IEEE P802.11
Wireless LANs

|  |
| --- |
| Comment Resolution for CIDs on PHY Transmit Spec. |
| Date: 2016-09-12 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Daewon Lee | Newracom | 9008 Research Dr.Irvine CA 92618 | +1 (678) 294-2598 | daewon.lee at newracom.com |
| Yujin Noh | Newracom | 9008 Research Dr.Irvine CA 92618 |  | yujin.noh at newracom.com |
| Minho Cheong | Newracom | 9008 Research Dr.Irvine CA 92618 |  | minho.cheong at newracom.com |
| Yongho Seok | Newracom | 9008 Research Dr.Irvine, CA 92618 |  | yongho.seok@newracom.com |
| Young Hoon Kwon | Newracom | 9008 Research Dr.Irvine, CA 92618 |  | younghoon.kwon@newracom.com |
| Reza Hedayat | Newracom | 9008 Research Dr.Irvine, CA 92618 |  | reza.hedayat@newracom.com |
| Minho Cheong | Newracom | 9008 Research Dr.Irvine, CA 92618 |  | minho.cheong@newracom.com |
| Ilan Sutskover | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | ilan.sutskover@intel.com |
| Robert Stacey | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA | +1-503-724-893 | robert.stacey@intel.com |
| Shahrnaz Azizi | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | shahrnaz.azizi@intel.com |
| Po-Kai Huang | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | po-kai.huang@intel.com |
| Qinghua Li | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | quinghua.li@intel.com |
| Xiaogang Chen | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | xiaogang.c.chen@intel.com |
| Chitto Ghosh | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | chittabrata.ghosh@intel.com |
| Laurent Cariou | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | laurent.cariou@intel.com |
| Yaron Alpert | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | yaron.alpert@intel.com |
| Assaf Gurevitz | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | assaf.gurevitz@intel.com |
| Feng Jiang | Intel | 2111 NE 25th Ave, Hillsboro OR 97124, USA |  | feng1.jiang@intel.com |
| Bin Tian | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | btian@qti.qualcomm.com |
| Lin Yang | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | linyang@qti.qualcomm.com |
| Alice Chen | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | alicel@qti.qualcomm.com |
| Albert Van Zelst | Qualcomm | Straatweg 66-S Breukelen, 3621 BR Netherlands |  | allert@qti.qualcomm.com |
| Alfred Asterjadhi | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | aasterja@qti.qualcomm.com |
| Carlos Aldana | Qualcomm | 1700 Technology Drive San Jose, CA 95110, USA |  | caldana@qca.qualcomm.com |
| George Cherian | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | gcherian@qti.qualcomm.com |
| Gwendolyn Barriac | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | gbarriac@qti.qualcomm.com |
| Hemanth Sampath | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | hsampath@qti.qualcomm.com |
| Lochan Verma | Qualcomm | 5775 Morehouse Dr. San Diego, CA USA |  | lverma@qti.qualcomm.com |
| Menzo Wentink | Qualcomm | Straatweg 66-S Breukelen, 3621 BR Netherlands |  | mwentink@qti.qualcomm.com |
| Naveen Kakani | Qualcomm | 2100 Lakeside BoulevardSuite 475, RichardsonTX 75082, USA |  | nkakani@qti.qualcomm.com |
| Raja Banerjea | Qualcomm | 1060 Rincon Circle San JoseCA 95131, USA |  | rajab@qit.qualcomm.com |
| Richard Van Nee | Qualcomm | Straatweg 66-S Breukelen, 3621 BR Netherlands |  | rvannee@qti.qualcomm.com |
| Rolf De Vegt | Qualcomm | 1700 Technology Drive San Jose, CA 95110, USA |  | rolfv@qca.qualcomm.com |
| Sameer Vermani | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | svverman@qti.qualcomm.com |
| Simone Merlin | Qualcomm | 5775 Morehouse Dr. San Diego, CA, USA |  | smerlin@qti.qualcomm.com |
| Tevfik Yucek | Qualcomm | 1700 Technology Drive San Jose, CA 95110, USA |  | tyucek@qca.qualcomm.com |
| VK Jones | Qualcomm | 1700 Technology Drive San Jose, CA 95110, USA |  | vkjones@qca.qualcomm.com |
| Youhan Kim | Qualcomm | 1700 Technology Drive San Jose, CA 95110, USA |  | youhank@qca.qualcomm.com |

Abstract

This document contain comment resolutions for CID 538, 496, 497, 498, 499, 344, 501, 1026, 1115, 2351, 500.

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 TGax Draft. This introduction is not part of the adopted material.

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

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **CID** | **Commenter** | **Clause Number(C)** | **Page(C)** | **Line(C)** | **Comment** | **Proposed Change** | **Resolution** |
| 538 | Eunsung Park | 26.3.13.4.3 | 158 | 28 | We need to include a table for allowed relative constellation error versus constellation size and coding rate. | Include a table for allowed relative constellation error versus constellation size and coding rate. For 1024 QAM with 3/4 and 5/6 of code rate, allowed relative constellation error is -35dB (PHY Motion 113 [11-15/1516r3]). | REVISEEven the EVM values for BPSK, QPSK, 16QAM, and 256QAM is missing. Add EVM requirement table for all constellation sizes.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 496 | Daewon Lee | 26.3.13.4.3 | 158 | 27 | content for transmit EVM is missing. Add content | as commented | REVISED.Add EVM requirement table for all constellation sizes.(Note: resolution is identical to CID 538)*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 497 | Daewon Lee | 26.3.13.1 | 158 | 4 | spectral mask section is missing. Add content | as commented | REVISED.Added the spectral mask definitions for HE PPDU according to TGax PHY Motion #76.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 498 | Daewon Lee | 26.3.13.2 | 158 | 6 | spectral flatness section is missing. Add content. It should be noted that spectral flatness defintion from 11ac cannot be directly used due to OFDMA transmission characteristics. An updated requirement may be needed for MU transmissions. | as commented | REVISED.Spectral flatness definition should apply to HE PPDU without any RU boosting. Add the spectral flatness requirement for HE PPDU.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 499 | Daewon Lee | 26.3.13.3 | 158 | 8 | actual torelance levels is missing. Add content | as commented | REVISED.Add text that the symbol clock frequency and transmit center frequency maximum tolerance shall be ±20 ppm.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 344 | Bin Tian | 26.3.13.1 | 158 | 3 | IEEE PHY Motion #76 regarding 11ax spectral mask for non-OFDMA was approved but no corresponding spec text is present in the draft | please add | REVISED.Added the spectral mask definitions for HE PPDU according to TGax PHY Motion #76.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec(Note: This is the same comment resolution as CID 497) |
| 501 | Daewon Lee | 26.3.13.4.1 | 158 | 17 | introduction for modulation accuracy section is missing. Add content | as commented | REVISED.Add EVM requirement table for all constellation sizes.(Note: resolution is identical to CID 538)*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 1026 | Kazuyuki Sakoda | 26.3.13.3 | 158 | 13 | For UL MU operation, non-AP STA needs to maintain higher resolution of transmit center frequency and symbol clock frequency. The requirements for AP and non-AP STA should be different. Also, regarding non-AP STA transmit specification, requirements for (1) non-MU transmission, (2) OFDMA transmission, and (3) UL MU-MIMO transmission could be different. Transmit specification for all of these cases should be specified. | 1. Create subclauses under 26.3.13.3 (Transmit center frequency and symbol clock frequency tolerance) as follows:(a) spec for AP STA, IBSS STA, and mesh STA.(b) spec for non-AP STA in an HE infrastructure BSS applied to non-MU transmission(c) spec for non-AP STA in an HE infrastructure BSS applied to OFDMA transmission(d) spec for non-AP STA in an HE infrastructure BSS applied to MU-MIMO transmission.2. define Transmit center frequency and symbol clock frequency tolerance for each cases above. | Revise.For UL MU operation two types of STAs are defined, class A and class B. Different class STAs have different requirements. See PHY motion 120. However, the different class STAs differ in measurement accuracy and transmit power accuracy. Whether TGax requires four different tolerance values should be subject to discussion and requires an IEEE contribution.It is clarified that additional requirement for trigger-based PPDU is defined in 26.3.14 (Transmit requirements for an HE trigger-based PPDU)*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |
| 1115 | Koichi Ishihara | 26.3.13.1 | 158 | 3 | Transmit spectral masks at each bandwidth are not mentioned in the current draft although these are defined in SFD. | Transmit spectral masks at each bandwidth should be defined as in SFD. | REVISED.Added the spectral mask definitions for HE PPDU according to TGax PHY Motion #76.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec(Note: This is the same comment resolution as CID 497) |
| 2351 | Yasuhiko Inoue | 26.3.13.1 | 158 | 3 | Since 802.11ax introduces a new OFDM PHY, the spectrum mask has to be specified. | Add the figures of spectrum mask contained in the latest version of the TGax SFD. | REVISED.Added the spectral mask definitions for HE PPDU according to TGax PHY Motion #76.*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec(Note: This is the same comment resolution as CID 497) |
| 500 | Daewon Lee | 26.3.13.4 | 158 | 14 | modulation accuracy is missing. Add content | as commented | REVISED.Add EVM requirement table for all constellation sizes.(Note: resolution is identical to CID 538)*TGax Editor*: make changes as in 11-16-xxxx-00-00ax CR-for-CID-on-PHY-trasmit-spec |

**Discussion:**

Proposed resolutions for CIDs 538, 496, 497, 498, 499, 344, 501, 1026, 1115, 2351, and 500.

**Proposed Text Changes:**

------------- Begin Text Changes ---------------

26.3.13 Transmit specification

26.3.13.1 Transmit spectral mask

NOTE 1—In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements and the mask defined in this subclause.

NOTE 2—Transmit spectral mask figures in this subclause are not drawn to scale.

NOTE 3—For rules regarding TX center frequency leakage levels, see 26.3.13.4.2 (Transmit center frequency leakage). The spectral mask requirements in this subclause do not apply to the RF LO.

Bandwidth of the spectral mask PPDU shall be determined by the bandwidth indicated by the bandwidth subfield of HE-SIG-A field. All HE PPDU formats shall be compliant with the transmit spectral mask described in this section.

For a 20 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 19.5 MHz, –20 dBr at 10.25 MHz frequency offset, –28 dBr at 20 MHz frequency offset, and –40 dBr at 30 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 9.75 and 10.25 MHz, 10.25 and 20 MHz, and 20 and 30 MHz shall be linearly interpolated in dB domain from the requirements for 9.75 MHz, 10.25 MHz, 20 MHz, and 30 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and –53 dBm/MHz at any frequency offset. Figure 26-X (Example transmit spectral mask for a 20 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –53 dBm/MHz.



Figure 26-X—Example transmit spectral mask for a 20 MHz mask PPDU

For a 40 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 39 MHz, –20 dBr at 20.5 MHz frequency offset, –28 dBr at 40 MHz frequency offset, and –40 dBr at 60 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 19.5 and 20.5 MHz, 20.5 and 40 MHz, and 40 and 60 MHz shall be linearly interpolated in dB domain from the requirements for 19.5 MHz, 20.5 MHz, 40 MHz, and 60 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and –56 dBm/MHz at any frequency offset greater than 19.5 MHz. Figure 26-X (Example transmit spectral mask for a 40 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –56 dBm/MHz.



Figure 26-X—Example transmit spectral mask for a 40 MHz mask PPDU

For an 80 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 79 MHz, –20 dBr at 40.5 MHz frequency offset, –28 dBr at 80 MHz frequency offset, and –40 dBr at 120 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 39.5 and 40.5 MHz, 40.5 and 80 MHz, and 80 and 120 MHz shall be linearly interpolated in dB domain from the requirements for 39.5 MHz, 40.5 MHz, 80 MHz, and 120 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 26-X (Example transmit spectral mask for an 80 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.



Figure 26-X—Example transmit spectral mask for a 80 MHz mask PPDU

For a 160 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 159 MHz, –20 dBr at 80.5 MHz frequency offset, –28 dBr at 160 MHz frequency offset, and –40 dBr at 240 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 79.5 and 80.5 MHz, 80.5 and 160 MHz, and 160 and 240 MHz shall be linearly interpolated in dB domain from the requirements for 79.5 MHz, 80.5 MHz, 160 MHz, and 240 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 26-X (Example transmit spectral mask for a 160 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.



Figure 26-X—Example transmit spectral mask for a 160 MHz mask PPDU

For an 80+80 MHz mask PPDU of HE format, the overall transmit spectral mask is constructed in the following manner. First, the 80 MHz interim spectral mask is placed on each of the two 80 MHz segments. Then, for each frequency at which both of the 80 MHz interim spectral masks have values greater than –40 dBr and less than –20 dBr, the sum of the two interim mask values (summed in linear domain) shall be taken as the overall spectral mask value. Next, for each frequency at which neither of the two 80 MHz interim masks have values greater than or equal to –20 dBr and less than or equal to 0 dBr, the higher value of the two interim masks shall be taken as the overall interim spectral value. Finally, for any frequency region where the mask value has not been defined yet, linear interpolation (in dB domain) between the nearest two frequency points with the interim spectral mask value defined shall be used to define the interim spectral mask value. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 26-X (Example transmit spectral mask for an 80+80 MHz mask PPDU) shows an example of a transmit spectral mask for a noncontiguous transmission using two 80 MHz channels where the center frequency of the two 80 MHz channels are separated by 160 MHz and the –40 dBr spectrum level is above –59 dBm/MHz.

Different center frequency separation between the two 80 MHz frequency segments of the spectral mask as well as different peak levels of each 80 MHz frequency segment of the spectral mask are possible, in which case a similar procedure in determining the spectral mask as in Figure 26-X (Example transmit spectral mask for an 80+80 MHz mask PPDU) is followed.

The transmit spectral mask for noncontiguous transmissions using two nonadjacent 80 MHz channels is applicable only in regulatory domains that allow for such transmissions.



Figure 26-X—Example transmit spectral mask for a 80+80 MHz mask PPDU

Measurements shall be made using a 25 kHz resolution bandwidthand a 7.5 kHz video bandwidth.

26.3.13.2 Spectral flatness

Spectral flatness measurements shall be conducted using BPSK modulated HE PPDUs. Demodulate the HE PPDUs according to the following (or equivalent) procedure:

1. Start of PPDU shall be detected.
2. Transition from L-STF to L-LTF shall be detected and fine timing shall be established.
3. Coarse and fine frequency offsets shall be estimated.
4. Symbols in a PPDU shall be manipulated to account for both frequency error and timing drift error.
5. For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase.
6. For each of the data OFDM symbols: transform the symbol into subcarrier received values.

The spectral flatness test shall be performed over at least 20 HE PPDUs. The PPDUs under test shall be at least

16 data OFDM symbols long.

Evaluate spectral flatness using the subcarrier received values or the magnitude of the channel estimation of the occupied subcarriers of the transmissted HE PPDUs. Non-occupied subcarriers of the transmitted HE PPDUs shall be ignored during averaging and testing. Resource unit power boosting and beamforming should not be used when measuring spectral flatness.

Let *Ei,avg* denote the magnitude of the channel estimation on subcarrier *i* or the average constellation energy of a BPSK modulated subcarrier *i* in a HE data symbol. In a contiguous HE transmission having a bandwidth listed in Table 26-Y (Maximum transmit spectral flatness deviations), *Ei,avg* of each of the subcarriers with indices listed as tested subcarrier indices shall not deviate by more than the specified maximum deviation in Table 26-X (Maximum transmit spectral flatness deviations) from the average of *Ei,avg* over subcarrier indices listed as averaging subcarrier indices. Averaging of *Ei,avg* is done in the linear domain.

|  |
| --- |
| Table 26-X— Maximum transmit spectral flatness deviations(11ac) |
| Format | Bandwidth of transmission (MHz) | Averaging subcarrier indices (inclusive) | Tested subcarrier indices (inclusive) | Maximum deviation (dB) |
| HE PPDUI | 20 | –84 to –2 and +2 to +84 | –84 to –2 and +2 to +84 | ±4 |
| –122 to –85 and +85 to +122 | +4/–6 |
| 40 | –168 to –3 and +3 to +168 | –168 to –3 and +3 to +168 | ±4 |
| –244 to –169 and +169 to +244 | +4/–6 |
| 80 | –344 to –3 and +3 to +3441 | –344 to –3 and +3 to +344 | ±4 |
| –500 to –345 and +345 to +500 | +4/–6 |
| 160 | –696 to –515, –509 to –166, +166 to +509, and +515 to +696 | –696 to –515, –509 to –166, +166 to +509, and +515 to +696 | ±4 |
| –1012 to –697, –165 to –12, +12 to +165, and +697 to +1012 | +4/–6 |

In an 80+80 MHz transmission, each segment shall meet the spectral flatness requirement for an 80 MHz transmission.

For the spectral flatness test, the transmitting STA shall be configured to use a spatial mapping matrix *Qk* (see 26.3.10.13 (OFDM modulation)) with flat frequency response. Each output port under test of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz transmissions.

26.3.13.3 Transmit center frequency and symbol clock frequency tolerance

Transmit center frequency and the symbol clock frequency for all transmit antennas and frequency segments shall be derived from the same reference oscillator. The symbol clock frequency and transmit center frequency maximum tolerance shall be ±20 ppm. HE trigger-based PPDU format is subject to additional requirements as defined in 26.3.14 (Transmit requirements for an HE trigger-based PPDU).

26.3.13.4 Modulation accuracy

26.3.13.4.1 Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 26.3.13.4.2 (Transmit center frequency leakage) and 26.3.13.3 (Transmitter constellation error). The test method is described in 26.3.13.4 (Transmitter modulation accuracy (EVM) test).

26.3.13.4.2 Transmit center frequency leakage

The TX LO leakage requirement for all transmission modes shall be the following. The power measured at

the location of the RF LO using resolution BW 78.125 kHz shall not exceed the maximum of –32 dB

relative to the total transmit power and –20 dBm, or equivalently max(P–32, –20), where P is the transmit

power per antenna in dBm. The transmit center frequency leakage is specified per antenna.

For an 80+80 MHz transmission where the RF LO falls outside both frequency segments, the RF LO shall additionally met the spectral mask requirements as defined in 26.3.13.1 (Transmit spectrum mask).

26.3.13.4.3 Transmitter constellation error

The relative constellation RMS error, calculated by first averaging over subcarriers, frequency segments, HE PPDUs, and spatial streams (see Equation (26-X)) shall not exceed a data-rate dependent value according to Table 26-Y (Allowed relative constellation error versus constellation size and coding rate). The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized testing instrumentation input ports. In the test, *NSS = NSTS* (no STBC) shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz noncontiguous transmissions.

|  |
| --- |
| Table 26-Y—Allowed relative constellation error versus constellation size and coding rate(11ac) |
| Modulation | Coding rate | Relative constellation error in HE SU PPDU, HE Extended SU PPDUHE SU, and HE MU PPDU without preamble puncturing (dB) | Relative constellation error in HE MU PPDU with preambling puncturing and HE Trigger-based PPDU (dB) |
| Without DCM | With DCM |
| N/A | BPSK | 1/2 | –5 | TBD |
| BPSK | QPSK | 1/2 | –5 | TBD |
| QPSK | 16-QAM | 1/2 | –10 | TBD |
| QPSK | 16-QAM | 3/4 | –13 | TBD |
| 16-QAM | N/A | 1/2 | –16 | TBD |
| 16-QAM | N/A | 3/4 | –19 | TBD |
| 64-QAM | N/A | 2/3 | –22 | TBD |
| 64-QAM | N/A | 3/4 | –25 | TBD |
| 64-QAM | N/A | 5/6 | –27 | TBD |
| 256-QAM | N/A | 3/4 | –30 | TBD |
| 256-QAM | N/A | 5/6 | –32 | TBD |
| 1024-QAM | N/A | 3/4 | –35 | TBD |
| 1024-QAM | N/A | 5/6 | –35 | TBD |

**21.3.17.4.4 Transmitter modulation accuracy (EVM) test**

The transmit modulation accuracy test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted; except that

* For noncontiguous transmissions, each frequency segment may be tested independently.

In this case, transmit modulation accuracy of each segment shall meet the required value in Table 26-Y (Allowed relative constellation error versus constellation size and coding rate) using only the occupied data subcarriers within the corresponding segment.

LO leakage that can potentially show up in center frequency of the HE PPDU tone plan and its +/- 3 tone neighbors shall be excluded from the computation of the transmitter modulation accuracy test. The potential LO leakage tones for 20MHz operating devices are the center of primary20 of the HE PPDU tone plan and +/- 3 tones. The potential LO leakage tones for 40MHz operating devices are the center of the primary40 of the PPDU tone plan and +/- 3 tones. For 80MHz capable devices that transmits 20MHz or 40MHz PPDU, the potential LO leakage tone exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

1. Start of PPDU shall be detected.
2. Transition from L-STF to L-LTF shall be detected and fine timing shall be established.
3. Coarse and fine frequency offsets shall be estimated.
4. Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated. Note that amplitude drift shall not be compensated by the testing instrument.
5. For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and derotate the subcarrier values according to the estimated phase.
6. Estimate the complex channel response coefficient for each of the subcarriers and each of the transmit streams.
7. For each of the data OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase, group the results from all of the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel.
8. For each data-carrying subcarrier in each spatial stream of RU under test, find the closest constellation point and compute the Euclidean distance from it.
9. Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (26-X).

 (26-X)

where

*I0*(*if*, *is*, *iss*, *isc*) *Q0*(*if*, *is*, *iss*, *isc*) denotes the ideal symbol point in the complex plane in *isc*-th data tone of the RU under test, spatial stream *iss*, and OFDM symbol is of frame *if*.

*Ie*(*if*, *is*, *iss*, *isc*) *Qe*(*if*, *is*, *iss*, *isc*) denotes the equalized observed symbol point in the complex plane in *isc*-th data tone of the RU under test, spatial stream *iss*, and OFDM symbol is of frame *if*.

*P0* is the average power of constellation

*Nf* is the number of tested frames

*NST* is the number of data tones of the occupied RU

*NSS* is the number of spatial streams of the data

*NSYM* is the number of data OFDM symbols

NOTE1—In the case the transmit modulation accuracy test is performed simultaneously for the two frequency segments of the 80+80 MHz transmissions with 2x996-subcarrier RU.

The test shall be performed over at least 20 PPDUs (*Nf* as defined in Equation (26-X)). The PPDUs under

test shall be at least 16 data OFDM symbols long. Random data shall be used for the symbols.

For HE trigger-based PPDU and preamble-punctured HE MU PPDU, additional transmit modulation accuracy test for the un-occupied subcarriers of the PPDU shall be performed. The transmit modulation accuracy of un-occupied subcarriers of the PPDU test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted; except that for noncontiguous transmissions, only the frequency segment with occupied subcarriers is tested. The transmit modulation accuracy of maximum average un-occupied subcarriers error of the PPDU shall meet relative constellation error minus TBD margin in dB scale for each modulation and code rates using the un-occupied subcarriers within the corresponding segment.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

1. Start of PPDU shall be detected.
2. Transition from L-STF to L-LTF shall be detected and fine timing shall be established.
3. Coarse and fine frequency offsets shall be estimated.
4. Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated. Note that amplitude drift shall not be compensated by the testing instrument.
5. For each of the data OFDM symbols: transform the symbol into subcarrier received values, estimate the power of each subcarriers.
6. Compute the average un-occupied subcarrier error vetor magnitude for each PPDU over 26 subcarriers and average across PPDUs of the RMS of all errors per PPDU as given by Equation (26-A)

 (26-A)

1. Compute the maximum average un-occupied subcarrier error vector magnitude as given by Equation (26-B).

 (26-B)

The test shall be performed over at least 20 PPDUs (*Nf* as defined in Equation (26-X)). The PPDUs under

test shall be at least 16 data OFDM symbols long. The un-equalized observed symbol of potential LO leakage subcarrier locations shall be treated as zero during un-occupied subcarriers transmit modulation accuracy test. Random data shall be used for the symbols.

**21.3.17.5 Time of Departure accuracy**

The Time of Departure accuracy test evaluates TIME\_OF\_DEPARTURE against aTxPHYTxStartRMS and aTxPHYTxStartRMS against TIME\_OF\_DEPARTURE\_ACCURACY\_TEST\_THRESH as defined in Annex P with the following test parameters:

— MULTICHANNEL\_SAMPLING\_RATE is:

 sample/s, for a CH\_BANDWIDTH parameter equal to CBW20

 sample/s, for a CH\_BANDWIDTH parameter equal to CBW40

 sample/s, for a CH\_BANDWIDTH parameter equal to CBW80

 sample/s, for a CH\_BANDWIDTH parameter equal to CBW160 or CBW80+80

where

*fH* is the nominal center frequency in Hz of the highest channel in the channel set

*fL* is the nominal center frequency in Hz of the lowest channel in the channel set, the channel set is the set of channels upon which frames providing measurements are transmitted, the channel set comprises channels uniformly spaced across.

* FIRST\_TRANSITION\_FIELD is L-STF.
* SECOND\_TRANSITION\_FIELD is L-LTF.
* TRAINING\_FIELD is L-LTF windowed in a manner which should approximate the windowing described in 17.3.2.5 (Mathematical conventions in the signal descriptions) with TTR = 100 ns.
* TIME\_OF\_DEPARTURE\_ACCURACY\_TEST\_THRESH is 80 ns.

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

-------------- End Text Changes ----------------