

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

Submission Title: [Resolution to comments ID 15 and 629 on EVM]

Date Submitted: [10 September 2008]

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Abstract: [Resolution to comments ID 15 and 629 on EVM]

Purpose: [802.15.3c contribution]

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Resolution to comments ID 15 and 629 on EVM

- The objective of this presentation is to present resolution to comments ID 15 and 629 on EVM. In addition, the objective includes
 - To define a measuring technique of EVM for SC
 - To define requirement of receiver properties to measure EVM

Resolution to Comment ID 15

- CID 15 says
 - Where is 'sufficient rate accuracy' defined?
 - Add a definitions of 'sufficient rate and accuracy'.
More generally, it probably would be beneficial to devote a section to the precise definition of a generalized 'ideal receiver'.
- Proposed resolution:
 - Reject comment. Mentioned definitions are not needed.

Resolution to Comment ID 629

- CID 629 says
 - The EVM specification is incomplete. How many frames are to be used? What length? What preamble type? Shall channel estimate updates be performed throughout the frame?
 - Please complete the definition.
- Proposed resolution:
- Accept in principle. 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.

802.15.3c D00 - Table 120 [SC]

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

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

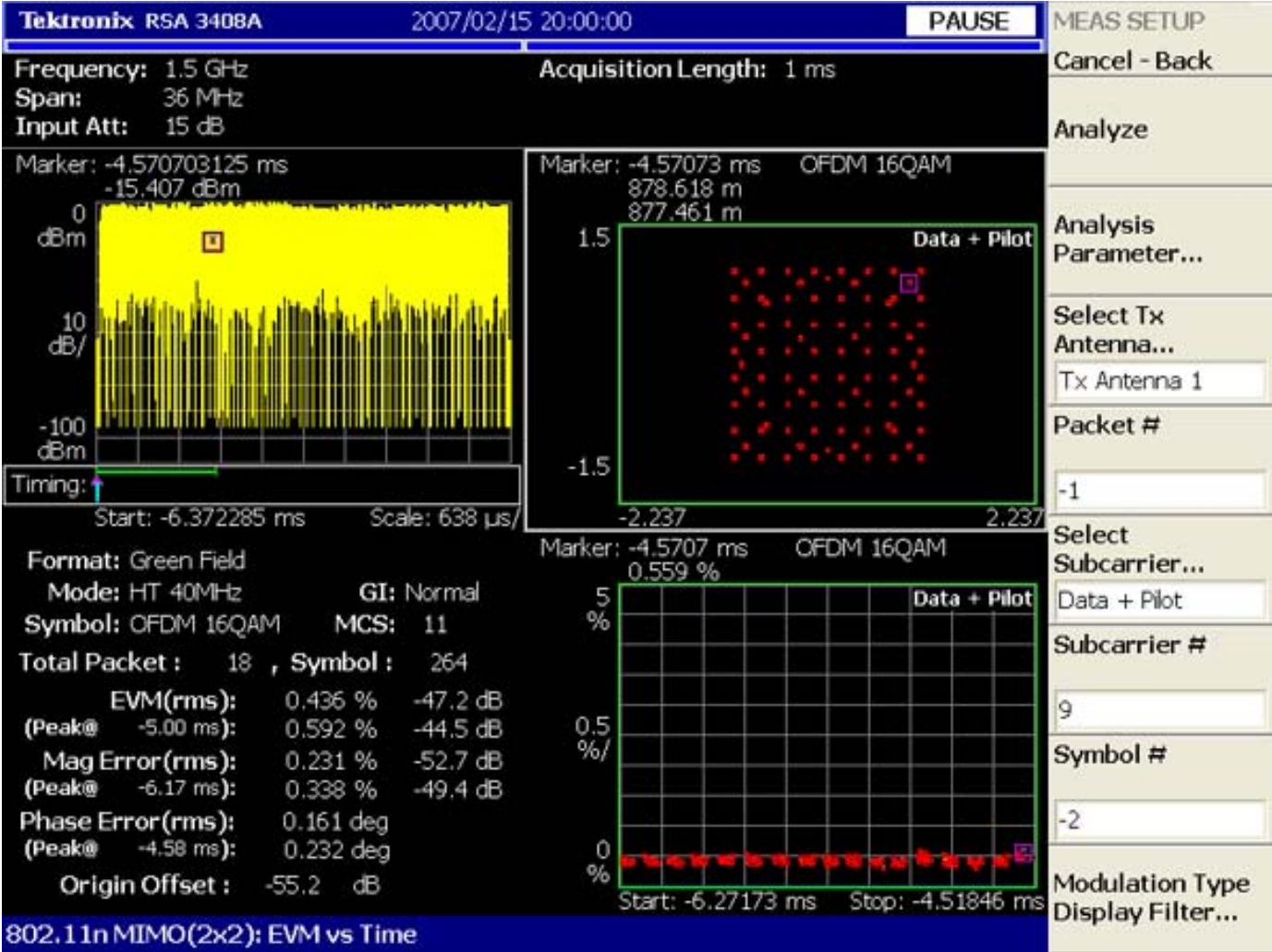
MCS	Equivalent EVM (dB) = $20\log_{10}(\%EVM)$	EVM (%) In spec
4QAM (No Equalization)	-18.4	12%
16QAM (No Equalization)	-24.43	6%
4QAM (With Equalization)	-20	10%
16QAM (With Equalization)	-30.45	3%
64QAM (With Equalization)	-36.47	1.5%

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

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

EVM Measurement (2 of 2)



Conclusion

- 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
- Related AV OFDM presentation can be found in document 561v1 and a document on SC EVM presented in an earlier teleconference can be found in 554r1, both in 802.15.3c server