Curve fitting to Petar Pepeljugoski's modal noise simulations,

supporting P802.3cm d2.0 comment 38

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Background (1 of 2)

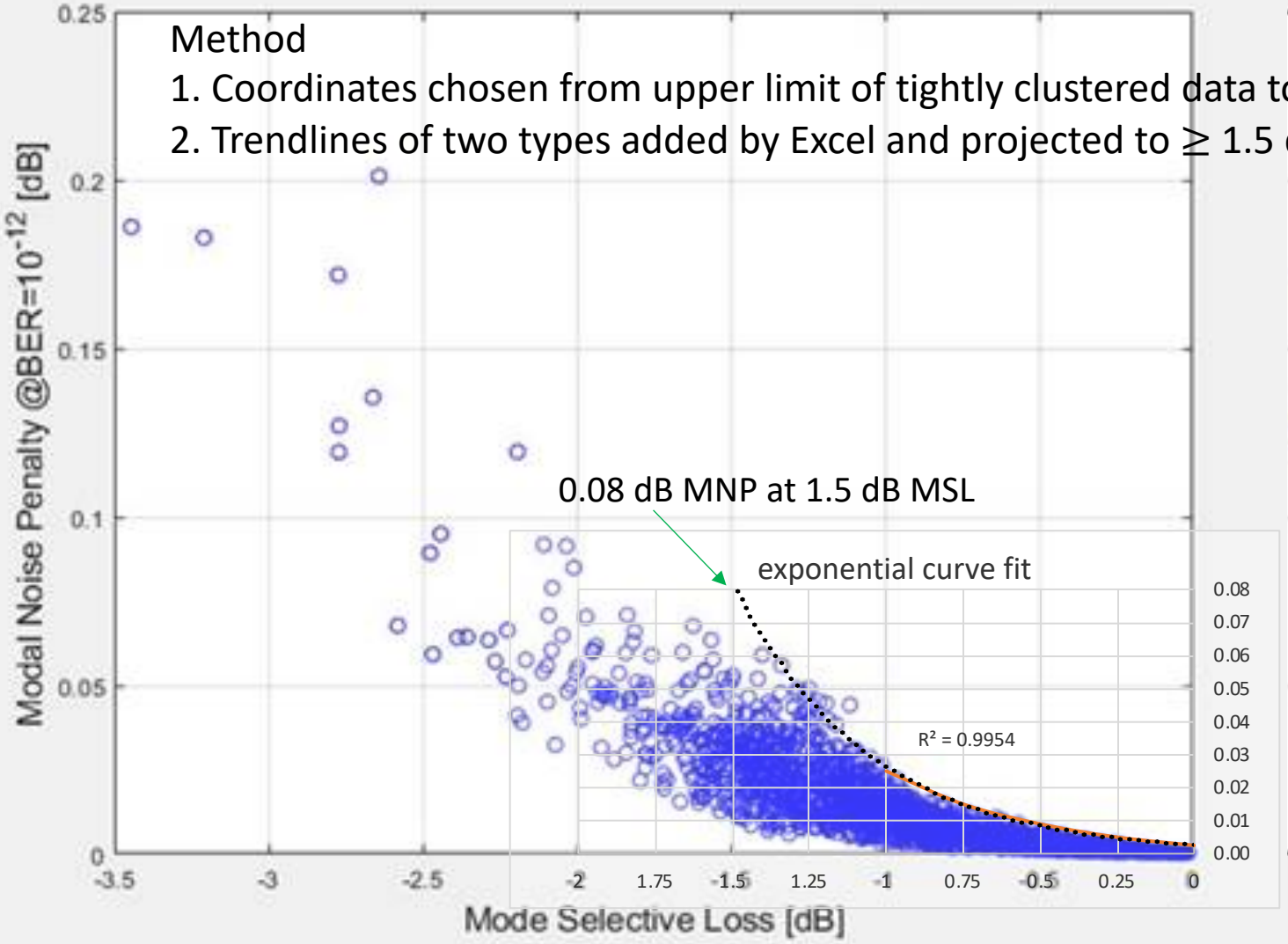
- Proper allocations for modal noise penalty have been the subject of several past comments and contributions.
- In king_3cm_01_0319 (king) a reference was made to simulation work done by Petar Pepeljugoski that provides insights to the magnitude of modal noise penalty (MNP) as a function of mode selective loss (MSL) and mode partition noise k factor (MPNk).
- The referenced graphical data for MPNk = 0.1 was obscured by data at higher MPNk values. Fortunately, Petar subsequently provided the complete unobscured data for MPNk = 0.1 and gave permission to use it here. Thank you Petar!

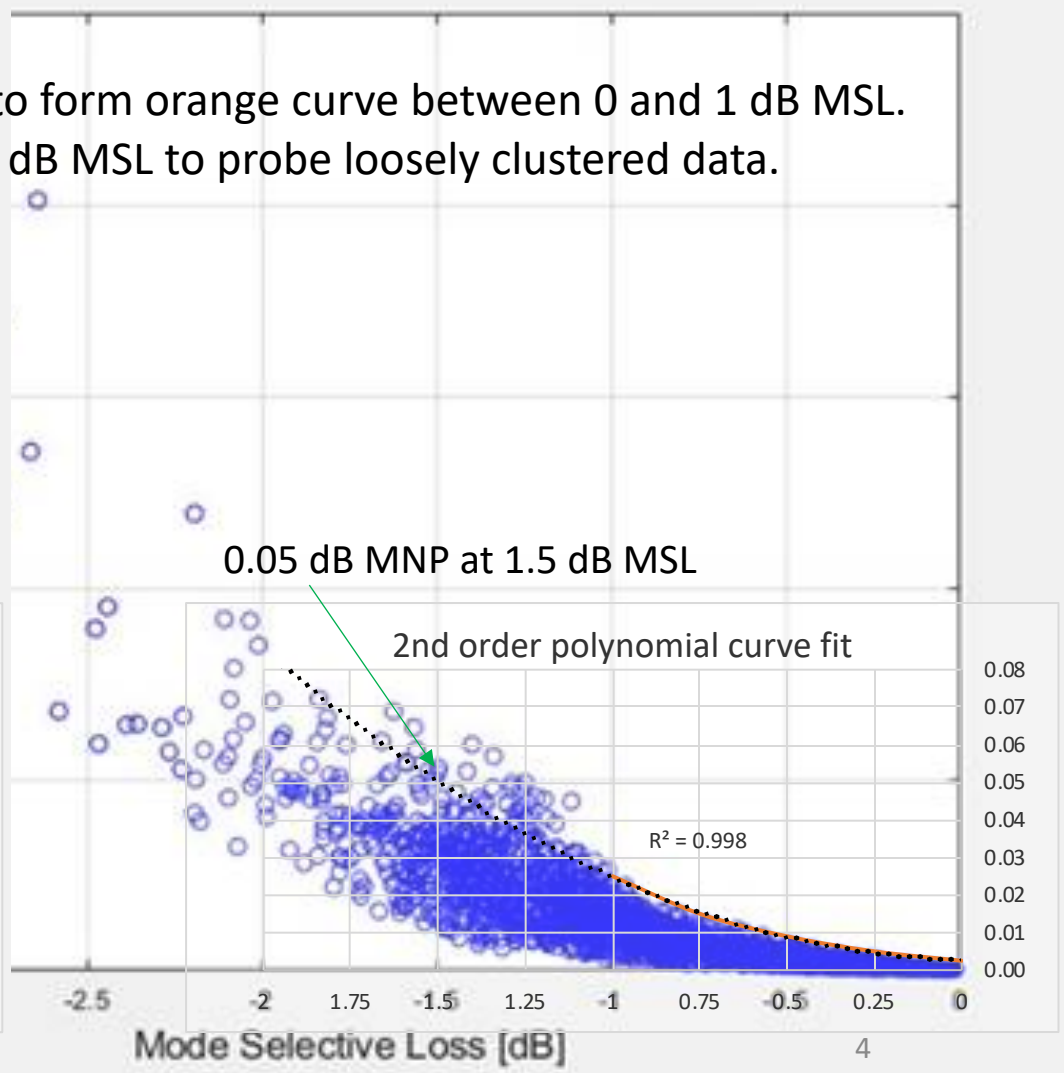
Background (2 of 2)

- The graphical data is dense and forms a sharp boundary for MSL between 0 and 1 dB that can be used to create an upper bound curve.
- The data becomes less dense and more scattered at higher MSL, so the trendline functions of Excel were used to project the curve from 1.0 dB to 1.5 dB MSL. See next slide.
- Two trendline functions were selected: an exponential fit and a 2nd order polynomial fit, with projections of 0.08 dB and 0.05 dB MNP at 1.5 dB MSL, respectively. Note: 1.5 dB is the maximum connection loss allocation stated in the draft standard, so is a reasonable case limit.

Curve fits to Petar's Modal Noise sims for MPNk = 0.1

Method
1. Coordinates chosen from upper limit of tightly clustered data to form orange curve between 0 and 1 dB MSL.
2. Trendlines of two types added by Excel and projected to ≥ 1.5 dB MSL to probe loosely clustered data.





Observations

- The polynomial fit (right graph) excludes some data points, but has slightly superior curve fit, $R^2 = 0.998$, compared to the exponential curve fit, $R^2 = 0.995$.
- The exponential curve fit (left graph) encompasses nearly all data, but is on a trajectory that appears unrealistically severe.

Insights

- Petar's simulations are for NRZ (i.e. PAM2) signaling without FEC operating at lower system bandwidth. Conversions of the MNP values per method of king must be made to apply the simulation results to 400GBASE-SR4.2.
- Petar's simulations use a laser source population developed for defining laser-optimized multimode fiber. This population predated the volume production of 10Gb/s VCSELs and included sources with mode content profiles believed not seen in production VCSELs at 850 nm (or 910 nm). Specifically the source population included this mode group (i.e. spectral line) mixture:
  - $1/7^{th}$ single-mode (not seen in production)
  - $3/7^{ths}$ 2-mode (not seen in production)
  - $2/7^{ths}$ 3-mode
  - $1/7^{th}$ 4-mode
- The single-mode and likely the 2-mode sources create higher MNP due to greater coherence producing more speckle contrast per references in king. Therefore, higher MNP values may be discounted.

Recommendations

- Use the polynomial curve fit to estimate the MNP at 1.5 dB MSL.
- Multiply its projected 0.05 dB MNP by the factor of 3.8 from the king contribution to allocate 0.19 dB for modal noise penalty of 400GBASE-SR4.2. This rounds to 0.2 dB of additional power budget.
- Change the Tx and/or Rx specifications in tables 150-7 and/or 150-8 to deliver the additional power budget.
- Reflect these changes in informative table 150-9 regarding the cable.
- Comment 38 has been submitted on draft 2.0 to this effect.