IEEE P802.11
Wireless LANs

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| Performance Requirements for the EDMG OFDM Mode |
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Abstract

This document proposes specification text for subclause 30.6.10 (Performance requirements) defining performance requirements for the EDMG OFDM PPDUs.

The proposed text addresses CIDs 1324, 1885, 1918, and 1992.

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| --- | --- | --- | --- | --- |
| **CID** | **Clause** | **Page** | **Comment** | **Proposed change** |
| 1324 | 30.6.10 | 367.18 | OFDM performance is undefined | Add performance requirements |
| 1885 | 30 | 216.03 | Tx EVM for SC, OFDM and MIMO are missing | The Tx EVM for SC, OFDM and MIMO are missing |
| 1918 | 30.6.10 | 367.17 | No text in section. | Either add text or remove section |
| 1992 | 30 | 216.03 | Tx EVM for SC, OFDM and MIMO are missing | The Tx EVM for SC, OFDM and MIMO are missing |

**Proposed resolution**: Revised

***Modification:*** *Include the text proposed in this document in subclause 30.6.10 (Performance requirements).*

**30.6.10 Performance requirements**

**30.6.10.1 Transmit requirements**

**30.6.10.1.1 Transmit modulation accuracy (EVM) test and requirements**

This subclause specifies the EVM test and corresponding requirements for PPDUs transmitted with the TXVECTOR parameter EDMG\_MODULATION equal to EDMG\_OFDM\_MODE, and with TXVECTOR parameter CH\_BANDWIDTH equal to CBW216, CBW432, CBW648, CBW864, CBW216+216, and CBW432+432.

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 OFDM sampling rate $F\_{s}$. The TXVECTOR parameters NUM\_STS and NUM\_TX\_CHAINS shall be equal, and the value of both parameters shall be equal to the number of utilized testing instrumentation input ports. Each transmit chain of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. In the test, $N\_{SS}=N\_{STS}$ (no STBC) shall be used. If the TXVECTOR parameter NUM\_STS is set to a value greater than 1, the two or more space-time streams shall have the same modulation type.

The instrumentation used shall have sufficient accuracy in terms of I/Q arm amplitude and phase balance, DC offsets, phase noise, and analog-to-digital quantization noise, so as not to mask or degrade the true EVM measurement. 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. Detect the start of the PPDU.
2. Establish fine timing.
3. Estimate coarse and fine frequency offsets.
4. De-rotate the symbols in the PPDU according to the estimated frequency offset.
5. Estimate the complex channel for each of the subcarriers and each of the spatial streams using the EDMG-CEF field.
6. For each of the OFDM symbols: Transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, de-rotate the subcarrier values according to the estimated phase, group the results from all RF chains in each subcarrier to a vector, and multiply the vector by an equalization matrix generated from the estimated channel.
7. For each data-carrying subcarrier and each spatial stream, find the closest constellation point and compute the Euclidean distance from it.
8. Compute the average relative constellation RMS error (EVM) across PPDUs according to the formula:

$$EVM=20log\_{10}\left(\frac{1}{N\_{f}}\sum\_{f=1}^{N\_{f}}\sqrt{\frac{\sum\_{n=0}^{N\_{SYMS}-1}\sum\_{j=1}^{N\_{SS}}\sum\_{kϵM\_{d}\left(k\right)}^{}\left(I\left(f,n,j,k\right)-I^{\*}\left(f,n,j,k\right)\right)^{2}+\left(Q\left(f,n,j,k\right)-Q^{\*}\left(f,n,j,k\right)\right)^{2}}{N\_{SYMS}×N\_{SS}×N\_{SD}×P\_{0}}}\right)$$

where

* $N\_{f}$ is the number of frames for the measurement
* $N\_{SYMS}$ is the number of OFDM symbols
* $N\_{SS}$ is the number of spatial streams
* $M\_{d}\left(k\right)$ is the set of data subcarriers defined in 30.6.1.5
* $N\_{SD} $is the number of data subcarriers
* $P\_{0}$ is the average power of the constellation
* $I\left(f,n,j,k\right)$ and $Q\left(f,n,j,k\right)$ denote the observed symbol point in the complex plane for the *k*-th subcarrier of the *n*-th OFDM symbol and *j*-th spatial stream within the *f*-th frame
* $I^{\*}\left(f,n,j,k\right)$ and $Q^{\*}\left(f,n,j,k\right)$ denote the ideal symbol point in the complex plane for the *k*-th subcarrier of the *n*-th OFDM symbol and *j*-th spatial stream within the *f*-th frame

The total number of symbol points used in the test, which is equal to $N\_{f}×N\_{SYMS}×N\_{SS}×N\_{SD}$, shall be at least 1000.

The EVM shall not exceed an MCS dependent value provided in Table 1. If the TXVECTOR parameter CH\_BANDWIDTH is set to either CBW216+216 or CBW432+432, the transmission in the two 2.16 GHz channels (for CBW216+216) or 4.32 GHz channels (for CBW432+432) may be tested independently. In this case, the transmit modulation accuracy of each 2.16 GHz channel (CBW216+216) or of each 4.32 GHz channel (CBW432+432) shall meet the required value in Table 1.

**Table 1: EVM requirement for the EDMG OFDM mode**

|  |  |  |  |
| --- | --- | --- | --- |
| **MCS** | **Modulation** | **Code rate** | **EVM value [dB]** |
| 1 | DCM BPSK | 1/2  | -7 |
| 2 | DCM BPSK | 5/8 | -9 |
| 3 | DCM BPSK | 3/4 | -10 |
| 4 | DCM BPSK | 13/16 | -12 |
| 5 | DCM BPSK | 7/8 | -13 |
| 6 | DCM QPSK | 1/2  | -10 |
| 7 | DCM QPSK | 5/8 | -11 |
| 8 | DCM QPSK | 3/4 | -12 |
| 9 | DCM QPSK | 13/16 | -14 |
| 10 | DCM QPSK | 7/8 | -15 |
| 11 | 16-QAM | 1/2  | -15 |
| 12 | 16-QAM | 5/8 | -16 |
| 13 | 16-QAM | 3/4 | -17 |
| 14 | 16-QAM | 13/16 | -18 |
| 15 | 16-QAM | 7/8 | -19 |
| 16 | 64-QAM | 1/2  | -21 |
| 17 | 64-QAM | 5/8 | -22 |
| 18 | 64-QAM | 3/4 | -23 |
| 19 | 64-QAM | 13/16 | -25 |
| 20 | 64-QAM | 7/8 | -27 |

**30.6.10.1.2 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 set to 1760×106 sample/s.
* FIRST\_TRANSITION\_FIELD is L-STF of the waveform transmitted in the primary channel.
* SECOND\_TRANSITION\_FIELD is L-CEF of the waveform transmitted in the primary channel.
* TRAINING\_FIELD is L-CEF of the waveform transmitted in the primary channel.
* TIME\_OF\_DEPARTURE\_ACCURACY\_TEST\_THRESH is 80 ns.

**30.6.10.2 Receive requirements**

**30.6.10.2.1 CCA**

CCA sensitivity requirements are defined in 30.3.8.