $M_{r,u}+m$ as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals)

$w_{T_{\text{HE-STF-NT}}}$ is the windowing function for HE-STF field in the non-HE TB PPDU

$\left|K_r^{\text{HE-STF}}\right|$ is the cardinality of the set of subcarriers $K_r^{\text{HE-STF}}$

N_{RU}, $N_{STS,r,total}$, $N_{user,r}$, and $N_{STS,r,u}$ are defined in 27-15 (Frequently used parameters)

The time domain representation of the signal for an HE TB PPDU transmitted by user u in the r-th RU on frequency segment i_{Seg} and transmit chain i_{TX} shall be as specified in Equation (27-39).

$$r_{\text{HE-STF},\,r,\,u}^{(i_{Seg},\, i_{TX})}(t) = \frac{1}{\sqrt{\left|K_r^{\text{HE-STF}}\right| N_{STS,\,r,\,total}}} w_{T_{\text{HE-STF-T}}}(t) \sum_{k \in K_r} \sum_{m=1}^{N_{STS,\,r,\,u}} \left(\left[Q_{k,\,u}^{(i_{Seg})} \right]_{i_{TX},\, m} HES_k \cdot \exp(j2\pi k \Delta_{F,\,\text{HE}}(t - T_{CS,\,HE}(M_{r,\,u}+m))) \right) \tag{27-39}$$

where

$w_{T_{\text{HE-STF-T}}}$ is the windowing function for HE-STF field in the HE TB PPDU

$Q_{k,\,u}^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals)

It is recommended that the spatial mapping matrix applied to HE-STF and beyond is chosen such that it preserves the smoothness of the physical channel, achieved by limiting the variation of each element's real and imaginary values in the spatial mapping matrix across successive tones within one RU.

27.3.11.10 HE-LTF

The 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 and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB 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 subcarrier in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. When single stream pilot is used in HE-LTF, the pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a matrix $R_{\text{HE-LTF}}$ defined below to allow receivers to track phase and/or frequency offset during MIMO channel estimation using the HE-LTF. Single stream pilots shall be used in the HE-LTF field for SU, DL and UL OFDMA, DL MU-MIMO and partial bandwidth UL MU-MIMO transmissions. Single stream pilots shall be used in the HE-LTF field for a full bandwidth UL MU-MIMO transmission if single stream pilot HE-LTF mode is selected.

In an HE SU PPDU, HE ER SU PPDU and HE MU PPDU with a single RU (the RU having an MU-MIMO allocation or an SU allocation), the number of HE-LTF symbols, $N_{\text{HE-LTF}}$, is a function of the total number of space-time streams N_{STS} as shown in Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition), replacing $N_{VHT\text{-}LTF}$ by $N_{HE\text{-}LTF}$ and replacing $N_{STS,total}$ by N_{STS}. In an HE TB PPDU, $N_{\text{HE-LTF}}$ is indicated in the Trigger frame that triggers the transmission of the PPDU. In an HE MU PPDU, $N_{\text{HE-LTF}}$ is indicated in the HE-SIG-A field. In an HE MU PPDU with more than one RU and in an HE TB PPDU, $N_{\text{HE-LTF}}$ may take a value 1, 2, 4, 6 or 8 that is greater than or equal to the maximum value of the initial number of HE-LTF symbols for each RU, where the initial number of HE-LTF symbols is calculated as a function of $N_{STS,r,total}$ (where r is the index of the RU) based on Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition) with $N_{VHT\text{-}LTF}$ replaced by $N_{HE\text{-}LTF}$.

In a non-OFDMA HE TB 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 Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition), replacing $N_{VHT\text{-}LTF}$ by $N_{HE\text{-}LTF}$. For an OFDMA HE TB PPDU $N_{HE\text{-}LTF}$ may be 1, 2, 4, 6 or 8, which is greater than or equal to the maximum value of the initial number of HE-LTF symbols for each RU r, which is calculated as a function of $N_{STS,r,total}$, separately based on Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition), replacing $N_{VHT\text{-}LTF}$ by $N_{HE\text{-}LTF}$.

An HE PPDU supports 3 HE-LTF types: 1x HE-LTF, 2x HE-LTF and 4x HE-LTF. Table 27-31 (HE-LTF type and GI duration combinations for various HE PPDU formats) defines whether a particular HE-LTF type and GI duration combination is mandatory, conditional mandatory or optional for each HE PPDU format.

Table 27-31—HE-LTF type and GI duration combinations for various HE PPDU formats

HE-LTF type and GI duration combination	HE SU PPDU	HE MU PPDU	HE ER SU PPDU	HE TB PPDU	HE sounding NDP	HE TB feedback NDP
1x HE-LTF 0.8 µs GI	O	N/A	O	N/A	N/A	N/A
1x HE-LTF 1.6 µs GI	N/A	N/A	N/A	CM3	N/A	N/A
2x HE-LTF 0.8 µs GI	M	M	M	N/A	M	N/A
2x HE-LTF 1.6 µs GI	M	M	M	M	M	N/A
4x HE-LTF 0.8 µs GI	CM1	CM2	O	N/A	N/A	N/A
4x HE-LTF 3.2 µs GI	M	M	M	M	O	M

M = mandatory
CM1 = Mandatory if the STA supports 4x HE-LTF 0.8 µs GI for HE ER SU PPDU. Otherwise, optional.
CM2 = For an AP, mandatory for transmission if the AP supports 4x HE-LTF 0.8 µs GI for HE ER SU PPDU. For a non-AP STA, mandatory for reception if the non-AP STA supports 4x HE-LTF 0.8 µs GI for HE ER SU PPDU. Otherwise, optional.
CM3 = Mandatory for full bandwidth UL MU-MIMO if the STA supports UL MU-MIMO. Otherwise, not supported. N/A for partial bandwidth UL MU-MIMO or UL OFDMA.
O = optional
N/A = not supported by the PPDU format

If a STA does not support transmission or reception of a particular PPDU format, then the M/CM/O designation is not applicable for the transmission or reception, respectively, of that PPDU format.

In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.19 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.18 (HE TB feedback NDP).

The duration of each HE-LTF symbol excluding GI is $T_{\text{HE-LTF}}$, defined in Equation (27-40).

$$T_{\text{HE-LTF}} = \begin{cases} T_{\text{HE-LTF-1X}}, \text{ if 1x HE-LTF} \\ T_{\text{HE-LTF-2X}}, \text{ if 2x HE-LTF} \\ T_{\text{HE-LTF-4X}}, \text{ if 4x HE-LTF} \end{cases} \tag{27-40}$$

where $T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$, $T_{\text{HE-LTF-4X}}$ are defined in Table 27-12 (Timing-related constants).

In a 20 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-41).

$$
\begin{array}{l}
HELTF_{-122,122} = \\
\quad \{0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, \\
\quad 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\
\quad 1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\
\quad -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, \\
\quad -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
\quad 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, \\
\quad 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, \\
\quad 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0\}
\end{array}
\tag{27-41}
$$

In a 20 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-42).

$$
\begin{array}{l}
HELTF_{-122,122} = \\
\quad \{-1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, \\
\quad -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, \\
\quad -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
\quad +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, \\
\quad +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, 0, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, \\
\quad +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, \\
\quad +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, \\
\quad -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, \\
\quad -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1\}
\end{array}
\tag{27-42}
$$

In a 20 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-43).

$$
\begin{array}{l}
HELTF_{-122,122} = \\
\quad \{-1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, \\
\quad -1, -1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, -1, +1, -1, -1, +1, +1, -1, +1, +1, +1, \\
\quad +1, -1, -1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, \\
\quad -1, +1, -1, -1, -1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, - \\
\quad 1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1, -1, - \\
\quad 1, +1, -1, +1, +1, +1, 0, 0, 0, -1, +1, -1, +1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, - \\
\quad 1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, - \\
\quad 1, -1, -1, -1, -1, +1, -1, +1, -1, -1, -1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, -1, +1, \\
\quad +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, \\
\quad -1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, \\
\quad -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1\}
\end{array}
\tag{27-43}
$$

In a 40 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-44).

$$
\begin{aligned}
&HELTF_{-244,244} = \\
&\quad \{+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&\quad 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, \\
&\quad 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&\quad 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\
&\quad 1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, \\
&\quad -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, \\
&\quad 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, \\
&\quad 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, +1, 0, \\
&\quad 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, \\
&\quad 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, - \\
&\quad 1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\
&\quad -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&\quad 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&\quad 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, \\
&\quad 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\
&\quad +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1\}
\end{aligned}
\tag{27-44}
$$

In a 40 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-45).

$$
\begin{aligned}
&HELTF_{-244,244} = \\
&\quad \{+1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, \\
&\quad -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
&\quad -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, \\
&\quad +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
&\quad +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, \\
&\quad +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, \\
&\quad +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, \\
&\quad -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, \\
&\quad +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, 0, 0, 0, 0, 0, -1, 0, -1, 0, -1, \\
&\quad 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, \\
&\quad 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, \\
&\quad 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, \\
&\quad 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, \\
&\quad 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&\quad 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, \\
&\quad 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, \\
&\quad 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, \\
&\quad 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1\}
\end{aligned}
\tag{27-45}
$$

In a 40 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-46).

$$
\begin{array}{l}
HELTF_{-244,244} = \\
\{+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, \\
+1, -1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, +1, -1, +1, \\
+1, +1, -1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, \\
-1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, \\
-1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, \\
-1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, -1, - \\
1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, - \\
1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, \\
+1, +1, +1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, \\
-1, -1, -1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1, \\
+1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, 0, 0, 0, 0, 0, -1, +1, +1, +1, +1, -1, +1, +1, \\
-1, -1, +1, -1, +1, -1, +1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, +1, \\
-1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, \\
+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, \\
+1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, \\
-1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, \\
+1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, - \\
1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, \\
+1, -1, +1, -1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, -1, \\
-1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, \\
+1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, \\
-1, -1, -1, -1\}
\end{array}
\tag{27-46}
$$

In an 80 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (27-47).

$$
\begin{aligned}
&HELTF_{-500,500} = \\
&\{-1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, - \\
&1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, \\
&0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, \\
&0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\
&1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, \\
&0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, \\
&0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, - \\
&1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, \\
&-1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, \\
&0, 0, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, \\
&0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, \\
&0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, \\
&0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, \\
&0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, \\
&+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\
&0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, \\
&0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, \\
&0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, \\
&0, 0, 0, +1\}
\end{aligned}
\qquad (27\text{-}47)
$$

In an 80 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (27-48).

$$
\begin{aligned}
& HELTF_{-500,500} = \\
& \{+1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, \\
& 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, \\
& 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, \\
& 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, \\
& 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, \\
& 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, \\
& 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, \\
& 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, \\
& 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\
& 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, \\
& 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, \\
& 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, \\
& 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, \\
& 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, \\
& 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\
& 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, \\
& 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, \\
& 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, \\
& +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, \\
& -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, \\
& +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
& +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, \\
& +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, \\
& +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, \\
& +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, \\
& +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, \\
& -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
& +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, \\
& -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, \\
& +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, \\
& -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, \\
& -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
& -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, \\
& -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, \\
& -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, \\
& +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1\}
\end{aligned}
\tag{27-48}
$$

In an 80 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (27-49).

$$
\begin{array}{l}
HELTF_{-500,500} = \\
\{+1, +1, -1, +1, -1, +1, -1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -1, \\
+1, +1, +1, +1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, \\
+1, +1, +1, -1, -1, -1, -1, -1, -1, +1, +1, +1, +1, +1, +1, -1, +1, +1, +1, -1, +1, +1, -1, \\
-1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, -1, \\
+1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, +1, +1, +1, +1, -1, -1, +1, \\
+1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, \\
+1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, \\
+1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, \\
+1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, \\
+1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, \\
-1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, \\
+1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, \\
+1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, -1, -1, -1, \\
-1, -1, -1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, \\
+1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1, \\
+1, -1, +1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, \\
-1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, \\
+1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, \\
+1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, -1, \\
+1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, \\
+1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, \\
-1, -1, +1, -1, +1, -1, -1, -1, -1, +1, +1, +1, -1, -1, +1, 0, 0, 0, 0, 0, +1, -1, -1, -1, -1, \\
-1, -1, +1, -1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, -1, -1, \\
+1, +1, -1, +1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1, +1, -1, \\
+1, +1, +1, -1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, -1, -1, -1, +1, \\
+1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, \\
-1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, \\
-1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, +1, -1, \\
-1, +1, -1, +1, +1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, \\
-1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, \\
+1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, -1, +1, +1, -1, -1, -1, \\
-1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, \\
+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, +1, +1, \\
-1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1, \\
-1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, \\
+1, +1, +1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, \\
-1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, \\
+1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, \\
+1, -1, -1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1, +1, -1, +1, -1, +1, -1, +1, -1, -1, \\
+1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, \\
+1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, \\
+1, -1, +1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, \\
+1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, \\
-1, +1, +1, -1, -1, +1, -1, +1, -1, +1\}
\end{array}
\tag{27-49}
$$

In a 160 MHz transmission using a 1x HE-LTF, the 1x HE-LTF sequence is given by Equation (27-50).

$$HELTF_{-1012,1012} = \{LTF_{80\mathrm{MHz\_lower\_1x}}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80\mathrm{MHz\_upper\_1x}}\} \quad (27\text{-}50)$$

where

$LTF_{80\mathrm{MHz\_lower\_1x}} = \{LTF_{80\mathrm{MHz\_left\_1x}}, 0, LTF_{80\mathrm{MHz\_right\_1x}}\}$ shall be used in the lower 80 MHz frequency segment

$LTF_{80\mathrm{MHz\_upper\_1x}} = \{LTF_{80\mathrm{MHz\_left\_1x}}, 0, -LTF_{80\mathrm{MHz\_right\_1x}}\}$ shall be used in the upper 80 MHz frequency segment

$LTF_{80\mathrm{MHz\_left\_1x}}$ = {–1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0}

$LTF_{80\mathrm{MHz\_right\_1x}}$ = {0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 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 a 160 MHz transmission using a 2x HE-LTF, the 2x HE-LTF sequence is given by Equation (27-51).

$$HELTF_{-1012,1012} = \{LTF_{80\mathrm{MHz\_lower\_2x}}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80\mathrm{MHz\_upper\_2x}}\} \quad (27\text{-}51)$$

where

$LTF_{80\mathrm{MHz\_lower\_2x}} = \{LTF_{80\mathrm{MHz\_part1\_2x}}, LTF_{80\mathrm{MHz\_part2\_2x}}, LTF_{80\mathrm{MHz\_part3\_2x}}, LTF_{80\mathrm{MHz\_part4\_2x}}, LTF_{80\mathrm{MHz\_part5\_2x}}\}$ shall be used in the lower 80 MHz frequency segment

$LTF_{80MHz\_upper\_2x}$ = {$LTF_{80MHz\_part1\_2x}$, –$LTF_{80MHz\_part2\_2x}$, $LTF_{80MHz\_part3\_2x}$, $LTF_{80MHz\_part4\_2x}$, –$LTF_{80MHz\_part5\_2x}$} shall be used in the upper 80 MHz frequency segment

$LTF_{80MHz\_part1\_2x}$ = {+1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0}

$LTF_{80MHz\_part2\_2x}$ = {+1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0}

$LTF_{80MHz\_part3\_2x}$ = {+1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1}

$LTF_{80MHz\_part4\_2x}$ = {0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1}

$LTF_{80MHz\_part5\_2x}$ = {0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1}

In a 160 MHz transmission using a 4x HE-LTF, the 4x HE-LTF sequence is given by Equation (27-52).

$$HELTF_{-1012,1012} = \{LTF_{80MHz\_lower\_4x}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80MHz\_upper\_4x}\} \qquad (27\text{-}52)$$

where

$LTF_{80MHz\_lower\_4x}$ = {$LTF_{80MHz\_left\_4x}$, 0, $LTF_{80MHz\_right\_4x}$} shall be used in the lower 80 MHz frequency segment

$LTF_{80MHz\_upper\_4x}$ = {$LTF_{80MHz\_left\_4x}$, 0, –$LTF_{80MHz\_right\_4x}$} shall be used in the upper 80 MHz frequency segment

$LTF_{80\mathrm{MHz\_left\_4x}}$ = {+1, +1, –1, +1, –1, +1, –1, –1, –1, +1, –1, –1, –1, +1, +1, –1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, +1, –1, +1, –1, +1, –1, –1, +1, +1, –1, +1, +1, +1, –1, –1, +1, –1, –1, –1, –1, +1, +1, +1, –1, –1, –1, –1, –1, –1, +1, +1, +1, +1, +1, +1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, +1, –1, –1, +1, +1, –1, +1, –1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, +1, +1, –1, +1, +1, –1, +1, –1, –1, +1, +1, +1, +1, –1, –1, +1, +1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, –1, –1, +1, –1, +1, –1, +1, +1, –1, +1, –1, +1, –1, +1, +1, +1, –1, +1, +1, +1, –1, –1, +1, –1, –1, –1, –1, –1, +1, +1, –1, –1, –1, –1, +1, –1, +1, –1, +1, +1, –1, –1, +1, –1, –1, –1, +1, +1, –1, +1, +1, +1, +1, –1, –1, –1, +1, +1, +1, +1, –1, +1, +1, +1, +1, +1, +1, +1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, +1, –1, –1, +1, –1, +1, +1, –1, +1, +1, –1, +1, –1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, +1, +1, –1, +1, +1, –1, +1, –1, –1, +1, –1, +1, –1, +1, –1, +1, +1, +1, –1, +1, +1, +1, –1, –1, +1, –1, –1, –1, –1, –1, +1, +1, –1, –1, –1, –1, +1, –1, +1, –1, +1, +1, +1, +1, +1, –1, –1, –1, +1, +1, +1, +1, –1, +1, –1, –1, +1, –1, –1, –1, +1, +1, –1, +1, +1, +1, +1, –1, –1, –1, –1, –1, –1, +1, –1, –1, –1, +1, –1, –1, +1, +1, +1, –1, +1, –1, +1, +1, –1, –1, +1, –1, +1, –1, –1, –1, –1, –1, +1, +1, –1, –1, –1, +1, –1, –1, +1, +1, +1, –1, +1, –1, –1, +1, –1, –1, +1, –1, +1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, –1, –1, +1, –1, +1, –1, +1, +1, –1, +1, –1, +1, –1, +1, +1, +1, –1, +1, +1, +1, –1, –1, +1, –1, –1, –1, –1, –1, +1, +1, –1, –1, –1, –1, +1, –1, +1, –1, +1, +1, –1, –1, +1, –1, –1, –1, +1, +1, –1, +1, +1, +1, +1, –1, –1, –1, +1, +1, +1, +1, –1, –1, +1, +1, +1, +1, +1, +1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –1, +1, –1, –1, +1, +1, –1, +1, –1, +1, +1, +1, +1, +1, –1, –1, +1, +1, +1, –1, +1, +1, –1, –1, –1, +1, –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}

$LTF_{80\mathrm{MHz\_right\_4x}}$ = {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, +1, +1, +1, –1, +1, +1, –1, –1, +1, –1, +1, –1, +1}

For an 80+80 MHz transmission using a 1x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 1x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_lower\_1x}}$, and the upper 80 MHz frequency segment shall use the 80 MHz 1x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_upper\_1x}}$.

For an 80+80 MHz transmission using a 2x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 2x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_lower\_2x}}$, and the upper 80 MHz frequency segment shall use the 80 MHz 2x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_upper\_2x}}$.

For an 80+80 MHz transmission using a 4x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 4x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_lower\_4x}}$, and the upper 80 MHz frequency segment shall use the 80 MHz 4x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\mathrm{MHz\_upper\_4x}}$.

For an OFDMA transmission, the values of HE-LTF sequence (defined in Equation (27-41) to Equation (27-56)) are set to zero if they are assigned to subcarriers within RUs that are not allocated to any user (see 27.3.10 (Mathematical description of signals)).

In an UL MU-MIMO transmission using the HE masked HE-LTF sequence mode, the HE-LTF sequence per frequency segment is generated by masking the nonzero elements in the common HE-LTF sequence repeatedly with a distinct orthogonal code as defined by Equation (27-53).

$$HELTF^{\mathrm{Mask}}_{k,u,m} = HELTF_k \cdot \left[P_{8\times 8}\right]_{M_{r,u}+m,\left(\left(\left\lceil \frac{k}{N_{\mathrm{HE\text{-}LTF\text{-}Type}}} \right\rceil - 1\right) \bmod 8\right)+1} \tag{27-53}$$

where

$HELTF_k$ is the value of the common HE-LTF sequence on subcarrier k generated by one of the equations from Equation (27-41) to Equation (27-52) depending on the bandwidth and the HE-LTF type (excluding the 1x HE-LTF, which shall not be masked).

$\left[P_{8\times 8}\right]$ is defined in Equation (21-46)

$M_{r,u} + m$ is the row index of the $\left[P_{8\times 8}\right]$ corresponding to spatial time stream m of user u in the r-th RU

$$N_{\mathrm{HE\text{-}LTF\text{-}Type}} = \begin{cases} 2, \text{ for 2x HE-LTF} \\ 1, \text{ for 4x HE-LTF} \end{cases}$$

In the HE TB feedback NDP, neither HE single stream pilot HE-LTF mode nor HE masked HE-LTF sequence mode is applied to the HE-LTF sequence. Only 4x HE-LTF shall be used in the HE TB feedback NDP. The 4x HE-LTF sequence is generated by Equation (27-54).

$$HELTF^{\mathrm{TB\_NDP}}_{k,u} = \begin{cases} HELTF_k, \text{ if } k \in K_{\mathrm{tone\_NDP}_u} \\ 0, \text{ otherwise} \end{cases} \tag{27-54}$$

where

$HELTF_k$ is the value of the common HE-LTF sequence on subcarrier k generated by one of the 4x HE-LTF equations (Equation (27-43), Equation (27-46), Equation (27-49), Equation (27-52)) according to the channel bandwidth

$K_{\mathrm{tone\_NDP}u}$ is the set of subcarrier indices for user u and is defined in Table 27-32 (HE-LTF subcarrier mapping for the HE TB feedback NDP) according to the RU_TONE_SET_INDEX and FEEDBACK_STATUS.

The generation of the time domain HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, and HE ER SU PPDU is shown in Figure 27-32 (Generation of HE-LTF symbols per frequency seg-

Table 27-32—HE-LTF subcarrier mapping for the HE TB feedback NDP

	80 MHz		40 MHz		20 MHz	
RU_ TONE_ SET_ INDEX	K_{tone_NDPu} if FEEDBACK _STATUS is 1	K_{tone_NDPu} if FEEDBACK _STATUS is 0	K_{tone_NDPu} if FEEDBACK _STATUS is 1	K_{tone_NDPu} if FEEDBACK _STATUS is 0	K_{tone_NDPu} if FEEDBACK_ STATUS is 1	K_{tone_NDPu} if FEEDBACK_ STATUS is 0
1	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices – 384	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices – 384	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices – 128	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices – 128	–113, –77, –41, 6, 42, 78	–112, –76, –40, 7, 43, 79
2					–111, –75, –39, 8, 44, 80	–110, –74, –38, 9, 45, 81
3					–109, –73, –37, 10, 46, 82	–108, –72, –36, 11, 47, 83
4					–107, –71, –35, 12, 48, 84	–106, –70, –34, 13, 49, 85
5					–105, –69, –33, 14, 50, 86	–104, –68, –32, 15, 51, 87
6					–103, –67, –31, 16, 52, 88	–102, –66, –30, 17, 53, 89
7					–101, –65, –29, 18, 54, 90	–100, –64, –28, 19, 55, 91
8					–99, –63, –27, 20, 56, 92	–98, –62, –26, 21, 57, 93
9					–97, –61, –25, 22, 58, 94	–96, –60, –24, 23, 59, 95
10					–95, –59, –23, 24, 60, 96	–94, –58, –22, 25, 61, 97
11					–93, –57, –21, 26, 62, 98	–92, –56, –20, 27, 63, 99
12					–91, –55, –19, 28, 64, 100	–90, –54, –18, 29, 65, 101
13					–89, –53, –17, 30, 66, 102	–88, –52, –16, 31, 67, 103
14					–87, –51, –15, 32, 68, 104	–86, –50, –14, 33, 69, 105
15					–85, –49, –13, 34, 70, 106	–84, –48, –12, 35, 71, 107
16					–83, –47, –11, 36, 72, 108	–82, –46, –10, 37, 73, 109
17					–81, –45, –9, 38, 74, 110	–80, –44, –8, 39, 75, 111
18					–79, –43, –7, 40, 76, 112	–78, –42, –6, 41, 77, 113

Table 27-32—HE-LTF subcarrier mapping for the HE TB feedback NDP *(continued)*

	80 MHz		40 MHz		20 MHz	
RU_ TONE_ SET_ INDEX	**K_{tone_NDPu} if FEEDBACK _STATUS is 1**	**K_{tone_NDPu} if FEEDBACK _STATUS is 0**	**K_{tone_NDPu} if FEEDBACK _STATUS is 1**	**K_{tone_NDPu} if FEEDBACK _STATUS is 0**	**K_{tone_NDPu} if FEEDBACK_ STATUS is 1**	**K_{tone_NDPu} if FEEDBACK_ STATUS is 0**
19-36	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices – 128	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices – 128	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices + 128	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices + 128		
37-54	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices + 128	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices + 128				
55-72	Use 20 MHz FEED-BACK_STA-TUS = 1 Subcarrier Indices + 384	Use 20 MHz FEED-BACK_STA-TUS = 0 Subcarrier Indices + 384				
The RU_TONE_SET_INDEX for 80+80 MHz and 160 MHz shall use the 80 MHz RU_TONE_SET_INDEX definition for the lower and upper 80 MHz. The RU_TONE_SET_INDEX values 1-72 are mapped to the lower 80 MHz and the RU_TONE_SET_INDEX values 73-144 are mapped to the upper 80 MHz.						

ment in an HE SU PPDU, HE MU PPDU, and HE ER SU PPDU) where $A^k_{\text{HE-LTF}}$ is given by Equation (27-55).

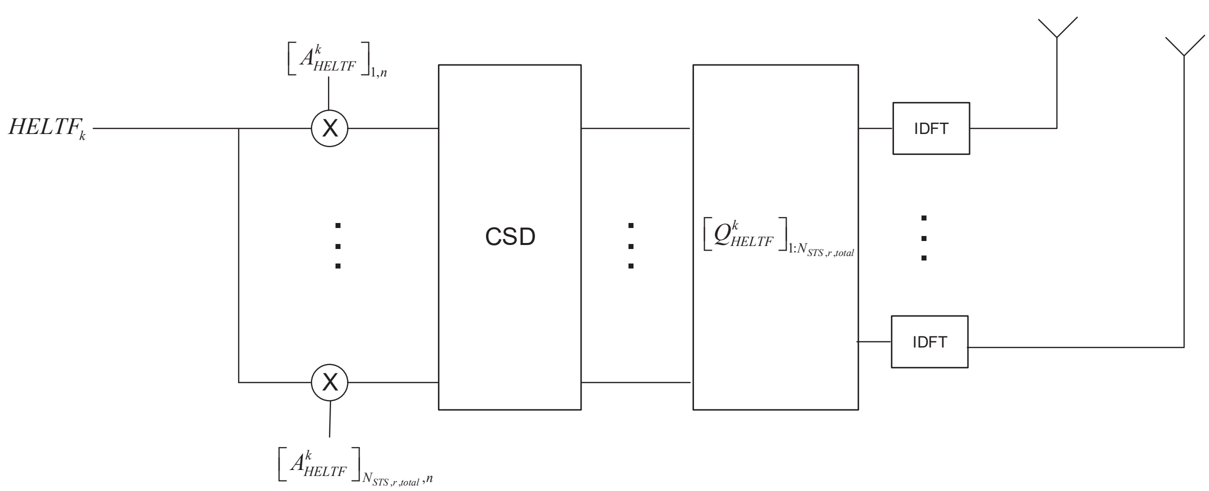

Figure 27-32—Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, and HE ER SU PPDU

The generation of the time domain HE-LTF symbols per frequency segment in an HE TB PPDU is shown in Figure 27-33 (Generation of HE-LTF symbols per frequency segment in an HE TB PPDU for user u on RU r).

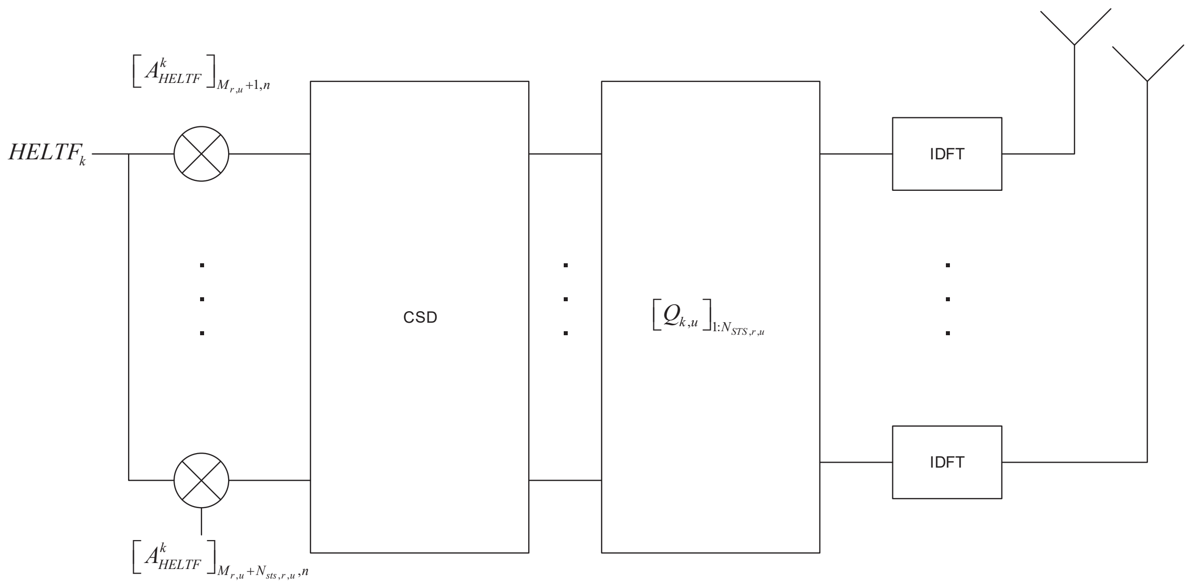

Figure 27-33—Generation of HE-LTF symbols per frequency segment in an HE TB PPDU for user *u* on RU *r*

The generation of the time domain symbol of a 1x HE-LTF is equivalent to modulating every 4 subcarriers in an OFDM symbol of 12.8 μs excluding GI, and then transmitting only the first ¼ of the OFDM symbol in the time domain, as shown in Figure 27-34 (Generation of 1x HE-LTF symbols per frequency segment).

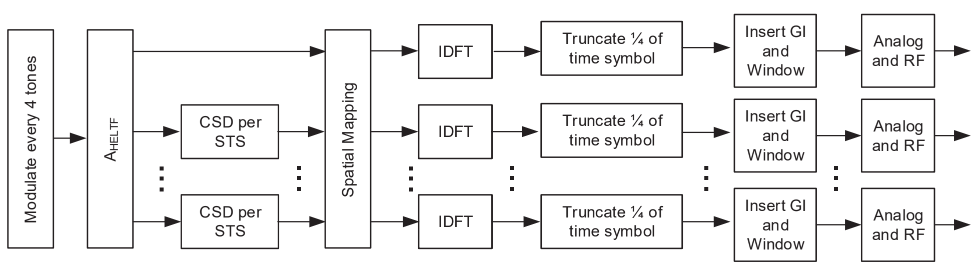

Figure 27-34—Generation of 1x HE-LTF symbols per frequency segment

The generation of the time domain symbol of a 2x HE-LTF is equivalent to modulating every other subcarrier in an OFDM symbol of 12.8 μs excluding GI, and then transmitting only the first half of the OFDM symbol in time domain, as shown in Figure 27-35 (Generation of 2x HE-LTF symbols per frequency segment).

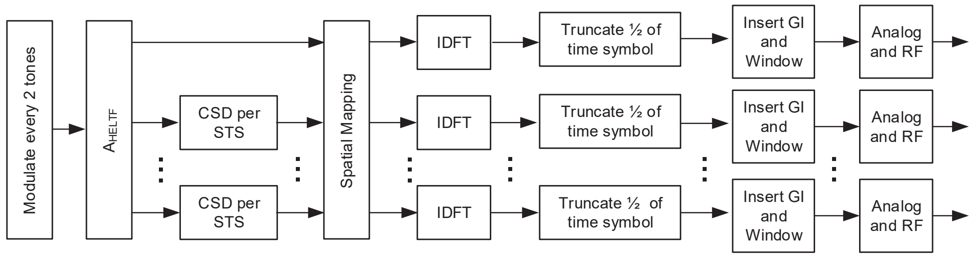

Figure 27-35—Generation of 2x HE-LTF symbols per frequency segment

$A^k_{\text{HE-LTF}}$ is given by Equation (27-55).

$$A^k_{\text{HE-LTF}} = \begin{cases} R_{\text{HE-LTF}}, \text{ if } k \in K_{\text{Pilot}} \text{ and HE single stream pilot HE-LTF mode is used} \\ P_{\text{HE-LTF}}, \text{ otherwise} \end{cases} \tag{27-55}$$

where

K_{Pilot} is the set of subcarrier indices for the pilot subcarriers as defined in 27.3.2.4 (Pilot subcarriers).

$R_{\text{HE-LTF}}$ is a $N_{\text{HE-LTF}} \times N_{\text{HE-LTF}}$ matrix whose elements are defined in Equation (27-56).

$$\left[R_{\text{HE-LTF}}\right]_{m,n} = \left[P_{\text{HE-LTF}}\right]_{1,n},\ 1 \le m, n \le N_{\text{HE-LTF}} \tag{27-56}$$

$P_{\text{HE-LTF}}$ is defined in Equation (27-57).

$$P_{\text{HE-LTF}} = \begin{cases} P_{4\times4}, N_{\text{HE-LTF}} = 1, 2, 4 \\ P_{6\times6}, N_{\text{HE-LTF}} = 6 \\ P_{8\times8}, N_{\text{HE-LTF}} = 8 \end{cases} \tag{27-57}$$

where $P_{4\times4}$ is defined in Equation (19-27), $P_{6\times6}$ is defined in Equation (21-44), and $P_{8\times8}$ is defined in Equation (21-45).

If the 1x HE-LTF is used for non-OFDMA UL MU-MIMO, the HE no pilot HE-LTF mode is used.

In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the time domain representation of the waveform transmitted on frequency segment i_{Seg} and transmit chain i_{TX} shall be as described by Equation (27-58).

$$\begin{aligned} r^{(i_{Seg}, i_{TX})}_{\text{HE-LTF}}(t) = {} & \frac{1}{\sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{\text{HE-LTF}}-1} w_{T_{\text{HE-LTF}}}(t - nT_{\text{HE-LTF}}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \sqrt{|K_r|}}{\sqrt{N_{STS,r,total}\left|K_r^{\text{HE-LTF}}\right|}} \\ & \sum_{k \in K_r} \eta_{\text{HE-LTF},k} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})}\right]_{i_{TX},(M_{r,u}+m)} \left[A^k_{\text{HE-LTF}}\right]_{(M_{r,u}+m),(n+1)} HELTF''_{k,u,m} \right. \\ & \left. \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{\text{HE-LTF-SYM}} - T_{GI,\text{HE-LTF}} - T_{CS,\text{HE}}(M_{r,u}+m))) \right) \end{aligned} \tag{27-58}$$

In an HE TB PPDU, the time domain representation of the waveform of user u in the r-th RU, transmitted on frequency segment i_{Seg} and transmit chain i_{TX}, shall be as described by Equation (27-59).

$$r^{(i_{Seg},\, i_{TX})}_{\text{HE-LTF},\, r,\, u}(t) = \frac{1}{\sqrt{N_{STS,\, r,\, u}\left|K_r^{\text{HE-LTF}}\right|}} \sum_{n=0}^{N_{\text{HE-LTF}}-1} w_{T_{\text{HE-LTF}}}(t - nT_{\text{HE-LTF}}) \sum_{k \in K_r} \sum_{m=1}^{N_{STS,\, r,\, u}} \left(\left[Q^{(i_{Seg})}_{k,\, u}\right]_{i_{TX},\, m} \left[A^{k}_{\text{HE-LTF}}\right]_{(M_{r,\, u}+m),\, (n+1)} HELTF''_{k,\, u,\, m} \cdot \exp(j2\pi k\Delta_{F,\, \text{HE}}(t - nT_{\text{HE-LTF-SYM}} - T_{GI,\, \text{HE-LTF}} - T_{CS,\, \text{HE}}(M_{r,\, u}+m))) \right) \tag{27-59}$$

In Equation (27-58) and Equation (27-59) the following notations are used:

$N_{user,r}$ is the number of HE MU PPDU recipients (see Table 27-15 (Frequently used parameters)) in RU r

$HELTF''_{k,\, u,\, m}$ is the HE-LTF sequence applied on subcarrier k for spatial stream m of user u

$$HELTF''_{k,\, u,\, m} = \begin{cases} HELTF^{\text{Mask}}_{k,\, u,\, m}, \text{ if HE masked HE-LTF sequence mode is used} \\ HELTF^{\text{TB\_NDP}}_{k,\, u}, \text{ for an HE TB NDP report response} \\ HELTF_k, \text{ otherwise} \end{cases}$$

α_r is defined in 27.3.10 (Mathematical description of signals)

$\eta_{\text{HE-LTF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-LTF},\, k} = \begin{cases} \sqrt{2}, \text{ for an HE ER SU PPDU} \\ 1, \text{ otherwise} \end{cases}$$

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

$T_{CS,\, \text{HE}}(M_{r,\, u}+m)$ represents the cyclic shift for space-time stream $M_{r,u} + m$ as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$Q^{(i_{Seg})}_{k}$ and $Q^{(i_{Seg})}_{k,\, u}$ are defined in 27.3.10 (Mathematical description of signals)

$A^{k}_{\text{HE-LTF}}$ is defined in Equation (27-55)

$M_{r,u}$ is given in Table 27-15 (Frequently used parameters) for HE SU PPDU, HE ER SU PPDU and HE MU PPDU. For an HE TB PPDU it is given in the Starting Spatial Stream subfield in the SS Allocation subfield of Trigger frame User info field for u-th user in r-th occupied RU in Figure 9-64e (SS Allocation subfield format).

K_r is the set of subcarrier indices for the tones in the RU r as defined in 27.3.10 (Mathematical description of signals)

$|K_r|$ and $\left|K_r^{\text{HE-LTF}}\right|$ are defined below Equation (27-5)

$\left|K_r^{\text{HE-LTF}}\right|$ is the cardinality of the set of modulated subcarriers within K_r for HE-LTF field, as defined in 27.3.10 (Mathematical description of signals)

Other variables are defined below Equation (27-1), Equation (27-3), Equation (27-4), Equation (27-6), Equation (27-8), Equation (27-12) and Equation (27-40)

27.3.12 Data field

27.3.12.1 General

The number of OFDM symbols in the Data field is determined by the LENGTH field in the L-SIG field (see Equation (27-11)), the preamble duration and the settings of the GI+HE-LTF Size, Pre-FEC Padding Factor and PE Disambiguity fields in the HE-SIG-A field (see 27.3.11.7 (HE-SIG-A)) for an HE SU PPDU, HE ER

SU PPDU and HE MU PPDU, or in the soliciting Triggering frame for an HE TB PPDU. Data field OFDM symbols in an HE PPDU shall use a DFT period of 12.8 µs and subcarrier spacing of 78.125 kHz. An HE STA shall support Data field OFDM symbols in an HE PPDU with guard interval durations of 0.8 µs, 1.6 µs and 3.2 µs. HE PPDUs shall have HE single stream pilot in the Data field. In UL MU-MIMO transmissions, all streams use the same pilot sequence.

If BCC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the pre-FEC PHY padding bits, the tail bits, and the post-FEC padding bits. If LDPC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the pre-FEC PHY padding bits, and the post-FEC padding bits. No tail bits are present if LDPC encoding is used.

The Data field of the HE PPDU contains data for one or more users.

27.3.12.2 Pre-FEC padding process

A two-step padding process is applied to an HE PPDU. A pre-FEC padding process including both pre-FEC MAC and pre-FEC PHY padding is applied before conducting FEC coding, and a post-FEC PHY padding process is applied on the FEC encoded bits.

Four pre-FEC padding boundaries partition the last one (in the case of non-STBC) or two (in the case of STBC) OFDM symbols of an HE PPDU into four symbol segments. The pre-FEC padding may pad toward one of the four possible boundaries. The four pre-FEC padding boundaries are represented by a pre-FEC padding factor parameter.

Figure 27-36 (HE PPDU padding process in the last OFDM symbol (non-STBC) if a = 1) illustrates these four 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, represented by the pre-FEC padding factor, is 1. In the case of STBC, the FEC output bits and post-FEC padding bits are modulated into the last two OFDM symbols by STBC encoding, each with the same pre-FEC padding boundary.

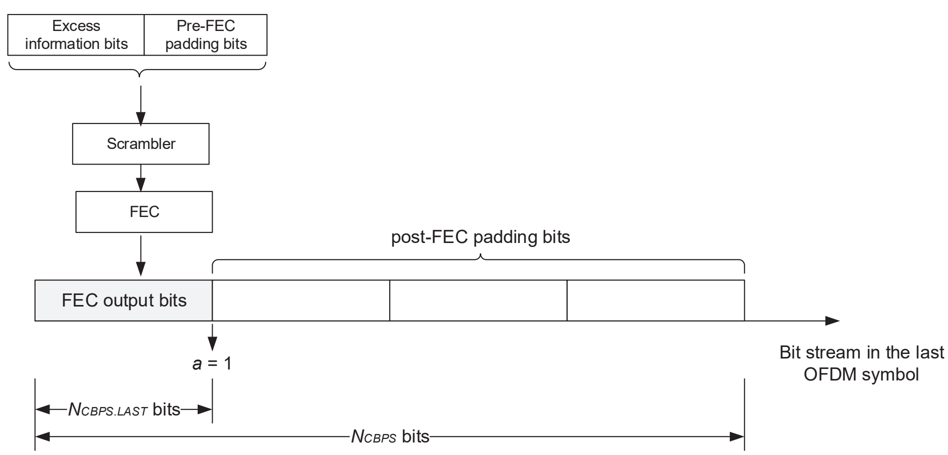

Figure 27-36—HE PPDU padding process in the last OFDM symbol (non-STBC) if *a* = 1

The pre-FEC padding process is described in this subclause, and the encoding and post-FEC padding process are described in 27.3.12.5 (Coding). While this subclause describes the pre-FEC padding processing of an SU transmission, its extension to MU transmission is described in 27.3.12.5.4 (Encoding process for an HE MU PPDU) and 27.3.12.5.5 (Encoding process for an HE TB PPDU).

In an HE SU PPDU and HE ER SU PPDU transmission, the transmitter first computes the number of bits left in the last OFDM symbol(s) based on Equation (27-60).

$$N_{Excess} = mod(8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}, m_{STBC} \cdot N_{DBPS}) \tag{27-60}$$

where

m_{STBC} is 2 if STBC is used, and 1 otherwise

APEP_LENGTH is the TXVECTOR parameter APEP_LENGTH

N_{Tail} is the number of tail bits per encoder as defined in Table 27-12 (Timing-related constants)

$N_{service}$ is the number of bits in the SERVICE field as defined in Table 27-12 (Timing-related constants)

N_{DBPS} is the number of data bits per symbol

Based on N_{Excess}, compute the initial number of symbol segments in the last OFDM symbol(s), initial pre-FEC padding factor value or a_{init}, as shown in Equation (27-61).

$$a_{init} = \begin{cases} 4, & \text{if } N_{Excess} = 0 \\ \min\left(\left\lceil \dfrac{N_{Excess}}{m_{STBC} \cdot N_{DBPS,short}} \right\rceil, 4\right), & \text{otherwise} \end{cases} \tag{27-61}$$

where

$N_{DBPS,short} = N_{CBPS,short} \cdot R$, in which R is the coding rate, and

$N_{CBPS,short} = N_{SD,short} \cdot N_{SS} \cdot N_{BPSCS}$;

The parameter $N_{SD,short}$ values for different RU sizes are as shown in Table 27-33 (NSD,short values).

Table 27-33—$N_{SD,short}$ values

RU Size	$N_{SD,short}$	
	DCM = 0	**DCM = 1**
26-tone	6	2
52-tone	12	6
106-tone	24	12
242-tone	60	30
484-tone	120	60
996-tone	240	120
2×996-tone	492	246

Given the a_{init} values, the initial number of data bits per symbol and the initial number of coded bits per symbol in the last OFDM symbol(s) are defined in Equation (27-62).

$$N_{DBPS,\,last,\,init} = \begin{cases} a_{init}N_{DBPS,\,short}, \text{ if } a_{init} < 4 \\ N_{DBPS}, \text{ if } a_{init} = 4 \end{cases}$$
$$N_{CBPS,\,last,\,init} = \begin{cases} a_{init}N_{CBPS,\,short}, \text{ if } a_{init} < 4 \\ N_{CBPS}, \text{ if } a_{init} = 4 \end{cases} \qquad (27\text{-}62)$$

For an HE SU PPDU and HE ER SU PPDU, the number of pre-FEC pad bits is calculated using Equation (27-63).

$$\begin{aligned} N_{PAD,\,\text{Pre-FEC}} = {} & (N_{SYM.init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,\,last,\,init} \\ & - 8 \cdot \text{APEP\_LENGTH} - N_{Tail} - N_{service} \end{aligned} \qquad (27\text{-}63)$$

where $N_{SYM,init}$ is the initial number of data OFDM symbols with BCC or LDPC encoding in an HE SU PPDU or HE ER SU PPDU as defined by Equation (27-64).

$$N_{SYM,\,init} = m_{STBC} \cdot \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}}{m_{STBC}N_{DBPS}} \right\rceil \qquad (27\text{-}64)$$

Among the pre-FEC padding bits, the MAC delivers a PSDU that fills the available octets in the Data field of the HE PPDU (see A-MPDU padding for HE PPDUs in 26.6.2.2 (A-MPDU padding in an HE SU PPDU, HE ER SU PPDU and HE MU PPDU) and 26.6.2.3 (A-MPDU padding in an HE TB PPDU)), toward the desired initial pre-FEC padding boundary, represented by a_{init} value, in the last OFDM symbol(s). The number of pre-FEC pad bits added by MAC will always be a multiple of 8. The PHY then determines the number of remaining 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 (27-65).

$$\begin{aligned} N_{PAD,\,\text{Pre-FEC,MAC}} &= \left\lfloor \frac{N_{PAD,\,\text{Pre-FEC}}}{8} \right\rfloor \cdot 8 \\ N_{PAD,\,\text{Pre-FEC,PHY}} &= N_{PAD,\,\text{Pre-FEC}} \bmod 8 \end{aligned} \qquad (27\text{-}65)$$

27.3.12.3 SERVICE field

The SERVICE field of HE PPDU is shown in Table 27-34 (SERVICE field).

Table 27-34—SERVICE field

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

27.3.12.4 Scrambler

The SERVICE field, PSDU, and pre-FEC PHY padding of the Data field shall be scrambled by the scrambler defined in 17.3.5.5 (PHY DATA scrambler and descrambler). The Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) TXVECTOR parameters CH_BANDWIDTH_IN_NON_HT and DYN_BANDWIDTH_IN_NON_HT are not present and therefore the initial state of the scrambler is set to a nonzero pseudorandom seed. A different nonzero pseudorandom seed may be used for each user in an HE MU PPDU.

27.3.12.5 Coding

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 27.3.12.5.1 (BCC coding and puncturing) or the low density parity check (LDPC) code defined in 27.3.12.5.2 (LDPC coding). The coding type is selected by the Coding field in HE-SIG-A in an HE SU PPDU or an HE ER SU PPDU, or the Coding field in HE-SIG-B per user subfield(s) in an HE MU PPDU, or the UL FEC Coding Type subfield in User Info field in the corresponding Trigger frame in the case of an HE TB PPDU, as defined in 27.3.11.7 (HE-SIG-A), 27.3.11.8 (HE-SIG-B) and 9.3.1.22 (Trigger frame format), respectively.

When conducting BCC FEC encoding for an HE PPDU, the number of encoders is always 1.

LDPC is the only FEC coding scheme in the HE PPDU Data field for a 484-, 996-, and 2×996-tone RU. LDPC is the only FEC coding scheme in the HE PPDU Data field for HE-MCSs 10 and 11. Support for BCC coding is limited to less than or equal to four spatial streams and HE-MCSs 0 to 9 (per user in the case of MU-MIMO), and is mandatory (for both transmit and receive) for RU sizes less than or equal to a 242-tone RU. The LDPC Coding In Payload subfield of the HE Capabilities element indicates support for the transmission and reception of the LDPC encoded PPDUs. Support for LDPC coding (for both transmit and receive) is mandatory for HE STAs declaring support for at least one of HE 40/80/160/80+80 SU PPDU bandwidths, for HE STAs declaring support for more than 4 spatial streams, or for HE STAs declaring support for HE-MCSs 10 and 11, according to the LDPC Coding In Payload subfield of the HE Capabilities element as defined in 9.4.2.247 (HE Capabilities element). Otherwise, support of LDPC coding for either transmit or receive is optional.

27.3.12.5.1 BCC coding and puncturing

The information bits and pre-FEC padding bits of user u are encoded by a rate $R = 1/2$ convolutional encoder defined in 17.3.5.6 (Convolutional encoder). After encoding, the encoded data is punctured by the method defined in 17.3.5.6 (Convolutional encoder) (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 19.3.11.6 (Binary convolutional coding and puncturing).

If DCM is used with BPSK modulation in a 106-tone or 242-tone RU with $N_{SS} = 1$, then after every $2 \times N_{DBPS}$ coded bits, one padding bit is added. The padding bit may be set to any value.

For an HE SU PPDU and HE ER SU PPDU with BCC encoding,

$$N_{SYM} = N_{SYM,init} \tag{27-66}$$

and

$$a = a_{init} \tag{27-67}$$

where $N_{SYM,init}$ is defined in Equation (27-64), a_{init} is defined in Equation (27-61) and a is the pre-FEC padding factor.

The number of data bits per symbol in the last OFDM symbol(s) of an HE SU PPDU or HE ER SU PPDU is $N_{DBPS,last} = N_{DBPS,last,init}$, where $N_{DBPS,last,init}$ is defined in Equation (27-62).

The number of coded bits per symbol in the last OFDM symbol(s) of an HE SU PPDU or HE ER SU PPDU is $N_{CBPS,last} = N_{CBPS,last,init}$, where $N_{CBPS,last,init}$ is defined in Equation (27-62).

27.3.12.5.2 LDPC coding

For an HE SU PPDU or HE ER SU PPDU using LDPC coding on the Data field, the LDPC coding process described in 19.3.11.7 (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 (27-68) instead of Equation (19-35).

$$N_{pld} = (N_{SYM,\,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,\,last,\,init} \tag{27-68}$$

where $N_{SYM,init}$ is defined in Equation (27-64).

Following the calculation of N_{pld}, N_{avbits} shall be computed using Equation (27-69) instead of Equation (19-36).

$$N_{avbits} = (N_{SYM,\,init} - m_{STBC}) \cdot N_{CBPS} + m_{STBC} \cdot N_{CBPS,\,last,\,init} \tag{27-69}$$

In addition, in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process), if the following condition is met:

$$(N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1-R)) \text{ AND } \left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1-R}\right) \text{ is true OR if}$$

$$N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1-R) \text{ is true,}$$

then the LDPC Extra Symbol Segment field of HE-SIG-A shall be set to 1, N_{avbits} shall be increased according to the Equation (27-70) instead of Equations (19-39), and N_{punc} shall be recomputed as in Equation (19-40):

$$N_{avbits} = \begin{cases} N_{avbits} + m_{STBC} \cdot (N_{CBPS} - 3N_{CBPS,\,short}), & \text{if } a_{init} = 3 \\ N_{avbits} + m_{STBC} \cdot N_{CBPS,\,short}, & \text{otherwise} \end{cases} \tag{27-70}$$

and then compute the pre-FEC padding factor a and N_{SYM} using Equation (27-71):

$$\begin{cases} N_{SYM} = N_{SYM,\,init} + m_{STBC} \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM,\,init} \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \tag{27-71}$$

If in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process), the above mentioned condition is not met, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 0, and

$$\begin{aligned} N_{SYM} &= N_{SYM,\,init} \\ a &= a_{init} \end{aligned} \tag{27-72}$$

Using the pre-FEC padding factor a, compute the N_{CBPS} of the last symbol as:

$$N_{CBPS,\,last} = \begin{cases} a \cdot N_{CBPS,\,short}, & \text{if } a < 4 \\ N_{CBPS}, & \text{if } a = 4 \end{cases} \tag{27-73}$$

The number of data bits of the last symbol is calculated as $N_{DBPS,last} = N_{DBPS,last,init}$.

LDPC coding used in HE MU PPDUs shall also follow the definitions in 19.3.11.7 (LDPC codes). Refer to 27.3.12.5.4 (Encoding process for an HE MU PPDU) for a description of the LDPC encoding process for HE MU PPDUs.

27.3.12.5.3 Post-FEC padding

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

$$N_{PAD,Post\text{-}FEC} = N_{CBPS} - N_{CBPS,last} \tag{27-74}$$

The last m_{STBC} symbols shall consist of $N_{CBPS,last}$ bits from the FEC output followed by $N_{PAD,Post\text{-}FEC}$ post-FEC padding bits. The values of the post-FEC padding bits are not specified and are left up to implementation.

27.3.12.5.4 Encoding process for an HE MU PPDU

For an HE MU PPDU, all the users shall use a common pre-FEC padding factor value and a common N_{SYM} value. The padding process is described as follows.

First compute initial pre-FEC padding factor value, $a_{init,u}$, for each user u using Equation (27-61), and the initial number of OFDM symbols, $N_{SYM,init,u}$, for each user u using Equation (27-64). Among all the users, derive the user index with the longest encoded packet duration, as in Equation (27-75).

$$u_{\max} = \arg\max_{u=0}^{N_{user,total}-1}\left(N_{SYM,init,u} - m_{STBC} + \frac{m_{STBC}a_{init,u}}{4}\right) \tag{27-75}$$

where

$\arg\max f(x) := \{x \mid x \in [0, N_{user,total}-1] \wedge \forall y \in [0, N_{user,total}-1]; f(y) \le f(x)\}$

m_{STBC} is the common STBC setting among all the users, as described in 27.3.11.7 (HE-SIG-A).

Then the common a_{init} and $N_{SYM,init}$ values among all the users are derived by Equation (27-76):

$$\begin{aligned} N_{SYM,init} &= N_{SYM,init,u_{\max}} \\ a_{init} &= a_{init,u_{\max}} \end{aligned} \tag{27-76}$$

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

$$\begin{aligned} N_{DBPS,last,init,u} &= \begin{cases} a_{init}N_{DBPS,short,u}, \text{ if } a_{init} < 4 \\ N_{DBPS,u}, \text{ if } a_{init} = 4 \end{cases} \\ N_{CBPS,last,init,u} &= \begin{cases} a_{init}N_{CBPS,short,u}, \text{ if } a_{init} < 4 \\ N_{CBPS,u}, \text{ if } a_{init} = 4 \end{cases} \end{aligned} \tag{27-77}$$

For each user with LDPC encoding, the number of pre-FEC padding bits is computed as in Equation (27-78):

$$\begin{aligned} N_{PAD,\text{Pre-FEC},u} = {} & (N_{SYM,init} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,init,u} \\ & - 8 \cdot \text{APEP\_LENGTH}_u - N_{service} \end{aligned} \tag{27-78}$$

For each user with LDPC encoding, the parameters $N_{pld,u}$ and $N_{avbits,u}$ are computed using Equation (27-79) and Equation (27-80) respectively:

$$N_{pld,u} = (N_{SYM,init} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,init,u} \tag{27-79}$$

$$N_{avbits,u} = (N_{SYM,init} - m_{STBC})N_{CBPS,u} + m_{STBC}N_{CBPS,last,init,u} \tag{27-80}$$

For each user with LDPC encoding continue LDPC encoding process as in 19.3.11.7.5 (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 for which step d) of the LDPC encoding process in 19.3.11.7.5 (LDPC PPDU encoding process) meets the following condition:

$$(N_{punc,u} > 0.1 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u)) \text{ AND } \left(N_{shrt,u} < 1.2 \times N_{punc,u} \times \frac{R_u}{1 - R_u}\right) \text{ is true OR if}$$

$$N_{punc,u} > 0.3 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u) \text{ is true,}$$

where $N_{punc,u}$, $N_{CW,u}$, $L_{LDPC,u}$ and $N_{shrt,u}$ are the LDPC encoding parameters for user u, as defined in 19.3.11.7.5 (LDPC PPDU encoding process), and R_u is the coding rate of user u, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 1, and all the users with LDPC encoding shall increment N_{avbits} and recomputed N_{punc}, by the following two equations once:

$$N_{avbits,u} = \begin{cases} N_{avbits,u} + m_{STBC} \cdot (N_{CBPS,u} - 3N_{CBPS,short,u}), & \text{if } a_{init} = 3 \\ N_{avbits,u} + m_{STBC} \cdot N_{CBPS,short,u}, & \text{otherwise} \end{cases} \tag{27-81}$$

$$N_{punc,u} = \max(0, (N_{CW,u} \times L_{LDPC,u}) - N_{avbits,u} - N_{shrt,u}) \tag{27-82}$$

Update the common pre-FEC padding factor and N_{SYM} values for all users by the following equation:

$$\begin{cases} N_{SYM} = N_{SYM,init} + m_{STBC} \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM,init} \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \tag{27-83}$$

If none of the users with LDPC encoding in step d) of 19.3.11.7.5 (LDPC PPDU encoding process) meet the condition $(N_{punc,u} > 0.1 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u))$ and $\left(N_{shrt,u} < 1.2 \times N_{punc,u} \times \frac{R_u}{1 - R_u}\right)$ are true or $N_{punc,u} > 0.3 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u)$ is true, or if all the users in the HE MU PPDU are BCC encoded, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 0, and the common pre-FEC padding factor and N_{SYM} values for all users shall be updated by Equation (27-84).

$$a = a_{init}, N_{SYM} = N_{SYM,init} \tag{27-84}$$

For the users with LDPC encoding, $N_{DBPS,last,u} = N_{DBPS,last,init,u}$.

For the users with BCC encoding, update the N_{DBPS} of the last symbol as

$$N_{DBPS,last,u} = \begin{cases} a \cdot N_{DBPS,short,u}, \text{ if } a < 4 \\ N_{DBPS,u}, \text{ if } a = 4 \end{cases} \tag{27-85}$$

For each user with either LDPC or BCC encoding, update the N_{CBPS} of the last symbol as

$$N_{CBPS,\,last,\,u} = \begin{cases} a \cdot N_{CBPS,\,short,\,u}, \text{ if } a < 4 \\ N_{CBPS,\,u}, \text{ if } a = 4 \end{cases}$$

For the users with BCC encoding, the number of pre-FEC padding bits is shown in Equation (27-86).

$$N_{PAD,\,\text{Pre-FEC},\,u} = (N_{SYM} - m_{STBC})N_{DBPS,\,u} + m_{STBC}N_{DBPS,\,last,\,u} - 8 \cdot \text{APEP\_LENGTH}_u - N_{Tail} - N_{service} \quad (27\text{-}86)$$

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 (27-87):

$$N_{PAD,\,\text{Post-FEC},\,u} = N_{CBPS,\,u} - N_{CBPS,\,last,\,u} \quad (27\text{-}87)$$

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 initial pre-FEC padding boundary represented by a_{init} for users encoded by LDPC and the pre-FEC padding boundary represented by a for users encoded by BCC, in 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 (27-88) and Equation (27-89).

$$N_{PAD,\,\text{Pre-FEC},\,MAC,\,u} = 8 \cdot \left\lfloor \frac{N_{PAD,\,\text{Pre-FEC},\,u}}{8} \right\rfloor \quad (27\text{-}88)$$

$$N_{PAD,\,\text{Pre-FEC},\,PHY,\,u} = N_{PAD,\,\text{Pre-FEC},\,u} \bmod 8 \quad (27\text{-}89)$$

27.3.12.5.5 Encoding process for an HE TB PPDU

For an HE TB PPDU sent in response to a Trigger frame, the AP indicates the UL Length, GI And HE-LTF Type, Number Of HE-LTF Symbols And Midamble Periodicity, Pre-FEC Padding Factor, UL STBC, LDPC Extra Symbol Segment, PE Disambiguity and Doppler fields in the Trigger frame. The common values T_{PE} and N_{SYM} are derived by non-AP STAs as shown in Equation (27-114) and Equation (27-115).

NOTE—The AP might select any value for the pre-FEC padding factor and LDPC Extra Symbol Segment fields for the solicited HE TB PPDU regardless of the respective values derived from the calculations described in the BCC or LDPC encoding process.

For an HE TB PPDU sent in response to a frame containing a TRS Control subfield, the parameters used to derive the common values T_{PE} and N_{SYM} are described in 26.5.2.3.4 (TXVECTOR parameters for HE TB PPDU response to TRS Control subfield).

For an HE TB PPDU with BCC encoding, follow the HE SU PPDU padding and encoding process as introduced in 27.3.12.2 (Pre-FEC padding process), 27.3.12.5.1 (BCC coding and puncturing), and 27.3.12.5.3 (Post-FEC padding) with initial parameters as follows:

- If the TXVECTOR parameter TRIGGER_METHOD is TRIGGER_FRAME, the initial parameters are $N_{SYM,init} = N_{SYM}$, and $a_{init} = a$, where a is the pre-FEC padding factor indicated in the Pre-FEC Padding Factor subfield of the Common Info field in the Trigger frame and N_{SYM} is the common number of data OFDM symbols derived from the UL Length, Number Of HE-LTF Symbols And Midamble Periodicity, and Doppler subfields of the Common Info field in the Trigger frame.
- If the TXVECTOR parameter TRIGGER_METHOD is TRS, the initial parameters are $N_{SYM,init} = F_{VAL} + 1$, and $a_{init} = 4$, where F_{VAL} is the value of the UL Data Symbols subfield of the TRS Control subfield.

For an HE TB PPDU with LDPC encoding, follow the HE SU PPDU padding and encoding process as introduced in 27.3.12.2 (Pre-FEC padding process), 27.3.12.5.2 (LDPC coding), and 27.3.12.5.3 (Post-FEC padding), with the following exceptions:

- If the TXVECTOR parameter TRIGGER_METHOD is TRIGGER_FRAME and the LDPC Extra Symbol Segment field in the Trigger frame is 1, set the initial parameters following Equation (27-90).

$$\begin{cases} a_{init} = 4 \text{ and } N_{SYM,\,init} = N_{SYM} - m_{STBC}, & \text{if } a = 1 \\ a_{init} = a - 1 \text{ and } N_{SYM,\,init} = N_{SYM}, & \text{otherwise} \end{cases} \tag{27-90}$$

  where m_{STBC} is 2 if the Trigger frame indicates STBC and 1 otherwise. Then continue with the LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of 19.3.11.7.5 (LDPC PPDU encoding process), always increment N_{avbits} as in Equation (27-70), and always recompute N_{punc} as in Equation (19-40).

- If the TXVECTOR parameter TRIGGER_METHOD is TRIGGER_FRAME and the LDPC Extra Symbol Segment field in the Trigger frame is 0, set initial parameters to $N_{SYM,init} = N_{SYM}$, and $a_{init} = a$. Then continue with the LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of 19.3.11.7.5 (LDPC PPDU encoding process), N_{avbits} and N_{punc} are not changed, and $a = a_{init}$.

- If the TXVECTOR parameter TRIGGER_METHOD is TRS then the parameter LDPC_EXTRA_SYMBOL is 1 and initial parameters set to $N_{SYM,init} = F_{VAL} + 1$ and $a_{init} = 3$, where F_{VAL} is the value of the UL Data Symbols subfield of the TRS Control subfield. Then continue with the LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of 19.3.11.7.5 (LDPC PPDU encoding process), always increment N_{avbits} as in Equation (27-70), and always recompute N_{punc} as in Equation (19-40).

27.3.12.6 Stream parser

After scrambling, coding, puncturing and post-FEC padding, the data bits are processed in groups of N_{CBPS} bits. Each of these groups is re-arranged into N_{SS} blocks of N_{CBPSS} bits ($N_{SS,u}$ blocks of $N_{CBPSS,u}$ bits in the case of an HE MU transmission). This operation is referred to as "stream parsing" and is described in this subclause.

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 (27-91).

$$s = max\left(1, \frac{N_{BPSCS}}{2}\right) \tag{27-91}$$

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

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

For the N_{CBPS} bits of each OFDM symbol, S bits from the output of the encoder are divided among all spatial streams, s bits per stream.

NOTE—For all RU sizes the coded bits per OFDM symbol are always evenly allocated to N_{SS} 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

$$i = (i_{SS} - 1)s + S \cdot \left\lfloor \frac{k}{s} \right\rfloor + (k \bmod s)$$

$$i_{SS} = 1, 2, \ldots, N_{SS}$$

$$i = 0, 1, \ldots, N_{CBPS} - 1$$

$$k = 0, 1, \ldots, N_{CBPSS} - 1$$

27.3.12.7 Segment parser

The description in this subclause is for an SU transmission. For an MU transmissions, the rearrangements are carried out in the same way but per user.

For a 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz transmission with a 26-, 52-, 106-, 242-, 484- or 996-tone RU, the segment parser is bypassed and the output bits are as specified in Equation (27-92).

$$y_{k,l} = x_k \tag{27-92}$$

where

- x_k is bit k of a block of N_{CBPSS} bits, $k = 0$ to $N_{CBPSS} - 1$
- l is the frequency subblock index and $l = 0$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU.
- $y_{k,l}$ is bit k of the frequency subblock l

For a 160 MHz and 80+80 MHz transmission with a 2×996-tone RU, the output bits of each stream parser are first divided into blocks of N_{CBPSS} bits ($N_{CBPSS,u}$ bits in the case of an MU transmission). Then, each block is further divided into two frequency subblocks of $N_{CBPSS}/2$ bits as shown in Equation (27-93).

$$y_{k,l} = x_m \tag{27-93}$$

$$m = 2s \cdot \left\lfloor \frac{k}{s} \right\rfloor + l \cdot s + (k \bmod s), \quad k = 0, 1, \ldots, \frac{N_{CBPSS}}{2} - 1 \tag{27-94}$$

and

- x_m is bit m of a block of N_{CBPSS} bits and $m = 0, \ldots, N_{CBPSS} - 1$
- l is the frequency subblock index and $l = 0, 1$
- $y_{k,l}$ is bit k of the frequency subblock l
- s is defined in Equation (27-91)

27.3.12.8 BCC interleavers

For ease of explanation, the operation of the interleaver is described only for the SU case. For user u 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_{CBPS}, and N_{BPSCS} with $N_{SS,u}$, $N_{CBPSS,u}$, $N_{CBPS,u}$ and $N_{BPSCS,u}$, respectively. That is, the operation of the interleaver is the same as if the transmission were an SU one, consisting of bits from only that user.

The BCC interleaver operation is specified in 21.3.10.8 (BCC interleaver). The interleaver parameters, N_{COL}, N_{ROW}, and N_{ROT}, for the Data field depend on the RU size and whether or not DCM is used and are defined in the RU size column of Table 27-35 (BCC interleaver parameters).

Table 27-35—BCC interleaver parameters

DCM	Parameter	RU size (tones)				HE-SIG-A/HE-SIG-B (tones)
		26	52	106	242	56
Not used	N_{COL}	8	16	17	26	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$6 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$4 \times N_{BPSCS}$
	N_{ROT}	2	11	29	58	-
Used	N_{COL}	4	8	17	13	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$2 \times N_{BPSCS}$
	N_{ROT}	2	2	11	29	-

The interleaver parameters, N_{COL} and N_{ROW}, for the HE-SIG-A and HE-SIG-B fields are defined in the HE-SIG-A/HE-SIG-B column of Table 27-35 (BCC interleaver parameters).

NOTE—DCM is not used on the HE-SIG-A field.

27.3.12.9 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 defined in 21.3.10.9 (Constellation mapping).

For 1024-QAM, the mapping of the bits at the output of the stream parser or segment parser (if present) to the complex constellation points is defined in Figure 27-37 (Constellation bit encoding for 1024-QAM (1st quadrant)), Figure 27-38 (Constellation bit encoding for 1024-QAM (2nd quadrant)), Figure 27-39 (Constellation bit encoding for 1024-QAM (3rd quadrant)) and Figure 27-40 (Constellation bit encoding for 1024-QAM (4th quadrant)).

Figure 27-37—Constellation bit encoding for 1024-QAM (1st quadrant)

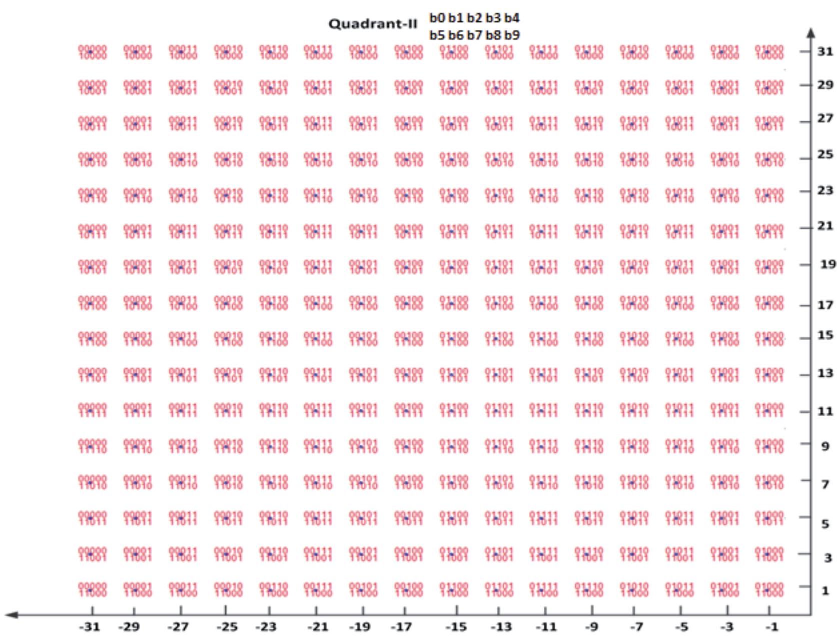

Figure 27-38—Constellation bit encoding for 1024-QAM (2nd quadrant)

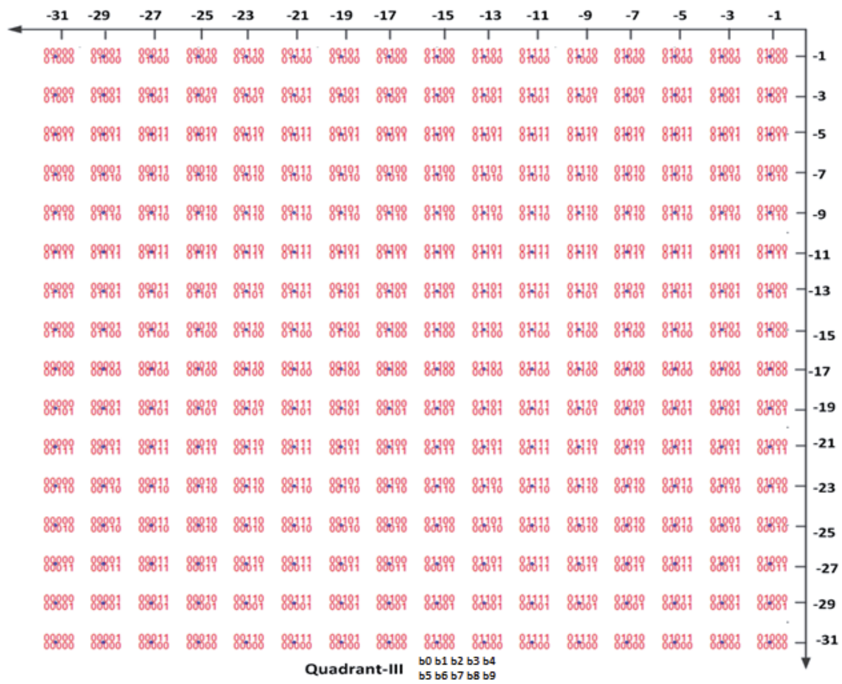

Figure 27-39—Constellation bit encoding for 1024-QAM (3rd quadrant)

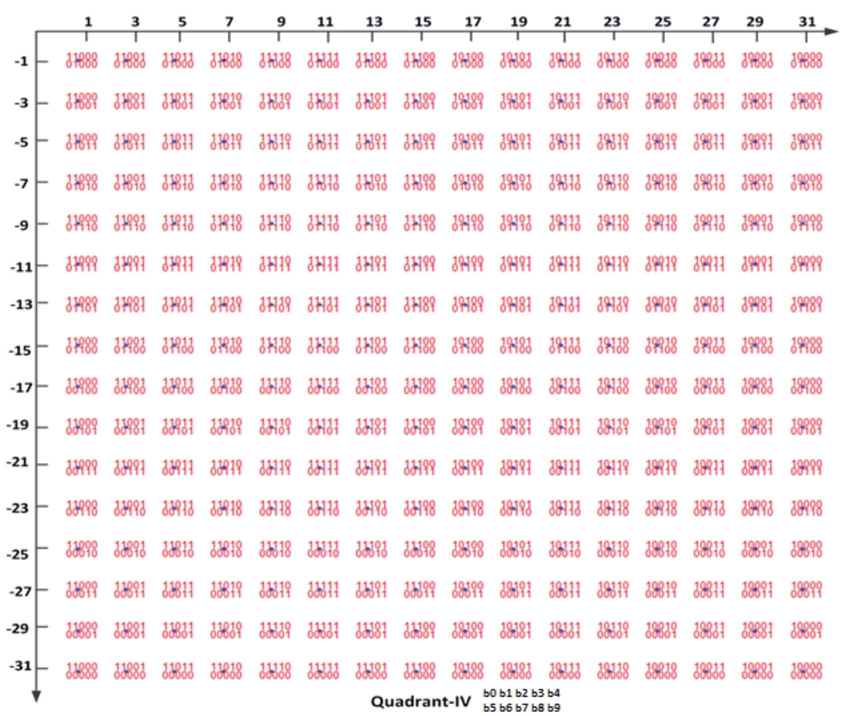

Figure 27-40—Constellation bit encoding for 1024-QAM (4th quadrant)

The bit string convention in Figure 27-37 (Constellation bit encoding for 1024-QAM (1st quadrant)), Figure 27-38 (Constellation bit encoding for 1024-QAM (2nd quadrant)), Figure 27-39 (Constellation bit encoding for 1024-QAM (3rd quadrant)) and Figure 27-40 (Constellation bit encoding for 1024-QAM (4th quadrant)) follows the bit string convention outlined in 17.3.5.8.

The normalization factor K_{mod} for 1024 QAM is $1/\sqrt{682}$.

DCM is an optional modulation scheme for the HE-SIG-B and Data fields. DCM can be applied to an HE SU PPDU and an HE ER SU PPDU. In an HE MU PPDU or HE TB PPDU, DCM can be applied to an RU containing data for one user but cannot be applied to an RU containing data for more than one user.

DCM is applicable to only HE-MCSs 0, 1, 3 and 4. DCM is applicable to only $N_{SS} = 1$ or $N_{SS} = 2$ (in the case of single user RU in an HE MU PPDU, $N_{SS,r,u} = 1$ or $N_{SS,r,u} = 2$). DCM is not applicable with MU-MIMO or with STBC.

If DCM is employed, bit sequences are mapped to a pair of symbols $(d'_k, d'_{q(k)})$ where k is in the range of $0 \le k \le N_{SD} - 1$ and $q(k)$ is in the range of $N_{SD} \le q(k) \le 2N_{SD} - 1$ in order to exploit frequency diversity for a 996-tone or smaller RU, and $0 \le k \le N_{SD}/2 - 1$ and $q(k)$ is in the range of $N_{SD}/2 \le q(k) \le N_{SD} - 1$ for a 2×996-tone RU. To maximize the frequency diversity, the indices of a pair of DCM subcarriers $(k, q(k))$ is $q(k) = k + N_{SD}$ for a 996-tone or smaller RU and $q(k) = k + N_{SD}/2$ for a 2×996-tone RU. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For BPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u} - 1})$. Each bit B_k is BPSK modulated to a sample d'_k. This generates the samples for the lower half of the data subcarriers. For the upper half of the subcarriers, the samples are generated as $d'_{k+N_{SD}} = d'_k \times e^{j(k+N_{SD})\pi}, k = 0, 1, \ldots, N_{SD} - 1$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For QPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u} - 1})$. Each pair of bits (B_{2k}, B_{2k+1}) is QPSK modulated to a symbol d'_k. This generates the constellation points for the lower half the data subcarriers in the RU. For the upper half of the data subcarriers in the RU, $d'_{k+N_{SD}} = conj(d'_k)$, where *conj*() represents the complex conjugate operation. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For 16-QAM modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u} - 1})$. A group of 4 bits $(B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3})$ is 16-QAM modulated to a sample d'_k as described in 17.3.5.8 (Subcarrier modulation mapping). This is the sample on subcarrier k in the lower half. In the upper half, the sample $d'_{k+N_{SD}}$ on subcarrier $k + N_{SD}$ is obtained by 16-QAM modulating a permutation of the bits $(B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3})$. Specifically, $d'_{k+N_{SD}}$ is obtained by applying the 16-QAM modulation procedure in 18.3.5.8 to the bit group $(B_{4k+1}, B_{4k}, B_{4k+3}, B_{4k+2})$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

27.3.12.10 LDPC tone mapper

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

D_{TM_DCM} are constant for each RU size and the values for different RU sizes are given in Table 27-36 (LDPC tone mapping distance for each RU size).

Table 27-36—LDPC tone mapping distance for each RU size

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

NOTE—The LDPC tone mapping parameters D_{TM} and D_{TM_DCM} are applied for each frequency subblock, $l = 0$ and $l = 1$.

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 27.3.12.9 (Constellation mapping)) as defined by Equation (27-95).

$$d''_{t(k),i,n,l,r,u} = d'_{k,i,n,l,r,u} \tag{27-95}$$

where

$$k = \begin{cases} 0, 1, \ldots, N_{SD} - 1 & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD}/2 - 1 & \text{for a 2×996-tone RU} \end{cases}$$

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

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

$$l = \begin{cases} 0 & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 & \text{for a 2×996-tone RU} \end{cases}$$

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

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

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

$$t(k) = \begin{cases} D_{TM}\left(k \bmod \dfrac{N_{SD}}{D_{TM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM}}{N_{SD}} \right\rfloor, & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ D_{TM}\left(k \bmod \dfrac{N_{SD}/2}{D_{TM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM}}{N_{SD}/2} \right\rfloor, & \text{for a 2×996-tone RU} \end{cases}$$

For an HE PPDU with DCM applied to the Data field, 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 27.3.12.9 (Constellation mapping)) as defined by Equation (27-96).

$$d''_{t(k),i,n,l,r,u} = d'_{k,i,n,l,r,u} \tag{27-96}$$

where

$$k = \begin{cases} 0, 1, \ldots, 2N_{SD} - 1 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD} - 1 \text{ for a 2×996-tone RU} \end{cases}$$

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

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

$$l = \begin{cases} 0 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 \text{ for a 2×996-tone RU} \end{cases}$$

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

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

N_{SD} is the number of data tones in the r-th RU if DCM is applied

For a 26-, 52-, 106-, 242-, 484- and 996-tone RU,

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \dfrac{N_{SD}}{D_{TM\_DCM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM\_DCM}}{N_{SD}} \right\rfloor, \text{ for } k < N_{SD} \\ D_{TM\_DCM}\left((k - N_{SD}) \bmod \dfrac{N_{SD}}{D_{TM\_DCM}}\right) + \left\lfloor \dfrac{(k - N_{SD}) \cdot D_{TM\_DCM}}{N_{SD}} \right\rfloor + N_{SD}, \text{ for } k \geq N_{SD} \end{cases}$$

For a 2×996-tone RU,

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \dfrac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, \text{ for } 0 \leq k < N_{SD}/2 \\ D_{TM\_DCM}\left((k - N_{SD}/2) \bmod \dfrac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \dfrac{(k - N_{SD}/2) \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor + N_{SD}/2, \text{ for } N_{SD}/2 \leq k < N_{SD} \end{cases}$$

D_{TM_DCM} is the LDPC tone mapping distance for the r-th RU if DCM is applied.

NOTE—LDPC tone mapper for a 26-, 52-, 106-, 242-, 484- and 996-tone RU is defined as one segment. LDPC tone mapping is performed separately for the upper and lower 80 MHz frequency segments of a 2×996-tone RU as indicated by the frequency subblock index l.

Since LDPC tone mapping is not performed on BCC coded streams, for BCC coded spatial streams, Equation (27-97) applies.

$$d''_{k, i, n, l, r, u} = d'_{k, i, n, l, r, u} \qquad (27\text{-}97)$$

where

$$k = \begin{cases} 0, 1, \ldots, N_{SD} - 1 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD}/2 - 1 \text{ for a 2×996-tone RU} \end{cases}$$

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

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

$$l = \begin{cases} 0 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 \text{ for a 2×996-tone RU} \end{cases}$$

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

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

27.3.12.11 Segment deparser

For a 26-, 52-, 106-, 242-, 484- and 996-tone RU, the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,r,u}$ is specified in Equation (27-98).

$$d^{(i_{Seg})}_{k,i,n,r,u} = d''_{k,i,n,0,r,u}, \quad \text{if } 0 \le k \le N_{SD} - 1,\ i_{Seg} = 0 \tag{27-98}$$

For a 2×996-tone RU in a 160 MHz HE PPDU, the two frequency subblocks at the output of the LDPC tone mapper are combined into one frequency segment as specified in Equation (27-99).

$$d^{(i_{Seg})}_{k,i,n,r,u} = \begin{cases} d''_{k,i,n,0,r,u}, & \text{if } 0 \le k \le \dfrac{N_{SD}}{2} - 1 \\ d''_{k-\frac{N_{SD}}{2},i,n,l,r,u}, & \text{if } \dfrac{N_{SD}}{2} \le k \le N_{SD} - 1 \end{cases},\ i_{Seg} = 0 \tag{27-99}$$

For a 2×996-tone RU in an 80+80 MHz HE PPDU, the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,r,u}$ is specified in Equation (27-100).

$$d^{(i_{Seg})}_{k,i,n,r,u} = d''_{k,i,n,i_{Seg},r,u}, \quad \text{if } 0 \le k \le N_{SD} - 1,\ i_{Seg} = 0, 1 \tag{27-100}$$

NOTE—As per Table 21-7 (center frequency for frequency segment iSeg = 0), $f_c^{(0)}$ is always less than $f_c^{(1)}$ in the case of an 80+80 MHz HE PPDU. Hence, $d''_{k,i,n,0,r,u}$ (frequency subblock 0) is always transmitted in the frequency segment lower in frequency, while $d''_{k,i,n,1,r,u}$ (frequency subblock 1) is always transmitted in the frequency segment higher in frequency.

27.3.12.12 Space-time block coding

For an HE PPDU, STBC is applied only with 1 spatial stream and only if DCM is not applied. Its application is indicated by the STBC field in HE-SIG-A. In an HE MU PPDU, STBC coding is used in all RUs or not used in any of the RUs. If any RU in an HE MU PPDU uses DL MU-MIMO, STBC shall not be used in any RU in the HE MU PPDU.

The STBC encoding process is described in 21.3.10.9.4 (Space-time block coding), with $N_{SS,0} = 1$ and $N_{STS,0} = 2$.

27.3.12.13 Pilot subcarriers

For a user transmitting on the i-th 26-tone RU in a given PPDU BW, two pilot subcarriers shall be inserted in subcarriers $k \in K_{R26_i}$, where K_{R26_i} is given by the i-th pilot index set in the row of given PPDU BW of Table 27-37 (Pilot indices for a 26-tone RU).

Table 27-37—Pilot indices for a 26-tone RU

PPDU BW	K_{R26_i}
20 MHz, i = 1:9	{−116, −102}, {−90, −76}, {−62, −48}, {−36, −22}, {−10, 10}, {22, 36}, {48, 62}, {76, 90}, {102, 116}
40 MHz, i = 1:18	{−238, −224}, {−212, −198}, {−184, −170}, {−158, −144}, {−130, −116}, {−104, −90}, {−78, −64}, {−50, −36}, {−24, −10}, {10, 24}, {36, 50}, {64, 78}, {90, 104}, {116, 130}, {144, 158}, {170, 184}, {198, 212}, {224, 238}
80 MHz, i = 1:37	{−494, −480}, {−468, −454}, {−440, −426}, {−414, −400}, {−386, −372}, {−360, −346}, {−334, −320}, {−306, −292}, {−280, −266}, {−252, −238}, {−226, −212}, {−198, −184}, {−172, −158}, {−144, −130}, {−118, 104}, {−92, −78}, {−64, −50}, {−38, −24}, {−10, 10}, {24, 38}, {50, 64}, {78, 92}, {104, 118}, {130, 144}, {158, 172}, {184, 198}, {212, 226}, {238, 252}, {266, 280}, {292, 306}, {320, 334}, {346, 360}, {372, 386}, {400, 414}, {426, 440}, {454, 468}, {480, 494}
160 MHz, i = 1:74	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier k for symbol n shall be as specified in Equation (27-101).

$$
\begin{aligned}
P_n^{K_{R26_i}} &= \{\Psi_{n \bmod 2}, \Psi_{(n+1) \bmod 2}\} \\
P_n^{k \notin K_{R26_i}} &= 0
\end{aligned}
\tag{27-101}
$$

where

Ψ_m is defined in Table 27-38 (The 2 pilot values for a 26–tone RU)

Table 27-38—The 2 pilot values for a 26–tone RU

Ψ_0	Ψ_1
1	−1

For a user transmitting on the *i*-th 52-tone RU in a given PPDU BW, four pilot subcarriers shall be inserted in subcarriers $k \in K_{R52_i}$, where K_{R52_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 27-39 (Pilot indices for 52-tone RU transmission).

Table 27-39—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 subcarrier indices in 80 MHz –512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (27-102).

$$
\begin{aligned}
P_n^{K_{R52_i}} &= \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\} \\
P_n^{k \notin K_{R52_i}} &= 0
\end{aligned}
\tag{27-102}
$$

where

Ψ_m is defined in Table 27-40 (The 4 pilot values in a 52- and 106-tone RU)

Table 27-40—The 4 pilot values in a 52- and 106-tone RU

Ψ_0	Ψ_1	Ψ_2	Ψ_3
1	1	1	–1

For a user transmitting on the i-th 106-tone RU in a given PPDU BW, four pilot subcarriers shall be inserted at subcarriers $k \in K_{R106_i}$, where K_{R106_i} is given by the i-th pilot index set in the row of given PPDU BW of Table 27-41 (Pilot indices for 106-tone RU transmission).

Table 27-41—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 subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier k for symbol n shall be as specified in Equation (27-103).

$$\begin{aligned} P_n^{K_{R106_i}} &= \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\} \\ P_n^{k \notin K_{R106_i}} &= 0 \end{aligned} \qquad (27\text{-}103)$$

where

Ψ_m is defined in Table 27-40 (The 4 pilot values in a 52- and 106-tone RU)

For a user transmitting on the i-th 242-tone RU in a given PPDU BW, 8 pilot subcarriers shall be inserted in subcarriers $k \in K_{R242_i}$, where K_{R242_i} is given by the i-th pilot index set in the row of given PPDU BW of Table 27-42 (Pilot indices for 242-tone RU transmission).

Table 27-42—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 subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier k for symbol n shall be as specified in Equation (27-104).

$$\begin{aligned} P_n^{K_{R242_i}} &= \{\Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ &\qquad \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}\} \\ P_n^{k \notin K_{R242_i}} &= 0 \end{aligned} \qquad (27\text{-}104)$$

where

Ψ_m is defined in Table 27-43 (The 8 pilot values in a 242-tone RU)

Table 27-43—The 8 pilot values in a 242-tone RU

Ψ_0	Ψ_1	Ψ_2	Ψ_3	Ψ_4	Ψ_5	Ψ_6	Ψ_7
1	1	1	–1	–1	1	1	1

For a user transmitting on the *i*-th 484-tone RU in a given PPDU BW, 16 pilot subcarriers shall be inserted in subcarriers $k \in K_{R484_i}$, where K_{R484_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 27-44 (Pilot indices for 484-tone RU transmission).

Table 27-44—Pilot indices for 484-tone RU transmission

PPDU BW	K_{R484_i}
40 MHz, *i* = 1	{–238, –212, –170, –144, –104, –78, –36, –10, 10, 36, 78, 104, 144, 170, 212, 238}
80 MHz, *i* = 1:2	{–494, –468, –426, –400, –360, –334, –292, –266, –252, –226, –184, –158, –118, –92, –50, –24}, {24, 50, 92, 118, 158, 184, 226, 252, 266, 292, 334, 360, 400, 426, 468, 494}
160 MHz, *i* = 1:4	{pilot subcarrier indices in 80 MHz –512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (27-105).

$$\begin{aligned} P_n^{K_{R484_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ & \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\ & \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\ & \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\ P_n^{k \notin K_{R484_i}} = {} & 0 \end{aligned} \tag{27-105}$$

where

Ψ_m is defined in Table 27-43 (The 8 pilot values in a 242-tone RU)

For a user transmitting on the i-th 996-tone RU in a given PPDU BW, 16 pilot subcarriers shall be inserted in subcarriers $k \in K_{R996_i}$, where K_{R996_i} is given by the i-th pilot index set in the row of given PPDU BW of Table 27-45 (Pilot indices for 996-tone RU transmission).

Table 27-45—Pilot indices for 996-tone RU transmission

PPDU BW	K_{R996_i}
80 MHz, i = 1	{–468, –400, –334, –266, –226, –158, –92, –24, 24, 92, 158, 226, 266, 334, 400, 468}
160 MHz, i = 1:2	{for i = 1 pilot subcarrier indices in 80 MHz –512, for i = 2 pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier k for symbol n shall be as specified in Equation (27-106).

$$
\begin{aligned}
P_n^{K_{R996_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\
& \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\
& \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\
& \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\
P_n^{k \notin K_{R996_i}} = {} & 0
\end{aligned}
\tag{27-106}
$$

where

Ψ_m is defined in Table 27-43 (The 8 pilot values in a 242-tone RU)

For a 160 MHz transmission (equivalently two 996-tone RU transmissions), the 80 MHz (equivalently 996-tone RU) pilot mapping is replicated in the two 80 MHz subchannels of the 160 MHz transmission. Specifically, 32 pilot subcarriers shall be inserted in subcarriers $k \in K_{\mathrm{R2\times996}_i}$, where $K_{\mathrm{R2\times996}_i}$ is given by {–980, –912, –846, –778, –738, –670, –604, –536, –488, –420, –354, –286, –246, –178, –112, –44, 44, 112, 178, 246, 286, 354, 420, 488, 536, 604, 670, 738, 778, 846, 912, 980}. The pilot mapping P_n^k for the subcarrier k for symbol n shall be as specified in Equation (27-107).

$$
\begin{aligned}
P_n^{K_{R2\times996_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\
& \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\
& \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\
& \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8}, \\
& \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\
& \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\
& \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\
& \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\
P_n^{k \notin K_{R2\times996_i}} = {} & 0
\end{aligned}
\tag{27-107}
$$

where

Ψ_m is defined in Table 27-43 (The 8 pilot values in a 242-tone RU)

For a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz pilot subcarrier allocation and values defined for 996-tone RU in 80 MHz transmission as specified in Equation (27-106).

The above pilot mapping shall be copied to all space-time streams before the space-time stream cyclic shifts are applied.

27.3.12.14 OFDM modulation

If midambles are not present, the time domain waveform of the Data field of an HE PPDU that is not an HE TB PPDU for transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ and frequency segment i_{Seg} shall be as defined in Equation (27-108).

$$r_{\text{HE-Data}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} (\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+2+N_{\text{HE-SIG-A}}+N_{\text{HE-SIG-B}}} P_n^k) \\ \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{SYM} - T_{GI,Data} - T_{CS,\text{HE}}(M_{r,u}+m))) \end{array} \right) \tag{27-108}$$

where

T_{SYM} is defined in Table 27-12 (Timing-related constants)

p_n is defined in 17.3.5.10 (OFDM modulation)

P_n^k is defined in 27.3.12.13 (Pilot subcarriers)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space-time stream $M_{r,u}+m$ as defined in 27.3.11.2.2 (Cyclic shift for HE modulated fields)

$T_{GI,Data}$ is the guard interval duration as defined in Table 27-12 (Timing-related constants)

$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)}$ is the transmitted constellation for user u in the r-th RU at subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined by Equation (27-109).

$$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} = \begin{cases} 0, & k \in K_{\text{Pilot}} \\ \tilde{d}_{M_r(k),m,n,r,u}^{(i_{Seg})}, & \text{otherwise} \end{cases} \tag{27-109}$$

where

K_{Pilot} is the set of subcarrier indices of pilot subcarriers, as defined in 27.3.2.4 (Pilot subcarriers)

$M_r(k)$ is defined in Equation (27-110)

$$M_r(k) = k - K_{r,\min} - \left| \{ k' : K_{r,\min} \le k' < k \} \cap K_{\text{Pilot}} \right| \tag{27-110}$$

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 ($k \in K_r$) into the index of data symbols in a transmission over RU r ($0 \le M_r(k) \le N_{SD}$). The subcarrier index k for the data subcarrier is first offset by the minimum value of subcarrier index $K_{r,min}$ (for the lower edge subcarrier) in this RU, and then subtracted by the number of pilot subcarriers falling in between the data subcarrier and the edge subcarrier.

In a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz HE subcarrier mapping as specified in 27.3.10 (Mathematical description of signals).

If midambles are not present, the time domain waveform of the Data field of an HE TB 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 (27-111).

$$r_{\text{HE-Data}, r, u}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{|K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \frac{1}{\sqrt{N_{STS, r, u}}} \sum_{k \in K_r} \sum_{m=1}^{N_{STS, r, u}} \left(\left[Q_{k, u}^{(i_{Seg})} \right]_{i_{TX}, m} (\tilde{D}_{k, m, n, r}^{(i_{Seg}, u)} + p_{n+4} P_n^k) \cdot \exp(j 2\pi k \Delta_{F, \text{HE}}(t - nT_{SYM} - T_{GI, Data} - T_{CS, HE}(M_{r, u} + m))) \right) \quad (27\text{-}111)$$

where

$Q_{k, u}^{(i_{Seg})}$ is defined in 27.3.10 (Mathematical description of signals).

27.3.12.15 Dual carrier modulation

DCM modulates the same information on a pair of subcarriers. DCM is an optional modulation scheme for the HE-SIG-B and Data fields. DCM is applicable to only HE-MCSs and HE-SIG-B-MCSs with indices 0, 1, 3 and 4.

The constellation mapper for DCM is defined in 27.3.12.9 (Constellation mapping). The LDPC tone mapper for DCM is defined in 27.3.12.10 (LDPC tone mapper). The BCC interleaver for DCM is defined in 27.3.12.8 (BCC interleavers).

27.3.12.16 Midambles

An HE STA may include midambles in an HE PPDU transmission in fast varying channels, i.e., channels with high Doppler, to facilitate channel estimation update during the PPDU. Midambles are inserted only if $N_{STS} \le 4$. The recipient might use the midambles to compensate the channel estimation if it is varying fast in channels with high Doppler.

If the Doppler field of the HE-SIG-A field is 1 in an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, or if the Doppler subfield in the Common Info field in the Trigger frame preceding an HE TB PPDU is 1, then midambles are present in the Data field of the HE PPDU every M_{MA} OFDM symbols, where M_{MA} is either 10 or 20 as indicated by the NSTS And Midamble Periodicity field in the HE-SIG-A field (see 27.3.11.7 (HE-SIG-A)) or by the Number Of HE-LTF Symbols And Midamble Periodicity subfield in the Common Info field in the Trigger frame (see 9.3.1.22 (Trigger frame format)).

Each midamble is the same as the HE-LTF field(s) in the preamble of the same PPDU as defined in 27.3.11.10 (HE-LTF), as shown in Figure 27-41 (HE PPDU with midamble).

An HE STA shall not transmit an HE MU PPDU with midambles if there is MU-MIMO on any RU.

The scrambling and encoding process of the bits in the Data field OFDM symbols are identical for transmissions with or without midamble.

If present, the number of midamble periods, N_{MA}, in a PPDU is calculated using Equation (27-112).

$$N_{MA} = max\left(0, \left\lceil \frac{N_{SYM} - 1}{M_{MA}} \right\rceil - 1\right) \tag{27-112}$$

where N_{SYM} is as defined in 27.3.12.5 (Coding).

As shown in Figure 27-41 (HE PPDU with midamble), the first midamble is inserted immediately after the M_{MA}-th OFDM symbol in the Data field, and a midamble is not inserted after the last data OFDM symbol if $\mathrm{mod}(N_{SYM}, M_{MA}) = 0$. At the end of an HE PPDU, if $\mathrm{mod}(N_{SYM}, M_{MA}) = 1$, there is also no midamble inserted before the last OFDM symbol, as shown in Figure 27-42 (Midamble at the end of an HE PPDU).

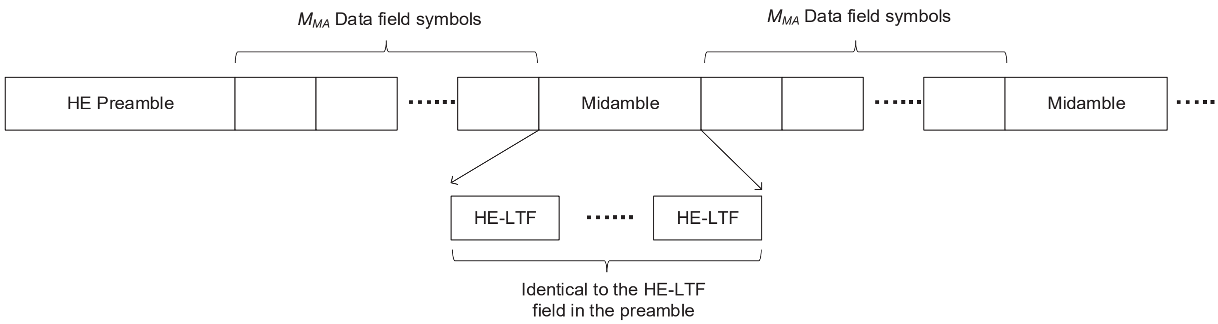

Figure 27-41—HE PPDU with midamble

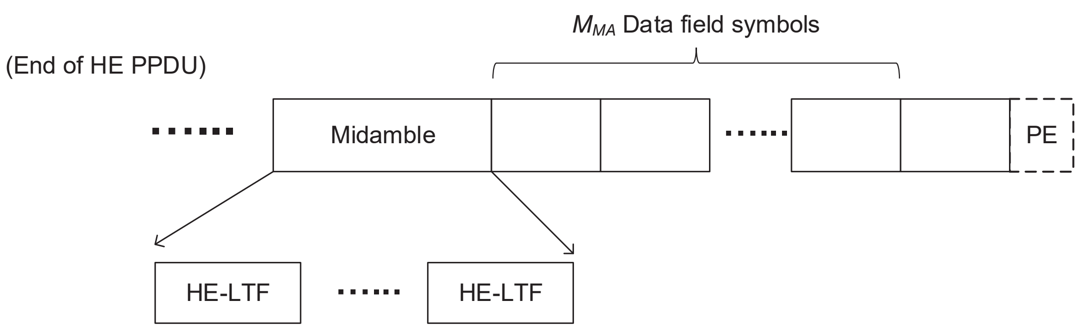

Figure 27-42—Midamble at the end of an HE PPDU

In an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, if the Doppler field of HE-SIG-A field is 1 and $N_{SYM} \leq M_{MA} + 1$, there is no midamble present in the current PPDU. In this case, the Doppler field setting to 1 indicates that the current channel between the transmitter and the recipient is with high channel Doppler, and recommends that midamble may be used for the PPDUs of the reverse link.

27.3.13 Packet extension

A PE field of duration 4 µs, 8 µs, 12 µs, or 16 µs may be present in an HE PPDU. The PE field provides additional receive processing time at the end of the HE PPDU. The PE field, if present, shall be transmitted with the same average power as the Data field and shall not cause significant power leakage outside of the spectrum used by the Data field. Other than that, its content is arbitrary. In an OFDMA HE PPDU, the spectrum used by the Data field for the purpose of packet extension is commensurate with the locations and sizes of the occupied RUs, not the PPDU bandwidth. For example, the Data field an OFDMA HE PPDU using a single 26-tones RU would have a spectrum that is approximately 2 MHz wide.

The duration of the PE field for an HE SU PPDU, HE ER SU PPDU or HE MU PPDU is determined by both the pre-FEC padding factor value in the last OFDM symbol(s) of the Data field, and the TXVECTOR parameter NOMINAL_PACKET_PADDING.

For an HE SU or HE ER SU PPDU, the nominal T_{PE} value ($T_{PE,nominal}$) is given by Table 27-46 (Nominal TPE values). In this case, a in Table 27-46 (Nominal TPE values) is given by Equation (27-71) or Equation (27-72).

For an HE MU PPDU, the nominal T_{PE} value ($T_{PE,nominal}$) is given by Equation (27-113).

$$T_{PE,nominal} = \max_u T_{PE,nominal,u} \tag{27-113}$$

where
$T_{PE,nominal,u}$ is the nominal T_{PE} value for user u and is also given by Table 27-46 (Nominal TPE values)
$\max_u f(u)$ is the maximum value of $f(u)$ over all values of u

In this case, a in Table 27-46 (Nominal TPE values) is given by Equation (27-83) or Equation (27-84).

Table 27-46—Nominal T_{PE} values

a	**TXVECTOR parameter NOMINAL_PACKET_PADDING (HE SU PPDU or HE ER SU PPDU) or NOMINAL_PACKET_PADDING[*u*] (HE MU PPDU)**		
	0 µs	**8 µs**	**16 µs**
1	0 µs	0 µs	4 µs
2	0 µs	0 µs	8 µs
3	0 µs	4 µs	12 µs
4	0 µs	8 µs	16 µs

The duration of the PE field, T_{PE}, may take values of 0, 4, 8, 12 or 16 µs. T_{PE} for an HE SU, HE ER SU or HE MU PPDU shall not be less than $T_{PE,nominal}$. T_{PE} for an HE SU, HE ER SU or HE MU PPDU should be equal to $T_{PE,nominal}$ to minimize the packet extension overhead. Figure 27-43 (PE field duration of an HE SU PPDU or HE ER SU PPDU without midambles if TXVECTOR parameter NOMINAL_PACKET_PAD-DING is 8 µs and TPE = TPE,nominal) and Figure 27-44 (PE field duration of an HE SU PPDU or HE ER SU PPDU without midambles if TXVECTOR parameter NOMINAL_PACKET_PADDING is 16 µs TPE = TPE,nominal) show examples of the PE field duration in an HE SU PPDU or HE ER SU PPDU without midambles if the TXVECTOR parameter NOMINAL_PACKET_PADDING is 8 µs and 16 µs, respectively, and $T_{PE} = T_{PE,nominal}$. STBC is not used in these examples.

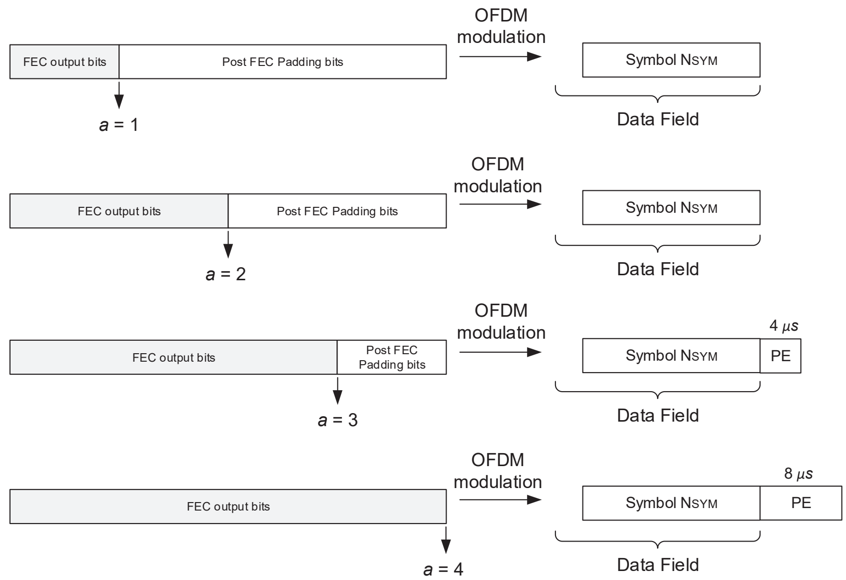

Figure 27-43—PE field duration of an HE SU PPDU or HE ER SU PPDU without midambles if TXVECTOR parameter NOMINAL_PACKET_PADDING is 8 µs and $T_{PE} = T_{PE,nominal}$

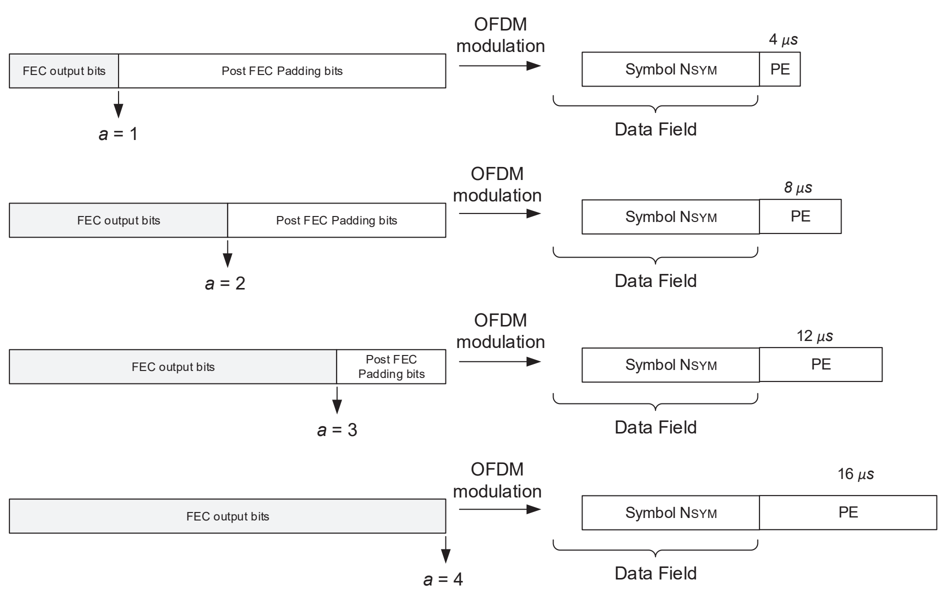

Figure 27-44—PE field duration of an HE SU PPDU or HE ER SU PPDU without midambles if TXVECTOR parameter NOMINAL_PACKET_PADDING is 16 µs $T_{PE} = T_{PE,nominal}$

T_{PE} for an HE sounding NDP is 4 µs.

If transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER_METHOD is TRIGGER_FRAME, each transmitter of an HE TB PPDU shall append a PE field with a duration T_{PE} calculated using Equation (27-114) except for an HE TB feedback NDP (see 27.3.4 (HE PPDU formats)), which has $T_{PE} = 0$.

$$T_{PE} = \left\lfloor \frac{\left(\frac{\mathrm{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}}\right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \quad (27\text{-}114)$$

where

$m = 2$ for an HE TB PPDU

LENGTH is the value indicated by UL Length subfield of the Common Info field in the Trigger frame

$T_{\text{HE-PREAMBLE}}$ is the value for an HE TB PPDU in Equation (27-121)

$T_{\text{HE-STF-T}}$, $T_{\text{HE-LTF-SYM}}$, $T_{\text{RL-SIG}}$ and $T_{\text{HE-SIG-A}}$ are defined in Table 27-12 (Timing-related constants)

N_{MA} is the number of midamble periods in the current PPDU

$$N_{SYM} = \left\lfloor \left(\frac{\mathrm{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}\right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}} \quad (27\text{-}115)$$

$b_{\text{PE-Disambiguity}}$ is the value of the TXVECTOR parameter HE_TB_PE_DISAMBIGUITY

There are multiple methods for computing N_{MA} for an HE TB PPDU that get the same result, one example is as follows. The duration of one midamble period is defined in Equation (27-116).

$$T_{MA} = M_{MA} T_{SYM} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \quad (27\text{-}116)$$

where M_{MA} is the midamble periodicity indicated by the Number of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field in the Trigger frame. Equation (27-117) for computing N_{MA} can be used instead of Equation (27-112).

$$N_{MA} = \begin{cases} 0, \text{ if Doppler} = 0 \\ max\left(0, \left\lfloor \left(\frac{LENGTH + 3 + m}{3} \times 4 - T_{\text{HE-PREAMBLE}} - (b_{\text{PE-Diambiguity}} + 2) \cdot T_{SYM}\right) / T_{MA} \right\rfloor\right), \text{ if Doppler} = 1 \end{cases} \quad (27\text{-}117)$$

where Doppler is indicated by the Doppler subfield of the Common Info field of the Trigger frame.

If transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER_METHOD is TRS, each transmitter of the HE TB PPDU shall append a PE field with the duration T_{PE} equal to the value specified in the TXVECTOR parameter DEFAULT_PE_DURATION.

The PE Disambiguity field of the HE-SIG-A field for an HE SU, HE ER SU (see Table 27-18 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU)) or HE MU PPDU (see Table 27-20 (HE-SIG-A field of an HE MU PPDU)) shall be set to 1 if the condition in Equation (27-118) is met, otherwise it shall be set to 0.

The PE Disambiguity subfield in the Common Info field of the Trigger frame (see Table 9-31f (Pre-FEC Padding Factor and PE Disambiguity subfields)) shall be set to 1 if the condition in Equation (27-118) is met for the HE TB PPDU solicited by the Trigger frame. Otherwise, it shall be set to 0.

$$T_{PE} + 4 \times \left(\left\lceil \frac{\mathrm{TXTIME} - SignalExtension - 20}{4} \right\rceil - \left(\frac{\mathrm{TXTIME} - SignalExtension - 20}{4}\right)\right) \geq T_{SYM} \quad (27\text{-}118)$$

where

T_{PE} is the PE field duration

T_{SYM} is the symbol duration of the Data field as defined in 27.3.9 (Timing-related parameters)

TXTIME (in µs) is defined in 27.4.3 (TXTIME and PSDU_LENGTH calculation)

SignalExtension is 0 µs if TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table 27-55 (HE PHY characteristics) if TXVECTOR parameter NO_SIG_EXTN is false

The receiver computes N_{SYM}, T_{PE} and N_{MA} using Equation (27-119), Equation (27-120) and Equation (27-122), respectively.

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}} \qquad (27\text{-}119)$$

$$T_{PE} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} \right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \qquad (27\text{-}120)$$

where

L_LENGTH is the value indicated by the LENGTH field of the L-SIG field

$$T_{\text{HE-PREAMBLE}} = \begin{cases} T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-T}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE TB PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE SU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE MU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A-R}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE ER SU PPDU} \end{cases} \qquad (27\text{-}121)$$

$T_{\text{RL-SIG}}$, $T_{\text{HE-STF-T}}$, $T_{\text{HE-STF-NT}}$, $T_{\text{HE-LTF-SYM}}$, $T_{\text{HE-SIG-A}}$, $T_{\text{HE-SIG-A-R}}$, $T_{\text{HE-SIG-B}}$ are defined in Table 27-12 (Timing-related constants)

$N_{\text{HE-SIG-B}}$, $N_{\text{HE-LTF}}$ are defined in Table 27-15 (Frequently used parameters)

$b_{\text{PE-Disambiguity}}$ is the value indicated by the PE Disambiguity subfield of the HE-SIG-A field for an HE SU, HE ER SU or HE MU PPDU, or the value indicated by the PE Disambiguity subfield in the Common Info field in the Trigger frame (see Table 9-31f (Pre-FEC Padding Factor and PE Disambiguity subfields)) for an HE TB PPDU.

N_{MA} may be computed by multiple methods that get the same result, one example of which is given in Equation (27-122).

$$N_{MA} = \begin{cases} 0, \text{ if Doppler} = 0 \\ max\left(0, \left\lfloor \left(\frac{\text{L\_LENGTH} + 3 + m}{3} \times 4 - T_{\text{HE-PREAMBLE}} - (b_{\text{PE-Diambiguity}} + 2) \cdot T_{SYM} \right) / T_{MA} \right\rfloor \right), \text{ if Doppler} = 1 \end{cases} \qquad (27\text{-}122)$$

where

T_{MA} is defined in Equation (27-116) except that M_{MA} is the midamble periodicity indicated by the NSTS And Midamble Periodicity subfield of the HE-SIG-A field in an HE SU PPDU and HE ER SU PPDU, or by the Number Of HE-LTF Symbols And Midamble Periodicity subfield of the HE-SIG-A field in an HE MU PPDU.

Doppler is indicated by the Doppler field of HE-SIG-A field.

27.3.14 Non-HT duplicate transmission

If 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 and HE STAs that may be present in a part of a 40 MHz, 80 MHz, or 160 MHz channel (see Table 21-2 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters)). The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF fields are not transmitted.

The L-STF and L-LTF fields shall be transmitted in the same way as in the HE transmission. The L-SIG field shall be transmitted in the same way as in the HE transmission, with the following exceptions:

- The Rate and Length fields shall follow 17.3.4 (SIGNAL field)
- The four additional subcarriers at indices ±27 and ±28 are not modulated (no energy)

NOTE—The L-STF, L-LTF and L-SIG fields are not transmitted in 20 MHz subchannels in which the preamble is punctured (see 27.3.7 (HE modulation and coding schemes (HE-MCSs))).

In a 40 MHz non-HT duplicate transmission, the Data field shall be as defined by Equation (19-61).

For 80 MHz and 160 MHz non-HT duplicate transmissions, the Data field shall be as defined by Equation (27-123).

$$r^{i_{TX}}_{\text{non-HT},\,BW}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{NON\_HT\_DUP\_OFDM-Data}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \left(\begin{array}{l} (1 - \text{INACTIVE\_SUBCHANNELS}[i_{BW}]) \displaystyle\sum_{k=-26}^{26} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,BW}(D_{k,n} + p_{n+1}P_k) \\ \quad \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{BW}))\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{\text{CS}})) \end{array} \right) \tag{27-123}$$

where

N_{20MHz} and $K_{Shift}(i)$ are defined in 21.3.8.2.4

P_k and P_n are defined in 17.3.5.10

$D_{k,n}$ is defined in Equation (21-26)

$\Upsilon_{k,\,BW}$ is defined in Equation (21-16) and Equation (21-17)

$T^{i_{TX}}_{CS}$ represents the cyclic shift for transmit chain i_{TX} with a value given in Table 21-10.

$N^{\text{Tone}}_{\text{NON\_HT\_DUP\_OFDM-Data}}$ has the value given in Table 27-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

INACTIVE_SUBCHANNELS[x] is bit x of the TXVECTOR parameter INACTIVE_SUBCHANNELS if present, and is 0, otherwise.

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 Equation (27-123).

For each non-HT duplicate PPDU transmission that is a preamble punctured PPDU, each punctured 20 MHz subchannel is indicated as punctured by including the value of 113 (01110001 in binary representation) in the 8 bits of the TXVECTOR parameter RU_ALLOCATION corresponding to the 242-tone RU that is most closely aligned with the punctured 20 MHz subchannel. Each 20 MHz subchannel that is not punctured is indicated as such by including the value of 192 (11000000 in binary representation) in the 8 bits of the TXVECTOR parameter RU_ALLOCATION corresponding to the 242-tone RU that is most closely aligned with that 20 MHz subchannel.

27.3.15 Transmit requirements for PPDUs sent in response to a triggering frame

27.3.15.1 Introduction

An AP may solicit simultaneous HE TB PPDU transmissions, or simultaneous non-HT or non-HT duplicate PPDU transmissions from multiple non-AP STAs using a triggering frame. Since there are multiple transmitters, transmission time, frequency, sampling symbol clock, and power pre-correction (in the case of an HE TB PPDU) by the non-AP STAs is necessary to mitigate synchronization and interference issues at the AP. Frequency and sampling clock pre-corrections are needed to prevent inter-carrier interference. Power pre-correction is necessary to control interference between HE TB PPDU transmissions from the non-AP STAs. An AP may solicit simultaneous HE TB PPDU transmissions from both Class A and Class B devices. A non-AP STA that supports HE TB PPDU transmission shall support power pre-correction as described in 27.3.15.2 (Power pre-correction) and shall meet the pre-correction accuracy requirements described in 27.3.15.3 (Pre-correction accuracy requirements).

27.3.15.2 Power pre-correction

Each STA that is scheduled in a triggering frame calculates the UL transmit power, Tx_{pwr}^{STA}, of the HE TB PPDU for the assigned HE-MCS using Equation (27-124).

$$Tx_{pwr}^{STA} = PL_{DL} + Target_{RSSI} \tag{27-124}$$

where

PL_{DL} represents DL pathloss

$Target_{RSSI}$ represents the target receive signal power of the HE TB PPDU averaged over the AP's antenna connectors. $Target_{RSSI}$ is the value, in dBm, indicated in the UL Target RSSI subfield of User Info field in Trigger frame or the TRS control field.

NOTE—A value of 127 in the UL Target RSSI subfield indicates that the HE TB PPDU is transmitted at its maximum transmit power for the assigned HE-MCS, and Equation (27-124) is not used.

Each STA computes PL_{DL} using Equation (27-125).

$$PL_{DL} = Tx_{pwr}^{AP} - DL_{RSSI} \tag{27-125}$$

where

Tx_{pwr}^{AP} is in dBm and represents the AP's transmission power and is equal to the value of the AP Tx Power subfield of the Common Info field in the Trigger frame, the encoding of which is specified in 9.3.1.22 (Trigger frame format) or the DL Tx Power subfield of the TRS Control field as specified in 9.2.4.6a.1 (TRS Control).

DL_{RSSI} represents the RSSI at the antenna connector(s) of the STA of the triggering PPDU normalized to 20 MHz bandwidth. DL_{RSSI} in dBm is an average of the received power over the antennas on which the average PL_{DL} is being computed. If the triggering PPDU is a HT-mixed, VHT or HE PPDU, then the received power is measured from the fields prior to the HT-STF, VHT-STF or HE-STF, respectively.

NOTE—An AP could account for its beamforming gain in Tx_{pwr}^{AP} or $Target_{RSSI}$ if the triggering PPDU used beamforming.

A STA that applies beamforming (BF) in the UL should take the BF gain into account when calculating the transmit power needed to meet the target RSSI.

The UL transmit power of the HE TB PPDU is further subject to a STA's minimum and maximum transmit power limit due to hardware capability, regulatory requirements and local maximum transmit power levels (see 11.8.5 (Specification of regulatory and local maximum transmit power levels)) as well as non-802.11 in-device coexistence requirements.

A STA that is scheduled in a Trigger frame includes its UL power headroom in the HE TB PPDU following the rules defined in 26.5.2.3 (Non-AP STA behavior for UL MU operation).

27.3.15.3 Pre-correction accuracy requirements

A STA that transmits an HE TB PPDU shall support per chain max(*P*–32, –10) dBm as the minimum transmit power, where *P* is the maximum power, in dBm, that the STA can transmit at the antenna connector of that chain using HE-MCS 0 while meeting the transmit EVM and spectral mask requirements. A STA transmitting at and above the minimum power shall support the EVM requirements for HE-MCS 7.

A STA that transmits an HE TB PPDU shall support the absolute and relative transmit power requirements and the RSSI measurement accuracy requirements defined in Table 27-47 (Transmit power and RSSI measurement accuracy).

Table 27-47—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	±3 dB	±5 dB	The difference between the RSSI and the received power. Requirements are valid from minimum receive to maximum receive input power.
Relative transmit power accuracy	N/A	±3 dB	Accuracy of achieving a change in transmit power for consecutive HE TB PPDU. The relative transmit power accuracy is applicable only to Class B devices.

The absolute transmit power accuracy is applicable for the entire range of transmit power that the STA is intending to use for the current band of operation. The RSSI accuracy requirements shall be applied to receive signal level range from –82 dBm to –20 dBm in the 2.4 GHz band and –82 dBm to –30 dBm in the 5 GHz and 6 GHz bands. The requirements are for nominal (room) temperature conditions. The RSSI shall be measured during the reception of the non-HE portion of the HE PPDU preamble.

A STA compensates for carrier frequency offset (CFO) error and symbol clock error with respect to the corresponding triggering PPDU when transmitting the following types of PPDUs:

— HE TB PPDU

— Non-HT or non-HT duplicate PPDU with the TXVECTOR parameter TRIGGER_RESPONDING set to true

NOTE—The MU-RTS Trigger frame is the only Trigger frame that solicits transmission of a non-HT or non-HT duplicate PPDU and not an HE TB PPDU. The non-HT or non-HT duplicate PPDU transmitted as a response to an MU-RTS Trigger frame carries a CTS frame.

After compensation, the absolute value of residual CFO error with respect to the corresponding triggering PPDU shall not exceed the following levels when measured at the 10% point of the complementary cumulative distribution function (CCDF) of CFO errors in AWGN at a received power of –60 dBm in the primary 20 MHz:

— 350 Hz for the data subcarriers of an HE TB PPDU

— 2 kHz for a non-HT PPDU or non-HT duplicate PPDU

The residual CFO error measurement on an HE TB PPDU shall be made after the HE-SIG-A field. The residual CFO error measurement on the non-HT or non-HT duplicate PPDU shall be made after the L-STF field. The symbol clock error shall be compensated by the same ppm amount as the CFO error.

A STA that transmits an HE TB PPDU, non-HT PPDU, or non-HT duplicate PPDU in response to a triggering PPDU shall ensure that the transmission start time of the HE TB PPDU, non-HT PPDU, or non-HT duplicate PPDU is within ±0.4 µs + 16 µs from the end, at the STA's antenna connector, of the last OFDM symbol of the triggering PPDU (if it contains no PE field) or of the PE field of the triggering PPDU (if the PE field is present).

NOTE—This end instant is before any signal extension, so this is equivalent to HE TB PPDU transmission within 0.4 µs of SIFS after the end of the triggering PPDU including signal extension.

27.3.16 SU-MIMO and DL MU-MIMO beamforming

27.3.16.1 General

SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones.

For SU-MIMO and 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_r is the set of used subcarrier indices in RU r, and $k \in K_r$) at beamformee u, $\boldsymbol{y}_{k,u} = [y_{k,0}, y_{k,1}, \ldots, y_{k,N_{RX_u}-1}]^T$, is shown in Equation (27-126), where $\boldsymbol{x}_k = [\boldsymbol{x}_{k,0}^T, \boldsymbol{x}_{k,1}^T, \ldots, \boldsymbol{x}_{k,N_{user,r}-1}^T]^T$ denotes the transmit signal vector in subcarrier k for all $N_{user,r}$ beamformees, with $\boldsymbol{x}_{k,u} = [x_{k,0}, x_{k,1}, \ldots, x_{k,N_{STS,r,u}-1}]^T$ being the transmit signal for beamformee u.

$$\boldsymbol{y}_{k,u} = \boldsymbol{H}_{k,u} \times [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}] \times \boldsymbol{x}_k + \boldsymbol{n} \tag{27-126}$$

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 (see Table 27-15 (Frequently used parameters)) in RU r

$\boldsymbol{n}$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission.

For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field).

27.3.16.2 Beamforming feedback matrix *V*

Upon receipt of an HE sounding NDP, the beamformee computes a set of matrices for feedback to the beamformer as described in 21.3.11.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU) from the measured channel before computing a set of matrices for feedback to the beamformer.

The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k in RU r shall be compressed in the form of angles using the method described in 19.3.12.3.6 (Compressed beamforming feedback matrix). The angles, $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 9-76 (Quantization of angles) with b_ψ defined by the Codebook Information field of the HE MIMO Control field (see 9.4.1.64 (HE MIMO Control field)). The compressed beamforming feedback matrix as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix) is the only Clause 27 (High Efficiency (HE) PHY specification) beamforming feedback matrix defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the HE sounding NDP.

After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (19-79). For SU-MIMO beamforming, the beamformer uses $V_{k,0}$, matrix to determine the steering matrix Q_k. For DL MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ using $V_{k,u}$ and $\Delta SNR_{k,u}$ $(0 \le u \le N_{user,r}-1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

27.3.16.3 CQI feedback

If the HE NDP Announcement frame requests CQI feedback, then upon receipt of the HE sounding NDP, the beamformee computes CQI feedback as described in 9.4.1.67 (HE CQI Report field). The CQI feedback, $CQI_{s,r,u}$, for beamformee u in RU r for space-time stream s shall be estimated using the method described in 9.4.1.67 (HE CQI Report field). The CQI values to be fed back are derived from quantized SNRs according to Table 9-93h (Average SNR of RU index k for space-time stream i subfield). The beamformee shall transmit the CQI feedback for space-time stream 1, …, Nc for each of the RU indices for which the CQI report is being requested by the beamformer. The beamformer may use the CQI feedback to determine the best range of RUs for a compressed beamforming/CQI report or for RU assignment during a subsequent MU transmissions. The actual use is implementation specific.

27.3.17 HE sounding NDP

The HE sounding NDP is a variant of the HE SU PPDU. The format of an HE sounding NDP is defined in Figure 27-45 (HE sounding NDP format).

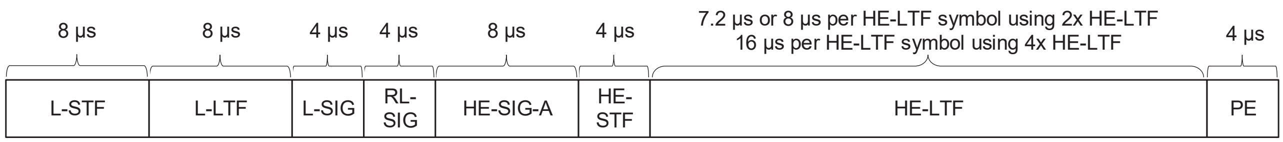

Figure 27-45—HE sounding NDP format

NOTE—The number of HE-LTF symbols in the HE sounding NDP is indicated in the NSTS And Midamble Periodicity field in the HE-SIG-A field.

The HE sounding NDP has the following properties:

— Uses the HE SU PPDU format but without the Data field

— Has a PE field that is 4 µs in duration

The HE sounding NDP overlapping the 242-tone RUs corresponding to bits with a value of 1 in the bitmap of the TXVECTOR parameter INACTIVE_SUBCHANNELS or overlapping a punctured center 26-tone RU of an HE sounding NDP are punctured. The center 26-tone RU of the HE sounding NDP is punctured if either one of the adjacent 242-tone RUs is punctured.

It is mandatory to support the 2x HE-LTF with 0.8 µs GI and 2x HE-LTF with 1.6 µs GI. It is optional to support the 4x HE-LTF with 3.2 µs GI. The other combinations of HE-LTF type and GI duration are disallowed.

If the Beamformed field in HE-SIG-A of an HE sounding NDP is 1, then the receiver of the HE sounding NDP should not perform channel smoothing when generating the compressed beamforming feedback report.

27.3.18 HE TB feedback NDP

The HE TB feedback NDP is used to carry the NDP feedback report information as introduced in 26.5.7 (NDP feedback report procedure). The PPDU structure of an HE TB feedback NDP is shown in Figure 27-46 (HE TB feedback NDP format).

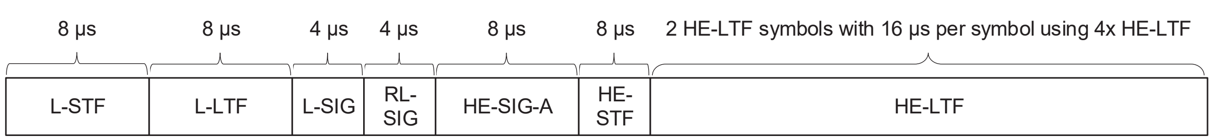

Figure 27-46—HE TB feedback NDP format

The HE TB feedback NDP has the following properties:

— Uses the HE TB PPDU format but without the Data field and PE field

— Has two 4x HE-LTF symbols

— 4x HE-LTF with 3.2 µs GI is the only HE-LTF type and GI duration combination for the HE-LTF

— The generation of HE-LTF symbols for the HE TB feedback NDP is defined in 27.3.11.10 (HE-LTF)

— The HE-STF and the pre-HE modulated fields are transmitted only on the 20 MHz channel where the STA is assigned

27.3.19 Transmit specification

27.3.19.1 Transmit spectral mask

The bandwidth of the spectral mask applied to an HE SU PPDU, an HE TB PPDU and an HE MU PPDU with the Bandwidth field of the HE-SIG-A field equal to 0, 1, 2 or 3 shall be determined by the bandwidth indicated in the Bandwidth field of the HE-SIG-A field. The bandwidth of the spectral mask applied to an HE ER SU PPDU is 20 MHz. The bandwidth of the spectral mask applied to an HE MU PPDU with the Bandwidth field of the HE-SIG-A field equal to 4 or 5 is 80 MHz. The bandwidth of the spectral mask applied to an HE MU PPDU with the Bandwidth field of the HE-SIG-A field equal to 6 or 7 is 160 MHz. All HE PPDU formats shall be compliant with the transmit spectral mask described in this section.

NOTE 1—In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements and the mask defined in this subclause.

NOTE 2—Transmit spectral mask figures in this subclause are not drawn to scale.

NOTE 3—For rules regarding transmit center frequency leakage levels, see 27.3.19.4.2 (Transmit center frequency leakage). The spectral mask requirements in this subclause do not apply to the RF LO.

For a 20 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 19.5 MHz, –20 dBr at 10.5 MHz frequency offset, –28 dBr at 20 MHz frequency offset, and –40 dBr at 30 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets between 9.75 and 10.5 MHz, 10.5 and 20 MHz, and 20 and 30 MHz shall be linearly interpolated in dB domain from the requirements for 9.75 MHz, 10.5 MHz, 20 MHz, and 30 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and –53 dBm/MHz at any frequency offset. Figure 27-47 (Example transmit spectral mask for a 20 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –53 dBm/MHz.

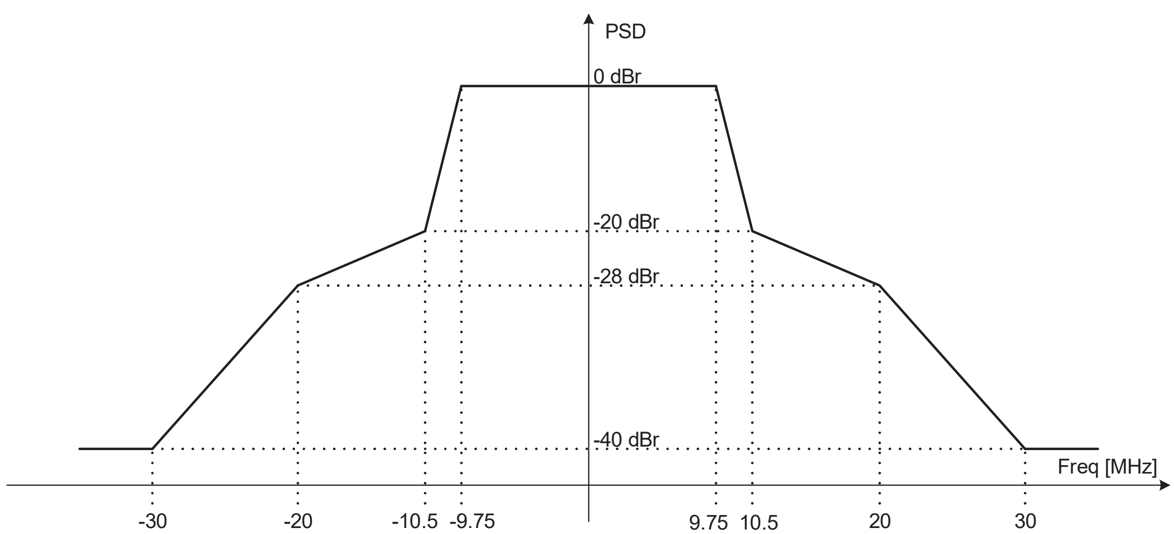

Figure 27-47—Example transmit spectral mask for a 20 MHz mask PPDU

For a 40 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 39 MHz, –20 dBr at 20.5 MHz frequency offset, –28 dBr at 40 MHz frequency offset, and –40 dBr at 60 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 19.5 and 20.5 MHz, 20.5 and 40 MHz, and 40 and 60 MHz shall be linearly interpolated in dB domain from the requirements for 19.5 MHz, 20.5 MHz, 40 MHz, and 60 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and –56 dBm/MHz at any frequency offset greater than 19.5 MHz. Figure 27-48 (Example transmit spectral mask for a 40 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –56 dBm/MHz.

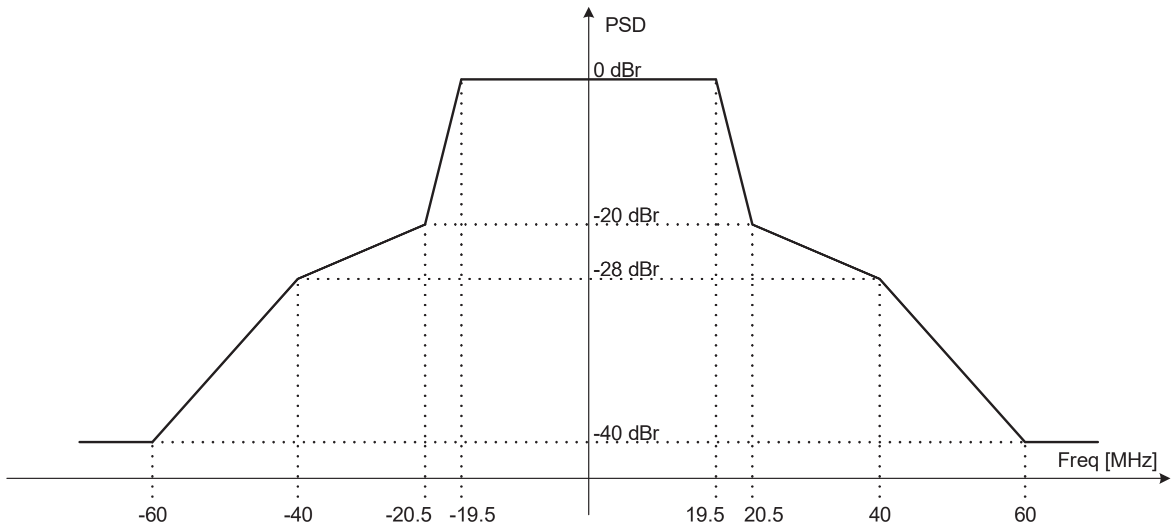

Figure 27-48—Example transmit spectral mask for a 40 MHz mask PPDU

For an 80 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 79 MHz, –20 dBr at 40.5 MHz frequency offset, –28 dBr at 80 MHz frequency offset, and –40 dBr at 120 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 39.5 and 40.5 MHz, 40.5 and 80 MHz, and 80 and 120 MHz shall be linearly interpolated in dB domain from the requirements for 39.5 MHz, 40.5 MHz, 80 MHz, and 120 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 27-49 (Example transmit spectral mask for an 80 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.

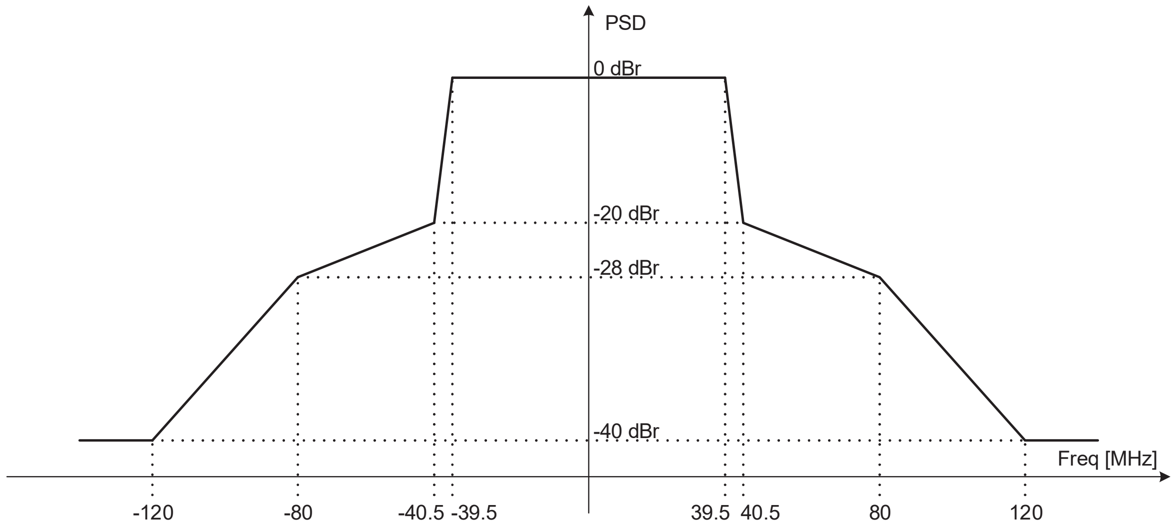

Figure 27-49—Example transmit spectral mask for an 80 MHz mask PPDU

For a 160 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 159 MHz, –20 dBr at 80.5 MHz frequency offset, –28 dBr at 160 MHz frequency offset, and –40 dBr at 240 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 79.5 and 80.5 MHz, 80.5 and 160 MHz, and 160 and 240 MHz shall be linearly interpolated in dB domain from the requirements for 79.5 MHz, 80.5 MHz, 160 MHz, and 240 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 27-50 (Example transmit spectral mask for a 160 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.

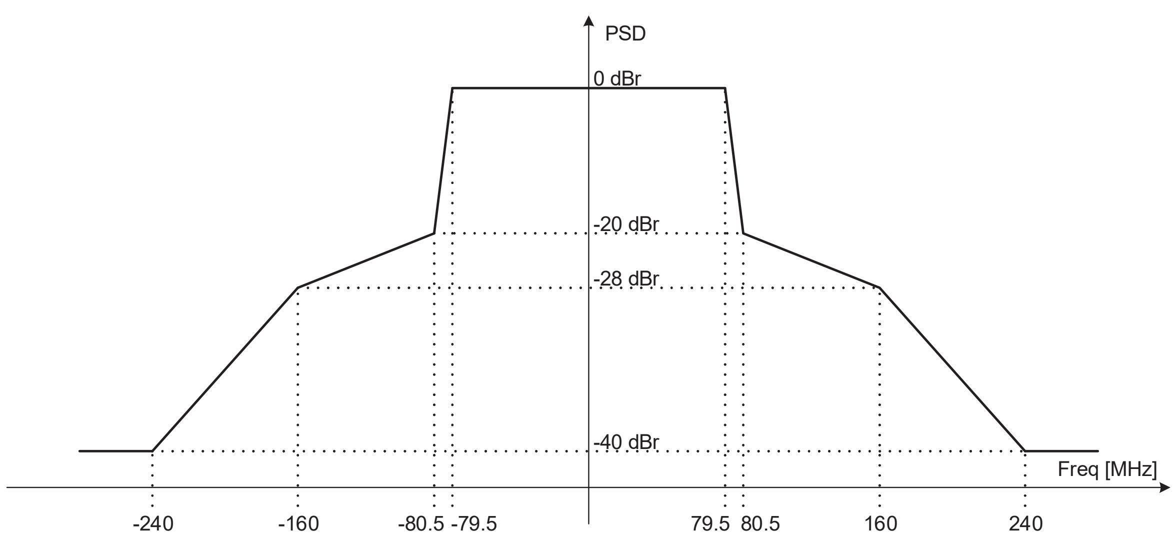

Figure 27-50—Example transmit spectral mask for a 160 MHz mask PPDU

For an 80+80 MHz mask PPDU of HE format, the overall transmit spectral mask is constructed in the following manner. First, the 80 MHz interim spectral mask is placed on each of the two 80 MHz segments. For each frequency at which either of the 80 MHz interim spectral mask has value equal to 0 dBr, then 0 dBr shall be taken as the overall interim spectral mask value. Then, for each frequency at which both of the 80 MHz interim spectral masks have values greater than –40 dBr and less than –20 dBr, the sum of the two interim mask values (summed in linear domain) shall be taken as the overall interim spectral mask value. Next, for each frequency at which neither of the two 80 MHz interim masks have values greater than or equal to –20 dBr, the higher value of the two interim masks shall be taken as the overall interim spectral mask value. Finally, for any frequency region where the overall interim spectral mask value has not been defined yet, linear interpolation (in dB domain) between the nearest two frequency points with the overall interim spectral mask value defined shall be used to define the overall interim spectral mask value. The transmit spectrum shall not exceed the maximum of the overall interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 27-51 (Example transmit spectral mask for an 80+80 MHz mask PPDU) shows an example of a transmit spectral mask for a noncontiguous transmission using two 80 MHz channels where the center frequency of the two 80 MHz channels are separated by 160 MHz and the –40 dBr spectrum level is above –59 dBm/MHz.

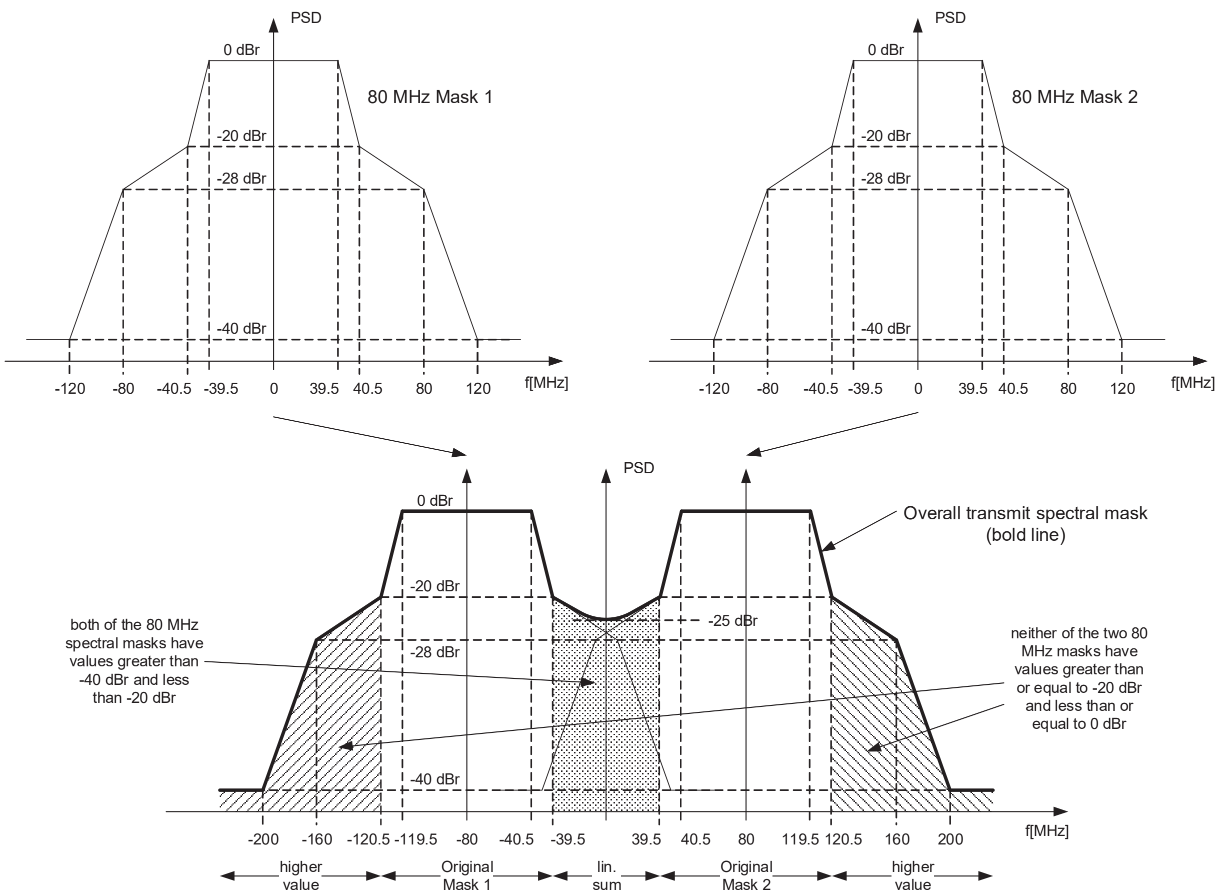

Figure 27-51—Example transmit spectral mask for an 80+80 MHz mask PPDU

Different center frequency separation between the two 80 MHz frequency segments of the spectral mask as well as different peak levels of each 80 MHz frequency segment of the spectral mask are possible, in which case a similar procedure in determining the spectral mask as in Figure 27-51 (Example transmit spectral mask for an 80+80 MHz mask PPDU) is followed.

The transmit spectral mask for noncontiguous transmissions using two nonadjacent 80 MHz channels is applicable only in regulatory domains that allow for such transmissions.

Measurements shall be made using a 100 kHz resolution bandwidth and a 7.5 kHz video bandwidth.

For preamble puncture, the signal leakage to the preamble punctured channel from the occupied subchannels shall be less than or equal to –20 dBr (dB relative to the maximum spectral density of the signal) starting 0.5 MHz from the boundary of the preamble punctured channel. Denote the number of 20 MHz punctured channels by *N*.

An example transmit spectral mask for an *N*×20 MHz preamble punctured channel with transmission on the both the upper and lower subchannels is shown in Figure 27-52 (Example transmit spectral mask for the N×20 MHz preamble punctured channel with transmissions on both upper and lower subchannels), where the X axis in the plot is centered in the middle of the punctured subbands.

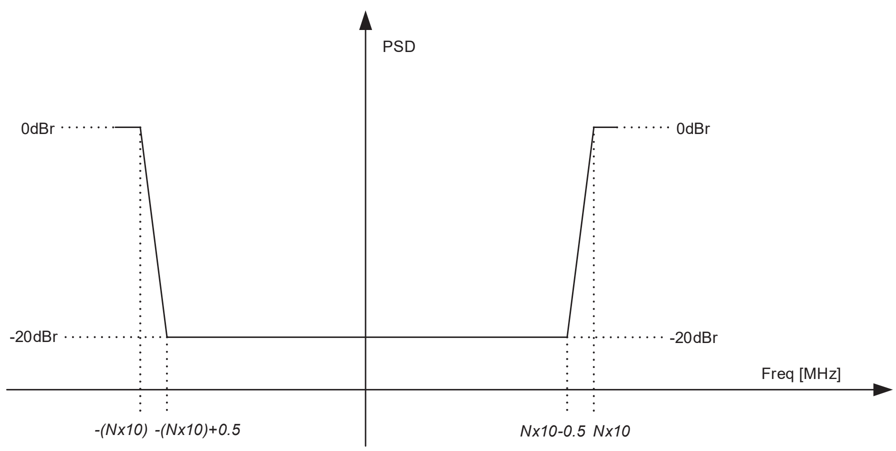

Figure 27-52—Example transmit spectral mask for the *N*×20 MHz preamble punctured channel with transmissions on both upper and lower subchannels

An example transmit spectral mask for the N×20 MHz preamble punctured channel with transmission on the lower subchannel is shown in Figure 27-53 (Example transmit spectral mask for the N×20 MHz preamble punctured channel with transmissions on the lower subchannel)

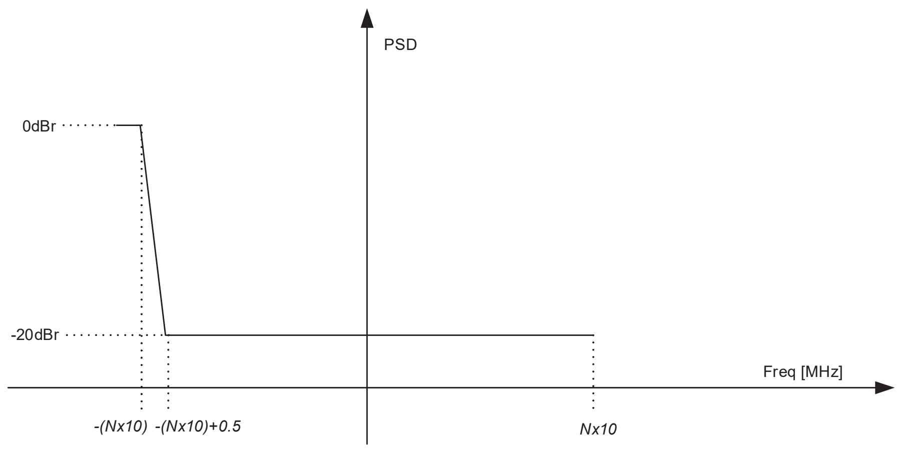

Figure 27-53—Example transmit spectral mask for the *N*×20 MHz preamble punctured channel with transmissions on the lower subchannel

27.3.19.2 Spectral flatness

Spectral flatness measurements shall be conducted using BPSK modulated HE PPDUs. The HE PPDUs shall be demodulated using the following (or equivalent) procedure:

a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be manipulated to account for both frequency error and sampling offset drift.

e) For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase.

f) For each of the data OFDM symbols: transform the symbol into subcarrier received values.

The spectral flatness test shall be performed over at least 20 HE PPDUs. The PPDUs under test shall be at least 16 data OFDM symbols long.

Evaluate spectral flatness using the subcarrier received values or the magnitude of the channel estimation of the occupied subcarriers of the transmission HE PPDUs. Nonoccupied subcarriers of the transmitted HE PPDUs shall be ignored during averaging and testing. Resource unit power boosting and beamforming should not be used when measuring spectral flatness.

Let $E_{i,avg}$ denote the magnitude of the channel estimation on subcarrier i or the average constellation energy of a BPSK modulated subcarrier i in an HE data symbol. In a contiguous HE transmission having a bandwidth listed in Table 27-48 (Maximum transmit spectral flatness deviations), $E_{i,avg}$ of each of the subcarriers with indices listed as tested subcarrier indices shall not deviate by more than the specified maximum deviation in Table 27-48 (Maximum transmit spectral flatness deviations) from the average of $E_{i,avg}$ over subcarrier indices listed as averaging subcarrier indices. Averaging of $E_{i,avg}$ is done in the linear domain.

Table 27-48—Maximum transmit spectral flatness deviations

Bandwidth of transmission (MHz)	Averaging subcarrier indices (inclusive)	Tested subcarrier indices (inclusive)	Maximum deviation (dB)
20	–84 to –2 and +2 to +84	–84 to –2 and +2 to +84	±4
		–122 to –85 and +85 to +122	+4/–6
40	–168 to –3 and +3 to +168	–168 to –3 and +3 to +168	±4
		–244 to –169 and +169 to +244	+4/–6
80	–344 to –3 and +3 to +344	–344 to –3 and +3 to +344	±4
		–500 to –345 and +345 to +500	+4/–6
160	–696 to –515, –509 to –166, +166 to +509, and +515 to +696	–696 to –515, –509 to –166, +166 to +509, and +515 to +696	±4
		–1012 to –697, –165 to –12, +12 to +165, and +697 to +1012	+4/–6

In an 80+80 MHz transmission, each segment shall meet the spectral flatness requirement for an 80 MHz transmission.

For the spectral flatness test, the transmitting STA shall be configured to use a spatial mapping matrix Q_k (see 27.3.12.14 (OFDM modulation)) with flat frequency response. Each output port under test of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements shall apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz transmissions.

27.3.19.3 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. The symbol clock frequency and transmit center frequency tolerance shall be ±20 ppm in the 5 GHz and 6 GHz bands and ±25 ppm in the 2.4 GHz band. HE TB PPDU format is subject to additional requirements as defined in 27.3.15 (Transmit requirements for PPDUs sent in response to a triggering frame).

Transmit signals with TXVECTOR parameter CH_BANDWIDTH set to CBW160 or CBW80+80 may be generated using two separate RF LOs, one for each of the lower and upper 80 MHz frequency portions.

NOTE—The signal phase of the two 80 MHz frequency portions might not be correlated.

27.3.19.4 Modulation accuracy

27.3.19.4.1 Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 27.3.19.4.2 (Transmit center frequency leakage) and 27.3.19.4.3 (Transmitter constellation error). The test method is described in 27.3.19.4.4 (Transmitter modulation accuracy (EVM) test).

27.3.19.4.2 Transmit center frequency leakage

For an 80+80 MHz transmission where the RF LO falls outside both frequency segments, the RF LO shall meet the spectral mask requirements as defined in 27.3.19.1 (Transmit spectral mask). Otherwise, 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.

27.3.19.4.3 Transmitter constellation error

The relative constellation RMS error in the test, calculated by first averaging over subcarriers, frequency segments, HE PPDUs, and spatial streams (see Equation (27-127)) as described in 27.3.19.4.4 (Transmitter modulation accuracy (EVM) test) shall not exceed a data-rate dependent value according to Table 27-49 (Allowed relative constellation error versus constellation size and coding rate). The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized testing instrumentation input ports. In the test, $N_{SS} = N_{STS}$ (no STBC) and no beamforming steering matrix shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements shall apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz noncontiguous transmissions.

Table 27-49—Allowed relative constellation error versus constellation size and coding rate

Modulation		Coding rate	Relative constellation error in an HE SU PPDU, HE ER SU PPDU and HE MU PPDU (dB)	Relative constellation error in an HE TB PPDU when transmit power is larger than the maximum power of HE-MCS 7 (dB)	Relative constellation error in an HE TB PPDU when transmit power is less than or equal to the maximum power of HE-MCS 7 (dB)
Without DCM	With DCM				
N/A	BPSK	1/2	–5	–13	–27
BPSK	QPSK	1/2	–5	–13	–27
QPSK	16-QAM	1/2	–10	–13	–27
QPSK	16-QAM	3/4	–13	–13	–27
16-QAM	N/A	1/2	–16	–16	–27
16-QAM	N/A	3/4	–19	–19	–27
64-QAM	N/A	2/3	–22	–22	–27
64-QAM	N/A	3/4	–25	–25	–27
64-QAM	N/A	5/6	–27	–27	–27
256-QAM	N/A	3/4	–30	–30	–30
256-QAM	N/A	5/6	–32	–32	–32
1024-QAM	N/A	3/4	–35/–32	–35/–32	–35/–32

Table 27-49—Allowed relative constellation error versus constellation size and coding rate

Modulation		Coding rate	Relative constellation error in an HE SU PPDU, HE ER SU PPDU and HE MU PPDU (dB)	Relative constellation error in an HE TB PPDU when transmit power is larger than the maximum power of HE-MCS 7 (dB)	Relative constellation error in an HE TB PPDU when transmit power is less than or equal to the maximum power of HE-MCS 7 (dB)
Without DCM	With DCM				
1024-QAM	N/A	5/6	–35/–32	–35/–32	–35/–32
NOTE—The maximum power of HE-MCS 7 can be measured by setting the UL Target RSSI subfield as defined in Table 9-31i (UL Target RSSI subfield encoding) in the Trigger frame to 127 for the RU for which the EVM test is conducted.					

For 1024-QAM, the relative constellation error shall meet one of the following requirements:

— The relative constellation error shall less than or equal to –35 dB if amplitude drift compensation is disabled in the test equipment

— The relative constellation error shall be less than or equal to –35 dB with amplitude drift compensation enabled in the test equipment, and the relative constellation error shall be less than or equal to –32 dB with amplitude drift compensation disabled in the test equipment

For all other constellations the relative constellation error shall be less than or equal to the values in Table 27-49 (Allowed relative constellation error versus constellation size and coding rate) whether or not amplitude drift compensation is enabled in the test equipment.

27.3.19.4.4 Transmitter modulation accuracy (EVM) test

The transmit modulation accuracy test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted except that for a noncontiguous transmissions each frequency segment may be tested independently.

In this case, transmit modulation accuracy of each segment shall meet the required value in Table 27-49 (Allowed relative constellation error versus constellation size and coding rate) using only the occupied data subcarriers within the corresponding segment. For HE TB PPDU transmission, two sets of EVM requirements are defined in Table 27-49 (Allowed relative constellation error versus constellation size and coding rate) for different transmission power levels to assist AP in better managing the interference among multiple STAs responding to a Trigger frame.

LO leakage that can potentially show up at the center frequency of the HE PPDU tone plan and within ±3 neighboring subcarriers shall be excluded from the computation of the transmitter modulation accuracy test. The potential LO leakage subcarriers for 20 MHz operating devices are the center of primary 20 MHz of the HE PPDU tone plan and ±3 subcarriers of it. The potential LO leakage subcarriers for 40 MHz operating devices are the center of the primary 40 MHz of the PPDU tone plan and ±3 subcarriers. The potential LO leakage subcarriers for 80 MHz operating devices are the center of the primary 80 MHz of the PPDU tone plan and ±3 subcarriers of it. The potential LO leakage tones for 160 MHz operating devices are the center of the 160 MHz of the PPDU tone plan and ±3 subcarriers of it. The potential LO leakage tones for 80+80 MHz operating devices exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 40 MHz capable devices that transmits 20 MHz, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 80 MHz capable devices that transmits 20 MHz or 40 MHz PPDU, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 160 or 80+80 MHz capable devices that transmits 20 MHz or 40 MHz PPDU or 80 MHz PPDU, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver using the following or equivalent procedure:

a) Start of PPDU shall be detected.
b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.
c) Coarse and fine frequency offsets shall be estimated.
d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.
e) For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and derotate the subcarrier values according to the estimated phase.
f) Estimate the complex channel response coefficient for each of the subcarriers and each of the transmit streams. If midambles are present in the Data field of the PPDU, the channel response coefficients shall be based upon the most recently received midamble symbols.
g) For each of the data OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase, group the results from all of the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel.
h) For each data-carrying subcarrier in each spatial stream of RU under test, find the closest constellation point and compute the Euclidean distance from it. If midambles are present in the Data field of the PPDU, the midamble symbols shall not be used to compute the Euclidean distance.
i) Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (27-127).

$$Error_{RMS} = \frac{1}{N_f}\sum_{i_f=1}^{N_f}\sqrt{\frac{\sum_{i_s=1}^{N_{SYM}}\sum_{i_{ss}=1}^{N_{SS}}\sum_{i_{sc}=1}^{N_{SD}}\left(I_e(i_f,i_s,i_{ss},i_{sc})-I_0(i_f,i_s,i_{ss},i_{sc})\right)^2+\left(Q_e(i_f,i_s,i_{ss},i_{sc})-Q_0(i_f,i_s,i_{ss},i_{sc})\right)^2}{N_{SYM}N_{SS}N_{SD}P_0}} \quad (27\text{-}127)$$

where

$I_0(i_f, i_s, i_{ss}, i_{sc})$ $Q_0(i_f, i_s, i_{ss}, i_{sc})$ denotes the ideal symbol point in the complex plane in data subcarrier i_{sc} of the RU under test, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f.

$I_e(i_f, i_s, i_{ss}, i_{sc})$ $Q_e(i_f, i_s, i_{ss}, i_{sc})$ denotes the equalized observed symbol point in the complex plane of the data subcarrier i_{sc} of the RU under test, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f.

P_0 is the average power of constellation

N_f is the number of tested frames

N_{SD} is the number of data tones of the occupied RU. For an 80+80 MHz transmission, N_{SD} is the total number of data subcarriers in both 80 MHz frequency segments.

N_{SS} is the number of spatial streams of the data

N_{SYM} is the number of data OFDM symbols

The test shall be performed over at least 20 PPDUs (N_f as defined in Equation (27-127)). If the occupied RU has 26 tones, the PPDUs under test shall be at least 32 data OFDM symbols long. For occupied RUs that have more than 26 tones, the PPDUs under test shall be at least 16 data OFDM symbols long. Random data shall be used for the symbols.

For an HE TB PPDU with an RU smaller than a 2×996-tone RU, additional transmit modulation accuracy test for the unoccupied subcarriers of the PPDU shall be performed. The transmit modulation accuracy of unoccupied subcarriers of the PPDU test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted except that for noncontiguous transmissions, only the frequency segment with occupied subcarriers is tested. The transmit modulation accuracy of unoccupied subcarriers of the PPDU shall meet the relative constellation error staircase mask specified in Equation (27-131) for each modulation and coding rate using the unoccupied subcarriers within the corresponding segment.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.

e) For each of the data OFDM symbols, transform the symbol into subcarrier received values and estimate the power of each subcarrier.

f) Compute the average unoccupied subcarrier error vector magnitude for each unoccupied 26-tone RU and average across PPDUs of the RMS of all errors per PPDU as given by Equation (27-128).

$$UnusedToneError_{RMS}(k) = \frac{1}{N_f}\sum_{i_f=1}^{N_f}\sqrt{\frac{\sum_{i_s=1}^{N_{SYM}}\sum_{i_{sc}\in\Omega_k}(I_u(i_f, i_s, i_{sc}))^2 + (Q_u(i_f, i_s, i_{sc}))^2}{N_{SYM}\cdot 26\cdot P_S}} \tag{27-128}$$

where

$I_u(i_f, i_s, i_{sc})$ $Q_u(i_f, i_s, i_{sc})$ denotes unequalized observed symbol point in the complex plane in subcarrier i_{sc} of the unoccupied 26-tone RU and OFDM symbol i_s of frame i_f.

Ω_k is a set of subcarriers for k-th 26-tone RU as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU) and Table 27-9 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU and in a non-OFDMA 80 MHz HE PPDU)

P_S is the average data subcarrier power of the occupied RU under test and is given by Equation (27-129)

$$P_S = \frac{1}{N_{SYM}N_{SD}}\sum_{i_s=1}^{N_{SYM}}\sum_{i_{sc}=1}^{N_{SD}}(I_u(i_f, i_s, i_{SC}))^2 + (Q_u(i_f, i_s, i_{SC}))^2 \tag{27-129}$$

N_f is the number of tested frames

N_{SYM} is the number of data OFDM symbols

N_{SD} is the number of data subcarriers in the occupied RU

g) For all HE-MCSs, for an occupied RU bandwidth of r in units of a 26-tone RU as defined by Equation (27-130)

$$r = \begin{cases} 1, \text{ if 26-tone RU} \\ 2, \text{ if 52-tone RU} \\ 4, \text{ if 106-tone RU} \\ 9, \text{ if 242-tone RU} \\ 18, \text{ if 484-tone RU} \\ 37, \text{ if 996-tone RU} \end{cases} \tag{27-130}$$

The average unused subcarrier error vector magnitude for each unoccupied 26-tone RU as calculated in step f) shall meet the staircase mask requirement in Equation (27-131) and Equation (27-132), where m defines the gap in the units of 26-tone RU to the occupied RU from either side with $m = \pm 1$ being the adjacent 26-tone RUs.

$$UnusedToneError(i_{RU26,\,start} + m) \le \begin{cases} max(\varepsilon - 2, -35\text{ dB}), \text{ if } -r \le m \le -1 \\ max(\varepsilon - 12, -35\text{ dB}), \text{ if } -2r \le m \le -r-1 \\ max(\varepsilon - 22, -35\text{ dB}), \text{ if } -3r \le m \le -2r-1 \\ -35\text{ dB}, \text{ otherwise} \end{cases} \tag{27-131}$$

The valid range for m for Equation (27-131) is as follows:

$-i_{RU26,\,start} + 1 \le m \le -1$ for a 20 MHz, 40 MHz, 80 MHz or 160 MHz PPDU

$-i_{RU26,\,start} + 1 \le m \le -1$ for an 80+80 MHz PPDU and $i_{RU26,\,start} \le 37$

$-i_{RU26,\,start} + 38 \le m \le -1$ for an 80+80 MHz PPDU and $i_{RU26,\,start} > 37$

$$UnusedToneError(i_{RU26,\,end} + m) \le \begin{cases} max(\varepsilon - 2, -35\text{ dB}), \text{ if } 1 \le m \le r \\ max(\varepsilon - 12, -35\text{ dB}), \text{ if } r+1 \le m \le 2r \\ max(\varepsilon - 22, -35\text{ dB}), \text{ if } 2r+1 \le m \le 3r \\ -35\text{ dB}, \text{ otherwise} \end{cases} \tag{27-132}$$

The valid range for m for Equation (27-132) is as follows:

$1 \le m \le N_{RU26} - i_{RU26,\,end}$ for a 20 MHz, 40 MHz, 80 MHz or 160 MHz PPDU

$1 \le m \le 37 - i_{RU26,\,end}$ for an 80+80 MHz PPDU and $i_{RU26,\,start} \le 37$

$1 \le m \le 74 - i_{RU26,\,end}$ for an 80+80 MHz PPDU and $i_{RU26,\,start} > 37$

where

$i_{RU26,start}$ is equal to i_{RU} if the occupied RU is a 26-tone RU, and is defined in Table 27-50 (iRU26,start for RUs other than a 26-tone RU) for other RU sizes

Table 27-50—$i_{RU26,start}$ for RUs other than a 26-tone RU

i_{RU}	52-tone RU	106-tone RU	242-tone RU	484-tone RU	996-tone RU
1	1	1	1	1	1
2	3	6	10	20	38
3	6	10	20	38	
4	8	15	29	57	
5	10	20	38		
6	12	25	47		
7	15	29	57		
8	17	34	66		
9	20	38			
10	22	43			
11	25	47			
12	27	52			
13	29	57			
14	31	62			
15	34	66			
16	36	71			
17	38				
18	40				
19	43				
20	45				
21	47				
22	49				
23	52				
24	54				
25	57				
26	59				
27	62				
28	64				
29	66				
30	68				
31	71				

Table 27-50—$i_{RU26,start}$ for RUs other than a 26-tone RU *(continued)*

i_{RU}	52-tone RU	106-tone RU	242-tone RU	484-tone RU	996-tone RU
32	73				

$i_{RU26,end}$ is equal to $i_{RU26,start} + r - 1$

i_{RU} is the index of the occupied RU

N_{RU26} is the maximum number of 26-tone RUs for the given bandwidth of the HE TB PPDU as defined in Table 27-15 (Frequently used parameters)

ε is the relative constellation error requirement for an occupied RU of an HE TB PPDU as defined in Table 27-49 (Allowed relative constellation error versus constellation size and coding rate)

NOTE—For an 80+80 MHz PPDU the unused subcarrier error is measured only in the 80 MHz segment in which the occupied RU is located. This leads to the different valid range for *m* in Equation (27-131) and Equation (27-132) for the 80+80 MHz PPDU.

The test shall be performed over at least 20 PPDUs (N_f as defined in Equation (27-127)). The PPDUs under test shall be at least 16 data OFDM symbols long. The unequalized observed symbol of potential LO leakage subcarrier locations shall be treated as zero during unoccupied subcarriers transmit modulation accuracy test. Random data shall be used for the symbols.

27.3.20 Receiver specification

27.3.20.1 General

For receiver minimum input sensitivity, adjacent channel rejection, nonadjacent channel rejection, receiver maximum input level and CCA sensitivity requirements described in this subclause, the input levels are measured at the antenna connectors and are referenced as the average power per receive antenna. The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized Device Under Test input ports. Each output port of the transmitting STA shall be connected through a cable to one input port of the Device Under Test.

NOTE—Additional test requirements and/or test methods may be needed to meet regulatory requirements.

The requirements on receiver minimum input sensitivity in 27.3.20.2 (Receiver minimum input sensitivity), adjacent channel rejection in 27.3.20.3 (Adjacent channel rejection) and nonadjacent channel rejection in 27.3.20.4 (Nonadjacent channel rejection) apply to PPDUs that meet all the following conditions:

— STBC is not used

— 0.8 µs GI is used

— If the PPDU bandwidth is 20 MHz and the HE-MCS is less than 10, then BCC is used. Otherwise, LDPC is used.

— The PPDU is an HE SU PPDU

27.3.20.2 Receiver minimum input sensitivity

The packet error rate (PER) shall be less than 10% for a PSDU with the rate-dependent input levels listed in Table 27-51 (Receiver minimum input level sensitivity). The PSDU length shall be 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations.

Table 27-51—Receiver minimum input level sensitivity

Modulation		Rate (R)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
Without DCM	With DCM					
N/A	BPSK	1/2	–82	–79	–76	–73
BPSK	QPSK	1/2	–82	–79	–76	–73
QPSK	16-QAM	1/2	–79	–76	–73	–70
QPSK	16-QAM	3/4	–77	–74	–71	–68
16-QAM	N/A	1/2	–74	–71	–68	–65
16-QAM	N/A	3/4	–70	–67	–64	–61
64-QAM	N/A	2/3	–66	–63	–60	–57
64-QAM	N/A	3/4	–65	–62	–59	–56
64-QAM	N/A	5/6	–64	–61	–58	–55
256-QAM	N/A	3/4	–59	–56	–53	–50
256-QAM	N/A	5/6	–57	–54	–51	–48
1024-QAM	N/A	3/4	–54	–51	–48	–45
1024-QAM	N/A	5/6	–52	–49	–46	–43

27.3.20.3 Adjacent channel rejection

Adjacent channel rejection for W MHz (where W is 20, 40, 80, or 160) shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 27-51 (Receiver minimum input level sensitivity) and raising the power of the interfering signal of W MHz bandwidth until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. The difference in power between the signals in the interfering channel and the desired channel is the corresponding adjacent channel rejection. The center frequency of the adjacent channel shall be placed W MHz away from the center frequency of the desired signal.

Adjacent channel rejection for 80+80 MHz channels shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 27-51 (Receiver minimum input level sensitivity). Then, an interfering signal of 80 MHz bandwidth is introduced, where the center frequency of the interfering signal is placed 80 MHz away from the center frequency of the frequency segment lower in the frequency of the desired signal. The power of interfering signal is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_1 be the difference between the interfering and desired signal. Next, the interfering signal of 80 MHz bandwidth is moved to the frequency where the center frequency of the interfering signal is 80 MHz away from the center frequency of the frequency segment higher in frequency of the desired signal. The power of the interfering is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_2 be the power difference between the interfering and desired signal. The smaller value between ΔP_1 and ΔP_2 is the corresponding adjacent channel rejection.

The interfering signal in the adjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 27-52 (Minimum required adjacent and nonadjacent channel rejection levels).

Table 27-52—Minimum required adjacent and nonadjacent channel rejection levels

Modulation		Rate (R)	Adjacent channel rejection (dB)		Nonadjacent channel rejection (dB)	
Without DCM	With DCM		20/40/80/160 MHz Channel	80+80 MHz Channel	20/40/80/160 MHz Channel	80+80 MHz Channel
N/A	BPSK	1/2	16	13	32	29
BPSK	QPSK	1/2	16	13	32	29
QPSK	16-QAM	1/2	13	10	29	26
QPSK	16-QAM	3/4	11	8	27	24
16-QAM	N/A	1/2	8	5	24	21
16-QAM	N/A	3/4	4	1	20	17
64-QAM	N/A	2/3	0	–3	16	13
64-QAM	N/A	3/4	–1	–4	15	12
64-QAM	N/A	5/6	–2	–5	14	11
256-QAM	N/A	3/4	–7	–10	9	6
256-QAM	N/A	5/6	–9	–12	7	4
1024-QAM	N/A	3/4	–12	–15	4	1
1024-QAM	N/A	5/6	–14	–17	2	–1

The measurement of adjacent channel rejection for 160 MHz operation in regulatory domain is required only if such a frequency band plan is permitted in the regulatory domain.

27.3.20.4 Nonadjacent channel rejection

Nonadjacent channel rejection for W MHz channels (where W is 20, 40, 80, or 160) shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 27-51 (Receiver minimum input level sensitivity), and raising the power of the interfering signal of W MHz bandwidth until a 10% PER occurs for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. The difference in power between the signals in the interfering channel and the desired channel is the corresponding nonadjacent channel rejection. The nonadjacent channel rejection shall be met with any nonadjacent channels located at least $2 \times W$ MHz away from the center frequency of the desired signal.

Nonadjacent channel rejection for 80+80 MHz channels shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 27-51 (Receiver minimum input level sensitivity). Then, an interfering signal of 80 MHz bandwidth is introduced, where the center frequency of the interfering signal is placed at least 160 MHz away from the center frequency of the frequency segment lower in the frequency of the desired signal. The center frequency of the interfering signal shall also be at least 160 MHz away from the center frequency of the frequency segment higher in frequency of the desired signal. The power of interfering signal is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_1 be the difference between the interfering and desired signal. Next, the interfering signal of 80 MHz bandwidth is moved to the frequency where the center frequency of the interfering signal is at least 160 MHz away from the center frequency of the frequency segment higher in frequency of the desired signal. The center frequency of the interfering signal shall also be at least 160 MHz away from the center frequency of the frequency segment lower in frequency of the desired signal. The power of the interfering is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_2 be the power difference between the interfering and desired signal. The smaller value between ΔP_1 and ΔP_2 is the corresponding nonadjacent channel rejection.

The interfering signal in the nonadjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 27-52 (Minimum required adjacent and nonadjacent channel rejection levels).

The measurement of nonadjacent channel rejection for 160 MHz operation in regulatory domain is required only if such a frequency band plan is permitted in the regulatory domain.

27.3.20.5 Receiver maximum input level

The receiver shall provide a maximum PER of 10% at a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations, for a maximum input level of –30 dBm in the 5 GHz and 6 GHz bands and –20 dBm in the 2.4 GHz band, measured at each antenna for any baseband HE modulation.

27.3.20.6 CCA sensitivity

27.3.20.6.1 General

The thresholds in this subclause are compared with the signal level at each receiving antenna.

27.3.20.6.2 CCA sensitivity for operating classes requiring CCA-ED

For the operating classes requiring CCA-Energy Detect (CCA-ED), the PHY shall indicate a medium busy condition if CCA-ED detects a channel busy condition. For improved spectrum sharing, CCA-ED is required in some bands. The behavior class indicating CCA-ED is given in Table D-2 (Behavior limits). The operating classes requiring the corresponding CCA-ED behavior class are given in E.1 (Country information and operating classes). The PHY of a STA that is operating within an operating class that requires CCA-ED shall operate with CCA-ED.

CCA-ED for a STA that is attempting a non-preamble puncturing transmission shall detect a channel busy condition if the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for the primary 20 MHz channel, dot11OFDMEDThreshold for the secondary 20 MHz channel (if present), dot11OFDMEDThreshold + 3 dB for the secondary 40 MHz channel (if present), and dot11OFDMEDThreshold + 6 dB for the secondary 80 MHz channel (if present). The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

CCA-ED for a STA that is attempting a preamble puncturing transmission shall detect a channel busy condition if the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for the primary 20 MHz channel and dot11OFDMEDThreshold for each nonprimary 20 MHz subchannel. The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

For the HE TB PPDU transmission, for each of 20 MHz sub-channels that require CCA, CCA-ED shall detect a channel busy condition if the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold. The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

For transmissions that carry a frame that includes a BQR Control subfield (see 9.2.4.6a (Control subfield variants of an A-Control subfield)), CCA-ED shall detect a channel busy condition if the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for primary 20 MHz channel and dot11OFDMEDThreshold for each nonprimary 20 MHz channel (if present). The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

NOTE—The requirement to detect a channel busy condition as stated in 27.3.20.6.3 (CCA sensitivity for the primary 20 MHz channel) and 27.3.20.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel) is a mandatory energy detect requirement on all Clause 27 (High Efficiency (HE) PHY specification) receivers. Support for CCA-ED is an additional requirement that relates specifically to the sensitivities described in D.2.5 (CCA-ED threshold).

27.3.20.6.3 CCA sensitivity for the primary 20 MHz channel

The PHY shall issue a PHY-CCA.indication primitive with the STATUS parameter set to BUSY if one of the conditions listed in Table 27-53 (Conditions for CCA BUSY on the primary 20 MHz) is met in an otherwise idle 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz operating channel width. The channel-list parameter is present and set to {primary} if the operating channel width is greater than 20 MHz. With > 90% probability, the PHY shall detect the start of a PPDU that occupies at least the primary 20 MHz channel under the conditions listed in Table 27-53 (Conditions for CCA BUSY on the primary 20 MHz) within a period of aCCATime (see 21.4.4 (VHT PHY)) and hold the CCA signal busy (not issue a PHY-CCA.indication primitive with the STATUS parameter set to IDLE) for the duration of the PPDU, unless it receives a CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation).

Table 27-53—Conditions for CCA BUSY on the primary 20 MHz

Operating Channel Width	Conditions
20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz	The start of a 20 MHz non-HT PPDU in the primary 20 MHz channel as defined in 17.3.10.6 (CCA requirements). The start of an HT PPDU under the conditions defined in 19.3.19.5 (CCA sensitivity). The start of a 20 MHz VHT PPDU in the primary 20 MHz channel at or above –82 dBm. The start of a 20 MHz HE PPDU in the primary 20 MHz channel at or above –82 dBm.
40 MHz, 80 MHz, 160 MHz, or 80+80 MHz	The start of a 40 MHz non-HT duplicate, VHT or HE PPDU in the primary 40 MHz channel at or above –79 dBm. The start of an HT PPDU under the conditions defined in 19.3.19.5 (CCA sensitivity).
80 MHz, 160 MHz, or 80+80 MHz	The start of an 80 MHz non-HT duplicate, VHT or HE PPDU in the primary 80 MHz channel at or above –76 dBm.
160 MHz or 80+80 MHz	The start of a 160 MHz or 80+80 MHz non-HT duplicate, VHT or HE PPDU at or above –73 dBm.

The receiver shall issue a PHY-CCA.indication primitive with the STATUS parameter set to BUSY for any signal that exceeds a threshold equal to 20 dB above the minimum modulation and coding rate sensitivity (–82 + 20 = –62 dBm) in the primary 20 MHz channel within a period of aCCATime after the signal arrives at the receiver's antenna(s). If the operating channel width is greater than 20 MHz, then the channel-list parameter is present and shall be set to {primary}. Following the indication and while the threshold continues to be exceeded, the receiver shall not issue a PHY-CCA.indication primitive with the STATUS parameter set to IDLE or with a change in the channel-list parameter.

27.3.20.6.4 CCA sensitivity for signals not occupying the primary 20 MHz channel

The PHY shall issue a PHY-CCA.indication primitive with the STATUS parameter set to BUSY and with the channel-list parameter set to {secondary} if the conditions for issuing a PHY-CCA.indication primitive with the STATUS parameter set to BUSY as defined in 27.3.20.6.3 (CCA sensitivity for the primary 20 MHz channel) are not present and at least one of the following conditions is present in an otherwise idle 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

- Any signal within the secondary 20 MHz channel at or above a threshold of –62 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s).
- A 20 MHz non-HT, HT_MF, HT_GF, VHT or HE PPDU is detected in the secondary 20 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY)).

Following the indication and while the threshold continues to be exceeded, the receiver shall not issue a PHY-CCA.indication primitive with the STATUS parameter set to IDLE, or with the STATUS parameter set to BUSY and the channel-list parameter set to {secondary40} or {secondary80}.

The PHY shall issue a PHY-CCA.indication primitive with the STATUS parameter set to BUSY and the channel-list parameter set to {secondary40} if the conditions for issuing a PHY-CCA.indication with the STATUS parameter set to BUSY as defined in 27.3.20.6.3 (CCA sensitivity for the primary 20 MHz channel) and above are not present and at least one of the following conditions is present in an otherwise idle 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

- Any signal within the secondary 40 MHz channel at or above a threshold of –59 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s).
- A 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT or HE PPDU is detected in the secondary 40 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$ + 3 dB) with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY)).
- A 20 MHz non-HT, HT_MF, HT_GF, VHT or HE PPDU is detected in any 20 MHz subchannel of the secondary 40 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with > 90% probability within a period aCCAMidTime.

Following the indication and while the threshold continues to be exceeded, the receiver shall not issue a PHY-CCA.indication primitive with the STATUS parameter set to IDLE, or with the STATUS parameter set to BUSY and the channel-list parameter set to {secondary80}.

The PHY shall issue a PHY-CCA.indication primitive with the STATUS parameter set to BUSY and the channel-list parameter set to {secondary80} if the conditions for issuing a PHY-CCA.indication primitive with the STATUS parameter set BUSY as defined in 27.3.20.6.3 (CCA sensitivity for the primary 20 MHz channel) and above are not present and at least one of the following conditions is present in an otherwise idle 160 MHz or 80+80 MHz operating channel width:

- Any signal within the secondary 80 MHz channel at or above –56 dBm.
- An 80 MHz non-HT duplicate, VHT or HE PPDU is detected in the secondary 80 MHz channel at or above max(–69 dBm, $OBSS\_PD_{level}$ + 6 dB) with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY)).

- A 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT or HE PPDU is detected in any 40 MHz subchannel of the secondary 80 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$ + 3 dB) with > 90% probability within a period aCCAMidTime.
- A 20 MHz non-HT, HT_MF, HT_GF, VHT or HE PPDU is detected in any 20 MHz subchannel of the secondary 80 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with > 90% probability within a period aCCAMidTime.

$OBSS\_PD_{level}$ is defined in 26.10.2.4 (Adjustment of OBSS PD and transmit power) and applied in the equations to define the detection level in this subclause if an HE STA has ignored a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz inter-BSS PPDU following the procedure in 26.10.2.2 (General operation with non-SRG OBSS PD level) or 26.10.2.3 (General operation with SRG OBSS PD level). It is applied to any secondary channels within the PPDU bandwidth of the inter-BSS PPDU and during the RXTIME of the inter-BSS PPDU. Otherwise, $OBSS\_PD_{level}$ is not applied in the equations to define the detection level in this subclause.

27.3.20.6.5 Per 20 MHz CCA sensitivity

If the operating channel width is greater than 20 MHz and the PHY issues a PHY-CCA.indication primitive, the PHY shall set the per20bitmap to indicate the busy/idle status of each 20 MHz subchannel. A 20 MHz subchannel is busy if at least one of the following conditions is present in an otherwise idle 40 MHz, 80 MHz, 80+80 MHz or 160 MHz channel:

- A signal is present on the 20 MHz subchannel at or above a threshold of –62 dBm at the receiver's antenna(s). The PHY shall indicate that the 20 MHz subchannel is busy a period aCCATime after the signal starts and shall continue to indicate the 20 MHz subchannel is busy while the threshold continues to be exceeded.
- The 20 MHz subchannel is in a channel on which an 80 MHz non-HT duplicate, VHT or HE PPDU at or above max(–69 dBm, $OBSS\_PD_{level}$ + 6 dB) at the receiver's antenna(s) is present. The PHY shall indicate that the 20 MHz subchannel is busy with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY)).
- The 20 MHz subchannel is in a channel on which a 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT or HE PPDU at or above max(–72 dBm, $OBSS\_PD_{level}$ + 3 dB) at the receiver's antenna(s) is present. The PHY shall indicate that the 20 MHz subchannel is busy with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY)).
- A 20 MHz non-HT, HT_MF, HT_GF, VHT, or HE PPDU at or above max(–72 dBm, $OBSS\_PD_{level}$) at the receiver's antenna(s) is present on the 20 MHz subchannel. The PHY shall indicate that the 20 MHz subchannel is busy with > 90% probability within a period aCCAMidTime (see 27.4.4 (HE PHY))).

NOTE—Following the receipt of a Trigger frame with the CS Required subfield in the Common Info field set to 1, the HE PHY is only required to detect a signal at the –62 dBm threshold since the other conditions require more time than is available before the response is expected.

$OBSS\_PD_{level}$ is defined in 26.10.2.4 (Adjustment of OBSS PD and transmit power) and applied in the equations to define the detection level in this subclause if an HE STA has ignored a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz inter-BSS PPDU following the procedure in 26.10.2.2 (General operation with non-SRG OBSS PD level) or 26.10.2.3 (General operation with SRG OBSS PD level). It is applied to any secondary channels within the PPDU bandwidth of the inter-BSS PPDU and during the RXTIME of the inter-BSS PPDU. Otherwise, $OBSS\_PD_{level}$ is not applied in the equations to define the detection level in this subclause.

27.3.21 HE transmit procedure

There are five options for the transmit PHY procedure. The first four options, for which typical transmit procedures are shown in Figure 27-54 (PHY transmit procedure for an HE SU PPDU), Figure 27-55 (PHY transmit procedure for an HE ER SU PPDU), Figure 27-56 (PHY transmit procedure for an HE MU PPDU) and Figure 27-57 (PHY transmit procedure for an HE TB PPDU), are selected if the FORMAT field of the PHY-TXSTART.request(TXVECTOR) primitive is equal to HE_SU, HE_MU, HE_ER_SU, or HE_TB, respectively. These transmit procedures do not describe the operation of optional features, such as DCM.

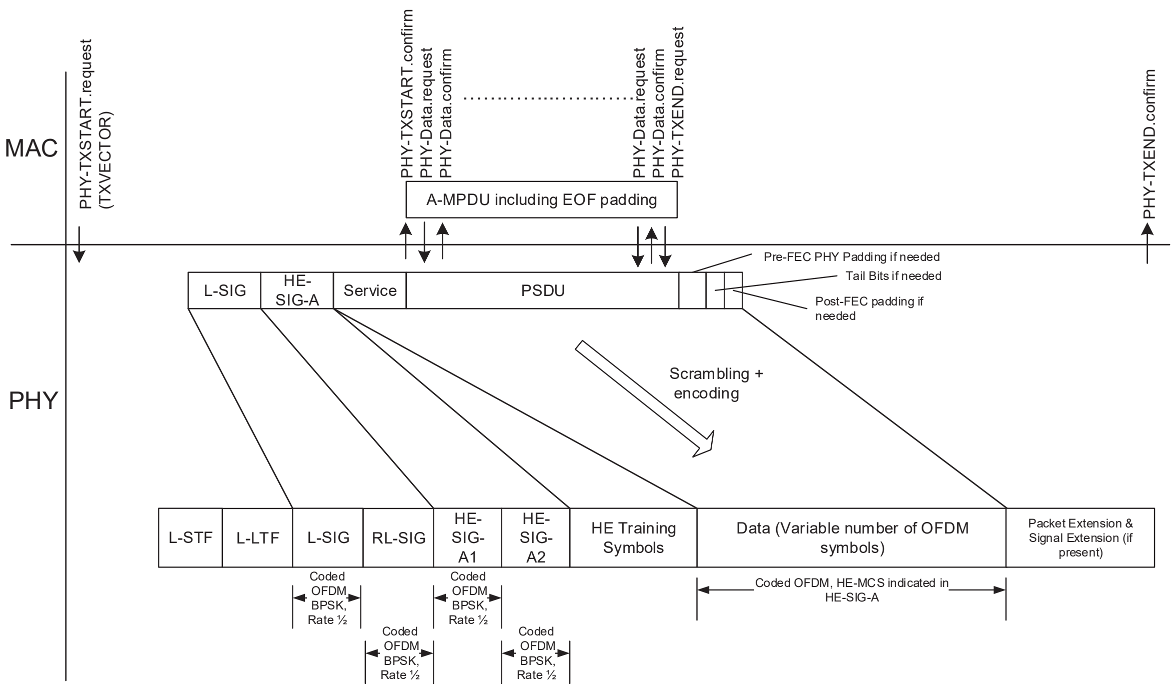

Figure 27-54—PHY transmit procedure for an HE SU PPDU

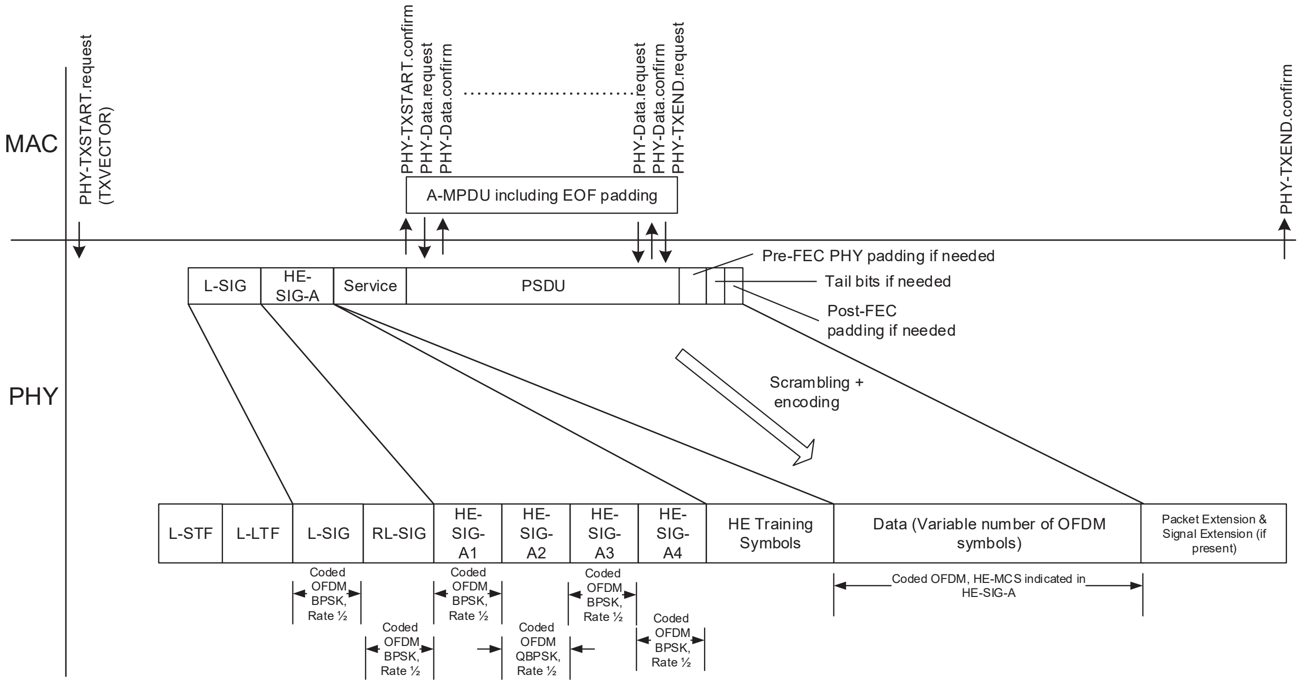

Figure 27-55—PHY transmit procedure for an HE ER SU PPDU

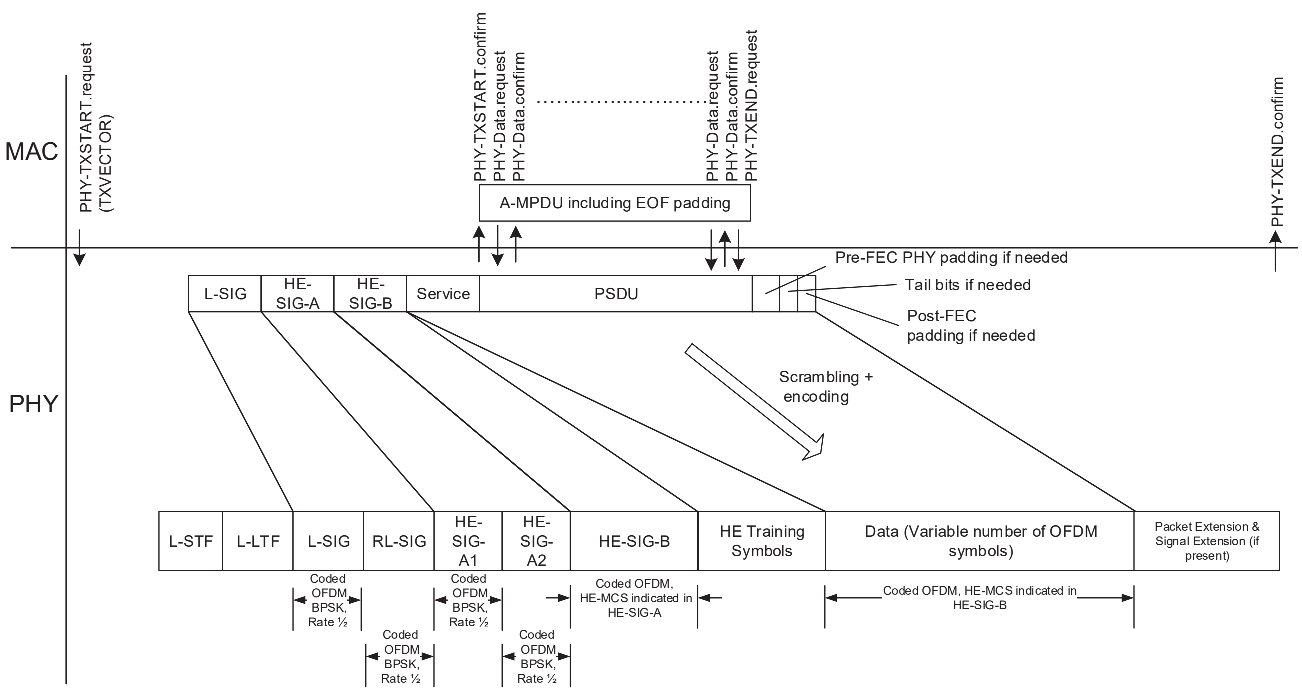

Figure 27-56—PHY transmit procedure for an HE MU PPDU

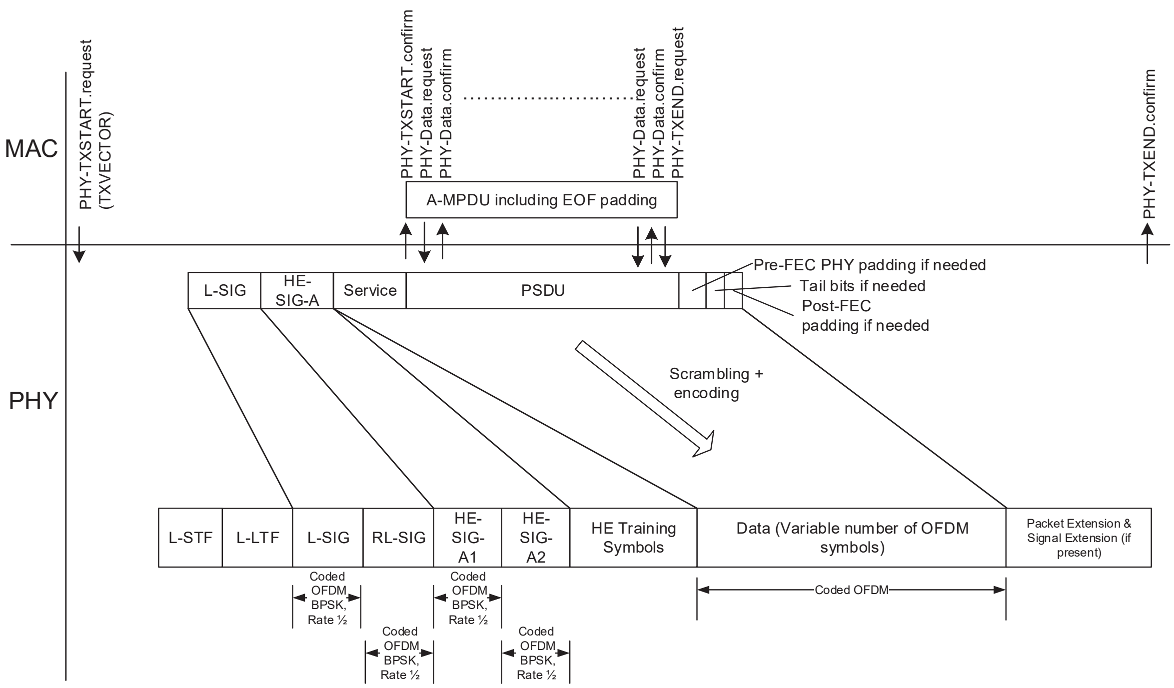

Figure 27-57—PHY transmit procedure for an HE TB PPDU

The fifth option is to follow the transmit procedure in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or Clause 18 (Extended Rate PHY (ERP) specification) if the FORMAT parameter of the PHYTXSTART.request(TXVECTOR) primitive is NON_HT. In addition, if the FORMAT parameter is NON_HT and the NON_HT_MODULATION parameter is OFDM, then the transmit procedure defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) is followed. If the FORMAT parameter is NON_HT and the NON_HT_MODULATION parameter is NON_HT_DUP_OFDM the transmit procedure defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) is followed except that the signal is generated simultaneously on each of the 20 MHz channels identified by the CH_BANDWIDTH parameter as defined in 27.3.11 (HE preamble) and 27.3.14 (Non-HT duplicate transmission). If the FORMAT parameter is NON_HT, the CH_BANDWIDTH parameter is NON_HT_CBW20, and the NON_HT_MODULATION parameter is not OFDM, then the transmit procedure defined in Clause 18 (Extended Rate PHY (ERP) specification) is followed.

NOTE 1—For an HE MU PPDU the A-MPDU is per user in the MAC sublayer and the HE Training Symbols, and Data are per user in the PHY in Figure 27-56 (PHY transmit procedure for an HE MU PPDU), with the number HE Training Symbols depending on the maximum total number of space-time streams across all RUs.

NOTE 2—The transmit procedure for NON_HT, HT_MF, HT_GF, and VHT format are specified in 27.2.6 (Support for non-HT, HT and VHT formats).

In all options, in order to transmit data, the MAC generates a PHY-TXSTART.request primitive, which causes the PHY entity to enter the transmit state. Further, the PHY is set to operate at the appropriate frequency through station management via the PLME, as specified in 27.4 (HE PLME). Other transmit parameters, such as HE-MCS, Coding types and transmit power, are set via the PHY-SAP using the PHYTXSTART.request(TXVECTOR) primitive, as described in 27.2.2 (TXVECTOR and RXVECTOR parameters). After transmitting a PPDU that carries a Trigger frame, the MAC sublayer issues a PHY-TRIGGER.request with a TRIGVECTOR parameter that provides the PHY entity with the information needed to demodulate the expected HE TB PPDU response. The remainder of the clause applies to the first four options.

The PHY indicates the state of the primary channel and other channels (if any) via the PHY-CCA.indication primitive (see 21.3.18.5 (CCA sensitivity) and 8.3.5.12 (PHY-CCA.indication)). Transmission of the PPDU shall be initiated by the PHY after receiving the PHY-TXSTART.request(TXVECTOR) primitive. The TXVECTOR parameters for the PHY-TXSTART.request primitive are specified in Table 27-1 (TXVECTOR and RXVECTOR parameters).

After the PHY preamble transmission is started, the PHY entity immediately initiates data scrambling and data encoding. The encoding method for the Data field is based on the FEC_CODING, CH_BANDWIDTH, NUM_STS, STBC, MCS, and NUM_USERS parameters of the TXVECTOR, as described in 27.3.4 (HE PPDU formats).

The SERVICE field and PSDU are encoded as described in 27.3.5 (Transmitter block diagram). The data shall be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. PHY padding bits are appended to the PSDU to make the number of bits in the coded PSDU an integral multiple of the number of coded bits per OFDM symbol.

Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PSDU transmission is terminated by receiving a PHY-TXEND.request primitive. Each PHY-TXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY.

A packet extension and/or a signal extension may be present in the PPDU. The PHY-TXEND.confirm primitive is generated at the latest of the actual ending time of the PPDU, the end of the packet extension if present, and the end of the signal extension if present.

In the PHY, the GI with GI duration indicated in GI_TYPE parameter of the TXVECTOR is inserted in every data OFDM symbol as a countermeasure against delay spread.

Once the PPDU transmission is completed the PHY entity enters the receive state.

A typical state machine implementation for the transmission of an HE PPDU without midambles is shown in Figure 27-58 (PHY transmit state machine for an HE PPDU without midambles). Request (.request) and confirmation (.confirm) primitives are issued once per state as shown. This state machine does not describe the operation of optional features, such as DCM.

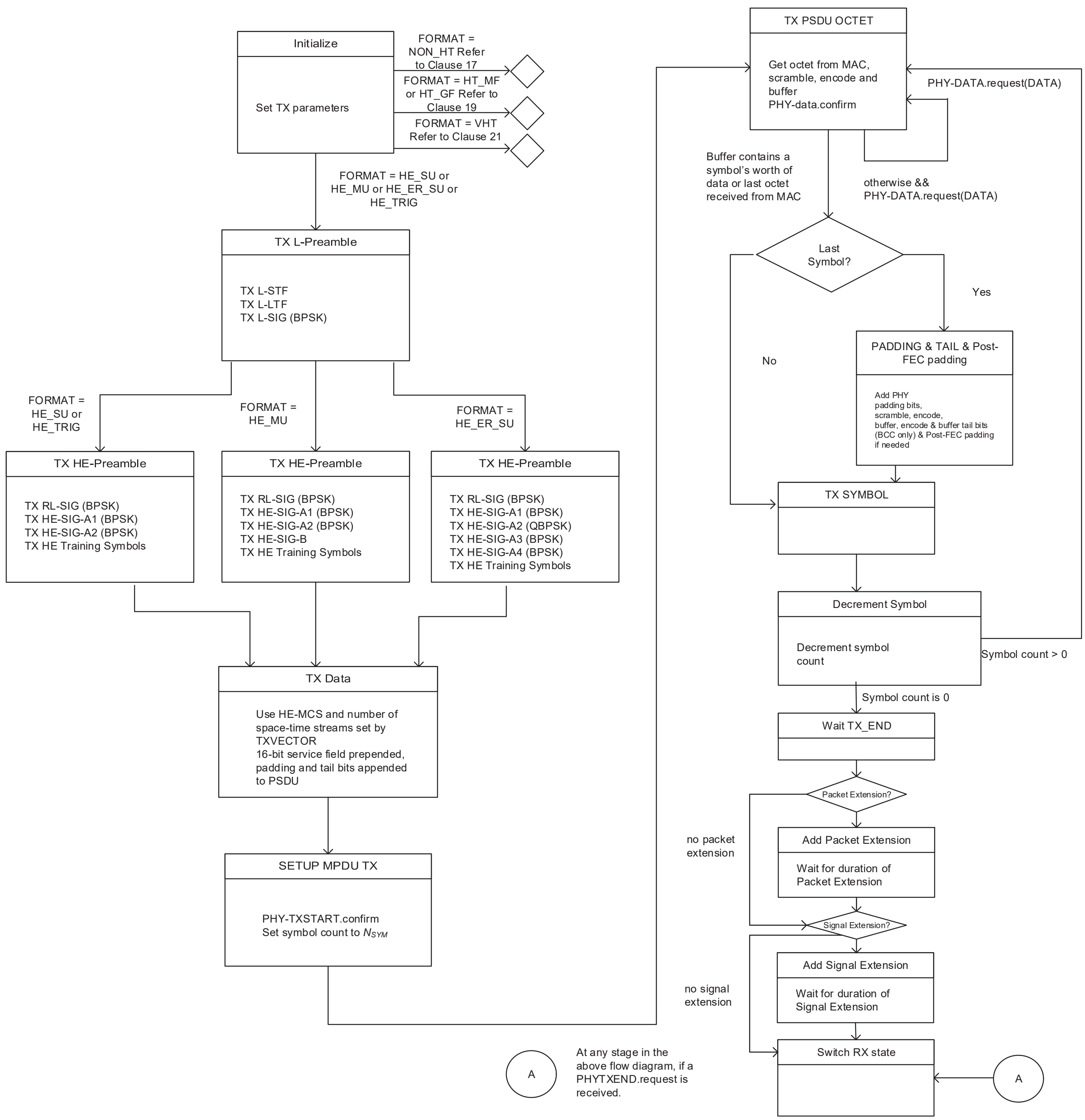

Figure 27-58—PHY transmit state machine for an HE PPDU without midambles

27.3.22 HE receive procedure

Typical PHY receive procedures are shown in Figure 27-59 (PHY receive procedure for an HE SU PPDU), Figure 27-60 (PHY receive procedure for an HE ER SU PPDU), Figure 27-61 (PHY receive procedure for an HE MU PPDU), and Figure 27-62 (PHY receive procedure for an HE TB PPDU) respectively.

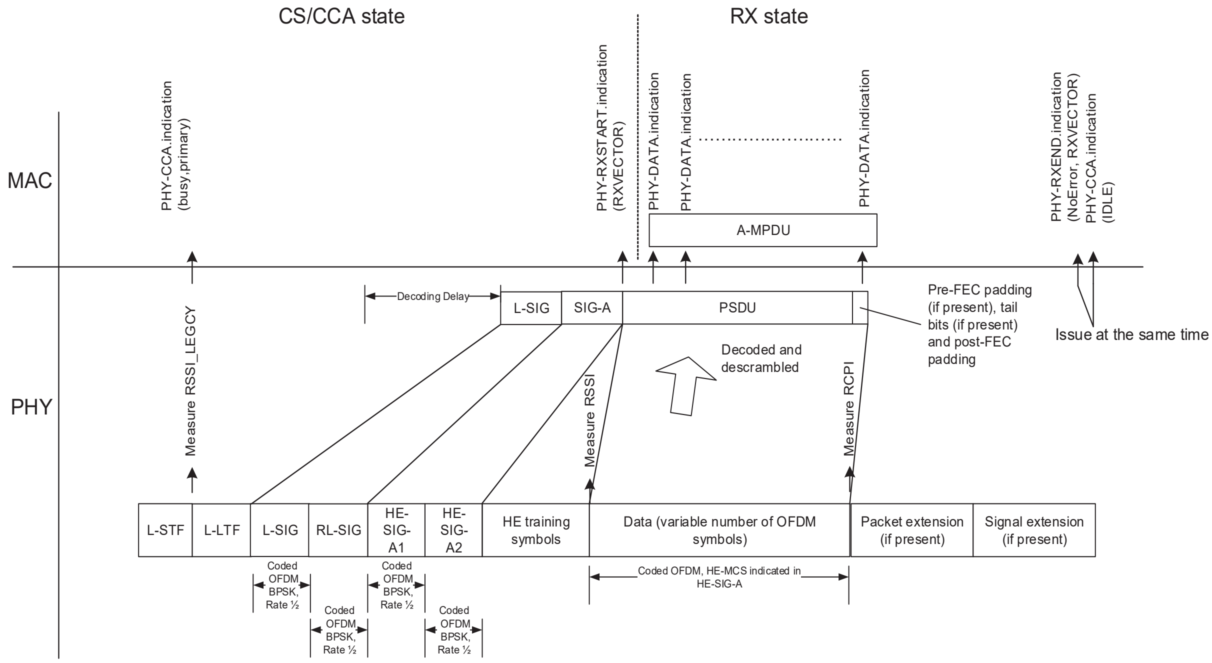

Figure 27-59—PHY receive procedure for an HE SU PPDU

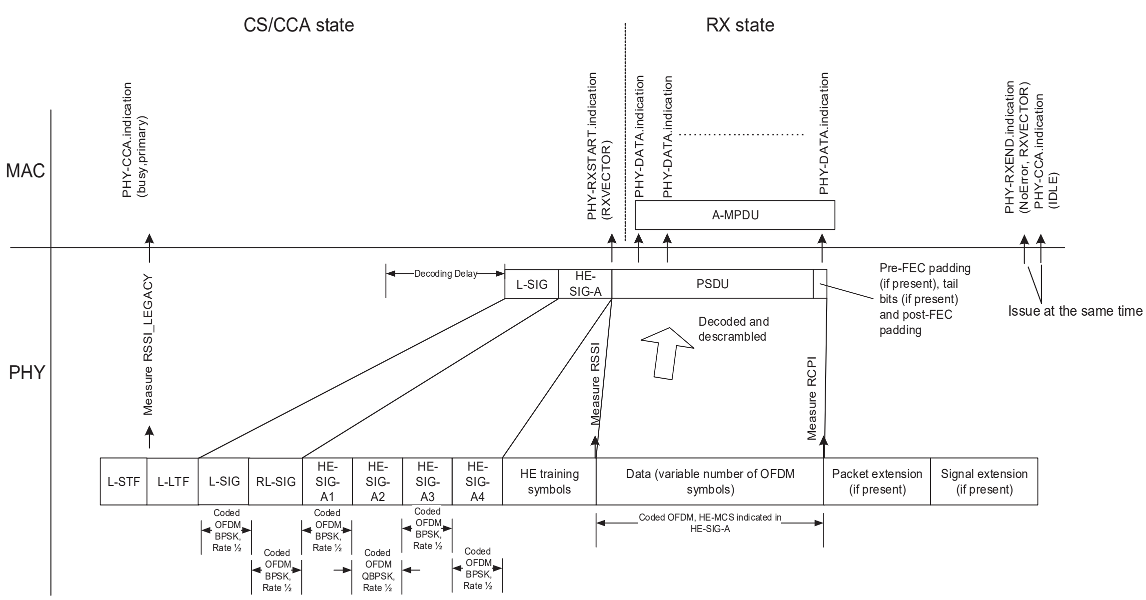

Figure 27-60—PHY receive procedure for an HE ER SU PPDU

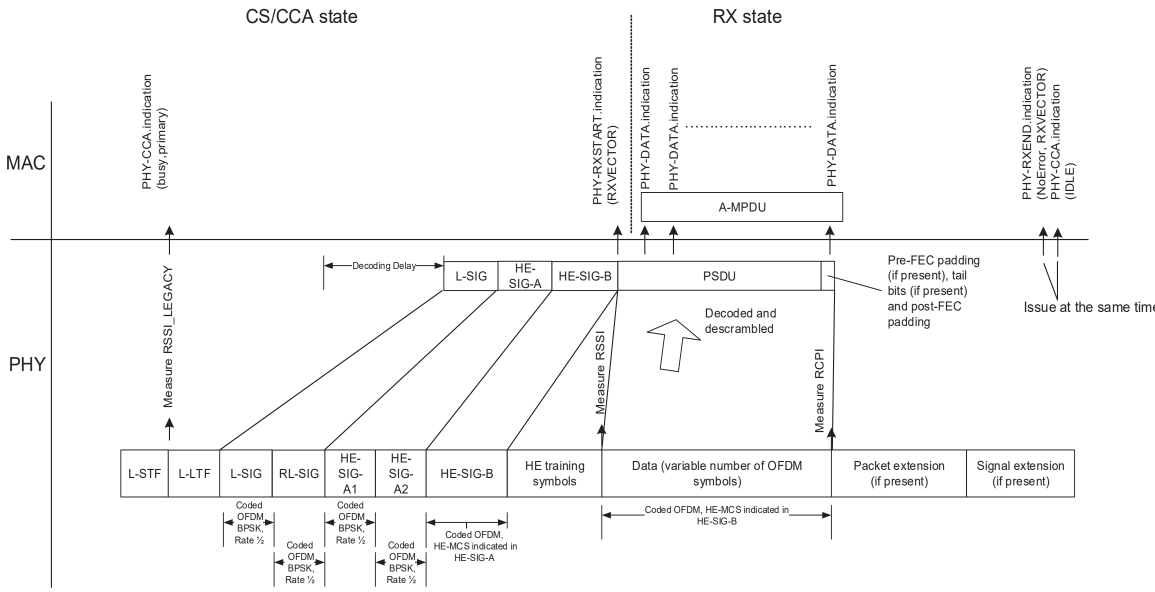

Figure 27-61—PHY receive procedure for an HE MU PPDU

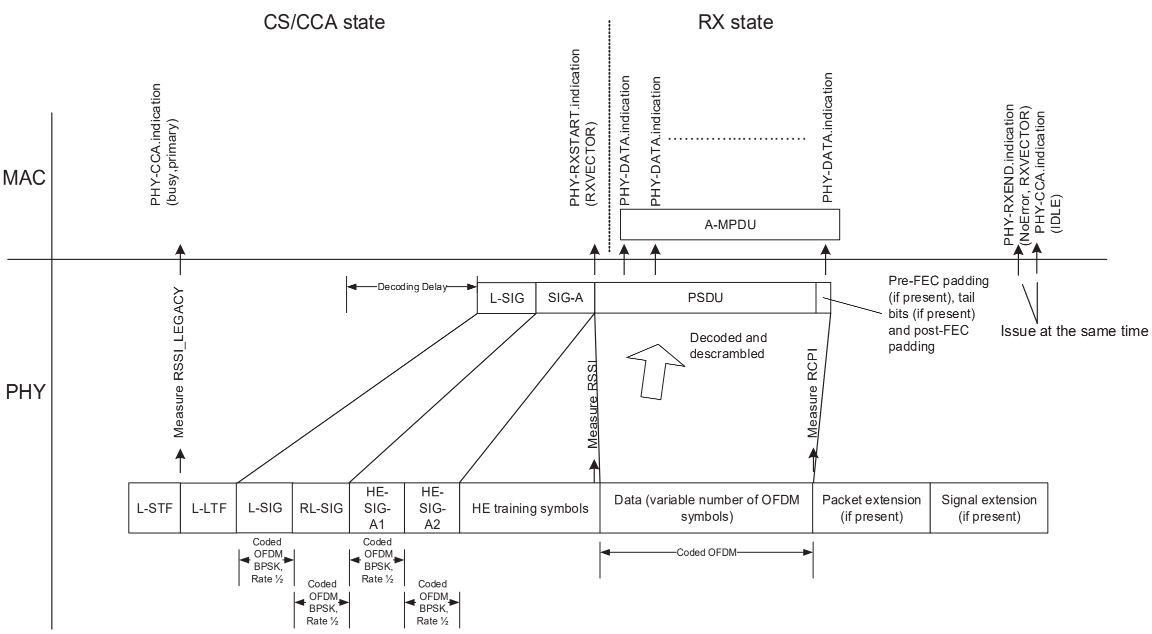

Figure 27-62—PHY receive procedure for an HE TB PPDU

A typical state machine implementation of the receive PHY is given in Figure 27-63 (PHY receive state machine if midambles are not present).

This receive procedure and state machine do not describe the operation of optional features, such as DCM. If the detected format indicates a non-HT PPDU, refer to the receive procedure and state machine in Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division

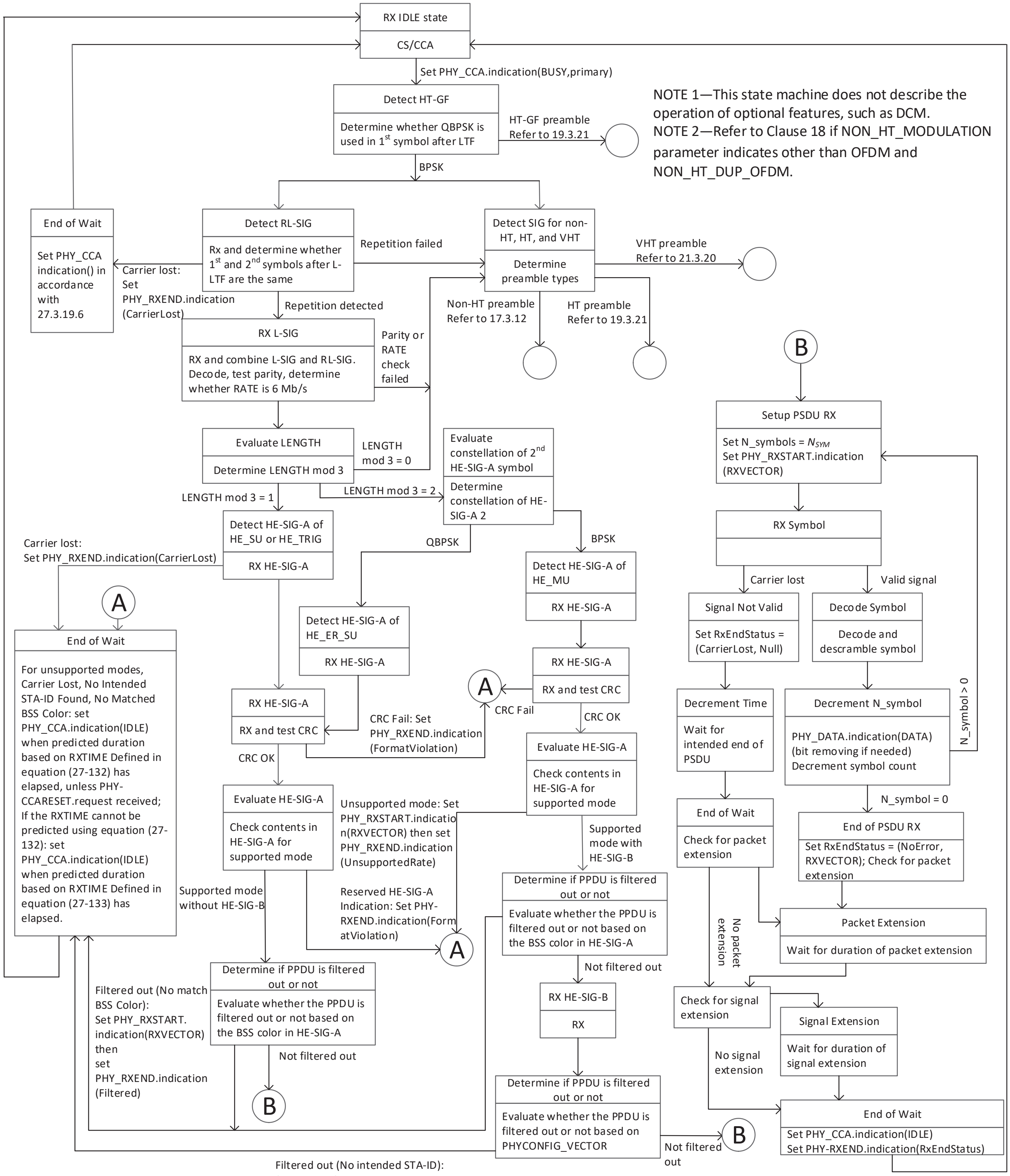

Figure 27-63—PHY receive state machine if midambles are not present

multiplexing (OFDM) PHY specification) and Clause 18 (Extended Rate PHY (ERP) specification). If the detected format indicates an HT PPDU format, refer to the receive procedure and state machine in Clause 19 (High Throughput (HT) PHY specification). If the detected format indicates a VHT PPDU format, refer to the receive procedure and state machine in Clause 21 (Very High Throughput (VHT) PHY specification).Through station management (via the PLME) the PHY is set to the appropriate frequency, as specified in 27.4 (HE PLME). The PHY has also been configured with BSS identification information and STA identification information (i.e., BSS color value and STA-ID in the BSS) so that it can receive data intended for the STA in the specific cell. Other receive parameters, such as RSSI and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted PHY preamble in a greater than or equal to 20 MHz BSS, the PHY measures a receive signal strength. This activity is indicated by the PHY to the MAC via a PHY-CCA.indication primitive. A PHY-CCA.indication(BUSY, channel-list) primitive is also issued as an initial indication of reception of a signal as specified in 27.3.20.6 (CCA sensitivity). The channel-list parameter of the PHY-CCA.indication primitive is absent when the operating channel width is 20 MHz. The channel-list parameter is present when the operating channel width is 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz.

The PHY shall not issue a PHY-RXSTART.indication primitive in response to a PPDU that does not overlap the primary channel unless the PHY at an AP receives the HE TB PPDU solicited by the AP. For the HE TB PPDU solicited by the AP, the PHY shall issue a PHY-RXSTART.indication primitive for a PPDU received in the primary or at the secondary 20 MHz channel, the secondary 40 MHz channel, or the secondary 80 MHz channel.

The PHY includes the measured RSSI and RSSI_LEGACY value in the PHY-RXSTART.indication(RXVECTOR) primitive issued to the MAC.

After the PHY-CCA.indication(BUSY, channel-list) primitive is issued, the PHY entity shall begin receiving the training symbols and searching for the preambles for non-HT, HT, VHT, and HE PPDUs, respectively. If the constellation used in the first symbol after the first long training field is QBPSK, the PHY entity shall continue to detect the received signal using the receive procedure for HT-GF depicted in Clause 19. Otherwise, for detecting the HE preamble, the PHY entity shall search for L-SIG and RL-SIG in order to set the maximum duration of the data stream. If RL-SIG is detected, the PHY entity should check the parity bit and RATE fields in L-SIG and RL-SIG. If either the check of the parity bit is invalid or the RATE field is not set to 6 Mb/s in non-HT, a PHY-RXSTART.indication primitive is not issued. If the check of the parity bit is valid and the RATE field indicates 6 Mb/s in non-HT but the LENGTH field value in L-SIG is a multiple of 3, a PHY-RXSTART.indication primitive is not issued. In both cases, the PHY should continue to detect the received signal using non-HT, HT, and VHT receive procedure in Clauses 17, 19, and 21, respectively.

If a valid parity bit and the RATE with 6 Mb/s in non-HT are indicated in L-SIG and RL-SIG and the LENGTH field value in L-SIG and RL-SIG meets the condition that the remainder is 1 after LENGTH divided by 3, the PHY entity should begin receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for HE SU PPDU and HE TB PPDU as shown in Figure 27-59 (PHY receive procedure for an HE SU PPDU) and Figure 27-62 (PHY receive procedure for an HE TB PPDU), respectively. After RL-SIG, the PHY entity shall receive two symbols of HE-SIG-A immediately followed by HE-STF.

The PHY entity shall check CRC of the HE-SIG-A field. If the CRC check is valid, the PHY entity shall report TXOP, BSS color and check Format field, and continue to receive HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in the HE-SIG-A field. The PHY entity shall check the BSS color in the HE-SIG-A field. If the BSS color does not contain an intended value, the PHY entity shall issue a PHY-RXSTART.indication(RXVECTOR) then issue a PHY-RXEND.indication(Filtered).

The PHY entity shall check the Format field in the HE-SIG-A field. If the Format field indicates an HE SU PPDU, the PHY entity shall receive HE-STF for 4 μs after the HE-SIG-A field. If the Format field indicates an HE TB PPDU, the PHY entity shall receive HE-STF for 8 μs after the HE-SIG-A field.

If the HE-SIG-A field indicates a valid CRC and a reserved HE-SIG-A indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channel-list) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (27-133), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation). If the HE-SIG-A field indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate) primitive. If the HE-SIG-A field indicates a reserved HE-SIG-A indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (27-134) unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation).

If the HE-SIG-A field indicates an invalid CRC, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (27-134). A reserved HE-SIG-A indication is defined as an HE-SIG-A field with Reserved bits equal to 0 or any other HE-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 27 (High Efficiency (HE) PHY specification).

If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is QBPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for an HE ER SU PPDU shown in Figure 27-60 (PHY receive procedure for an HE ER SU PPDU). After RL-SIG, the PHY entity shall receive four symbols of HE-SIG-A immediately followed by HE-STF.

The PHY entity shall check the CRC of the HE-SIG-A field. If the CRC is valid, the PHY entity shall report TXOP and BSS color, and continue to receive the HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A.

The PHY entity shall check the BSS color in the HE-SIG-A field. If the BSS color does not contain an intended value, the PHY entity shall issue a PHY-RXSTART.indication(RXVECTOR) then issue a PHY-RXEND.indication(Filtered).

The PHY entity shall receive the HE-STF for 4 μs after HE-SIG-A.

If the HE-SIG-A field indicates a valid CRC and a reserved HE-SIG-A indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channel-list) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (27-133), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation). If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate) primitive.

If the HE-SIG-A field indicates a reserved HE-SIG-A indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channel-list) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (27-134) unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation). A reserved HE-SIG-A indication is defined as an HE-SIG-A field with Reserved bits equal to 0 or any other

HE-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 27 (High Efficiency (HE) PHY specification).

If the HE-SIG-A field indicates an invalid CRC, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (27-134), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation).

If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is BPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF for an HE MU PPDU shown in Figure 27-61 (PHY receive procedure for an HE MU PPDU). After RL-SIG, the PHY entity shall receive two symbols of the HE-SIG-A field immediately followed by the HE-SIG-B field. The PHY entity shall check CRC of the HE-SIG-A field. If the CRC check is valid, the PHY entity shall report TXOP and BSS color, and continue to receive HE-SIG-B. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in the HE-SIG-A field.

The PHY entity shall check the BSS color in the HE-SIG-A field. If the BSS color does not contain an intended value, the PHY entity shall issue a PHY-RXSTART.indication(RXVECTOR) then issue a PHY-RXEND.indication(Filtered).

After the HE-SIG-A field, the PHY entity shall receive the HE-SIG-B field for the number of symbols predicted from the HE-SIG-A field. If the Common field is present in the HE-SIG-B field, the PHY entity shall check the CRC of the Common field. If the CRC in the Common field is valid or the Common field is not present, the PHY entity shall search for intended STA-ID in each User Specific subfield with a valid CRC. If no CRC is valid or no intended STA-ID is detected, the PHY entity shall issue a PHY-RXSTART.indication(RXVECTOR) then issue a PHY-RXEND.indication(Filtered). If a complete allocation of an intended STA-ID is detected in block with valid CRC, the PHY entity shall continue receiving HE-STF for 4 µs after HE-SIG-B for the detected and intended STA.

If the HE-SIG-A field indicates a valid CRC and a reserved HE-SIG-A indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (27-133), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation).

If the HE-SIG-A field indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate) primitive.

If the HE-SIG-A field indicates a reserved HE-SIG-A indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (27-134) unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation). A reserved HE-SIG-A indication is defined as an HE-SIG-A with Reserved bits equal to 0 or any other HE-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 27 (High Efficiency (HE) PHY specification).

If the HE-SIG-A field indicates an invalid CRC, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in

Equation (27-134), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 26.10 (Spatial reuse operation).

If signal loss occurs during reception prior to completion of the PSDU reception, the error condition PHY-RXEND.indication(CarrierLost) shall be reported to the MAC. After waiting for the end of the PPDU as determined by Equation (27-133) the PHY shall set the PHY-CCA.indication (IDLE) primitive and return to the RX IDLE state.

$$\mathrm{RXTIME}(\mu\mathrm{s}) = 20 + T_{\mathrm{HE\_PREAMBLE}} + N_{SYM}T_{SYM} + N_{MA}N_{\mathrm{HE\text{-}LTF}}T_{\mathrm{HE\text{-}LTF\text{-}SYM}} + T_{PE} + SignalExtension \tag{27-133}$$

where

$T_{\mathrm{HE\text{-}PREAMBLE}}$, N_{SYM}, T_{PE} and N_{MA} are defined in Equation (27-119), Equation (27-120), Equation (27-121) and Equation (27-122), respectively.

SignalExtension is defined in Table 27-55 (HE PHY characteristics).

$$\mathrm{RXTIME}(\mu\mathrm{s}) = \left\lceil \frac{\mathrm{LENGTH} + 3}{3} \right\rceil \cdot 4 + 20 + SignalExtension \tag{27-134}$$

where

LENGTH is the LENGTH field in L-SIG

SignalExtension is defined in Table 27-55 (HE PHY characteristics)

Except in an HE sounding NDP and HE TB feedback NDP, a Data field follows the HE-STF and HE-LTF fields. The number of symbols in the Data field and the packet extension duration are computed from Equation (27-119) and Equation (27-120), respectively.

The received PSDU bits are assembled into octets, decoded, and present to the MAC using a series of PHY-DATA.indication(DATA) primitive exchanges. Any final bits that cannot be assembled into a complete octet are considered pad bits and discarded. After the reception of the final bit of the last PSDU octet, and possible padding and tail bits, the PHY entity shall check whether packet extension and/or signal extension is applied. If packet extension and/or signal extension is applied, the PHY entity shall wait until the packet extension and/or signal extension expires before returning to the RX IDLE state, as shown in Figure 27-63 (PHY receive state machine if midambles are not present).

27.3.23 Channel numbering

27.3.23.1 General

The STA may operate in the 2.4 GHz band, 5 GHz band or 6 GHz band. The set of valid operating channel numbers by regulatory domain is defined in Annex E. Channel allocation for each band is defined as follows:

- In 19.3.15.2 (Channel allocation in the 2.4 GHz band) for the 2.4 GHz band
- In 19.3.15.3 (Channel allocation in the 5 GHz band) for the 5 GHz band
- In 27.3.23.2 (Channel allocation in the 6 GHz band) for the 6 GHz band

27.3.23.2 Channel allocation in the 6 GHz band

Channel center frequencies are defined at every integer multiple of 5 MHz above 5940 MHz. The relationship between center frequency and channel number is given in Equation (27-135).

$$\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}\ (\mathrm{MHz}) \tag{27-135}$$

where

$n_{ch} = 1, \ldots, 253$

Channel starting frequency is 5.940 GHz

27.3.24 Regulatory requirements

Wireless LANs (WLANs) implemented in accordance with this standard are subject to equipment certification and operating requirements established by regional and national regulatory administrations. The PHY specification establishes minimum technical requirements for interoperability, based upon established regulations at the time this standard was issued. These regulations are subject to revision or may be superseded. Requirements that are subject to local geographic regulations are annotated within the PHY specification. Regulatory requirements that do not affect interoperability are not addressed in this standard. Implementers are referred to the regulatory sources in Annex D for further information. Operation in countries within defined regulatory domains might be subject to additional or alternative national regulations.

27.4 HE PLME

27.4.1 PLME_SAP sublayer management primitives

Table 27-54 (HE PHY MIB attributes) 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).

27.4.2 PHY MIB

HE PHY MIB attributes are defined in Annex C with specific values defined in Table 27-54 (HE PHY MIB attributes). The "Operational semantics" column in Table 27-54 (HE PHY MIB attributes) contains two types: static and dynamic.

- Static MIB attributes are fixed and cannot be modified for a given PHY implementation.
- Dynamic MIB attributes are interpreted according to the MAX-ACCESS field of the MIB attribute. If MAX-ACCESS is equal to read-only, the MIB attribute value may be updated by the PLME and

read from the MIB attribute by management entities. if MAX-ACCESS is equal to read-write, the MIB attribute may be read and written by management entities.

Table 27-54—HE PHY MIB attributes

Managed object	Default value/range	Operational semantics
dot11PHYOperationTable		
dot11PHYType	he	Static
dot11PHYTxPowerTable		
dot11NumberSupportedPowerLevelsImplemented	Implementation dependent	Static
dot11TxPowerLevel1	Implementation dependent	Static
dot11TxPowerLevel2	Implementation dependent	Static
dot11TxPowerLevel3	Implementation dependent	Static
dot11TxPowerLevel4	Implementation dependent	Static
dot11TxPowerLevel5	Implementation dependent	Static
dot11TxPowerLevel6	Implementation dependent	Static
dot11TxPowerLevel7	Implementation dependent	Static
dot11TxPowerLevel8	Implementation dependent	Static
dot11CurrentTxPowerLevel	Implementation dependent	Static
dot11TxPowerLevelExtended	Implementation dependent	Static
dot11CurrentTxPowerLevelExtended	Implementation dependent	Static
dot11PHYOFDMTable		
dot11TwentyMHzOperationImplemented	false/Boolean	Static
dot11PHYHTTable		
dot11CurrentPrimaryChannel	Implementation dependent	Dynamic
dot11CurrentSecondaryChannel	Implementation dependent	Dynamic
dot11FortyMHzOperationImplemented	false/Boolean	Static
dot11FortyMHzOperationActivated	false/Boolean	Dynamic

Table 27-54—HE PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11NumberOfSpatialStreamsImplemented	Implementation dependent	Static
dot11NumberOfSpatialStreamsActivated	Implementation dependent	Dynamic
dot11HTGreenfieldOptionImplemented	false/Boolean	Static
dot11HTGreenfieldOptionActivated	false/Boolean	Dynamic
dot11ShortGIOptionInTwentyImplemented	false/Boolean	Static
dot11ShortGIOptionInTwentyActivated	false/Boolean	Dynamic
dot11ShortGIOptionInFortyImplemented	false/Boolean	Static
dot11ShortGIOptionInFortyActivated	false/Boolean	Dynamic
dot11LDPCCodingOptionImplemented	false/Boolean	Static
dot11LDPCCodingOptionActivated	false/Boolean	Dynamic
dot11TxSTBCOptionImplemented	false/Boolean	Static
dot11TxSTBCOptionActivated	false/Boolean	Dynamic
dot11RxSTBCOptionImplemented	false/Boolean	Static
dot11RxSTBCOptionActivated	false/Boolean	Dynamic
dot11BeamFormingOptionImplemented	false/Boolean	Static
dot11BeamFormingOptionActivated	false/Boolean	Dynamic
dot11PHYVHTTable		
dot11CurrentChannelWidth	Implementation dependent	Dynamic
dot11CurrentChannelCenterFrequencyIndex0	Implementation dependent	Dynamic
dot11CurrentChannelCenterFrequencyIndex1	Implementation dependent	Dynamic
dot11VHTChannelWidthOptionImplemented	Implementation dependent	Static
dot11EightyMHzOperationImplemented	false/Boolean	Static
dot11EightyMHzOperationActivated	false/Boolean	Dynamic
dot11VHTShortGIOptionIn80Implemented	false/Boolean	Static
dot11VHTShortGIOptionIn80Activated	false/Boolean	Dynamic
dot11VHTShortGIOptionIn160and80p80Implemented	false/Boolean	Static
dot11VHTShortGIOptionIn160and80p80Activated	false/Boolean	Dynamic
dot11VHTLDPCCodingOptionImplemented	false/Boolean	Static
dot11VHTLDPCCodingOptionActivated	false/Boolean	Dynamic

Table 27-54—HE PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11VHTTxSTBCOptionImplemented	false/Boolean	Static
dot11VHTTxSTBCOptionActivated	false/Boolean	Dynamic
dot11VHTRxSTBCOptionImplemented	false/Boolean	Static
dot11VHTRxSTBCOptionActivated	false/Boolean	Dynamic
dot11VHTMaxNTxChainsImplemented	Implementation dependent	Static
dot11VHTMaxNTxChainsActivated	Implementation dependent	Dynamic
dot11TransmitBeamformingConfigTable		
dot11ReceiveStaggerSoundingOptionImplemented	false/Boolean	Static
dot11TransmitStaggerSoundingOptionImplemented	false/Boolean	Static
dot11ReceiveNDPOptionImplemented	false/Boolean	Static
dot11TransmitNDPOptionImplemented	false/Boolean	Static
dot11ImplicitTransmitBeamformingOptionImplemented	false/Boolean	Static
dot11CalibrationOptionImplemented	Implementation dependent	Static
dot11ExplicitCSITransmitBeamformingOptionImplemented	false/Boolean	Static
dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented	false/Boolean	Static
dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitNoncompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitCompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11NumberBeamFormingCSISupportAntenna	Implementation dependent	Static
dot11NumberNonCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11NumberCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11VHTTransmitBeamformingConfigTable		
dot11VHTSUBeamformeeOptionImplemented	false/Boolean	Static
dot11VHTSUBeamformerOptionImplemented	false/Boolean	Static
dot11VHTMUBeamformeeOptionImplemented	false/Boolean	Static
dot11VHTMUBeamformerOptionImplemented	false/Boolean	Static

Table 27-54—HE PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11VHTNumberSoundingDimensions	Implementation dependent	Static
dot11VHTBeamformeeNTxSupport	Implementation dependent	Static
dot11PHYHETable		
dot11HECurrentChannelWidthSet	Implementation dependent	Dynamic
dot11HEPuncturedPreambleRxImplemented	Implementation dependent	Static
dot11HEDeviceClass	Implementation dependent	Static
dot11HELDPCCodingInPayloadImplemented	false/Boolean	Static
dot11HESUPPDUwith1xHELTFand0point8GIlmplemented	false/Boolean	Static
dot11HESUPPDUandHEMUPPDUwith4xHELTFand0point8GIlmplemented	false/Boolean	Static
dot11HEERSUPPDUwith4xHELTFand0point8GIImplemented	false/Boolean	Static
dot11HEERSUPPDUwith1xHELTFand0point8GIImplemented	false/Boolean	Static
dot11HEMidambleRxMaxNSTS	false/Boolean	Dynamic
dot11HENDPwith4xHELTFand3point2GIImplemented	false/Boolean	Static
dot11HESTBCTxLessThanOrEqualTo80Implemented	false/Boolean	Static
dot11HESTBCRxLessThanOrEqualTo80Implemented	false/Boolean	Static
dot11HESTBCTxGreaterThan80Implemented	false/Boolean	Static
dot11HESTBCRxGreaterThan80Implemented	false/Boolean	Static
dot11HEDopplerTxImplemented	false/Boolean	Static
dot11HEDopplerRxImplemented	false/Boolean	Static
dot11HEDCMImplemented	Implementation dependent	Static
dot11HEFullBWULMUMIMOImplemented	false/Boolean	Static
dot11HEPartialBWULMUMIMOImplemented	false/Boolean	Static
dot11HEPartialBWDLMUMIMOImplemented	false/Boolean	Static
dot11HEULMUPayloadImplemented	false/Boolean	Static
dot11HEPSRbasedSRSupportImplemented	false/Boolean	Static
dot11HEPowerBoostFactorImplemented	false/Boolean	Static
dot11HEPartialBWERSUPayloadImplemented	false/Boolean	Static
dot11HETransmitBeamformingConfigTable		
dot11HESUBeamformerOptionImplemented	false/Boolean	Static

Table 27-54—HE PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11HESUBeamformeeOptionImplemented	false/Boolean	Static
dot11HEMUBeamformerOptionImplemented	false/Boolean	Static
dot11HEBeamformeeSTSSupportLessThanOrEqualTo80	Implementation dependent	Static
dot11HEBeamformeeSTSSupportGreaterThan80	Implementation dependent	Static
dot11HENumberSoundingDimensionsLessThanOrEqualTo80	Implementation dependent	Static
dot11HENumberSoundingDimensionsGreaterThan80	Implementation dependent	Static
dot11HENG16SUFeedbackSupport	false/Boolean	Static
dot11HENG16MUFeedbackSupport	false/Boolean	Static
dot11HECodebookSizePhi4Psi2SUFeedbackSupport	false/Boolean	Static
dot11HECodebookSizePhi7Psi5MUFeedbackSupport	false/Boolean	Static
dot11HETriggeredSUBeamformingFeedbackImplemented	false/Boolean	Static
dot11HETriggeredMUBeamformingFeedbackImplemented	false/Boolean	Static
dot11HETriggeredCQIFeedbackSupportImplemented	false/Boolean	Static

27.4.3 TXTIME and PSDU_LENGTH calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an HE PPDU using Equation (27-136).

$$\mathrm{TXTIME} = 20 + T_{\text{HE-PREAMBLE}} + N_{SYM}T_{SYM} + N_{MA}N_{\text{HE-LTF}}T_{\text{HE-LTF-SYM}} + T_{PE} + SignalExtension \tag{27-136}$$

where

$T_{\text{HE-PREAMBLE}}$ is defined as in Equation (27-121) and *SignalExtension* takes the value of aSignalExtension as defined in Table 27-55 (HE PHY characteristics).

For an HE sounding NDP and HE TB feedback NDP, there is no Data field and $N_{SYM} = 0$.

For an HE SU PPDU and HE ER SU PPDU using BCC encoding, the total number of data OFDM symbols, N_{SYM}, is given by Equation (27-66).

For an HE SU PPDU and HE ER SU PPDU using LDPC encoding, the total number of data OFDM symbols, N_{SYM}, is given in 27.3.12.5.2 (LDPC coding).

For an HE MU PPDU (including both MU-MIMO and OFDMA), the total number of data OFDM symbols, N_{SYM}, is given in 27.3.12.5.4 (Encoding process for an HE MU PPDU).

For an HE TB PPDU, the total number of data OFDM symbols, N_{SYM}, is given in 27.3.12.5.5 (Encoding process for an HE TB PPDU).

T_{PE} is given in 27.3.13 (Packet extension).

N_{MA} is the number of midambles. It is given by Equation (27-117) for an HE TB PPDU and by Equation (27-112) for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU if the TXVECTOR value DOPPLER is 1, and is 0 otherwise.

$N_{HE\text{-}LTF}$ and $T_{HE\text{-}LTF}$ are given in 27.3.9 (Timing-related parameters).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE SU PPDU, HE ER SU PPDU and HE TB PPDU is calculated using Equation (27-137).

$$\text{PSDU\_LENGTH} = \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,last,init} - N_{service} - N_{tail}}{8} \right\rfloor \quad (27\text{-}137)$$

where

$N_{SYM,init}$ is given by Equation (27-64) for BCC encoding, by Equation (27-64) for LDPC encoding for an HE SU PPDU and HE ER SU PPDU, and in 27.3.12.5.5 (Encoding process for an HE TB PPDU) for an HE TB PPDU

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

N_{DBPS} is given in 27.5 (Parameters for HE-MCSs)

$N_{DBPS,last,init}$ is given by Equation (27-62)

The value of the PSDU_LENGTH parameter for user u returned in the PLME-TXTIME.confirm primitive for an HE MU PPDU is calculated using Equation (27-138) and Equation (27-139) for users using BCC and LDPC, respectively.

$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,u} - N_{service} - N_{tail}}{8} \right\rfloor \quad (27\text{-}138)$$

$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,init,u} - N_{service}}{8} \right\rfloor \quad (27\text{-}139)$$

where

$N_{SYM,init}$ is given by Equation (27-76)

$N_{DBPS,u}$ is given in Table 27-15 (Frequently used parameters)

$N_{DBPS,last,u}$ is given by Equation (27-85)

$N_{DBPS,last,init,u}$ is given by Equation (27-77)

For an HE SU PPDU, HE ER SU PPDU and HE TB PPDU, the value of the PSDU_LENGTH parameter returned in the RXVECTOR is calculated using Equation (27-140).

$$\text{PSDU\_LENGTH} = \left\lfloor \frac{(N_{SYM,RX} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,last,RX} - N_{service} - N_{tail}}{8} \right\rfloor \quad (27\text{-}140)$$

where

$N_{SYM,RX}$ is given by Equation (27-141)

m_{STBC} is 1 if the STBC field in HE-SIG-A is 0 and 2 if the STBC field is 1

$N_{DBPS,last,RX}$ is given by Equation (27-142)

N_{DBPS} is defined in Table 27-15 (Frequently used parameters)
$N_{service}$ and N_{tail} are defined in Table 27-12 (Timing-related constants)

$$N_{SYM,RX} = \begin{cases} N_{SYM} - m_{STBC}, & \begin{array}{l}\text{if the Coding field is 1,}\\ \text{the LDPC Extra Symbol Segment field is 1, and}\\ \text{the Pre-FEC Padding Factor field is 1 in HE-SIG-A}\end{array} \\ N_{SYM}, \text{ othewise} \end{cases} \tag{27-141}$$

where
N_{SYM} is given by Equation (27-119)

$$N_{DBPS,last,RX} = \begin{cases} N_{DBPS}, \text{ if } a_{RX} = 4 \\ a_{RX} \cdot N_{SD,short} \cdot N_{SS} \cdot N_{BPSCS} \cdot R, \text{ otherwise} \end{cases} \tag{27-142}$$

where
a_{RX} is given by Equation (27-143)
$N_{SD,short}$ is defined in Table 27-33 (NSD,short values)
N_{SS}, N_{BPSCS}, R are defined in Table 27-15 (Frequently used parameters)

$$a_{RX} = \begin{cases} 4, & \begin{array}{l}\text{if } a = 1\text{, the Coding field is 1 and}\\ \text{the LDPC Extra Symbol Segment field is 1 in HE-SIG-A}\end{array} \\ a-1, & \begin{array}{l}\text{if } a > 1\text{, the Coding field is 1 and}\\ \text{the LDPC Extra Symbol Segment field is 1 in HE-SIG-A}\end{array} \\ a, & \text{otherwise} \end{cases} \tag{27-143}$$

where
a is the pre-FEC padding factor (ranging from 1 to 4) indicated in HE-SIG-A

For an HE MU PPDU, the value of the RXVECTOR parameter PSDU_LENGTH returned for user u is calculated using Equation (27-144).

$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM,RX,u} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,RX,u} - N_{service} - N_{tail,u}}{8} \right\rfloor \tag{27-144}$$

where
$N_{SYM,RX,u}$ is given by Equation (27-145)
m_{STBC} is 1 if the STBC field in HE-SIG-A is 0 and 2 if the STBC field is 1
$N_{DBPS,last,RX,u}$ is given by Equation (27-146)
$N_{DBPS,u}$ is defined in Table 27-15 (Frequently used parameters)
$N_{service}$ and N_{tail} are defined in Table 27-12 (Timing-related constants)

$$N_{SYM,RX,u} = \begin{cases} N_{SYM} - m_{STBC}, & \begin{array}{l}\text{if } a = 1\text{, the Coding field is 1 in the HE-SIG-B User field}\\ \text{corresponding to user u}\\ \text{and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A}\end{array} \\ N_{SYM}, \text{ othewise} \end{cases} \tag{27-145}$$

where

N_{SYM} is given by Equation (27-119)

$$N_{DBPS,\,last,\,RX,\,u} = \begin{cases} N_{DBPS,\,u}, \text{ if } a_{RX,\,u} = 4 \\ a_{RX,\,u} \cdot N_{SD,\,short,\,u} \cdot N_{SS,\,u} \cdot N_{BPSCS,\,u} \cdot R_u, \text{ otherwise} \end{cases} \tag{27-146}$$

where

$a_{RX,u}$ is given by Equation (27-147)

$N_{SD,short,u}$ is $N_{SD,short}$ defined in Table 27-33 (NSD,short values) for user u

$N_{SS,u}$, $N_{BPSCS,u}$, R_u are defined in Table 27-15 (Frequently used parameters)

$$a_{RX,\,u} = \begin{cases} 4, & \begin{array}{l}\text{if } a = 1\text{, the Coding field is 1 in the HE-SIG-B User field} \\ \text{corresponding to the user } u \\ \text{and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A}\end{array} \\ a - 1, & \begin{array}{l}\text{if } a > 1\text{, the Coding field is 1 in the HE-SIG-B User field} \\ \text{corresponding to the user } u \\ \text{and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A}\end{array} \\ a, & \text{otherwise} \end{cases} \tag{27-147}$$

where

a is the pre-FEC padding factor (ranging from 1 to 4) indicated in HE-SIG-A

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE sounding NDP is 0.

27.4.4 HE PHY

The static HE PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 19-25 (HT PHY characteristics) unless otherwise listed in Table 27-55 (HE PHY characteristics). The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 27-55—HE PHY characteristics

Characteristic	Value
aTxPHYDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aSignalExtension	0 µs if operating in the 5 GHz or 6 GHz band 6 µs if operating in the 2.4 GHz band
aCCAMidTime	25 µs
aPPDUMaxTime	5.484 ms
aPSDUMaxLength	6 500 631 octets (see NOTE)
aRxPHYStartDelay	32 µs for HE SU and HE TB PPDUs. 40 µs for HE ER SU PPDUs. 32 + 4 × $N_{HE\text{-}SIG\text{-}B}$ µs for HE MU PPDUs, where $N_{HE\text{-}SIG\text{-}B}$ is the number of OFDM symbols in the HE-SIG-B field.
NOTE—This is the maximum length in octets for an HE SU PPDU with a bandwidth of 160 MHz or 80+80 MHz using 2×996 RU, HE-MCS 11, 8 spatial streams, 0.8 µs GI duration, 1x HE-LTF, LDPC coding, 0 µs duration of the PE field, pre-FEC padding factor value of 4, and limited by 398 possible Data field OFDM symbols in aPPDUMaxTime. This is the maximum PSDU length an HE PHY could support assuming no restrictions in MAC. See 10.3.2 (Procedures common to the DCF and EDCAF) and 9.2.4.7.1 (General) for additional restrictions on the maximum number of octets the MAC could support.	

27.5 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, 2×996-tone RU and non-OFDMA 160 MHz and 80+80 MHz N_{SS} = 1, …, 8 are provided in the 27.5.1 (HE-MCSs for 26-tone RU) through 27.5.7 (HE-MCSs for 2×996-tone RU). Support for HE-MCS 8, 9, 10, and 11 is optional in all cases.

HE-MCSs are defined for both SU transmission and for user u of the 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}, and N_{DBPS} are replaced with $N_{SS,u}$, R_u, $N_{BPSCS,u}$, $N_{CBPS,u}$, and $N_{DBPS,u}$, respectively.

N_{DBPS} shall be an integer and is computed as follows $N_{DBPS} = \lfloor N_{CBPS}/R \rfloor$, where R is the coding rate.

27.5.1 HE-MCSs for 26-tone RU

The rate-dependent parameters for the 26-tone RU are provided in Table 27-56 (HE-MCSs for 26-tone RU, NSS = 1) through Table 27-63 (HE-MCSs for 26-tone RU, NSS = 8).

Table 27-56—HE-MCSs for 26-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	12	12	6	0.4	0.4	0.4
	0		1/2		24	24	12	0.9	0.8	0.8
1	1	QPSK	1/2	2	12	24	12	0.9	0.8	0.8
	0		1/2		24	48	24	1.8	1.7	1.5
2	N/A		3/4		24	48	36	2.6	2.5	2.3
3	1	16-QAM	1/2	4	12	48	24	1.8	1.7	1.5
	0		1/2		24	96	48	3.5	3.3	3.0
4	1		3/4		12	48	36	2.6	2.5	2.3
	0		3/4		24	96	72	5.3	5.0	4.5
5	N/A	64-QAM	2/3	6	24	144	96	7.1	6.7	6.0
6			3/4				108	7.9	7.5	6.8
7			5/6				120	8.8	8.3	7.5
8		256-QAM	3/4	8		192	144	10.6	10.0	9.0
9			5/6				160	11.8	11.1	10.0
10		1024-QAM	3/4	10		240	180	13.2	12.5	11.3
11			5/6				200	14.7	13.9	12.5

Table 27-57—HE-MCSs for 26-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	1	BPSK	1/2	1	12	24	12	0.9	0.8	0.8
	0		1/2		24	48	24	1.8	1.7	1.5
1	1	QPSK	1/2	2	12	48	24	1.8	1.7	1.5
	0		1/2		24	96	48	3.5	3.3	3.0
2	N/A		3/4		24	96	72	5.3	5.0	4.5
3	1	16-QAM	1/2	4	12	96	48	3.5	3.3	3.0
	0		1/2		24	192	96	7.1	6.7	6.0
4	1		3/4		12	96	72	5.3	5.0	4.5
	0		3/4		24	192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6	24	288	192	14.1	13.3	12.0
6			3/4				216	15.9	15.0	13.5
7			5/6				240	17.6	16.7	15.0
8		256-QAM	3/4	8		384	288	21.2	20.0	18.0
9			5/6				320	23.5	22.2	20.0
10		1024-QAM	3/4	10		480	360	26.5	25.0	22.5
11			5/6				400	29.4	27.8	25.0

Table 27-58—HE-MCSs for 26-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	24	72	36	2.6	2.5	2.3
1		QPSK	1/2	2		144	72	5.3	5.0	4.5
2			3/4				108	7.9	7.5	6.8
3		16-QAM	1/2	4		288	144	10.6	10.0	9.0
4			3/4				216	15.9	15.0	13.5
5		64-QAM	2/3	6		432	288	21.2	20.0	18.0
6			3/4				324	23.8	22.5	20.3
7			5/6				360	26.5	25.0	22.5
8		256-QAM	3/4	8		576	432	31.8	30.0	27.0
9			5/6				480	35.3	33.3	30.0
10		1024-QAM	3/4	10		720	540	39.7	37.5	33.8
11			5/6				600	44.1	41.7	37.5

Table 27-59—HE-MCSs for 26-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	24	96	48	3.5	3.3	3.0
1		QPSK	1/2	2		192	96	7.1	6.7	6.0
2			3/4				144	10.6	10.0	9.0
3		16-QAM	1/2	4		384	192	14.1	13.3	12.0
4			3/4				288	21.2	20.0	18.0
5		64-QAM	2/3	6		576	384	28.2	26.7	24.0
6			3/4				432	31.8	30.0	27.0
7			5/6				480	35.3	33.3	30.0
8		256-QAM	3/4	8		768	576	42.4	40.0	36.0
9			5/6				640	47.1	44.4	40.0
10		1024-QAM	3/4	10		960	720	52.9	50.0	45.0
11			5/6				800	58.8	55.6	50.0

Table 27-60—HE-MCSs for 26-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	24	120	60	4.4	4.2	3.8
1		QPSK	1/2	2		240	120	8.8	8.3	7.5
2			3/4				180	13.2	12.5	11.3
3		16-QAM	1/2	4		480	240	17.6	16.7	15.0
4			3/4				360	26.5	25.0	22.5
5		64-QAM	2/3	6		720	480	35.3	33.3	30.0
6			3/4				540	39.7	37.5	33.8
7			5/6				600	44.1	41.7	37.5
8		256-QAM	3/4	8		960	720	52.9	50.0	45.0
9			5/6				800	58.8	55.6	50.0
10		1024-QAM	3/4	10		1 200	900	66.2	62.5	56.3
11			5/6				1 000	73.5	69.4	62.5

Table 27-61—HE-MCSs for 26-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	24	144	72	5.3	5.0	4.5
1		QPSK	1/2	2		288	144	10.6	10.0	9.0
2			3/4				216	15.9	15.0	13.5
3		16-QAM	1/2	4		576	288	21.2	20.0	18.0
4			3/4				432	31.8	30.0	27.0
5		64-QAM	2/3	6		864	576	42.4	40.0	36.0
6			3/4				648	47.6	45.0	40.5
7			5/6				720	52.9	50.0	45.0
8		256-QAM	3/4	8		1 152	864	63.5	60.0	54.0
9			5/6				960	70.6	66.7	60.0
10		1024-QAM	3/4	10		1 440	1 080	79.4	75.0	67.5
11			5/6				1 200	88.2	83.3	75.0

Table 27-62—HE-MCSs for 26-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	24	168	84	6.2	5.8	5.3
1		QPSK	1/2	2		336	168	12.4	11.7	10.5
2			3/4				252	18.5	17.5	15.8
3		16-QAM	1/2	4		672	336	24.7	23.3	21.0
4			3/4				504	37.1	35.0	31.5
5		64-QAM	2/3	6		1 008	672	49.4	46.7	42.0
6			3/4				756	55.6	52.5	47.3
7			5/6				840	61.8	58.3	52.5
8		256-QAM	3/4	8		1 344	1 008	74.1	70.0	63.0
9			5/6				1 120	82.4	77.8	70.0
10		1024-QAM	3/4	10		1 680	1 260	92.6	87.5	78.8
11			5/6				1 400	102.9	97.2	87.5

Table 27-63—HE-MCSs for 26-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	24	192	96	7.1	6.7	6.0
1		QPSK	1/2	2		384	192	14.1	13.3	12.0
2			3/4				288	21.2	20.0	18.0
3		16-QAM	1/2	4		768	384	28.2	26.7	24.0
4			3/4				576	42.4	40.0	36.0
5		64-QAM	2/3	6		1 152	768	56.5	53.3	48.0
6			3/4				864	63.5	60.0	54.0
7			5/6				960	70.6	66.7	60.0
8		256-QAM	3/4	8		1 536	1 152	84.7	80.0	72.0
9			5/6				1 280	94.1	88.9	80.0
10		1024-QAM	3/4	10		1 920	1 440	105.9	100.0	90.0
11			5/6				1 600	117.6	111.1	100.0

27.5.2 HE-MCSs for 52-tone RU

The rate-dependent parameters for the 52-tone RU are provided in Table 27-64 (HE-MCSs for 52-tone RU, NSS = 1) through Table 27-71 (HE-MCSs for 52-tone RU, NSS = 8).

Table 27-64—HE-MCSs for 52-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	24	24	12	0.9	0.8	0.8
	0		1/2		48	48	24	1.8	1.7	1.5
1	1	QPSK	1/2	2	24	48	24	1.8	1.7	1.5
	0		1/2		48	96	48	3.5	3.3	3.0
2	N/A		3/4		48	96	72	5.3	5.0	4.5
3	1	16-QAM	1/2	4	24	96	48	3.5	3.3	3.0
	0		1/2		48	192	96	7.1	6.7	6.0
4	1		3/4		24	96	72	5.3	5.0	4.5
	0		3/4		48	192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6	48	288	192	14.1	13.3	12.0
6			3/4				216	15.9	15.0	13.5
7			5/6				240	17.6	16.7	15.0
8		256-QAM	3/4	8		384	288	21.2	20.0	18.0
9			5/6				320	23.5	22.2	20.0
10		1024-QAM	3/4	10		480	360	26.5	25.0	22.5
11			5/6				400	29.4	27.8	25.0

Table 27-65—HE-MCSs for 52-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	24	48	24	1.8	1.7	1.5
	0		1/2		48	96	48	3.5	3.3	3.0
1	1	QPSK	1/2	2	24	96	48	3.5	3.3	3.0
	0		1/2		48	192	96	7.1	6.7	6.0
2	N/A		3/4		48	192	144	10.6	10.0	9.0
3	1	16-QAM	1/2	4	24	192	96	7.1	6.7	6.0
	0		1/2		48	384	192	14.1	13.3	12.0
4	1		3/4		24	192	144	10.6	10.0	9.0
	0		3/4		48	384	288	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6	48	576	384	28.2	26.7	24.0
6			3/4				432	31.8	30.0	27.0
7			5/6				480	35.3	33.3	30.0
8		256-QAM	3/4	8		768	576	42.4	40.0	36.0
9			5/6				640	47.1	44.4	40.0
10		1024-QAM	3/4	10		960	720	52.9	50.0	45.0
11			5/6				800	58.8	55.6	50.0

Table 27-66—HE-MCSs for 52-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	144	72	5.3	5.0	4.5
1		QPSK	1/2	2		288	144	10.6	10.0	9.0
2			3/4				216	15.9	15.0	13.5
3		16-QAM	1/2	4		576	288	21.2	20.0	18.0
4			3/4				432	31.8	30.0	27.0
5		64-QAM	2/3	6		864	576	42.4	40.0	36.0
6			3/4				648	47.6	45.0	40.5
7			5/6				720	52.9	50.0	45.0
8		256-QAM	3/4	8		1 152	864	63.5	60.0	54.0
9			5/6				960	70.6	66.7	60.0
10		1024-QAM	3/4	10		1 440	1 080	79.4	75.0	67.5
11			5/6				1 200	88.2	83.3	75.0

Table 27-67—HE-MCSs for 52-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	192	96	7.1	6.7	6.0
1		QPSK	1/2	2		384	192	14.1	13.3	12.0
2			3/4				288	21.2	20.0	18.0
3		16-QAM	1/2	4		768	384	28.2	26.7	24.0
4			3/4				576	42.4	40.0	36.0
5		64-QAM	2/3	6		1 152	768	56.5	53.3	48.0
6			3/4				864	63.5	60.0	54.0
7			5/6				960	70.6	66.7	60.0
8		256-QAM	3/4	8		1 536	1 152	84.7	80.0	72.0
9			5/6				1 280	94.1	88.9	80.0
10		1024-QAM	3/4	10		1 920	1 440	105.9	100.0	90.0
11			5/6				1 600	117.6	111.1	100.0

Table 27-68—HE-MCSs for 52-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	240	120	8.8	8.3	7.5
1		QPSK	1/2	2		480	240	17.6	16.7	15.0
2			3/4				360	26.5	25.0	22.5
3		16-QAM	1/2	4		960	480	35.3	33.3	30.0
4			3/4				720	52.9	50.0	45.0
5		64-QAM	2/3	6		1 440	960	70.6	66.7	60.0
6			3/4				1080	79.4	75.0	67.5
7			5/6				1 200	88.2	83.3	75.0
8		256-QAM	3/4	8		1 920	1 440	105.9	100.0	90.0
9			5/6				1 600	117.6	111.1	100.0
10		1024-QAM	3/4	10		2 400	1 800	132.4	125.0	112.5
11			5/6				2 000	147.1	138.9	125.0

Table 27-69—HE-MCSs for 52-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	288	144	10.6	10.0	9.0
1		QPSK	1/2	2		576	288	21.2	20.0	18.0
2			3/4				432	31.8	30.0	27.0
3		16-QAM	1/2	4		1 152	576	42.4	40.0	36.0
4			3/4				864	63.5	60.0	54.0
5		64-QAM	2/3	6		1 728	1 152	84.7	80.0	72.0
6			3/4				1 296	95.3	90.0	81.0
7			5/6				1 440	105.9	100.0	90.0
8		256-QAM	3/4	8		2 304	1 728	127.1	120.0	108.0
9			5/6				1 920	141.2	133.3	120.0
10		1024-QAM	3/4	10		2 880	2 160	158.8	150.0	135.0
11			5/6				2 400	176.5	166.7	150.0

Table 27-70—HE-MCSs for 52-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	336	168	12.4	11.7	10.5
1		QPSK	1/2	2		672	336	24.7	23.3	21.0
2			3/4				504	37.1	35.0	31.5
3		16-QAM	1/2	4		1 344	672	49.4	46.7	42.0
4			3/4				1 008	74.1	70.0	63.0
5		64-QAM	2/3	6		2 016	1 344	98.8	93.3	84.0
6			3/4				1 512	111.2	105.0	94.5
7			5/6				1 680	123.5	116.7	105.0
8		256-QAM	3/4	8		2 688	2 016	148.2	140.0	126.0
9			5/6				2 240	164.7	155.6	140.0
10		1024-QAM	3/4	10		3 360	2 520	185.3	175.0	157.5
11			5/6				2 800	205.9	194.4	175.0

Table 27-71—HE-MCSs for 52-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	48	384	192	14.1	13.3	12.0
1		QPSK	1/2	2		768	384	28.2	26.7	24.0
2			3/4				576	42.4	40.0	36.0
3		16-QAM	1/2	4		1 536	768	56.5	53.3	48.0
4			3/4				1 152	84.7	80.0	72.0
5		64-QAM	2/3	6		2 304	1 536	112.9	106.7	96.0
6			3/4				1 728	127.1	120.0	108.0
7			5/6				1 920	141.2	133.3	120.0
8		256-QAM	3/4	8		3 072	2 304	169.4	160.0	144.0
9			5/6				2 560	188.2	177.8	160.0
10		1024-QAM	3/4	10		3 840	2 880	211.8	200.0	180.0
11			5/6				3 200	235.3	222.2	200.0

27.5.3 HE-MCSs for 106-tone RU

The rate-dependent parameters for the 106-tone RU are provided in Table 27-72 (HE-MCSs for 106-tone RU, NSS = 1) through Table 27-79 (HE-MCSs for 106-tone RU, NSS = 8).

Table 27-72—HE-MCSs for 106-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	51	51	25	1.8	1.7	1.6
	0		1/2		102	102	51	3.8	3.5	3.2
1	1	QPSK	1/2	2	51	102	51	3.8	3.5	3.2
	0		1/2		102	204	102	7.5	7.1	6.4
2	N/A		3/4		102	204	153	11.3	10.6	9.6
3	1	16-QAM	1/2	4	51	204	102	7.5	7.1	6.4
	0		1/2		102	408	204	15.0	14.2	12.8
4	1		3/4		51	204	153	11.3	10.6	9.6
	0		3/4		102	408	306	22.5	21.3	19.1
5	N/A	64-QAM	2/3	6	102	612	408	30.0	28.3	25.5
6			3/4				459	33.8	31.9	28.7
7			5/6				510	37.5	35.4	31.9
8		256-QAM	3/4	8		816	612	45.0	42.5	38.3
9			5/6				680	50.0	47.2	42.5
10		1024-QAM	3/4	10		1 020	765	56.3	53.1	47.8
11			5/6				850	62.5	59.0	53.1

Table 27-73—HE-MCSs for 106-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	1	BPSK	1/2	1	51	102	51	3.8	3.5	3.2
	0		1/2		102	204	102	7.5	7.1	6.4
1	1	QPSK	1/2	2	51	204	102	7.5	7.1	6.4
	0		1/2		102	408	204	15.0	14.2	12.8
2	N/A		3/4		102	408	306	22.5	21.3	19.1
3	1	16-QAM	1/2	4	51	408	204	15.0	14.2	12.8
	0		1/2		102	816	408	30.0	28.3	25.5
4	1		3/4		51	408	306	22.5	21.3	19.1
	0		3/4		102	816	612	45.0	42.5	38.3
5	N/A	64-QAM	2/3	6	102	1 224	816	60.0	56.7	51.0
6			3/4				918	67.5	63.8	57.4
7			5/6				1 020	75.0	70.8	63.8
8		256-QAM	3/4	8		1 632	1 224	90.0	85.0	76.5
9			5/6				1 360	100.0	94.4	85.0
10		1024-QAM	3/4	10		2 040	1 530	112.5	106.3	95.6
11			5/6				1 700	125.0	118.1	106.3

Table 27-74—HE-MCSs for 106-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	102	306	153	11.3	10.6	9.6
1		QPSK	1/2	2		612	306	22.5	21.3	19.1
2			3/4				459	33.8	31.9	28.7
3		16-QAM	1/2	4		1 224	612	45.0	42.5	38.3
4			3/4				918	67.5	63.8	57.4
5		64-QAM	2/3	6		1 836	1 224	90.0	85.0	76.5
6			3/4				1 377	101.3	95.6	86.1
7			5/6				1 530	112.5	106.3	95.6
8		256-QAM	3/4	8		2 448	1 836	135.0	127.5	114.8
9			5/6				2 040	150.0	141.7	127.5
10		1024-QAM	3/4	10		3 060	2 295	168.8	159.4	143.4
11			5/6				2 550	187.5	177.1	159.4

Table 27-75—HE-MCSs for 106-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	102	408	204	15.0	14.2	12.8
1		QPSK	1/2	2		816	408	30.0	28.3	25.5
2			3/4				612	45.0	42.5	38.3
3		16-QAM	1/2	4		1 632	816	60.0	56.7	51.0
4			3/4				1 224	90.0	85.0	76.5
5		64-QAM	2/3	6		2 448	1 632	120.0	113.3	102.0
6			3/4				1 836	135.0	127.5	114.8
7			5/6				2 040	150.0	141.7	127.5
8		256-QAM	3/4	8		3 264	2 448	180.0	170.0	153.0
9			5/6				2 720	200.0	188.9	170.0
10		1024-QAM	3/4	10		4 080	3 060	225.0	212.5	191.3
11			5/6				3 400	250.0	236.1	212.5

Table 27-76—HE-MCSs for 106-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	102	510	255	18.8	17.7	15.9
1		QPSK	1/2	2		1 020	510	37.5	35.4	31.9
2			3/4				765	56.3	53.1	47.8
3		16-QAM	1/2	4		2 040	1 020	75.0	70.8	63.8
4			3/4				1 530	112.5	106.3	95.6
5		64-QAM	2/3	6		3 060	2 040	150.0	141.7	127.5
6			3/4				2 295	168.8	159.4	143.4
7			5/6				2 550	187.5	177.1	159.4
8		256-QAM	3/4	8		4 080	3 060	225.0	212.5	191.3
9			5/6				3 400	250.0	236.1	212.5
10		1024-QAM	3/4	10		5 100	3 825	281.3	265.6	239.1
11			5/6				4 250	312.5	295.1	265.6

Table 27-77—HE-MCSs for 106-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	102	612	306	22.5	21.3	19.1
1		QPSK	1/2	2		1 224	612	45.0	42.5	38.3
2			3/4				918	67.5	63.8	57.4
3		16-QAM	1/2	4		2 448	1 224	90.0	85.0	76.5
4			3/4				1 836	135.0	127.5	114.8
5		64-QAM	2/3	6		3 672	2 448	180.0	170.0	153.0
6			3/4				2 754	202.5	191.3	172.1
7			5/6				3 060	225.0	212.5	191.3
8		256-QAM	3/4	8		4 896	3 672	270.0	255.0	229.5
9			5/6				4 080	300.0	283.3	255.0
10		1024-QAM	3/4	10		6 120	4 590	337.5	318.8	286.9
11			5/6				5 100	375.0	354.2	318.8

Table 27-78—HE-MCSs for 106-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	102	714	357	26.3	24.8	22.3
1		QPSK	1/2	2		1 428	714	52.5	49.6	44.6
2			3/4				1 071	78.8	74.4	66.9
3		16-QAM	1/2	4		2 856	1 428	105.0	99.2	89.3
4			3/4				2 142	157.5	148.8	133.9
5		64-QAM	2/3	6		4 284	2 856	210.0	198.3	178.5
6			3/4				3 213	236.3	223.1	200.8
7			5/6				3 570	262.5	247.9	223.1
8		256-QAM	3/4	8		5 712	4 284	315.0	297.5	267.8
9			5/6				4 760	350.0	330.6	297.5
10		1024-QAM	3/4	10		7 140	5 355	393.8	371.9	334.7
11			5/6				5 950	437.5	413.2	371.9

Table 27-79—HE-MCSs for 106-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	102	816	408	30.0	28.3	25.5
1		QPSK	1/2	2		1 632	816	60.0	56.7	51.0
2			3/4				1 224	90.0	85.0	76.5
3		16-QAM	1/2	4		3 264	1 632	120.0	113.3	102.0
4			3/4				2 448	180.0	170.0	153.0
5		64-QAM	2/3	6		4 896	3 264	240.0	226.7	204.0
6			3/4				3 672	270.0	255.0	229.5
7			5/6				4 080	300.0	283.3	255.0
8		256-QAM	3/4	8		6 528	4 896	360.0	340.0	306.0
9			5/6				5 440	400.0	377.8	340.0
10		1024-QAM	3/4	10		8 160	6 120	450.0	425.0	382.5
11			5/6				6 800	500.0	472.2	425.0

27.5.4 HE-MCSs for 242-tone RU

The rate-dependent parameters for the 242-tone RU are provided in Table 27-80 (HE-MCSs for 242-tone RU, NSS = 1) through Table 27-87 (HE-MCSs for 242-tone RU, NSS = 8).

Table 27-80—HE-MCSs for 242-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	117	117	58	4.3	4.0	3.6
	0		1/2		234	234	117	8.6	8.1	7.3
1	1	QPSK	1/2	2	117	234	117	8.6	8.1	7.3
	0		1/2		234	468	234	17.2	16.3	14.6
2	N/A		3/4		234	468	351	25.8	24.4	21.9
3	1	16-QAM	1/2	4	117	468	234	17.2	16.3	14.6
	0		1/2		234	936	468	34.4	32.5	29.3
4	1		3/4		117	468	351	25.8	24.4	21.9
	0		3/4		234	936	702	51.6	48.8	43.9
5	N/A	64-QAM	2/3	6	234	1 404	936	68.8	65.0	58.5
6			3/4				1 053	77.4	73.1	65.8
7			5/6				1 170	86.0	81.3	73.1
8		256-QAM	3/4	8		1 872	1 404	103.2	97.5	87.8
9			5/6				1 560	114.7	108.3	97.5
10		1024-QAM	3/4	10		2 340	1 755	129.0	121.9	109.7
11			5/6				1 950	143.4	135.4	121.9

Table 27-81—HE-MCSs for 242-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	117	234	117	8.6	8.1	7.3
	0		1/2		234	468	234	17.2	16.3	14.6
1	1	QPSK	1/2	2	117	468	234	17.2	16.3	14.6
	0		1/2		234	936	468	34.4	32.5	29.3
2	N/A		3/4		234	936	702	51.6	48.8	43.9
3	1	16-QAM	1/2	4	117	936	468	34.4	32.5	29.3
	0		1/2		234	1 872	936	68.8	65.0	58.5
4	1		3/4		117	936	702	51.6	48.8	43.9
	0		3/4		234	1 872	1 404	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6	234	2 808	1 872	137.6	130.0	117.0
6			3/4				2 106	154.9	146.3	131.6
7			5/6				2 340	172.1	162.5	146.3
8		256-QAM	3/4	8		3 744	2 808	206.5	195.0	175.5
9			5/6				3 120	229.4	216.7	195.0
10		1024-QAM	3/4	10		4 680	3 510	258.1	243.8	219.4
11			5/6				3 900	286.8	270.8	243.8

Table 27-82—HE-MCSs for 242-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	702	351	25.8	24.4	21.9
1		QPSK	1/2	2		1 404	702	51.6	48.8	43.9
2			3/4				1 053	77.4	73.1	65.8
3		16-QAM	1/2	4		2 808	1 404	103.2	97.5	87.8
4			3/4				2 106	154.9	146.3	131.6
5		64-QAM	2/3	6		4 212	2 808	206.5	195.0	175.5
6			3/4				3 159	232.3	219.4	197.4
7			5/6				3 510	258.1	243.8	219.4
8		256-QAM	3/4	8		5 616	4 212	309.7	292.5	263.3
9			5/6				4 680	344.1	325.0	292.5
10		1024-QAM	3/4	10		7 020	5 265	387.1	365.6	329.1
11			5/6				5 850	430.1	406.3	365.6

Table 27-83—HE-MCSs for 242-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	936	468	34.4	32.5	29.3
1		QPSK	1/2	2		1 872	936	68.8	65.0	58.5
2			3/4				1 404	103.2	97.5	87.8
3		16-QAM	1/2	4		3 744	1 872	137.6	130.0	117.0
4			3/4				2 808	206.5	195.0	175.5
5		64-QAM	2/3	6		5 616	3 744	275.3	260.0	234.0
6			3/4				4 212	309.7	292.5	263.3
7			5/6				4 680	344.1	325.0	292.5
8		256-QAM	3/4	8		7 488	5 616	412.9	390.0	351.0
9			5/6				6 240	458.8	433.3	390.0
10		1024-QAM	3/4	10		9 360	7 020	516.2	487.5	438.8
11			5/6				7 800	573.5	541.7	487.5

Table 27-84—HE-MCSs for 242-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	1 170	585	43.0	40.6	36.6
1		QPSK	1/2	2		2 340	1 170	86.0	81.3	73.1
2			3/4				1 755	129.0	121.9	109.7
3		16-QAM	1/2	4		4 680	2 340	172.1	162.5	146.3
4			3/4				3 510	258.1	243.8	219.4
5		64-QAM	2/3	6		7 020	4 680	344.1	325.0	292.5
6			3/4				5 265	387.1	365.6	329.1
7			5/6				5 850	430.1	406.3	365.6
8		256-QAM	3/4	8		9 360	7 020	516.2	487.5	438.8
9			5/6				7 800	573.5	541.7	487.5
10		1024-QAM	3/4	10		11 700	8 775	645.2	609.4	548.4
11			5/6				9 750	716.9	677.1	609.4

Table 27-85—HE-MCSs for 242-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	1 404	702	51.6	48.8	43.9
1		QPSK	1/2	2		2 808	1 404	103.2	97.5	87.8
2			3/4				2 106	154.9	146.3	131.6
3		16-QAM	1/2	4		5 616	2 808	206.5	195.0	175.5
4			3/4				4 212	309.7	292.5	263.3
5		64-QAM	2/3	6		8 424	5 616	412.9	390.0	351.0
6			3/4				6 318	464.6	438.8	394.9
7			5/6				7 020	516.2	487.5	438.8
8		256-QAM	3/4	8		11 232	8 424	619.4	585.0	526.5
9			5/6				9 360	688.2	650.0	585.0
10		1024-QAM	3/4	10		14 040	10 530	774.3	731.3	658.1
11			5/6				11 700	860.3	812.5	731.3

Table 27-86—HE-MCSs for 242-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	1 638	819	60.2	56.9	51.2
1		QPSK	1/2	2		3 276	1 638	120.4	113.8	102.4
2			3/4				2 457	180.7	170.6	153.6
3		16-QAM	1/2	4		6 552	3 276	240.9	227.5	204.8
4			3/4				4 914	361.3	341.3	307.1
5		64-QAM	2/3	6		9 828	6 552	481.8	455.0	409.5
6			3/4				7 371	542.0	511.9	460.7
7			5/6				8 190	602.2	568.8	511.9
8		256-QAM	3/4	8		13 104	9 828	722.6	682.5	614.3
9			5/6				10 920	802.9	758.3	682.5
10		1024-QAM	3/4	10		16 380	12 285	903.3	853.1	767.8
11			5/6				13 650	1 003.7	947.9	853.1

Table 27-87—HE-MCSs for 242-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	234	1 872	936	68.8	65.0	58.5
1		QPSK	1/2	2		3 744	1 872	137.6	130.0	117.0
2			3/4				2 808	206.5	195.0	175.5
3		16-QAM	1/2	4		7 488	3 744	275.3	260.0	234.0
4			3/4				5 616	412.9	390.0	351.0
5		64-QAM	2/3	6		11 232	7 488	550.6	520.0	468.0
6			3/4				8 424	619.4	585.0	526.5
7			5/6				9 360	688.2	650.0	585.0
8		256-QAM	3/4	8		14 976	11 232	825.9	780.0	702.0
9			5/6				12 480	917.6	866.7	780.0
10		1024-QAM	3/4	10		18 720	14 040	1 032.4	975.0	877.5
11			5/6				15 600	1 147.1	1 083.3	975.0

27.5.5 HE-MCSs for 484-tone RU

The rate-dependent parameters for the 484-tone RU are provided in Table 27-88 (HE-MCSs for 484-tone RU, NSS = 1) through Table 27-95 (HE-MCSs for 484-tone RU, NSS = 8).

Table 27-88—HE-MCSs for 484-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	234	234	117	8.6	8.1	7.3
	0		1/2		468	468	234	17.2	16.3	14.6
1	1	QPSK	1/2	2	234	468	234	17.2	16.3	14.6
	0		1/2		468	936	468	34.4	32.5	29.3
2	N/A		3/4		468	936	702	51.6	48.8	43.9
3	1	16-QAM	1/2	4	234	936	468	34.4	32.5	29.3
	0		1/2		468	1 872	936	68.8	65.0	58.5
4	1		3/4		234	936	702	51.6	48.8	43.9
	0		3/4		468	1 872	1 404	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6	468	2 808	1 872	137.6	130.0	117.0
6			3/4				2 106	154.9	146.3	131.6
7			5/6				2 340	172.1	162.5	146.3
8		256-QAM	3/4	8		3 744	2 808	206.5	195.0	175.5
9			5/6				3 120	229.4	216.7	195.0
10		1024-QAM	3/4	10		4 680	3 510	258.1	243.8	219.4
11			5/6				3 900	286.8	270.8	243.8

Table 27-89—HE-MCSs for 484-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	234	468	234	17.2	16.3	14.6
	0		1/2		468	936	468	34.4	32.5	29.3
1	1	QPSK	1/2	2	234	936	468	34.4	32.5	29.3
	0		1/2		468	1 872	936	68.8	65.0	58.5
2	N/A		3/4		468	1 872	1 404	103.2	97.5	87.8
3	1	16-QAM	1/2	4	234	1 872	936	68.8	65.0	58.5
	0		1/2		468	3 744	1 872	137.6	130.0	117.0
4	1		3/4		234	1 872	1 404	103.2	97.5	87.8
	0		3/4		468	3 744	2 808	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6	468	5 616	3 744	275.3	260.0	234.0
6			3/4				4 212	309.7	292.5	263.3
7			5/6				4 680	344.1	325.0	292.5
8		256-QAM	3/4	8		7 488	5 616	412.9	390.0	351.0
9			5/6				6 240	458.8	433.3	390.0
10		1024-QAM	3/4	10		9 360	7 020	516.2	487.5	438.8
11			5/6				7 800	573.5	541.7	487.5

Table 27-90—HE-MCSs for 484-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	468	1 404	702	51.6	48.8	43.9
1		QPSK	1/2	2		2 808	1 404	103.2	97.5	87.8
2			3/4				2 106	154.9	146.3	131.6
3		16-QAM	1/2	4		5 616	2 808	206.5	195.0	175.5
4			3/4				4 212	309.7	292.5	263.3
5		64-QAM	2/3	6		8 424	5 616	412.9	390.0	351.0
6			3/4				6 318	464.6	438.8	394.9
7			5/6				7 020	516.2	487.5	438.8
8		256-QAM	3/4	8		11 232	8 424	619.4	585.0	526.5
9			5/6				9 360	688.2	650.0	585.0
10		1024-QAM	3/4	10		14 040	10 530	774.3	731.3	658.1
11			5/6				11 700	860.3	812.5	731.3

Table 27-91—HE-MCSs for 484-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	N/A	BPSK	1/2	1	468	1 872	936	68.8	65.0	58.5
1		QPSK	1/2	2		3 744	1 872	137.6	130.0	117.0
2			3/4				2 808	206.5	195.0	175.5
3		16-QAM	1/2	4		7 488	3 744	275.3	260.0	234.0
4			3/4				5 616	412.9	390.0	351.0
5		64-QAM	2/3	6		11 232	7 488	550.6	520.0	468.0
6			3/4				8 424	619.4	585.0	526.5
7			5/6				9 360	688.2	650.0	585.0
8		256-QAM	3/4	8		14 976	11 232	825.9	780.0	702.0
9			5/6				12 480	917.6	866.7	780.0
10		1024-QAM	3/4	10		18 720	14 040	1 032.4	975.0	877.5
11			5/6				15 600	1 147.1	1 083.3	975.0

Table 27-92—HE-MCSs for 484-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	468	2 340	1 170	86.0	81.3	73.1
1		QPSK	1/2	2		4 680	2 340	172.1	162.5	146.3
2			3/4				3 510	258.1	243.8	219.4
3		16-QAM	1/2	4		9 360	4 680	344.1	325.0	292.5
4			3/4				7 020	516.2	487.5	438.8
5		64-QAM	2/3	6		14 040	9 360	688.2	650.0	585.0
6			3/4				10 530	774.3	731.3	658.1
7			5/6				11 700	860.3	812.5	731.3
8		256-QAM	3/4	8		18 720	14 040	1 032.4	975.0	877.5
9			5/6				15 600	1 147.1	1 083.3	975.0
10		1024-QAM	3/4	10		23 400	17 550	1 290.4	1 218.8	1 096.9
11			5/6				19 500	1 433.8	1 354.2	1 218.8

Table 27-93—HE-MCSs for 484-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	468	2 808	1404	103.2	97.5	87.8
1		QPSK	1/2	2		5 616	2808	206.5	195.0	175.5
2			3/4				4212	309.7	292.5	263.3
3		16-QAM	1/2	4		11 232	5616	412.9	390.0	351.0
4			3/4				8424	619.4	585.0	526.5
5		64-QAM	2/3	6		16 848	11 232	825.9	780.0	702.0
6			3/4				12 636	929.1	877.5	789.8
7			5/6				14 040	1 032.4	975.0	877.5
8		256-QAM	3/4	8		22 464	16 848	1 238.8	1 170.0	1 053.0
9			5/6				18 720	1 376.5	1 300.0	1 170.0
10		1024-QAM	3/4	10		28 080	21 060	1 548.5	1 462.5	1 316.3
11			5/6				23 400	1 720.6	1 625.0	1 462.5

Table 27-94—HE-MCSs for 484-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	468	3 276	1 638	120.4	113.8	102.4
1		QPSK	1/2	2		6 552	3 276	240.9	227.5	204.8
2			3/4				4 914	361.3	341.3	307.1
3		16-QAM	1/2	4		13 104	6 552	481.8	455.0	409.5
4			3/4				9 828	722.6	682.5	614.3
5		64-QAM	2/3	6		19 656	13 104	963.5	910.0	819.0
6			3/4				14 742	1 084.0	1 023.8	921.4
7			5/6				16 380	1 204.4	1 137.5	1 023.8
8		256-QAM	3/4	8		26 208	19 656	1 445.3	1 365.0	1 228.5
9			5/6				21 840	1 605.9	1 516.7	1 365.0
10		1024-QAM	3/4	10		32 760	24 570	1 806.6	1 706.3	1 535.6
11			5/6				27 300	2 007.4	1 895.8	1 706.3

Table 27-95—HE-MCSs for 484-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	468	3 744	1 872	137.6	130.0	117.0
1		QPSK	1/2	2		7 488	3 744	275.3	260.0	234.0
2			3/4				5 616	412.9	390.0	351.0
3		16-QAM	1/2	4		14 976	7 488	550.6	520.0	468.0
4			3/4				11 232	825.9	780.0	702.0
5		64-QAM	2/3	6		22 464	14 976	1 101.2	1 040.0	936.0
6			3/4				16 848	1 238.8	1 170.0	1 053.0
7			5/6				18 720	1 376.5	1 300.0	1 170.0
8		256-QAM	3/4	8		29 952	22 464	1 651.8	1 560.0	1 404.0
9			5/6				24 960	1 835.3	1 733.3	1 560.0
10		1024-QAM	3/4	10		37 440	28 080	2 064.7	1 950.0	1 755.0
11			5/6				31 200	2 294.1	2 166.7	1 950.0

27.5.6 HE-MCSs for 996-tone RU

The rate-dependent parameters for the 996-tone RU are provided in Table 27-96 (HE-MCSs for 996-tone RU, NSS = 1) through Table 27-103 (HE-MCSs for 996-tone RU, NSS = 8).

Table 27-96—HE-MCSs for 996-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	490	490	245	18.0	17.0	15.3
	0		1/2		980	980	490	36.0	34.0	30.6
1	1	QPSK	1/2	2	490	980	490	36.0	34.0	30.6
	0		1/2		980	1960	980	72.1	68.1	61.3
2	N/A		3/4		980	1960	1 470	108.1	102.1	91.9
3	1	16-QAM	1/2	4	490	1960	980	72.1	68.1	61.3
	0		1/2		980	3920	1 960	144.1	136.1	122.5
4	1		3/4		490	1960	1 470	108.1	102.1	91.9
	0		3/4		980	3920	2 940	216.2	204.2	183.8
5	N/A	64-QAM	2/3	6	980	5 880	3 920	288.2	272.2	245.0
6			3/4				4 410	324.3	306.3	275.6
7			5/6				4 900	360.3	340.3	306.3
8		256-QAM	3/4	8		7 840	5 880	432.4	408.3	367.5
9			5/6				6 533	480.4	453.7	408.3
10		1024-QAM	3/4	10		9 800	7 350	540.4	510.4	459.4
11			5/6				8 166	600.4	567.1	510.4

Table 27-97—HE-MCSs for 996-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	Data rate (Mb/s) 1.6 µs GI	Data rate (Mb/s) 3.2 µs GI
0	1	BPSK	1/2	1	490	980	490	36.0	34.0	30.6
	0		1/2		980	1 960	980	72.1	68.1	61.3
1	1	QPSK	1/2	2	490	1 960	980	72.1	68.1	61.3
	0		1/2		980	3 920	1 960	144.1	136.1	122.5
2	N/A		3/4		980	3 920	2 940	216.2	204.2	183.8
3	1	16-QAM	1/2	4	490	3 920	1 960	144.1	136.1	122.5
	0		1/2		980	7 840	3 920	288.2	272.2	245.0
4	1		3/4		490	3 920	2 940	216.2	204.2	183.8
	0		3/4		980	7 840	5 880	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6	980	11 760	7 840	576.5	544.4	490.0
6			3/4				8 820	648.5	612.5	551.3
7			5/6				9 800	720.6	680.6	612.5
8		256-QAM	3/4	8		15 680	11 760	864.7	816.7	735.0
9			5/6				13 066	960.7	907.4	816.6
10		1024-QAM	3/4	10		19 600	14 700	1 080.9	1 020.8	918.8
11			5/6				16 333	1 201.0	1 134.2	1 020.8

Table 27-98—HE-MCSs for 996-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	2 940	1 470	108.1	102.1	91.9
1		QPSK	1/2	2		5 880	2 940	216.2	204.2	183.8
2			3/4				4 410	324.3	306.3	275.6
3		16-QAM	1/2	4		11 760	5 880	432.4	408.3	367.5
4			3/4				8 820	648.5	612.5	551.3
5		64-QAM	2/3	6		17 640	11 760	864.7	816.7	735.0
6			3/4				13 230	972.8	918.8	826.9
7			5/6				14 700	1 080.9	1 020.8	918.8
8		256-QAM	3/4	8		23 520	17 640	1 297.1	1 225.0	1 102.5
9			5/6				19 600	1 441.2	1 361.1	1 225.0
10		1024-QAM	3/4	10		29 400	22 050	1 621.3	1 531.3	1 378.1
11			5/6				24 500	1 801.5	1 701.4	1 531.3

Table 27-99—HE-MCSs for 996-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s) 0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	3 920	1 960	144.1	136.1	122.5
1		QPSK	1/2	2		7 840	3 920	288.2	272.2	245.0
2			3/4				5 880	432.4	408.3	367.5
3		16-QAM	1/2	4		15 680	7 840	576.5	544.4	490.0
4			3/4				11 760	864.7	816.7	735.0
5		64-QAM	2/3	6		23 520	15 680	1 152.9	1 088.9	980.0
6			3/4				17 640	1 297.1	1 225.0	1 102.5
7			5/6				19 600	1 441.2	1 361.1	1 225.0
8		256-QAM	3/4	8		31 360	23 520	1 729.4	1 633.3	1 470.0
9			5/6				26 133	1 921.5	1 814.8	1 633.3
10		1024-QAM	3/4	10		39 200	29 400	2 161.8	2 041.7	1 837.5
11			5/6				32 666	2 401.9	2 268.5	2 041.6

Table 27-100—HE-MCSs for 996-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	4 900	2 450	180.1	170.1	153.1
1		QPSK	1/2	2		9 800	4 900	360.3	340.3	306.3
2			3/4				7 350	540.4	510.4	459.4
3		16-QAM	1/2	4		19 600	9 800	720.6	680.6	612.5
4			3/4				14 700	1 080.9	1 020.8	918.8
5		64-QAM	2/3	6		29 400	19 600	1 441.2	1 361.1	1 225.0
6			3/4				22 050	1 621.3	1 531.3	1 378.1
7			5/6				24 500	1 801.5	1 701.4	1 531.3
8		256-QAM	3/4	8		39 200	29 400	2 161.8	2 041.7	1 837.5
9			5/6				32 666	2 401.9	2 268.5	2 041.6
10		1024-QAM	3/4	10		49 000	36 750	2 702.2	2 552.1	2 296.9
11			5/6				40 833	3 002.4	2 835.6	2 552.1

Table 27-101—HE-MCSs for 996-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	5 880	2 940	216.2	204.2	183.8
1		QPSK	1/2	2		11 760	5 880	432.4	408.3	367.5
2			3/4				8 820	648.5	612.5	551.3
3		16-QAM	1/2	4		23 520	11 760	864.7	816.7	735.0
4			3/4				17 640	1 297.1	1 225.0	1 102.5
5		64-QAM	2/3	6		35 280	23 520	1 729.4	1 633.3	1 470.0
6			3/4				26 460	1 945.6	1 837.5	1 653.8
7			5/6				29 400	2 161.8	2 041.7	1 837.5
8		256-QAM	3/4	8		47 040	35 280	2 594.1	2 450.0	2 205.0
9			5/6				39 200	2 882.4	2 722.2	2 450.0
10		1024-QAM	3/4	10		58 800	44 100	3 242.6	3 062.5	2 756.3
11			5/6				49 000	3 602.9	3 402.8	3 062.5

Table 27-102—HE-MCSs for 996-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	6 860	3 430	252.2	238.2	214.4
1		QPSK	1/2	2		13 720	6 860	504.4	476.4	428.8
2			3/4				10 290	756.6	714.6	643.1
3		16-QAM	1/2	4		27 440	13 720	1 008.8	952.8	857.5
4			3/4				20 580	1 513.2	1 429.2	1 286.3
5		64-QAM	2/3	6		41 160	27 440	2 017.6	1 905.6	1 715.0
6			3/4				30 870	2 269.9	2 143.8	1 929.4
7			5/6				34 300	2 522.1	2 381.9	2 143.8
8		256-QAM	3/4	8		54 880	41 160	3 026.5	2 858.3	2 572.5
9			5/6				45 733	3 362.7	3 175.9	2 858.3
10		1024-QAM	3/4	10		68 600	51 450	3 783.1	3 572.9	3 215.6
11			5/6				57 166	4 203.4	3 969.9	3 572.9

Table 27-103—HE-MCSs for 996-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	980	7 840	3 920	288.2	272.2	245.0
1		QPSK	1/2	2		15 680	7 840	576.5	544.4	490.0
2			3/4				11 760	864.7	816.7	735.0
3		16-QAM	1/2	4		31 360	15 680	1 152.9	1 088.9	980.0
4			3/4				23 520	1 729.4	1 633.3	1 470.0
5		64-QAM	2/3	6		47 040	31 360	2 305.9	2 177.8	1 960.0
6			3/4				35 280	2 594.1	2 450.0	2 205.0
7			5/6				39 200	2 882.4	2 722.2	2 450.0
8		256-QAM	3/4	8		62 720	47 040	3 458.8	3 266.7	2 940.0
9			5/6				52 266	3 843.1	3 629.6	3 266.6
10		1024-QAM	3/4	10		78 400	58 800	4 323.5	4 083.3	3 675.0
11			5/6				65 333	4 803.9	4 537.0	4 083.3

27.5.7 HE-MCSs for 2×996-tone RU

The rate-dependent parameters for 2×996-tone RU are provided in Table 27-104 (HE-MCSs for 2×996-tone RU, NSS = 1) through Table 27-111 (HE-MCSs for 2×996-tone RU, NSS = 8).

Table 27-104—HE-MCSs for 2×996-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	980	980	490	36.0	34.0	30.6
	0		1/2		1 960	1 960	980	72.1	68.1	61.3
1	1	QPSK	1/2	2	980	1 960	980	72.1	68.1	61.3
	0		1/2		1 960	3 920	1 960	144.1	136.1	122.5
2	N/A		3/4		1 960	3 920	2 940	216.2	204.2	183.8
3	1	16-QAM	1/2	4	980	3 920	1 960	144.1	136.1	122.5
	0		1/2		1 960	7 840	3 920	288.2	272.2	245.0
4	1		3/4		980	3 920	2 940	216.2	204.2	183.8
	0		3/4		1 960	7 840	5 880	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6	1 960	11 760	7 840	576.5	544.4	490.0
6			3/4				8 820	648.5	612.5	551.3
7			5/6				9 800	720.6	680.6	612.5
8		256-QAM	3/4	8		15 680	11 760	864.7	816.7	735.0
9			5/6				13 066	960.7	907.4	816.6
10		1024-QAM	3/4	10		19 600	14 700	1 080.9	1 020.8	918.8
11			5/6				16 333	1 201.0	1 134.2	1 020.8

Table 27-105—HE-MCSs for 2×996-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	1	BPSK	1/2	1	980	1 960	980	72.1	68.1	61.3
	0		1/2		1 960	3 920	1 960	144.1	136.1	122.5
1	1	QPSK	1/2	2	980	3 920	1 960	144.1	136.1	122.5
	0		1/2		1 960	7 840	3 920	288.2	272.2	245.0
2	N/A		3/4		1 960	7 840	5 880	432.4	408.3	367.5
3	1	16-QAM	1/2	4	980	7 840	3 920	288.2	272.2	245.0
	0		1/2		1 960	15 680	7 840	576.5	544.4	490.0
4	1		3/4		980	7 840	5 880	432.4	408.3	367.5
	0		3/4		1 960	15 680	11 760	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6	1 960	23 520	15 680	1 152.9	1 088.9	980.0
6			3/4				17 640	1 297.1	1 225.0	1 102.5
7			5/6				19 600	1 441.2	1 361.1	1 225.0
8		256-QAM	3/4	8		31 360	23 520	1 729.4	1 633.3	1 470.0
9			5/6				26 133	1 921.5	1 814.8	1 633.3
10		1024-QAM	3/4	10		39 200	29 400	2 161.8	2 041.7	1 837.5
11			5/6				32 666	2 401.9	2 268.5	2 041.6

Table 27-106—HE-MCSs for 2×996-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	5 880	2 940	216.2	204.2	183.8
1		QPSK	1/2	2		11 760	5 880	432.4	408.3	367.5
2			3/4				8 820	648.5	612.5	551.3
3		16-QAM	1/2	4		23 520	11 760	864.7	816.7	735.0
4			3/4				17 640	1 297.1	1 225.0	1 102.5
5		64-QAM	2/3	6		35 280	23 520	1 729.4	1 633.3	1 470.0
6			3/4				26 460	1 945.6	1 837.5	1 653.8
7			5/6				29 400	2 161.8	2 041.7	1 837.5
8		256-QAM	3/4	8		47 040	35 280	2 594.1	2 450.0	2 205.0
9			5/6				39 200	2 882.4	2 722.2	2 450.0
10		1024-QAM	3/4	10		58 800	44 100	3 242.6	3 062.5	2 756.3
11			5/6				49 000	3 602.9	3 402.8	3 062.5

Table 27-107—HE-MCSs for 2×996-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	7 840	3 920	288.2	272.2	245.0
1		QPSK	1/2	2		15 680	7 840	576.5	544.4	490.0
2			3/4				11 760	864.7	816.7	735.0
3		16-QAM	1/2	4		31 360	15 680	1 152.9	1 088.9	980.0
4			3/4				23 520	1 729.4	1 633.3	1 470.0
5		64-QAM	2/3	6		47 040	31 360	2 305.9	2 177.8	1 960.0
6			3/4				35 280	2 594.1	2 450.0	2 205.0
7			5/6				39 200	2 882.4	2 722.2	2 450.0
8		256-QAM	3/4	8		62 720	47 040	3 458.8	3 266.7	2 940.0
9			5/6				52 266	3 843.1	3 629.6	3 266.6
10		1024-QAM	3/4	10		78 400	58 800	4 323.5	4 083.3	3 675.0
11			5/6				65 333	4 803.9	4 537.0	4 083.3

Table 27-108—HE-MCSs for 2×996-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	9 800	4 900	360.3	340.3	306.3
1		QPSK	1/2	2		19 600	9 800	720.6	680.6	612.5
2			3/4				14 700	1 080.9	1 020.8	918.8
3		16-QAM	1/2	4		39 200	19 600	1 441.2	1 361.1	1 225.0
4			3/4				29 400	2 161.8	2 041.7	1 837.5
5		64-QAM	2/3	6		58 800	39 200	2 882.4	2 722.2	2 450.0
6			3/4				44 100	3 242.6	3 062.5	2 756.3
7			5/6				49 000	3 602.9	3 402.8	3 062.5
8		256-QAM	3/4	8		78 400	58 800	4 323.5	4 083.3	3 675.0
9			5/6				65 333	4 803.9	4 537.0	4 083.3
10		1024-QAM	3/4	10		98 000	73 500	5 404.4	5 104.2	4 593.8
11			5/6				81 666	6 004.9	5 671.3	5 104.1

Table 27-109—HE-MCSs for 2×996-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	11 760	5 880	432.4	408.3	367.5
1		QPSK	1/2	2		23 520	11 760	864.7	816.7	735.0
2			3/4				17 640	1 297.1	1 225.0	1 102.5
3		16-QAM	1/2	4		47 040	23 520	1 729.4	1 633.3	1 470.0
4			3/4				35 280	2 594.1	2 450.0	2 205.0
5		64-QAM	2/3	6		70 560	47 040	3 458.8	3 266.7	2 940.0
6			3/4				52 920	3 891.2	3 675.0	3 307.5
7			5/6				58 800	4 323.5	4 083.3	3 675.0
8		256-QAM	3/4	8		94 080	70 560	5 188.2	4 900.0	4 410.0
9			5/6				78 400	5 764.7	5 444.4	4 900.0
10		1024-QAM	3/4	10		11 7600	88 200	6 485.3	6 125.0	5 512.5
11			5/6				98 000	7 205.9	6 805.6	6 125.0

Table 27-110—HE-MCSs for 2×996-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	13 720	6 860	504.4	476.4	428.8
1		QPSK	1/2	2		27 440	13 720	1 008.8	952.8	857.5
2			3/4				20 580	1 513.2	1 429.2	1 286.3
3		16-QAM	1/2	4		54 880	27 440	2 017.6	1 905.6	1 715.0
4			3/4				41 160	3 026.5	2 858.3	2 572.5
5		64-QAM	2/3	6		82 320	54 880	4 035.3	3 811.1	3 430.0
6			3/4				61 740	4 539.7	4 287.5	3 858.8
7			5/6				68 600	5 044.1	4 763.9	4 287.5
8		256-QAM	3/4	8		109 760	82 320	6 052.9	5 716.7	5 145.0
9			5/6				91 466	6 725.4	6 351.8	5 716.6
10		1024-QAM	3/4	10		137 200	102 900	7 566.2	7 145.8	6 431.3
11			5/6				114 333	8 406.8	7 939.8	7 145.8

Table 27-111—HE-MCSs for 2×996-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 µs GI	1.6 µs GI	3.2 µs GI
0	N/A	BPSK	1/2	1	1 960	15 680	7 840	576.5	544.4	490.0
1		QPSK	1/2	2		31 360	15 680	1 152.9	1 088.9	980.0
2			3/4				23 520	1 729.4	1 633.3	1 470.0
3		16-QAM	1/2	4		62 720	31 360	2 305.9	2 177.8	1 960.0
4			3/4				47 040	3 458.8	3 266.7	2 940.0
5		64-QAM	2/3	6		94 080	62 720	4 611.8	4 355.6	3 920.0
6			3/4				70 560	5 188.2	4 900.0	4 410.0
7			5/6				78 400	5 764.7	5 444.4	4 900.0
8		256-QAM	3/4	8		125 440	94 080	6 917.6	6 533.3	5 880.0
9			5/6				104 533	7 686.3	7 259.2	6 533.3
10		1024-QAM	3/4	10		156 800	117 600	8 647.1	8 166.7	7 350.0
11			5/6				130 666	9 607.8	9 074.0	8 166.6

27.6 Parameters for HE-SIG-B-MCSs

The HE-SIG-B-MCSs, defined in Table 27-112 (HE-SIG-B MCSs), are used for the HE-SIG-B field transmission in the HE MU PPDU.

Table 27-112—HE-SIG-B MCSs

HE-SIG-B-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	HE-SIG-B rate (Mb/s)
0	1	BPSK	1/2	1	26	26	13	3.3
	0		1/2		52	52	26	6.6
1	1	QPSK	1/2	2	26	52	26	6.6
	0		1/2		52	104	52	13.2
2	N/A		3/4		52	104	78	19.5
3	1	16-QAM	1/2	4	26	104	52	13.2
	0		1/2		52	208	104	26.0
4	1		3/4		26	104	78	19.5
	0		3/4		52	208	156	39.0
5	N/A	64-QAM	2/3	6	52	312	208	52.0

NOTE—The parameters N_{SD}, N_{CBPS} and N_{DBPS} are used for the HE-SIG-B field transmission in each 20 MHz subchannel.

Annex B

(normative)

Protocol Implementation Conformance Statement (PICS) proforma

B.4 PICS proforma—IEEE Std 802.11-<year>

Change B.4.3 as follows:

B.4.3 IUT configuration

Item	IUT configuration	References	Status	Support
	What is the configuration of the IUT?			
* CFOFDM	Orthogonal frequency division multiplexing (OFDM) PHY	—	O.2 CFHT5G:M CFTVHT:M CFS1G: M CFHE:M	Yes ☐ No ☐
…				
*CFHT	High-throughput (HT) PHY	9.4.2.55 (HT Capabilities element)	O.2 CFVHT:M CFHE:M	Yes ☐ No ☐
…				
*CFHT2G4	HT operation in the 2.4 GHz band	Clause 19	CFHT:O.6 CFHE:M	Yes ☐ No ☐ N/A ☐
*CFHT5G	HT operation in the 5 GHz band	Clause 19	CFHT:O.6 CFVHT:M CFHE:M	Yes ☐ No ☐ N/A ☐
…				
*CFVHT	Very High Throughput (VHT) features	9.4.2.157 (VHT Capabilities element)	O.2 CFHE:M	Yes ☐ No ☐
…				
*CFESM	Extended spectrum management	10.23.3 (Operation with operating classes)	O CFVHT OR CFTVHT:M	Yes ☐ No ☐
*CFHE	High efficiency (HE) operation	9.4.2.247 (HE Capabilities element)	O CFHE20:M CFHE80:M	Yes ☐ No ☐
*CFHE2G4	HE operation in the 2.4 GHz band	Clause 27	O.8	Yes ☐ No ☐
*CFHE5G	HE operation in the 5 GHz band	Clause 27	O.8	Yes ☐ No ☐
*CFHE6G	HE operation in the 6 GHz band	Clause 27	O.8	Yes ☐ No ☐

B.4.3 IUT configuration *(continued)*

Item	IUT configuration	References	Status	Support
*CFHE20	HE operation as a 20 MHz-only non-AP HE STA	Clause 27	CFIndepSTA and CFHE:M	Yes ☐ No ☐
*CFHE80	HE operation with capability of 80 MHz or wider channel width	Clause 27	CFAP and CFHE and CFVHT:M CFIndepSTA and CFHE and CFVHT:M	Yes ☐ No ☐
CF2G4n6G	Operation in the 2.4 GHz and 6 GHz bands	26.17.2.4 (Out of band discovery of a 6 GHz BSS)	(CFHT2G4 or CFHE2G4): O CFHE6G: M	Yes ☐ No ☐ N/A ☐
CF5Gn6G	Operation in the 5 GHz and 6 GHz bands	26.17.2.4 (Out of band discovery of a 6 GHz BSS)	(CFHT5G or CFHE5G): O CFHE6G: M	Yes ☐ No ☐ N/A ☐

B.4.4 MAC protocol

Change B.4.4.1 as follows:

B.4.4.1 MAC protocol capabilities

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol capabilities supported?			
PC46	Dynamic fragmentation	10.3 (DCF), 10.4 (MSDU, A-MSDU, and MMPDU fragmentation)		
PC46.1	Dynamic fragmentation level 1	26.3.2.2 (Level 1 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐
PC46.2	Dynamic fragmentation level 2	26.3.2.3 (Level 2 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐
PC46.3	Dynamic fragmentation level 3	26.3.2.4 (Level 3 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐

Change B.4.4.2 as follows:

B.4.4.2 MAC frames

Item	MAC frame	References	Status	Support
	Is transmission of the following MAC frames supported?	9 (Frame formats)		
FT42	Transmission of Operating Mode Notification frame and Operating Mode Notification element	9.6.22.4 (Operating Mode Notification frame format), 9.4.2.165 (Operating Mode Notification element), 11.41 (Notification of operating mode changes)	O	Yes ☐ No ☐ N/A ☐
<u>FT53</u>	<u>Trigger frame</u>	<u>9 (Frame formats)</u>	<u>CFHE:M</u>	<u>Yes ☐ No ☐ N/A ☐</u>
	Is reception of the following MAC frames supported?	9 (Frame formats)		
FR41	VHT NDP Announcement	9 (Frame formats)	VHTM4.2:M TVHTM4.2:M	Yes ☐ No ☐ N/A ☐
FR42	Beamforming Report Poll	9 (Frame formats)	VHTM4.2:O VHTM4.4:M TVHTM4.2:O TVHTM4.4:M	Yes ☐ No ☐ N/A ☐
FR43	Reception of Operating Mode Notification frame and Operating Mode Notification element	9.6.23.4 (Operating Mode Notification frame format), 9.4.2.166 (Operating Mode Notification element), 11.42 (Notification of operating mode changes)	CFVHT:M CFTVHT:M	Yes ☐ No ☐ N/A ☐
<u>FR53</u>	<u>Trigger frame</u>	<u>9 (Frame formats)</u>	<u>CFHE:O</u>	<u>Yes ☐ No ☐ N/A ☐</u>

Change B.4.12 as follows:

B.4.12 QoS base functionality

Item	Protocol capability	References	Status	Support
…				
QB4	Block acknowledgments (block ack)			
…				
QB4.4	Multi-TID Block Ack	9.3.1.8.3 (Multi-TID BlockAck variant)	CFQoS:O CFHT OR CFT-VHT:M	Yes ☐ No ☐ N/A ☐
QB4.5	Multi-STA BlockAck	9.3.1.8.7 (Multi-STA BlockAck variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
…				

Insert a new subclause at the end of B.4 as follows:

B.4.33 High efficiency (HE) features

B.4.33.1 HE MAC features

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol features supported?			
HEM1	HE capabilities signaling			
HEM1.1	HE Capabilities element	9.4.2.247 (HE Capabilities element)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM1.2	Signaling of STA capabilities in Probe Request, (Re)Association Request frames	9.3.3.5 (Association Request frame format), 9.3.3.7 (Reassociation Request frame format), 9.3.3.9 (Probe Request frame format), 9.4.2.247 (HE Capabilities element)	(CFHE AND CFIndep-STA):M	Yes ☐ No ☐ N/A ☐

B.4.33.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
HEM1.3	Signaling of STA and BSS capabilities in Beacon, Probe Response, (Re)Association Response frames	9.3.3.2 (Beacon frame format), 9.3.3.6 (Association Response frame format), 9.3.3.8 (Reassociation Response frame format), 9.3.3.10 (Probe Response frame format), 9.4.2.247 (HE Capabilities element)	(CFVHT AND CFAP):M	Yes ☐ No ☐ N/A ☐
HEM2	Signaling of HE operation	9.4.2.248 (HE Operation element)	(CFHE AND CFAP):M	Yes ☐ No ☐ N/A ☐
HEM3	A-MPDU with multiple TIDs	26.6.3 (Multi-TID A-MPDU and ack-enabled single-TID A-MPDU)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4	HE variant HT Control			
HEM4.1	UL MU Response Scheduling	9.2.4.6a.1 (TRS Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.2	Operating Mode	9.2.4.6a.2 (OM Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.3	HE Link Adaptation	9.2.4.6a.3 (HLA Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.4	Buffer Status Report	9.2.4.6a.4 (BSR Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.5	UL Power Headroom	9.2.4.6a.5 (UPH Control)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM4.6	BQR Control	9.2.4.6a.6 (BQR Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.7	CAS Control	9.2.4.6a.7 (CAS Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5	Trigger frame			
HEM5.1	Basic Trigger frame	9.3.1.22.2 (Basic Trigger variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.2	BFRP Trigger frame	9.3.1.22.3 (Beamforming Report Poll (BFRP) variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.3	MU-BAR Trigger frame	9.3.1.22.4 (MU-BAR variant)	CFHE:O	Yes ☐ No ☐ N/A ☐

B.4.33.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
HEM5.4	MU-RTS Trigger frame transmission	9.3.1.22.5 (MU-RTS variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5.5	MU-RTS Trigger frame reception	9.3.1.22.5 (MU-RTS variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.6	BSRP Trigger frame	9.3.1.22.6 (Buffer Status Report Poll (BSRP) variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5.7	GCR MU-BAR Trigger frame	9.3.1.22.7 (GCR MU-BAR variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5.8	BQRP Trigger frame	9.3.1.22.8 (Bandwidth Query Report Poll (BQRP) variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5.9	NFRP Trigger frame	9.3.1.22.9 (NDP Feedback Report Poll (NFRP) variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM6	Transmit beamforming			
*HEM6.1	SU beamformer capable if the supported maximum number of transmit spatial streams is less than 4	9.4.2.247 (HE Capabilities element)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEM6.2	SU beamformer capable if the supported maximum number of transmit spatial streams is greater than or equal to 4	9.4.2.247 (HE Capabilities element)	CFHE:M	Yes ☐ No ☐ N/A ☐
*HEM6.3	SU beamformee capable	9.4.2.247 (HE Capabilities element)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEM6.4	MU beamformer capable if the supported maximum number of transmit spatial streams is less than 4	9.4.2.247 (HE Capabilities element)	CFAP AND CFHEM6.1:O	Yes ☐ No ☐ N/A ☐
*HEM6.5	MU beamformer capable if the supported maximum number of transmit spatial streams is greater than or equal to 4	9.4.2.247 (HE Capabilities element)	CFAP AND CFHEM6.2:M	Yes ☐ No ☐ N/A ☐
*HEM6.6	MU beamformee capable	9.4.2.247 (HE Capabilities element)	CFIndepSTA and VHTM7.2:O	Yes ☐ No ☐ N/A ☐
HEM6.7	Transmission of an HE sounding NDP	26.7 (HE sounding protocol)	HEM6.1:M HEM6.2:M	Yes ☐ No ☐ N/A ☐
HEM6.8	Reception of an HE sounding NDP	26.7 (HE sounding protocol)	HEM6.3:M	Yes ☐ No ☐ N/A ☐

B.4.33.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
*HEM6.9	Transmission of Trigger frame	26.7 (HE sounding protocol)	HEM6.1:O HEM6.2:O	Yes ☐ No ☐ N/A ☐
HEM6.10	Reception of Trigger frame	26.7 (HE sounding protocol)	HEM6.9:M	Yes ☐ No ☐ N/A ☐
HEM7	Sounding protocol			
HEM7.1	HE Sounding Protocol as SU beamformer	26.7 (HE sounding protocol)	HEM6.1:M HEM6.2:M	Yes ☐ No ☐ N/A ☐
HEM7.2	HE Sounding Protocol as SU beamformee	26.7 (HE sounding protocol)	HEM6.3:M	Yes ☐ No ☐ N/A ☐
HEM7.3	HE Sounding Protocol as MU beamformer	26.7 (HE sounding protocol)	HEM6.4:M HEM6.5:M	Yes ☐ No ☐ N/A ☐
HEM7.4	HE Sounding Protocol as MU beamformee	26.7 (HE sounding protocol)	HEM6.6:M	Yes ☐ No ☐ N/A ☐
HEM8	NAV update	26.2.4 (Updating two NAVs)		
HEM8.1	Update basic NAV	26.2.4 (Updating two NAVs)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM8.2	Update IntraBSS NAV	26.2.4 (Updating two NAVs)	CFAP AND CFHE:O CFIndepSTA AND CFHE:M	Yes ☐ No ☐ N/A ☐
HEM9	OFDMA-based random access	26.5.4 (UL OFDMA-based random access (UORA))	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM10	TWT operation	26.8 (TWT operation)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM11	Quiet time period			
HEM11.1	Transmission of Quiet Time Period Request frame	26.17.5 (Quiet HE STAs in an HE BSS)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM11.2	Reception of Quiet Time Period Response frame	26.17.5 (Quiet HE STAs in an HE BSS)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM12	HE BSS operation in the 6 GHz band			
HEM12.1	Scanning in the 6 GHz band	26.17.2.3 (Scanning in the 6 GHz band)	CFHE6G: O	Yes ☐ No ☐ N/A ☐
HEM12.2	Out of band discovery	26.17.2.4 (Out of band discovery of a 6 GHz BSS)	(CF2G4n6G or CF5Gn6G): M	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
HEP1	PHY operating modes			
HEP1.1	Operation according to Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 19 (High Throughput (HT) PHY specification) (High Throughput) and/or Clause 21 (Very High Throughput (VHT) PHY specification)	27.1.1 (Introduction to the HE PHY)	CFHE5G and (CFAP or CFHE80):M	Yes ☐ No ☐ N/A ☐
HEP1.2	Operation according Clause 19 (High Throughput (HT) PHY specification) (High Throughput) in the 5 GHz band	27.1.1 (Introduction to the HE PHY)	CFHE5G and CFHE20: M	Yes ☐ No ☐ N/A ☐
HEP1.3	Operation according Clause 19 (High Throughput (HT) PHY specification) (High Throughput) in the 2.4 GHz band	27.1.1 (Introduction to the HE PHY)	CFHE2G4:M	Yes ☐ No ☐ N/A ☐
HEP1.4	Operation according to Clause 17 in the 6 GHz band	27.1.1 (Introduction to the HE PHY)	CFHE6G:M	Yes ☐ No ☐ N/A ☐
HEP2	HE PPDU format	27.1.4 (PPDU formats)		
*HEP2.1	HE SU PPDU	27.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP2.2	HE ER SU PPDU	27.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP2.3	HE MU PPDU	27.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP2.4	HE TB PPDU	27.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP3	BSS bandwidth			
*HEP3.1	20 MHz operation	26.17 (HE BSS operation)	CFHE: M	Yes ☐ No ☐ N/A ☐
*HEP3.2	40 MHz operation	26.17 (HE BSS operation)	CFHE80 and (CFHE5G or CFHE6G):M CFHE2G4:O	Yes ☐ No ☐ N/A ☐
*HEP3.3	80 MHz operation	26.17 (HE BSS operation)	CFHE80 and (CFHE5G or CFHE6G):M	Yes ☐ No ☐ N/A ☐
*HEP3.4	160 MHz operation	26.17 (HE BSS operation)	CFHE80 and (CFHE5G or CFHE6G):O HEP3.5:M	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP3.5	80+80 MHz operation	26.17 (HE BSS operation)	CFHE80 and (CFHE5G or CFHE6G):O	Yes ☐ No ☐ N/A ☐
HEP4	PHY timing information			
HEP4.1	Values in 20 MHz channel	27.3.9 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.2	Values in 40 MHz channel	27.3.9 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.3	Values in 80 MHz channel	27.3.9 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.4	Values in 160 MHz channel	27.3.9 (Timing-related parameters)	HEP3.4:M	Yes ☐ No ☐ N/A ☐
HEP4.5	Values in 80+80 MHz channel	27.3.9 (Timing-related parameters)	HEP3.5:M	Yes ☐ No ☐ N/A ☐
HEP5	STBC	27.3.12.12 (Space-time block coding)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEP6	Tone allocation			
*HEP6.1	26-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarriers)	CFHE:M	Yes ☐ No ☐ N/A ☐
*HEP6.2	52-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarriers)	CFHE:M	Yes ☐ No ☐ N/A ☐
*HEP6.3	106-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarriers)	CFHE:M	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP6.4	242-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarri-ers)	CFHE80:M CFHE20:O	Yes ☐ No ☐ N/A ☐
*HEP6.5	484-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarri-ers)	CFHE80 and HEP3.2:M	Yes ☐ No ☐ N/A ☐
*HEP6.6	996-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarri-ers)	CFHE80 and HEP3.3:M CFHE80 and HEP3.4:M	Yes ☐ No ☐ N/A ☐
*HEP6.7	2×996-tone RU mapping	27.3.2.2 (Resource unit, guard and DC subcarriers), 27.3.2.3 (Null subcarriers) and 27.3.2.4 (Pilot subcarri-ers)	CFHE80 and HEP3.4:M	Yes ☐ No ☐ N/A ☐
HEP7	Coding			
HEP8.1	BCC with 4 or fewer spatial streams	27.3.12.5.1 (BCC coding and puncturing)	(HEP6.1 or HEP6.2 or HEP6.3 or HEP6.4):M (HEP3.1 and HEP2.1):M	Yes ☐ No ☐ N/A ☐
HEP8.2	LDPC with more than 4 spatial streams	27.3.12.5.2 (LDPC coding)	CFHE80:M CFHE20:M	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
HEP8.3	LDPC with 4 or fewer spatial streams	27.3.12.5.2 (LDPC coding)	(HEP6.5 or HEP6.6 or HEP6.7):M ((HEP3.2 or HEP3.3 or HEP3.4 or HEP3.5) and HEP2.1):M (HEP6.1 or HEP6.2 or HEP6.3 or HEP6.4):O (HEP3.1 and HEP2.1):O CFHE20: O	Yes ☐ No ☐ N/A ☐
HEP9	Coding and modulation schemes			
HEP9.1	For 26-, 52-, 106-, 242-, 484- and 996-tone mapping			
*HEP9.1.1	HE-MCS with Index 0-7 and N_{SS} = 1	27.5 (Parameters for HE-MCSs)	CFHE: M	Yes ☐ No ☐ N/A ☐
*HEP9.1.2	HE-MCS with Index 0-8 and N_{SS} = 1	27.5 (Parameters for HE-MCSs)	HEP9.1.1:O	Yes ☐ No ☐ N/A ☐
HEP9.1.3	HE-MCS with Index 0-9 and N_{SS} = 1	27.5 (Parameters for HE-MCSs)	HEP9.1.2:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.4	HE-MCS with Index 0-7 and N_{SS} = 2	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.5	HE-MCS with Index 0-8 and N_{SS} = 2	27.5 (Parameters for HE-MCSs)	HEP9.1.4:O	Yes ☐ No ☐ N/A ☐
HEP9.1.6	HE-MCS with Index 0-9 and N_{SS} = 2	27.5 (Parameters for HE-MCSs)	HEP9.1.5:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.7	HE-MCS with Index 0-7 and N_{SS} = 3	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.8	HE-MCS with Index 0-8 and N_{SS} = 3	27.5 (Parameters for HE-MCSs)	HEP9.1.7:O	Yes ☐ No ☐ N/A ☐
HEP9.1.9	HE-MCS with Index 0-9 and N_{SS} = 3	27.5 (Parameters for HE-MCSs)	HEP9.1.8:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.10	HE-MCS with Index 0-7 and N_{SS} = 4	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP9.1.11	HE-MCS with Index 0-8 and N_{SS} = 4	27.5 (Parameters for HE-MCSs)	HEP9.1.10:O	Yes ☐ No ☐ N/A ☐
HEP9.1.12	HE-MCS with Index 0-9 and N_{SS} = 4	27.5 (Parameters for HE-MCSs)	HEP9.1.11:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.13	HE-MCS with Index 0-7 and N_{SS} = 5	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.14	HE-MCS with Index 0-8 and N_{SS} = 5	27.5 (Parameters for HE-MCSs)	HEP9.1.13:O	Yes ☐ No ☐ N/A ☐
HEP9.1.15	HE-MCS with Index 0-9 and N_{SS} = 5	27.5 (Parameters for HE-MCSs)	HEP9.1.14:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.16	HE-MCS with Index 0-7 and N_{SS} = 6	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.17	HE-MCS with Index 0-8 and N_{SS} = 6	27.5 (Parameters for HE-MCSs)	HEP9.1.16:O	Yes ☐ No ☐ N/A ☐
HEP9.1.18	HE-MCS with Index 0-9 and N_{SS} = 6	27.5 (Parameters for HE-MCSs)	HEP9.1.17:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.19	HE-MCS with Index 0-7 and N_{SS} = 7	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.20	HE-MCS with Index 0-8 and N_{SS} = 7	27.5 (Parameters for HE-MCSs)	HEP9.1.19:O	Yes ☐ No ☐ N/A ☐
HEP9.1.21	HE-MCS with Index 0-9 and N_{SS} = 7	27.5 (Parameters for HE-MCSs)	HEP9.1.20:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.22	HE-MCS with Index 0-7 and N_{SS} = 8	27.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP9.1.23	HE-MCS with Index 0-8 and N_{SS} = 8	27.5 (Parameters for HE-MCSs)	HEP9.1.22:O	Yes ☐ No ☐ N/A ☐
HEP9.1.24	HE-MCS with Index 0-9 and N_{SS} = 8	27.5 (Parameters for HE-MCSs)	HEP9.1.23:O	Yes ☐ No ☐ N/A ☐
HEP9.2	For 242-, 484- and 996-tone plan			
*HEP9.2.1	HE-MCS with Index 0-10 and N_{SS} = 1	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.2	HE-MCS with Index 0-11 and N_{SS} = 1	27.5 (Parameters for HE-MCSs)	HEP9.2.1:O	Yes ☐ No ☐ N/A ☐

B.4.33.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP9.2.3	HE-MCS with Index 0-10 and $N_{SS} = 2$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.4	HE-MCS with Index 0-11 and $N_{SS} = 2$	27.5 (Parameters for HE-MCSs)	HEP9.2.3:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.5	HE-MCS with Index 0-10 and $N_{SS} = 3$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.6	HE-MCS with Index 0-11 and $N_{SS} = 3$	27.5 (Parameters for HE-MCSs)	HEP9.2.5:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.7	HE-MCS with Index 0-10 and $N_{SS} = 4$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.8	HE-MCS with Index 0-11 and $N_{SS} = 4$	27.5 (Parameters for HE-MCSs)	HEP9.2.7:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.9	HE-MCS with Index 0-10 and $N_{SS} = 5$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.10	HE-MCS with Index 0-11 and $N_{SS} = 5$	27.5 (Parameters for HE-MCSs)	HEP9.2.9:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.11	HE-MCS with Index 0-10 and $N_{SS} = 6$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.12	HE-MCS with Index 0-11 and $N_{SS} = 6$	27.5 (Parameters for HE-MCSs)	HEP9.2.11:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.13	HE-MCS with Index 0-10 and $N_{SS} = 7$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.14	HE-MCS with Index 0-11 and $N_{SS} = 7$	27.5 (Parameters for HE-MCSs)	HEP9.2.13:O	Yes ☐ No ☐ N/A ☐
*HEP9.2.15	HE-MCS with Index 0-10 and $N_{SS} = 8$	27.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP9.2.16	HE-MCS with Index 0-11 and $N_{SS} = 8$	27.5 (Parameters for HE-MCSs)	HEP9.2.15:O	Yes ☐ No ☐ N/A ☐

Annex C

(normative)

ASN.1 encoding of the MAC and PHY MIB

C.3 MIB Detail

```
-- **********************************************************************
-- * Major sections
-- **********************************************************************
-- Station ManagementT (SMT) Attributes
   -- DEFINED AS "The SMT object class provides the necessary support
   -- at the station to manage the processes in the station such that
   -- the station may work cooperatively as a part of an IEEE 802.11
   -- network."
```

Change the comment list following the dot11smt definition as follows (not all lines shown):

```
   dot11smt OBJECT IDENTIFIER ::= { ieee802dot11 1 }
   -- dot11GLKLinkMetricsTable                          ::= { dot11smt 41 }
   -- dot11HEStationConfigTable                         ::= { dot11smt 42 }
   -- dot11PPEThresholdsMappingsTable                   ::= { dot11smt 43 }

-- MAC Attributes
   -- DEFINED AS "The MAC object class provides the necessary support
   -- for the access control, generation, and verification of frame
   -- check sequences (FCSs), and proper delivery of valid data to
   -- upper layers."
```

Change the comment list following the dot11mac definition as follows (not all lines shown):

```
   dot11mac OBJECT IDENTIFIER ::= { ieee802dot11 2 }

-- MAC GROUPS
   -- dot11CDMGOperationTable ::= { dot11mac 11 }
   -- dot11MUEDCATable ::= { dot11mac 15 }
```

Change Dot11StationConfigEntry as follows (not all lines shown):

```
Dot11StationConfigEntry ::= SEQUENCE
   {
      dot11FutureChannelGuidanceActivated               TruthValue,
      dot11HEOptionImplemented                          TruthValue,
      dot11OBSSNarrowBWRUinOFDMATolerated               TruthValue,
      dot11HE6GOptionImplemented                        TruthValue,
      dot11OCTOptionImplemented                         TruthValue,
   }
```

Insert the following after the dot11FutureChannelGuidanceActivated OBJECT-TYPE element in the Dot11StationConfig TABLE:

```
dot11HEOptionImplemented 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 indicates whether the entity is HE Capable."
::= { dot11StationConfigEntry 181}

dot11OBSSNarrowBWRUinOFDMATolerated 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 indicates whether the AP STA is able to tolerate 26-tone RU UL
        OFDMA transmissions using HE TB PPDU from OBSS (not falsely classify the
        26-tone RU UL OFDMA transmissions as radar pulses)."
::= { dot11StationConfigEntry 182 }

dot11HE6GOptionImplemented 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 indicates whether the entity is capable of operating in the
        6 GHz band."
::= { dot11StationConfigEntry 194}

dot11OCTOptionImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities.

This attribute, when true, indicates that the station implementation is
capable of on-channel tunnelling operation. The capability is
disabled otherwise."
::= { dot11StationConfigEntry 187}
```

Insert the following after the dot11GLKLinkMetricsTable TABLE:

```
-- *******************************************************************
-- * dot11HEStationConfig TABLE
-- ********************************************************************

dot11HEStationConfigTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11HEStationConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Station Configuration attributes. In tabular form to allow for multiple
        instances on an agent."
    ::= { dot11smt 42 }

dot11HEStationConfigEntry OBJECT-TYPE
    SYNTAX Dot11HEStationConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An entry (conceptual row) in the dot11HEStationConfig Table.
```

```
        ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Inter-
        face tables in this MIB module are indexed by ifIndex."
    INDEX { ifIndex }
    ::= { dot11HEStationConfigTable 1 }

Dot11HEStationConfigEntry ::=
    SEQUENCE {
        dot11TRSOptionImplemented                            TruthValue,
        dot11OFDMARandomAccessOptionImplemented              TruthValue,
        dot11HEControlFieldOptionImplemented                 TruthValue,
        dot11OMIOptionImplemented                            TruthValue,
        dot11HEMCSFeedbackOptionImplemented                  INTEGER,
        dot11HEDynamicFragmentationLevel                     INTEGER,
        dot11AMPDUwithMultipleTIDOptionImplemented           TruthValue,
        dot11MPDUAskedforAckInMultiTIDAMPDU                  TruthValue,
        dot11TXOPDurationRTSThreshold                        Unsigned32,
        dot11PPEThresholdsRequired                           TruthValue,
        dot11IntraPPDUPowerSaveOptionActivated               TruthValue,
        dot11AMSDUFragmentationOptionImplemented             TruthValue,
        dot11BSSColorCollisionAPPeriod                       Unsigned32,
        dot11BSSColorCollisionSTAPeriod                      Unsigned32,
        dot11AutonomousBSSColorCollisionReportingImplemented TruthValue,
        dot11HEPSROptionImplemented                          TruthValue,
        dot11HEBSRControlImplemented                         TruthValue,
        dot11HEBQRControlImplemented                         TruthValue,
        dot11HECASControlImplemented                         TruthValue,
        dot11PartialBSSColorImplemented                      TruthValue,
        dot11ObssNbRuToleranceTime                           Unsigned32,
        dot11HESubchannelSelectiveTransmissionImplemented    TruthValue,
        dot11SRResponderOptionImplemented                    TruthValue,
        dot11AutonomousBSSColorInUseReportingImplemented     TruthValue,
        dot11ShortSSIDListImplemented                        TruthValue,
        dot11ColocatedRNRImplemented                         TruthValue,
        dot11SRGAPOBSSPDMinOffset                            Integer32,
        dot11SRGAPOBSSPDMaxOffset                            Integer32,
        dot11SRGAPBSSColorBitmap                             OCTET STRING,
        dot11SRGAPBSSIDBitmap                                OCTET STRING,
        dot11NonSRGAPOBSSPDMaxOffset                         Integer32,
        dot11HTVHTTriggerOptionImplemented                   TruthValue,
        dot11HEDynamicSMPowerSaveOptionImplemented           TruthValue,
        dot11MUEDCAParametersActived                         TruthValue,
        dot11CoHostedBSSIDImplemented                        TruthValue,
        dot11UnsolicitedProbeResponseOptionActivated         TruthValue,
        dot11MemberOfColocated6GHzESSOptionActivated         TruthValue,
        dot11AckEnabledAMPDUOptionImplemented                TruthValue,
        dot11MinPSCProbeDelay                                Unsigned32
    }

dot11TRSOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a TRS Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 1 }

dot11OFDMARandomAccessOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
```

```
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of an OFDMA random access operation. The capability is disabled
       otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 2}

dot11HEControlFieldOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of receiving the HE variant HT Control field. The capability is
       disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 3}

dot11OMIOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of receiving frames with an OM Control subfield. The capability is
       disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 4}

dot11HEMCSFeedbackOptionImplemented OBJECT-TYPE
    SYNTAX INTERGER {none(0), unsolicited(2), solicitedandunsolicited(3)}
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute indicates the HE-MCS feedback capability supported by the
       station implementation."
    DEFVAL { 0 }
    ::= { dot11HEStationConfigEntry 5}

dot11HEDynamicFragmentationLevel OBJECT-TYPE
    SYNTAX INTEGER{hedynamicfragmentationlevel1(1), hedynamicfragmentationlev-
       el2(2), hedynamicfragmentationlevel3(3)}
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       HEDynamicFragmentationLevel1 indicates support for up to one dynamic frag-
       ment that is a non-A-MPDU frame, no support for dynamic fragments within
```

```
        an A-MPDU that does not contain an S-MPDU.

        HEDynamicFragmentationLevel2 indicates support for up to one dynamic frag-
        ment that is a non-A-MPDU frame and support for up to one dynamic fragment
        for each MSDU, each A-MSDU (if supported by the recipient) and one MMPDU
        (if present) within an A-MPDU that does not contain an S-MPDU.

        HEDynamicFragmentationLevel3 indicates support for up to one dynamic frag-
        ment that is a non-A-MPDU frame and support for up to 4 dynamic fragments
        for each MSDU and for each A-MSDU (if supported by the recipient) within
        an A-MPDU and up to one dynamic fragment for one MMPDU (if present) in an
        A-MPDU that does not contain an S-MPDU"
    ::= { dot11HEStationConfigEntry 6}

dot11HEAMPDUwithMultipleTIDOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving an A-MPDU that contains QoS Data frames with two or
        more different TID values. The capability is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 7}

dot11MPDUAskedforAckInMultiTIDAMPDU OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving a multi-TID A-MPDU that can solicit either Ack or
        BlockAck, or both. The capability is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 8}

dot11TXOPDurationRTSThreshold OBJECT-TYPE
    SYNTAX Unsigned32 (1..1023)
    UNITS "32 microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity or by the MAC of a non-AP
        HE STA upon receiving an HE Operation element from the HE AP with which it
        is associated.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the duration of the transmission or TXOP above
        which an RTS/CTS handshake is performed. The value 1023 means this feature
        is disabled."
    DEFVAL { 1023 }
    ::= { dot11HEStationConfigEntry 9 }

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 PPE thresholds exist and are
       provided in dot11PPEThresholdsTable."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 10 }

dot11IntraPPDUPowerSaveOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of Intra PPDU Power Save operation. The capability is disabled
       otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 11 }

dot11AMSDUFragmentationOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable. Its value is determined by device
        capabilities.

        This attribute, when true, indicates that the STA implementation is
        capable of receiving dynamic fragments of A-MSDUs. The capability is
        disabled otherwise."
    DEFVAL { false }
::= { dot11HEStationConfigEntry 12 }

dot11BSSColorCollisionAPPeriod OBJECT-TYPE
    SYNTAX Unsigned32 (50..255)
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "The attribute indicates the duration for which an HE AP shall wait before
       disabling BSS color. The minimum value of this variable is 50."
    DEFVAL { 50 }
    ::= { dot11HEStationConfigEntry 13 }

dot11BSSColorCollisionSTAPeriod OBJECT-TYPE
    SYNTAX Unsigned32 (5..10)
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "The attribute indicates the interval between successive BSS color
        collision reports. The maximum value of this variable is 10."
    DEFVAL { 5 }
    ::= { dot11HEStationConfigEntry 14 }

dot11AutonomousBSSColorCollisionReportingImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a capability variable.
```

```
        Its value is determined by device capabilities.
        This attribute, when true, indicates that autonomously detecting and
        reporting of BSS color collision is implemented."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 15 }

dot11HEPSROptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable. Its value is determined by device
        capabilities.

        This attribute, when true, indicates that the STA implementation is
        capable of transmitting Spatial Reuse Parameters in HE PPDUs. The
        capability is disabled otherwise."
DEFVAL { false }
::= { dot11HEStationConfigEntry 16 }

dot11HEBSRControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a BSR Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 17 }

dot11HEBQRControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a BQR Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 18 }

dot11HECASControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a CAS Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 19 }

dot11PartialBSSColorImplemented OBJECT-TYPE
    SYNTAX TruthValue
```

```
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.
       This attribute, when true, indicates that the partial BSS color (see
       27.16.3 (AID assignment)) is implemented. The capability is disabled oth-
       erwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 20 }

dot11ObssNbRuToleranceTime OBJECT-TYPE
    SYNTAX Unsigned32 (0..3600)
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This attribute indicates the minimum time that needs to pass since the
       reception of the last Beacon frame from an OBSS AP that did not indicate
       tolerance to narrow bandwidth RU in OFDMA before the STA can transmit a
       Trigger frame or TRS Control subfield that allocates a 26-tone RU, or
       transmit an HE TB PPDU in a 26-tone RU."
    DEFVAL { 1800 }
    ::= { dot11HEStationConfigEntry 21 }

dot11HESubchannelSelectiveTransmissionImplemented 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 an HE subchannel selective
       transmission operation is implemented. The capability is disabled other-
       wise."
    DEFVAL { false }
::= { dot11HEStationConfigEntry 22 }

dot11SRResponderOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the PSR-based PSRT PPDU recep-
       tion (see 26.10.3 (PSR-based spatial reuse operation)) is implemented. The
       capability is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 23 }

dot11AutonomousBSSColorInUseReportingImplemented 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 autonomously
       reporting of BSS color in use is implemented."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 24 }
```

```
dot11ShortSSIDListImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable. Its value is determined by device capabil-
      ities.

      This attribute, when true, indicates that the STA implementation is capa-
      ble of transmitting and receiving Short SSID List element in Probe Request
      frames. The capability is disabled otherwise."
   DEFVAL { false }
   ::= { dot11HEStationConfigEntry 25 }

dot11ColocatedRNRImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable. Its value is determined by device capabil-
      ities.

      This attribute, when true, indicates that the STA implementation is capa-
      ble of transmitting or receiving a Reduced Neighbor Report element carry-
      ing information on APs that are in the same co-located AP set as the
      reporting AP in Probe Response, Beacon and FILS Discovery frames. The
      capability is disabled otherwise."
   DEFVAL { false }
::= { dot11HEStationConfigEntry 26 }

dot11SRGAPOBSSPDMinOffset OBJECT-TYPE
   SYNTAX Integer32
   UNITS "dBm"
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation.

      This attribute indicates the SRG OBSS PD Min Offset for an AP."
   DEFVAL { 0 }
::= { dot11HEStationConfigEntry 27 }

dot11SRGAPOBSSPDMaxOffset OBJECT-TYPE
   SYNTAX Integer32
   UNITS "dBm"
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation.

      This attribute indicates the SRG OBSS PD Max Offset for an AP."
   DEFVAL { 0 }
::= { dot11HEStationConfigEntry 28 }

dot11SRGAPBSSColorBitmap OBJECT-TYPE
   SYNTAX OCTET STRING (SIZE(8))
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
```

```
        "This is a control variable.
        This variable is a 64 bit bitmap that indicates which BSS color values are
        used by members of the SRG of which the AP is a member.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the SRG BSS Color Bitmap for an AP."
::= { dot11HEStationConfigEntry 29 }

dot11SRGAPBSSIDBitmap OBJECT-TYPE
    SYNTAX OCTET STRING (SIZE(8))
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a control variable.
        This variable is a 64 bit bitmap that indicates which Partial BSSID values
        are used by members of the SRG of which the AP is a member.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the SRG BSSID Bitmap for an AP."
::= { dot11HEStationConfigEntry 30 }

dot11NonSRGAPOBSSPDMaxOffset OBJECT-TYPE
    SYNTAX Integer32
    UNITS "dBm"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the Non SRG OBSS PD Max Offset for an AP."
    DEFVAL { 0 }
::= { dot11HEStationConfigEntry 31 }

dot11HTVHTTriggerOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the STA implementation is capa-
        ble of receiving Trigger frames in HT PPDUs and VHT PPDUs. The capability
        is disabled, otherwise."
    DEFVAL { false }
::= { dot11HEStationConfigEntry 32 }

dot11HEDynamicSMPowerSaveOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable. Its value is determined by device
        capabilities.

        This attribute, when true, indicates that the STA implementation is
        capable of enabling its multiple receive chains when it receives a
        Trigger frame. The capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HEStationConfigEntry 33 }
```

```
dot11MUEDCAParametersActived OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable used only if the STA is an AP. It is set to
      true by an AP that advertises MU EDCA parameters so that its associated
      STAs use MU EDCA parameters."
   DEFVAL { true }
::= { dot11HEStationConfigEntry 34 }

dot11CoHostedBSSIDImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.
      This attribute, when true, indicates that the station implementation is
      capable of supporting Co-Hosted BSSID."
   DEFVAL { false }
   ::= { dot11HEStationConfigEntry 35 }

dot11UnsolicitedProbeResponseOptionActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a control variable.

      This attribute, when true, indicates that the station implementation is an
      AP and schedules for transmission unsolicited Probe Response frames every
      20 TUs or less (see 26.17.2.3.2 (AP behavior for fast passive scanning)).
      The capability is disabled otherwise."
::= { dot11HEStationConfigEntry 36 }

dot11MemberOfColocated6GHzESSOptionActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a control variable.

      This attribute, when true, indicates that the station implementation is an
      AP that operates in the 6 GHz band and is part of an ESS where each AP has
      a corresponding AP operating in the 2.4 GHz or 5 GHz band that is in the
      same co-located AP set as that AP (see 26.17.2.4 (Out of band discovery of
      a 6 GHz BSS)). The capability is disabled otherwise."
::= { dot11HEStationConfigEntry 37 }

dot11AckEnabledAMPDUOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates that the station implementation is
      capable of receiving ack-enabled single-TID A-MPDU. The capability is dis-
      abled otherwise."
   ::= { dot11HEStationConfigEntry 38 }
```

```
dot11MinPSCProbeDelay OBJECT-TYPE
   SYNTAX Unsigned32 (5484..100000)
   UNITS "microseconds"
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation.

      A STA does not send a Probe Request frame if it is scanning a preferred
      scanning channel in the 6 GHz band unless the channel has been continu-
      ously idle for this duration since the start of the scan on that channel."
DEFVAL { 7000 }
::= { dot11HEStationConfigEntry 39 }


-- ********************************************************************
-- * End of dot11HEStationConfigTable TABLE
-- ********************************************************************

-- **********************************************************************
-- * dot11PPEThresholdsMappings TABLE
-- **********************************************************************
dot11PPEThresholdsMappingsTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11PPEThresholdsMappingsEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "A conceptual table for PPE thresholds mappings, which determines the nom-
      inal packet padding value as a function of the two PPE thresholds, PPET8
      and PPET16, for an HE PPDU of a particular RU allocation size and NSTS
      value. The MIB supports the ability to share separate PPE thresholds for
      each NSTS/RU pair. The thresholds mappings table contains one entry for
      each NSTS/RU pair and contains two fields for each entry: PPET8 and
      PPET16."
   REFERENCE "IEEE Std 802.11-<year>, 26.12 (HE PPDU post-FEC padding and packet
      extension)"
::= { dot11smt 43}

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                         Unsigned32,
   dot11PPEThresholdsMappingRUIndex                     Unsigned32,
   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 Unsigned32
    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 Unsigned32
    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 242 tones, 1 is 448 tones, 2 is 996
        tones, 3 is 2x996 tones."
::= { dot11PPEThresholdsMappingsEntry 3 }

dot11PPEThresholdsMappingPPET8 OBJECT-TYPE
    SYNTAX INTEGER{BPSK(0), QPSK(1), 16-QAM(2), 64-QAM(3), 256-QAM(4), 1024-
        QAM(5), NONE(7)}
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a nomi-
        nal packet padding value of at least 8 microseconds is required for the
        given NSS/RU pair corresponding to the row of the entry."
::= { dot11PPEThresholdsMappingsEntry 4 }

dot11PPEThresholdsMappingPPET16 OBJECT-TYPE
    SYNTAX INTEGER{BPSK(0), QPSK(1), 16-QAM(2), 64-QAM(3), 256-QAM(4), 1024-
        QAM(5), NONE(7)}
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a nomi-
        nal packet padding value of 16 microseconds is required for the given NSS/
        RU pair corresponding to the row of the entry."
::= { 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
-- ******************************************************************
```

Change dot11RTSThreshold as follows:

dot11RTSThreshold OBJECT-TYPE

SYNTAX Unsigned32 (0..~~4692480~~ 6500631)

```
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the number of octets in a PSDU, below which an
        RTS/CTS handshake is not performed if dot11TXOPDurationRTSThreshold is
        1023 or it is not present, except as RTS/CTS is used as a cross modulation
        protection mechanism as defined in 10.27 (Protection mechanisms). An RTS/
        CTS handshake is performed at the beginning of any frame exchange sequence
        where the PSDU contains an MPDU with the Type subfield equal to Data or
        Management and an individual address in the Address 1 field, and the
        length of the PSDU is greater than this threshold. Setting this attribute
        to be larger than the maximum PSDU size has the effect of turning off the
        RTS/CTS handshake for frames of Data or Management type transmitted by
        this STA. Setting this attribute to 0 has the effect of turning on the
        RTS/CTS handshake for all frames of Data or Management type transmitted by
        this STA."
    DEFVAL { 4692480 6500631 }
    ::= { dot11OperationEntry 2 }
```

Insert the following after the end of dot11CDMGOperationTable:

```
-- **********************************************************************
-- * SMT MU EDCA Config TABLE
-- **********************************************************************

dot11MUEDCATable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11MUEDCAEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Conceptual table for MU EDCA parameter values at a non-AP STA. This table
        contains the four entries of the MU EDCA parameters corresponding to four
        possible ACs. Index 1 corresponds to AC_BK, index 2 to AC_BE, index 3 to
        AC_VI, and index 4 to AC_VO."

    ::= { dot11mac 15 }

dot11MUEDCAEntry OBJECT-TYPE
    SYNTAX Dot11MUEDCAEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An Entry (conceptual row) in the MU EDCA Table.

        ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Inter-
        face tables in this MIB module are indexed by ifIndex."
    INDEX { ifIndex, dot11MUEDCATableIndex }
    ::= { dot11MUEDCATable  1 }

Dot11MUEDCAEntry ::=
    SEQUENCE {
        dot11MUEDCATableIndex                                   Unsigned32,
        dot11MUEDCATableCWmin                                   Unsigned32,
        dot11MUEDCATableCWmax                                   Unsigned32,
        dot11MUEDCATableAIFSN                                   Unsigned32,
        dot11MUEDCATableTimer                                   Unsigned32
}

dot11MUEDCATableIndex OBJECT-TYPE
    SYNTAX Unsigned32 (1..4)
    MAX-ACCESS not-accessible
```

```
    STATUS current
    DESCRIPTION
       "The auxiliary variable used to identify instances of the columnar objects
       in the MU EDCA Table. The value of this variable is
       1, if the value of the AC is AC_BK.
       2, if the value of the AC is AC_BE.
       3, if the value of the AC is AC_VI.
       4, if the value of the AC is AC_VO."
    ::= { dot11MUEDCAEntry 1 }

dot11MUEDCATableCWmin OBJECT-TYPE
    SYNTAX Unsigned32 (0..255)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the MAC upon receiving an MU EDCA Parameter Set.
       Changes take effect as soon as practical in the implementation.

       This attribute specifies the value of the minimum size of the window that
       is used by a STA for a particular AC for generating a random number for
       the backoff. The value of this attribute is such that it could always be
       expressed in the form of 2**X - 1, where X is an integer. "
    ::= { dot11MUEDCAEntry 2 }

dot11MUEDCATableCWmax OBJECT-TYPE
    SYNTAX Unsigned32 (0..65535)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the MAC upon receiving an MU EDCA Parameter Set.
       Changes take effect as soon as practical in the implementation.

       This attribute specifies the value of the maximum size of the window that
       is used by a STA for a particular AC for generating a random number for
       the backoff. The value of this attribute is such that it could always be
       expressed in the form of 2**X - 1, where X is an integer. "
    ::= { dot11MUEDCAEntry 3 }

dot11MUEDCATableAIFSN OBJECT-TYPE
    SYNTAX Unsigned32 (0..15)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the MAC upon receiving an MU EDCA Parameter Set element.
       Changes take effect as soon as practical in the implementation.

       This attribute specifies the number of slots, after a SIFS, that the STA,
       for a particular AC, senses the medium idle either before transmitting or
       executing a backoff. "
    ::= { dot11MUEDCAEntry 4 }


dot11MUEDCATableTimer OBJECT-TYPE
    SYNTAX Unsigned32 (1..255)
    UNITS "8 TUs"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity.
       Changes take effect as soon as the STA sends a frame in response to a
```

```
        Basic Trigger frame.

        This attribute specifies the duration of time during which the HE STA uses
        the MU EDCA parameters for the corresponding AC."
        REFERENCE
        "26.2.7 (EDCA operation using MU EDCA parameters)"
    ::= { dot11MUEDCAEntry 5 }



-- **********************************************************************
-- *    End of MU EDCA Config TABLE
-- **********************************************************************
```

Change dot11PHYType as follows:

```
dot11PHYType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7)
        dmg(8),
        vht(9),
        tvht(10),
        s1g(11),
        cdmg(12),
        cmmg(13),
        he (14)}
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the PHY.

        This is an 8-bit integer value that identifies the PHY type supported by
        the attached PLCP and PMD. Currently defined values and their correspond-
        ing PHY types are:

        FHSS 2.4 GHz = 01, DSSS 2.4 GHz = 02, IR Baseband = 03,
        OFDM = 04, HRDSSS = 05, ERP = 06, HT = 07, DMG = 08, VHT = 09,
        TVHT = 10, S1G = 11, CDMG = 12, CMMG = 13, HE = 14"
    ::= { dot11PhyOperationEntry 1 }
```

Change dot11PhyVHTEntry as follows:

```
Dot11PhyVHTEntry ::=
    SEQUENCE {
        dot11VHTChannelWidthOptionImplemented              INTEGER,
        dot11CurrentChannelWidth                           INTEGER,
        dot11CurrentChannelCenterFrequencyIndex0           Unsigned32,
        dot11CurrentChannelCenterFrequencyIndex1           Unsigned32,
        dot11EightyMHzOperationImplemented                 TruthValue,
        dot11VHTShortGIOptionIn80Implemented               TruthValue,
        dot11VHTShortGIOptionIn80Activated                 TruthValue,
        dot11VHTShortGIOptionIn160and80p80Implemented      TruthValue,
        dot11VHTShortGIOptionIn160and80p80Activated        TruthValue,
        dot11VHTLDPCCodingOptionImplemented                TruthValue,
        dot11VHTLDPCCodingOptionActivated                  TruthValue,
```

```
        dot11VHTTxSTBCOptionImplemented                       TruthValue,
        dot11VHTTxSTBCOptionActivated                         TruthValue,
        dot11VHTRxSTBCOptionImplemented                       TruthValue,
        dot11VHTRxSTBCOptionActivated                         TruthValue,
        dot11VHTMUMaxUsersImplemented                         Unsigned32,
        dot11VHTMUMaxNSTSPerUserImplemented                   Unsigned32,
        dot11VHTMUMaxNSTSTotalImplemented                     Unsigned32,
        dot11VHTMaxNTxChainsImplemented                       Unsigned32,
        dot11VHTMaxNTxChainsActivated                         Unsigned32,
    }
```

Insert the following after dot11VHTMaxNTxChainsActivated:

```
dot11EightyMHzOperationImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the 80 MHz operation is
        implemented"
    DEFVAL { false }
::= { dot11PhyVHTEntry 20 }
```

Insert the following after end of the dot11 TVHT Transmit Beamforming Config TABLE:

```
-- **********************************************************************
-- * dot11 Phy HE TABLE
-- **********************************************************************
dot11PhyHETable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11PhyHEEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Entry of attributes for dot11PhyHETable. Implemented as a table indexed
         on ifIndex to allow for multiple instances on an Agent."
::= { dot11phy 31 }

dot11PhyHEEntry OBJECT-TYPE
    SYNTAX Dot11PhyHEEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An entry in dot11PhyHEEntryTable. ifIndex - Each IEEE Std 802.11
         interface is represented by an ifEntry. Interface tables in this MIB
         module are indexed by ifIndex."
    INDEX {ifIndex}
::= { dot11PhyHETable 1 }

Dot11PhyHEEntry ::=
    SEQUENCE {
        dot11HECurrentChannelWidthSet                         Unsigned32,
        dot11HEPuncturedPreambleRxImplemented                 OCTET STRING,
        dot11HEDeviceClass                                    TruthValue,
        dot11HELDPCCodingInPayloadImplemented                 TruthValue,
        dot11HESUPPDUwith1xHELTFand0point8GIlmplemented       TruthValue,
        dot11HESUPPDUandHEMUPPDUwith4xHELTFand0point8GIlmplemented
                                                              TruthValue,
        dot11HEERSUPPDUwith4xHELTFand0point8GIImplemented     TruthValue,
```

```
        dot11HEERSUPPDUwith1xHELTFand0point8GIImplemented      TruthValue,
        dot11HEMidambleRxMaxNSTS                               Unsigned32,
        dot11HENDPwith4xHELTFand3point2GIImplemented           TruthValue,
        dot11HESTBCTxLessThanOrEqualTo80Implemented            TruthValue,
        dot11HESTBCRxLessThanOrEqualTo80Implemented            TruthValue,
        dot11HESTBCTxGreaterThan80Implemented                  TruthValue,
        dot11HESTBCRxGreaterThan80Implemented                  TruthValue,
        dot11HEDopplerTxImplemented                            TruthValue,
        dot11HEDopplerRxImplemented                            TruthValue,
        dot11HEDCMImplemented                                  TruthValue,
        dot11HEFullBWULMUMIMOImplemented                       TruthValue,
        dot11HEPartialBWULMUMIMOImplemented                    TruthValue,
        dot11HEPartialBWDLMUMIMOImplemented                    TruthValue,
        dot11HEULMUPayloadImplemented                          TruthValue,
        dot11HEPSRbasedSRSupportImplemented                    TruthValue,
        dot11HEPowerBoostFactorImplemented                     TruthValue,
        dot11HEPartialBWERSUPayloadImplemented                 TruthValue,
        dot11HEPuncturedSoundingOptionImplemented              TruthValue
    }

dot11HECurrentChannelWidthSet OBJECT-TYPE
    SYNTAX Unsigned32 (0..6)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a status variable.

        This attribute specifies the channel width set, equal to 0 for a 40 MHz
        channel width in the 2.4 GHz band, equal to 1 for a 40 MHz and 80 MHz chan-
        nel width in the 5 GHz or 6 GHz band, equal to 2 for a 160 MHz channel
        width in the 5 GHz or 6 GHz band, equal to 3 for a 160/80+80 MHz channel
        width in the 5 GHz or 6 GHz band, equal to 4 for 242-tone RUs in a 40 MHz
        HE MU PPDU in the 2.4 GHz band, equal to 5 for 242-tone RUs in a 40 MHz,
        80 MHz, 160 MHz, and 80+80 MHz HE MU PPDU in the 5 GHz or 6 GHz band, and
        the value 6 is reserved."
::= { dot11PhyHEEntry 1}

dot11HEPuncturedPreambleRxImplemented OBJECT-TYPE
    SYNTAX OCTET STRING(SIZE(2))
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute indicates the preamble prunctured channel, equal to 0 for
        the reception of an 80 MHz preamble where the secondary 20 MHz subchannel
        is punctured, equal to 1 for the reception of an 80 MHz preamble where one
        of the two 20 MHz subchannels in the secondary 40 MHz is punctured, equal
        to 2 for the reception of a 160 MHz or 80+80 MHz preamble where in the pri-
        mary 80 MHz of the preamble only the secondary 20 MHz is punctured, and
        equal to 3 for the reception of a 160 MHz or 80+80 MHz preamble where in
        the primary 80 MHz of the preamble, the primary 40 MHz is present."
::= { dot11PhyHEEntry 2}

dot11HEDeviceClass OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that the non-AP STA is operating as
        a Class A device. When false, this attribute indicates that the non-AP STA
```

```
        is operating as a Class B device."
::= { dot11PhyHEEntry 3}

dot11HELDPCCodingInPayloadImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the STA is capable of transmit-
        ting and receiving LDPC encoded packets. This capability is disabled oth-
        erwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 4}

dot11HESUPPDUwith1xHELTFand0point8GIlmplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE SU PPDU with 1x HE-LTF and 0.8 microsecond guard interval
        duration. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 5}

dot11HESUPPDUandHEMUPPDUwith4xHELTFand0point8GIlmplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE SU PPDU and HE MU PPDU with 4x HE-LTF and 0.8 microsecond
        guard interval duration. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 6}

dot11HEERSUPPDUwith4xHELTFand0point8GIImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE ER SU PPDU with 4x HE-LTF and 0.8 microsecond guard inter-
        val duration. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 7}

dot11HEERSUPPDUwith1xHELTFand0point8GIImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
```

```
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE ER SU PPDU with 1x HE-LTF and 0.8 microsecond guard inter-
        val duration. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 8}

dot11HEMidambleRxMaxNSTS OBJECT-TYPE
    SYNTAX Unsigned32 (0..3)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute specifies the maximum number of space-time streams sup-
        ported for reception when a midamble is present in the Data field, equal
        to 0 for 1 space-time stream, equal to 1 for 2 space-time streams, equal
        to 2 for 3 space-time streams, and equal to 3 for 4 space-time streams."
    DEFVAL { 0 }
::= { dot11PhyHEEntry 9 }

dot11HENDPwith4xHELTFand3point2GIImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an NDP with 4x HE-LTF and 3.2 microsecond guard interval dura-
        tion. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 10 }

dot11HESTBCTxLessThanOrEqualTo80Implemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        transmitting an HE PPDU that has a bandwidth less than or equal to 80 MHz
        and is using STBC with one spatial stream. This capability is disabled
        otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 11 }

dot11HESTBCRxLessThanOrEqualTo80Implemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE PPDU that has a bandwidth less than or equal to 80 MHz and
        is using STBC with one spatial stream. This capability is disabled other-
```

```
        wise."
    DEFVAL { false }
::= { dot11PhyHEEntry 12 }

dot11HESTBCTxGreaterThan80Implemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        transmitting an HE PPDU that has a bandwidth greater than 80 MHz and is
        using STBC with one spatial stream. This capability is disabled other-
        wise."
    DEFVAL { false }
::= { dot11PhyHEEntry 13 }

dot11HESTBCRxGreaterThan80Implemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving an HE PPDU that has a bandwidth greater than 80 MHz and is using
        STBC with one spatial stream. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 14 }

dot11HEDopplerTxImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        transmitting HE PPDUs with midamble. This capability is disabled other-
        wise."
    DEFVAL { false }
::= { dot11PhyHEEntry 15 }

dot11HEDopplerRxImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving HE PPDUs with midamble. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 16 }

dot11HEDCMImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
```

```
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA implementation
        supports DCM. This capability is disabled otherwise."
::= { dot11PhyHEEntry 17 }

dot11HEFullBWULMUMIMOImplemented 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 for an AP implementation, the
        MU-MIMO reception of an HE TB PPDU on an RU that spans the entire PPD
        bandwidth is supported; and for a non-AP STA implementation, the transmis-
        sion of an HE TB PPDU on an RU that spans the entire PPDU bandwidth is sup-
        ported.  This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 18 }

dot11HEPartialBWULMUMIMOImplemented 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 an AP is capable of receiving an
        RU in an HE TB PPDU where MU-MIMO is employed in the RU, the RU size is
        greater than or equal to 106-tones, and the RU does not span the entire
        PPDU bandwidth; and a non-AP STA is capable of transmitting an RU in an HE
        TB PPDU where MU-MIMO is employed in the RU, the RU size is greater than
        or equal to 106-tones, and the RU does not span the entire PPDU bandwidth.
        This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 19 }

dot11HEPartialBWDLMUMIMOImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        receiving a DL MU-MIMO transmission on an RU in an HE MU PPDU where the RU
        does not span the entire PPDU bandwidth. This capability is disabled oth-
        erwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 20 }

dot11HEULMUPayloadImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
```

```
        This attribute, when true, indicates that the AP is capable of receiving
        the payload on an RU in an HE MU PPDU where RU spans the entire PPDU band-
        width or a 106-tone RU within 20 MHz PPDU bandwidth.  This capability is
        disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 21 }

dot11HEPSRbasedSRSupportImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        supporting the PSR-based SR operation. This capability is disabled other-
        wise."
    DEFVAL { false }
::= { dot11PhyHEEntry 22 }

dot11HEPowerBoostFactorImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA implementation
        supports a power boost factor for the r-th RU in the range [0.5, 2]. This
        capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 23 }

dot11HEPartialBWERSUPayloadImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the non-AP STA is capable of
        transmitting and receiving an HE ER SU PPDU in which the HE modulated
        fields are transmitted over the higher frequency 106-tone RU within pri-
        mary 20 MHz channel. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11PhyHEEntry 24 }

dot11HEPuncturedSoundingOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the STA implementation is capa-
        ble of operating in a mode where some 242-tone RUs are not allowed to be
        used within a channel of width 80 MHz or 160 MHz. The capability is dis-
        abled, otherwise"
DEFVAL { false }
```

```
::= { dot11PhyHEEntry 25 }


-- **********************************************************************
-- * End of dot11 Phy HE TABLE
-- **********************************************************************


-- **********************************************************************
-- * dot11 HE Transmit Beamforming Config TABLE
-- **********************************************************************

dot11HETransmitBeamformingConfigTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11HETransmitBeamformingConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "Entry of attributes for dot11HETransmitBeamformingConfigTable. Imple-
      mented as a table indexed on ifIndex to allow for multiple instances on an
      Agent."
   ::= { dot11phy 32 }

dot11HETransmitBeamformingConfigEntry OBJECT-TYPE
   SYNTAX Dot11HETransmitBeamformingConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "An entry in dot11HETransmitBeamformingConfigTable.
      ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Inter-
      face tables in this MIB module are indexed by ifIndex."
   INDEX {ifIndex}
   ::= { dot11HETransmitBeamformingConfigTable 1 }

Dot11HETransmitBeamformingConfigEntry ::=
   SEQUENCE {
      dot11HESUBeamformerOptionImplemented                  TruthValue,
      dot11HESUBeamformeeOptionImplemented                  TruthValue,
      dot11HEMUBeamformerOptionImplemented                  TruthValue,
      dot11HEBeamformeeSTSSupportLessThanOrEqualTo80        Unsigned32,
      dot11HEBeamformeeSTSSupportGreaterThan80              Unsigned32,
      dot11HENumberSoundingDimensionsLessThanOrEqualTo80    Unsigned32,
      dot11HENumberSoundingDimensionsGreaterThan80          Unsigned32,
      dot11HENG16SUFeedbackSupport                          TruthValue,
      dot11HENG16MUFeedbackSupport                          TruthValue,
      dot11HECodebookSizePhi4Psi2SUFeedbackSupport          TruthValue,
      dot11HECodebookSizePhi7Psi5MUFeedbackSupport          TruthValue,
      dot11HETriggeredSUBeamformingFeedbackImplemented      TruthValue,
      dot11HETriggeredMUBeamformingFeedbackImplemented      TruthValue,
      dot11HETriggeredCQIFeedbackSupportImplemented         TruthValue
   }

dot11HESUBeamformerOptionImplemented 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 for a non-AP STA implementation,
      the operation as an SU beamformer is supported; for an AP implementation,
      the operation as an SU beamformer is supported when the AP is equipped
      with 4 or more spatial streams. When false, this attribute indicates that
      for the non-AP STA implementation, the operation as an SU beamformer is
```

```
        not supported."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 1 }

dot11HESUBeamformeeOptionImplemented 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 for an AP implementation, the
        operation as an SU beamformee is supported; for a non-AP STA implementa-
        tion, the operation as an SU beamformee is supported.  When false, this
        attribute indicates that for an AP implementation, the operation as an SU
        beamformee is not supported."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 2 }

dot11HEMUBeamformerOptionImplemented 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 for an AP implementation, the
        operation as an MU beamformer is supported when the SU Beamformer field is
        1. When false, this attribute indicates that for an AP implementation, the
        operation as an MU beamformer is not supported; for a non-AP STA implemen-
        tation, the operation as an MU beamformer is not supported."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 3 }

dot11HEBeamformeeSTSSupportLessThanOrEqualTo80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute indicates the maximum number of space-time streams that the
        non-AP STA can receive in an HE sounding NDP, the maximum value for the
        total number of space-time streams over all the users in RU r,
        NSTS,r,total that can be sent in a DL MU-MIMO transmission on an RU where
        the RU might or might not span the entire PPDU bandwidth, which includes
        that non-AP STA."
::= { dot11HETransmitBeamformingConfigEntry 4 }

dot11HEBeamformeeSTSSupportGreaterThan80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute indicates the maximum number of space-time streams that the
        non-AP STA can receive in an HE sounding NDP, the maximum value for the
        total number of space-time streams over all the users in RU r,
        NSTS,r,total that can be sent in a DL MU-MIMO transmission on an RU where
```

```
        the RU might or might not span the entire PPDU bandwidth, which includes
        that STA."
::= { dot11HETransmitBeamformingConfigEntry 5 }

dot11HENumberSoundingDimensionsLessThanOrEqualTo80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute specifies, for bandwidth less than or equal to 80 MHz, the
        beamformer's capability to indicate the maximum value of the TXVECTOR
        parameter NUM_STS for an HE sounding NDP."
::= { dot11HETransmitBeamformingConfigEntry 6 }

dot11HENumberSoundingDimensionsGreaterThan80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute specifies, for bandwidth greater than 80 MHz, the beam-
        former's capability to indicate the maximum value of the TXVECTOR parame-
        ter NUM_STS for an HE sounding NDP."
::= { dot11HETransmitBeamformingConfigEntry 7 }

dot11HENG16SUFeedbackSupport 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 the HE beamformee support for a tone
        grouping of 16 in the HE Compressed Beamforming Report field for SU feed-
        back. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 8 }

dot11HENG16MUFeedbackSupport 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 the HE beamformee support for a tone
        grouping of 16 in the HE Compressed Beamforming Report field for MU feed-
        back. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 9 }

dot11HECodebookSizePhi4Psi2SUFeedbackSupport 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 the HE beamformee support for a code-
        book size (psi, phy) = {4, 2} in the HE Compressed Beamforming Report
        field for SU feedback. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 10 }

dot11HECodebookSizePhi7Psi5MUFeedbackSupport 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 the HE beamformee support for a code-
        book size (psi, phy) = {7, 5} in the HE Compressed Beamforming Report
        field for MU feedback. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 11 }

dot11HETriggeredSUBeamformingFeedbackImplemented 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 for an AP implementation, the
        reception of partial and full bandwidth SU feedback in an HE TB sounding
        sequence is supported; for a non-AP STA implementation, the transmission
        of partial and full bandwidth SU feedback in an HE TB sounding sequence is
        supported. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 12 }

dot11HETriggeredMUBeamformingFeedbackImplemented 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 for an AP implementation, the
        reception of partial bandwidth MU feedback in an HE TB sounding sequence
        is supported; for a non-AP STA implementation, the transmission of partial
        bandwidth MU feedback in an HE TB sounding sequence is supported. This
        capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 13 }

dot11HETriggeredCQIFeedbackSupportImplemented 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 for an AP implementation, the
        reception of partial and full bandwidth CQI feedback in an HE TB sounding
```

```
        sequence is supported; for a non-AP STA implementation, the transmission
        of partial and full bandwidth CQI feedback in an HE TB sounding sequence
        is supported. This capability is disabled otherwise."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 14 }


-- **********************************************************************
-- * End of dot11 HE Transmit Beamforming Config TABLE
-- **********************************************************************
```

Insert the following after the dot11FineTimingMeasurement OBJECT-GROUP:

```
dot11SMTbase14 OBJECT-GROUP
    OBJECTS {
        dot11HEOptionImplemented
    }
    STATUS current
    DESCRIPTION
        "The SMTbase14 object class provides the necessary support at the STA to
        manage the processes in the STA such that the STA may work cooperatively
        as a part of an IEEE 802.11 network."
    ::= { dot11Groups 101 }
```

Change the MANDATORY-GROUPS element in the dot11Compliance MODULE-COMPLIANCE as follows:

```
dot11Compliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE
        802.11 MIB."
    MODULE -- this module
    MANDATORY-GROUPS {
        ~~dot11SMTbase13~~ dot11SMTbase14,
        dot11MACbase4,
        dot11CountersGroup4,
        dot11SmtAuthenticationAlgorithms,
        dot11ResourceTypeID,
        dot11PhyOperationComplianceGroup2 }
```

Insert the following compliance objects after the dot11S1GComplianceGroup object:

```
dot11HEComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11HEOptionImplemented,
        dot11OBSSNarrowBWRUinOFDMATolerated,
        dot11HE6GOptionImplemented,
        dot11OCTOptionImplemented,
        dot11TRSOptionImplemented,
        dot11OFDMARandomAccessOptionImplemented,
        dot11HEControlFieldOptionImplemented,
        dot11OMIOptionImplemented,
        dot11HEMCSFeedbackOptionImplemented,
        dot11HEDynamicFragmentationLevel,
        dot11AMPDUwithMultipleTIDOptionImplemented,
        dot11MPDUAskedforAckInMultiTIDAMPDU,
        dot11TXOPDurationRTSThreshold,
        dot11PPEThresholdsRequired,
        dot11IntraPPDUPowerSaveOptionActivated,
        dot11AMSDUFragmentationOptionImplemented,
        dot11BSSColorCollisionAPPeriod,
```

```
        dot11BSSColorCollisionSTAPeriod,
        dot11AutonomousBSSColorCollisionReportingImplemented,
        dot11HEPSROptionImplemented,
        dot11HEBSRControlImplemented,
        dot11HEBQRControlImplemented,
        dot11HECASControlImplemented,
        dot11PartialBSSColorImplemented,
        dot11ObssNbRuToleranceTime,
        dot11HESubchannelSelectiveTransmissionImplemented,
        dot11SRResponderOptionImplemented,
        dot11AutonomousBSSColorInUseReportingImplemented,
        dot11ShortSSIDListImplemented,
        dot11ColocatedRNRImplemented,
        dot11SRGAPOBSSPDMinOffset,
        dot11SRGAPOBSSPDMaxOffset,
        dot11SRGAPBSSColorBitmap,
        dot11SRGAPBSSIDBitmap,
        dot11NonSRGAPOBSSPDMaxOffset,
        dot11HTVHTTriggerOptionImplemented,
        dot11HEDynamicSMPowerSaveOptionImplemented,
        dot11MUEDCAParametersActived,
        dot11CoHostedBSSIDImplemented,
        dot11UnsolicitedProbeResponseOptionActivated,
        dot11MemberOfColocated6GHzESSOptionActivated,
        dot11AckEnabledAMPDUOptionImplemented,
        dot11MinPSCProbeDelay}
    STATUS current
    DESCRIPTION
        "Attributes that configure the HE Group for IEEE 802.11."
::= { dot11Groups 100 }

dot11HETransmitBeamformingGroup OBJECT-GROUP
    OBJECTS {
        dot11HESUBeamformerOptionImplemented,
        dot11HESUBeamformeeOptionImplemented,
        dot11HEMUBeamformerOptionImplemented,
        dot11HEBeamformeeSTSSupportLessThanOrEqualTo80,
        dot11HEBeamformeeSTSSupportGreaterThan80,
        dot11HENumberSoundingDimensionsLessThanOrEqualTo80,
        dot11HENumberSoundingDimensionsGreaterThan80,
        dot11HENG16SUFeedbackSupport,
        dot11HENG16MUFeedbackSupport,
        dot11HECodebookSizePhi4Psi2SUFeedbackSupport,
        dot11HECodebookSizePhi7Psi5MUFeedbackSupport,
        dot11HETriggeredSUBeamformingFeedbackImplemented,
        dot11HETriggeredMUBeamformingFeedbackImplemented,
        dot11HETriggeredCQIFeedbackSupportImplemented }
    STATUS current
    DESCRIPTION
        "Attributes that configure HE transmit beamforming for IEEE 802.11."
    ::= { dot11Groups 102 }

dot11PhyHEComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11HECurrentChannelWidthSet,
        dot11HEPuncturedPreambleRxImplemented,
        dot11HEPuncturedPreambleRxActivated,
        dot11HEDeviceClass,
        dot11HELDPCCodingInPayloadImplemented,
        dot11HESUPPDUwith1xHELTFand0point8GIlmplemented,
        dot11HESUPPDUandHEMUPPDUwith4xHELTFand0point8GIlmplemented,
        dot11HEERSUPPDUwith4xHELTFand0point8GIImplemented,
        dot11HEERSUPPDUwith1xHELTFand0point8GIImplemented,
        dot11HEMidambleRxMaxNSTS,
```

```
        dot11HENDPwith4xHELTFand3point2GIImplemented,
        dot11HESTBCTxLessThanOrEqualTo80Implemented,
        dot11HESTBCRxLessThanOrEqualTo80Implemented,
        dot11HESTBCTxGreaterThan80Implemented,
        dot11HESTBCRxGreaterThan80Implemented,
        dot11HEDopplerTxImplemented,
        dot11HEDopplerRxImplemented,
        dot11HEDCMImplemented,
        dot11HEFullBWULMUMIMOImplemented,
        dot11HEPartialBWULMUMIMOImplemented,
        dot11HEPartialBWDLMUMIMOImplemented,
        dot11HEULMUPayloadImplemented,
        dot11HEPSRbasedSRSupportImplemented,
        dot11HEPowerBoostFactorImplemented,
        dot11HEPartialBWERSUPayloadImplemented}
    STATUS current
    DESCRIPTION
        "Attributes that configure the HE PHY."
    ::= { dot11Groups 103 }
```

Change the dot11Compliance object as follows:

```
dot11Compliance MODULE-COMPLIANCE
    STATUS  current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE
        802.11 MIB."
    MODULE  -- this module
    MANDATORY-GROUPS {
        dot11SMTbase14,
        dot11MACbase4,
        dot11CountersGroup3,
        dot11SmtAuthenticationAlgorithms,
        dot11ResourceTypeID,
        dot11PhyOperationComplianceGroup2 }

    GROUP dot11PhyDSSSComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType is
        dsss.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyOFDMComplianceGroup3
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType is
        ofdm.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
```

```
      dot11DMGComplianceGroup
      dot11PhyVHTComplianceGroup
      dot11PhyTVHTComplianceGroup
      dot11PhyS1GComplianceGroup
      dot11PhyHEComplianceGroup"

   GROUP dot11PhyHRDSSSComplianceGroup
   DESCRIPTION
      "Implementation of this group is required when object dot11PHYType is
      hrdsss.
      This group is mutually exclusive to the following groups:
      dot11PhyIRComplianceGroup
      dot11PhyFHSSComplianceGroup2
      dot11PhyDSSSComplianceGroup
      dot11PhyOFDMComplianceGroup3
      dot11PhyERPComplianceGroup
      dot11PhyHTComplianceGroup
      dot11DMGComplianceGroup
      dot11PhyVHTComplianceGroup
      dot11PhyTVHTComplianceGroup
      dot11PhyS1GComplianceGroup
      dot11PhyHEComplianceGroup"

   GROUP dot11PhyERPComplianceGroup
   DESCRIPTION
      "Implementation of this group is required when object dot11PHYType is ERP.
      This group is mutually exclusive to the following groups:
      dot11PhyIRComplianceGroup
      dot11PhyFHSSComplianceGroup2
      dot11PhyDSSSComplianceGroup
      dot11PhyOFDMComplianceGroup3
      dot11PhyHRDSSSComplianceGroup
      dot11PhyHTComplianceGroup
      dot11DMGComplianceGroup
      dot11PhyVHTComplianceGroup
      dot11PhyTVHTComplianceGroup
      dot11PhyS1GComplianceGroup
      dot11PhyHEComplianceGroup"

   GROUP dot11PhyHTComplianceGroup
   DESCRIPTION
      "Implementation of this group is required when object dot11PHYType has the
      value of ht.
      This group is mutually exclusive to the following groups:
      dot11PhyIRComplianceGroup
      dot11PhyFHSSComplianceGroup2
      dot11PhyDSSSComplianceGroup
      dot11PhyOFDMComplianceGroup3
      dot11PhyHRDSSSComplianceGroup
      dot11PhyERPComplianceGroup
      dot11DMGComplianceGroup
      dot11PhyVHTComplianceGroup
      dot11PhyTVHTComplianceGroup
      dot11PhyS1GComplianceGroup
      dot11PhyHEComplianceGroup"

   GROUP dot11PhyVHTComplianceGroup
   DESCRIPTION
      "Implementation of this group is required when object dot11PHYType has the
      value of vht.
      This group is mutually exclusive to the following groups:
      dot11PhyIRComplianceGroup
      dot11PhyFHSSComplianceGroup2
      dot11PhyDSSSComplianceGroup
```

```
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyTVHTComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of tvht.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

GROUP dot11PhyS1GComplianceGroup
DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of s1g.
        This group is mutually exclusive to the following groups:
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyHEComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of HE.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup"

    GROUP dot11DMGComplianceGroup
    DESCRIPTION
        This group is mutually exclusive to the following groups:
"Implementation of this group is required when the object dot11PHYType is dmg.
This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
```

```
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"
```

Insert the following after GROUP dot11VHTMACAdditions:

```
    GROUP dot11HETransmitBeamformingGroup
    DESCRIPTION
        "The dot11HETransmitBeamformingGroup group is optional."

    GROUP dot11HEComplianceGroup
    DESCRIPTION
        "The dot11HEComplianceGroup group is optional."
```

Change OPTIONAL-GROUPS as follows:

```
-- OPTIONAL-GROUPS {
    -- dot11SMTprivacy
    -- dot11MACStatistics,
    -- dot11PhyAntennaComplianceGroup,
    -- dot11PhyTxPowerComplianceGroup,
    -- dot11PhyRegDomainsSupportGroup,
    -- dot11PhyAntennasListGroup,
    -- dot11PhyRateGroup,
    -- dot11MultiDomainCapabilityGroup,
    -- dot11PhyFHSSComplianceGroup2,
    -- dot11RSNAadditions,
    -- dot11OperatingClassesGroup,
    -- dot11Qosadditions,
    -- dot11RMCompliance,
    -- dot11FTComplianceGroup
    -- dot11PhyAntennaComplianceGroup2,
    -- dot11HTMACadditions,
    -- dot11PhyMCSGroup,
    -- dot11TransmitBeamformingGroup,
    -- dot11VHTTransmitBeamformingGroup,
    -- dot11PhyVHTComplianceGroup,
    -- dot11VHTMACAdditions,
    -- dot11TVHTTransmitBeamformingGroup,
    -- dot11PhyTVHTComplianceGroup,
    -- dot11HETransmitBeamformingGroup,
    -- dot11PhyHEComplianceGroup,
    -- dot11HEComplianceGroup,
    -- dot11WNMCompliance}
```

Insert the following after dot11S1GCompliance:

```
-- **********************************************************************
-- * Compliance Statements - HE
-- **********************************************************************
dot11HECompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "This object class provides the objects from the IEEE 802.11
        MIB used to operate at high efficiency."
    MODULE -- this module
    MANDATORY-GROUPS { dot11PhyHEComplianceGroup, dot11PhyTxPowerCompliance-
        Group2, dot11HETransmitBeamformingGroup, dot11HEComplianceGroup }
```

```
-- OPTIONAL-GROUPS { }
   ::= { dot11Compliances 22 }
```

Annex E

(normative)

Country elements and operating classes

E.1 Country information and operating classes

Editor's Note: Regulations on the 6 GHz band are in flux. Channelization may be revised when more information is available.

Insert the following rows and update the "reserved" row appropriately in Table E-4:

Table E-4—Global operating classes

Operating class	Nonglobal operating class(es)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Channel center frequency index	Behavior limits set
131		5.940	20	—	1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 45, 49, 53, 57, 61, 65, 69, 73, 77, 81, 85, 89, 93, 97, 101, 105, 109, 113, 117, 121, 125, 129, 133, 137, 141, 145, 149, 153, 157, 161, 165, 169, 173, 177, 181, 185, 189, 193, 197, 201, 205, 209, 213, 217, 221, 225, 229, 233	

Table E-4—Global operating classes *(continued)*

Operating class	Nonglobal operating class(es)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Channel center frequency index	Behavior limits set
132		5.940	40	—	3, 11, 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, 115, 123, 131, 139, 147, 155, 163, 171, 179, 187, 195, 203, 211, 219, 227	
133		5.940	80	—	7, 23, 39, 55, 71, 87, 103, 119, 135, 151, 167, 183, 199, 215	
134		5.940	160	—	15, 47, 79, 111, 143, 175, 207	
135		5.940	80	—	7, 23, 39, 55, 71, 87, 103, 119, 135, 151, 167, 183, 199, 215	80+

Annex G

(normative)

Frame exchange sequences

G.1 General

Change Table G.1 as follows:

Table G-1—Attributes applicable to frame exchange sequence definition

Attribute	Description
mu-user-respond	The preceding frame or A-MPDU is part of a VHT MU PPDU and is addressed to a user from which an immediate response is expected. See NOTE 3 and NOTE 4.
mu-users-respond	The preceding frame or A-MPDU is part of an HE MU PPDU.
mu-user-not-respond	The preceding frame or A-MPDU is part of a VHT MU PPDU and is addressed to a user from which no immediate response is expected. See NOTE 3 and NOTE 4.

G.4 HT and VHT and S1G sequences

Change as follows:

(* The per-user parts of a VHT MU PPDU and HE MU PPDU that do not require a response *)
other-users = {ppdu-not-requiring-response-per-user +mu-user-not-respond} +mu-ppdu-end;

Insert a new subclause G.5 as follows:

G.5 HE sequences

he-txop-sequence = he-nav-protected-sequence |
1{initiator-sequence};

(* an he-nav-protected-sequence consists of setting the NAV, performing one or more initiator-sequences and then resetting the NAV if time permits *)
he-nav-protected-sequence = he-nav-set 1 {initiator-sequence} [resync-sequence];

(* This is the sequence of frames that establish protection use MU-RTS *)
he-nav-set = (**MU-RTS Trigger** 1{**CTS**}) |
(**Data**[+HTC]+*individual*[+*null*][+*QoS*+*normal-ack*] **Ack**) |
Data[+HTC]+*individual*[+*QoS*+*block-ack*] |
Data+*group*[+*null*][+*QoS*] |
(1 {**Data**[+HTC]+*individual*+*QoS*+*implicit-bar*+*a-mpdu*}+*a-mpdu-end*}
BlockAck) |

(**BlockAckReq** (**BlockAck**|**Ack**)) |
(**BlockAck**|**Ack**);

he-dl-mu-sequence = (**BlockAck**+*delayed*[+*mu-users-respond*] **Ack** |
(**BlockAckReq**+delayed[+*mu-users-respond*] **Ack**) |
(**Data**[+HTC]+*individual*[+*null*][+*QoS*+*normal-ack*][+*mu-user-respond*] **Ack** |
Ack);

(* Trigger frame is sent by the AP to initiate non-AP UL transmission. A PPDU containing a Trigger frame is either a non-A-MPDU Trigger frame, or an A-MPDU carrying a Trigger frame *)

he-ul-mu-sequence = (**Basic Trigger**) | (**Basic Trigger**+*a-mpdu*+*mu-user-respond*+*a-mpdu-end*)
1{**Data**[+*HTC*]+*QoS*+(*no-ack* | *block-ack*)+*a-mpdu*}
+ *a-mpdu-end;*

he-cascading-sequence = he-dl-mu-sequence + he-ul-mu-sequence

(* HE beamforming sequence *)

he-non-trigger-based-sounding =
(**HE NDP Announcement**) (**HE sounding NDP**)
HE Compressed Beamforming/CQI;

he-trigger-based-sounding = (**HE NDP Announcement**) (**HE sounding NDP**) he-feedback
{**BFRP Trigger** he-feedback};

he-feedback = (**HE Compressed Beamforming/CQI**) | (* S-MPDU or non-HE PPDU *)
1{(**HE Compressed Beamforming/CQI**)+a-mpdu}+a-mpdu-end;

he-nfrp-report = (**NFRP Trigger**) n (**HE TB feedback NDP**)

Annex T

(informative)

Overlapping BSS (OBSS) management

T.1 Introduction

Change as follows:

When two or more BSSs overlap, the available bandwidth is shared and hence reduced for each BSS. The basic access mechanism, such as DCF, is able to work across OBSSs. Similarly, if EDCA is used, the OBSS might be considered a larger network, and access to the WM is basically shared according to the EDCA access mechanism. Note that for both DCF and EDCA overlapping networks, the sharing is affected by the relative traffic; and if more than two APs are sharing, the problem of "neighbor capture" might occur. The neighbor capture effect might occur when a BSS is in the middle of two other BSSs that are hidden from each other, where it might suffer a disproportionate degradation in throughput, relative to the total traffic in all three BSSs. A particular problem arises when there is some expectation of QoS. If EDCA admission control is in use, then it can be used to regulate the QoS traffic on its own BSS, but it might not take into account the EDCA admitted traffic on an OBSS. The result is that the QoS is compromised if each BSS admits traffic up to its local maximum. Similarly a BSS using HCCA might schedule traffic in its own BSS, to "guarantee" a service, but, if not controlled, this might suppress overlapping EDCA admission control BSS. Furthermore, if two HCCA BSSs overlap and they do not coordinate their scheduled TXOPs, then a degradation of QoS might result. An HE BSS advertises BSS color information which is a value between 1-63 that identifies the BSS. Based on the BSS color information, a receiving STA can make decisions on whether to access the medium while there is on-going transmission on the medium or go to doze state until the end of the received PPDU or update the NAV. The features described in this annex have been introduced in order to allow a degree of management for OBSSs and for mitigation of the basic problems outlined above.

Insert the following at the end of the Annex:

T.6 BSS color and spatial reuse

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 follow the channel access rules to perform spatial reuse. The objective of spatial reuse operation is to allow the medium to be used more often between OBSSs in dense deployment scenarios by the early identification of signals from OBSSs and interference management. See 26.10 (Spatial reuse operation).

Insert a new annex as follows:

Annex Z

(informative)

HE-SIG-B content examples

Z.1 General

This annex provides a number of examples to illustrate the content of HE-SIG-B content channels.

HE-SIG-B content channels are padded to the same length and to an OFDM symbol boundary as defined in 27.3.11.8.5 (Encoding and modulation). For illustration simplicity, the examples do not include the complete padding bits but only pad to make the two HE-SIG-B content channels equal in length and an integer number of 4 bits. All the padding bits in the examples are set to 0.

In the examples, the binary sequence of each HE-SIG-B field is in transmission order. For the entire content of each HE-SIG-B content channel, the binary sequences are converted to hexadecimal.

Z.2 Example 1

An example of the HE-SIG-B field with resource allocation signaling for an 80 MHz HE MU PPDU is shown in Table Z-1.

Table Z-1—Resource allocation signaling example 1

RU	484-tone RU 1	26-tone RU 19 (center 26-tone RU)	242-tone RU 3	242-tone RU 4
SS0	STA-ID 1441, HE-MCS 10, LDPC	STA-ID 1443, HE-MCS 3, BCC, 1SS, no beamforming, no DCM	STA-ID 1444, HE-MCS 4, BCC, 2SS, Tx beamforming	STA-ID 1445, HE-MCS 8, BCC
SS1				STA-ID 1446, HE-MCS 7, BCC
SS2	STA-ID 1442, HE-MCS 9, LDPC		N/A	STA-ID 1447, HE-MCS 6, BCC
SS3				STA-ID 1448, HE-MCS 5, BCC

The AP performs a dynamic split the User fields for the two MU-MIMO STAs on 484-tone RU 1 with 2 User fields assigned to HE-SIG-B content channel 1 and none to HE-SIG-B content channel 2, to balance their load. The User field for STAs 1441, 1442, 1443 and 1444 are in HE-SIG-B content channel 1 while

User field for STAs 1445, 1446, 1447 and 1448 are in HE-SIG-B content channel 2. The content of the entire HE-SIG-B for this example is shown in Table Z-2.

Table Z-2—HE-SIG-B content for example 1

	HE-SIG-B content channel 1		HE-SIG-B content channel 2	
Common field	10010011 00000011 1 1111 000000		01001110 11000011 1 1100 000000	
User fields	STA 1441	10000101101 0010 0101 0 1	STA 1445	10100101101 0000 0001 0 0
	STA 1442	01000101101 0010 1001 0 1	STA 1446	01100101101 0000 1110 0 0
	CRC & tail	0011 000000	CRC & tail	1101 000000
	STA 1444	00100101101 100 1 0010 0 0	STA 1447	11100101101 0000 0110 0 0
	STA 1443	11000101101 000 0 1100 0 0	STA 1448	00010101101 0000 1010 0 0
	CRC & tail	1000 000000	CRC & tail	1001 000000
	Padding	0	Padding	0
HE-SIG-B field content in hexa-decimal	0x9303F810B49545A529804B648C5A18400		0x4EC3E014B40465A1C681CB41815A14480	

Z.3 Example 2

An example of the HE-SIG-B field with full bandwidth MU-MIMO resource allocation for more than 1 user in an 80 MHz HE MU PPDU is shown in Table Z-3.

Table Z-3—Resource allocation signaling example 2

RU	996-tone RU 1
SS0	STA-ID 1449, HE-MCS 6, LDPC
SS1	
SS2	STA-ID 1450, HE-MCS 7, LDPC
SS3	STA-ID 1451, HE-MCS 8, LDPC

In this example, the HE-SIG-B Compression field in HE-SIG-A is set to 1 and the Common field is not present in either HE-SIG-B content channel. The User field for STA 1449 and STA 1450 is in HE-SIG-B content channel 1 and User field for STA 1451 is in HE-SIG-B content channel 2. The content of the HE-SIG-B field in this example is shown in Table Z-4.

Table Z-4—HE-SIG-B content for example 2

	HE-SIG-B content channel 1		HE-SIG-B content channel 2	
User fields	STA 1449	10010101101 1000 0110 0 1	STA 1451	11010101101 1000 0001 0 1
	STA 1450	01010101101 1000 1110 0 1	CRC & tail	0101 000000
	CRC & tail	0011 000000	Padding	000000000000000000000
HE-SIG-B field content in hexa-decimal	0x95B0CAAD8E4C0		0xD5B02A8000000	

Z.4 Example 3

An example of the HE-SIG-B field with signaling for a full bandwidth, single user resource allocation in an 80 MHz HE MU PPDU is shown in Table Z-5.

Table Z-5—Resource allocation signaling example 3

RU	996-tone RU 1
SS0	STA-ID 1452, HE-MCS 8, LDPC, 2SS, Tx beam-forming
SS1	

In this example, the HE-SIG-B Compression field in HE-SIG-A is set to 0 and the resource allocation is signaled as an OFDMA transmission with one user. The User field for STA 1452 is in HE-SIG-B content channel 1 and no User field is present in HE-SIG-B content channel 2. The content of the HE-SIG-B field is shown in Table Z-6.

Table Z-6—HE-SIG-B content for example 3

	HE-SIG-B content channel 1		HE-SIG-B content channel 2	
Common field	00001011 11001110 0 1011 000000		11001110 11001110 0 1110 000000	
User fields	STA 1452	00110101101 100 1 0001 0 1	Padding	000000000000000000000
	CRC & tail	1100 000000		
	Padding	00		
HE-SIG-B field content in hexa-decimal	0x0BCE5806B645C00		0xCECE70000000000	

Z.5 Example 4

An example of various dynamic split options to balance the load across HE-SIG-B content channels is shown in Table Z-7. Two users are transmitted using MU-MIMO in the lowest 484-tone RU of an 80 MHz or wider PPDU. The example shows just the associated RU Allocation subfields (i.e., a fragment of the HE-SIG-B field), which might be sent in one of three ways.

Table Z-7—RU Allocation subfields for different dynamic splits of User fields for the example of two MU-MIMO users in the lowest 484-tone RU of an 80 MHz or wider PPDU

Dynamic split option	First RU Allocation subfield of HE-SIG-B content channel 1	Number of User fields contributed to HE SIG-B content channel 1	First RU Allocation subfield of HE SIG-B content channel 2	Number of User fields contributed to HE SIG-B content channel 2
Both User fields signaled in HE-SIG-B content channel 1	MSB first: 11001001 LSB first: 10010011	2	MSB first: 01110010 LSB first: 01001110	0
Both User fields signaled in HE-SIG-B content channel 2	MSB first: 01110010 LSB first: 01001110	0	MSB first: 11001001 LSB first: 10010011	2
One User field per HE-SIG-B content channel	MSB first: 11001000 LSB first: 00010011	1	MSB first: 11001000 LSB first: 00010011	1