Comparison of EDC-Enabled Link Performance Using Measured Waveforms from 2.5G and 10G Lasers

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September 27, 2004

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Outline

- Motivation
- Data Capture/Simulation Description
- Results for Single Fiber
- Results across Cambridge 2.0 Model
- Summary

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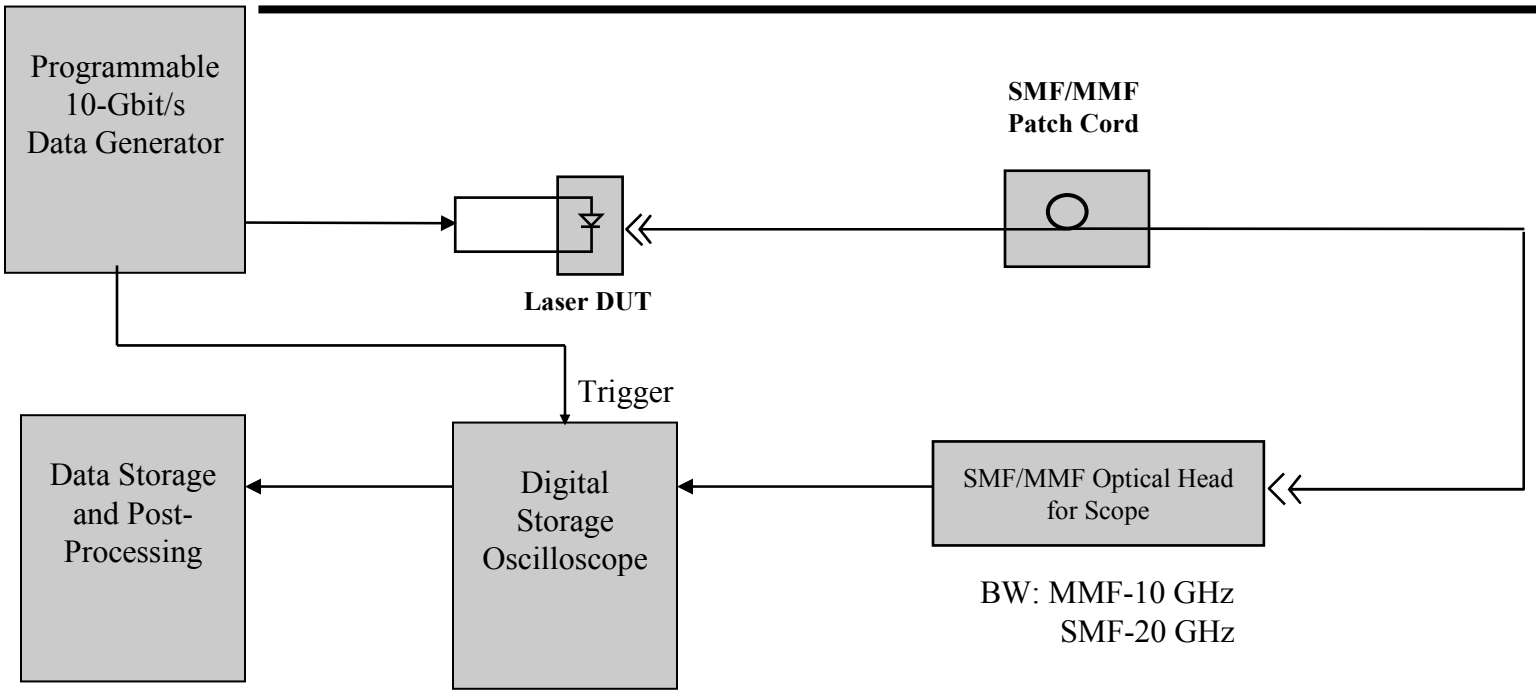
Motivation

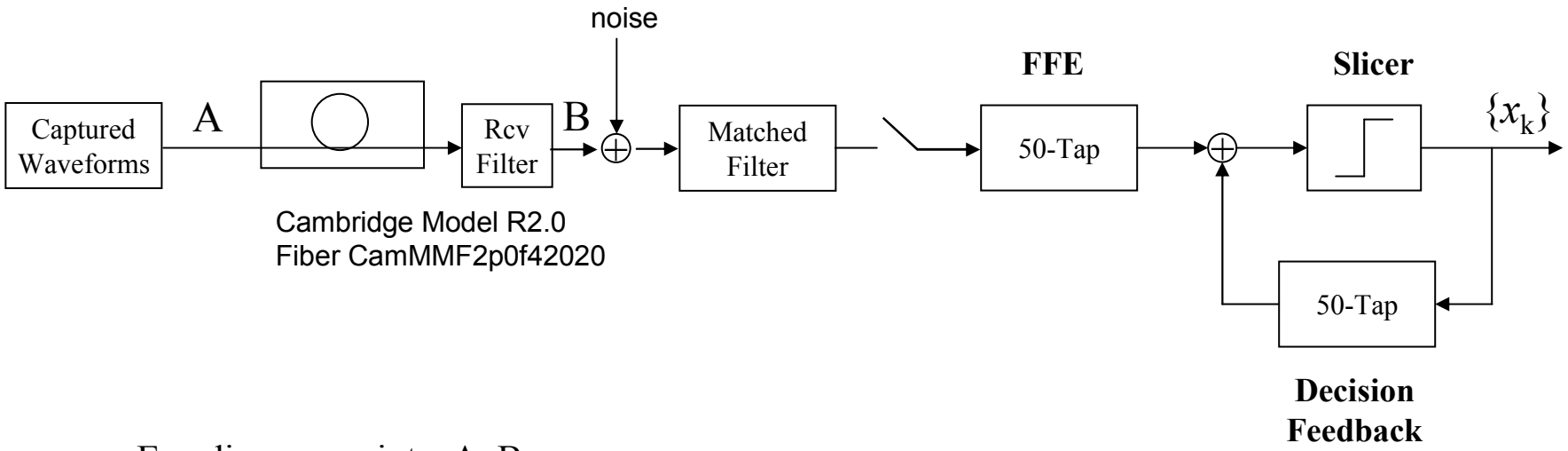
- Interest in relaxing TP2 test to allow greater flexibility in transmitter design choices
- Simulation has shown promising results
- Desire to explore feasibility using measured data from commercially available lasers with different nominal speeds
- Fiber propagation is simulated to allow generation of worst-case fiber effects
- Results shown for a single “bad” fiber

Data Capture



- Lasers modulated at 10 Gbps
- 127-bit pseudo-random sequence, averaged over 16 or 64 frames
- Used two DUTs: 2.5G FP and 10G FP
  - Each laser run at two different extinction ratio/OMA combinations

Simulation



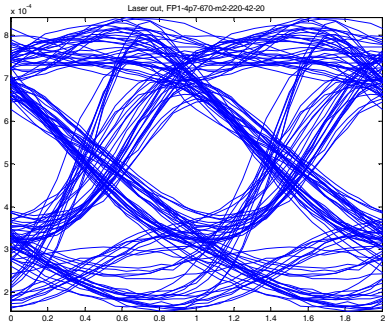
- Eye diagram points: A, B
- Cambridge R2.0 model
  - Same fiber as used in earlier analysis (lobel_1_0804.pdf), but that analysis used Cambridge R1.0 model
- Receive filter is BT with 7.5 GHz BW
- Ideal matched filter
- Pulse response estimated at point B using best linear fit
- Equalizer taps computed based on estimated pulse response

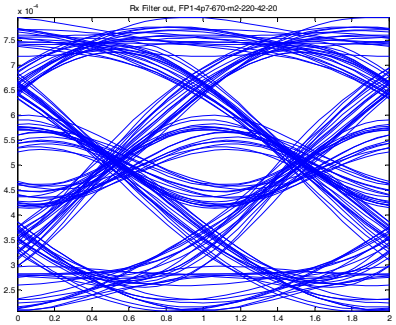
Eye Diagrams

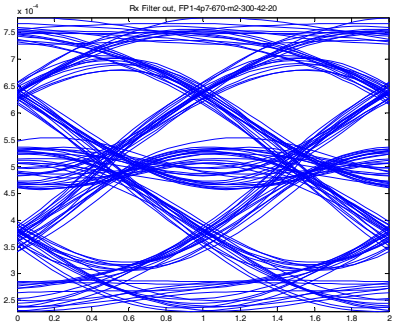
Out of laser | 220m | 300m

Laser/ER(db)/OMA(dBm)

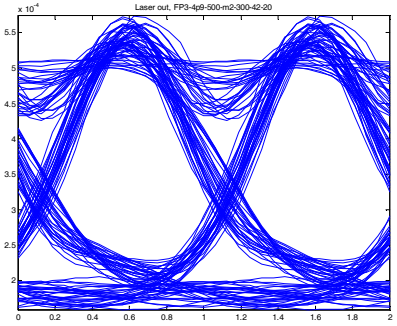
2.5G/4.7/-1.8

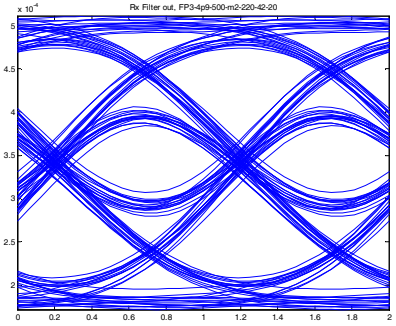


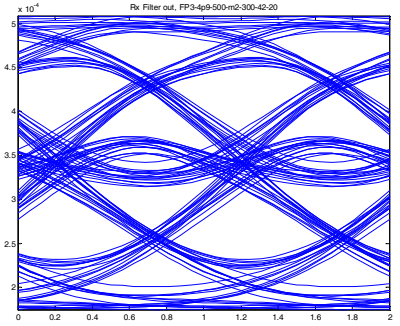




10G/4.9/-2.9







Fiber CamMMF2p0f42o20

Penalty Calculations

- Penalty vs 10G rectangular pulse matched-filter bound
  - Same reference as PIE-D
  - Finite-length feed-forward (50), feedback (50) sections
- Penalty computed four ways:
  - PIE-D
    - Based on linear channel assumption and estimated pulse response
    - Treats ISI as Gaussian
  - Analytic Finite
    - Approximates PIE-D using very long finite-length equalizer
    - Based on linear channel assumption and estimated pulse response
  - Linear, Semi-analytic
    - Linear approximation to waveform based on estimated pulse response
    - Computes BER for each ISI pattern and averages over all ISI patterns
  - Measured, Semi-analytic
    - Semi-analytic using measured waveform as propagated through simulated channel
    - Includes all laser nonlinearities

Penalties (dBo), 220m

Fiber CamMMF2p0f42o20

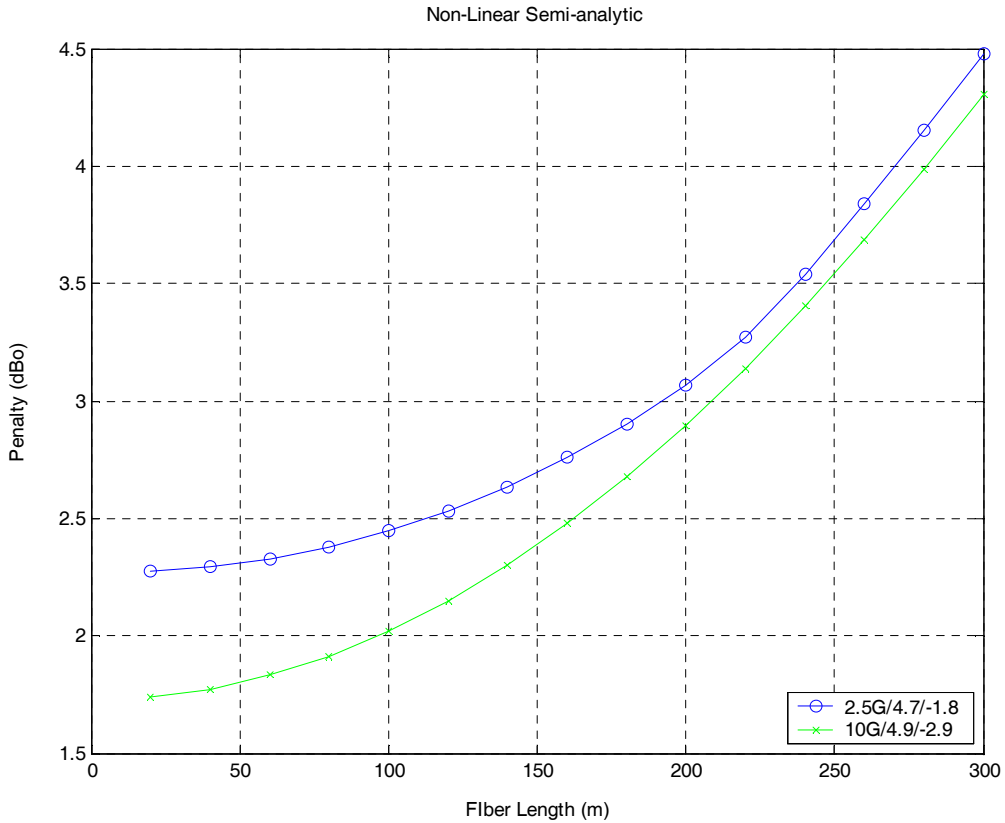
Laser/ER(dB)/OMA(dBm)	PIE-D	Analytic Finite	Linear Semi-Analytic	Measured Semi-Analytic
2.5G/3.5/-2.9	2.6	2.6	2.6	3.2
2.5G/4.7/-1.8	2.6	2.6	2.6	3.3
10G/4.9/-2.9	2.6	2.6	2.6	3.1
10G/5.5/-2.5	2.7	2.7	2.7	3.1

Penalties(dBo), 300m

Fiber CamMMF2p0f42o20

Laser/ER(dB)/OMA(dBm)	PIE-D	Analytic Finite	Linear Semi-Analytic	Measured Semi-Analytic
2.5G/3.5/-2.9	3.8	3.8	3.8	4.3
2.5G/4.7/-1.8	3.7	3.7	3.8	4.5
10G/4.9/-2.9	3.9	3.9	3.9	4.3
10G/5.5/-2.5	3.9	3.9	3.9	4.3

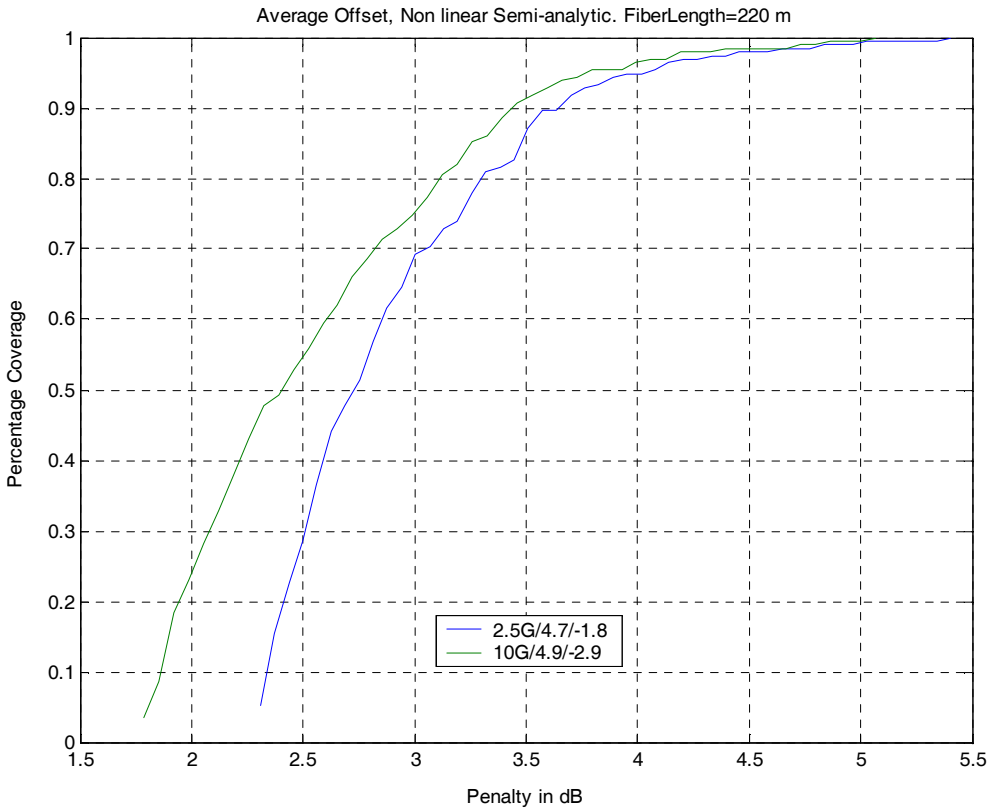
Penalty vs. Fiber Length



Note: penalties for laser and fiber are not additive

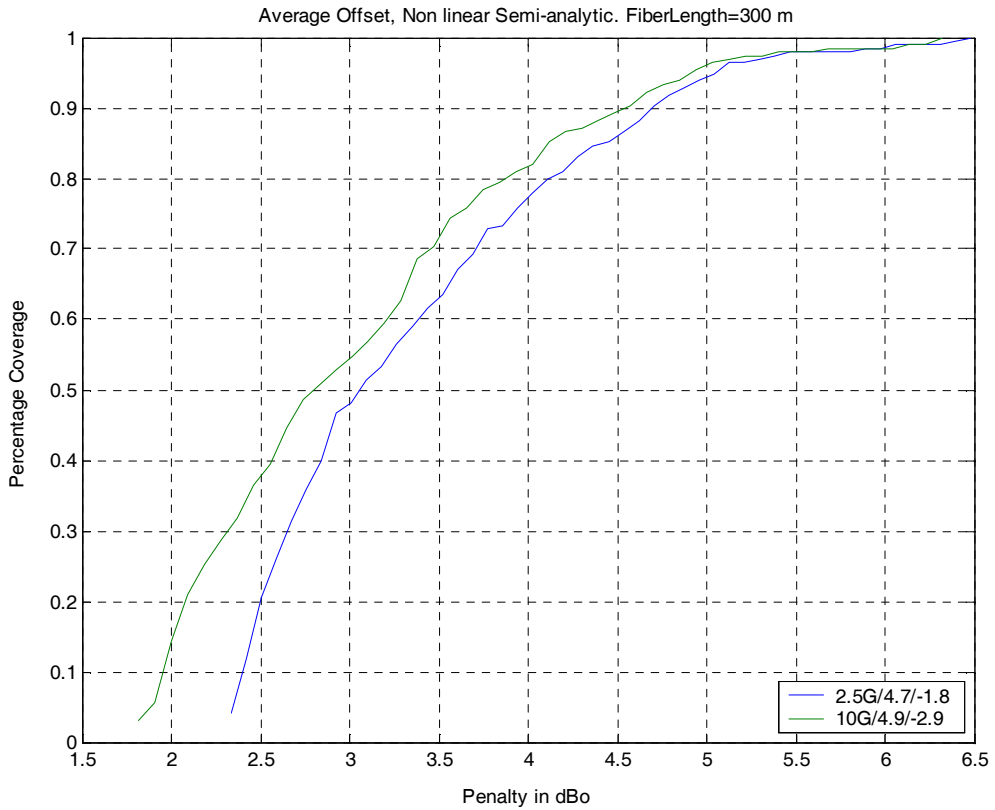
That is, penalty at 300m not equal to penalty of laser at 0m + penalty of fiber

220m Coverage of Cambridge 2.0 Fibers



Averaged over 17, 20, 23 micron offsets

300m Coverage of Cambridge 2.0 Fibers



Averaged over 17, 20, 23 micron offsets

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Summary

- Single Fiber Results
  - .1-.2 dB additional penalty using low-speed laser vs 10G laser
    - For the two lasers under test, the particular fiber simulated
  - .4-.8 dB penalty between PIE-D based on linear fit and simulation using measured laser output
  - Penalties of laser and fiber not additive
    - Penalties for two lasers get closer as fiber length increases
    - Attributed to laser nonlinearities that are filtered out by fiber at longer lengths
    - Penalties *may* be additive for strictly linear impairments
- Cambridge R2.0 Cumulative Results
  - Approximately .25 dB penalty difference for 80% coverage at either 220m or 300m
- Results show that very different waveforms at laser output can result in very similar penalties after fiber propagation and EDC
  - More work needed using other fibers, lasers
  - Motivation for “virtual TP3” type test for TP2