Updating the RIN$_X$OMA measurement method

Support for D1.0 comments #13-16, 518

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Supporters

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- Ernest Muhigana, Lumentum
- Roberto Rodes, Coherent
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P802.3dj D1.0 comments on RINxxOMA measurement

Cl **180** *SC* **180.8.11** *P*365 *L*52 # 13

LeCheminant, Greg — Keysight Technologies

Comment Type **T** *Comment Status* **X**

The required -3dB BW for the measurement system is not achievable with existing technology. (State of the art power meters with a maximum 120 GHz bandwidth, would require the bandwidth of the photodetetor to be substaitially higher than 120 GHz to achieve the current system bandiwdth required for the test system, as defined in clause 52)

SuggestedRemedy

The bandiwdth of the RIN-OMA test system should be based on the expected bandwidth of the system receivers and consider the expected noise spectrum of transmitters. Spec limits for RIN OMA may need adjustment to adapt to any changes in the test method

Comments #14, 15 and 16 are similar for clauses 181.8.11, 182.8.11 and 183.8.11.

Cl **180** *SC* **180.8.11** *P*365 *L*51 # 518

Dawe, Piers — Nvidia

Comment Type **T** *Comment Status* **X**

"The upper -3 dB limit of the measurement apparatus is to be approximately equal to the signaling rate": I believe this dates back at least to the first Fibre Channel, ~1 Gb/s, long before adaptive equalisers that optimise the receiver bandwidth. We have a RIN spec to help the accuracy of the TDECQ spec, which is the actual assessment of signal quality. Gigabit Ethernet now uses 937.5 MHz, 75% of the signalling rate. Measuring a peaky noise spectrum in too much bandwidth gives a flattering average, which is not what we want.

SuggestedRemedy

Change the bandwidth for RIN measurement to be the same as the TDECQ receiver's BT4 filter (50% of signalling rate ~ 53.1 GHz) or 75%, or something in between.

- While the commenters come at it from different directions, the problem is clear:
  - The legacy RINxxOMA test methodology that has been in use since 10GbE is no longer supportable at 200G per lane and must be updated.
- This contribution proposes a solution that addresses the concerns of both commenters.

Problems with legacy RIN_XOMA measurement

- 50G and 100G PAM4, and prior, PMDs have specified the RIN_XOMA measurement method of 52.9.6 (10GBASE-L), and this was continued in P802.3dj D1.0.
- The method of 52.9.6 specifies the use of a square wave signal and an RF power meter with 3dB bandwidth approximately equal to the signaling rate
- This method needs to be updated for 200G/L for several reasons:
  - The required O/E convertors, RF detectors and amplifiers with 3dB bandwidth > 112 GHz are not readily available.
  - Some modules' transmitters can't be easily operated without modulation.
  - The RIN peak frequency for DMLs scales with the signaling rate, but DMLs were not widely adopted at 100G/L and will not be used at 200G/L.
  - The RIN peak frequency for CW lasers used for 200G/L is only ~10GHz. Specifying averaging out to the signal rate underestimates average RIN_XOMA.
  - Most (all) users have migrated to measuring RIN_XOMA using noise histogram measurements on the same oscilloscopes used for measuring PAM4 TDECQ.

D1.0 $RIN_{XX}OMA$ measurement (Cl. 180 shown)

180.8.11 Relative intensity noise (RINxxOMA)

RINxxOMA, with "xx" referring to the value for optical return loss tolerance in Table 180–7, shall be as defined by the measurement methodology of 52.9.6 with the following exceptions:

— The optical return loss is equal to the value for Optical return loss tolerance in Table 180–7.

— Each lane may be tested individually with the sum of the optical power from all of the lanes not under test being below –30 dBm.

— The upper –3 dB limit of the measurement apparatus is to be approximately equal to the signaling rate (i.e., 106.3 GHz).

— The test pattern is according to Table 180–14.

52.9.6 RIN_XOMA measurement method

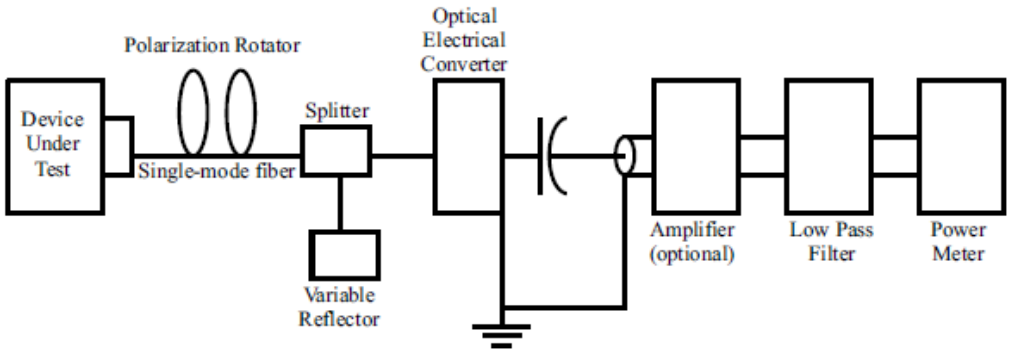

Figure 52–7—RIN_xOMA measurement setup

Polarization rotator: The polarization rotator is required to be capable of transforming an arbitrary orientation elliptically polarized wave into a fixed orientation linearly polarized wave.

O/E converter (and amplifier): If necessary, the noise may be amplified to a level consistent with accurate measurement by the power meter.

Filter: The upper –3 dB limit of the measurement apparatus is to be approximately equal to the bit rate (i.e., 10 GHz). The total filter bandwidth used in the RIN calculation is required to take the low-frequency cutoff of the DC-blocking capacitor into consideration. The low-frequency cutoff is recommended to be less than 1 MHz.

52.9.6.3 Test Procedure

Use the following procedure to test relative intensity noise optical modulation amplitude:

a) With the DUT disconnected, zero the power meter;
b) Connect the DUT, turn on the laser, and ensure that the laser is not modulated;
c) Operate the polarization rotator while observing the power meter output to maximize the noise read by the power meter. Note the maximum power, P_N;
d) Turn on the modulation to the laser using the square wave pattern of 52.9.1 and note the power measurement, P_M. It may be necessary to change or remove the effective reflection to obtain an accurate reading;
e) Calculate RIN from the observed electrical signal power and noise power by use of Equation (52–1).

$$RIN_xOMA = 10\log\frac{P_N}{BW \times P_M} \text{ (dB/Hz)} \qquad (52\text{–}1)$$

where:

RIN_xOMA= Relative Intensity Noise referred to optical modulation amplitude measured with x dB reflection,
P_N = Electrical noise power in watts with modulation off,
P_M = Electrical power in watts with modulation on,
BW = Low-pass bandwidth of filter – high-pass bandwidth of DC-blocking capacitor [noise bandwidth of the measuring system (Hz)].

For testing multimode components or systems, the polarization rotator is removed from the setup and the single-mode fiber replaced with a multimode fiber. Step c) of the test procedure is eliminated.

Proposed oscilloscope-based $RIN_{xx}OMA$ measurement

- Use the same oscilloscope-based reference receiver as used for TDECQ measurement with xx dB applied back reflection at worst case polarization
- Measure the RMS noise power of the 0 and 3 levels before equalization using the same pattern and sampling locations as for OMA_{outer}

$$RINxxOMA = 10\log_{10}\left[\frac{(N_3 + N_0)^2/4}{OMAouter^2\ B}\right]$$

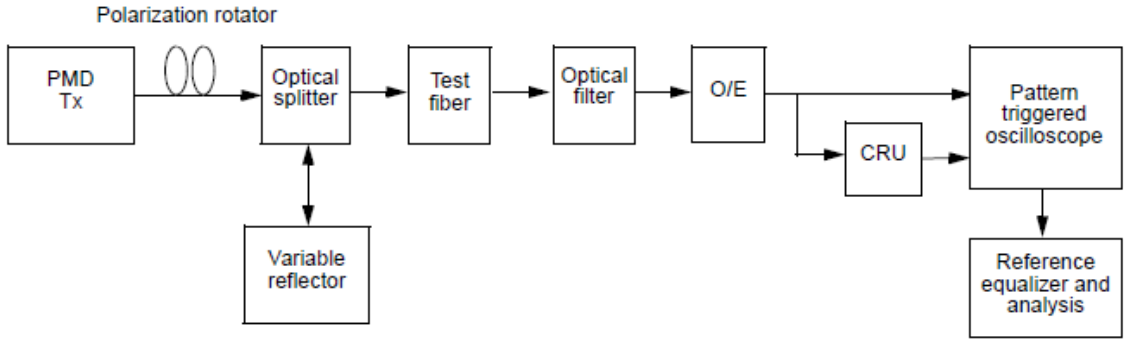

Figure 122–4—TDECQ conformance test block diagram

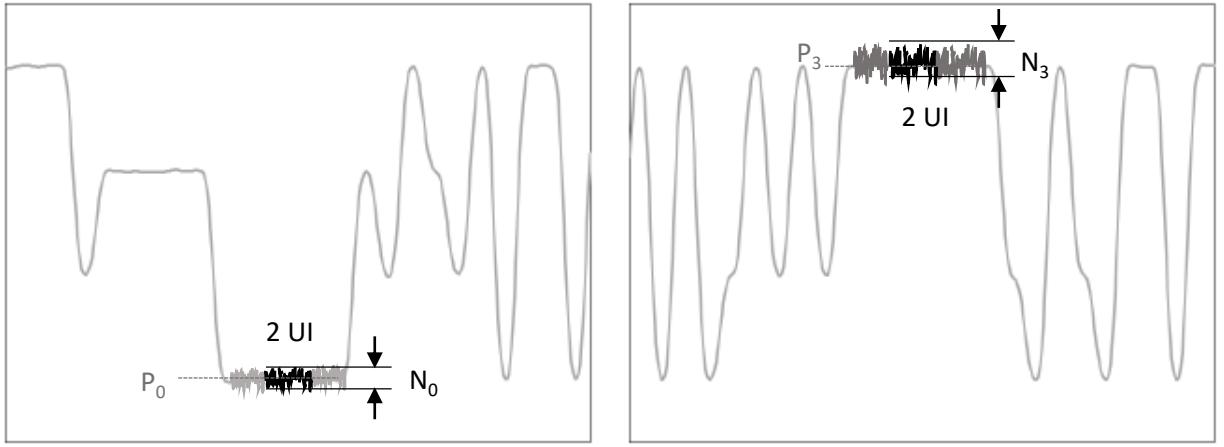

Figure 180–11—Example power levels P_0 and P_3 from PRBS13Q test pattern

For further reference on RINxOMA measurements, see: https://www.keysight.com/us/en/assets/7018-08468/application-notes/5989-5959.pdf

Proposed text (with editorial license)

180.8.11 Relative intensity noise ($RIN_{xx}OMA$)

$RIN_{xx}OMA$, with "xx" referring to the value for optical return loss tolerance in Table 180–7, shall be within the limit given in Table 180-7 when measured using the test pattern and sampling range specified for OMAouter measurement in 180.8.4, but with applied xx dB optical reflection and the reference receiver specified for TDECQ measurement in 180.8.5. The noise is measured before the reference equalizer.

$RIN_{XX}OMA$ is calculated as:

$$RINxxOMA = 10\log_{10}\left[\frac{(N_3 + N_0)^2/4}{OMAouter^2\ B}\right]$$

where:

- $RIN_{xx}OMA$ = Relative Intensity Noise referred to optical modulation amplitude, measured with *xx* dB optical reflection,
- N_3 = Optical noise power of the 3 level,
- N_0 = Optical noise power of the 0 level,
- B = Low-pass bandwidth of filter of the reference receiver (Hz).

Additional editorial instructions

- Update the test pattern for RINxxOMA in Table 180-13 to be “4 or 6”, the same as OMAouter.
- Modify Figure 180-11 with noise as shown on slide 7. Change the description to:
  - Example power levels P0 and P3 for OMAouter measurement, and noise levels N0 and N3 for RINxxOMA measurement, from PRBS13Q test pattern.

Conclusion

- The proposed text on slide 8 is intended to satisfy P802.3dj D1.0 comments #13-16 and #518 covering the following clauses, with editorial license:
  - 180.8.11
  - 181.8.11
  - 182.8.11
  - 183.8.11
- The authors believe that the proposed changes will improve standardization of $RIN_{xx}OMA$ measurement for 200G/L PMDs across the industry, and will dissuade users from using alternate, non-standard test methods to get around the inherent limitations of the method of 52.9.6.

Thank You