Analysis of connector losses and correlation with dispersion penalties

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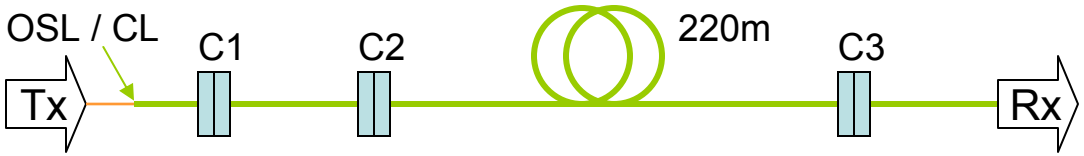
Introduction

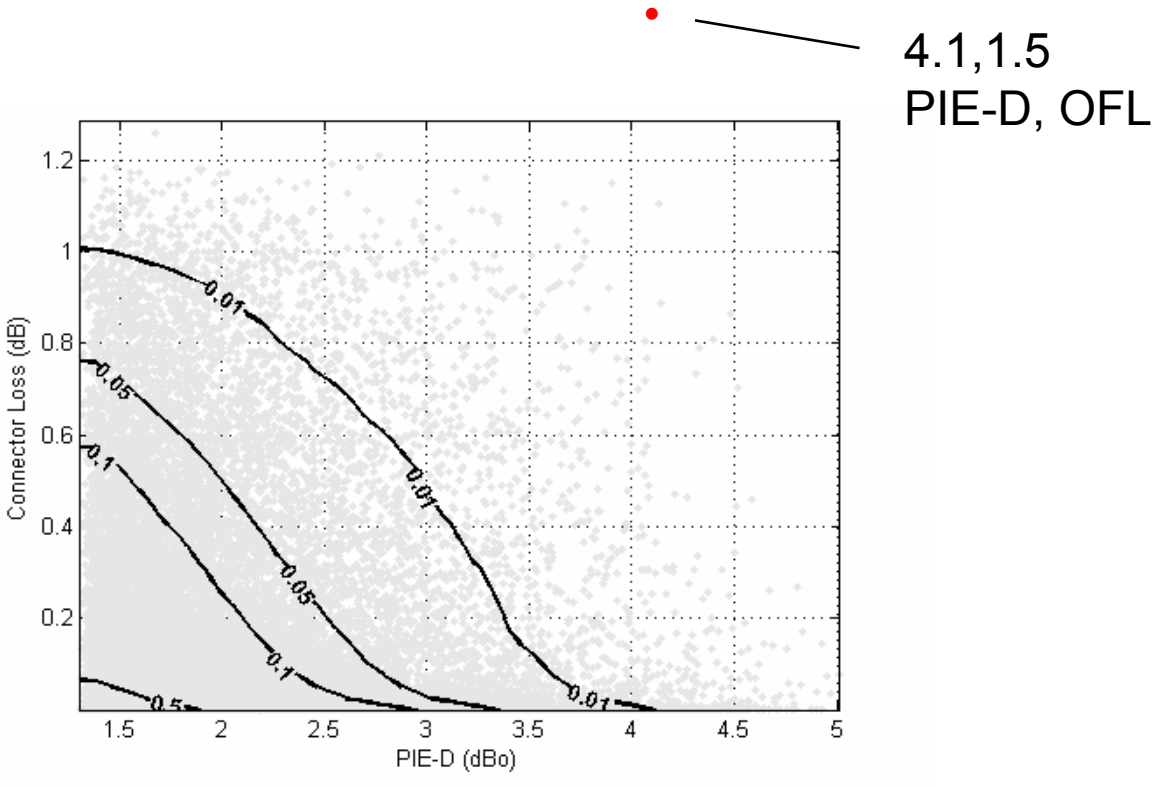
- Objective
  - Apply the LRM OM1 cabling model and investigate the impact of the combined statistics of dispersion and connector loss on the power budget
- Summary
  - The vast majority of operational connector losses are < 1 dB
  - High dispersion channels are improbable
  - There is some correlation between loss and dispersion: the highest dispersion results are generally concurrent with the lowest losses, etc.
  - Consideration of the combined statistics of these effects shows significant margin in the power budget

Simulation Parameters



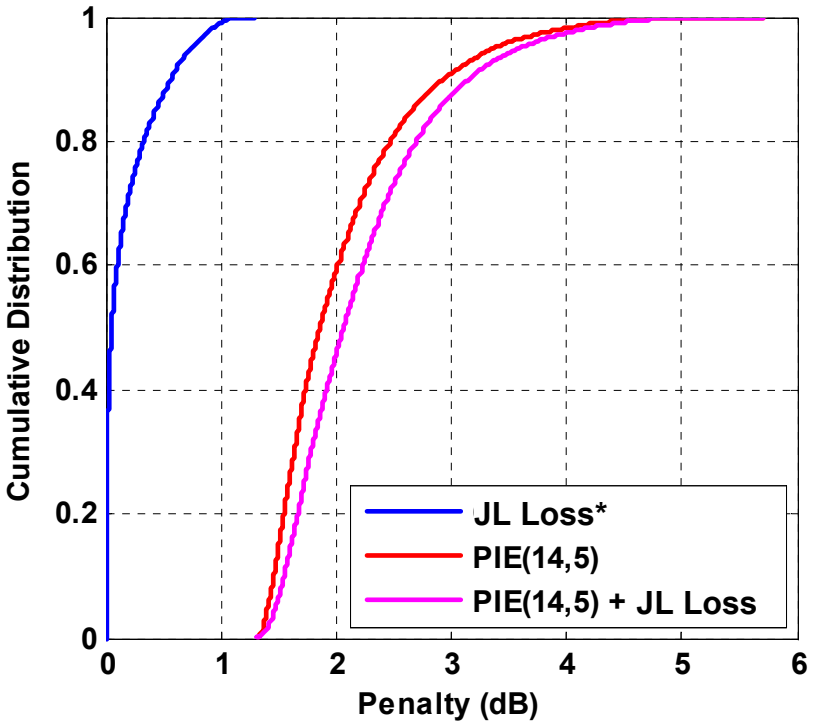
- Delay Sets
  - MC67 (≥ 500 MHz·km, 18 mode-groups)
- Single-mode launch
  - center launch (CL): 0μm → 3μm
  - offset launch (OSL):
    - 17μm → 23μm for 62.5μm fiber
  - joint launch: best chosen for each pair-wise combination of launches
- Link Configuration
  - fibers randomly chosen from set
  - 1-1-220-1
- Connectors
  - Random offset from Rayleigh distribution
    - mean = 3.58μm, truncated at 7μm
  - Total loss ≤ 1.5 dB
    - loss computed with OFL launch

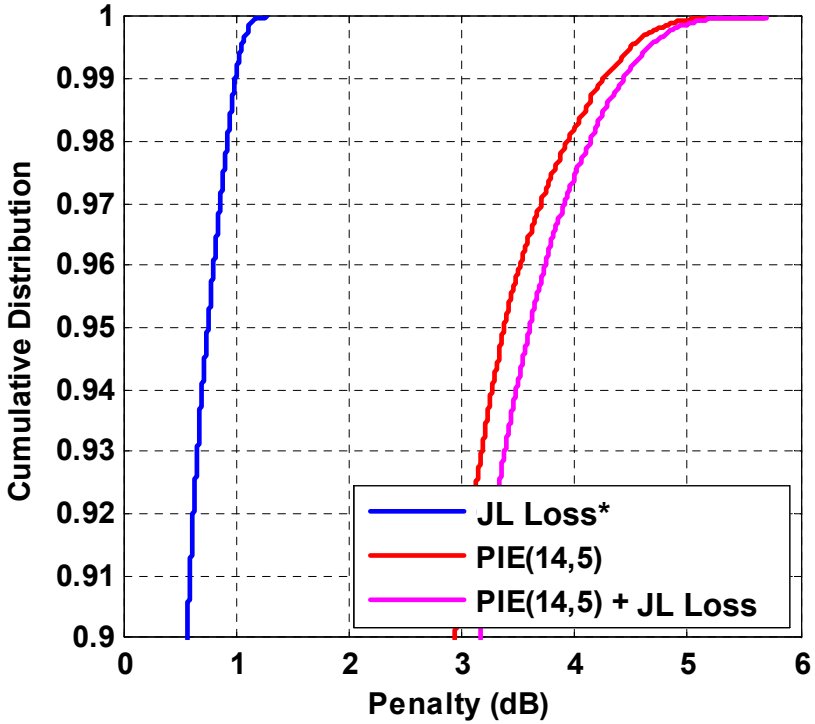
PIE-D vs. Connector Loss*



- *Joint launch – this should more closely approximate the actual loss observed in the link
- OFL is primarily a connector specification method – not a link budget issue

PIE(14,5) + Connector Loss





*JL = joint launch

99 %-tiles:

– JL loss = 1.0dB, PIE(14,5) = 4.25dB, PIE(14,5)+JL loss = 4.4dB

Budget analysis

TP3 tester budget

Item	dB	dBm
Stress test OMA		-6.5
Stress TWDP(14,5)	4.2	
Noise penalty	0.5	
Required effective Rx sensitivity		-11.2

Overall budget w/ TWDP, TP3 test, and combined dispersion & connector losses

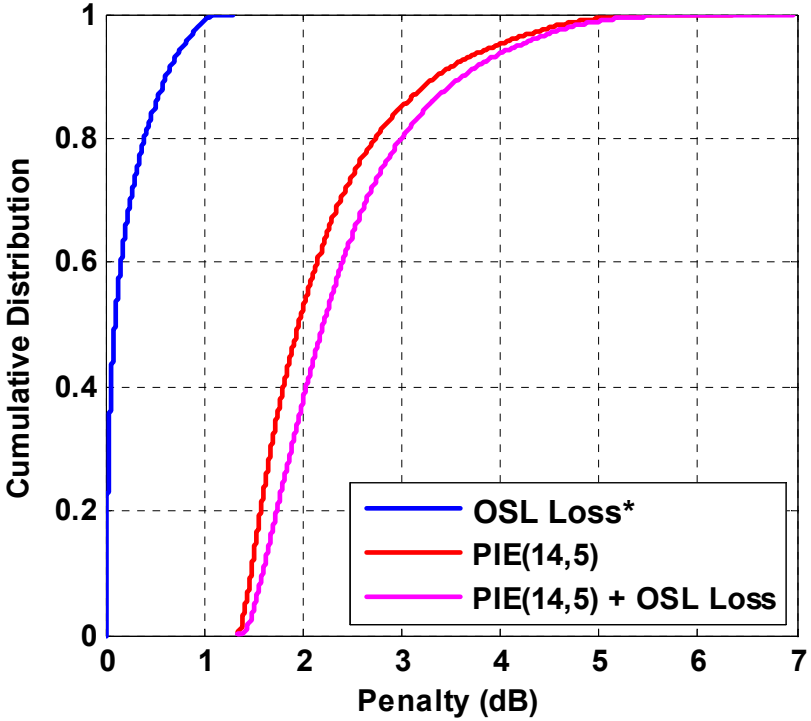
Item	dB	dBm
TWDP limit	4.7	
Tx_OMAmin		-4.5
Fiber DC loss	0.4	
TP3_TWDP(14,5)⊗conn_losses@99%220m	4.4	
Tx implementation penalty (TWDP limit - Stress TWDP(14,5))	0.5	
RIN penalty	0.3	
Modal noise penalty	0.2	
Required effective Rx sensitivity		-10.30
Unallocated margin		**0.9**

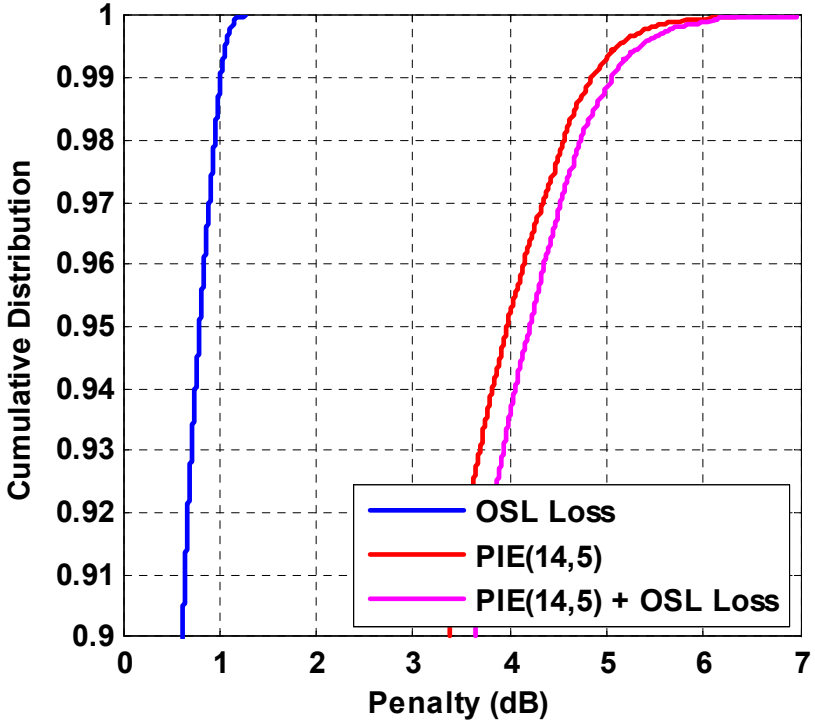
Conclusions

- The probability of high connector loss *and* high dispersion is *extremely* rare in operation
- Budgeting should be based on joint statistics
  - Do not simply add the limits of losses and dispersion penalties
- When considering combined statistics, there is significant unallocated margin in LRM
- This margin should be used to
  - allay concerns about robustness of LRM
  - increase TWDP limit to improve Tx yields & costs

Backup

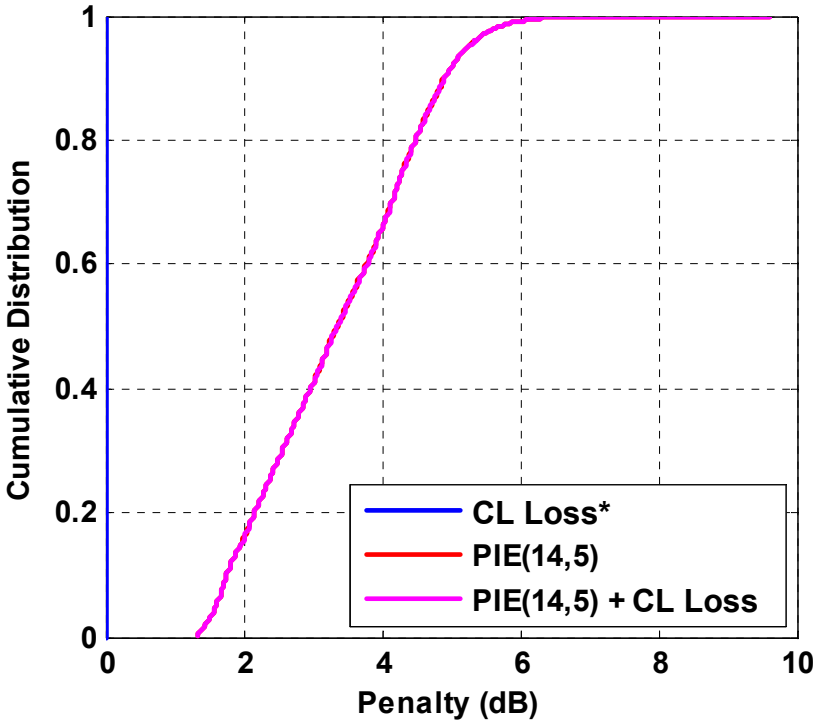
PIE(14,5) + Connector Loss: Offset Launch only

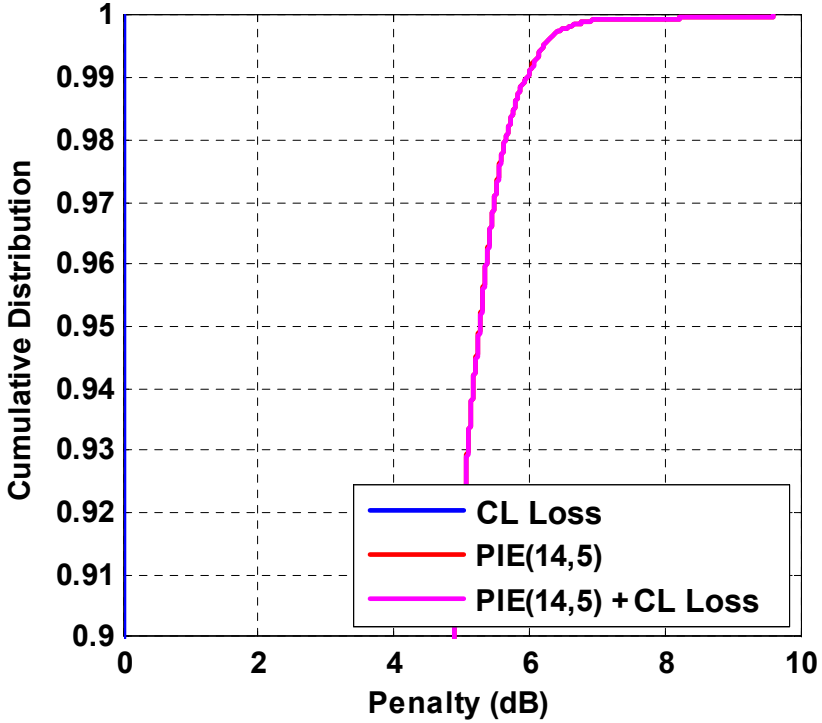




*OSL = offset launch

PIE(14,5) + Connector Loss: Center Launch only





*CL = center launch

Supporting Material for Comment 54 (TWDP limit)

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11 October 2005
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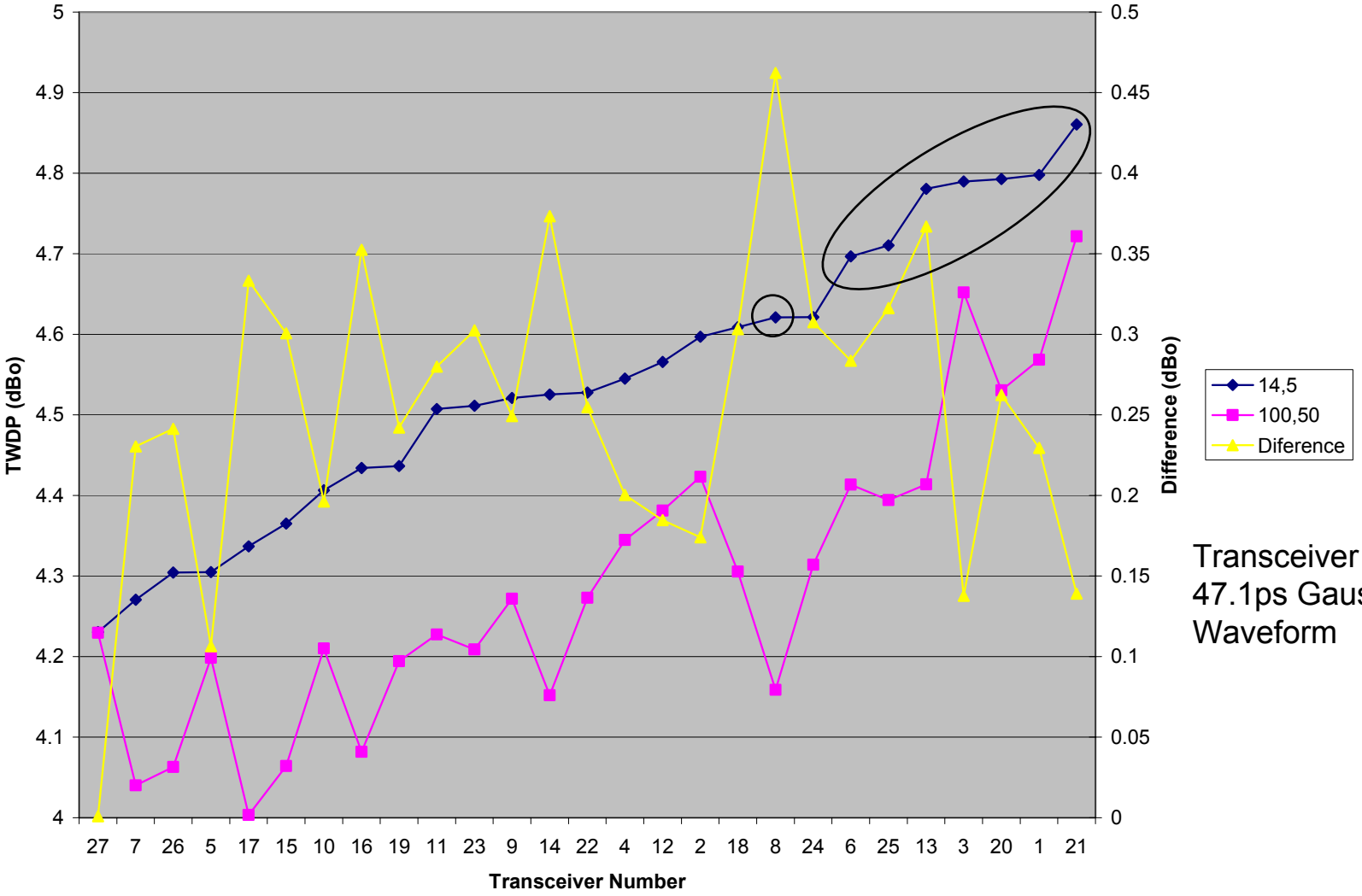
TWDP(100,50) and TWDP(14,5) for 26 LR Transceivers (Intel)



Transceiver 27 is the 47.1ps Gaussian Waveform

Distribution of 26 TWDP(14,5) Values (Intel)