Proposed spectral limits for 1310 nm Gigabit PMDs in EFM

Piers Dawe — Agilent Technologies

Jim Tatum — Honeywell

Meir Bartur — Zonu

Dispersion problem

- Extended temperature range means lasers are further from dispersion minimum
- Seek to use Fabry-Perot lasers
  - Finite spectral width, maybe implementer dependent
- Mode partition noise problem
  - Important at 10 km - borderline, needs care

More on mode partition noise

- Strength of the different FP modes varies rapidly (“mode partition”)
  - while the sum of the modes largely follows the signal
- Light of different wavelengths arrives at the receiver at different times
- Received pulses have variable shape and timing: noisy
  - Noise cannot be bought out by increased power at the receiver
  - Doubt that can predict it accurately enough

Example of simple spec

- For FP lasers, ITU-T and SONET demand:

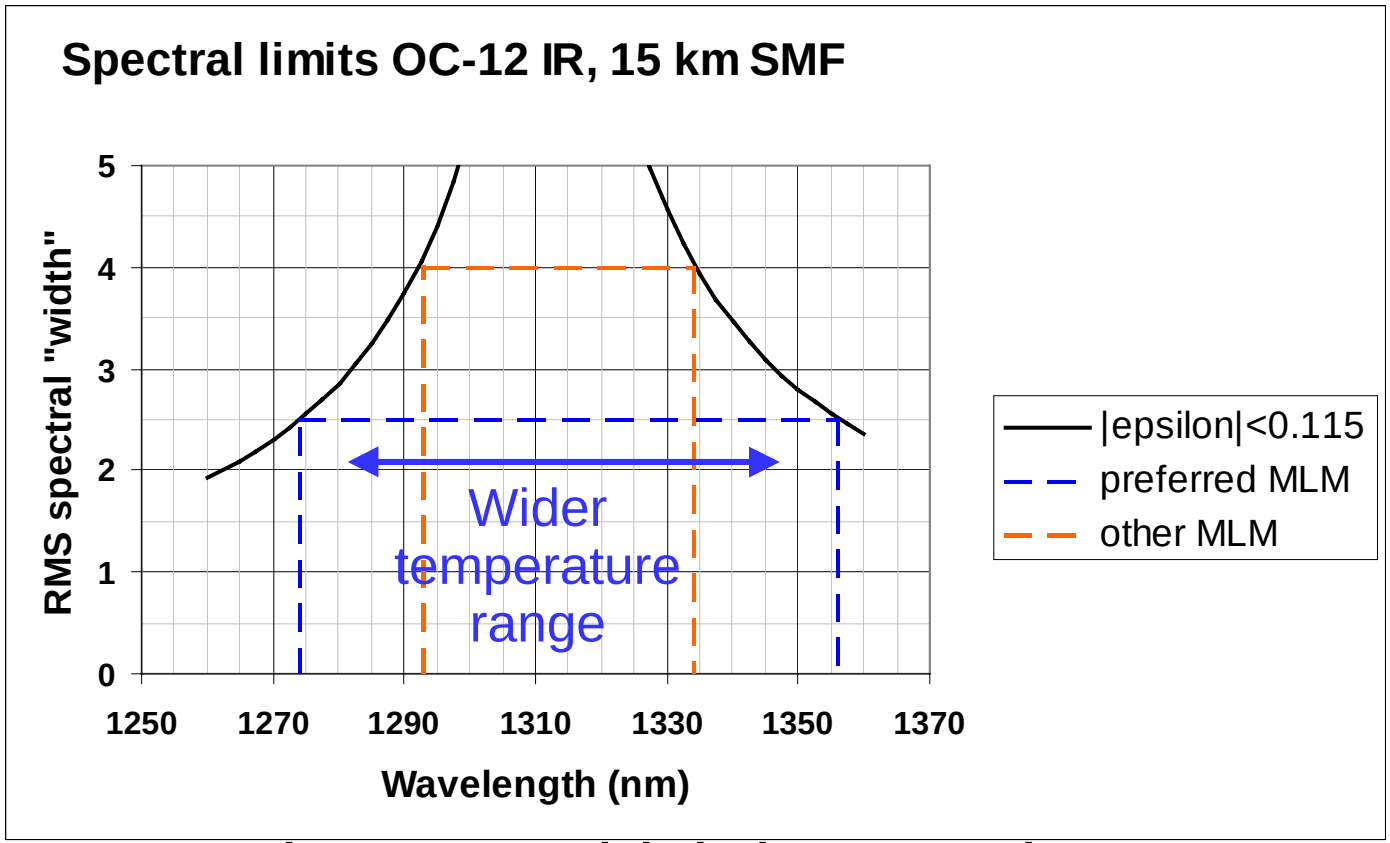
  |epsilon| <=0.115 (spec)

- where

  epsilon = Dispersion.length.spectral width.Baud

- epsilon is time-of-flight uncertainty normalised to bit period
- ITU-T specs fit boxes within epsilon limits
- This approach
  - Is simple, verifiable by customers
  - Leaves performance unused

Example of a 2-box spectral spec: OC-12 IR



Implementer chooses which box to obey

Guarantees |epsilon| <=0.115

epsilon = Dispersion.length.spectral width.Baud

Example of complicated spec

- FibreChannel “Triple trade off”
- Allows trade of transmitted power vs. predicted MPN penalty
- Prediction uses wavelength, spectral width, assumed effective k factor
- Flexible
  - Does not tie us to a temperature range
  - Variable power limit attractive for VCSELs
  - but maybe not for network operators
- More complicated than we need
- Not accurate - relies on assumptions

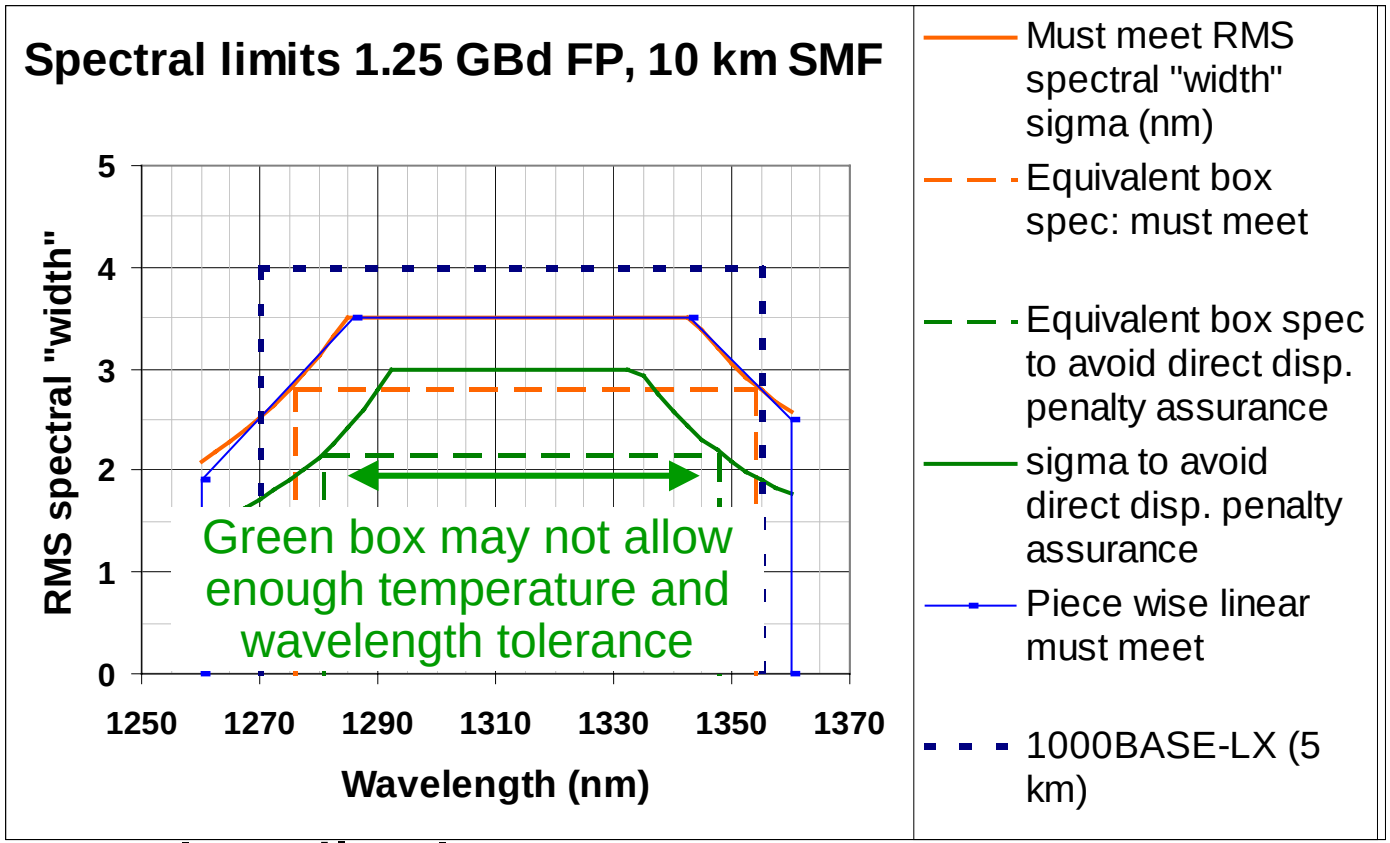
More on mode partition noise

- MPN factor k describes variability of the different FP modes
- *Effective* MPN factor k' describes MPnoise
- k' is not the same as k
  - It is much larger
  - It depends on many things in Tx and Rx
- Theories of MP and MPN are approximations
  - They work, but not as accurate as we need
  - Non-Gaussian statistics in real world

More on mode partition noise

- If we don’t know k’ we can’t set an optimistic limit for epsilon
- If we set a pessimistic limit for epsilon
  - we can’t achieve our reach, cost and temperature range objectives
- Therefore we must allow direct measurement approach
  - forget k and k’, spec MPN penalty
- Easier to spec it as part of a bucket with other penalties
- Spec “transmitter & dispersion penalty”, TDP

Proposed spectral spec for 10km 1.25 GBd



Must meet |epsilon| <=0.168

OK if |epsilon| <=0.115 (ITU-T spec)

Use TDP if in between

epsilon = Dispersion.length.spectral width.Baud

Proposed spec for 10km 1.25 GBd

- Blue “must meet” area
  - Approximates to orange curve
- Offer green “safe area”
- Assurance by TDP anywhere in blue area
- MPN penalty can be assumed <2dB in green area
- This approach maximises flexibility for moderate complexity
- Compatible with 1000BASE-LX
- We won’t have to re-open the standard to extend the temperature range

Measuring MPN

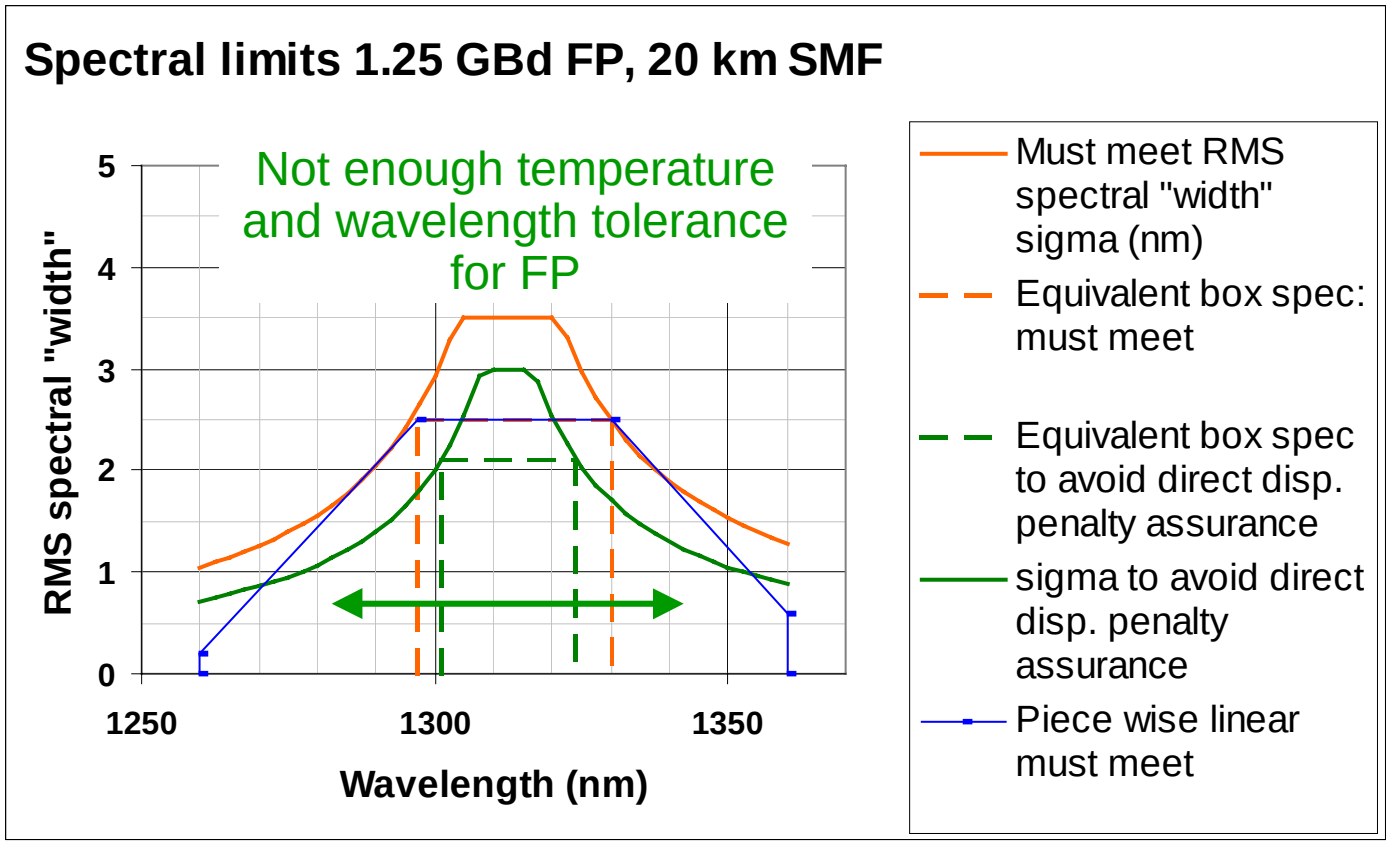
- Spectrum may vary over time, temperature
- Reasonable to expect that MPN would too
  - and MPN will depend on test receiver
- REALLY want to avoid “cliff edge” or BER floor
- Propose build in margin by “testing with” (assuring to) extra dispersion
  - Maybe extra 25%?
- At temperature extremes, regular SMF may create the dispersion you need
  - but more than 10 km of it! See http://www.ieee802.org/3/efm/public/may02/bartur_5_0502.pdf

Implementers may not wish to measure TDP in production

- Each implementer may devise his own spectral width, center wavelength specs to meet the templates
- Alternative proposal: in addition, each implementer could choose his own allowance for MPN, and test the Tx against this reduced margin
- Each implementer may make a different choice for these parameters
- Allows trade-offs depending on the available technology and desired temperature range

- TDP methodology allows flexibility and low cost in practice

What about 20km 1.25 GBd?



DFB is good choice

"Zero SMSR" DFB would work. Or FP and FEC?

Conclusions

- Box spec is too constraining
- Triple trade off may be too complicated
- Predictions from spectral width too inaccurate
- Combination of epsilon limit and TDP assurance is
  - most cost effective
  - compatible with 1000BASE-LX
  - avoids revisiting this issue in future