Comments on Serial PMD Optical Specs.

Marc Verdiell, LightLogic Inc.
mverdiell@lightlogic.com

Specifics of 10 Gb/s 1.3 and 1.5 μm single-mode links

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- Dispersion limited, laser chirp is important factor
- Transmitters are expensive
  - Fabry Perot = $, DFB= $$, Externally Modulated = $$$
  - Isolation comes at a price premium
  - Cooling comes at a price and power consumption premium
- Receivers are expensive
  - PIN=$, APDs= $$
- Need to avoid over-specifying optical interfaces
- Current interfaces specification is more difficult than SONET

Problematic Specifications

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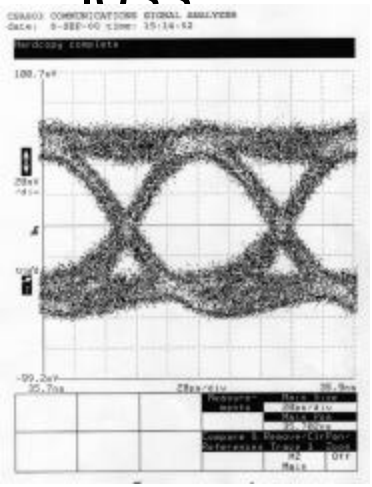
1. **10 km distance spec. eliminates Fabry Perot solution**. A 2 km spec could allow lower cost FP solution.
2. **12 dB return loss requires isolation at transmitter**. A 20 dB spec could allow unisolated DFB for 10 km, and 14 dB could allow unisolated Fabry-Perot over 2km.
3. **-20 dBm sensitivity requires APD receiver**. At -18 dB we could use PIN receiver.
4. **Eye mask is too stringent**. Even good SONET lasers (-14 dBm sensitivity at 10^{-12} BER) might not pass.
5. **Rise times too stringent**. Need only to pass eye mask and BER.
6. **Spectral quality not well specified**. RMS wavelength not relevant for 10 Gb/s Single Mode links. Should use dispersion penalty specification instead.
7. **-140 RIN is too stringent**. Might need double stage isolation/high power DFB. The link should not be RIN limited anyhow.

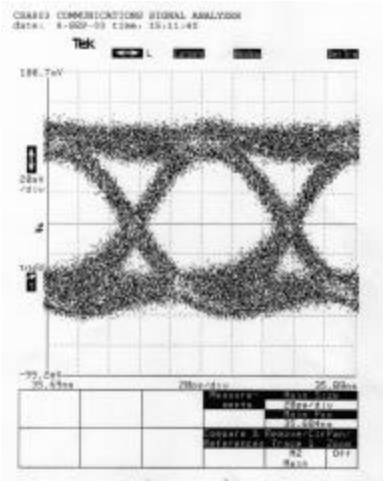
1.3um DFB with Back Reflection

- Common Conditions: T=50C, Extinction Ratio=6 dB, Distance=10 km
- Varying return loss from -40 to -14 dB
- This un-isolated DFB ***cannot*** work under -14 dB return loss



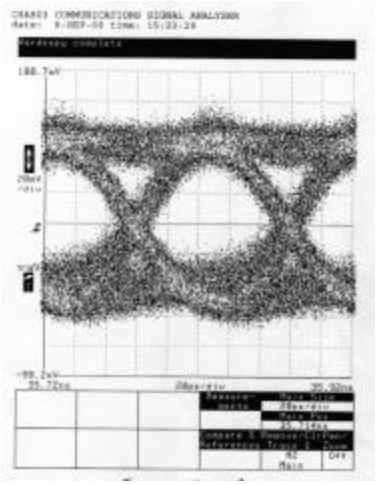
D = 10km

R = -40dB



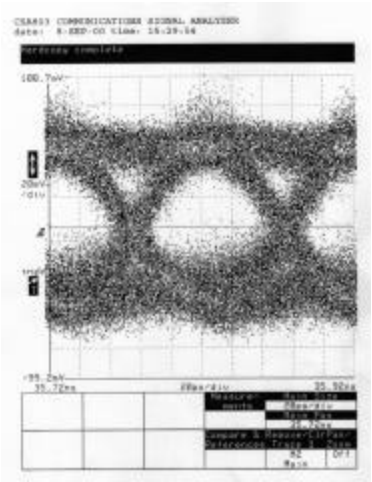
D = 10km

R = -27dB



D = 10km

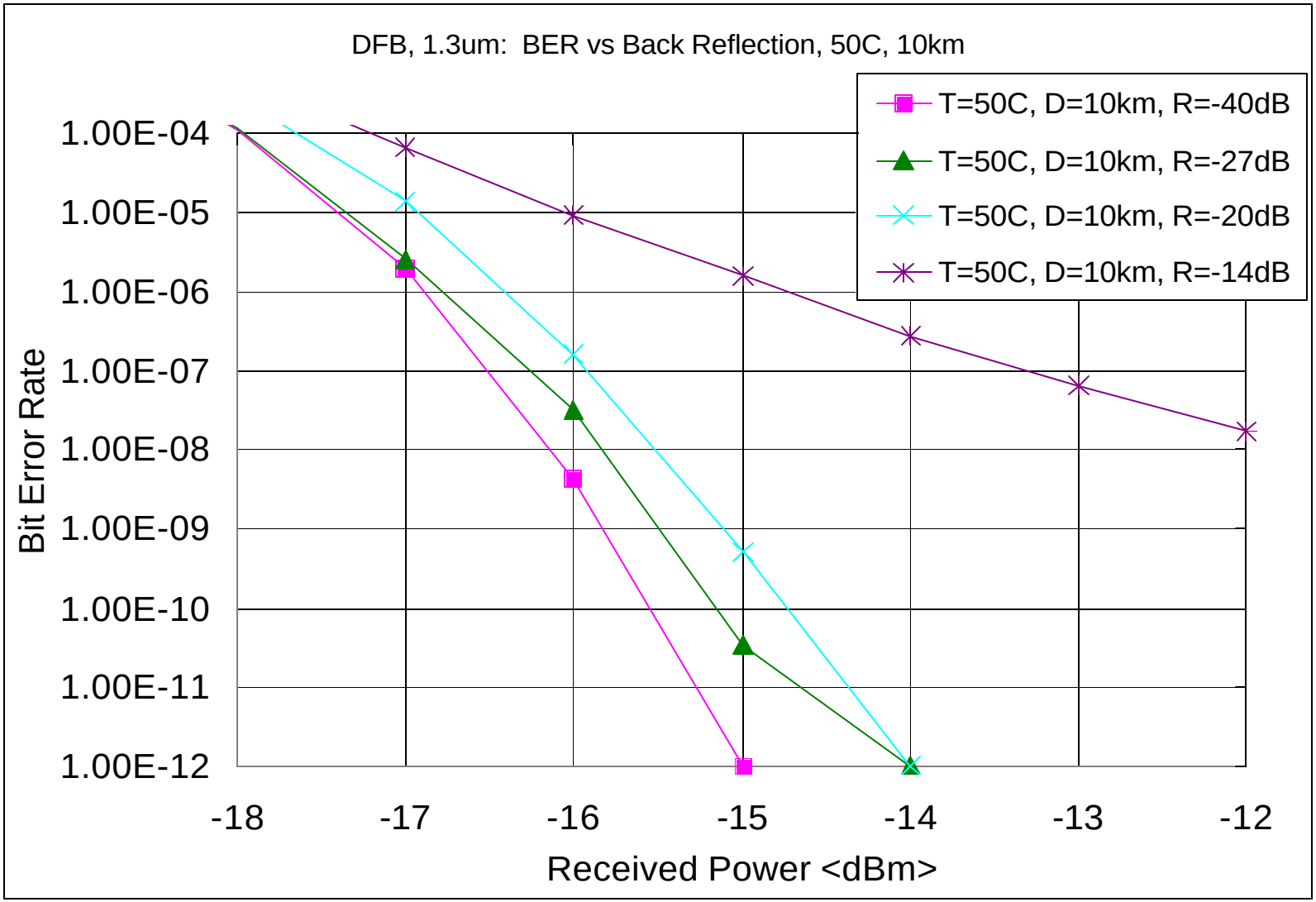
R = -20dB



D = 10km

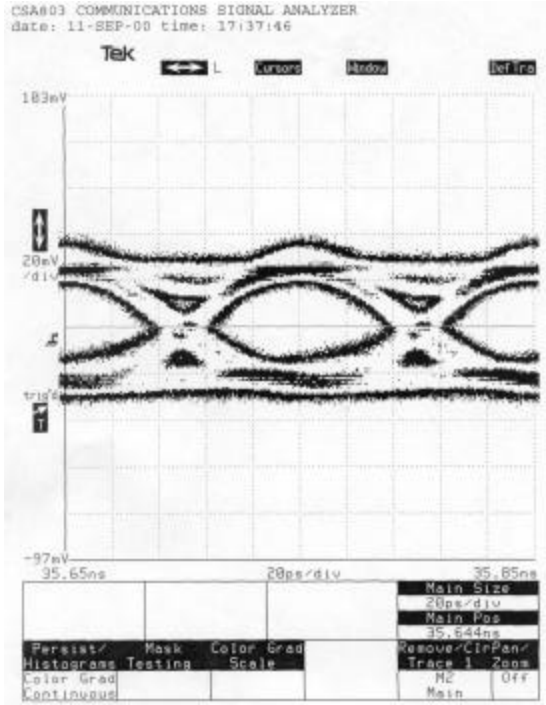
R = -14dB

DFB, 1.3um: BER vs. Back Reflection



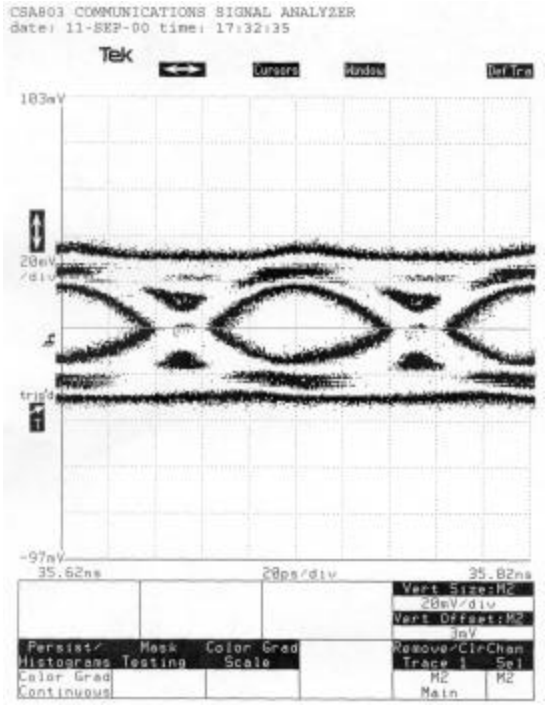
FP, 1.3um: Eye Diagrams vs. Back Reflection

- Common Conditions: T=25C, Extinction Ratio=6 dB
- This un-isolated FP ***can*** work under -14 dB return loss at 2 km



D = 0km

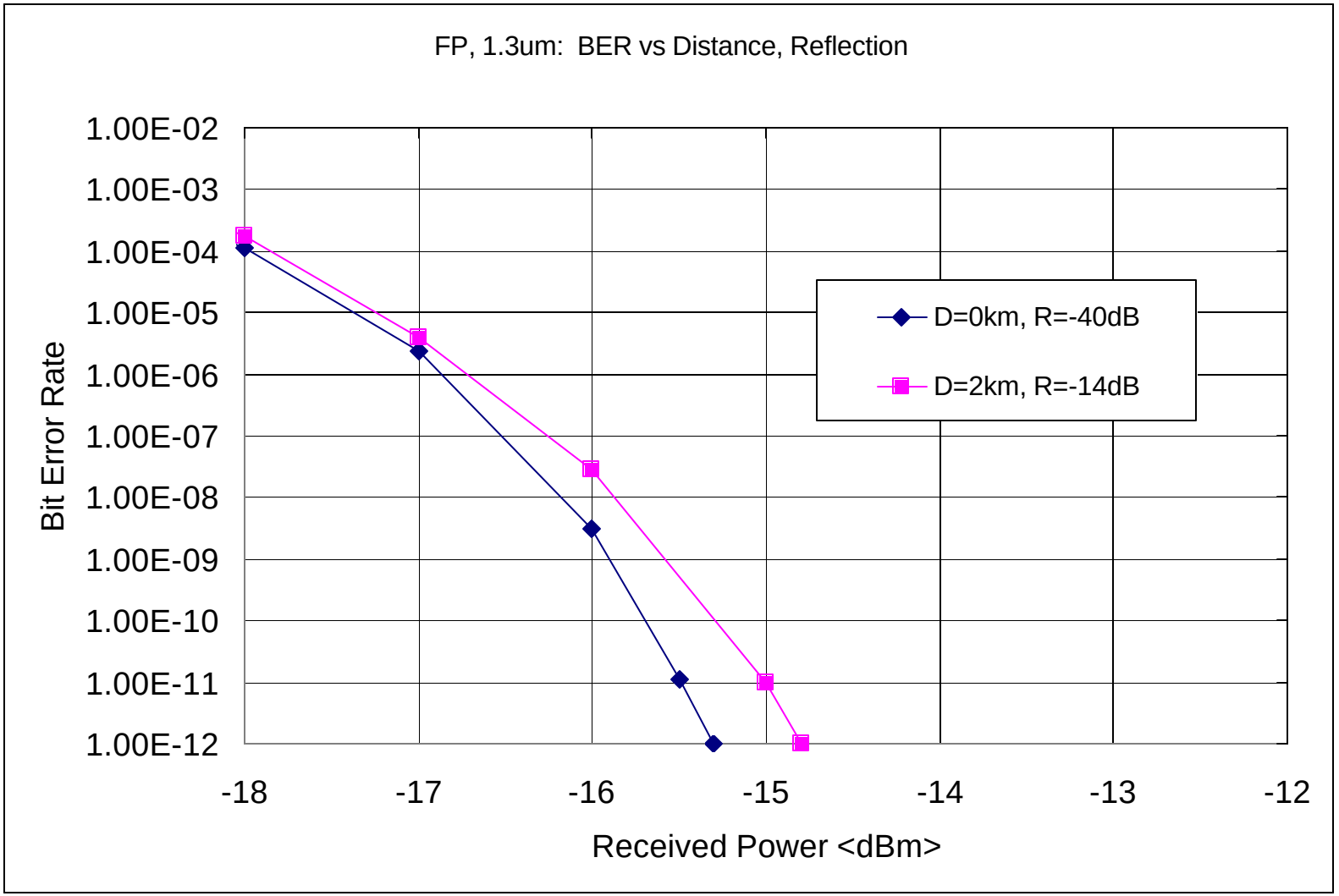
R = -14dB



D = 2km

R = -14dB

FP, 1.3um: BER vs. Back Reflection and Distance



OC-48 Sonet vs Proposed 10GbE

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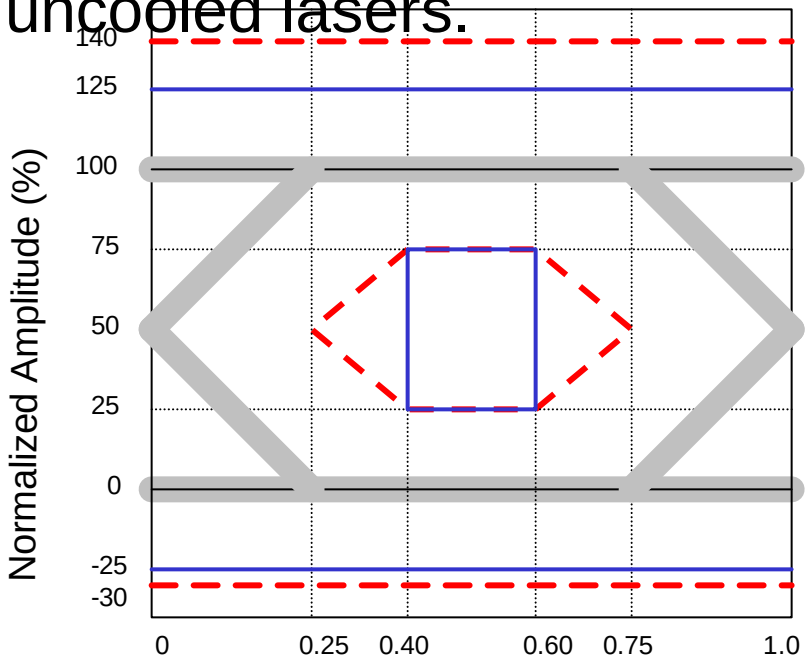
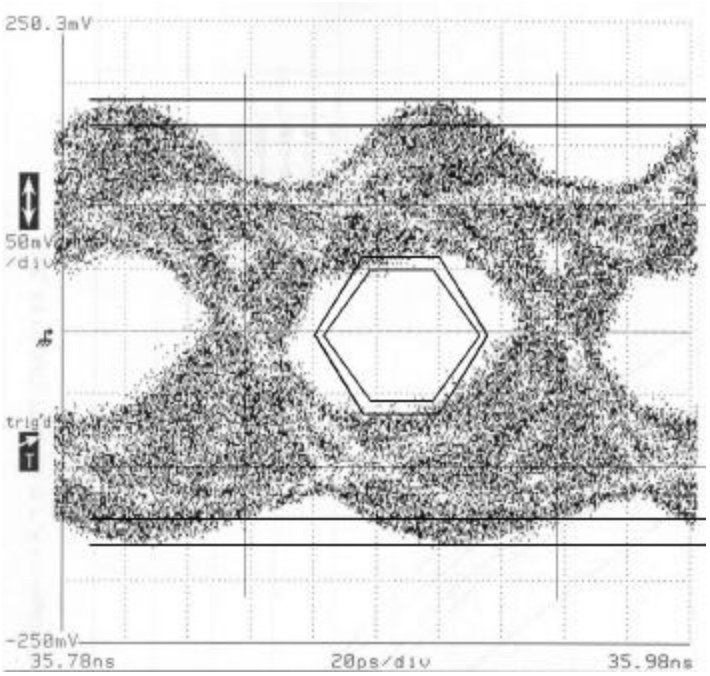
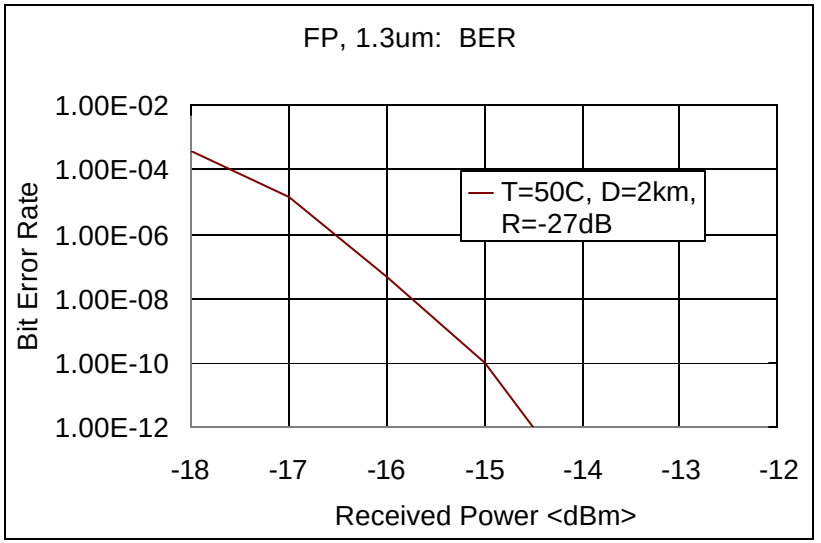
Our 10 GbE Proposal (dashed)

- Start with scaled OC-48 SONET mask (solid square)
- Added “corners” internal to eye, corresponding to previous 1GbE spec.
- Enlarged over and under shoot areas to allow for direct modulated, uncooled lasers.



Eye Mask Example 1 - Uncooled FP

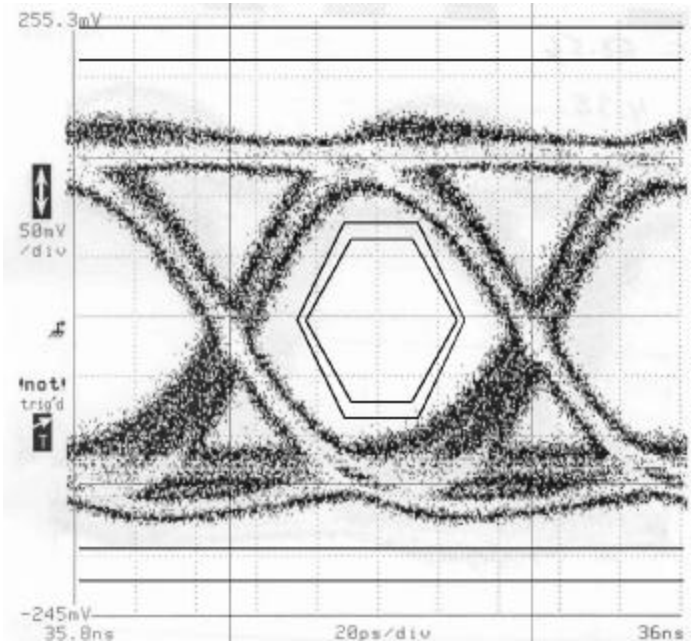


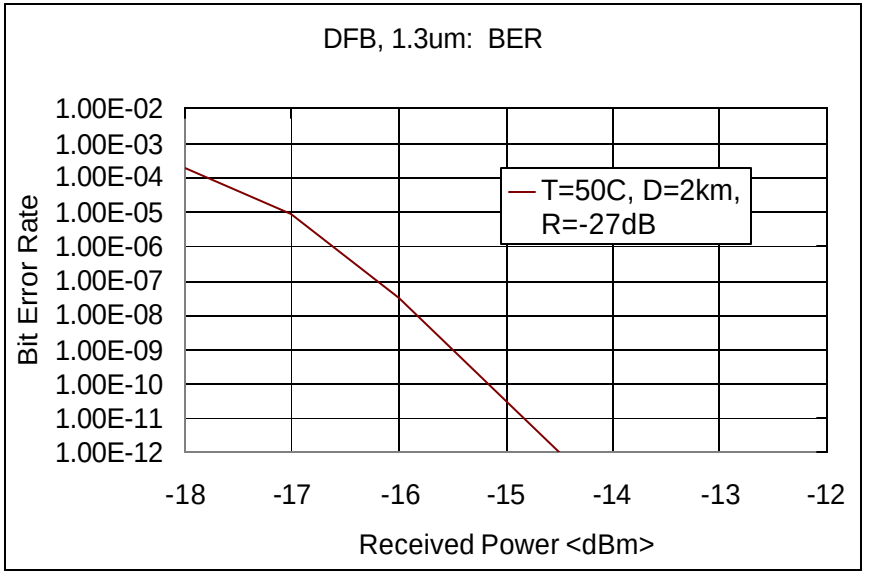


Eye of Diode with < 10^-12 BER @ -14 dBm received power

- Outside mask is currently proposed 10 GbE
- Inside mask is our proposed 10GbE (modified SONET)
- Fails both even though it passes BER

Eye Mask Example 2 - Uncooled DFB

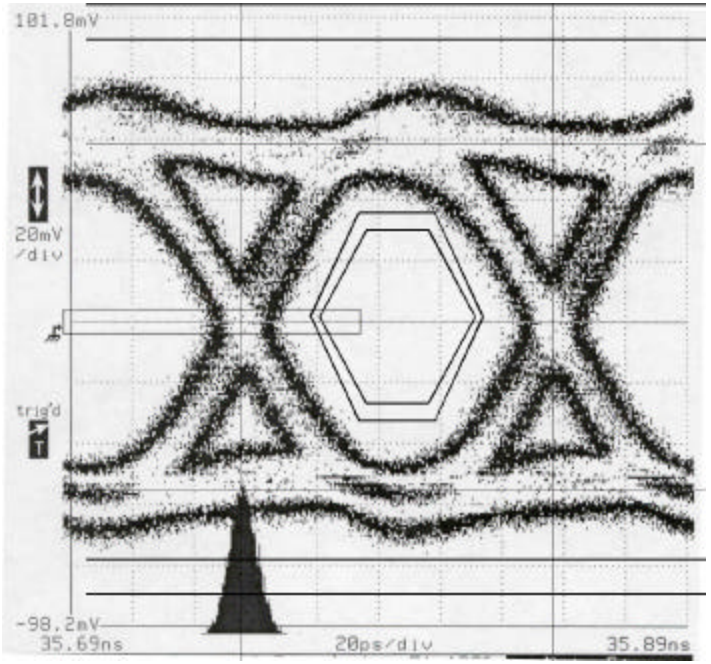


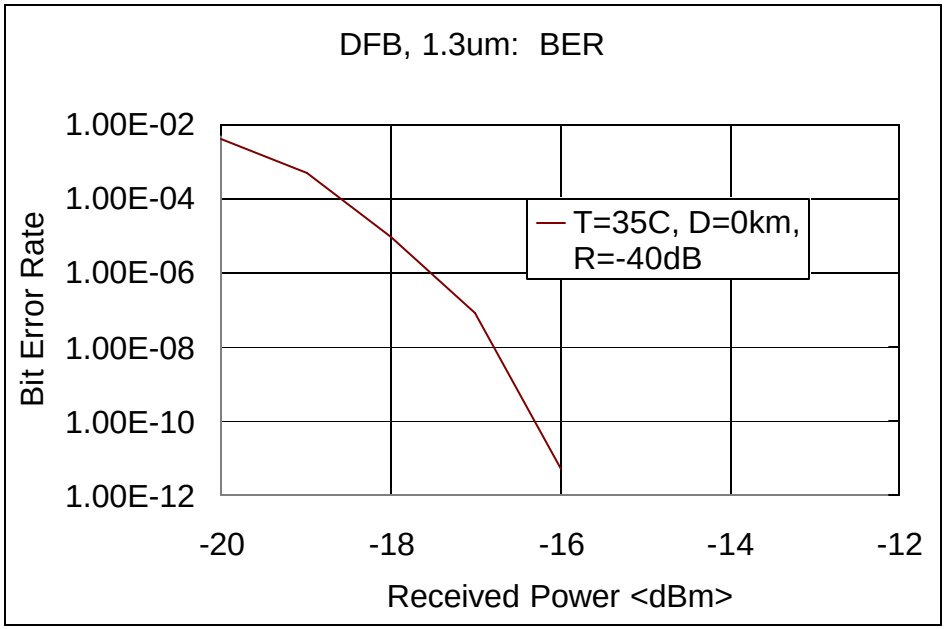


Uncooled DFB @ 50 C

- Fails original proposed 10GbE mask.
- Passes our proposed mask.
- BER performance < 10^-12 @ -14 dBm

Eye Mask Example 3 - Cooled Isolated DFB





Cooled/Isolated DFB

- Passes both proposed 10GbE mask and our proposed mask.
- BER < 10^-12 @ 16 dBm

Revised Table - Transmit

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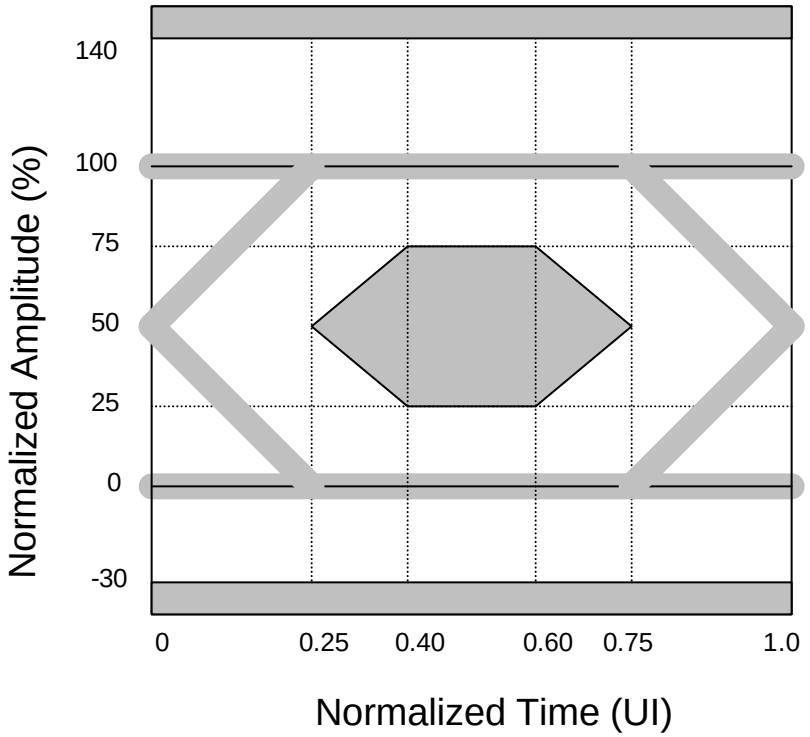
Table 60 - Transmit Characteristics

Descritpion	10GBASE-LX/LW	10GBASE-EX/EW	Units
~~Transmitter Type~~	Specified through performance only (mask, dispersion penalty, wavelength)	Covers whatever works: FP, DFB, EA-DFB, VCSEL…	
Signaling speed (range) 10GBASE-LX/EX 10GBASE-LW/EW	 10.3125+/-100ppm 9.95328+/-100ppm		GBd
Wavelength Range	1290 to 1330	1530 to 1565	nm
T_{rise}/T_{fall} (max, 20-80% response time)	50 ~~30~~	40 ~~30~~	ps
~~T_{rise}/T_{fall} (max, 20-80% response time)~~ Eye Mask	see graph		
~~RMS spectral width~~ Dispersion penalty	1.0	2.0	dB
Average launch power (max)	1.0	2.0	dBm
Average launch power (min)	-4.0	-2.0	dBm
Average launch power of OFF transmitter (max)	-30	-30	dBm
Extinction Ratio (min)	6	8	dB
RIN (max)	-130	-130 ~~-140~~	dB/Hz

Eye Mask Proposal



Revised Table - Receive

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Table 61 - Receive Characteristics

Descritpion	10GBASE-LX/LW	10GBASE-EX/EW	Units
Signaling speed (range) 10GBASE-LX/EX 10GBASE-LW/EW	 10.3125+/-100ppm 9.95328+/-100ppm		GBd
Wavelength Range	1290 to 1330	1530 to 1565	nm
Average Receive Power (max)	-1.0	-8.0	dBm
Receive Sensitivity	-14	-18 ~~-20~~	dBm
Return Loss	-20 ~~-12~~	-20 ~~-12~~	dB
Stressed Eye Sensitivity	-11.45	-15.41	dBm
Vertical eye closure penalty (?)	1.71	2.72	dB
Receive 3dB cutoff	8.0	8.0	GHz

Conclusion

- We should not make it harder than SONET!
- Proposed revised tables as starting point (need to be worked out further)
- Specification should leave opportunity to use (significantly) cheaper unisolated Fabry-Perot or DFB lasers for 600m-2km reach.