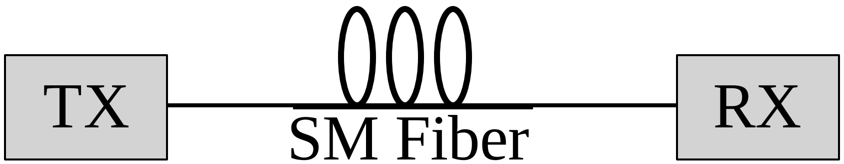
Golden test for dispersion penalty – 1550 Serial –

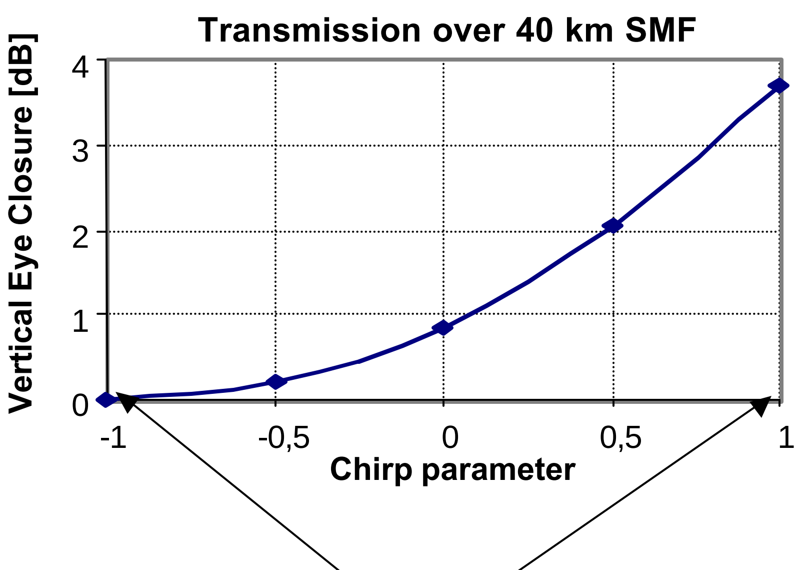
Peter Öhlen, Krister Fröjdh (Optillion)

SMF Transmission at 1550 nm

- Different from multi-mode transmission
  - Dispersion [ps/nm/km] is the important figure
- RMS spectral width is not critical here
- The transmitter chirp is important
  - laser wavelength changes with modulation
  - combination of chirp and dispersion gives a penalty
- PROBLEM:
  - Today's spec does not consider the interaction of chirp and dispersion in SMF transmission

Simulation results:
DFB-EA @ 1550 nm after 40 km SMF





Equal RMS spectral width

- Results from a simulation program in MatLab
- Simulation program freely available (but MatLab costs $)

This does not show up in any measurement standardized so far

Outline of the golden test

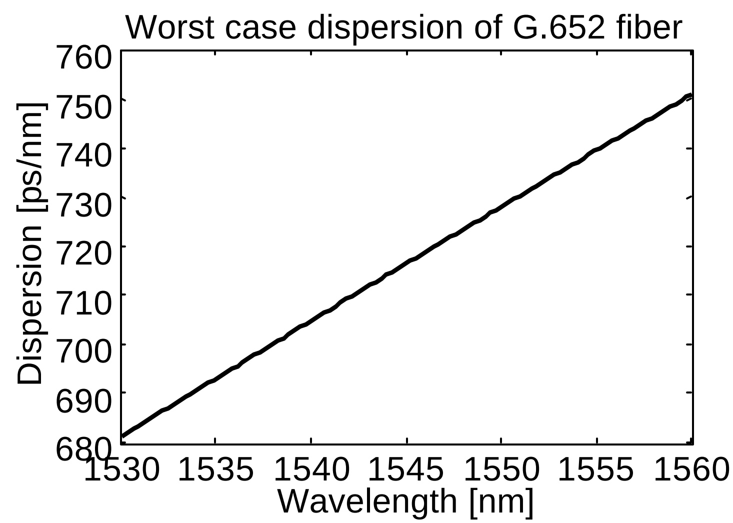
- Idea: Simulate worst-case conditions
- RX test as in 1 GbE
  - uses a stressed eye
  - shape of the stressed eye might need modifications
- TX test is new, applies to 1550 serial:
  - degradation from dispersion and chirp → dispersion penalty
  - test the TX with: golden fiber + golden RX

(In the following, * means that further work is needed)

Golden fiber

- Specify minimum dispersion over full wavelength region (worst case G.652 dispersion)
- Attenuation as small as possible to avoid use of ER-amplifier (a good fiber spool should be OK)
- Define dispersion measurement method for making the golden fiber: e.g. TIA/EIA-455-175A.

$$D(\text{ë}) > 40\,\frac{0.093}{4}\left[\text{ë} - \frac{1300^{4}}{\text{ë}^{3}}\right]\text{ps/nm}$$



Golden RX

Golden receiver

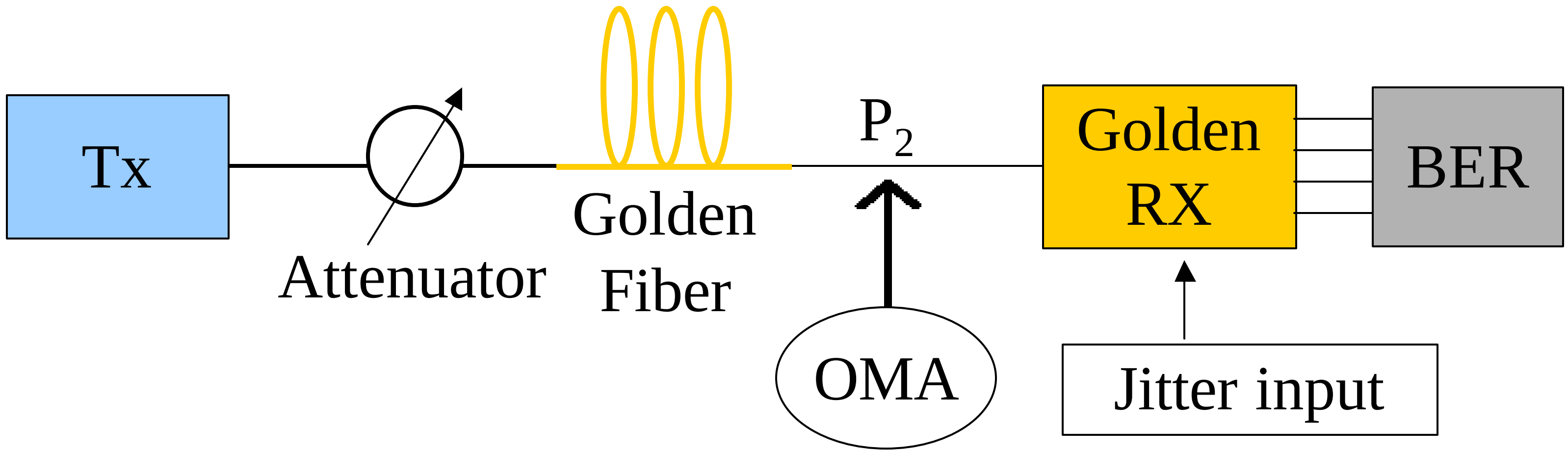
- Standard reference receiver with clock recovery but with jitter input
- Can be implemented with a commercially available reference receiver + BER.
- Standard Bessel filter (*)
  - another filter type might be more appropriate
  - the filter characteristic should be defined
- Sensitivity at infinite extinction ratio= P_0
  - $P_0 \leq -18$ dBm

Table values *

(Exact values to be defined)

Link insertion loss	IL	13	dB
Dispersion penalty (max)	DP_{max}	3	dB
Extinction ratio (min)	ER_{min}	4	dB
Link margin		2	dB
Nominal sensitivity	P_{sens}	-18	dBm
RMS Spectral width	redundant		nm

TX test at TP3 – dispersion penalty

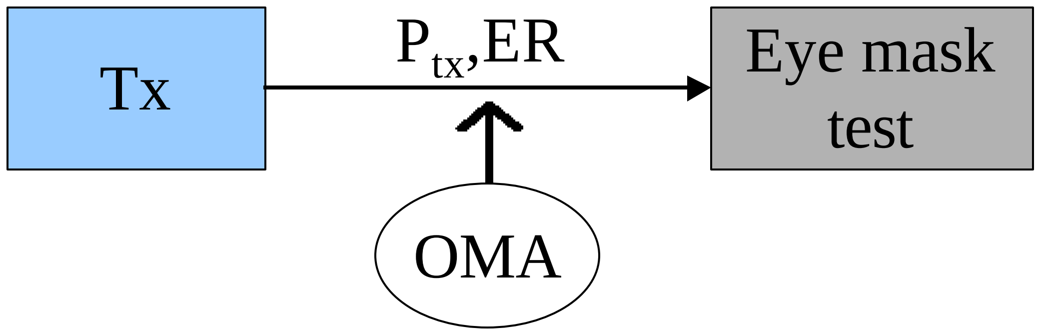


Measure P_2 at BER=10^{-12}

Pass condition:

– $DP = P_2 - P_0 < DP_{max} = 3$ dB

Transmitter test at TP2



Measure P_{tx},ER, and eye mask

Pass conditions:

- $ER > ER_{min}$
- P_{tx}>P_{sens}+IL+DP+margin = 0dBm (* more on this condition later)
- ”eye mask pass” (might not be needed)

Possible further improvement: P_{tx} condition at TP2

- In general: Margin = $(P_{tx} – IL – DP) – P_{sens}$
- First proposal: (DP < 3 dB) & (P_{tx} > 0 dBm)

Comparison of 2 transmitters:	TX #1	TX #2
Ptx	0 dBm	-1.5 dBm
Dispersion penalty	3 dB	0.5 dB
Link loss	13 dB	
Sensitivity (non-stressed)	-18 dBm	
Margin	2 dB	**3 dB**
PASS with current condition	YES	**NO**

This transceiver would work very good

- We can do someting better than this:
  - Require margin > 2 dB → P_{tx} – max(DP,0) > -3 dBm

Remaining issues for this test ….

- Cut-off frequencies for the RX (upper, lower)
- Golden RX filter characteristics
- Decide on the amount of jitter/phase degradation for the transmitter test
  - Is the TX eye mask test necessary ??
- Can we test other thing in the same test ??

Summary

- Rx test similar to 1 GbE, might need modified shape of the stressed eye
- Tx test with golden fiber
  - is a test for dispersion and chirp
  - other penalties like RIN are still allocated for in the link budget

Backup

Alternative test methods

- Eye mask after fiber
  - power level difficult
  - BER floors not detected
- Use a ”bad golden TX” to degrade the eye optically with dispersive fiber
  - we still need to specify the stressed eye, but on the optical side
  - we still need a ”good golden TX” for the golden RX calibration
  - hard to reproduce

Backup

Things not covered by the test

- For some parameters it is very difficult to generate a worst case condition
  - RIN and feedback sensitivity: This is dependent in a complicated way on the phase, polarisation, reflectance and distance to the feedback.
- For some parameters it is not obvious which case it the worst case:
  - Frequency response of the receiver.

Backup

Possible measurements

- Spectral width:
  - Does not give sufficient information
- Direct chirp measurement:
  - different types of chirp and complex measurement
- Dispersion penalty
  - this is what really matters
  - fairly simple

Golden Tx

Golden transmitter

Backup

- High bandwidth (>10 GHz*) modulator
- Chirp unimportant
- Moderate power needed
- Wavelength *should* not be important for a good RX design
  - The critical point is at the upper limit, 1565 nm