Technical Feasibility of 40km SMF 100GE Transceivers

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Outline

- Applicable HSSG Fiber Optic Ad Hoc SMF Alternative
- 100GE 40km Reach Techniques
- 40km 4x25G 1310nm EML Transceiver Architecture
- 40km 4x25G 1310nm EML Transceiver Optical Link
- Optically Amplified Receiver Sensitivity Data
- Discussion
- Post Script on 2km 4x25G 1310nm EML Transceiver (added during the HSSG meeting)

Reach (Technical) Feasibility of 100GE Alternatives

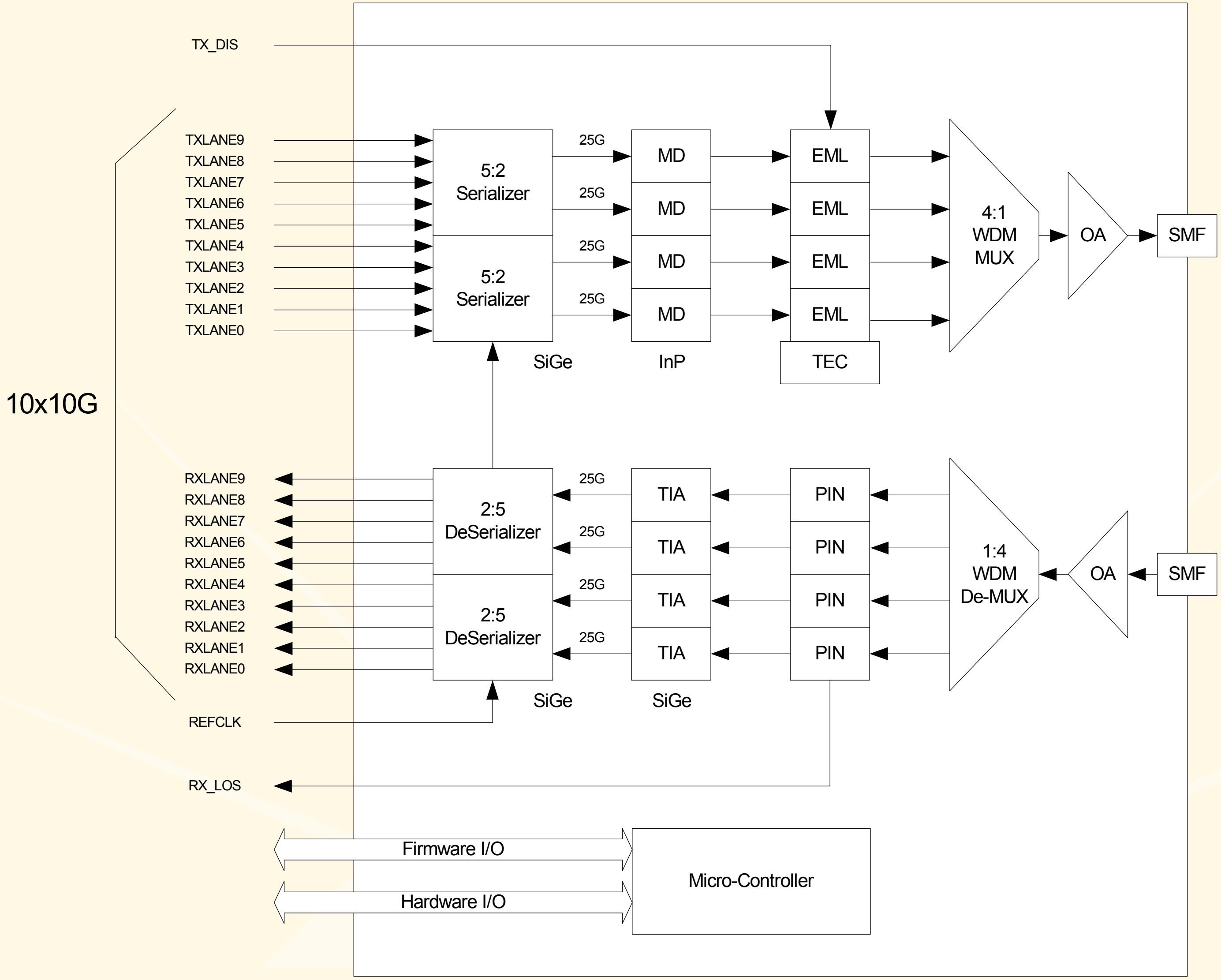
SMF	10km 1310nm	40km 1310nm	10km 1550nm	40km 1550nm
10x10G DML	yes + CL	yes + CL + OA	yes	maybe + OA
10x10G ML	yes + CL	yes + CL + OA	yes	yes + OA
5x20G / 4x25G DML	yes	maybe + OA	maybe	maybe + DC
5x20G / 4x25G ML	yes	yes + OA	yes	yes + DC
2x50G DQPSK I/Q ML	yes + CL	yes + CL + OA + DC	yes + CL + DC	yes + CL + OA + DC
1x100G TDM ML	yes + CL + OA	yes + CL + OA + DC	yes + CL + OA + DC	yes + CL + OA + DC

CL = Cooling (or semi-cooling,) OA = Optical Amplification, DC = Dispersion Compensation
Green shading designates alternatives under detailed study by Fiber Optic Ad Hoc contributors.
Red oval designates alternative in this presentation.

100GE 40km Reach Techniques

- Available Techniques
  - TX OA
  - RX OA
  - TX DC
  - RX DC
  - FEC
- Benefits of OA
  - Straightforward to analyze
  - Straightforward to measure
  - Straightforward to write a standard
  - Straightforward to interoperate
  - Extensive industry DWDM system experience
  - Incremental development to extend from 10km reach
  - Compact size for semiconductor implementations
- Benefits of DC
  - Enables alternatives for which OA is insufficient
  - Compact size for Signal Processing IC implementations
- Benefits of FEC
  - Compact size for IC implementations

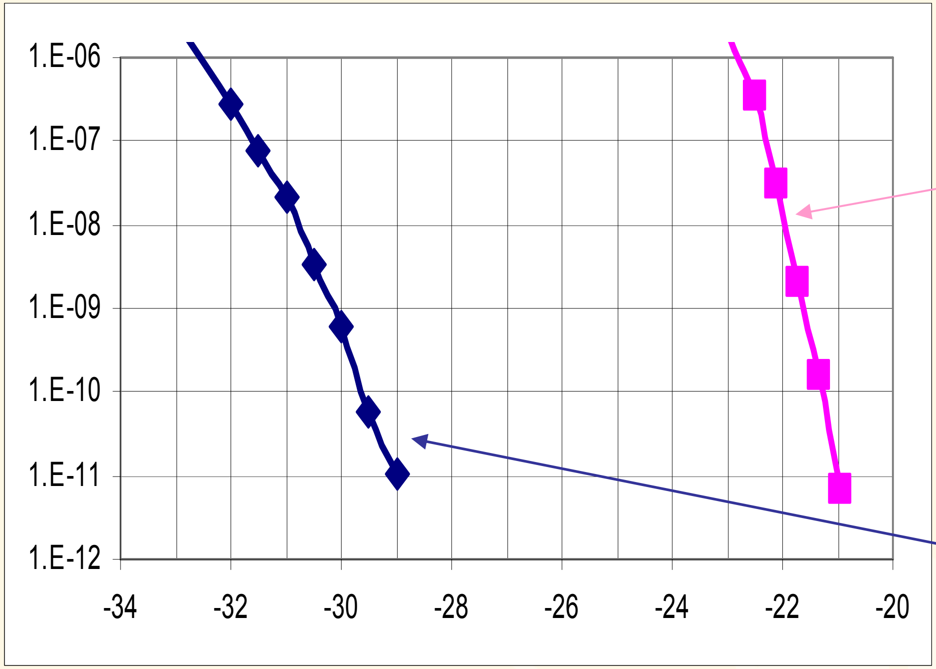
40km 4x25G 1310nm EML Transceiver Architecture



40km 4x25G 1310nm Transceiver Optical Link

- 40km 25G 1310nm per λ link budget
  - TP2 max output power: 4.0dBm
  - TP2 min output power: 0.0dBm
  - TP3 min input sensitivity: -22dBm (w/ ~2nm channel bandwidth)
  - TP2 to TP3 max penalty: 2dB (w/ max 80ps/nm dispersion)
  - TP2 to TP3 min path loss: 20dB (17dB fiber + 3dB other)
- TP2 output power is Technically Feasible, assuming cooled EML transmitter and output OA.
- TP2 output power may also be Technically Feasible with future high speed DML or high power ML alternatives.
- TP3 input sensitivity is Technically Feasible, assuming input OA and PIN receiver.
- TP3 input sensitivity may also be Technically Feasible with future high speed APD alternatives.

10G 1550nm LN MZ & SOA Sensitivity Data



10G Set-up PRBS 2^31-1

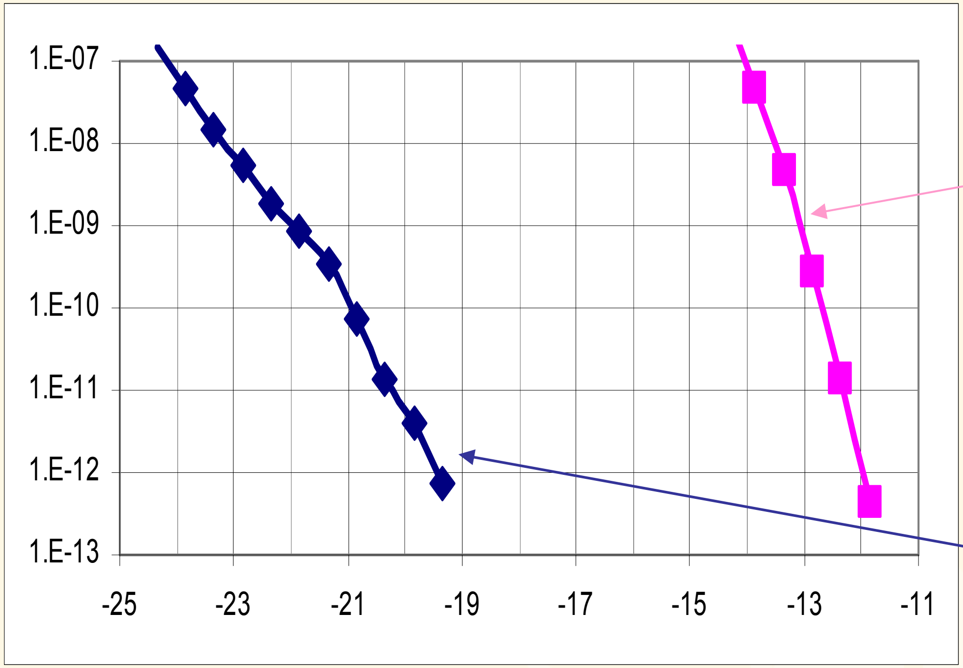
- TX: 10G 1536.2nm DFB → LN MZ
- Path: VOA + ISO
- RX: 10G PIN/TIA

10G OA Set-up PRBS 2^31-1

- TX: 10G 1536.2nm DFB → LN MZ
- Path: VOA + ISO
- RX: 22dB commercial SOA (25°C) → ISO → 0.65nm Optical Filter → 10G PIN/TIA
- Receiver Sensitivity = -28.6dBm

Yuri Vandyshev, Tedros Tsegaye, “OA Investigation,” Finisar Corp.

40G 1550nm EML & SOA Sensitivity Data



<u>40G Set-up PRBS 2^31-1</u>

- TX: 40G cooled 1552.6nm EML
- Path: VOA + ISO
- RX: 40G PIN/TIA

<u>40G OA Set-up PRBS 2^31-1</u>

- TX: 40G cooled 1552.6nm EML
- Path: VOA + ISO
- RX: 22dB commercial SOA (25°C) → ISO → 0.65nm Optical Filter → 40G PIN/TIA
- Receiver Sensitivity = -19.4dBm (Sensitivity limited by SOA signal spontaneous beat noise, and pattern distortion due to SOA operation in the saturated region.)

Yuri Vandyshev, Tedros Tsegaye, "OA Investigation," Finisar Corp.

50km 4x25G 1310nm EML & SOA Sensitivity Data

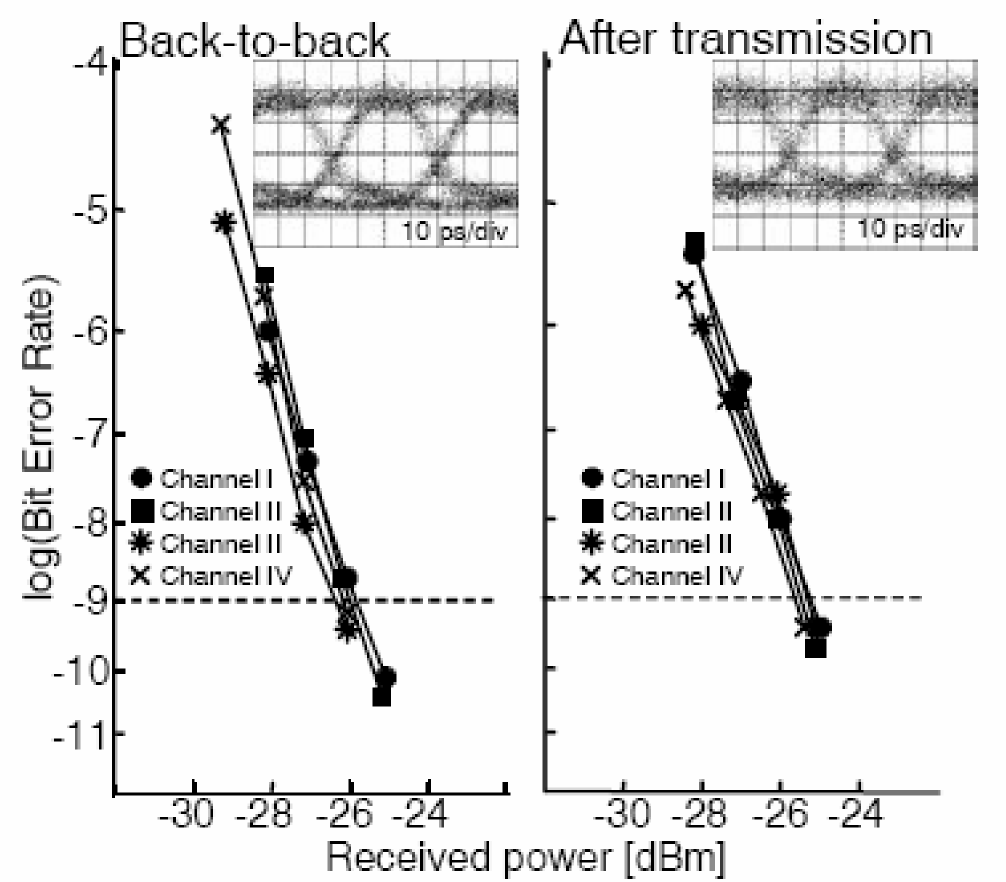


Fig. 4 *Result of measurements; PRBS 2^{31}-1*

<u>25G OA Set-up PRBS 2^31-1</u>

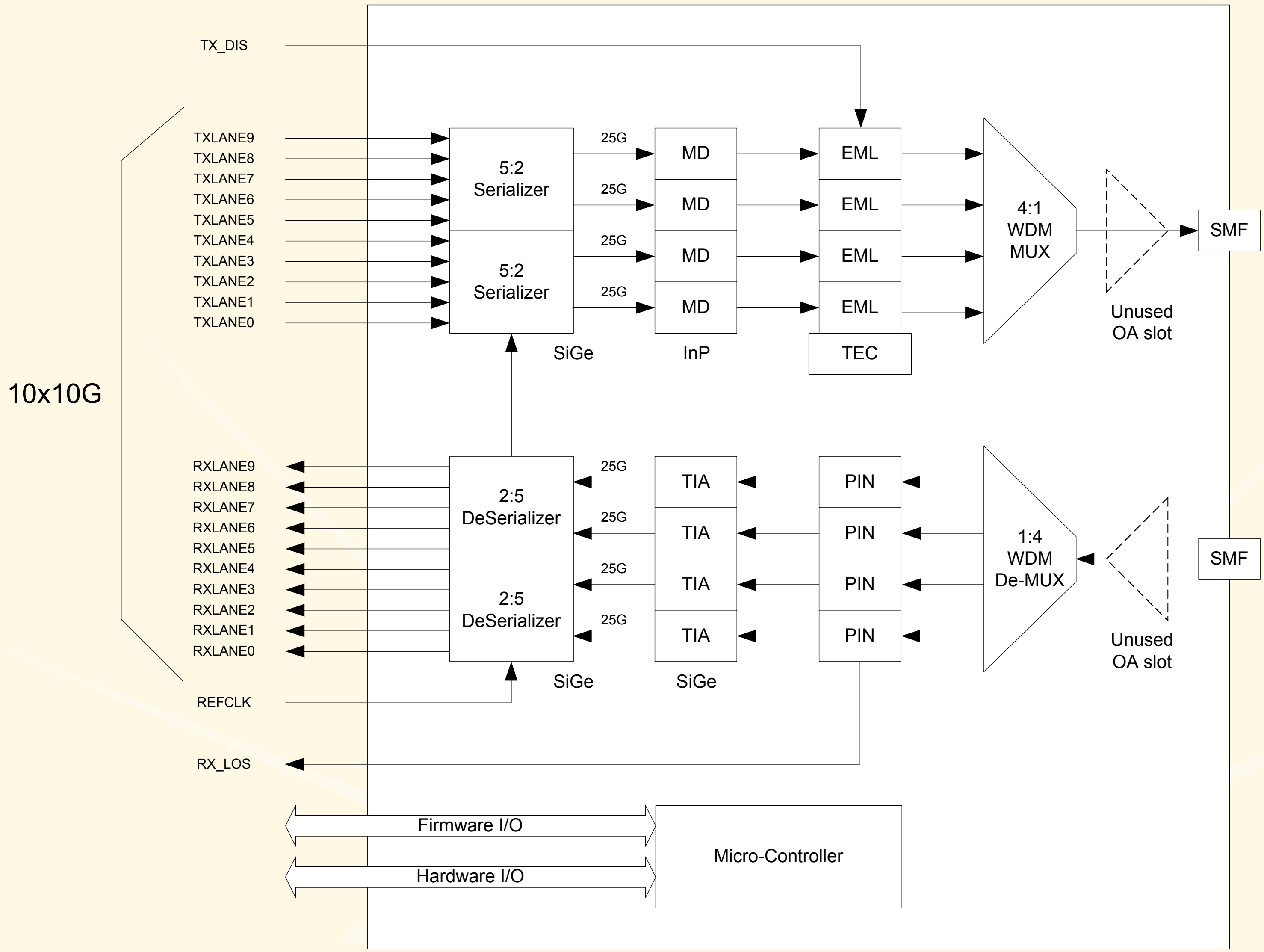
- TX: DFB → MUX → EAM → DSF → SOA
- Path: 50km SMF → VOA
- RX: SOA → DeMUX → PDRX
- Channel assignments:
  - Channel I λ = 1311.5 nm
  - Channel II λ = 1312.9 nm
  - Channel III λ = 1314.3 nm
  - Channel IV λ = 1315.6 nm
- Extrapolated Receiver Data:
  - Sensitivity = -24.9dBm
  - Path Penalty = 0.6dB

J.P. Turkiewicz, et. al., “Do we need 1310nm transmission in modern networks?,” Eindhoven University of Technology, Sept. 24-28, 2006, ECOC_06_We3.P.153

Discussion

- 40km reach is Technically Feasible through the use of OA Techniques in the Transmitter and Receiver.
- Other Techniques, by themselves or in combination with OA, may also lead to 40km reach Technical Feasibility.
- The 100GE Standard and Transceiver development efforts will be incremental for the 40km reach at 1310nm, if OA Techniques are used to extend 10km reach 1310nm technology.
- Additional results in support of 40km reach Technical and Economic Feasibility will be presented at future HSSG meetings.

P.S.1: 2km 4x25G EML Transceiver Architecture



P.S.2: 2km 4x25G 1310nm Transceiver Optical Link

- 2km 25G 1310nm per λ link budget
  - TP2 max output power: 0.0dBm
  - TP2 min output power: -4.0dBm
  - TP3 min input sensitivity: -8dBm
  - TP2 to TP3 max penalty: 1dB (w/ max 4ps/nm dispersion)
  - TP2 to TP3 min path loss: 3dB (1dB fiber + 2dB other)
- TP2 output power is Technically Feasible, assuming cooled EML transmitter.
- TP2 output power may also be Technically Feasible with high speed DML.
- TP3 input sensitivity is Technically Feasible, assuming PIN receiver.
- If the same WDM transmitter and WDM receiver are used for the 2km reach (or 10km reach) as for the 40km reach, without OAs, and with relaxed specifications (power, ER, sensitivity,) the following become shared:
  - TOSA and ROSA development program
  - TOSA and ROSA testing and manufacturing flow
  - Transceiver development program
  - Transceiver testing and manufacturing flow