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Source(s)	Yuval Lomnitz Yuval.Lomnitz@intel.com Elad Dayan Intel.
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Abstract	Corrections for EVM definitions in OFDMA PHY
Purpose	Adopt changes
Notice	
Release	
Patent Policy and Procedures	

Corrections for EVM definitions in OFDMA PHY

Yuval Lomnitz
Elad Dayan

1. Motivation

EVM (constellation error) definition seems to be borrowed from OFDM and not relevant for OFDMA this contribution proposes corrections for the definition.

2. Details

2.1. Problems

The following problems exist in the current definition in 8.4.12.3 (Transmitter constellation error and test method):

(1) No definition of EVM on empty subcarriers - this is important since no transmitter can avoid interference to unused subcarriers, and this interference affects other users in the UL.

(2) Frequency estimation is mentioned in EVM definition but not relevant per burst .

(3) Regarding test of frequency offset: It should be specified if EVM includes degradation due to frequency offset (currently it probably doesn't since 2% carrier spacing yields ICI of about 28dB, and requirement for 64QAM is 31.4dB). The treatment of frequency offset is different for BS and SS, since SS is expected to lock to BS frequency (therefore BS is not required to estimate SS frequency and lock on it).

(4) Need to define reference channel & phase estimation mechanism (esp for tiles)

(5) No definition of specific subchannel / averaging over subchannels for the EVM test

2.2. Discussion

- Equation (145) should be extended to include EVM measurement on unmodulated subcarriers.
- Regarding treatment of frequency and time offsets there are two approaches:
    1. If these errors are part of the EVM definition, then the test equipment should transmit a preamble to synchronize the SS, and measure EVM without correcting these errors. This approach is more comprehensive however complicates the test equipment and test definition. In addition since frequency offset of 2% carrier spacing is equivalent to EVM of 28.8dB, the EVM levels need to be changed.
    2. If these errors are not considered part of EVM, then the test equipment needs to estimate these parameters and correct them. In this case although the estimation may be complex, the test equipment is simpler (only needs to receive), and frequency locking should be tested separately.

- In this contribution we selected the 2nd approach, since it matches the spirit of the original definition, does not require change in the defined EVM levels, and the test equipment is simpler.

3. Changes summary

8.4.12.3 Transmitter constellation error and test method

[modify the text starting at p.629 line 6 as follows]

EVM measurement for BS:

The sampled signal shall be processed in a manner similar to an actual receiver, according to the following
steps, or an equivalent procedure [B29]. The test will be performed at PUSC when only 1/3 of the subcarriers are used:

a~~) Start of frame shall be detected~~.

a) Locate the Preamble.

b)~~ Transition from short sequences to channel estimation sequences shall be detected, and fine timing (with one sample resolution) shall be established~~.

b) Perform timing and frequency estimation.

c) ~~Coarse and fine frequency offsets shall be estimated.~~

d) The packet shall be de-rotated according to estimated timing and frequency offset.

e) The complex channel response coefficients shall be estimated for each of the subcarriers from the Preamble.

f) For each of the data OFDMA symbols: transform the symbol into subcarrier received values, estimate
the phase from the pilot subcarriers, de-rotate the subcarrier values according to estimated phase, and divide each subcarrier value with a complex estimated channel response coefficient.

g) For each data-carrying subcarrier, find the closest constellation point and compute the Euclidean distance from it.

h) Compute the RMS average of all errors in a packet. It is given by:

$$Error_{RMS} = \frac{1}{N_f}\sum_{1}^{N_f}\frac{\sum_{j=1}^{L_p}\sum_{\substack{k=0\\k\neq(Nused-1)/2}}^{Nused-1}\left[\left(I(i,j,k)-I_0(i,j,k)\right)^2+\left(Q(i,j,k)-Q_0(i,j,k)\right)^2\right]}{\sum_{j=1}^{L_p}\sum_{k=0}^{Nused-1}\left[I_0(i,j,k)^2+Q_0(i,j,k)^2\right]} \quad (145)$$

where:

L_P is the length of the packet;

N_f is the number of frames for the measurement;

($I_0(i,j,k)$, $Q_0(i,j,k)$) - denotes the ideal symbol point of the i-th frame, j-th OFDMA symbol of the frame, k-th subcarrier. of the OFDMA symbol in the complex plane. For the DC subcarrier and unmodulated (empty) subcarriers this value shall be 0;

($I(i,j,k)$, $Q(i,j,k)$) denotes the observed point of the i-th frame, j-th OFDMA symbol of the frame, k-th subcarrier, of the OFDMA symbol in the complex plane;

Nused denotes the maximal number of used subcarriers as defined in the symbol structure (see 8.4.6), including subcarriers that are not transmitted.

[Add the following text at the end of the section]

EVM measurement for SS:

a. The SS under test shall transmit on part of the UL subchannels. Recommended value is 1/4 of the UL subchannels.
b. The tester will locate a complete UL subframe.
c. Estimate the averaged timing and frequency offset.
d. The packet shall be de-rotated according to estimated timing and frequency offset.
e. Estimate the average channel according to the pilots (use linear interpolation between pilots).
f. For each symbol, transform the symbol into subcarrier received values, estimate the phase by the pilots, for symbols w/o pilots use linear interpolation to estimate the phase.
g. Each symbol, de-rotate the subcarrier values according to estimated phase, and divide each subcarrier value with a complex estimated channel response coefficient.
h. For each data-carrying subcarrier, find the closest constellation point and compute the Euclidean distance from it.
i. Compute the RMS average of all errors in a packet. It is given by equation (145).