IEEE P802.11  
Wireless LANs

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| TGaf PHY proposal | | | | |
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Abstract

Submission for candidate P802.11af draft PHY text for next draft. PHY proposal is made based on the approved motions in IEEE 802.11-12/0699r0 and IEEE 802.11-12/0709r0.

## Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGaf Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGaf Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGaf Editor: Editing instructions preceded by “TGaf Editor” are instructions to the TGaf editor to modify existing material in the TGaf draft. As a result of adopting the changes, the TGaf editor will execute the instructions rather than copy them to the TGaf Draft.***

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 notes will not be carried over into future editions because the changes will be incorporated into the base standard.

This amendment’s baseline is IEEE Std 802.11™–2012, as amended by

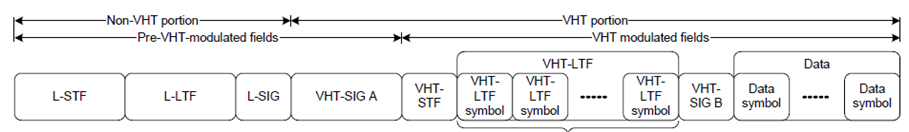
* Amendment 1 802.11ae-2012
* Amendment 2 802.11aa-2012
* Amendment 3 P802.11ad Draft 8.0
* Amendment 4 P802.11ac Draft 3.0

**Discussion:** There is no PHY description in current IEEE 802.11af draft (Draft P802.11af\_D1.08). During the IEEE May meeting (Session #133), we agreed following motions.

* To accept the baseline PHY design in document 11-12/699r0 for development of the TGaf draft.
* To accept the proposal on page 3 of 11-12/709r0 for development of the TGaf draft.

Followings are detail proposals in 11-12/699r0 and 11-12/709r0.

* The PHY for one TVWS channel (6MHz, 7MHz or 8MHz) is based on the 40MHz 128FFT VHT PHY as defined in clause 22 as-is.
* Support for multi-channel coexistence - the pre-VHT fields shall be placed around the middle of each TVWS channel irrespective of the number and location of the channels used for transmission

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* The tone spacing for 6MHz TVWS channels equals 6 MHz/144 which translates to a sampling clock of the 128FFT 2/3\*8 MHz
* The location of the pre-VHT and VHT fields for 2 contiguous channels shall be centered around tones -72 and 72 and with 4 contiguous channels around tones -216, -72, 72, 216
* The sampling clock for 8MHz channels is defined in the same way by having 144 tones in 8MHz
* The same number of DATA /Pilot tones and MCS for one channel shall be used for each of the channels used in a contiguous or non-contiguous multi-channel transmission
* An interleaver with structure as defined in 11ac (for VHT20/40/80) is applied before mapping to tones in any multi-channel transmission. The interleaver parameters Ncol and Nrot for 2 and 4 channel transmission (contiguous or non-contiguous) are TBD

Based on these decisions, we made PHY proposal with following highlevel concepts.

Clause 23 specifies the PHY entity for a TV high throughput (TVHT) orthogonal frequency division multiplexing (OFDM) system.

All TVHT transmissions in one frequency segment shall use the 40 MHz VHT PHY defined in subclauses 22.3-22.6 with a sampling clock change to fit into each of the basic channel unit bandwidths.

The design is based on defining 144 OFDM tones in the 6 MHz and 8 MHz channel units and using up to tone 58 on each side of the DC tone for data and pilots, exactly matching the VHT 40 MHz PHY parameters. The 7 MHz channel unit is split into 168 tones to maintain the same tone spacing and PHY design as used for 6 MHz channels (note the ratio of 168 to 144 is identical to the ratio of 7 to 6).

Bandwidths for Clause 23.

TVHT\_W: 6 MHz, 7 MHz, or 8 MHz

TVHT\_2W: 12 MHz, 14 MHz, or 16 MHz

TVHT\_W+W: 6+6 MHz, 7+7 MHz, or 8+8 MHz

TVHT\_4W: 24 MHz, 28 MHz, or 32 MHz

TVHT\_2W+2W: 12+12 MHz, 14+14 MHz, or 16+16 MHz

Transmission modes for Clause 23.

TVHT\_MODE\_1: transmission on TVHT\_W

TVHT\_MODE\_2C: transmission on TVHT\_2W

TVHT\_MODE\_2N: transmission on TVHT\_W+W

TVHT\_MODE\_4C: transmission on TVHT\_4W

TVHT\_MODE\_4N: transmission on TVHT\_2W+2W

A TVHT STA shall support:

— TVHT\_MODE\_1 (One frequency segment)

— Single spatial stream MCSs 0 to 7 (transmit and receive)

— Binary convolutional coding

— Guard interval (transmit and receive)

— Short guard interval (transmit and receive)

A TVHT STA may optionally support:

— TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C, or TVHT\_MODE\_4N (Two or four frequency segments)

— Two or more spatial streams (transmit and receive)

— Beamforming sounding (by sending a VHT NDP frame)

— Respond to transmit beamforming sounding (provide compressed beamforming feedback)

— STBC (transmit and receive)

— LDPC (transmit and receive)

— MU PPDUs (transmit and receive)

— MCSs 8 and 9 (transmit and receive)

The tone spacing, DFT duration and the other timing parameters remain unchanged for all optional modes compared with the mandatory mode (one segment).

The DATA encoding process for multi-segment transmissions is similar to one segment transmission.

TVHT supports following formats

* Non-HT format (NON\_HT). (NON\_HT\_DUP\_OFDM only)
* TVHT format (TVHT). Support for TVHT format is mandatory.

TVHT supports 1 to 4 single user space-time streams and up to four user multi user transmission.

The following table summarises timing related parameters and tone location.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | 6 MHz | 7 MHz | 8 MHz | Description |
| *NSD* | 108 | 108 | 108 | Number of complex data numbers per frequency segment |
| *NSP* | 6 | 6 | 6 | Number of pilot values per frequency segment |
| *NST* | 114 | 114 | 114 | Total number of subcarriers per frequency segment |
| *NSR* | 58 | 58 | 58 | Highest data subcarrier index per frequency segment |
| *∆F* |  |  |  | Subcarrier frequency spacing |
| *TDFT* | 24 µs | 24 µs | 18 µs | IDFT/DFT period |
| *TGI* | 6 µs = *TDFT* /4 | 6 µs = *TDFT* /4 | 4.5 µs = *TDFT* /4 | Guard interval duration |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | TVHT\_MODE\_1 | TVHT\_MODE\_2C | TVHT\_MODE\_2N | TVHT\_MODE\_4C | TVHT\_MODE\_4N | Description |
| *NST* | 114 | 114 | 114 | 114 | 114 | Total number of occupied subcarriers per frequency segment |
| *NTT* | 114 | 228 | 228 | 456 | 456 | Total number of occupied subcarriers across all frequency segments |
|  | -58 to -2 and +2 to +58 | -130 to -74, -70 to -14, +14 to +70, and +74 to +130 | -58 to -2 and +2 to +58 for each frequency segment | -274 to -218, -214 to -158, -130 to -74, -70 to -14, +14 to +70, +74 to +130, +158 to 214, and +218 to +274 | -130 to -74, -70 to -14, +14 to +70, and +74 to +130 for each frequency segment | Location of occupied subcarriers for 6 MHz and 8 MHz channel units |
|  | -58 to -2 and +2 to +58 | -142 to -86, -82 to -26, +26 to +82, and +86 to +142 | -58 to -2 and +2 to +58 for each frequency segment | -310 to -254, -250 to -194, -142 to -86, -82 to -26, +26 to +82, +86 to +142, +194 to 250, and +254 to +310 | -142 to -86, -82 to -26, +26 to +82, and +86 to +142 for each frequency segment | Location of occupied subcarriers for 7 MHz |

Other adjustments according to bandwidth, timing, etc.

* Cyclic shift value
* PMD receiver specification
* aPPDUMaxTime
* MCS datarate
* Etc…

**Propose:**

TGaf Editor: Make changes as shown and correct all cross-references in the draft.

TGaf Editor: Insert a new Clause 23 following Clause 22 as follows:

1. TV High Throughput (TVHT) PHY specification
   1. Introduction
      1. Introduction to the TVHT PHY

Clause 23 specifies the PHY entity for a TV high throughput (TVHT) orthogonal frequency division multiplexing (OFDM) system.

Three basic channel units are defined as 6 MHz, 7 MHz or 8 MHz depending on the regulatory domain and denoted in the rest of this clause in a general bandwidth agnostic term frequency segment or TVHT\_W. Similarly the following terminologies are used in the rest of this clause while exact value is depending on the regulatory domain. TVHT\_2W, TVHT\_W+W, TVHT\_4W and TVHT\_2W+2W represent two contiguous basic channel units (12 MHz, 14 MHz or 16 MHz), two non-contiguous basic channel units (6+6 MHz, 7+7 MHz, or 8+8 MHz), four contiguous basic channel units (24 MHz, 28 MHz, or 32 MHz), and two non-contiguous frequency sections whereby each frequency section is comprised of two contiguous basic channel units (12+12 MHz, 14+14 MHz, or 16+16 MHz), respectively.

The TVHT PHY is based solely on the VHT PHY as defined in subclauses 22.3 (VHT PLCP), 22.4 (VHT PLME), 22.5 (Parameters for VHT MCSs), and 22.6 (VHT PMD sublayer). The VHT acronym in Clause 22 is replaced with TVHT in Clause 23.

All TVHT transmissions in one frequency segment shall use the 40 MHz VHT PHY defined in subclauses 22.3 (VHT PLCP), 22.4 (VHT PLME), 22.5 (Parameters for VHT MCSs), and 22.6 (VHT PMD sublayer) with a sampling clock change to fit into each of the basic channel unit bandwidths.

Table 23-5a (Timing-related constants) describes the sampling clock for each of the basic channel units and the basic PHY parameters for transmissions over one frequency segment.

As shown in the Table 23-5a (Timing-related constants), the design is based on defining 144 OFDM tones in the 6 MHz and 8 MHz channel units and using up to tone 58 on each side of the DC tone for data and pilots, exactly matching the VHT 40 MHz PHY parameters. The 7 MHz channel unit is split into 168 tones to maintain the same tone spacing and PHY design as used for 6 MHz channels (note the ratio of 168 to 144 is identical to the ratio of 7 to 6).

The TVHT PHY defines the following transmission modes which are transmission on one, two or four frequency segments:

1. Mandatory transmission mode – one frequency segment (TVHT\_MODE\_1)
2. Optional transmission modes – multi-segment
   1. Two contiguous frequency segments (TVHT\_MODE\_2C)
   2. Two non-contiguous frequency segments (TVHT\_MODE\_2N)
   3. Four contiguous frequency segments (TVHT\_MODE\_4C)
   4. Two non-contiguous frequency sections whereby each frequency section is comprised of two contiguous frequency segments (TVHT\_MODE\_4N)

The tone spacing, DFT duration and the other timing parameters remain unchanged for all optional modes compared with the definition in Table 23-5a (Timing-related constants).

The number of occupied tones in each frequency segment of any optional mode is the same as the number defined in Table 23-5a (Timing-related constants).

The location of the occupied tones in each frequency segment of any optional mode is shown in Table 23-5b (Tone location).

The DATA encoding process for multi-segment transmissions is similar to one segment transmission and described in 23.3.10 (Data filed).

A TVHT STA shall support:

* TVHT\_MODE\_1 (One frequency segment)
* Single spatial stream MCSs 0 to 7 (transmit and receive)
* Binary convolutional coding
* Short guard interval (transmit and receive)
* Guard interval (transmit and receive)

A TVHT STA may optionally support:

* TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C, or TVHT\_MODE\_4N (Two or four frequency segments)
* Two or more spatial streams (transmit and receive)
* Beamforming sounding (by sending a VHT NDP frame)
* Respond to transmit beamforming sounding (provide compressed beamforming feedback)
* STBC (transmit and receive)
* LDPC (transmit and receive)
* MU PPDUs (transmit and receive)
* MCSs 8 and 9 (transmit and receive)
  + 1. Scope

The services provided to the MAC by the TVHT PHY consist of two protocol functions, defined as follows:

* A PHY convergence function, which adapts the capabilities of the physical medium dependent (PMD) system to the PHY service. This function is supported by the physical layer convergence procedure (PLCP), which defines a method of mapping the PSDUs into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs using the associated PMD system.
* A PMD system whose function defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. These STAs support a TVHT PHY.
  + 1. TVHT PHY functions
       1. General

(see 22.1.3.1 (General) with TVHT replacing VHT)

* + - 1. TVHT PLCP sublayer

(see 22.1.3.2 (VHT PLCP sublayer))

* + - 1. TVHT PMD sublayer

The TVHT PMD sublayer provides a means to send and receive data between two or more STAs. This clause is concerned with the below 1 GHz frequency TVWS bands.

* + - 1. PHY management entity (PLME)

(see 22.1.3.4 (PHY management entity (PLME))

* + - 1. Service specification method

(see 22.1.3.5 (Service specification method) with TVHT replacing VHT)

* + 1. PPDU formats

The structure of the PPDU transmitted by a TVHT STA is determined by the TXVECTOR parameters as defined in 23.2.2 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU, and includes:

* Non-HT format (NON\_HT). Support for Non-HT format is mandatory.
* TVHT format (TVHT). Support for TVHT format is mandatory.
  1. TVHT PHY service interface
     1. Introduction

(see 22.2.1 (Introduction))

* + 1. TXVECTOR and RXVECTOR parameters

The TXVECTOR and RXVECTOR parameters are defined in Table 22-1 (TXVECTOR and RXVECTOR parameters) with TVHT replacing VHT and the following modification/limitation.

The TXVECTOR parameter FORMAT shall be set to NON\_HT or TVHT. When the TXVECTOR parameter FORMAT equals to NON\_HT, then NON\_HT\_MODULATION shall be set to NON\_HT\_DUP\_OFDM.

When the TXVECTOR parameter FORMAT equals to NON\_HT, the TXVECTOR parameter L\_DATARATE indicates the data rate used to transmit the PSDU. The allowed values are 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s divided by 7.5 for 6 MHz and 7 MHz unit channels and by 5.625 for 8 MHz unit channels. The TXVECTOR parameter L\_DATARATE is not present when the TXVECTOR parameter FORMAT equals to TVHT.

When the TXVECTOR parameter FORMAT equals to TVHT, the TXVECTOR parameter CH\_BANDWIDTH indicates the channel width of the transmitted PPDU:

Enumerated type:

TVHT\_W for one frequency segment.

TVHT\_2W for two contiguous frequency segments.

TVHT\_W+W for two non-contiguous frequency segments.

TVHT\_4W for four contiguous frequency segments.

TVHT\_2W+2W for two non-contiguous frequency sections whereby each frequency section is comprised of two contiguous frequency segments.

Note that TVHT\_W represents the broadcast channel bandwidth for the regulatory domain, e.g. TVHT\_W is 6 MHz for U.S.A. TVHT\_2W represents two contiguous basic channel units with the same regulatory domain, e.g. TVHT\_2W is 12 MHz for U.S.A., etc.

When the TXVECTOR parameter FORMAT equals to NON\_HT, the TXVECTOR parameter CH\_BANDWIDTH indicates the channel width of the transmitted PPDU on transmission and the estimated channel width of the received PPDU on reception:

Enumerated type:

TVHT\_W, TVHT\_2W, TVHT\_W+W, TVHT\_4W, TVHT\_2W+2W.

When the TXVECTOR parameter FORMAT equals to TVHT, the TXVECTOR parameter NUM\_STS indicates the number of space-time streams: Integer: range 1-4 for SU, 1-3 per user for MU. NUM\_STS summed over all users is less than or equal to 4. The TXVECTOR parameter NUM\_STS is not present when the TXVECTOR parameter FORMAT equals to NON\_HT.

* + 1. Effects of CH\_BANDWIDTH parameter on PPDU format

Table 23-2 (PPDU format as a function of CH\_BANDWIDTH parameter) shows the PPDU format as a function of the CH\_BANDWIDTH and FORMAT parameters.

|  |  |  |
| --- | --- | --- |
| Table 23-2- PPDU format as a function of CH\_BANDWIDTH parameter | | |
| FORMAT | CH\_BANDWIDTH | PPDU format |
| TVHT | TVHT\_W | The STA transmits a TVHT PPDU with TVHT\_MODE\_1. |
| TVHT | TVHT\_2W | The STA transmits a TVHT PPDU (when FORMAT is TVHT) with TVHT\_MODE\_2C. |
| TVHT | TVHT\_4W | The STA transmits a TVHT PPDU (when FORMAT is TVHT) with TVHT\_MODE\_4C. |
| TVHT | TVHT\_W+W | The STA transmits a TVHT PPDU (when FORMAT is TVHT) with TVHT\_MODE\_2N. |
| TVHT | TVHT\_2W+2W | The STA transmits a TVHT PPDU (when FORMAT is TVHT) with TVHT\_MODE\_4N. |
| NON\_HT | TVHT\_W | The STA transmits a NON\_HT PPDU with NON\_HT\_MODULATION set to NON\_HT\_DUP\_OFDM using one TVHT\_W channel as defined in 23.3.10.12 (Non-HT duplicate transmission). If the BSS operating channel width is wider than TVHT\_W, then the transmission shall use the primary TVHT\_W channel. |
| NON\_HT | TVHT\_2W | The STA transmits a NON\_HT PPDU with NON\_HT\_MODULATION set to NON\_HT\_DUP\_OFDM using two adjacent TVHT\_W channels as defined in 23.3.10.12 (Non-HT duplicate transmission). If the BSS operating channel width is wider than TVHT\_2W, then the transmission shall use the primary TVHT\_2W channel. |
| NON\_HT | TVHT\_4W | The STA transmits a NON\_HT PPDU with NON\_HT\_MODULATION set to NON\_HT\_DUP\_OFDM using four adjacent TVHT\_W channels as defined in 23.3.10.12 (Non-HT duplicate transmission). |
| NON\_HT | TVHT\_W+W | The STA transmits a NON\_HT PPDU with NON\_HT\_MODULATION set to NON\_HT\_DUP\_OFDM using two non-adjacent frequency segments, with each frequency segment consisting of TVHT\_W channels as defined in 23.3.10.12 (Non-HT duplicate transmission). |
| NON\_HT | TVHT\_2W+2W | The STA transmits a NON\_HT PPDU with NON\_HT\_MODULATION set to NON\_HT\_DUP\_OFDM using two non-adjacent frequency segments, with each frequency segment consisting of two adjacent TVHT\_2W channels as defined in 23.3.10.12 (Non-HT duplicate transmission). |

* + 1. Support for NON\_HT and HT formats

Transmission of HT PPDU is not supported in Clause 23. Except for Non-HT duplicate transmission defined in 23.3.10.12 (Non-HT duplicate transmission), transmission of NON\_HT is not supported in Clause 23.

* 1. TVHT PLCP sublayer
     1. Introduction

(see 23.3.1 (Introduction))

* + 1. TVHT PPDU format

A single PPDU format is defined for this PLCP: the TVHT PPDU format. Figure 22-4 (VHT PPDU format) shows the TVHT PPDU format, with the timing parameters (8 us and 4 us) replaced by numbers from Table 23-5a (Timing-related constants).

The fields of the TVHT PPDU format are summarized in Table 23-4 (Fields of the TVHT PPDU).

|  |  |
| --- | --- |
| Table23-4 Fields of the TVHT PPDU | |
| Field | Description |
| L-STF | Non-HT Short Training field |
| L-LTF | Non-HT Long Training field |
| L-SIG | Non-HT SIGNAL field |
| TVHT-SIG-A | TVHT Signal A field |
| TVHT-STF | TVHT Short Training field |
| TVHT-LTF | TVHT Long Training field |
| TVHT-SIG-B | TVHT Signal B field |
| Data | The Data field includes the PSDU (PLCP Service Data Unit) |

The TVHT-SIG-A, TVHT-STF, TVHT-LTF, and TVHT-SIG-B fields exist only in TVHT PPDUs. In a TVHT NDP, the Data field is not present. The number of symbols in the TVHT-LTF field, *NTVHTLTF*, can be either 1, 2 or 4 and is determined by the total number of space-time streams across all users being transmitted in the TVHT PPDU (see Table 22-13 (Number of VHT-LTFs required for different numbers of space time streams)).

* + 1. Transmitter block diagram

Transmitter block diagram for TVHT is same as the VHT block diagrams in 22.3.3 (Transmitter block diagram) with TVHT replacing VHT while bandwidth should be corrected according to TVHT bandwidth.

* + 1. Overview of the PPDU encoding process
       1. General

This subclause provides an overview of the TVHT PPDU encoding process.

* + - 1. Construction of L-STF

Construct the L-STF field as defined in 23.3.8.1.2 (L-STF definition) following the procedure in 22.3.4.2 (Construction of L-STF) reading 23 for references to Clause 22 except:

c) Duplication and phase rotation: Duplicate the L-STF over the frequency segments of the CH\_BANDWIDTH. Apply appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of the L-LTF

Construct the L-LTF field as defined in 23.3.8.1.3 (L-LTF definition) following the procedure in 22.3.4.3 (Construction of the L-LTF) reading 23 for references to Clause 22 except:

c) Duplication and phase rotation: Duplicate the L-LTF over the frequency segments of the CH\_BANDWIDTH. Apply appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of L-SIG

Construct the L-SIG field as the SIGNAL field defined by 23.3.8.1.4 (L-SIG definition) following the procedure in 22.3.4.4 (Construction of L-SIG) reading 23 for references to Clause 22 except:

a) For a TVHT PPDU, set the RATE subfield in the SIGNAL field R1-R4 to 1101. Set the Length, Parity and Tail bits in the SIGNAL field as described in 23.3.8.1.4 (L-SIG definition). Add calculated one bit parity and  tail bits into the L-SIG symbol.

f) Duplication and phase rotation: Duplicate the L-SIG field over the frequency segments of the CH\_BANDWIDTH. Apply appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of TVHT-SIG-A

The TVHT-SIG-A field consists of two symbols, TVHT-SIG-A1 and TVHT-SIG-A2, constructed as defined in 23.3.8.2.3 (TVHT-SIG-A definition) following the procedure in 22.3.4.5 (Construction of VHT-SIG-A) reading 23 for references to Clause 22 except

e) Pilot insertion: Insert pilots following the steps described in 23.3.10.10 (Pilot subcarriers).

f) Duplication and phase rotation: Duplicate TVHT-SIG-A1 and TVHT-SIG-A2 over of the frequency segments of the CH\_BANDWIDTH. Apply the appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

i) Insert GI and apply windowing: Prepend a GI (LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of TVHT-STF

Construct the TVHT-STF field as described in 23.3.8.2.4 (TVHT-STF definition) following the procedure in 22.3.4.6 (Construction of VHT-STF) reading 23 for references to Clause 22 except:

b) Phase rotation: Apply appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

f) Insert GI and apply windowing: Prepend a GI (LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of TVHT-LTF

Construct the TVHT-LTF field as described in 23.3.8.2.5 (TVHT-LTF definition) following the procedure in 22.3.4.7 (Construction of VHT-LTF) reading 23 for references to Clause 22 except:

b) Phase rotation: Apply appropriate phase rotation as described in 23.3.7 (Mathematical description of signals).

c) Pilot insertion: Insert pilots following the steps described in 23.3.10.10 (Pilot subcarriers).

h) Insert GI and apply windowing: Prepend a GI (LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of TVHT-SIG-B

The TVHT-SIG-B field is constructed per-user as described in 22.3.4.8 (Construction of VHT-SIG-B) reading 23 for references to Clause 22 except:

k) Phase rotation: Apply the appropriate phase rotations as described in 23.3.7 (Mathematical description of signals).

m) Insert GI and apply windowing: Prepend a GI (LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of the Data field in an SU PPDU
         1. Using BCC

The construction of the Data field in a TVHT SU PPDU with BCC encoding proceeds as described in 22.3.4.9.1 (Using BCC) reading 23 for references to Clause 22 except:

o) Phase rotation: Apply the appropriate phase rotations as described in 23.3.7 (Mathematical description of signals).

q) Insert GI and apply windowing: Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - * 1. Using LDPC

The construction of the Data field in a TVHT SU PPDU with LDPC encoding proceeds as described in 22.3.4.9.2 reading 23 for references to Clause 22, except:

n) Phase rotation: Apply the appropriate phase rotations as described in 23.3.7 (Mathematical description of signals).

p) Insert GI and apply windowing: Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

* + - 1. Construction of the Data field in an MU PPDU
         1. General

(See 22.3.4.10.1 (General))

* + - * 1. Using BCC

A Data field with BCC encoding is constructed using the process described in 23.3.4.9.1 (Using BCC) before the spatial mapping block and repeated for each user that uses BCC encoding.

* + - * 1. Using LDPC

A Data field with LDPC encoding is constructed using the process described in 23.3.4.9.2 (Using LDPC) before the spatial mapping block and repeated for each user that uses LDPC encoding.

* + - * 1. Combining to form MU PPDU

The per-user data is combined as described in 22.3.4.10.4 (Combining to form MU PPDU) except:

a) Spatial Mapping: The *Q* matrix is applied as described in 23.3.10.11.1 (Transmission in TVHT format). The combining of all user data is done in this block.

b) Phase rotation: Apply the appropriate phase rotations as described in 23.3.7 (Mathematical description of signals).

d) Insert GI and apply windowing: Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 23.3.7 (Mathematical description of signals).

e) Analog and RF: Up-convert 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 23.3.7 (Mathematical description of signals) and 23.3.8 (TVHT preamble) for details.

* + 1. Modulation and coding scheme (MCS)

The MCS is a value that determines the modulation and coding used in the Data field of the PPDU. It is a compact representation that is carried in the TVHT-SIG-A field for SU PPDUs and in the TVHT-SIG-B field for MU PPDUs. Rate-dependent parameters for the full set of MCSs are shown in Table 23-30 (TVHT MCSs for TVHT\_MODE\_1, NSS = 1) to Table 23-41 (TVHT MCSs for TVHT\_MODE\_4Cand TVHT\_MODE\_4N, NSS = 4) (in 23.5 (Parameters for TVHT MCSs)). These tables give rate-dependent parameters for MCSs with indices 0 to 9, with number of spatial streams from 1 to 4 and bandwidth options of one, two or four frequency segments. Equal modulation (EQM) is applied to all streams for a particular user.

Table 23-30 (TVHT MCSs for TVHT\_MODE\_1, NSS = 1) to Table 23-33 (TVHT MCSs for TVHT\_MODE\_1 MHz, NSS = 4) show rate-dependent parameters for MCSs for one to four streams for one frequency segment operation. Table 23-34 (TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 1) to Table 23-37 (TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 4) show rate-dependent parameters for MCSs for one to four streams for dual frequency segment operation. Table 23-38 (TVHT MCSs for TVHT\_MODE\_4C and transmission TVHT\_MODE\_4N, NSS = 1) to Table 23-41 (TVHT MCSs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS = 4) show rate-dependent parameters for MCSs for one to four streams for quad frequency segment operation.

* + 1. Timing-related parameters

Table 23-5a (Timing-related constants) and Table 23-5b (Tone location) define the timing-related parameters for TVHT format and location of occupied tones.

**Table 23-5a – Timing-related constants**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | 6 MHz | 7 MHz | 8 MHz | Description |
| *NSD* | 108 | 108 | 108 | Number of complex data numbers per frequency segment |
| *NSP* | 6 | 6 | 6 | Number of pilot values per frequency segment |
| *NST* | 114 | 114 | 114 | Total number of subcarriers per frequency segment |
| *NSR* | 58 | 58 | 58 | Highest data subcarrier index per frequency segment |
| *∆F* |  |  |  | Subcarrier frequency spacing |
| *TDFT* | 24 µs | 24 µs | 18 µs | IDFT/DFT period |
| *TGI* | 6 µs = *TDFT* /4 | 6 µs = *TDFT* /4 | 4.5 µs = *TDFT* /4 | Guard interval duration |

Other timing parameters are derived as in Table 22-5 (Timing-related constants) using the definition of *TDFT* in Table 23-5a (Timing-related constants). Table 23-5b (Tone location) defines the number of occupied tones and their location in all transmission modes. The table uses brackets [] to delineate a contiguous section and 0 denotes the DC tone of any contiguous section.

**Table 23-5b – Tone location**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | TVHT\_MODE\_1 | TVHT\_MODE\_2C | TVHT\_MODE\_2N | TVHT\_MODE\_4C | TVHT\_MODE\_4N | Description |
| *NST* | 114 | 114 | 114 | 114 | 114 | Total number of occupied subcarriers per frequency segment |
| *NTT* | 114 | 228 | 228 | 456 | 456 | Total number of occupied subcarriers across all frequency segments |
|  | -58 to -2 and +2 to +58 | -130 to -74, -70 to -14, +14 to +70, and +74 to +130 | -58 to -2 and +2 to +58 for each frequency segment | -274 to -218, -214 to -158, -130 to -74, -70 to -14, +14 to +70, +74 to +130, +158 to 214, and +218 to +274 | -130 to -74, -70 to -14, +14 to +70, and +74 to +130 for each frequency segment | Location of occupied subcarriers for 6 MHz and 8 MHz channel units |
|  | -58 to -2 and +2 to +58 | -142 to -86, -82 to -26, +26 to +82, and +86 to +142 | -58 to -2 and +2 to +58 for each frequency segment | -310 to -254, -250 to -194, -142 to -86, -82 to -26, +26 to +82, +86 to +142, +194 to 250, and +254 to +310 | -142 to -86, -82 to -26, +26 to +82, and +86 to +142 for each frequency segment | Location of occupied subcarriers for 7 MHz |

Refer to Table 22-6 (Frequently used parameters) for parameters definition. The definitions in the table are applicable to Clause 23 with the exception that in each transmission mode in Clause 23 *NCBPSSI= NCBPSS* for SU and MU PPDUs.

* + 1. Mathematical description of signals

For a description of the conventions used for the mathematical description of the signals, see 18.3.2.5 (Mathematical conventions in the signal descriptions).

For all TVHT PPDU transmission modes the signal is transmitted on subcarriers as defined in Table 23-5b (Tone location).

Let

*fc*,*idx*0 = dot11CurrentChannelCenterFrequencyIndex0(#4322) (see Table 23-22 (Fields to specify TVHT channels)

*fc*,*idx1*= dot11CurrentChannelCenterFrequencyIndex1(#4322) (see Table 23-22 (Fields to specify TVHT channels)

dot11CurrentPrimaryChannel (see Table 23-22 (Fields to specify TVHT channels) and where TVHT\_W refers to a basic channel unit of 6 MHz,7 MHz or 8 MHz)

Channel starting frequency given in the operation class (Annex E)

In operation TVHT\_MODE\_1, TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C, and TVHT\_MODE\_4N,  and  *fc*,*idx*0 shall have the relationship specified in Equation (23-1)

*fPW*,*idx*= *fc*,*idx*0+ *nPW* (#43 (23-1)

where  is an integer with possible range , and

.

In operation TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C, and TVHT\_MODE\_4N,

* The primary TVHT\_W channel is the channel with TVHT\_W bandwidth centered at  MHz.
* The secondary TVHW\_W channel is the channel with TVHT\_W bandwidth centered at , where *fSW*,*idx* is given in Equation (23-2)

 (23-2)

In operation TVHT\_MODE\_4C and TVHT\_MODE\_4N

* The primary TVHT\_2W channel is the channel with TVHT\_2W bandwidth centered at  MHz, where  is given in Equation (23-3).
* The secondary TVHT\_2W channel is the channel with TVHT\_2W bandwidth centered at  MHz, where  is given in Equation (23-4).

(#43

  (23-3)

 (23-4)

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (22-7) in Clause 22. represents the center frequency of the PPDU transmitted in frequency segment in each transmission mode in Clause 23.

Note that in TVHT\_MODE\_2C and TVHT\_MODE\_4C, the gap between the center frequencies of the adjacent segments is as shown in Table 23-5b (Tone location).

Table 23-7 (Center frequency of a PPDU transmitted in frequency segment) shows  as a function of dot11CurrentChannelBandwidth.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 23-7 - Center frequency of a PPDU transmitted in frequency segment *iSeg* | | | |
| dot11CurrentChannelBandwidth | CH\_BANDWIDTH |  | |
|  |  |
| TVHT\_W | TVHT\_W | *fc*,*idx*0 | - |
| TVHT\_2W | TVHT\_W |  | - |
| TVHT\_2W | *fc*,*idx*0 | - |
| TVHT\_W+W | TVHT\_W+W | *fc*,*idx*0 | *fc*,*idx*1 |
| TVHT\_4W | TVHT\_W |  | - |
| TVHT\_2W |  | - |
| TVHT\_4W | *fc*,*idx*0 | - |
| TVHT\_2W+2W | TVHT\_2W+2W | *fc*,*idx*0 | *fc*,*idx*1 |

NOTE—Transmitted signals in TVHT\_MODE\_2N and TVHT\_MODE\_4N may have different impairments such as phase offset or phase noise between the two frequency segments in TVHT\_MODE\_2N or two frequency sections in TVHT\_MODE\_4N, which is not shown in Equation (22-7) for simplicity. See 23.3.18.3 (Transmit center frequency and Symbol clock frequency tolerance).

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The signal transmitted on frequency segment  is described by Equation 22-8 in 22.3.7 (Mathematical description of signals). The timing boundaries for the various fields are shown in Figure 22-15 (Timing boundaries for VHT PPDU fields).

Each field is defined as the summation of one or more subfields, where each subfield is defined to be an inverse discrete Fourier transform as specified in Equation (22-9) and where references to Table 22-5 (Timing-related constants), Table 22-6 (Frequently used parameters), Table 22-8 (Tone scaling factor and guard interval duration values for PLCP fields), Table 22-9 (CH\_BANDWIDTH and γ*k*,BW), Table 22-10 (Cyclic shift values for L-STF, L-LTF, L-SIG and VHT-SIG-A fields of the PPDU), Table 22-11 (Cyclic shift values for the VHT modulated fields of a PPDU) are replaced by the corresponding descriptions in Clause 23 including Table 23-5a (Timing-related constants), Table 23-5b (Tone location), Table 23-8 (Tone scaling factor and guard interval duration values for PLCP fields), Table 23-9 (Transmission mode and γ*k*,M).

Table 23-8 (Tone scaling factor and guard interval duration values for PLCP fields) summarizes the various values of  as a function of number of frequency segments (TVHT\_MODE\_1 has one frequency segment, TVHT\_MODE\_2C and TVHT\_MODE\_2N have two frequency segments, and TVHT\_MODE\_4C and TVHT\_MODE\_4N have four frequency segments).

**Table 23-8 – Tone scaling factor and guard interval duration values for PLCP fields**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Field | as a function of the number of frequency segments | | | Guard interval duration |
| One | Two | Four |
| L-STF | 24 | 48 | 96 | - |
| L-LTF | 104 | 208 | 416 | *TGI2* |
| L-SIG | 104 | 208 | 416 | *TGI* |
| TVHT-SIG-A | 104 | 208 | 416 | *TGI* |
| TVHT-STF | 24 | 48 | 96 | - |
| TVHT-LTF | 114 | 228 | 456 | *TGI* |
| TVHT-SIG-B | 114 | 228 | 456 | *TGI* |
| TVHT-Data | 114 | 228 | 484 | *TGI* or *TGIS*  (see NOTE 2) |
| NON\_HT\_DUP\_OFDM-Data  (see NOTE 1) | 104 | 208 | 416 | *TGI* |
| NOTE 1—For notational convenience, NON\_HT\_DUP\_OFDM-Data is used as a label for the Data field of a NON\_HT PPDU with format type NON\_HT\_DUP\_OFDM.  NOTE2— *TGI* denotes guard interval duration when TXVECTOR parameter GI\_TYPE equals LONG\_GI, *TGIs* denotes short guard interval duration when TXVECTOR parameter GI\_TYPE equals SHORT\_GI. | | | | |

In addition, the parameter  in Equation (22-9) is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M).

.

|  |  |
| --- | --- |
| Table 23-9 - Transmission mode and | |
| Transmission mode |  |
| TVHT\_MODE\_1, TVHT\_MODE\_2N | per segment |
| TVHT\_MODE\_2C, TVHT\_MODE\_4N | per two contiguous segments |
| TVHT\_MODE\_4C |  |

For TVHT\_MODE\_1 and TVHT\_MODE\_2N PPDU transmission,

 (23-11)

For TVHT\_MODE\_2C and TVHT\_MODE\_4N PPDU transmission,

 (23-12)

For TVHT\_MODE\_4C PPDU transmission,

 (23-13)

* + 1. TVHT preamble

A TVHT preamble is defined to carry the required information to operate in either single user or multi-user mode.

* + - 1. Non-TVHT portion of TVHT format preamble

23.3.8.1.1 Cyclic shift for pre-TVHT modulated fields

The cyclic shift value  for the L-STF, L-LTF, L-SIG and TVHT-SIG-A fields of the PPDU for transmit chain  out of a total of  are as defined in Table 22-10 (Cyclic shift values for L-STF, L-LTF, L-SIG and VHT-SIG-A fields of the PPDU) with a correction factor to account for the change in sampling clock frequency.

The correction factor for transmissions over 6 MHz and 7 MHz channels is 7.5.

The correction factor for transmissions over 8 MHz channels is 5.625.

As an example, the CSD value for antenna-2 with 2-transmit antennas is -200nS and the corresponding CSD value for 6 MHz channels is -1.5uS.

* + - * 1. L-STF definition

The L-STF field for each frequency segment in any transmission mode is defined by Equation (20-9) in 20.3.9.3.3 (L-STF definition).

The time domain representation of the signal on frequency segment  in transmit chain  is specified in Equation (22-16) and where  is replaced by  as defined in Table 23-9 (CH\_BANDWIDTH and γ*k*,BW) and with *NSR*  as defined in Table 23-5a (Timing-related constants).

* + - * 1. L-LTF definition

The L-LTF field for each frequency segment in any transmission mode is defined by Equation (20-12) in 20.3.9.3.4 (L-LTF definition).

Note that these equations do not include the phase rotations as defined in Table 23-9 (Transmission mode and γ*k*,M).

The time domain representation of the signal on transmit chain  is specified in Equation (22-19) and where  is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M) and with *NSR* defined in Table 23-5a (Timing-related constants).

* + - * 1. L-SIG definition

The L-SIG field is used to communicate data rate and length information. The structure of the L-SIG field is defined in 22.3.8.1.4 (L-SIG definition).

The time domain waveform of the L-SIG field in each frequency segment is specified in Equation (22-21) using=2, where is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M) and with the rest of the variables as specified in 23.3.7 (Mathematical description of signals).

* + - 1. TVHT portion of TVHT format preamble
         1. Introduction

The TVHT portion of the TVHT format preamble consists of the TVHT-SIG-A, TVHT-STF, TVHT-LTF and TVHT-SIG-B fields.

Notational conventions are specified in 22.3.8.2.1 (Introduction).

* + - * 1. Cyclic shift for TVHT modulated fields

The definition, application and CSD values are defined in 22.3.8.2.2 (Cyclic shift for VHT modulated fields) with correction factors as defined in 23.3.8.1.1(Cyclic shift for pre-TVHT modulated fields).

* + - * 1. TVHT-SIG-A definition

The TVHT-SIG-A field carries information required to interpret TVHT PPDU and defined in 22.3.8.2.3 (VHT-SIG-A definition).

The time domain waveform of the TVHT-SIG-A field in each frequency segment is specified in Equation (22-24) using =2 and the rest of the variables as specified in 23.3.7 (Mathematical description of signals).

Fields in the TVHT-SIG-A fields are the same as in Table 22-12 (Fields in the VHT-SIG-A field) except for the description B0-B1 (BW) in TVHT-SIG-A1 is as follows.

Set to 1 for TVHT\_MODE\_1, 2 for TVHT\_MODE\_2C and TVHT\_MODE\_2N, 3 for TVHT\_MODE\_4C and TVHT\_MODE\_4N. Value 0 is not used.

* + - * 1. TVHT-STF definition

The TVHT-STF field for each frequency segment in any transmission mode is defined by Equation (22-26) in 22.3.8.2.4 (VHT-STF definition).

The time domain waveform of the TVHT-STF field in each frequency segment is specified in Equation (22-29) where  is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M) and with *NSR* as defined in Table 23-5a (Timing-related constants).

* + - * 1. TVHT-LTF definition

The TVHT-LTF field is defined in 22.3.8.2.5 (VHT-LTF definition).

The TVHT-LTF sequence transmitted for each frequency segment in any transmission mode is defined by Equation (22-33).

The time domain waveform of the TVHT-LTF field in each frequency segment is specified in Equation (22-38) where  is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M) and with *NSR* as defined in Table 23-5a (Timing-related constants).

* + - * 1. TVHT-SIG-B definition

The TVHT-SIG-B field for each frequency segment in any transmission mode is as defined in 22.3.8.2.6 (VHT-SIG-B definition) for 40 MHz bandwidth. The time domain waveform for the VHT-SIG-B field in a VHT PPDU is specified by Equation (22-43) where  is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M) and with *NSR* as defined in Table 23-5a (Timing-related constants).

* + 1. Transmission of NON\_HT and HT PPDUs with multiple antennas
       1. Transmission of NON\_HT PPDUs with more than one antenna

A TVHT STA that transmits a NON\_HT PPDU shall apply the cyclic shifts defined in 23.3.8.1.1 (Cyclic shift for pre-TVHT modulated fields) for L-STF, L-LTF, L-SIG and VHT-SIG-A fields of the PPDU.

* + - 1. Transmission of HT PPDUs with more than four antennas

Transmission of HT PPDU with any number of antennas is not supported in Clause 23.

* + 1. Data field
       1. General

(See 22.3.10.1 (General) with TVHT replacing VHT).

* + - 1. SERVICE field

(See 22.3.10.2 (SERVICE field) with TVHT replacing VHT).

23.3.10.3 CRC calculation for TVHT-SIG-B

The CRC calculation and insertion is illustrated in Figure 22-21 (VHT-SIG-B and SERVICE field relationship).

The value of the CRC field shall be the ones complement of Equation (22-55) with the values of *N* set to 21 for all Modes.

* + - 1. Scrambler

(see 22.3.10.4 (Scrambler))

23.3.10.5 Coding

(see 22.3.10.5 (Coding) with TVHT replacing VHT)

23.3.10.6 Stream parser

After coding and puncturing, the data bit streams at the output of the FEC encoders are processed in groups of *NCBPS* bits. Each of these groups is(#5185) re-arranged into *NSS* blocks of *NCBPSS* bits (*NSS,u* blocks of *NCBPSS,u* bits in the case of an MU(#4668) transmission). This operation is referred to as “stream parsing” and is described in 22.3.10.6 (Stream parser).

* + - 1. Segment parser

The segment parser is not used in Clause 23. All modes of operation use an interleaver.

* + - 1. BCC interleaver

The BCC interleaver and deinterleaver for one frequency segment (TVHT\_MODE\_1) is as defined in 22.3.10.8 (BCC interleaver) for 40 MHz.

The BCC interleaver and deinterleaver for TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C and TVHT\_MODE\_4N re-use the same formulas as described in 22.3.10.8 (BCC interleaver) for 40 MHz with values for , *NROW* and *NROT* as defined in Table 23-17.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 23-17- Number of rows and columns in the interleaver | | | |
| Parameter | TVHT\_MODE\_1 | TVHT\_MODE\_2C, TVHT\_MODE\_2N | TVHT\_MODE\_4C, TVHT\_MODE\_4N |
|  | 18 | 27 | 48 |
|  |  | 8 x *NBPSCS* | 9 x *NBPSCS* |
| (*NSS* ≤ 4) | 29 | 46 | 78 |

23.3.10.9 Constellation mapping

* + - * 1. General

The mapping between bits at the output of the interleaver and complex constellation points is as described in 22.3.10.9.1 (General).

The streams of complex numbers in frequency subblock *l* for user *u* are denoted

for all transmission modes.

* + - * 1. LDPC tone mapping

The LDPC tone mapping for one frequency segment (TVHT\_MODE\_1) is as defined in 22.3.10.9.2 (LDPC tone mapping) for 40 MHz.

The LDPC tone mapping for TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C and TVHT\_MODE\_4N re-uses the same formulas as described in 22.3.10.9.2 (LDPC tone mapping) for 40 MHz with values for as defined in Table 23-21 (LDPC Tone Mapping Distance for each Transmission Mode).

**Table 23-21 – LDPC Tone Mapping Distance for each Transmission Mode**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | TVHT\_MODE\_1 | TVHT\_MODE\_2C, TVHT\_MODE\_2N | TVHT\_MODE\_4C, TVHT\_MODE\_4N |
|  | 6 | 8 | 9 |

For all Clause 23 transmission modes, the LDPC tone mapping for LDPC-coded streams corresponding to user *u* is done by permuting the stream of complex numbers(#5189)

 for all transmission modes (23-83)

generated by the constellation mappers, to obtain(#5189)

 for all transmission modes (23-84)

where

 for all transmission modes (23-85)

* + - * 1. Segment deparser

The segment deparser is not used in Clause 23. All modes of operation use a deinterleaver.

23.3.10.9.4 Space-time block coding

(See 22.3.10.9.4 (Space-time block coding) with TVHT replacing VHT)

* + - 1. Pilot subcarriers

For TVHT\_MODE\_1 transmission, six pilot tones shall be inserted in subcarriers –53, –25, –11, 11, 25, and 53. The pilots are generated as described in 22.3.10.10 (Pilot subcarriers) for 40 MHz transmission.

When multiple frequency segments are used (TVHT\_MODE\_2C, TVHT\_MODE\_2N, TVHT\_MODE\_4C, or TVHT\_MODE\_4N), each frequency segment shall use the same pilot tones which are generated as described in 22.3.10.10 (Pilot subcarriers) for 40 MHz transmission.

* + - 1. OFDM modulation
         1. Transmission in TVHT format

For TVHT transmissions, the signal from transmit chain *iTX*, 1  *iTX*  *NTX* shall be as specified in Equation (22-94).

For TVHT\_MODE\_1 transmission, parameters shall be selected to be the same with 40 MHz VHT transmission as defined in 22.3.10.11.1 (Transmission in VHT format).

For multi-segment transmissions, each frequency segment shall follow the subcarrier mapping as specified in Equation (22-94) and Table 23-5b (Tone location).

* + - 1. Non-HT duplicate transmission

When the TXVECTOR parameter FORMAT is NON\_HT and the TXVECTOR parameter NON\_HT\_MODULATION is NON\_HT\_DUP\_OFDM, the transmitted PPDU shall be a non-HT duplicate. Non-HT duplicate transmission is used to transmit to TVHT STAs that may be present in a part of a channe l using more than one frequency segment.

For non-HT duplicate transmission, the Data field shall be as defined in section 22.3.10.12, replacing VHT with TVHT and references to section 22 with references to section 23, using the parameter values as follows

**Table 23-21b – Parameters for Non-HT duplicate transmissions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | TVHT\_MODE\_1 | TVHT\_MODE\_2C | TVHT\_MODE\_2N | TVHT\_MODE\_4C | TVHT\_MODE\_4N |
| N\_20MHz | 2 | 4 | 2 | 8 | 4 |
| N^TONE\_NON\_HT\_DUP\_OFDM-Data | 104 | 208 | 104 | 416 | 208 |

In addition, the parameter  is replaced by  as defined in Table 23-9 (Transmission mode and γ*k*,M).

.

* + 1. SU-MIMO and MU-MIMO Beamforming

(See 22.3.11 (SU-MIMO and MU-MIMO Beamforming) with TVHT replacing VHT).

* + 1. VHT preamble format for sounding PPDUs

(See 22.3.12 (VHT preamble format for sounding PPDUs) with TVHT replacing VHT).

23.3.13 Regulatory requirements

(see 22.3.13(Regulatory requirements))

23.3.14 Channelization

A TVHT channel is specified by the four PLME MIB fields specified in Table 23-22 (Fields to specify TVHT channels).

|  |  |
| --- | --- |
| Table 23-22 - Fields to specify TVHT channels | |
| Field | Meaning |
| dot11CurrentChannelCenterFrequencyIndex0 | In TVHT\_MODE\_1, TVHT\_MODE\_2C and TVHT\_MODE\_4C operation, denotes the center frequency of lowest TV channel.  In TVHT\_MODE\_2N and TVHT\_MODE\_4N operation, denotes the center frequency of the lowest TV channel in the segment which contains the primary channel.  Valid range is 1 to 200.See Equation (23-101). |
| dot11CurrentChannelCenterFrequencyIndex1 | In TVHT\_MODE\_2N and TVHT\_MODE\_4N operation, denotes the center frequency of the lowest TV channel in the segment which does not contain the primary channel.  Valid range is 1 to 200.See Equation (23-101). Undefined for TVHT\_MODE\_1, TVHT\_MODE\_2C and TVHT\_MODE\_4C operation. |
| dot11CurrentPrimaryChannel | Denotes the location of the primary TVHT\_W channel.  Valid range is 1 to 200.  See Equation (23-102). |

Let *W* be the value in MHz of a frequency segment for the regulatory domain.

Given dot11CurrentChannelCenterFrequencyIndex0 and dot11CurrentChannelCenterFrequencyIndex1, the respective center frequency is given by Equation (23-101).

Channel center frequency [MHz] (23-101)

= Channel starting frequency + *W*  × dot11CurrentChannelCenterFrequencyIndex + ChannelCenterFrequencyCorrection

where Channel starting frequency is given by the operating class (Annex E) and dot11CurrentChannelCenterFrequencyIndex is either dot11CurrentChannelCenterFrequencyIndex0 or dot11CurrentChannelCenterFrequencyIndex1

and

ChannelCenterFrequencyCorrection is

0 for TVHT\_MODE\_1,

0.5xTVHT\_W for TVHT\_MODE\_2C and TVHT\_MODE\_2N,

1.5xTVHT\_W for TVHT\_MODE\_4C and TVHT\_MODE\_4N.

The center frequency of the primary TVHT\_W channel is given by Equation (23-102).

Primary channel center frequency [MHz] (23-102)

= Channel starting frequency + *W* × dot11CurrentPrimaryChannel

The channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz.

For TVHT\_MODE\_2N operation, any two non-identical channels may be used.

For TVHT\_MODE\_4N operation, any two channels that would each be allowed as TVHT\_2W channels and whose center frequencies are separated by greater than TVHT\_2W (difference between dot11CurrentChannelCenterFrequencyIndex0 and dot11CurrentChannelCenterFrequencyIndex1 corresponds to a frequency difference greater than TVHT\_2W) may be used.

For example, in U.S.A., a channel specified by

dot11CurrentChannelBandwidth = TVHT\_2W (12 MHz)

dot11CurrentChannelCenterFrequencyIndex0 = 15

dot11CurrentPrimaryChannel = 16

is an 12 MHz channel with a center frequency of 482 MHz and the primary 6 MHz channel centered at 485 MHz.

A channel specified by

dot11CurrentChannelBandwidth = TVHT\_4W (24 MHz)

dot11CurrentChannelCenterFrequencyIndex0 = 14

dot11CurrentPrimaryChannel = 17

is a 24 MHz channel with a center frequency of 482 MHz and the primary 6 MHz channel centered at 491 MHz.

A channel specified by

dot11CurrentChannelBandwidth = TVHT\_2W+2W (12+12 MHz)

dot11CurrentChannelCenterFrequencyIndex0=15

dot11CurrentChannelCenterFrequencyIndex1 = 40

dot11CurrentPrimaryChannel = 16

is an 12+12 MHz channel in which frequency segment 0 has 12 MHz bandwidth and center frequency of 482 MHz. Frequency segment 1 also has 12 MHz bandwidth and center frequency of 632 MHz. The primary 6 MHz channel is centered at 485 MHz.

* + 1. Transmit RF delay

The transmitter RF delay is defined in 18.3.8.6 (TX RF delay).

* + 1. Slot time

The slot time for the TVHT PHY shall be 24 us for 6 MHz and 7 MHz channel units and 20 us for 8 MHz channel units.

* + 1. Transmit and receive port impedance

Transmit and receive antenna port impedance for each transmit and receive antenna is defined in 18.3.8.8 (Transmit and receive antenna port impedance).

23.3.18 PMD transmit specification

* + - 1. Transmit spectrum mask

For transmission in TVHT\_MODE\_1, TVHT\_MODE\_2C and TVHT\_MODE\_4C, the transmit spectral mask shall be as described for 40 MHz mask PPDU in 22.3.18.1 with the frequenciy axis scaled as defined in Table 23-23a

Table 23-23a Spectral mask frequency scaling for contiguous transmission

|  |  |  |  |
| --- | --- | --- | --- |
| Mode | Scaling for 6 MHz channels | Scaling for 7 MHz channels | Scaling for 8 MHz channels |
| TVHT\_MODE\_1 | 6 / 40 | 7 / 40 | 8 / 40 |
| TVHT\_MODE\_2C | 12 / 40 | 14 / 40 | 16 / 40 |
| TVHT\_MODE\_4C | 24 / 40 | 28 / 40 | 32 / 40 |

For transmission in mode TVHT\_MODE\_2N and TVHT\_MODE\_4N, the transmit spectral mask shall be as described for 80+80 MHz mask PPDU in section 22.3.18.1 with the frequency axis scaled as defined in Table 23-23b

Table 23-23b Spectral mask frequency scaling for non-contiguous transmision

|  |  |  |  |
| --- | --- | --- | --- |
| Mode | Scaling for 6 MHz channels | Scaling for 7 MHz channels | Scaling for 8 MHz channels |
| TVHT\_MODE\_2N | 6 / 80 | 7 / 80 | 8 / 80 |
| TVHT\_MODE\_4N | 12 / 80 | 14 / 80 | 16 / 80 |

NOTE 1— In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements (measured as defined in the relevant regulation) and the mask defined in this section.

NOTE 2— For rules regarding TX center frequency leakage levels see 23.3.18.4.2 (Transmit center frequency leakage).

* + - 1. Spectral flatness

Spectral flatness measurements shall be conducted using BPSK modulated PPDUs. See 23.3.18.4.4 (Transmitter modulation accuracy (EVM) test) for the demodulation procedure of the PPDUs, as well as the number of PPDUs and OFDM symbols to be used for testing.

Let  denote the average constellation energy of a BPSK modulated subcarrier *i* in a TVHT data symbol.

For TVHT\_MODE\_1 contiguous non-HT duplicate or TVHT transmission having a bandwidth listed in Table 23-23 (Maximum transmit spectral flatness deviations),  of each of the subcarriers with indices listed as tested subcarrier indices shall not deviate by more than the specified maximum deviation in Table 23-23 (Maximum transmit spectral flatness deviations) from the average of  over subcarrier indices listed as averaging subcarrier indices. Averaging of  is done in the linear domain.

**Table 23-23 – Maximum transmit spectral flatness deviations**

|  |  |  |  |
| --- | --- | --- | --- |
| Format | Averaging subcarrier indices (inclusive) | Tested subcarrier indices (inclusive) | Maximum deviation (dB) |
| TVHT | -42 to -2 and +2 to +42 | -42 to -2 and +2 to +42 | ±4 |
| -58 to -43 and +43 to +58 | +4/-6 |
| non-HT duplicate | -42 to -33, -31 to -6,  +6 to +31, and +33 to +42 | -42 to -33, -31 to -6, +6 to +31, and +33 to +42 | ±4 |
| -43 to -58 and +43 to +58 | +4/-6 |

For transmissions consisting of multiple contiguous or non-contiguous frequency segments, each segment shall meet the spectral flatness requirement for TVHT\_MODE\_1 transmission.

For the spectral flatness test, the transmitting STA shall be configured to use a spatial mapping matrix *Qk* (see 23.3.10.11 (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.

* + - 1. Transmit center frequency and symbol clock frequency tolerance

The transmitter center frequency maximum allowable deviation shall be ±25 ppm. Carrier (LO) and symbol clock frequencies for the all transmit chains and frequency segments shall be derived from the same reference oscillator.

NOTE—For multi-channel operation, the signal phase of each segment might not be correlated.

The symbol clock frequency tolerance shall be maximum ±25 ppm. The transmit center frequency and the symbol clock frequency for all transmit antennas and contiguous frequency segments shall be derived from the same reference oscillator.

* + - 1. Modulation accuracy
         1. Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 23.3.18.4.2 (Transmit center frequency leakage) and 23.3.18.4.3 (Transmitter constellation error). The test method is described in 23.3.18.4.4 (Transmitter modulation accuracy (EVM) test).

* + - * 1. Transmit center frequency leakage

TX LO leakage shall meet the following requirements TVHT\_MODE\_1, TVHT\_MODE\_2C and TVHT\_MODE\_4C:

* When the RF LO is in the center of the transmitted PPDU BW, the power measured at the center of transmission BW using resolution BW (6/144 or 8/144) MHz shall not exceed the average power per-subcarrier of the transmitted PPDU, or equivalently, (), where *P* is the transmit power per antenna in dBm and *NST* is defined in Table 23-5a (Timing related parameters).
* When the RF LO is not at the center of the transmitted PPDU BW, the power measured at the location of the RF LO using resolution BW (6/144 or 8/144) MHz shall not exceed the maximum of -32 dB relative to the total transmit power and -20 dBm, or equivalently , where *P* is the transmit power per antenna in dBm and *NST* is defined in Table 23-5a (Timing related parameters).

For transmissions using TVHT\_MODE\_2N and TVHT\_MODE\_4N, where the RF LO falls outside both frequency segments, the RF LO shall follow the spectral mask requirements as defined in 23.3.18.1 (Transmit spectrum mask).

The transmit center frequency leakage is specified per antenna.

* + - * 1. Transmitter constellation error

For all modes defined in TVHT PHY, the requirements for transmit constellation RMS error is same as defined in 22.3.18.4.3 (Transmitter constellation error).

For non-HT duplicate transmissions, requirements defined in 18.3.9.7.4 (Transmitter constellation error) apply to each half of the channel bandwidth. The channel bandwidth is determined by the TXVECTOR parameter CH\_BANDWIDTH.

* + - * 1. Transmitter modulation accuracy (EVM) test

For transmit modulation accuracy test, same methodology defined in 22.3.18.4.4 (Transmitter modulation accuracy (EVM) test) shall be followed noting that each subchannel is half of the channel bandwidth wide. The channel bandwidth is determined by the TXVECTOR parameter CH\_BANDWIDTH.

* + 1. TVHT PMD receiver specification

(see 22.3.19 (VHT PMD receiver specification))

23.3.19.1 Receiver minimum input sensitivity

The packet error ratio (PER) shall be less than 10% for a PSDU length of 4096 octets with the rate-dependent input levels listed in Table 23-25 (Receiver minimum input level sensitivity). The test in this subclause and the minimum sensitivity levels specified in Table 23-25 (Receiver minimum input level sensitivity) apply only to non-STBC modes, long GI, BCC and TVHT PPDUs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Table 23-25-Receiver minimum input level sensitivity | | | | | | | |
| Modulation | Rate (R) | Minimum sensitivity (6 or 7 MHz (TVHT\_MODE\_1) PPDU)  (dBm) | Minimum sensitivity (12/14 MHz (TVHT\_MODE\_2C) or 6+6/7+7 MHz (TVHT\_MODE\_2N) PPDU)  (dBm) | Minimum sensitivity (24/28 MHz (TVHT\_MODE\_4C) or 12+12/14+14 MHz (TVHT\_MODE\_4N)  PPDU)  (dBm) | Minimum sensitivity (8 MHz (TVHT\_MODE\_1) PPDU)  (dBm) | Minimum sensitivity (16 MHz (TVHT\_MODE\_2C) or 8+8 MHz (TVHT\_MODE\_2N) PPDU)  (dBm) | Minimum sensitivity (32 MHz (TVHT\_MODE\_4C) or 16+16/16+16 MHz (TVHT\_MODE\_4N)  PPDU)  (dBm) |
| BPSK | 1/2 | -87.75 | -84.75 | -81.75 | -86.5 | -83.5 | -80.5 |
| QPSK | 1/2 | -84.75 | -81.75 | -78.75 | -83.5 | -80.5 | -77.5 |
| QPSK | 3/4 | -82.75 | -79.75 | -76.75 | -81.5 | -78.5 | -75.5 |
| 16-QAM | 1/2 | -79.75 | -76.75 | -73.75 | -78.5 | -75.5 | -72.5 |
| 16-QAM | 3/4 | -75.75 | -72.75 | -69.75 | -74.5 | -71.5 | -68.5 |
| 64-QAM | 2/3 | -71.75 | -68.75 | -65.75 | -70.5 | -67.5 | -64.5 |
| 64-QAM | 3/4 | -70.75 | -67.75 | -64.75 | -69.5 | -66.5 | -63.5 |
| 64-QAM | 5/6 | -69.75 | -66.75 | -63.75 | -68.5 | -65.5 | -62.5 |
| 256-QAM | 3/4 | -64.75 | -61.75 | -58.75 | -63.5 | -60.5 | -57.5 |
| 256-QAM | 5/6 | -62.75 | -59.75 | -56.75 | -61.5 | -58.5 | -55.5 |

23.3.19.2 Adjacent channel rejection

Adjacent channel rejection for TVHT\_MODE\_1, TVHT\_MODE\_2C, and TVHT\_MODE\_4C follow the definition in the first paragraph of 22.3.19.2 (Adjacent channel rejection) and use the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

Adjacent channel rejection for TVHT\_MODE\_2N (TVHT\_W+W) and TVHT\_MODE\_4N (TVWT\_2W+2W) follow the definition in the second paragraph of 22.3.19.2 (Adjacent channel rejection) whereby 80MHz is replaced by TVHT\_W for TVHT\_MODE\_2N and TVHT\_2W for TVHT\_MODE\_4N and use the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

The definitions in the rest of 22.3.19.2 (Adjacent channel rejection) apply to Clause 23 using the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 23-26- Minimum required adjacent and nonadjacent channel rejection levels | | | | | |
| Modulation | Rate (R) | Adjacent channel rejection (dB) | | Nonadjacent channel rejection (dB) | |
| 6 MHz, 7 MHz, 8 MHz, 12 MHz (TVHT\_MODE\_2C), 14 MHz (TVHT\_MODE\_2C), 16 MHz (TVHT\_MODE\_2C), 24 MHz (TVHT\_MODE\_4C), 28 MHz (TVHT\_MODE\_4C), 32 MHz (TVHT\_MODE\_4C) | 6+6 MHz (TVHT\_MODE\_2N), 7+7 MHz (TVHT\_MODE\_2N), 8+8 MHz (TVHT\_MODE\_2N), 12+12 MHz (TVHT\_MODE\_4N), 14+14 MHz (TVHT\_MODE\_4N), 16+16 MHz (TVHT\_MODE\_4N) | 6 MHz, 7 MHz, 8 MHz, 12 MHz (TVHT\_MODE\_2C), 14 MHz (TVHT\_MODE\_2C), 16 MHz (TVHT\_MODE\_2C), 24 MHz (TVHT\_MODE\_4C), 28 MHz (TVHT\_MODE\_4C), 32 MHz (TVHT\_MODE\_4C) | 6+6 MHz (TVHT\_MODE\_2N), 7+7 MHz (TVHT\_MODE\_2N), 8+8 MHz (TVHT\_MODE\_2N), 12+12 MHz (TVHT\_MODE\_4N), 14+14 MHz (TVHT\_MODE\_4N), 16+16 MHz (TVHT\_MODE\_4N) |
| BPSK | 1/2 | 16 | 13 | 32 | 29 |
| QPSK | 1/2 | 13 | 10 | 29 | 26 |
| QPSK | 3/4 | 11 | 8 | 27 | 24 |
| 16-QAM | 1/2 | 8 | 5 | 24 | 21 |
| 16-QAM | 3/4 | 4 | 1 | 20 | 17 |
| 64-QAM | 2/3 | 0 | -3 | 16 | 13 |
| 64-QAM | 3/4 | -1 | -4 | 15 | 12 |
| 64-QAM | 5/6 | -2 | -5 | 14 | 11 |
| 256-QAM | 3/4 | -7 | -10 | 9 | 6 |
| 256-QAM | 5/6 | -9 | -12 | 7 | 4 |

23.3.19.3 Nonadjacent channel rejection

Nonadjacent channel rejection for TVHT\_MODE\_1, TVHT\_MODE\_2C, and TVHT\_MODE\_4C follow the definition in the first paragraph of 22.3.19.3 (Nonadjacent channel rejection) and use the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

Nonadjacent channel rejection for TVHT\_MODE\_2N (TVHT\_W+W) and TVHT\_MODE\_4N (TVWT\_2W+2W) follow the definition in the second paragraph of 22.3.19.3 (Nonadjacent channel rejection) whereby 80MHz is replaced by TVHT\_W for TVHT\_MODE\_2N and TVHT\_2W for TVHT\_MODE\_4N and use the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

The definitions in the rest of 22.3.19.3 (Nonadjacent channel rejection) apply to Clause 23 using the values in Table 23-26 (Minimum required adjacent and nonadjacent channel rejection levels).

23.3.19.4 Receiver maximum input level

(see 22.3.19.4 (Receiver maximum input level) with TVHT replacing VHT)

* + - 1. CCA sensitivity

23.3.19.5.1 General

The thresholds in this subclause are compared with the signal level at each receiving antenna.

23.3.19.5.2 CCA sensitivity for operating classes requiring CCA-ED

For the operating classes requiring CCA-Energy Detect (CCA-ED), CCA shall also detect a medium busy condition when 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 limit sets). The operating classes requiring the corresponding CCA-ED behavior class are given in Annex E. A STA that is operating within an operating class that requires CCA-ED shall operate with CCA-ED. The CCA-ED is not required for license-exempt operation in any band.

CCA-ED shall indicate a channel busy condition when the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for the primary TVHT\_W channel and the secondary TVHT\_W channel and dot11OFDMEDThreshold+3 dB for the secondary TVHT\_2W channel. 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 issue a CCA signal busy as stated in 23.3.19.5.3 (CCA sensitivity for signals occupying the primary TVHT\_W channel) and 23.3.19.5.3 (CCA sensitivity for signals occupying the primary TVHT\_W channel) is a mandatory energy detect requirement on all Clause 23

receivers. Support for CCA-ED is an additional requirement that relates specifically to the sensitivities described in D.2.5 (CCA-ED threshold).

23.3.19.5.3 CCA sensitivity for signals occupying the primary channel

The PHY shall issue a PHY-CCA.indication(BUSY, {primary TVHT\_W}) if one of the conditions listed in Table 23-27 (Conditions for CCA BUSY on the primary TVHT\_W) is met in an otherwise idle TVHT\_W(TVHT\_MODE\_1), TVHT\_2W (TVHT\_MODE\_2C), TVHT\_4W (TVHT\_MODE\_4C), TVHT\_W+W (TVHT\_MODE\_2N) and TVHT\_2W+2W (TVHT\_MODE\_4N) operating channel width. With >90% probability, the PHY shall detect the start of a PPDU that occupies at least the primary TVHT\_W channel under the conditions listed in Table 23-27 (Conditions for CCA BUSY on the primary TVHT\_W) within a period of aCCATime (see 23.4.4 (PHY characteristics)) and hold the CCA signal busy (PHY\_CCA.indicate(BUSY, channel-list)) for the duration of the PPDU.

|  |  |
| --- | --- |
| Table 23-27-Conditions for CCA BUSY on the primary channel | |
| Freqency segment width | Conditions |
| 6 MHz | The start of a 6 MHz non-HT duplicate or TVHT PPDU in the primary 6 MHz channel at or above -87.75 dBm. |
| 7 MHz | The start of a 7 MHz non-HT duplicate or TVHT PPDU in the primary 7 MHz channel at or above -87.75 dBm. |
| 8 MHz | The start of a 8 MHz non-HT duplicate or TVHT PPDU in the primary 8 MHz channel at or above -86.5 dBm. |

The receiver shall issue a PHY-CCA.indication(BUSY, {primary TVHT\_W}) for any signal that exceeds a threshold equal to 20 dB above the minimum modulation and coding rate sensitivity (-87.75 + 20 = -67.75 dBm in the case of 6 MHz channel) in the primary TVHT\_Wchannel within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the receiver shall not issue a PHY-CCA.indication(BUSY,{secondary TVHT\_W}), PHY-CCA.indication(BUSY,{secondary TVHT\_2W}), or PHY-CCA.indication(IDLE) while the threshold continues to be exceeded.

23.3.19.5.3 CCA sensitivity for signals not occupying the primary channel

The PHY shall issue a PHY-CCA.indication(BUSY, {secondary TVHT\_W}) if the conditions for issuing PHY-CCA.indication(BUSY, {primary TVHT\_W}) are not present and one of the following conditions are present in an otherwise idle TVHT\_W(TVHT\_MODE\_1), TVHT\_2W (TVHT\_MODE\_2C), TVHT\_4W (TVHT\_MODE\_4C), TVHT\_W+W(TVHT\_MODE\_2N) and TVHT\_2W+2W (TVHT\_MODE\_4N) operating channel width:

* Any signal within the secondary TVHT\_Wchannel at or above a threshold (-67.75 dBm for 6 MHz, -67.75 dBm for 7 MHz and –66.5 dBm for 8 MHz) within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue a PHY-CCA.indication(BUSY,{secondary TVHT\_2W}), or PHY-CCA.indication(IDLE) while the threshold continues to be exceeded.
* A TVHT\_W non-HT duplicate or TVHT PPDU detected in the secondary TVHT\_Wchannel at or above a threshold (-80.75 dBm for 6 MHz, -80.75 dBm for 7 MHz and –79.5 dBm for 8 MHz) with >90% probability within a period aCCAMidTime (see 23.4.4 (PHY characteristics)).

The PHY shall issue a PHY-CCA.indication(BUSY, {secondary TVHT\_2W}) if the conditions for issuing PHY-CCA.indication(BUSY, {primary TVHT\_W}) and PHY-CCA.indication(BUSY, {secondary TVHT\_W}) are not present and one of the following conditions are present in an otherwise idle TVHT\_2W (TVHT\_MODE\_2C), TVHT\_4W (TVHT\_MODE\_4C), TVHT\_W+W(TVHT\_MODE\_2N) and TVHT\_2W+2W (TVHT\_MODE\_4N) operating channel width:

* Any signal within the secondary TVHT\_2W channel at or above a threshold (-64.75 dBm for 12 MHz, -64.75 dBm for 14 MHz and –66.5 dBm for 16 MHz) within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue a PHY-CCA.indication(IDLE) while the threshold continues to be exceeded.
* A TVHT\_2W non-HT duplicate, or TVHT PPDU detected in the secondary TVHT\_2W channel at or above the threshold of (-77.75 dBm for 6+6 or 12 MHz, -77.75dBm for 7+7 or 14 MHz and –76.5 dBm for 8+8 or 16 MHz ) with >90% probability within a period aCCAMidTime (see 23.4.4 (PHY characteristics)).
* A TVHT\_Wnon-HT duplicate or TVHT PPDU detected in any TVHT\_Wsub-channel of the secondary TVHT\_2W channel at or above the threshold of (-80.75 dBm for 6 MHz, -80.75 dBm for 7 MHz and –79.5 dBm for 8 MHz ) with >90% probability within a period aCCAMidTime.

23.3.19.6 RSSI

(see 22.3.19.6 (RSSI) with TVHT replacing VHT)

23.3.20 PLCP transmit procedure

(see 22.3.20 (PLCP transmit procedure) with TVHT replacing VHT)

23.3.21 PLCP receive procedure

(see 22.3.21 (PLCP receive procedure) with TVHT replacing VHT)

* 1. TVHT PLME

23.4.1 PLME\_SAP sublayer management primitives

(see 22.4.1 (PLME\_SAP sublayer management primitives) with TVHT replacing VHT)

23.4.2 PHY MIB

(see 22.4.1 (PHY MIB) with TVHT replacing VHT)

23.4.3 TXTIME and PSDU\_LENGTH calculation

(see 22.4.3 (TXTIME and PSDU\_LENGTH calculation) with TVHT replacing VHT)

23.4.4 PHY characteristics

The static TVHT PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-25 (MIMO PHY characteristics) except parameters listed in Table 23-29 (TVHT PHY characteristics) and aPreambleLength, aSTFOneLength, aSTFTwoLength, aLTFOneLength, aLTFTwoLength, aPLCPHeaderLength, and aPLCPSigTwoLength which are multiplied by 7.5 for 6 MHz and 7 MHz unit channels and by 5.625 for 8 MHz unit channels. The definitions for these characteristics are given in 6.5 (PLME SAP interface).

|  |  |
| --- | --- |
| Table 23-29-TVHT PHY characteristics | |
| Characteristics | Value |
| aSlotTime | 24 µs (basic channel units: 6 or 7 MHz)  20 µs (basic channel units: 8 MHz) |
| aSignalExtension | 0 µs |
| aCCATime | < 15 µs (6 or 7 MHz)  < 11.25 µs (8 MHz) |
| aCCAMidTime | < 94 µs (6 or 7 MHz)  < 70 µs (8 MHz) |
| aAirPropagationTime | 3 µs |
| aPPDUMaxTime | 10 ms |
| aPSDUMaxLength | 709920 octets (see NOTE) |
| NOTE—this is the maximum length in octets for SU PPDUs with a bandwidth of 32 or 16+16 MHz, MCS9 and 4 spatial streams, limited by 493 possible Short GI data symbols in aPPDUMaxTime. | |

23.5 Parameters for TVHT MCSs

The rate-dependent parameters for one frequency segment mode (6 MHz, 7 MHz and 8 MHz), and corresponding two and four frequency segment modes with NSS = 1, …, 4 are given in Table 23-30 (TVHT MCSs for TVHT\_MODE\_1, NSS =1) through Table 23-41 (TVHT MCs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS=4). Support for MCS 8 and 9 (when valid) is optional in all cases. A TVHT STA shall support single spatial stream MCSs within the range MCS 0 to MCS 7 for all channel widths for which it has indicated support regardless of the Tx or Rx Highest Supported Data Rate subfield values in the TVHT Supported MCS Set field. When more than one spatial stream is supported, the Tx or Rx Highest Supported Data Rate subfield values in the TVHT Supported MCS Set field may result in a reduced MCS range (cut-off) for NSS = 2, …, 4 . Support for 6 MHz, 7 MHz or 8 MHz with  is mandatory. Support for 6 MHz, 7 MHz or 8 MHz with NSS = 2, …, 4 is optional. Support for two frequency segment modes with 12 MHz, 14 MHz and 16 MHz, or 6+6 MHz, 7+7 MHz and 8+8 MHz with NSS = 1, …, 4 is optional. Support for 4 segment modes with 24 MHz, 28 MHz and 32 MHz or 12+12 MHz, 14+14 MHz and 16+16 MHz with NSS = 1, …, 4 is optional. *NES* values were chosen to yield an integer number of punctured blocks per OFDM symbol. Note that *NES* values are 1 for all Clause 23 modulations.

Table 23-30 (TVHT MCSs for TVHT\_MODE\_1, NSS =1) through Table 23-41 ( TVHT MCs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS=4) define TVHT MCSs not only for SU transmission but also for user *u* of MU transmission. In the case of TVHT MCSs for MU transmission, the parameters, *NSS*, *R*, *NBPSCS*, *NCBPS*, *NDBPS*, and *NES* are replaced with *NSS,u*, *Ru*, *NBPSCS,u*, *NCBPS, u*, *NDBPS,u*, and *NES,u*, respectively.

Table 23-30 - TVHT MCSs for TVHT\_MODE\_1, NSS = 1

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 6 or 7 MHz | | Data rate (Mb/s) for 8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 108 | 6 | 108 | 54 | 1.8 | 2.0 | 2.4 | 2.7 |
| 1 | QPSK | 1/2 | 2 | 108 | 6 | 216 | 108 | 3.6 | 4.0 | 4.8 | 5.3 |
| 2 | QPSK | 3/4 | 2 | 108 | 6 | 216 | 162 | 5.4 | 6.0 | 7.2 | 8.0 |
| 3 | 16-QAM | 1/2 | 4 | 108 | 6 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 4 | 16-QAM | 3/4 | 4 | 108 | 6 | 432 | 324 | 10.8 | 12.0 | 14.4 | 16.0 |
| 5 | 64-QAM | 2/3 | 6 | 108 | 6 | 648 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 6 | 64-QAM | 3/4 | 6 | 108 | 6 | 648 | 486 | 16.2 | 18.0 | 21.6 | 24.0 |
| 7 | 64-QAM | 5/6 | 6 | 108 | 6 | 648 | 540 | 18.0 | 20.0 | 24.0 | 26.7 |
| 8 | 256-QAM | 3/4 | 8 | 108 | 6 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 9 | 256-QAM | 5/6 | 8 | 108 | 6 | 864 | 720 | 24.0 | 26.7 | 32.0 | 35.6 |

Table 23-31 - TVHT MCSs for TVHT\_MODE\_1, NSS = 2

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 6 or 7 MHz | | Data rate (Mb/s) for 8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 108 | 6 | 216 | 108 | 3.6 | 4.0 | 4.8 | 5.3 |
| 1 | QPSK | 1/2 | 2 | 108 | 6 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 2 | QPSK | 3/4 | 2 | 108 | 6 | 432 | 324 | 10.8 | 12.0 | 14.4 | 16.0 |
| 3 | 16-QAM | 1/2 | 4 | 108 | 6 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 4 | 16-QAM | 3/4 | 4 | 108 | 6 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 5 | 64-QAM | 2/3 | 6 | 108 | 6 | 1296 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 6 | 64-QAM | 3/4 | 6 | 108 | 6 | 1296 | 972 | 32.4 | 36.0 | 43.2 | 48.0 |
| 7 | 64-QAM | 5/6 | 6 | 108 | 6 | 1296 | 1080 | 36.0 | 40.0 | 48.0 | 53.3 |
| 8 | 256-QAM | 3/4 | 8 | 108 | 6 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 9 | 256-QAM | 5/6 | 8 | 108 | 6 | 1728 | 1440 | 48.0 | 53.3 | 64.0 | 71.1 |

Table 23-32 - TVHT MCSs for TVHT\_MODE\_1, NSS = 3

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 6 or 7 MHz | | Data rate (Mb/s) for 8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 108 | 6 | 324 | 162 | 5.4 | 6.0 | 7.2 | 8.0 |
| 1 | QPSK | 1/2 | 2 | 108 | 6 | 648 | 324 | 10.8 | 12.0 | 14.4 | 16.0 |
| 2 | QPSK | 3/4 | 2 | 108 | 6 | 648 | 486 | 16.2 | 18.0 | 21.6 | 24.0 |
| 3 | 16-QAM | 1/2 | 4 | 108 | 6 | 1296 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 4 | 16-QAM | 3/4 | 4 | 108 | 6 | 1296 | 972 | 32.4 | 36.0 | 43.2 | 48.0 |
| 5 | 64-QAM | 2/3 | 6 | 108 | 6 | 1944 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 6 | 64-QAM | 3/4 | 6 | 108 | 6 | 1944 | 1458 | 48.6 | 54.0 | 64.8 | 72.0 |
| 7 | 64-QAM | 5/6 | 6 | 108 | 6 | 1944 | 1620 | 54.0 | 60.0 | 72.0 | 80.0 |
| 8 | 256-QAM | 3/4 | 8 | 108 | 6 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 9 | 256-QAM | 5/6 | 8 | 108 | 6 | 2592 | 2160 | 72.0 | 80.0 | 96.0 | 106.7 |

Table 23-33 - TVHT MCSs for TVHT\_MODE\_1, NSS = 4

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 6 or 7 MHz | | Data rate (Mb/s) for 8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 108 | 6 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 1 | QPSK | 1/2 | 2 | 108 | 6 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 2 | QPSK | 3/4 | 2 | 108 | 6 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 3 | 16-QAM | 1/2 | 4 | 108 | 6 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 4 | 16-QAM | 3/4 | 4 | 108 | 6 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 5 | 64-QAM | 2/3 | 6 | 108 | 6 | 2592 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 6 | 64-QAM | 3/4 | 6 | 108 | 6 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 7 | 64-QAM | 5/6 | 6 | 108 | 6 | 2592 | 2160 | 72.0 | 80.0 | 96.0 | 106.7 |
| 8 | 256-QAM | 3/4 | 8 | 108 | 6 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 9 | 256-QAM | 5/6 | 8 | 108 | 6 | 3456 | 2880 | 96.0 | 106.7 | 128.0 | 142.2 |

Table 23-34 - TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 1

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 12/14 MHz or 6+6/7+7 MHz | | Data rate (Mb/s) for 16 MHz or 8+8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 216 | 12 | 216 | 108 | 3.6 | 4.0 | 4.8 | 5.3 |
| 1 | QPSK | 1/2 | 2 | 216 | 12 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 2 | QPSK | 3/4 | 2 | 216 | 12 | 432 | 324 | 10.8 | 12.0 | 14.4 | 16.0 |
| 3 | 16-QAM | 1/2 | 4 | 216 | 12 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 4 | 16-QAM | 3/4 | 4 | 216 | 12 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 5 | 64-QAM | 2/3 | 6 | 216 | 12 | 1296 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 6 | 64-QAM | 3/4 | 6 | 216 | 12 | 1296 | 972 | 32.4 | 36.0 | 43.2 | 48.0 |
| 7 | 64-QAM | 5/6 | 6 | 216 | 12 | 1296 | 1080 | 36.0 | 40.0 | 48.0 | 53.3 |
| 8 | 256-QAM | 3/4 | 8 | 216 | 12 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 9 | 256-QAM | 5/6 | 8 | 216 | 12 | 1728 | 1440 | 48.0 | 53.3 | 64.0 | 71.1 |

Table 23-35 - TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 2

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 12/14 MHz or 6+6/7+7 MHz | | Data rate (Mb/s) for 16 MHz or 8+8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 216 | 12 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 1 | QPSK | 1/2 | 2 | 216 | 12 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 2 | QPSK | 3/4 | 2 | 216 | 12 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 3 | 16-QAM | 1/2 | 4 | 216 | 12 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 4 | 16-QAM | 3/4 | 4 | 216 | 12 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 5 | 64-QAM | 2/3 | 6 | 216 | 12 | 2592 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 6 | 64-QAM | 3/4 | 6 | 216 | 12 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 7 | 64-QAM | 5/6 | 6 | 216 | 12 | 2592 | 2160 | 72.0 | 80.0 | 96.0 | 106.7 |
| 8 | 256-QAM | 3/4 | 8 | 216 | 12 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 9 | 256-QAM | 5/6 | 8 | 216 | 12 | 3456 | 2880 | 96.0 | 106.7 | 128.0 | 142.2 |

Table 23-36 - TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 3

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 12/14 MHz or 6+6/7+7 MHz | | Data rate (Mb/s) for 16 MHz or 8+8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 216 | 12 | 648 | 324 | 10.8 | 12.0 | 14.4 | 16.0 |
| 1 | QPSK | 1/2 | 2 | 216 | 12 | 1296 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 2 | QPSK | 3/4 | 2 | 216 | 12 | 1296 | 972 | 32.4 | 36.0 | 43.2 | 48.0 |
| 3 | 16-QAM | 1/2 | 4 | 216 | 12 | 2592 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 4 | 16-QAM | 3/4 | 4 | 216 | 12 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 5 | 64-QAM | 2/3 | 6 | 216 | 12 | 3888 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 6 | 64-QAM | 3/4 | 6 | 216 | 12 | 3888 | 2916 | 97.2 | 108.0 | 129.6 | 144.0 |
| 7 | 64-QAM | 5/6 | 6 | 216 | 12 | 3888 | 3240 | 108.0 | 120.0 | 144.0 | 160.0 |
| 8 | 256-QAM | 3/4 | 8 | 216 | 12 | 5184 | 3888 | 129.6 | 144.0 | 172.8 | 192.0 |
| 9 | 256-QAM | 5/6 | 8 | 216 | 12 | 5184 | 4320 | 144.0 | 160.0 | 192.0 | 213.3 |

Table 23-37 - TVHT MCSs for TVHT\_MODE\_2C and TVHT\_MODE\_2N, NSS = 4

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 12/14 MHz or 6+6/7+7 MHz | | Data rate (Mb/s) for 16 MHz or 8+8 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 216 | 12 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 1 | QPSK | 1/2 | 2 | 216 | 12 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 2 | QPSK | 3/4 | 2 | 216 | 12 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 3 | 16-QAM | 1/2 | 4 | 216 | 12 | 3456 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 4 | 16-QAM | 3/4 | 4 | 216 | 12 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 5 | 64-QAM | 2/3 | 6 | 216 | 12 | 5184 | 3456 | 115.2 | 128.0 | 153.6 | 170.7 |
| 6 | 64-QAM | 3/4 | 6 | 216 | 12 | 5184 | 3888 | 129.6 | 144.0 | 172.8 | 192.0 |
| 7 | 64-QAM | 5/6 | 6 | 216 | 12 | 5184 | 4320 | 144.0 | 160.0 | 192.0 | 213.3 |
| 8 | 256-QAM | 3/4 | 8 | 216 | 12 | 6912 | 5184 | 172.8 | 192.0 | 230.4 | 256.0 |
| 9 | 256-QAM | 5/6 | 8 | 216 | 12 | 6912 | 5760 | 192.0 | 213.3 | 256.0 | 284.4 |

Table 23-38 - TVHT MCSs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS = 1

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 24/28 MHz or 12+12/14+14 MHz | | Data rate (Mb/s) for 32 MHz or 16+16 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 432 | 24 | 432 | 216 | 7.2 | 8.0 | 9.6 | 10.7 |
| 1 | QPSK | 1/2 | 2 | 432 | 24 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 2 | QPSK | 3/4 | 2 | 432 | 24 | 864 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 3 | 16-QAM | 1/2 | 4 | 432 | 24 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 4 | 16-QAM | 3/4 | 4 | 432 | 24 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 5 | 64-QAM | 2/3 | 6 | 432 | 24 | 2592 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 6 | 64-QAM | 3/4 | 6 | 432 | 24 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 7 | 64-QAM | 5/6 | 6 | 432 | 24 | 2592 | 2160 | 72.0 | 80.0 | 96.0 | 106.7 |
| 8 | 256-QAM | 3/4 | 8 | 432 | 24 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 9 | 256-QAM | 5/6 | 8 | 432 | 24 | 3456 | 2880 | 96.0 | 106.7 | 128.0 | 142.2 |

Table 23-39 - TVHT MCSs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS = 2

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 24/28 MHz or 12+12/14+14 MHz | | Data rate (Mb/s) for 32 MHz or 16+16 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 432 | 24 | 864 | 432 | 14.4 | 16.0 | 19.2 | 21.3 |
| 1 | QPSK | 1/2 | 2 | 432 | 24 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 2 | QPSK | 3/4 | 2 | 432 | 24 | 1728 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 3 | 16-QAM | 1/2 | 4 | 432 | 24 | 3456 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 4 | 16-QAM | 3/4 | 4 | 432 | 24 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 5 | 64-QAM | 2/3 | 6 | 432 | 24 | 5184 | 3456 | 115.2 | 128.0 | 153.6 | 170.7 |
| 6 | 64-QAM | 3/4 | 6 | 432 | 24 | 5184 | 3888 | 129.6 | 144.0 | 172.8 | 192.0 |
| 7 | 64-QAM | 5/6 | 6 | 432 | 24 | 5184 | 4320 | 144.0 | 160.0 | 192.0 | 213.3 |
| 8 | 256-QAM | 3/4 | 8 | 432 | 24 | 6912 | 5184 | 172.8 | 192.0 | 230.4 | 256.0 |
| 9 | 256-QAM | 5/6 | 8 | 432 | 24 | 6912 | 5760 | 192.0 | 213.3 | 256.0 | 284.4 |

Table 23-40 - TVHT MCSs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS = 3

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 24/28 MHz or 12+12/14+14 MHz | | Data rate (Mb/s) for 32 MHz or 16+16 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 432 | 24 | 1296 | 648 | 21.6 | 24.0 | 28.8 | 32.0 |
| 1 | QPSK | 1/2 | 2 | 432 | 24 | 2592 | 1296 | 43.2 | 48.0 | 57.6 | 64.0 |
| 2 | QPSK | 3/4 | 2 | 432 | 24 | 2592 | 1944 | 64.8 | 72.0 | 86.4 | 96.0 |
| 3 | 16-QAM | 1/2 | 4 | 432 | 24 | 5184 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 4 | 16-QAM | 3/4 | 4 | 432 | 24 | 5184 | 3888 | 129.6 | 144.0 | 172.8 | 192.0 |
| 5 | 64-QAM | 2/3 | 6 | 432 | 24 | 7776 | 5184 | 172.8 | 192.0 | 230.4 | 256.0 |
| 6 | 64-QAM | 3/4 | 6 | 432 | 24 | 7776 | 5832 | 194.4 | 216.0 | 259.2 | 288.0 |
| 7 | 64-QAM | 5/6 | 6 | 432 | 24 | 7776 | 6480 | 216.0 | 240.0 | 288.0 | 320.0 |
| 8 | 256-QAM | 3/4 | 8 | 432 | 24 | 10368 | 7776 | 259.2 | 288.0 | 345.6 | 384.0 |
| 9 | 256-QAM | 5/6 | 8 | 432 | 24 | 10368 | 8640 | 288.0 | 320.0 | 384.0 | 426.7 |

Table 23-41 - TVHT MCSs for TVHT\_MODE\_4C and TVHT\_MODE\_4N, NSS = 4

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MCS Index | Modula- tion | *R* | *NBPSCS* | *NSD·NSeg* | *NSP* | *NCBPS* | *NDBPS* | Data rate (Mb/s) for 24/28 MHz or 12+12/14+14 MHz | | Data rate (Mb/s) for 32 MHz or 16+16 MHz | |
| 6.0 us GI | 3.0 us GI | 4.5 us GI | 2.25 us GI |
| 0 | BPSK | 1/2 | 1 | 432 | 24 | 1728 | 864 | 28.8 | 32.0 | 38.4 | 42.7 |
| 1 | QPSK | 1/2 | 2 | 432 | 24 | 3456 | 1728 | 57.6 | 64.0 | 76.8 | 85.3 |
| 2 | QPSK | 3/4 | 2 | 432 | 24 | 3456 | 2592 | 86.4 | 96.0 | 115.2 | 128.0 |
| 3 | 16-QAM | 1/2 | 4 | 432 | 24 | 6912 | 3456 | 115.2 | 128.0 | 153.6 | 170.7 |
| 4 | 16-QAM | 3/4 | 4 | 432 | 24 | 6912 | 5184 | 172.8 | 192.0 | 230.4 | 256.0 |
| 5 | 64-QAM | 2/3 | 6 | 432 | 24 | 10368 | 6912 | 230.4 | 256.0 | 307.2 | 341.3 |
| 6 | 64-QAM | 3/4 | 6 | 432 | 24 | 10368 | 7776 | 259.2 | 288.0 | 345.6 | 384.0 |
| 7 | 64-QAM | 5/6 | 6 | 432 | 24 | 10368 | 8640 | 288.0 | 320.0 | 384.0 | 426.7 |
| 8 | 256-QAM | 3/4 | 8 | 432 | 24 | 13824 | 10368 | 345.6 | 384.0 | 460.8 | 512.0 |
| 9 | 256-QAM | 5/6 | 8 | 432 | 24 | 13824 | 11520 | 384.0 | 426.7 | 512.0 | 568.9 |

* 1. VHT PMD sublayer
     1. Scope and field of application

(See 22.6.1 (Scope and field of application))

* + 1. Overview of service

(See 22.6.2 (Overview of service) with TVHT replacing VHT)

* + 1. Overview of interactions

(See 22.6.3 (Overview of interactions) with TVHT replacing VHT)

* + 1. Basic service and options
       1. Status of service primitives

(See 22.6.4.1 (Status of service primitives))

* + - 1. PMD\_SAP peer-to-peer service primitives

(See 22.6.4.2 (PMD\_SAP peer-to-peer service primitives))

* + - 1. PMD\_SAP sublayer-to-sublayer service primitives

(See 22.6.4.3 (PMD\_SAP sublayer-to-sublayer service primitives))

* + - 1. PMD\_SAP service primitive parameters

Table 23-64 (List of parameters for PMD primitives) shows the parameters used by one or more of the PMD\_SAP service primitives.

|  |  |  |
| --- | --- | --- |
| Table 23-64 - List of parameters for PMD primitives | | |
| Parameter | Associated primitive | Value |
| TXD\_UNIT | PMD\_DATA.request | One OFDM symbol value, *NCBPS* bits. See NOTE. |
| RXD\_UNIT | PMD\_DATA.indication | One OFDM symbol value, *NCBPS* bits See NOTE. |
| TXPWR\_LEVEL | PMD\_TXPWRLVL.request | 1 to 128 (maximum of 128 levels) |
| MCS | PMD\_TX\_PARAMETERS.request | 0 to 9, MCS index defined in 23.5 (Parameters for TVHT MCSs). See NOTE. |
| NUM\_STS | PMD\_TX\_PARAMETERS.request | Indicates the number of space-time streams  Range 1-4 for SU, 0-3 for MU. See NOTE. |
| CH\_BANDWIDTH | PMD\_TX\_PARAMETERS.request  PMD\_CBW.indication | The CH\_BANDWIDTH parameter indicates the channel width of the transmitted PPDU:  Enumerated type:  TVHT\_W for the basic channel unit (6 MHz, 7 MHz, or 8 MHz)  TVHT\_2W for two contiguous basic channel units (12 MHz, 14 MHz or 16 MHz),  TVHT\_4W for four contiguous basic channel units (24 MHz, 28 MHz, or 32 MHz)  TVHT\_W+W for two non-contiguous basic channel units (6+6 MHz, 7+7 MHz, or 8+8 MHz)  TVHT\_2W+2W for two non-contiguous frequency sections whereby each frequency section is comprised of two contiguous basic channel units (12+12 MHz, 14+14 MHz, or 16+16 MHz)  NOTE—In the case of PMD\_CBW.indication, this parameter provides an estimate of the channel  Width. |
| STBC | PMD\_TX\_PARAMETERS.request | Set to 0 indicates no STBC (*NSTS*=*NSS*)  Set to 1 indicates *NSTS*=2*NSS* |
| GI\_TYPE | PMD\_TX\_PARAMETERS.request | Set to 0 indicates short GI is not used in the PPDU  Set to 1 indicates short GI is used in the PPDU and the Short GI NSYM Disambiguation field in TVHT-SIG-A2 is 0  Set to 2 indicates short GI is used in the PPDU and the Short GI NSYM Disambiguation field in TVHT-SIG-A2 is 1 |
| FEC\_CODING | PMD\_TX\_PARAMETERS.request | Indicates which FEC encoding is used.  Enumerated type:  BCC\_CODING indicates binary convolutional code.  LDPC\_CODING\_0 indicates low-density parity check code and the LDPC Extra OFDM Symbol field in TVHT-SIG-A2 is 0.  LDPC\_CODING\_1 indicates low-density parity check code and the LDPC Extra OFDM Symbol field in TVHT-SIG-A2 is 1. |
| GROUP\_ID | PMD\_TX\_PARAMETERS.request | 0-63; value indicates SU or MU (see 9.17a (Group ID and partial AID in VHT PPDUs)) |
| PARTIAL\_AID | PMD\_TX\_PARAMETERS.request | Provides an abbreviated indication of the intended recipient(s) of the frame (see 9.17a (Group ID and partial AID in VHT PPDUs)).  Integer: range 0-511. |
| CHAN\_MAT | PMD\_CHAN\_MAT.indication | *NSD* complex matrices of size *NRX* × *NSTS* |
| RSSI | PMD\_RSSI.indication | 0 to 255 |
| RCPI | PMD\_RCPI.indication | 0 to 255; see 20.3.21.6 (Received channel power indicator (RCPI) measurement) for definition of each value. |
| FORMAT | PMD\_FORMAT.indication | Set to 0 for NON\_HT  Set to 4 for TVHT |
| EXPANSION\_MAT | PMD\_TX\_PARAMETERS.request | *NSD* complex matrices of size *NTX* × *NSTS* |
| NOTE—These parameters are present for one user for an SU PPDU and present per user for an MU PPDU. They are conceptually supplied as an array of values indexed by *u*, where *u* takes values 1 to NUM\_USERS. | | |

* + 1. PMD\_SAP detailed service specification
       1. Introduction to PMD\_SAP service specification

(See 22.6.5.1 (Introduction to PMD\_SAP service specification))

* + - 1. PMD\_DATA.request

(See 22.6.5.2 (PMD\_DATA.request))

* + - 1. PMD\_DATA.indication

(See 22.6.5.3 (PMD\_DATA.indication))

* + - 1. PMD\_TXSTART.request

(See 22.6.5.4 (PMD\_TXSTART.request))

* + - 1. PMD\_TXEND.request

(See 22.6.5.5 (PMD\_TXEND.request))

* + - 1. PMD\_TXEND.confirm

(See 22.6.5.6 (PMD\_TXEND.confirm))

* + - 1. PMD\_TXPWRLVL.request

(See 22.6.5.7 (PMD\_TXPWRLVL.request))

* + - 1. PMD\_RSSI.indication

(See 22.6.5.8 (PMD\_RSSI.indication) with TVHT replacing VHT)

* + - 1. PMD\_RCPI.indication

(See 22.6.5.9 (PMD\_RCPI.indication) with TVHT replacing VHT)

* + - 1. PMD\_TX\_PARAMETERS.request

(See 22.6.5.10 (PMD\_TX\_PARAMETERS.request))

* + - 1. PMD\_CHAN\_MAT.indication

(See 22.6.5.11 (PMD\_CHAN\_MAT.indication))

* + - 1. PMD\_FORMAT.indication

(See 22.6.5.12 (PMD\_FORMAT.indication) with TVHT replacing VHT)

* + - 1. PMD\_CBW.indication

23.6.5.13.1 Function

This primitive, generated by the PMD sublayer, provides an estimate of the bandwidth of the received PPDU to the PLCP.

NOTE— The bandwidth is determined by estimation, not by inspection of the signal fields or scrambling sequence. The PLCP is able to determine bandwidth from the header of TVHT PPDUs, or from the scrambling sequence of NON\_HT\_DUPLICATE PPDUs.

* + - * 1. Semantics of the service primitive

This primitive shall provide the following parameter: PMD\_CBW.indication(CH\_BANDWIDTH)

CH\_BANDWIDTH represents an estimate of the channel width in which the data are transmitted.

* + - * 1. When generated

(See 22.6.5.13.3 (When generated))

* + - * 1. Effect of receipt

(See 22.6.5.13.4 (Effect of receipt))