TDECQ and SECQ methodology for 400GBASE-SR4.2

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IEEE P802.3cm 400 Gb/s over Multimode Fiber Task Force

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Introduction

- The TDECQ and SECQ methodology for 400GBASE-SR4.2 is proposed to be based on Clause 138
- However, Clause 138 PMDs use transmission in the 840 to 860 nm wavelength range, whereas 400GBASE-SR4.2 uses the 844 to 863 nm and 900 to 918 nm wavelength ranges
- Therefore, the TDECQ reference response must be recalculated based on the worst-case bandwidth of the three MMF channels (70 m OM3, 100 m OM4 and 150 m OM5) over the allowed wavelengths
- The SECQ reference response is not dependent on the MMF channel. Clause 138 uses a fourth-order Bessel-Thomson filter response with “a bandwidth of approximately 13.28125 GHz”. This should be used for 400GBASE-SR4.2 also

EMB of OM3, OM4 and OM5

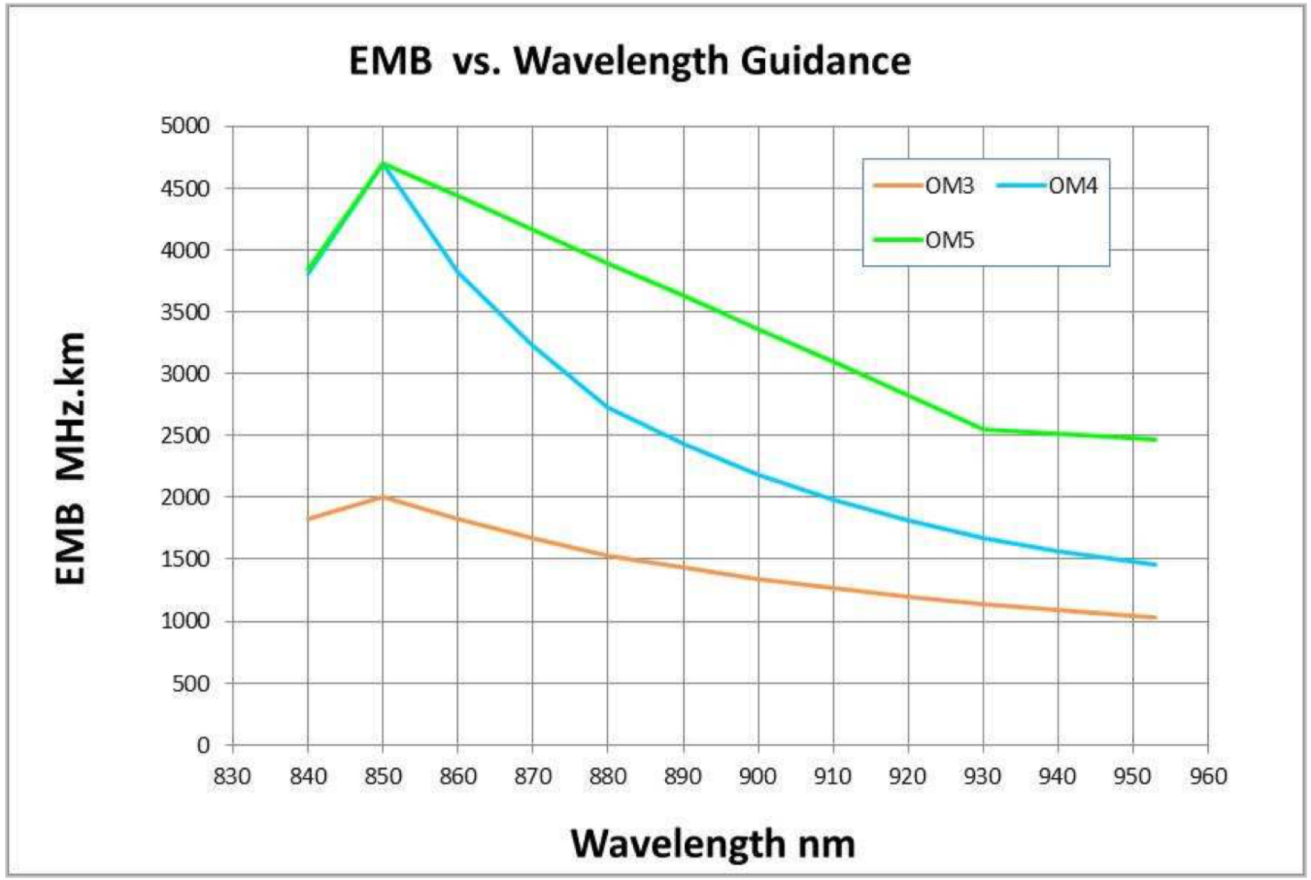


Figure reproduced from "OM3, OM4, OM5 modal bandwidth over wavelengths for WDM," P. Kolesar, J. Abbott, P. Pondillo, S. Swanson, M. Bigot, A. Amezcua, R. Samamra, K. Balemarthy, R. Shubochkin, J. Castro, R. Pimpinella, B. Lane and B. Kose, IEEE 802.3 Next-Generation 200 Gb/s and 400 Gb/s MMF PHYs Study Group, Geneva, January 2018

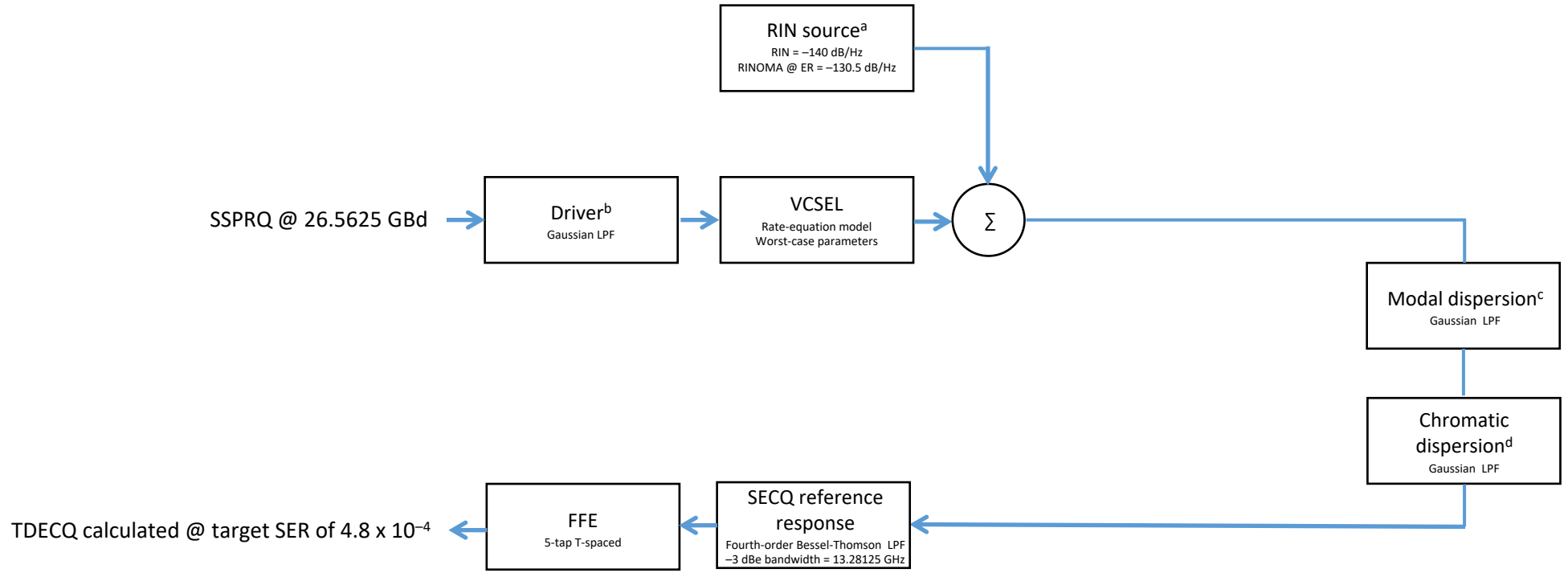
Methodology for determining the TDECQ reference response

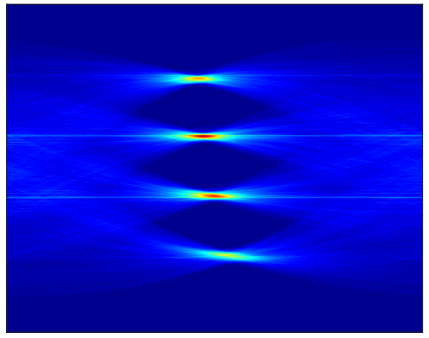
- Use fourth-order polynomial characteristics in draft IEC 60793-2-10 to obtain OM3 and OM4 EMB
- Use piecewise linear characteristics in IEC 60793-2-10 to obtain OM5 EMB

1) Simulate link performance with three LPFs cascaded: (i) a Gaussian LPF for modal dispersion, (ii) a Gaussian LPF for chromatic dispersion and (iii) a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 13.28125 GHz, i.e. the SECQ reference response
2) Locate the worst-case wavelength over the allowed wavelengths (844 to 863 nm and 900 to 918 nm)
3) Replace the three LPFs with a single fourth-order Bessel-Thomson LPF
4) Adjust the –3 dBe bandwidth of the single fourth-order Bessel-Thomson LPF for identical TDECQ
5) Repeat for the three MMF channels

- This methodology is based on that used to determine the TDEC reference response in Clause 95 (100GBASE-SR4) and the TDECQ reference response in Clause 138 (50GBASE-SR, 100GBASE-SR2 and 200GBASE-SR4)

Simulation

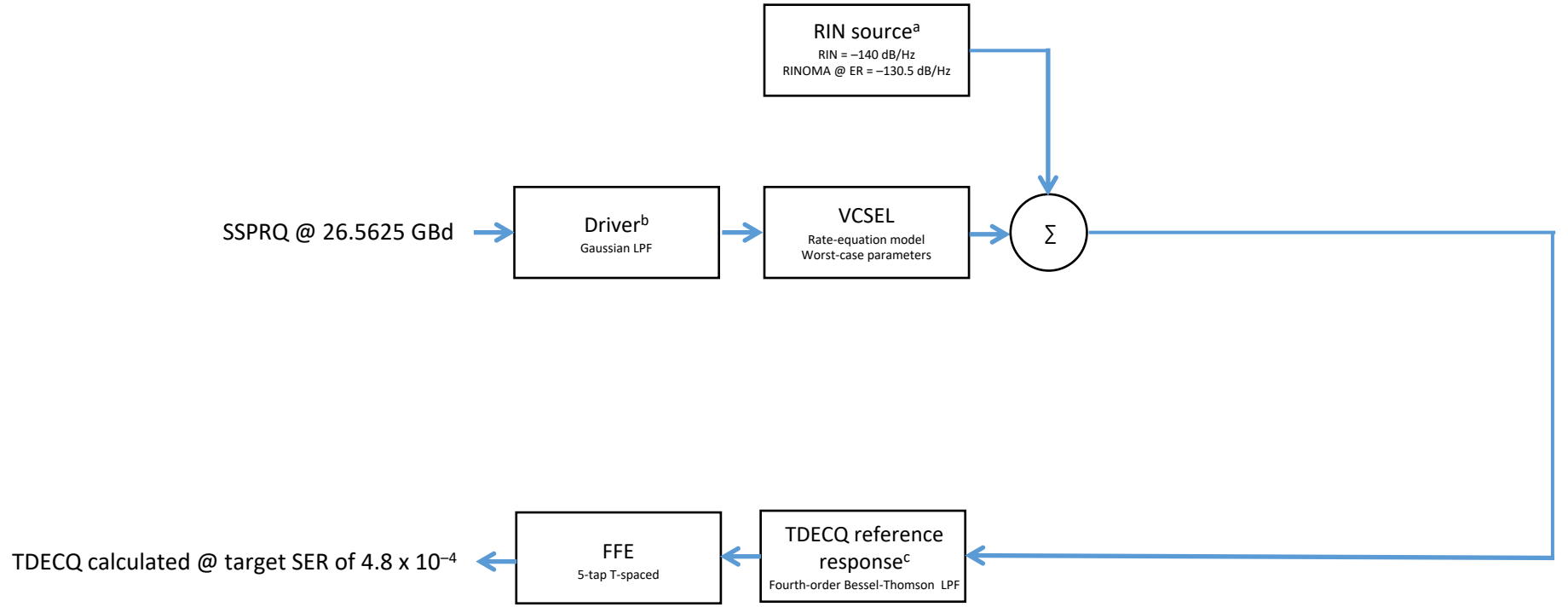


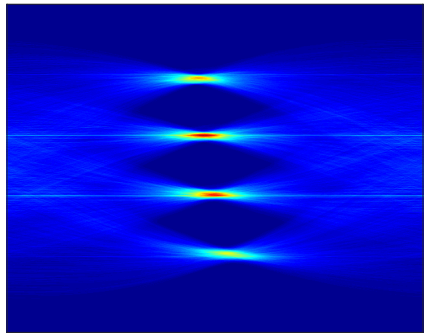


Example eye diagram with TDECQ of 4.5 dBo for 100 m OM4 at 916 nm with a Gaussian LPF for modal dispersion, a Gaussian LPF for chromatic dispersion and the SECQ reference response

[a]RIN PSD set by 4th-order Bessel-Thomson LPF with –3 dBo bandwidth of 18 GHz (ER of 3 dB assumed for RIN calculation)
[b]Driver transition time is adjusted for TDECQ of 4.5 dBo
[c]Modal bandwidth calculated from EMB
[d]Chromatic bandwidth calculated using 10 GbE spreadsheet methodology with zero-dispersion wavelengths of 1320 nm (OM3 and OM4) and 1328 nm (OM5) and zero-dispersion slopes of 0.11 ps/(nm^2 km) (OM3 and OM4) and 0.093477 ps/(nm^2 km) (OM5). RMS spectral width of the VCSEL is assumed to be 0.6 nm

Simulation *with a single equivalent LPF*





Example eye diagram with TDECQ of 4.5 dBo for 100 m OM4 at 916 nm with a TDECQ reference response with –3 dBe bandwidth of 9.08 GHz

[a]RIN PSD set by 4th-order Bessel-Thomson LPF with –3 dBo bandwidth of 18 GHz (ER of 3 dB assumed for RIN calculation)

[b]Driver transition time is adjusted for TDECQ of 4.5 dBo with configuration on previous slide

[c]–3 dBe bandwidth of TDECQ reference response is adjusted to obtain identical TDECQ of 4.5 dBo

Results

- 70 m OM3 worst-case bandwidth occurs at 918 nm and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.05 GHz
- 100 m OM4 worst-case bandwidth occurs at 918 nm and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.08 GHz
- 150 m OM5 worst-case bandwidth occurs at 918 nm and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.01 GHz
- *To be conservative, recommend rounding down so that the TDECQ reference response is a fourth-order Bessel-Thomson filter response with a –3 dBe bandwidth of 9.0 GHz*

Proposal

- Propose that 400GBASE-SR4.2 uses an identical TDECQ and SECQ methodology to Clause 138, with the exception of the TDECQ reference response

- The TDECQ reference response is proposed to be a fourth-order Bessel-Thomson filter response with a –3 dBe bandwidth of 9.0 GHz, representative of the worst-case bandwidth of the three MMF channels over the allowed wavelengths

Additional material

Results (900 to 918 nm wavelength range)

- 70 m OM3 worst-case bandwidth occurs at 918 nm[a] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.05 GHz
- 100 m OM4 worst-case bandwidth occurs at 918 nm[b] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.08 GHz
- 150 m OM5 worst-case bandwidth occurs at 918 nm[c] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.01 GHz
- *To be conservative, recommend rounding down so that the TDECQ reference response is a fourth-order Bessel-Thomson filter response with a –3 dBe bandwidth of 9.0 GHz*

[a]EMB = 1208 MHz km
[b]EMB = 1846 MHz km
[c]EMB = 2885 MHz km

Results (844 to 863 nm wavelength range)

- 70 m OM3 worst-case bandwidth occurs at 863 nm[a] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 10.35 GHz
- 100 m OM4 worst-case bandwidth occurs at 844 nm[b] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 10.39 GHz
- 150 m OM5 worst-case bandwidth occurs at 844 nm[c] and is equivalent to a fourth-order Bessel-Thomson LPF with a –3 dBe bandwidth of 9.08 GHz
- *The lowest worst-case bandwidth for the 844 to 863 nm wavelength range is only 70 MHz higher than the lowest worst-case bandwidth for the 900 to 918 nm wavelength range. Hence, the proposed value of 9.0 GHz for the 900 to 918 nm wavelength range is an appropriate choice for both wavelength ranges*

[a]EMB = 1778 MHz km
[b]EMB = 4184 MHz km
[c]EMB = 4184 MHz km