# Model Noise Measurement for an Expanded Beam Connector

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*Multi-Gigabit Automotive Optical PHY Study Group*
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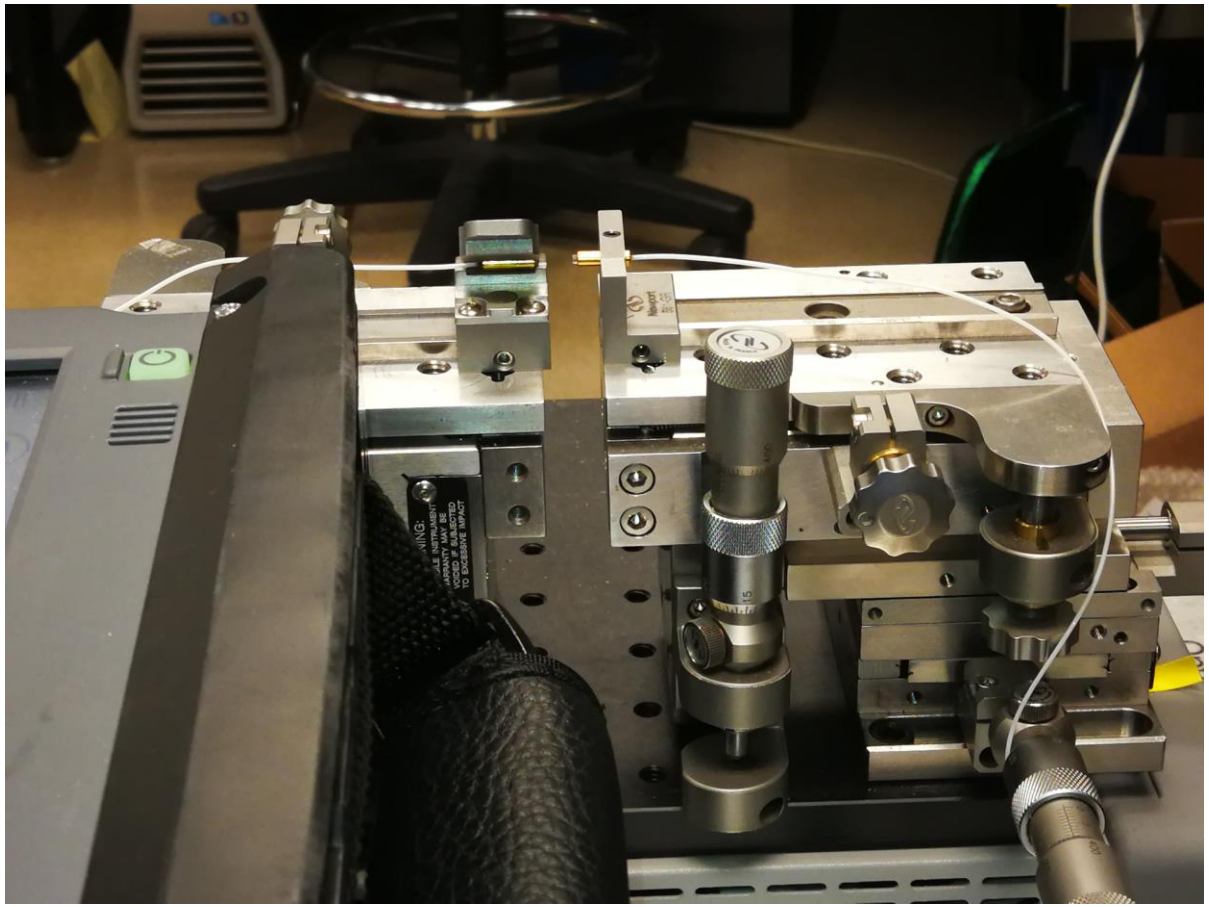
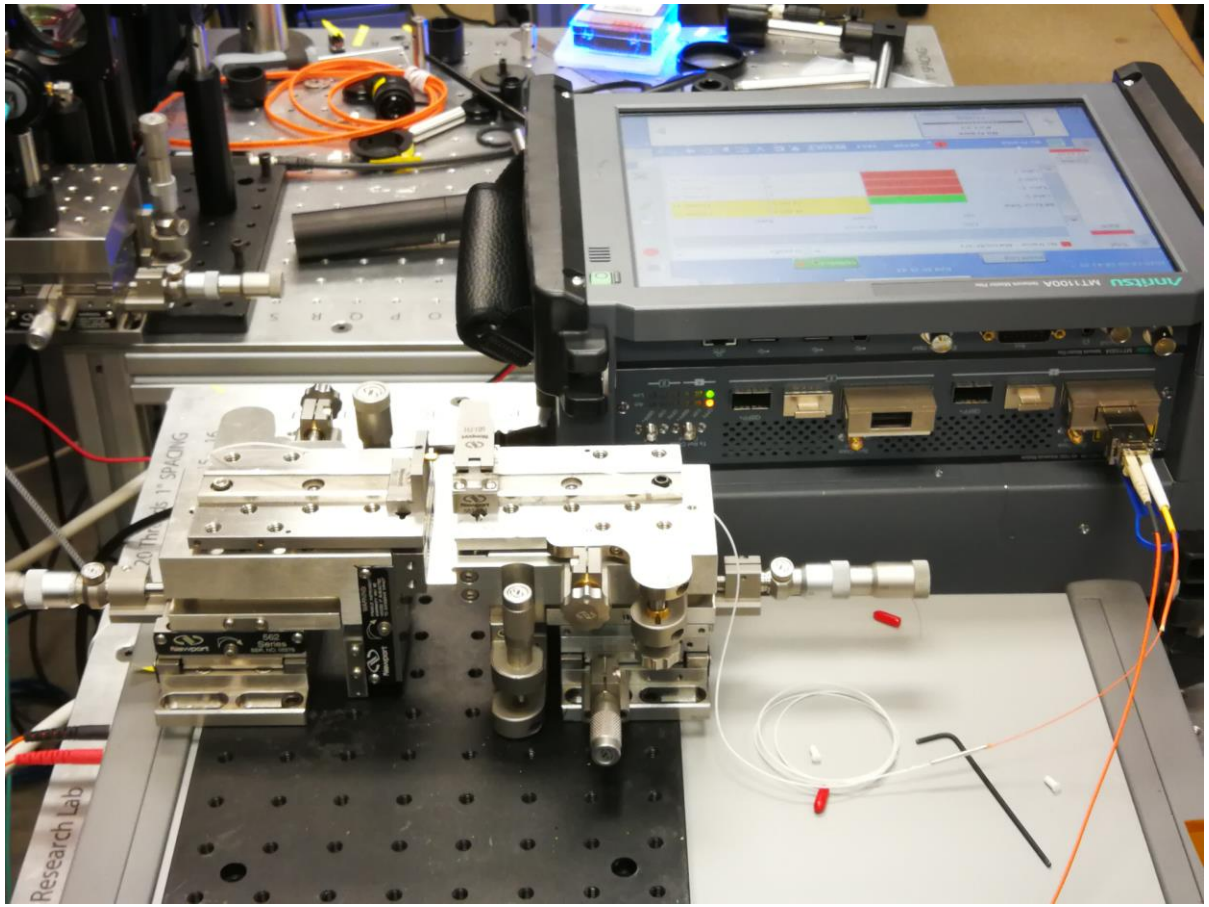
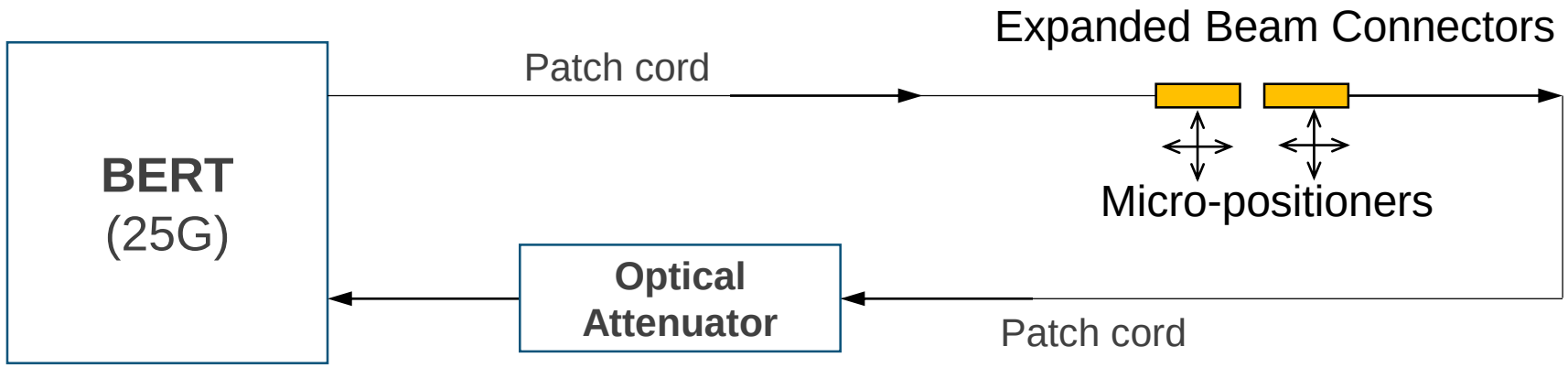
# Bit Error Rate vs. Connector Insertion Loss

*25 Gb/s NRZ Signaling*

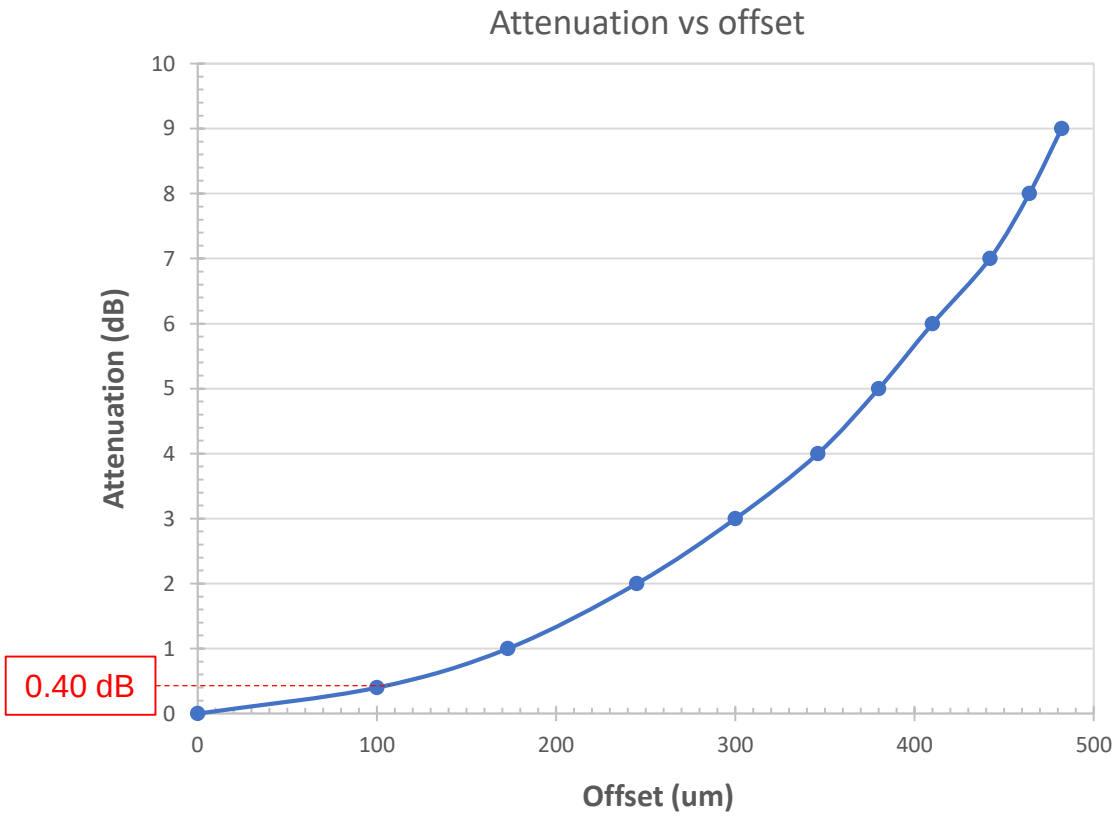


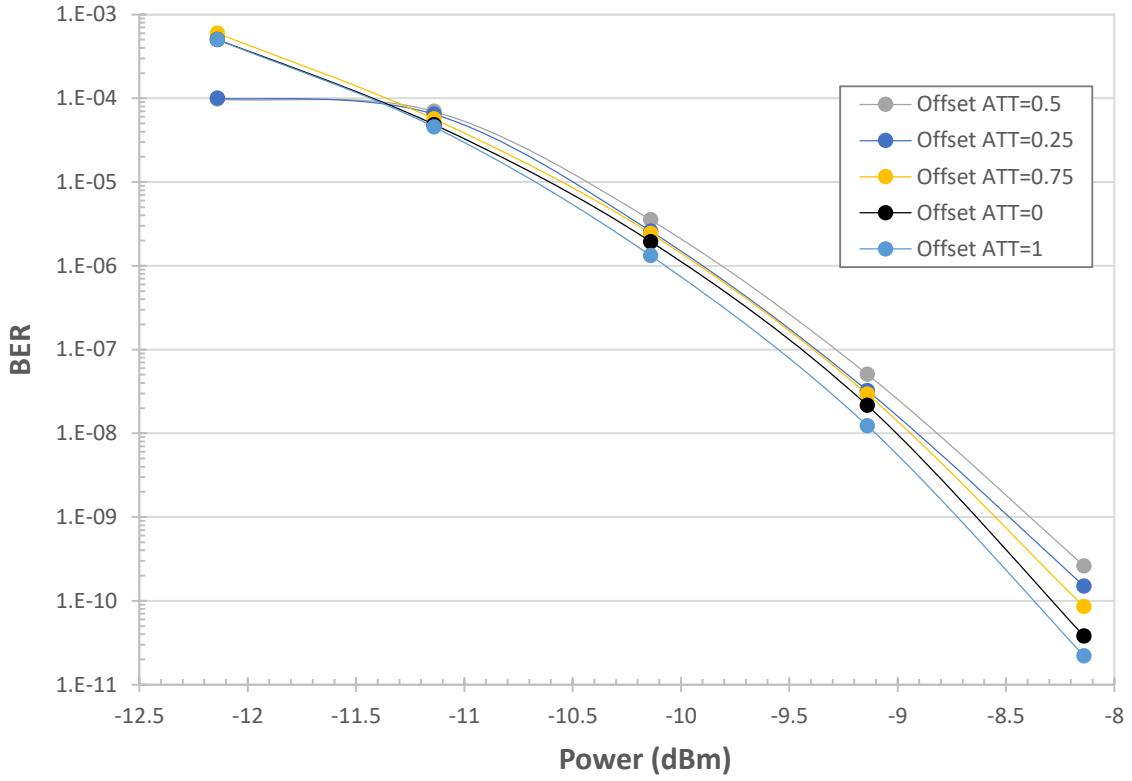


# Error Rate (BER) Channel Test Setup

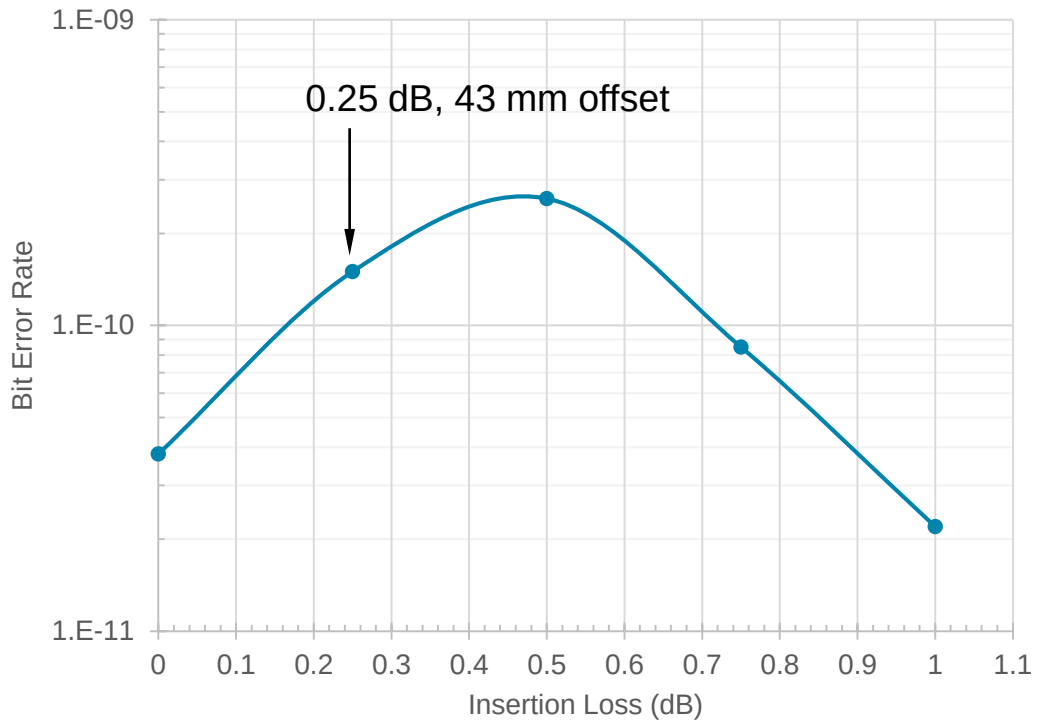


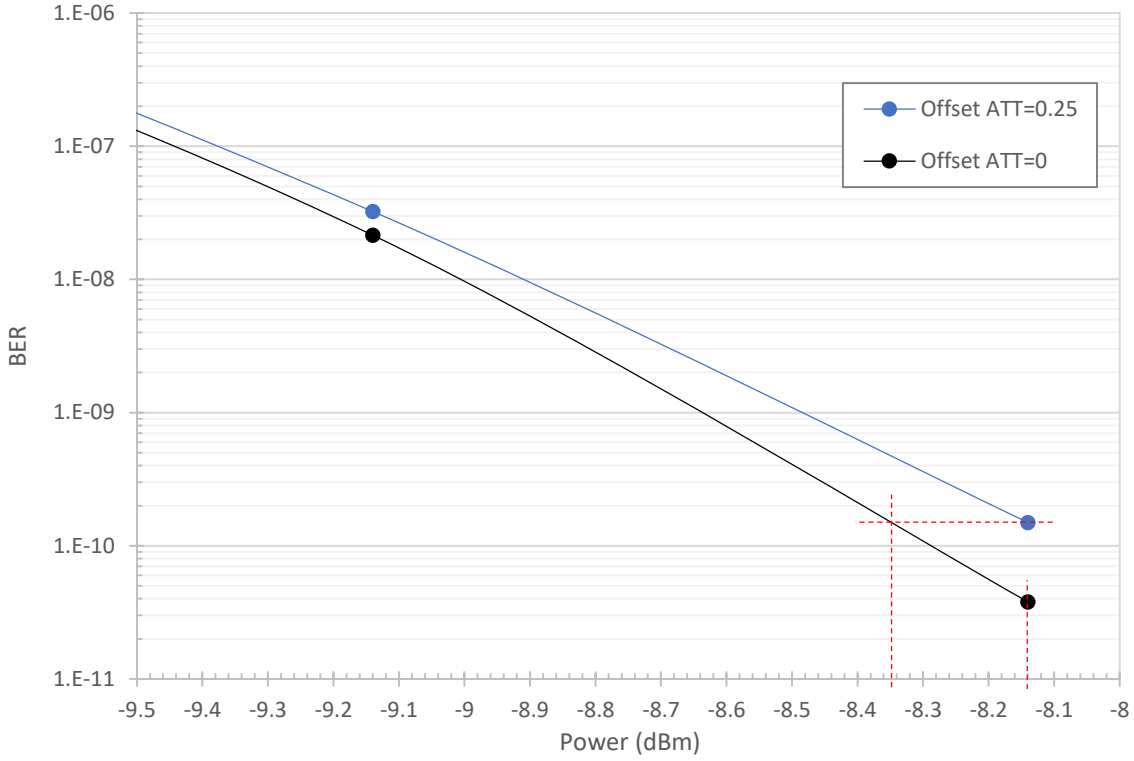
# BER Results


Attenuation vs offset
Attenuation (dB)
Offset (um)
0.40 dB
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500


BER
Power (dBm)
Offset ATT=0.5
Offset ATT=0.25
Offset ATT=0.75
Offset ATT=0
Offset ATT=1
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
-12.5
-12
-11.5
-11
-10.5
-10
-9.5
-9
-8.5
-8

# Test Results & Estimated MN power penalty



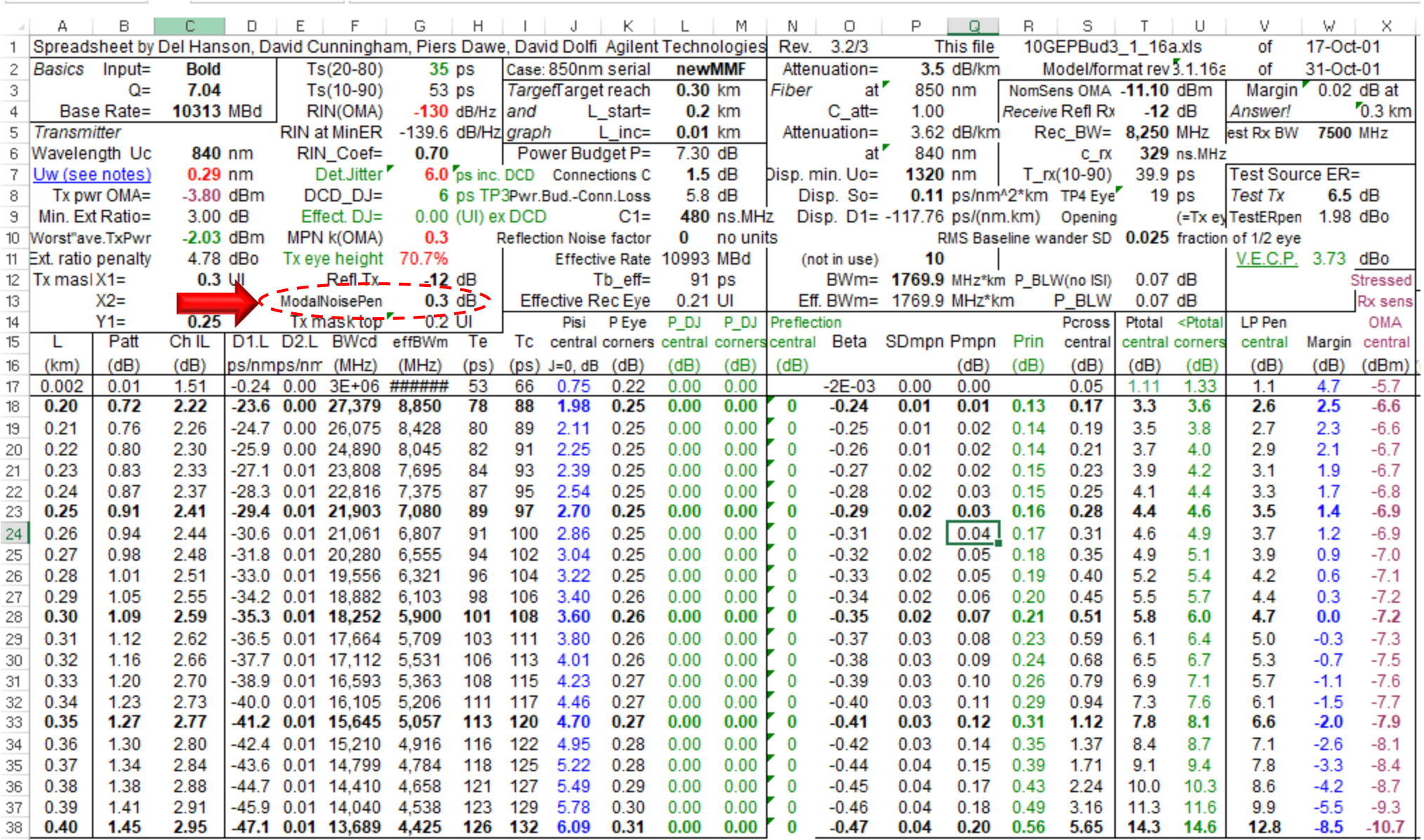

Optical penalty = 0.2 dB

For offset of:

43 μm
or 0.25 dB

**+/- 10 μm = 0.05 dB penalty**

# IEEE Link Model – 10 Gb/s



Spreadsheet by Del Hanson, David Cunningham, Piers Dawe, David Dolfi Agilent Technologies — Rev. 3.2/3 — This file 10GEPBud3_1_16a.xls of 17-Oct-01 — Model/format rev 3.1.16a of 31-Oct-01

| L (km) | Patt (dB) | Ch IL (dB) | D1.L ps/nm | D2.L ps/nm | BWcd (MHz) | effBWm (MHz) | Te (ps) | Tc (ps) | Pisi central J=0, dB | P Eye corners (dB) | P_DJ central (dB) | P_DJ corners (dB) | Preflection central (dB) | Beta | SDmpn | Pmpn (dB) | Prin (dB) | Pcross central (dB) | Ptotal central (dB) | <Ptotal corners (dB) | LP Pen central (dB) | Margin (dB) | OMA central (dBm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.002 | 0.01 | 1.51 | -0.24 | 0.00 | 3E+06 | ###### | 53 | 66 | 0.75 | 0.22 | 0.00 | 0.00 | | -2E-03 | 0.00 | 0.00 | | 0.05 | 1.11 | 1.33 | 1.1 | 4.7 | -5.7 |
| **0.20** | **0.72** | **2.22** | **-23.6** | **0.00** | **27,379** | **8,850** | **78** | **88** | **1.98** | **0.25** | **0.00** | **0.00** | **0** | **-0.24** | **0.01** | **0.01** | **0.13** | **0.17** | **3.3** | **3.6** | **2.6** | **2.5** | **-6.6** |
| 0.21 | 0.76 | 2.26 | -24.7 | 0.00 | 26,075 | 8,428 | 80 | 89 | 2.11 | 0.25 | 0.00 | 0.00 | 0 | -0.25 | 0.01 | 0.02 | 0.14 | 0.19 | 3.5 | 3.8 | 2.7 | 2.3 | -6.6 |
| 0.22 | 0.80 | 2.30 | -25.9 | 0.00 | 24,890 | 8,045 | 82 | 91 | 2.25 | 0.25 | 0.00 | 0.00 | 0 | -0.26 | 0.01 | 0.02 | 0.14 | 0.21 | 3.7 | 4.0 | 2.9 | 2.1 | -6.7 |
| 0.23 | 0.83 | 2.33 | -27.1 | 0.01 | 23,808 | 7,695 | 84 | 93 | 2.39 | 0.25 | 0.00 | 0.00 | 0 | -0.27 | 0.02 | 0.02 | 0.15 | 0.23 | 3.9 | 4.2 | 3.1 | 1.9 | -6.7 |
| 0.24 | 0.87 | 2.37 | -28.3 | 0.01 | 22,816 | 7,375 | 87 | 95 | 2.54 | 0.25 | 0.00 | 0.00 | 0 | -0.28 | 0.02 | 0.03 | 0.15 | 0.25 | 4.1 | 4.4 | 3.3 | 1.7 | -6.8 |
| **0.25** | **0.91** | **2.41** | **-29.4** | **0.01** | **21,903** | **7,080** | **89** | **97** | **2.70** | **0.25** | **0.00** | **0.00** | **0** | **-0.29** | **0.02** | **0.03** | **0.16** | **0.28** | **4.4** | **4.6** | **3.5** | **1.4** | **-6.9** |
| 0.26 | 0.94 | 2.44 | -30.6 | 0.01 | 21,061 | 6,807 | 91 | 100 | 2.86 | 0.25 | 0.00 | 0.00 | 0 | -0.31 | 0.02 | 0.04 | 0.17 | 0.31 | 4.6 | 4.9 | 3.7 | 1.2 | -6.9 |
| 0.27 | 0.98 | 2.48 | -31.8 | 0.01 | 20,280 | 6,555 | 94 | 102 | 3.04 | 0.25 | 0.00 | 0.00 | 0 | -0.32 | 0.02 | 0.05 | 0.18 | 0.35 | 4.9 | 5.1 | 3.9 | 0.9 | -7.0 |
| 0.28 | 1.01 | 2.51 | -33.0 | 0.01 | 19,556 | 6,321 | 96 | 104 | 3.22 | 0.25 | 0.00 | 0.00 | 0 | -0.33 | 0.02 | 0.05 | 0.19 | 0.40 | 5.2 | 5.4 | 4.2 | 0.6 | -7.1 |
| 0.29 | 1.05 | 2.55 | -34.2 | 0.01 | 18,882 | 6,103 | 98 | 106 | 3.40 | 0.26 | 0.00 | 0.00 | 0 | -0.34 | 0.02 | 0.06 | 0.20 | 0.45 | 5.5 | 5.7 | 4.4 | 0.3 | -7.2 |
| **0.30** | **1.09** | **2.59** | **-35.3** | **0.01** | **18,252** | **5,900** | **101** | **108** | **3.60** | **0.26** | **0.00** | **0.00** | **0** | **-0.35** | **0.02** | **0.07** | **0.21** | **0.51** | **5.8** | **6.0** | **4.7** | **0.0** | **-7.2** |
| 0.31 | 1.12 | 2.62 | -36.5 | 0.01 | 17,664 | 5,709 | 103 | 111 | 3.80 | 0.26 | 0.00 | 0.00 | 0 | -0.37 | 0.03 | 0.08 | 0.23 | 0.59 | 6.1 | 6.4 | 5.0 | -0.3 | -7.3 |
| 0.32 | 1.16 | 2.66 | -37.7 | 0.01 | 17,112 | 5,531 | 106 | 113 | 4.01 | 0.26 | 0.00 | 0.00 | 0 | -0.38 | 0.03 | 0.09 | 0.24 | 0.68 | 6.5 | 6.7 | 5.3 | -0.7 | -7.5 |
| 0.33 | 1.20 | 2.70 | -38.9 | 0.01 | 16,593 | 5,363 | 108 | 115 | 4.23 | 0.27 | 0.00 | 0.00 | 0 | -0.39 | 0.03 | 0.10 | 0.26 | 0.79 | 6.9 | 7.1 | 5.7 | -1.1 | -7.6 |
| 0.34 | 1.23 | 2.73 | -40.0 | 0.01 | 16,105 | 5,206 | 111 | 117 | 4.46 | 0.27 | 0.00 | 0.00 | 0 | -0.40 | 0.03 | 0.11 | 0.29 | 0.94 | 7.3 | 7.6 | 6.1 | -1.5 | -7.7 |
| **0.35** | **1.27** | **2.77** | **-41.2** | **0.01** | **15,645** | **5,057** | **113** | **120** | **4.70** | **0.27** | **0.00** | **0.00** | **0** | **-0.41** | **0.03** | **0.12** | **0.31** | **1.12** | **7.8** | **8.1** | **6.6** | **-2.0** | **-7.9** |
| 0.36 | 1.30 | 2.80 | -42.4 | 0.01 | 15,210 | 4,916 | 116 | 122 | 4.95 | 0.28 | 0.00 | 0.00 | 0 | -0.42 | 0.03 | 0.14 | 0.35 | 1.37 | 8.4 | 8.7 | 7.1 | -2.6 | -8.1 |
| 0.37 | 1.34 | 2.84 | -43.6 | 0.01 | 14,799 | 4,784 | 118 | 125 | 5.22 | 0.28 | 0.00 | 0.00 | 0 | -0.44 | 0.04 | 0.15 | 0.39 | 1.71 | 9.1 | 9.4 | 7.8 | -3.3 | -8.4 |
| 0.38 | 1.38 | 2.88 | -44.7 | 0.01 | 14,410 | 4,658 | 121 | 127 | 5.49 | 0.29 | 0.00 | 0.00 | 0 | -0.45 | 0.04 | 0.17 | 0.43 | 2.24 | 10.0 | 10.3 | 8.6 | -4.2 | -8.7 |
| 0.39 | 1.41 | 2.91 | -45.9 | 0.01 | 14,040 | 4,538 | 123 | 129 | 5.78 | 0.30 | 0.00 | 0.00 | 0 | -0.46 | 0.04 | 0.18 | 0.49 | 3.16 | 11.3 | 11.6 | 9.9 | -5.5 | -9.3 |
| **0.40** | **1.45** | **2.95** | **-47.1** | **0.01** | **13,689** | **4,425** | **126** | **132** | **6.09** | **0.31** | **0.00** | **0.00** | **0** | **-0.47** | **0.04** | **0.20** | **0.56** | **5.65** | **14.3** | **14.6** | **12.8** | **-8.5** | **-10.7** |

# Summary

- We measured the BER vs. lateral offsets of an EBO connector to quantify the impact of modal noise
- We have limited data, however no red flags were raised
- Measured MN penalty  was less than 0.1 dB
- The MN penalty for our baseline proposal can be lowered from the traditional 0.3 dB for butt coupled connector channels