IEEE P802.11
Wireless LANs

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| Updated EVM Measurement Text |
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Abstract

This document proposes modified text for subclause 29.5.11.1.1 and 29.6.11.1.1 (Transmit modulation accuracy (EVM) test and requirements) for the EDMG SC PPDUs and EDMG OFDM PPDUs, respectively. The changes are relative to D2.1.

**Discussion:**

The current constraint states that “The total number of symbols used in the test, which is equal to , shall be at least 1000”. This constraint may provide too much flexibility in testing. For example, if a small value of is used, then it may not provide a reliable estimate of the EVM for packets with longer lengths. Therefore, we suggest adding a constraint that for EDMG SC PHY, and for EDMG OFDM PHY to ensure that longer packet lengths are tested.

In Clauses 17, 19 and 21, the EVM “test shall be performed over at least 20 frames”. In order to align Clause 29 with these other Clauses, we proposed adding the following constraint: .

Finally, clauses 17, 19, and 21, specifically mention that the measurement shall use random data for the transmitted symbols. We believe that this requirement is also necessary in order to measure an accurate EVM value.

**Proposed modified text:**

29.5.11.1.1 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\_SC\_MODE and with TXVECTOR parameter CH\_BANDWIDTH equal to CBW216, CBW432, CBW648, CBW864, CBW216+216, and CBW432+432; and
* PPDUs transmitted with the TXVECTOR parameter NON\_EDMG\_MODULATION equal to NON\_EDMG\_DUP\_SC\_MODE and with TXVECTOR parameter CH\_BANDWIDTH equal to 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 SC chip rate, except that:

* If the TXVECTOR parameter NON\_EDMG\_MODULATION is set to NON\_EDMG\_DUP\_SC\_MODE, the transmission in the two or more 2.16 GHz channels may be tested independently, and
* If the TXVECTOR parameter CH\_BANDWIDTH is set to either CBW216+216 or CBW432+432, the transmission in the two (adjacent or non-adjacent) 2.16 GHz channels (for CBW216+216) or 4.32 GHz channels (for CBW432+432) may be tested independently.

In the two cases indicated above, transmit modulation accuracy of each 2.16 GHz channel (when NON\_EDMG\_MODULATION is set to NON\_EDMG\_DUP\_SC\_MODE or when CH\_BANDWIDTH is set to CBW216+216) or of each 4.32 GHz channel (when CH\_BANDWIDTH is set to CBW432+432) shall meet the required value in Table 91 through Table 94 using only the signal within the corresponding channel.

If the TXVECTOR parameter EDMG\_MODULATION is set to EDMG\_SC\_MODE, 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. In the test, *NSS* = *NSTS* (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. Each transmit chain of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation.

The instrumentation used in the transmit EVM accuracy test 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:

* Detect the start of the PPDU.
* Establish fine timing.
* Estimate the coarse and fine frequency offsets.
* De-rotate the frame according to the estimated frequency offset.
* Estimate the complex channel impulse response for each of the transmit chains using the EDMG-CEF field, if present. If not, channel estimation is performed using the L-CEF field.
* For each SC symbol block, estimate time-dependent phase variations using guard interval symbols (for example, by interpolating the phase between the prefix and postfix GI samples), and de-rotate the corresponding symbol samples accordingly.
* For each SC symbol block, perform demodulation and apply a minimum mean square error equalization matrix generated from the channel estimate. Group the demodulated symbols from each SC symbol block, and combine the demodulated data from each spatial stream into a vector.
* For each element of the vector, find the closest constellation point and compute the Euclidian distance from it.
* Compute the average relative constellation RMS error (EVM) across PPDUs according to the formula:

where:

*Nf* is the number of frames for the measurement

*NBLKS* is the number of SC symbol blocks within each frame

*NSS* is the number of spatial streams of each frame

*NSPB* is the number of data modulated symbols per SC symbol block

*P0* is the average power of the constellation

 and denote the observed symbol point in the complex plane for the *kth* symbol of the *nth* SC symbol block and *jth* spatial stream within the *fth* frame

 and denote the ideal symbol point in the complex plane for the *kth* symbol of the *nth* SC symbol block and *jth* spatial stream within the *fth* frame

 and are the complex DC term chosen to minimize the EVM, which may be dependent on the frame index (*f*) and spatial stream index (*j*)

The total number of symbols used in the test, which is equal to , shall be at least 1000, with the constraint that shall be at least 20 and that shall be at least 20. Random data shall be used for the symbols and frames.

The test equipment shall use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurements.

The transmit pulse shaping filter impulse response is implementation specific.

The EVM shall not exceed an MCS dependent value provided in Table 91 through Table 94.

Transmit requirements of PPDUs transmitted with TXVECTOR parameter NON\_EDMG\_MODULATION equal to SC\_MODE are defined in 20.6.4.

29.6.11.1.1 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 TXVECTOR parameter CH\_BANDWIDTH equal to CBW216, CBW432, CBW648, CBW864, CBW216+216, or 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 *Fs*. 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, *NSS* = *NSTS* (i.e., 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:

* Detect the start of the PPDU.
* Establish fine timing.
* Estimate coarse and fine frequency offsets.
* De-rotate the symbols in the PPDU according to the estimated frequency offset.
* Estimate the complex channel for each of the subcarriers and each of the spatial streams using the EDMG-CEF field.
* 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.
* For each data-carrying subcarrier and each spatial stream, find the closest constellation point and compute the Euclidean distance from it.
* Compute the average relative constellation RMS error (EVM) across PPDUs according to the formula:

where:

*Nf* is the number of frames for the measurement

*NSYMS* is the number of OFDM symbols

*NSS* is the number of spatial streams

*Md(k)* is set of data subcarriers defined in 29.6.2.5

*NSD* is the number of data subcarriers

*P0* is the average power of the constellation

*I(f,n,j,k)* and *Q(f,n,j,k)* denote the observed symbol point in the complex plane for the *kth* subcarrier of the *nth* OFDM symbol and *jth* spatial stream within the *fth* frame

*I\*(f,n,j,k)* and *Q\*(f,n,j,k)* denote the ideal symbol point in the complex plane for the *kth* subcarrier of the *nth* OFDM symbol and *jth* spatial stream within the *fth* frame

The total number of symbol points used in the test, which is equal to *Nf*×*NSYMS*×*NSS*×*NSD*, shall be at least 1000, with the constraint that shall be at least 16 and that shall be at least 20. Random data shall be used for the symbols and frames.

The EVM shall not exceed an MCS dependent value provided in Table 107. 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 107.