Single Fiber, Single wavelength, GbE link

Meir Bartur, ZONU, Inc.
Tom Murphy, Infineon Technologies

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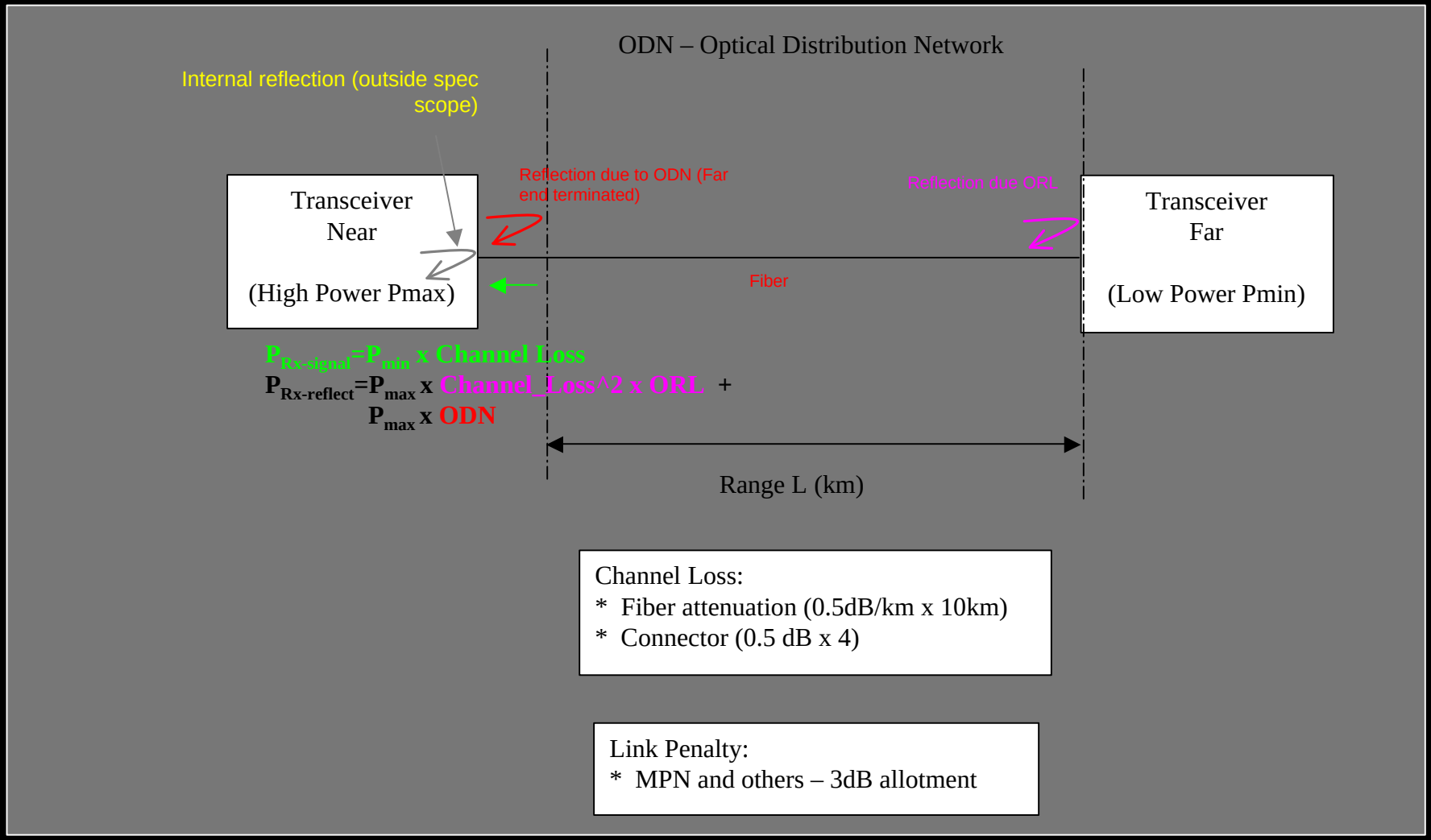
SFWG - Single Fiber Single Wavelength GbE

- Vipul paper "*Cross-Talk in Bi-Di Single Wavelength Single fiber GbE*" Demonstrated feasibility

http://grouper.ieee.org/groups/802/3/efm/public/jul01/presentations/bhatt_1_0701.pdf

- Reflections - Link "Engineering" issues
- Test methodology examples
- Results

Link reflections – P transmit issues



Link “Engineering” – Vipul’s model adaptation

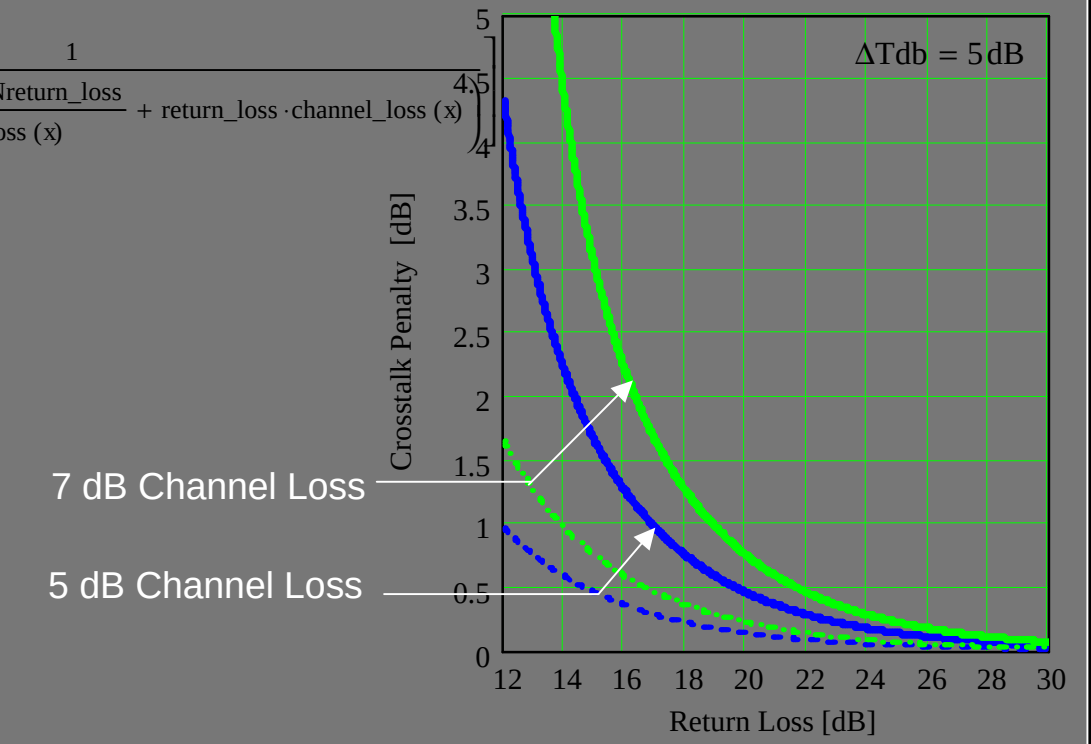
Design Recommendations

Modify the receiver design to add an offset to the receiver threshold. Keep the return loss of transceiver-cable interface to at least 5 dB higher than the total channel insertion loss, so as to keep the Crosstalk Penalty to well under 2 dB.

- Include Transmitter power range (e.g. 5 dB)
- Include worst case reflections condition (short link with minimal losses)
- Treat two distinct parameters:
  - Transceiver ORL
  - ODN ORL

Effect of 5 dB P transmit power range ($P_{max} - P_{min}$)

$$Xtalk\_Penalty1(x) := 10 \cdot \log\left[\frac{1}{1-(1+\Delta T)\cdot\left(\frac{XTALK + ODNreturn\_loss}{channel\_loss(x)} + return\_loss \cdot channel\_loss(x)\right)}\right]$$



ODN ORL - Background

- From major carriers:
  - Current networks are >30dB ORL
  - “Old” networks can be as “bad” as > 20 dB
- SC-PC connections are specified >35 (40) db
- 802.3 - 2000

The maximum link distances for single-mode fiber are calculated based on an allocation of 2.0 dB total connection and splice loss. For example, this allocation supports four connections with an average insertion loss per connection of 0.5 dB. Connections with different loss characteristics may be used provided the requirements of Table 38–11 and Table 38–12 are met.

38.11.2.2 Connection return loss

The return loss for multimode connections shall be greater than 20 dB.

The return loss for single-mode connections shall be greater than 26 dB.

- ODN ORL of 20dB allows 4 worst-case connectors according to current spec.

Transceiver ORL

- Worst case situation for 0 dB link insertion loss
- SIGNAL/Reflection = Pmin - (Pmax-ORL)
  - Pmax – Pmin = 5dB
  - For SIGNAL/Reflection = 10 dB requires ORL = 15 dB
- Vipul have shown that SIGNAL/Reflection = 5 dB at the far end results in penalty < 1.6 dB
- Our measurement shows 1dB penalty for SIGNAL/Reflection = 5.4 dB
- ***CONCLUSION: ORL of 17dB has plenty of margin***

ODN ORL – Open end

- Worst Case (un-intended loopback):
  - All lumped at the interface (no link loss)
  - Open Fiber yields –14dB reflection
  - High power Tx (P_{max})

  SD - Signal Detect (assert) = LOS – Loss Of Signal (de-assert)
- Attenuation Link budget (10km) - 7dB
- Min power received P_{min} – 7dB
- SD should be set < P_{min} – 7dB
- Max reflection P_{max} – 14dB
- SD should be set > P_{max} – 14dB

$$P_{max} - 14dB < SD < P_{min} - 7dB$$

Setting at the Tx SD during mfg. will guarantee no un-intended loopback

ORL total

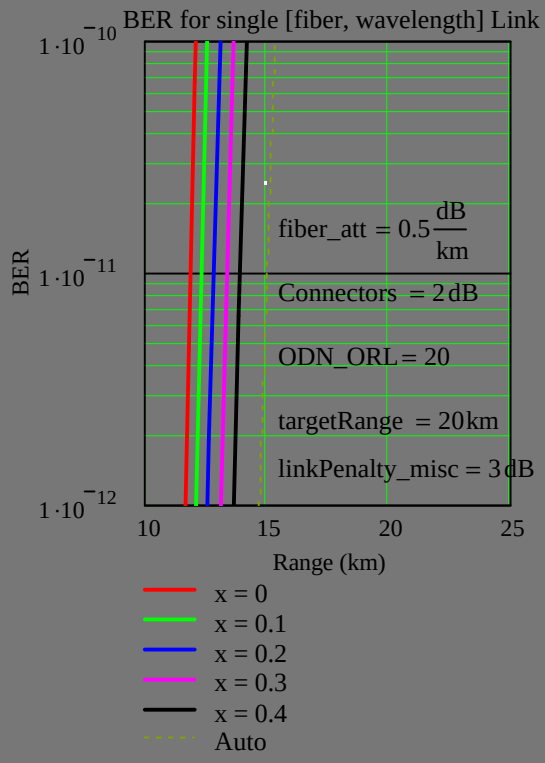
- To enable simple installation worst case reflections (for connected link) should not assert SD
- SD_{assert} = Pmin - $Channel\_Loss_{max}$ – XdB
- SD_{assert} > $Reflection_{worst\ case}$
- $Reflection_{worst\ case}$ = Pmax * (10^-.1*ODN_ORL + 10^-.1* ORL)

- Example
  - Pmin = - 9dBm; $Channel\_Loss_{max}$= 7dB; Pmax = - 4 dBm
  - ODN_ORL = 20dB ; ORL = 17 dB (- total ORL = 15.2 dB)
- *Since total ORL < Open Connector ORL SD issues are not relevant.*

Sensitivity under reflection is treated next.

10 km design example

Rdbm(10) = −16 dBm Signal Strength worst-case (Connectors=2dB)



ODNreturn_loss_test_db = −21

Sensitivity_Under_Test = −20.3

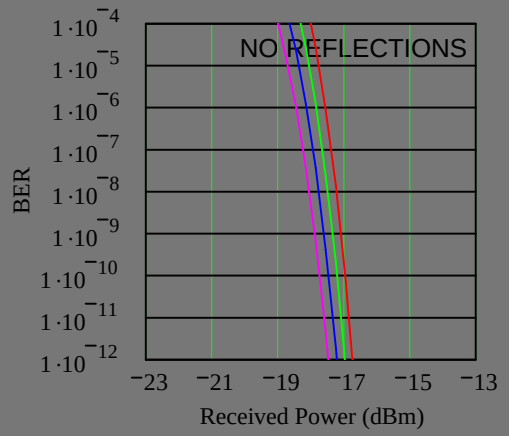
P_{AVGmax} = −4 dBm

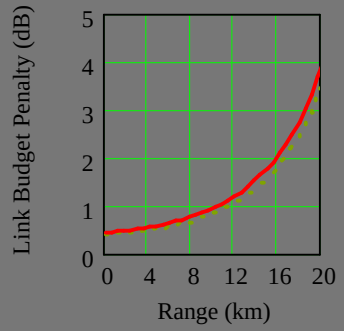
P_{AVGmin} = −9 dBm

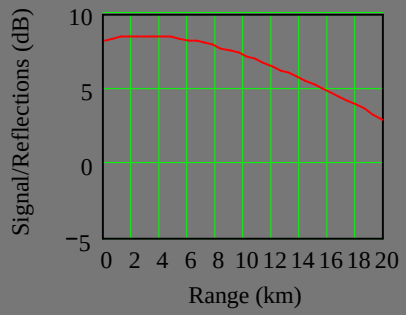
ORL = 17

I_{noise} = 0.4 µA R = 0.36

Cdbm(0) = −19.2 dBm Reflections worst-case (Connectors=0dB)







x - Fixed Offset Threshold adjustment [Fraction of received signal at targetRange]

See http://grouper.ieee.org/groups/802/3/efm/public/jul01/presentations/bhatt_1_0701.pdf

Data Rate issues

- Specification can include 125Mb/s with same range parameters
- At high volume should be neglible cost difference

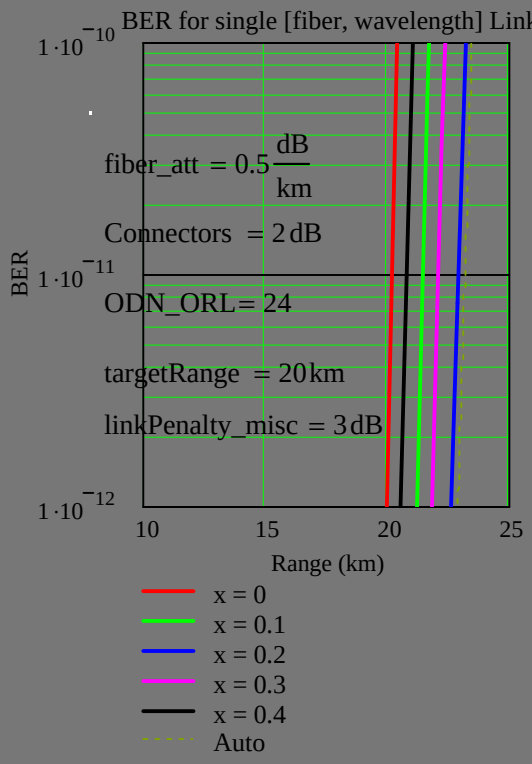
- ONE PMD IS POSSIBLE for 1.25Gb/s and 125 Mb/s

20km issues

- MPN limited to 2dB and treated separately
- ODN_ORL requirement 24dB
- Pmax – Pmin 4dBm
- Interoperability (mix 20km and 10km units for links <10km) Possible
- Specification can include 125Mb/s with same parameters
- ONE PMD IS POSSIBLE (20/10km,1250/125Mb/s)
- How to handle open – end? Solution exists. Beyond scope for this meeting.

20 km design example

Rdbm(20) = –20 dBm Signal Strength worst-case (Connectors=2dB)



ODNreturn_loss_test_db = –21

Sensitivity_Under_Test = –21.7

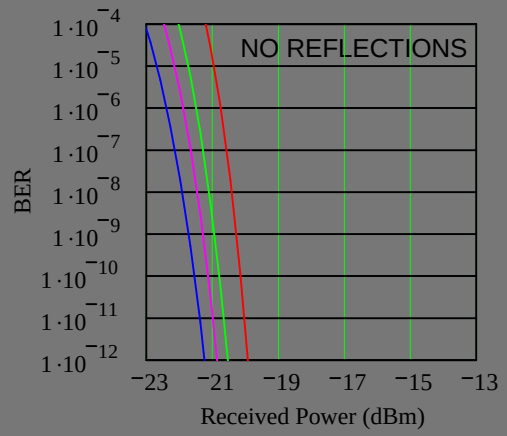
P_{AVGmax} = –4 dBm

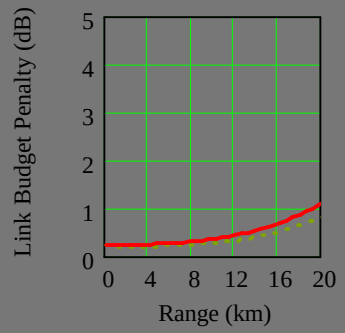
P_{AVGmin} = –8 dBm

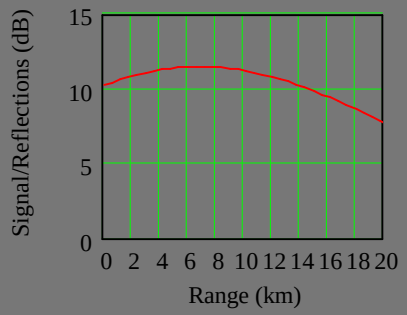
ORL = 17

I_{noise} = 0.2 µA R = 0.36

Cdbm(0) = –20.2dBm Reflections worst-case (Connectors=0dB)







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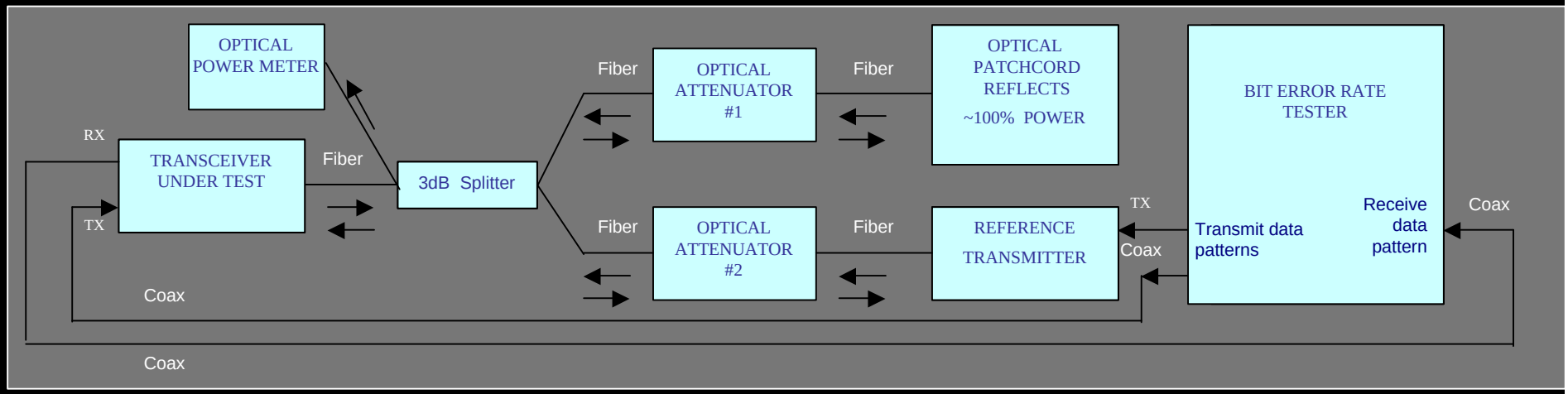
Example: Generalized Sensitivity measurement Variable Optical Return Signal

- Measure Transceiver Under Test (TUT) output power P_0, ER, t_r, t_f, etc.
- Use calibrated symmetric 2 way splitter combiner (~3.5dB)
- Increase the optical attenuation of the reflection leg (#1) to max.
- Measure sensitivity by adjusting attenuator #2 (no reflections)
- Turn ref. Tx off and reduce reflectance leg attenuator (#1) until power meter reads the desired P_0 – target_ORL
- Turn ref. Tx on and re-measure sensitivity under ORL condition



Measurements

- Test 1
  - Pout = - 6dBm
  - Measured sensitivity (no reflections)

    –23 dBm (model predicts –23.5 dBm; 0.5dB loss due to electrical cross-talk?)
  - Introduce ODN reflection 21.4 ORL (-27.4dBm)
  - Sensitivity measured –22dBm (model predicts–22 dBm)
- Test 2
  - Signal –18dBm; Sensitivity –22.8dBm
  - Reflection to cause 1E-12 BER –22.7dBm
  - Signal/Reflection 4.7dB both predicted and measured
- Theoretical predictions are accurate and reliable!

Measurements (Cont)

- Test 3
  - Link – Pout1 = - 5.7dBm Pout2 = -2.3dBm
  - Measured sensitivity in the presence of direct light into the laser
  - Unit 1 was cooled to get a wavelength sweep to cover the overlapp)
  - Both sensitivity and noise floor were measured.
  - Sensitivity was not changed

Example: Practical Sensitivity measurement Fixed Optical Return Signal

- Utilize 3 dB splitter with un-terminated connection.
- Total ORL = ~ 21-22 dB