IEEE P802.11  
Wireless LANs

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| Proposed Draft Text (PDT-PHY): Modulation Accuracy | | | | |
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Abstract

This submission proposed modifications on modulation accuracy of TGbe D0.1 to resolve TBDs.

This document is based on TGbe D0.1 and following motions.

802.11be defines only PPDU with contiguous signal bandwidth, including 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 320 MHz.

* NOTE – Noncontiguous 80+80 MHz and 160+160 MHz are not defined.

[Motion 137, #SP288, [3] and [4]]

802.11be shall not support STBC.

[Motion 135, #SP218, [21] and [39]]

Revision 2: table 36-45 update. 3x996-tone RU make is black text. Also, all indices are updated based on new 26-tone RU indices, 11-20/1845r2 SP1.

For example, for 80MHz, add +1 RU from RU19 and RU19 is not used. This will make alignment with 11ax indices.

For large size MRU, some of MRUs are not contiguous, so it is not valid for table 36-45. It should be discussed in non-contiguous ones.

i\_rus are the RU and MRU indices are based on agreed indices as well as 11-20/1845r2 SP2.

Revision 3: delete “except that for a noncontiguous transmissions each frequency segment may be tested independently” as 11be does not support 80+80 or 160+160MHz transmission.

Proposed Changes #1:

***TGbe Editor: Modify ‘78-tone RU’ to ‘26+52-tone MRU’, ‘132-tone RU’ to ‘26+106-tone MRU’, ‘484-tone RU+242-tone RU’ to ‘484+242 tone MRU’, ‘996-tone RU+484-tone RU’ to ‘996+484-tone MRU’, ‘2x996-tone RU+484-tone RU’ to ‘2x996+484 MRU’, ‘3x996-tone RU+484-tone RU’ to ‘3x996+484 MRU’ and ‘3x996-tone RU’ to ‘3x996-tone MRU’ in Equation (36-88) and Table 36-45, and delete Editor’s note on that.***

Proposed Changes #2:

***TGbe Editor: Modify text in 36.3.18.4 (Modulation accuracy):***

* Modulation accuracy
* Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 36.3.18.4.2 (Transmit center frequency leakage) and 36.3.18.4.3 (Transmitter constellation error). The test method is described in 36.3.18.4.4 (Transmitter modulation accuracy (EVM) test).

* Transmit center frequency leakage

For 20/40/80/160 MHz transmission, 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 , where *P* is the transmit power per antenna in dBm. The transmit center frequency leakage is specified per antenna. The transmit center frequency leakage for 320 MHz transmission is TBD.

* Transmitter constellation error

The relative constellation RMS error in the test, calculated by first averaging over subcarriers, frequency segments, EHT PPDUs, and spatial streams (see Equation (36-85)) as described in 36.3.18.4.4 (Transmitter modulation accuracy (EVM) test)) shall not exceed a data-rate dependent value according to Table 36-44 (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,  and no beamforming steering matrix shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements shall apply to 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 320 MHz contiguous transmissions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| * Allowed relative constellation error versus constellation size and coding rate | | | | |
| Modulation | Coding rate | Relative constellation error in an EHT MU PPDU (dB) | Relative constellation error in an EHT TB PPDU when transmit power is larger than the maximum power of EHT-MCS 7 (dB) | Relative constellation error in an EHT TB PPDU when transmit power is less than or equal to the maximum power of EHT-MCS 7 (dB) |
|
| BPSK | 1/2 | –5 | –13 | –27 |
| QPSK | 1/2 | –10 | –13 | –27 |
| QPSK | 3/4 | –13 | –13 | –27 |
| 16-QAM | 1/2 | –16 | –16 | –27 |
| 16-QAM | 3/4 | –19 | –19 | –27 |
| 64-QAM | 2/3 | –22 | –22 | –27 |
| 64-QAM | 3/4 | –25 | –25 | –27 |
| 64-QAM | 5/6 | –27 | –27 | –27 |
| 256-QAM | 3/4 | –30 | –30 | –30 |
| 256-QAM | 5/6 | –32 | –32 | –32 |
| 1024-QAM | 3/4 | [–35/–32] (TBD) | [–35/–32] (TBD) | [–35/–32] (TBD) |
| 1024-QAM | 5/6 | [–35/–32] (TBD) | [–35/–32] (TBD) | [–35/–32] (TBD) |
| 4096-QAM | 3/4 | –38 | –38 | –38 |
| 4096-QAM | 5/6 | –38 | –38 | –38 |
| BPSK-DCM | 1/2 | –5 | –13 | –27 |
| NOTE—The maximum power of EHT-MCS 7 can be measured by setting the UL Target RSSI subfield as defined in Table 9-31j (UL Target Receive Power subfield in Trigger frame) in the Trigger frame to 127 for the RU for which the EVM test is conducted. | | | | |

* Per the authors of 20/1253r6, the following two paragraphs are TBD.
* The relative constellation error shall be less than or equal to –35 dB if amplitude drift compensation is disabled in the test equipment
* The relative constellation error shall be less than or equal to –35 dB with amplitude drift compensation enabled in the test equipment, and the relative constellation error shall be less than or equal to –32 dB with amplitude drift compensation disabled in the test equipment

For all other constellations the relative constellation error shall be less than or equal to the values in Table 27-49 (Allowed relative constellation error versus constellation size and coding rate) whether or not amplitude drift compensation is enabled in the test equipment.

* 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.

In this case, transmit modulation accuracy of each segment shall meet the required value in Table 36-44 (Allowed relative constellation error versus constellation size and coding rate) using only the occupied data subcarriers within the corresponding segment. For EHT TB PPDU transmission, two sets of EVM requirements are defined in Table 36-44 (Allowed relative constellation error versus constellation size and coding rate) for different transmission power levels to assist AP in better managing the interference among multiple STAs responding to a Trigger frame.

LO leakage that can potentially show up at the center frequency of the EHT PPDU tone plan and within ±3 neighboring subcarriers shall be excluded from the computation of the transmitter modulation accuracy test. The potential LO leakage subcarriers for 20 MHz operating devices are the center of primary 20 MHz of the EHT PPDU tone plan and ±3 subcarriers of it. The potential LO leakage subcarriers for 40 MHz operating devices are the center of the primary 40 MHz of the PPDU tone plan and ±3 subcarriers. The potential LO leakage subcarriers for 80 MHz operating devices are the center of the primary 80 MHz of the PPDU tone plan and ±3 subcarriers of it. The potential LO leakage tones for 160 MHz operating devices are the center of the primary 160 MHz of the PPDU tone plan and ±3 subcarriers of it. The potential LO leakage tones for 320 MHz operating devices are the center of the 320 MHz of the PPDU tone plan and ±3 subcarriers of it. For 40 MHz operating devices that transmits 20 MHz, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 80 MHz operating devices that transmits 20 MHz or 40 MHz PPDU, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 160 MHz operating devices that transmits 20 MHz or 40 MHz PPDU or 80 MHz PPDU, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 320 MHz operating devices that transmits 20 MHz or 40 MHz PPDU or 80 MHz PPDU or 160 MHz PPDU, the potential LO leakage subcarriers exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test.

The transmitter modulation accuracy test procedure for the occupied subcarriers of the PPDU is similar as in steps of the transmit modulation accuracy test procedure defined in 27.3.19.4.4 (Transmitter modulation accuracy (EVM) test) as follows.

* Start of PPDU shall be detected.
* Transition from L-STF to L-LTF shall be detected and fine timing shall be established.
* Coarse and fine frequency offsets shall be estimated.
* Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.
* For each EHT-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.
* Estimate the complex channel response coefficient for each of the subcarriers and each of the transmit streams.
* 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.
* 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.
* Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (36-85).

where

 denotes the ideal symbol point in the complex plane in data subcarrier  of the RU under test, spatial stream , and OFDM symbol  of frame .

 denotes the equalized observed symbol point in the complex plane of the data subcarrier  of the RU under test, spatial stream , and OFDM symbol  of frame .

 is the average power of constellation.

 is the number of tested frames.

 is the number of data tones of the occupied RU.

 is the number of spatial streams of the data.

 is the number of data OFDM symbols.

The test shall be performed over at least 20 PPDUs ( as defined in Equation (36-85)). If the occupied RU has 26 tones, the PPDUs under test shall be at least 32 data OFDM symbols long. For occupied RUs that have more than 26 tones, the PPDUs under test shall be at least 16 data OFDM symbols long. Random data shall be used for the symbols.

For an EHT TB PPDU with an RU or MRU smaller than a 4996-tone RU, additional transmit modulation accuracy test for the unoccupied subcarriers of the PPDU shall be performed. There are two cases, one with a single RU or a continuous MRU and the other with a noncontinuous MRU.

*N* RU Allocation subfields are present in an EHT-SIG content channel, where:

* Start of PPDU shall be detected.
* BCC interleaver: Interleave as described in 17.3.5.7 (Data interleavers).
* Constellation Mapper: BPSK modulate as described in 36.3.12.7 (Constellation mapping).
* Pilot insertion: Insert pilots as described in 36.3.11.5 (L-SIG).
* Extra subcarrier insertion: Four extra subcarriers are inserted at  for channel estimation purpose and the values on these four extra subcarriers are respectively.
* Compute the average unoccupied subcarrier error vector magnitude for each unoccupied 26-tone RU and average across PPDUs of the RMS of all errors per PPDU as given by Equation (36-86).

where

 denotes unequalized observed symbol point in the complex plane in subcarrier ** of the unoccupied 26-tone RU and OFDM symbol  of frame .

 is a set of subcarriers for *k*-th 26-tone RU as defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU), Table 36-5 (Data and pilot subcarrier indices for RUs in an 80 MHz EHT PPDU), Table 36-6 (Data and pilot subcarrier indices for RUs in a 160 MHz EHT PPDU), and Table 36-7 (Data and pilot subcarrier indices for RUs in a 320 MHz EHT PPDU).

 is the average data subcarrier power of the occupied RU under test and is given by Equation (36-87).



where

 is the number of tested frames

 is the number of data OFDM symbols.

 is the number of data subcarriers in the occupied RU

.

* For all EHT-MCSs, for an occupied RU bandwidth of *r* in units of a 26-tone RU as defined by Equation (36-88).





The average unused subcarrier error vector magnitude for each unoccupied 26-tone RU as calculated in step f) shall meet the staircase mask requirement in Equation (36-89) and Equation (36-90), where *m* defines the gap in the units of 26-tone RU to the occupied RU from either side with  being the adjacent 26-tone RUs.



* Per the authors of 20/1253r6, Equation (36-89) is TBD.



* Per the authors of 20/1253r6, Equation (36-90) is TBD.

where

** is equal to  if the occupied RU is a 26-tone RU, and is defined in Table 36-45 (iRU26, start for RUs other than a 26-tone RU) for other RU sizes.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| * *iRU26, start* for RUs other than a 26-tone RU | | | | | | | | | | | | | |
| *iRU* | 52-tone RU | 26+52-tone MRU | 106-tone RU | 26+106-tone MRU | 242-tone RU | 484-tone RU | 484+242-tone MRU | 996-tone RU | 996+484-tone MRU | 2996-tone RU | 2996 +484-tone MRU | 3996-tone MRU | 3996 +484-tone MRU |
| 1 | 1 | 2 | 1 | 1 | 1 | 1 | 10 | 1 | 20 | 1 | 20 | 38 | 20 |
| 2 | 3 | 3 | 6 | 5 | 10 | 20 | N/A | 38 | N/A | 75 | N/A | N/A | N/A |
| 3 | 6 | 6 | 10 | 10 | 20 | 38 | N/A | 75 | N/A |  | N/A | N/A | N/A |
| 4 | 8 | 11 | 15 | 14 | 29 | 57 | 1 | 112 | 1 |  | N/A | 1 | N/A |
| 5 | 10 | 12 | 20 | 20 | 38 | 75 | 47 |  | 94 |  | N/A |  | N/A |
| 6 | 12 | 15 | 25 | 24 | 47 | 94 | N/A |  | N/A |  | 1 |  | N/A |
| 7 | 15 | 21 | 29 | 29 | 57 | 112 | N/A |  | N/A |  | N/A |  | N/A |
| 8 | 17 | 22 | 34 | 33 | 66 | 131 | 38 |  | 75 |  | N/A |  | 1 |
| 9 | 20 | 25 | 38 | 38 | 75 |  | 84 |  |  |  | N/A |  |  |
| 10 | 22 | 30 | 43 | 42 | 84 |  | N/A |  |  |  | N/A |  |  |
| 11 | 25 | 31 | 47 | 47 | 94 |  | N/A |  |  |  | N/A |  |  |
| 12 | 27 | 34 | 52 | 51 | 103 |  | 75 |  |  |  | 57 |  |  |
| 13 | 29 | 39 | 57 | 57 | 112 |  | 121 |  |  |  | N/A |  |  |
| 14 | 31 | 40 | 62 | 61 | 121 |  | N/A |  |  |  | N/A |  |  |
| 15 | 34 | 43 | 66 | 66 | 131 |  | N/A |  |  |  | N/A |  |  |
| 16 | 36 | 48 | 71 | 70 | 140 |  | 112 |  |  |  | N/A |  |  |
| 17 | 38 | 49 | 75 | 75 |  |  |  |  |  |  | N/A |  |  |
| 18 | 40 | 52 | 80 | 79 |  |  |  |  |  |  | 38 |  |  |
| 19 | 43 | 58 | 84 | 84 |  |  |  |  |  |  |  |  |  |
| 20 | 45 | 59 | 89 | 88 |  |  |  |  |  |  |  |  |  |
| 21 | 47 | 62 | 94 | 94 |  |  |  |  |  |  |  |  |  |
| 22 | 49 | 67 | 99 | 98 |  |  |  |  |  |  |  |  |  |
| 23 | 52 | 68 | 103 | 103 |  |  |  |  |  |  |  |  |  |
| 24 | 54 | 71 | 108 | 107 |  |  |  |  |  |  |  |  |  |
| 25 | 57 | 76 | 112 | 112 |  |  |  |  |  |  |  |  |  |
| 26 | 59 | 77 | 117 | 116 |  |  |  |  |  |  |  |  |  |
| 27 | 62 | 80 | 121 | 121 |  |  |  |  |  |  |  |  |  |
| 28 | 64 | 85 | 126 | 125 |  |  |  |  |  |  |  |  |  |
| 29 | 66 | 86 | 131 | 131 |  |  |  |  |  |  |  |  |  |
| 30 | 68 | 89 | 136 | 135 |  |  |  |  |  |  |  |  |  |
| 31 | 71 | 95 | 140 | 140 |  |  |  |  |  |  |  |  |  |
| 32 | 73 | 96 | 145 | 144 |  |  |  |  |  |  |  |  |  |
| 33 | 75 | 99 |  |  |  |  |  |  |  |  |  |  |  |
| 34 | 77 | 104 |  |  |  |  |  |  |  |  |  |  |  |
| 35 | 80 | 105 |  |  |  |  |  |  |  |  |  |  |  |
| 36 | 82 | 108 |  |  |  |  |  |  |  |  |  |  |  |
| 37 | 84 | 113 |  |  |  |  |  |  |  |  |  |  |  |
| 38 | 86 | 114 |  |  |  |  |  |  |  |  |  |  |  |
| 39 | 89 | 117 |  |  |  |  |  |  |  |  |  |  |  |
| 40 | 91 | 122 |  |  |  |  |  |  |  |  |  |  |  |
| 41 | 94 | 123 |  |  |  |  |  |  |  |  |  |  |  |
| 42 | 96 | 126 |  |  |  |  |  |  |  |  |  |  |  |
| 43 | 99 | 132 |  |  |  |  |  |  |  |  |  |  |  |
| 44 | 101 | 133 |  |  |  |  |  |  |  |  |  |  |  |
| 45 | 103 | 136 |  |  |  |  |  |  |  |  |  |  |  |
| 46 | 105 | 141 |  |  |  |  |  |  |  |  |  |  |  |
| 47 | 108 | 142 |  |  |  |  |  |  |  |  |  |  |  |
| 48 | 110 | 145 |  |  |  |  |  |  |  |  |  |  |  |
| 49 | 112 |  |  |  |  |  |  |  |  |  |  |  |  |
| 50 | 114 |  |  |  |  |  |  |  |  |  |  |  |  |
| 51 | 117 |  |  |  |  |  |  |  |  |  |  |  |  |
| 52 | 119 |  |  |  |  |  |  |  |  |  |  |  |  |
| 53 | 121 |  |  |  |  |  |  |  |  |  |  |  |  |
| 54 | 123 |  |  |  |  |  |  |  |  |  |  |  |  |
| 55 | 126 |  |  |  |  |  |  |  |  |  |  |  |  |
| 56 | 128 |  |  |  |  |  |  |  |  |  |  |  |  |
| 57 | 131 |  |  |  |  |  |  |  |  |  |  |  |  |
| 58 | 133 |  |  |  |  |  |  |  |  |  |  |  |  |
| 59 | 136 |  |  |  |  |  |  |  |  |  |  |  |  |
| 60 | 138 |  |  |  |  |  |  |  |  |  |  |  |  |
| 61 | 140 |  |  |  |  |  |  |  |  |  |  |  |  |
| 62 | 142 |  |  |  |  |  |  |  |  |  |  |  |  |
| 63 | 145 |  |  |  |  |  |  |  |  |  |  |  |  |
| 64 | 147 |  |  |  |  |  |  |  |  |  |  |  |  |

 is equal to .

 is the index of the occupied RU or MRU.

 is the maximum number of 26-tone RUs for the given bandwidth of the EHT TB PPDU.

is the relative constellation error requirement for an occupied RU of an EHT TB PPDU as defined in Table 36-44 (Allowed relative constellation error versus constellation size and coding rate).



All the RUs with N/A in Table 36-45 (iRU26, start for RUs other than a 26-tone RU) are for noncontiguous MRU.

The valid range for *m* for Equation (36-89) is as follows:

*  for a 20 MHz, 40 MHz, 80 MHz, 160 MHz or 320 MHz PPDU

The valid range for *m* for Equation (36-90) is as follows:

*  for a 20 MHz, 40 MHz, 80 MHz, 160 MHz or 320 MHz PPDU

The test shall be performed over at least 20 PPDUs (*Nf* as defined in Equation (36-85)). The PPDUs under test shall be at least 16 data OFDM symbols long. The unequalized observed symbol of potential LO leakage subcarrier locations shall be treated as zero during unoccupied subcarriers transmit modulation accuracy test. Random data shall be used for the symbols.

In case of a noncontinuous MRU, how to perform the transmit modulation accuracy test for the unoccupied subcarriers of the PPDU is TBD.

**End of proposed changes.**