Addressing measurement requirements for EVM

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Agenda/intent

- Motivation: Close the TBD status of Error Vector Magnitude in clause 156
- This presentation is in support of a comment against draft 1.0

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Click on column headers for help

Category	Page	Sub-clause	Line #	Comment	Proposed Change	Must Be Satisfied
Technical	76	156.9.9	31	The definition of error-vector-magnitude (EVM) is currently in TBD status. EVM requires a definition as well as a specification limit. Small changes in EVM can be seen as large changes in OSNR (see http://grouper.ieee.org/groups/802/3/cn/public/adhoc/18_1025/anslow_3cn_01_181025.pdf). A specification limit requires a known method of measurement. The complexity of the EVM measurement requires a specific analysis process to achieve consistent results. This process should be explcitly defined. See https://grouper.ieee.org/groups/802/3/cn/public/adhoc/19_0207/lecheminant_3cn_01_190207.pdf and https://grouper.ieee.org/groups/802/3/cn/public/adhoc/19_0509/lecheminant_3ct_01_190509.pdf	A method for computing EVM has been developed by Keysight Technologies and used in ITU and OIF standards. This is contained within a large Matlab script. The computation details need to be followed exactly to achieve consistent results. This script is available for use within the IEEE 802.3 standard. It is likely too large to be directly written into the standard document, so If used, guidance from the group is requested on the details for script management and inclusiion within the 802.3cw clauses. A presentation on the Keysight EVM script is planned to support this comment	

Current EVM status

Table 156–6—400GBASE-ZR transmit characteristics

Description	Value	Unit
Signaling rate (range)	59.84375 +/– 20ppm	GBd
Modulation format	DP-16QAM	—
Minimum channel spacing	75	GHz
Average channel output power (max)	–6	dBm
Average channel output power (min)	–10	dBm
Nominal center frequency	The frequency in Table 156–4 where the channel index number equals the variable Tx_optical_channel_index	THz
Spectral excursion (max)	TBD	GHz
Side-mode suppression ratio (SMSR) (min)	TBD	dB
Laser linewidth (max)	500	kHz
Offset between the carrier and the nominal center frequency (max)	1.8	GHz
Power difference between X and Y polarizations (max)	1.5	dB
Skew between X and Y polarizations (max)	5	ps
Error vector magnitude (max)	TBD	%
I-Q offset (max)	TBD	dB
Transmitter In-band OSNR (min)	34	dB(12.5 GHz)
Average launch power of OFF transmitter (max)	–20	dBm
Transmitter reflectance[a] (max)	–20	dB

[a]Transmitter reflectance is defined looking into the transmitter.

be within the limits given in Table 156–6.

156.9.8 Skew between X and Y polarizations

The skew between the X and Y polarizations, as defined in Recommendation ITU-T G.698.2, shall be within the limits given in Table 156–6.

156.9.9 Error vector magnitude

The error vector magnitude, as defined in TBD, shall be within the limits given in Table 156–6.

156.9.10 I-Q offset

The I-Q offset, as defined in TBD, shall be within the limits given in Table 156–6.

156.9.11 Optical signal-to-noise ratio (OSNR)

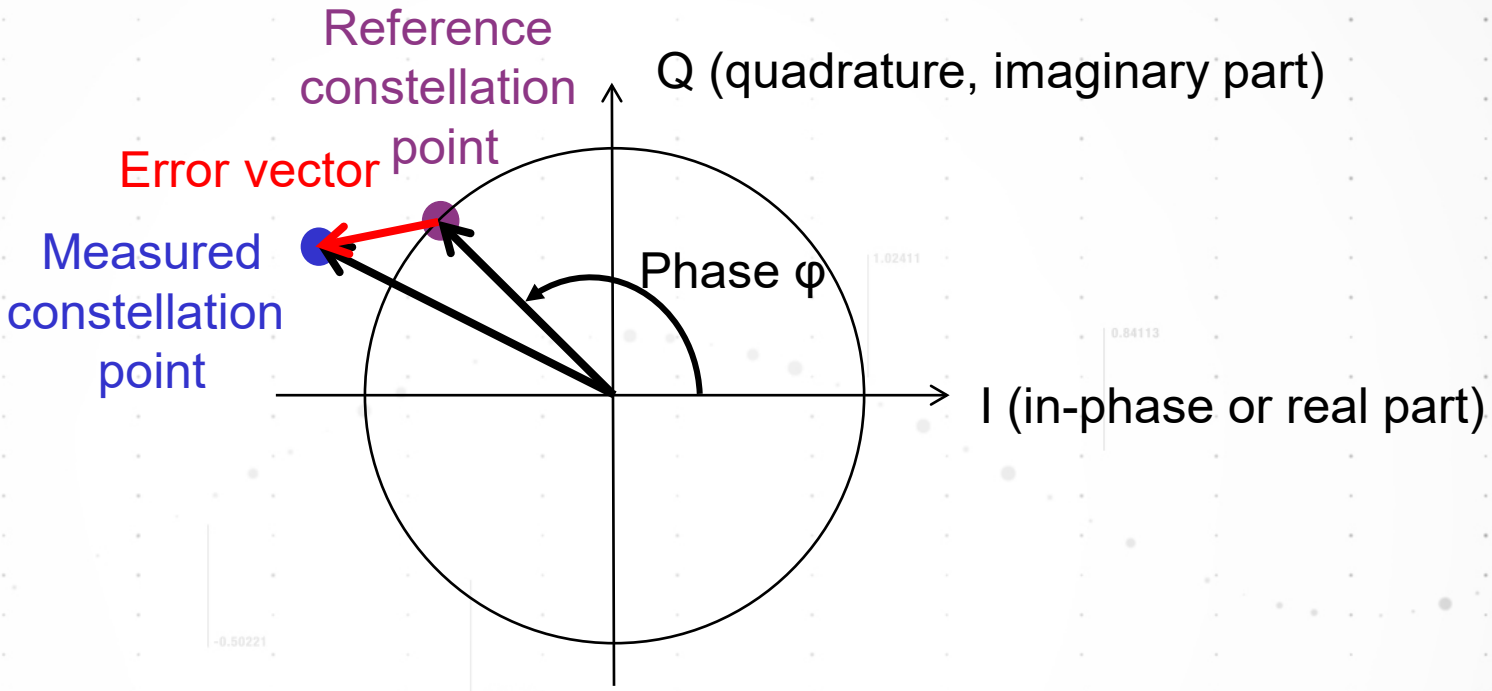
The optical signal-to-noise ratio (OSNR) at TP3 shall be within the limits given in Table 156–8. The OSNR is defined as the ratio of the average signal power in the wanted channel to the highest noise power density (referred to 12.5 GHz) in the range of the central frequency plus and minus the maximum spectral excursion. For the purposes of this definition, the noise is defined to be that which would be present if the signal in the

What is Error Vector Magnitude and how should it be measured?

- See https://grouper.ieee.org/groups/802/3/cn/public/adhoc/19_0207/lecheminant_3cn_01_190207.pdf
- See https://grouper.ieee.org/groups/802/3/cn/public/adhoc/19_0509/lecheminant_3ct_01_190509.pdf

No signifciant technical changes in two years since the above contributions were made

Quality metrics for phase modulated data signals



The **Error Vector** connects the measured vector and the reference vector! An **Error Vector = 0** means we have an **ideal signal**!

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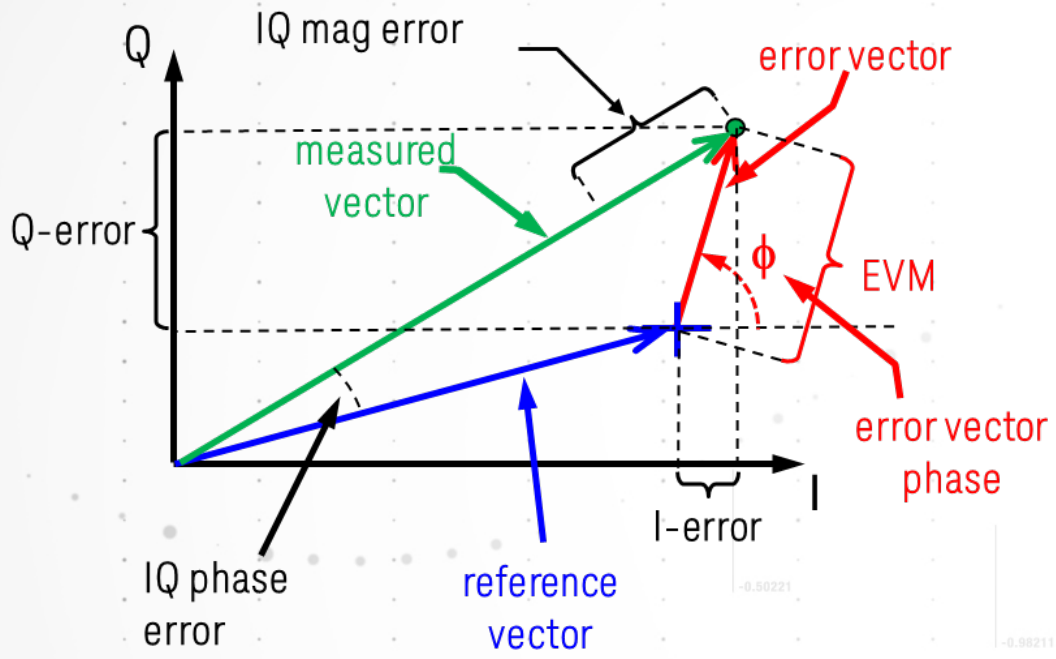
Multiple EVM values provide an overall quality metric for complexly modulated data signals



$$EVM(n) = \sqrt{I_{err}(n)^2 + Q_{err}(n)^2}$$

where n = symbol index

$$I_{err} = I_{meas} - I_{ref}$$

$$Q_{err} = Q_{meas} - Q_{ref}$$

$$EVM_{rms} = \frac{\sqrt{\frac{1}{N}\sum_{n=1}^{N} EVM(n)^2}}{|peak\ ref.vector|}$$

where N is the number of EVM points

The above process requires well-defined signal processing methods for consistent computation of EVM

- Common mathematics have been used in both ITU and OIF to achieve the previously described processes for computing EVM
  - Used in ITU-T G.698.2 (Q6/SG15)
  - Used in OIF 400ZR

Proposal

- Update 156.9.9 to include a reference to the OIF 400ZR document
  - https://www.oiforum.com/wp-content/uploads/OIF-400ZR-01.0_reduced2.pdf (Appendix C 20.1 through) 20.4.
  - OIF also has a Password protected Matlab script that executes the EVM mathematics.
- ITU: Currently an EVM script (along with example data and corresponding results) is used but accessible only for members
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- What makes sense for 802.3cw?