

**Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)**

**Submission Title:** [Comments on EVM and Required Study]

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**Abstract:** [Comments on EVM and Required Study]

**Purpose:** [This document provides a list of the editing staff that will be working on 802.15.3c.]

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# Comments on EVM and Required Study

- Need to work on SC, OFDM EVM and Test capabilities separately
- Hence the objective of this presentation is
  - To propose modification of current SC EVM values
  - To define a measuring technique of EVM for SC
  - To define requirement of receiver properties to measure EVM

# 802.15.3c D00 - Table 120 [SC]

| <b>MCS</b>          | <b>EVM (dB)<br/>(in spec)</b> | Equivalent EVM (%)<br>= $10^{(dB/20)}$ |
|---------------------|-------------------------------|--|
| <b>Class 1</b>      | <b>-7</b>                     | 44.3%                                  |
| <b>Class 2</b>      | <b>-14</b>                    | 19.95%                                 |
| <b>Class 3</b>      | <b>-21</b>                    | 8.91%                                  |
| <b>Class 4 OOK</b>  | <b>-7</b>                     | 44.3%                                  |
| <b>Class 4 DAMI</b> | <b>-14</b>                    | <b>19.95%</b>                          |

## Comments on EVM values in the Table 120:

- Class 1: We may need slightly more tight EVM value
- Class 2: Seems reasonable
- Class 3: -21 dB is too stringent, 11% (-19 dB) could be a better choice
- Class 4: Seems reasonable

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# Summary of EVM Measurement Spec

## Reference data

- **[SC] 802.11 (R2003)** and **802.11b (R2003)** mention that the EVM should be measured over 1000 samples taken in twice the chip rate (chip rate is 11 Mchips/s). **802.15.3** recommends measuring over 1000 symbols.
- **[SC] 802.16(d)\_2004** (WiMax) mentions that “*EVM shall be measured over the continuous portion of a burst occupying at least 1/4 of the total transmission frame at maximum power setting.*”
- **[OFDM] 802.11a/g** mentions that
  - A random data transmitted shall be sampled at 20 Msamples/s
  - Over at least 20 frames
  - The packets under test shall be at least 16 OFDM symbols long
- **[OFDM] 802.11 (R2007)** adopted the above mentioned **802.11a/g** spec. **802.11n** adopted the 11a/g spec. with 40 Msamples/s.

## 802.11(R2003) and 11b(R2003) [SC]

- EVM < **0.35 or 35%** or -9.11 dB for all modulation types
  - 802.11(R2003) SC DSSS PHY specifies DBPSK, DQPSK for 1Mbps and 2 Mbps respectively
  - 802.11b(R2003) SC DSSS PHY specifies DBPSK, DQPSK for data rates of 1, 2 Mbps respectively and CCK for 5.5, 11 Mbps

# 802.11a/g [OFDM]

| Data rate in Mbps (MCS)                    | EVM (dB)<br>(in spec) | Equivalent EVM (%)<br>= $10^{(dB/20)}$ |
|--|-----------------------|--|
| <b>6</b> (BPSK code rate $\frac{1}{2}$ )   | <b>-5</b>             | 56%                                    |
| <b>9</b> (BPSK code rate $\frac{3}{4}$ )   | <b>-8</b>             | 40%                                    |
| <b>12</b> (QPSK code rate $\frac{1}{2}$ )  | <b>-10</b>            | 31%                                    |
| <b>18</b> (QPSK code rate $\frac{3}{4}$ )  | <b>-13</b>            | 22%                                    |
| <b>24</b> (16QAM code rate $\frac{1}{2}$ ) | <b>-16</b>            | 15.85%                                 |
| <b>36</b> (16QAM code rate $\frac{3}{4}$ ) | <b>-19</b>            | 11.22%                                 |
| <b>48</b> (64QAM code rate $\frac{2}{3}$ ) | <b>-22</b>            | 7.94%                                  |
| <b>54</b> (64QAM code rate $\frac{3}{4}$ ) | <b>-25</b>            | 5.6%                                   |

- The table was also adopted for **802.11(R2007)** by adding the modulations shown in blue. **802.11n** also adopted a similar spec.

# 802.16(d)\_2004 [WiMax SC]

| <b>MCS</b>                           | <b>Equivalent EVM (dB)<br/>= <math>20\log_{10}(\%EVM)</math></b> | <b>EVM (%)<br/>In spec</b> |
|--------------------------------------|--|----------------------------|
| <b>4QAM (No Equalization)</b>        | -18.4  | <b>12%</b>                 |
| <b>16QAM (No Equalization)</b>       | -24.43   | <b>6%</b>                  |
| <b>4QAM (With Equalization)</b>      | -20  | <b>10%</b>                 |
| <b>16QAM (With<br/>Equalization)</b> | -30.45   | <b>3%</b>                  |
| <b>64QAM (With<br/>Equalization)</b> | -36.47   | <b>1.5%</b>                |

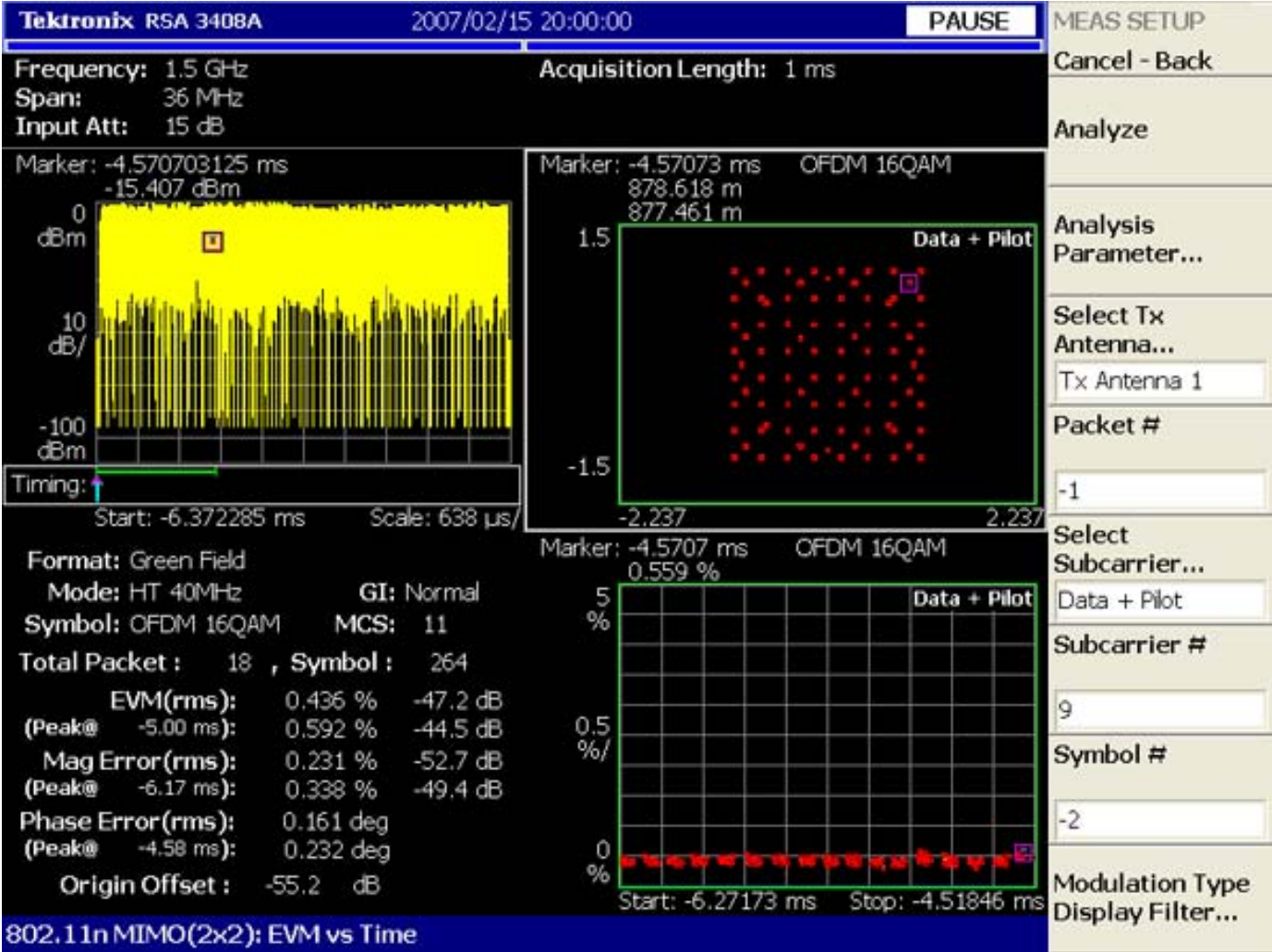
# EVM Measurement (1 of 2)

- The rule of thumb is that the receiver should have sensitivity of around 20 dB better than the value of EVM to be measured

| <b>Standard</b>   | <b>The Most-stringent value of EVM defined in the spec</b> | <b>Requirement of instrument sensitivity (from Tektronix Japan)</b>                      |
|---|--|--|
| IEEE 802.11a/g<br>54 Mbps OFDM                          | -25 dB   | -44 dB or lower for 2.447 GHz<br>-42 dB or lower for 5.5 GHz                             |
| IEEE 802.11b<br>11 Mbps CCK<br>(Raised cosine filtered) | -9.11 dB   | 0.7% (-43 dB) or lower for 2.447 GHz   |
| IEEE 802.11n<br>SISO 16QAM                              | -19 dB   | -46 dB or lower at 2.447 GHz for 20 MHz BW<br>-42 dB or lower at 2.447 GHz for 40 MHz BW |
| IEEE 802.11n<br>MIMO 16QAM                              | -19 dB   | -42 dB or lower at 2.447 GHz for 20 MHz BW<br>-42 dB or lower at 2.447 GHz for 40 MHz BW |



# EVM Measurement (2 of 2)



# Conclusion

- We propose class 1 and 3 SC EVM values to change to -9 dB (35%) and -19 dB (11%) respectively. Class 1 and 4 EVM values are reasonable and can be kept as is.
- Measuring of SC EVM over 1000 samples is recommended
- The measuring device should have sensitivity of at least 20 dB better than the value of EVM to be measured
- OFDM side should come up with their data