Using Low Bandwidth Optics for 10G NRZ

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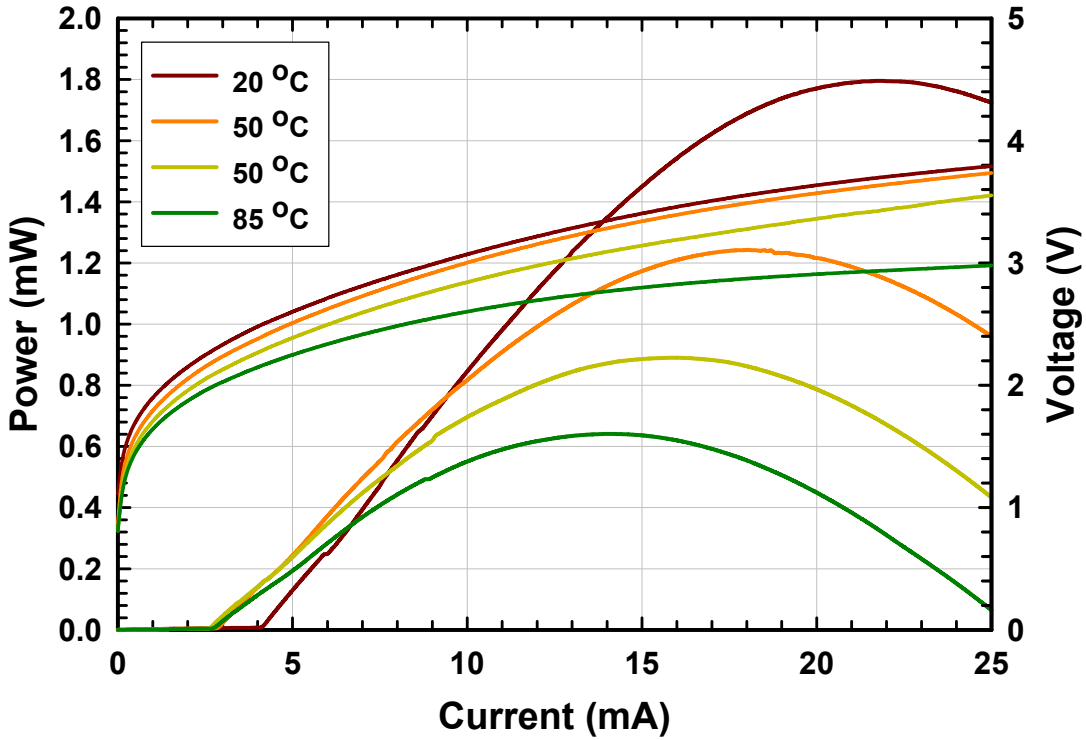
Module Economy Considerations

- **Significant module economies (cost and/or power) dictated by:**
  - **relaxed packaging (lower bandwidth TOSA and/or ROSA) [Voois, Swenson, Cornejo, Jan'04]**
  - **Low-cost, low-power lasers such as 1310nm VCSELs**
- **Up to 7G Hz ROSA/TOSA may be designed to achieve approximately the 4G optics economies.**
- **Typical 3.125G tx optics bandwidth (each arm of LX-4) higher than 4GHz**
- **Poor linearity characteristics of lasers such as LW-VCSELs make use of modulation schemes req high linearity difficult to use.**
- **Significant potential cost advantages with binary 10G NRZ relative to 10GBASE-LR and LX-4**

LW-VCSEL LIV Characteristics

ϕ =12 μm λ=1,322 nm



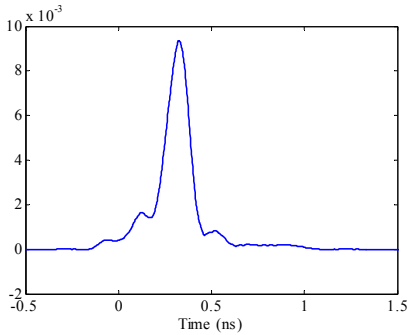
- VCSEL is an excellent low cost digital binary light source but not a good candidate for analog applications
- Just like 850 nm VCSELs, multimode LW VCSEL linearity changes due to mode beating & thermal roll over

Effect of Using Low Bandwidth Optics

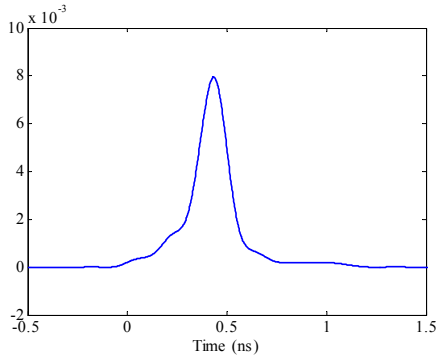
- **Binary 10G serial data stream: Increased channel ISI due to the limited ROSA/TOSA bandwidths.**
- **Relative to worst-case MMF channels (aggregate bandwidth could even fall below 2GHz), minor additional ISI.**
- **Fairly well compensated by standard EDC architectures**
  - **Even more effectively compensated by simple analog front-end (such as “high-pass” filtering/ high frequency (close to Nyquist) gaining**
  - **Analog front-end not factored in simulation results.**

On Serial Binary NRZ (10Gb/s): Low Bandwidth ROSA and TOSA

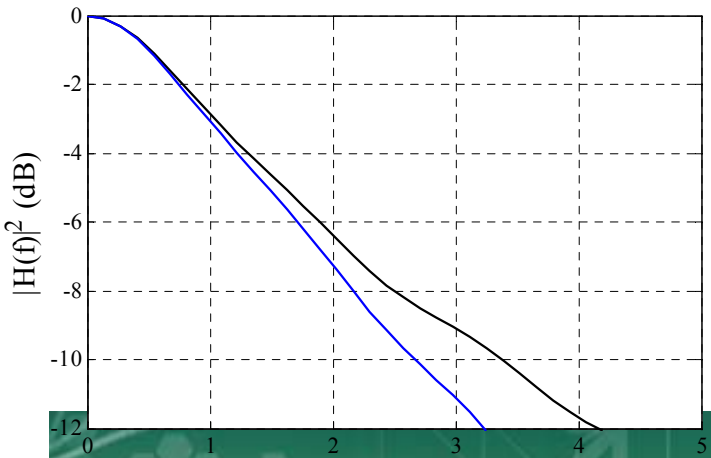
802.3z Waveform 1



Impulse response:
300m of fiber



Impulse response:
5G ROSA+5GTOSA+300m of fiber



Black trace – 300m fiber
Blue trace – 300m fiber+5G ROSA+5G TOSA

Performance of Serial Binary NRZ (10Gb/s): Low Bandwidth ROSA and TOSA

Performance across bandwidth and distance of fiber: EDC architecture: 16 tap T/2 spaced FFE + 3-tap DFE

	100 m	200 m	300 m
5-GHz ROSA, 5-GHz TOSA	2.1 dB	3.6 dB	5.0 dB
7-GHz ROSA, 7-GHz TOSA	1.9 dB	3.35 dB	4.75 dB
8.5-GHz ROSA, 10-GHz TOSA	1.7 dB	3.1 dB	4.5 dB

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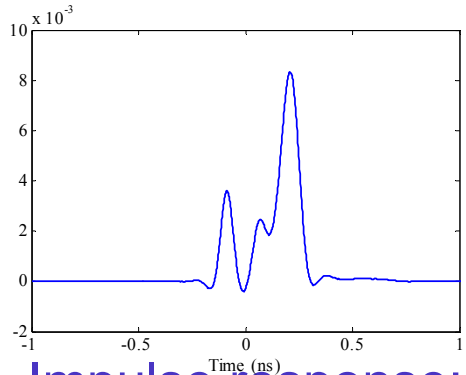
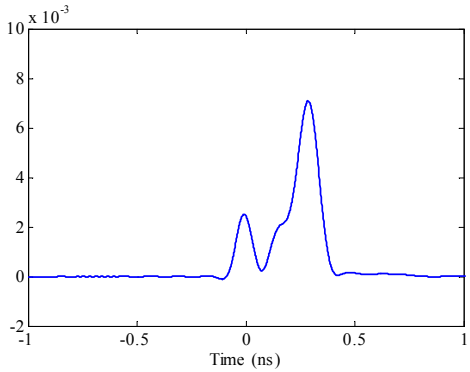


Impulse response:
300m of fiber



Impulse response:
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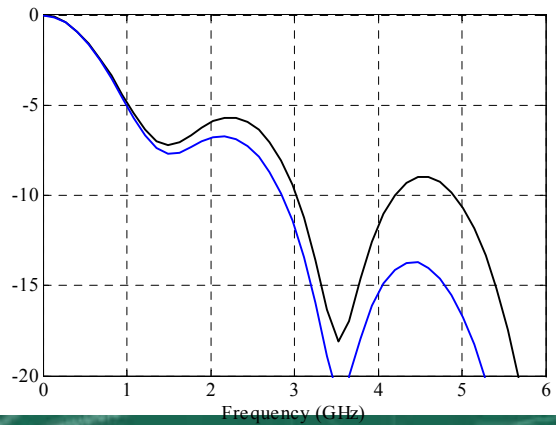

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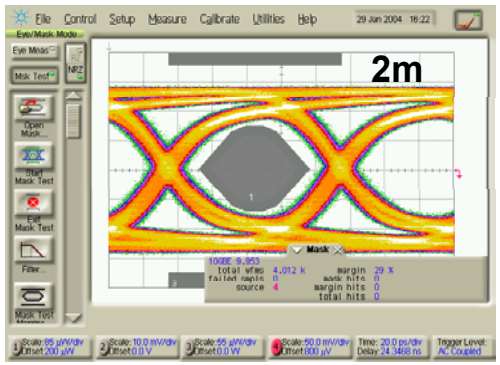
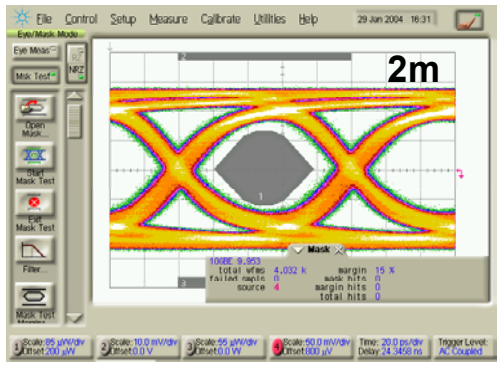
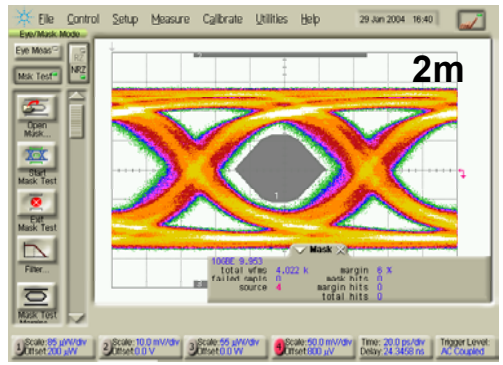
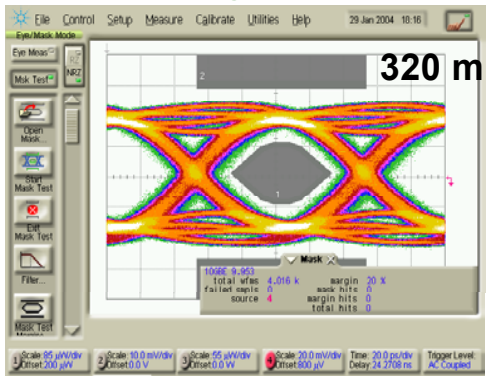
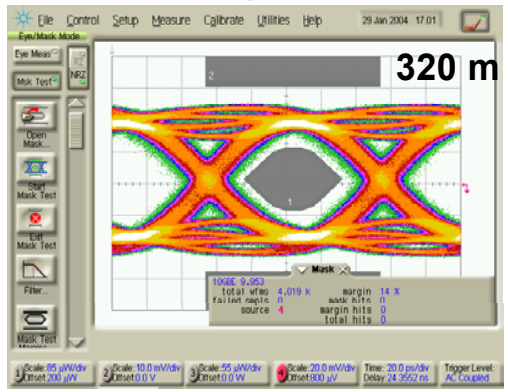
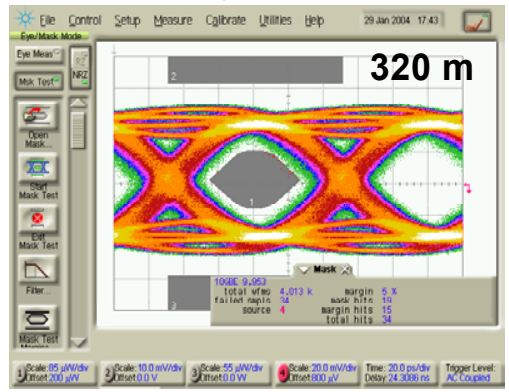
10 GbE Xmission over 300m of MMF up to ~70C using Electronic Dispersion Compensation

20ºC	50ºC	70ºC
		
Total Hits 0 Margin 25%	Total Hits 0 Margin 15%	Total Hits 0 Margin 5%
		
Total Hits 0 Margin 20%	Total Hits 0 Margin 10%	Mask Hits 19 Margin Hits 15 Margin 5%

10 Gb/s modulation before transmission

10 Gb/s after transmission through 320 m MMF + EDC

10 GbE Mask 4,000 wfms

Conclusions

- Small degradation of performance using 10G binary NRZ even with low bandwidth ROSA and TOSA.
  - Further reduced with simple, enhanced analog front-end.
- The compliance testing at the transmitter could be based on the eye mask with lower data rate signal such as 4Gb/s to 7 Gb/s
- The cost of lower data rate TOSA/ROSA packaging could be significantly lower than that of 10G TOSA/ROSA
- Poor laser linearity as with LW-VCSELs makes modulation schemes requiring high linearity difficult to use.
- Next steps: Experimentally confirm simulations with 4G VCSELs/FPs and EDC!