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Re:	IEEE P802.16-2004/ Cor1-D1
Abstract	Corrections for EVM definitions in OFDMA PHY
Purpose	Adopt changes
Notice	
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Corrections for EVM definitions in OFDMA PHY

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1. Motivation

RMS 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 RMS constellation error 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 RMS constellation error definition but not relevant per burst .

(3) Regarding test of frequency offset: It should be specified if RMS constellation error 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 RMS constellation error test

2.2. Discussion

- Equation (149) should be extended to include RMS constellation error measurement on unmodulated subcarriers, for the uplink. For the downlink the RMS constellation error is calculated on modulated subcarriers only (since interference caused by constellation error on other segments in the downlink, where other segment is received with reduced power, is significantly lower than interference caused by one SS to another in the UL).
- Regarding treatment of frequency and time offsets there are two approaches:
    1. If these errors are part of the RMS constellation error definition, then the test equipment should transmit a preamble to synchronize the SS, and measure RMS constellation error 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 RMS constellation error of 28.8dB, the RMS constellation error levels need to be changed.
2. If these errors are not considered part of RMS constellation error, 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 RMS constellation error levels, and the test equipment is simpler.

3. Changes summary

[add section 8.4.12.3 to the document]

[Note: the following text includes editing instructions to modify 8.4.12.3 in 802.16-2004 which are to be included in 802.16Cor1/D1]

8.4.12.3 Transmitter constellation error and test method

[modify the text starting at p.626 from "The sampled signal…" as follows, and add sub-sections as indicated below]

8.4.12.3.1 RMS constellation error measurement for BS (downlink):

The test will be performed in PUSC. The FCH configuration (used PUSC groups) shall be determined according to the desired BS configuration. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps:~~, or an equivalent procedure [B29]~~.

a) Locate the Preamble.
b) Perform timing and frequency estimation.
c) 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.
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 equation 149 ~~:~~

8.4.12.3.2 RMS constellation error measurement for SS

The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps:

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 (149).
j. Normal RMS constellation error measurement shall be performed in scenarios where the number of modulated subcarriers is constant across symbols.
k. In case the number of subcarriers varies between symbols, it is recommended to measure RMS constellation error separately for symbols with different power levels.

8.4.12.3.3 calculation of RMS constellation error

$$Error_{RMS}{}^{2} = \frac{1}{N_f}\sum_{1}^{N_f}\frac{\sum_{j=1}^{L_p}\sum_{k\in S}\left[\left(I(i,j,k)-I_0(i,j,k)\right)^2+\left(Q(i,j,k)-Q_0(i,j,k)\right)^2\right]}{\sum_{j=1}^{L_p}\sum_{k\in S}\left[I_0(i,j,k)^2+Q_0(i,j,k)^2\right]} \quad (149)$$

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;

S is the group of subcarriers on which the measurement is performed. For downlink RMS constellation error measurement, *S* includes all the modulated subcarriers. For uplink RMS constellation error measurement, *S* includes all subcarriers defined in the symbol structure (see 8.4.6), except the DC subcarrier, including subcarriers that are not transmitted (N_{used}-1 subcarriers overall).