Dispersion penalty test
– 1550 Serial –

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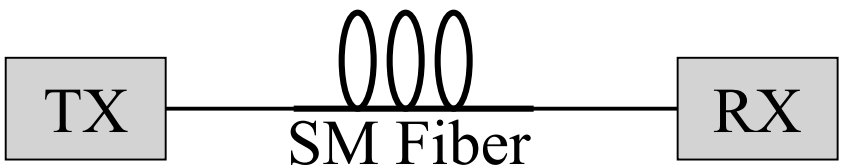
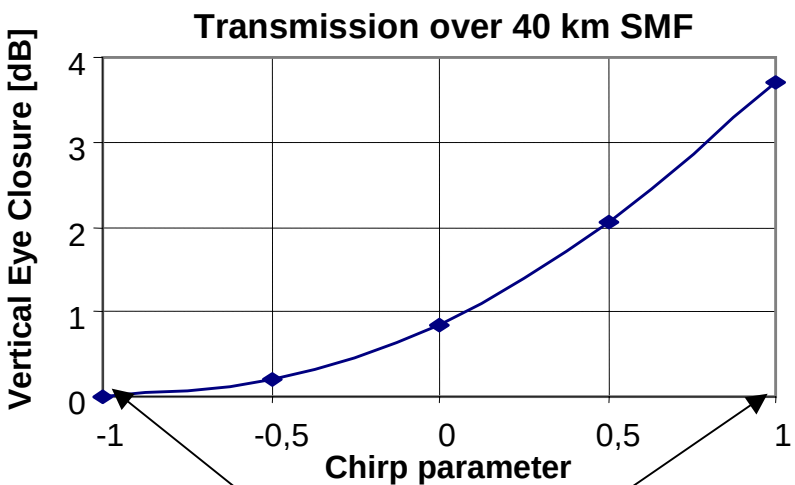
Optillion

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
- We need to test this
  - measurement of dispersion penalty is the most straight forward way to do this

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 TX & RX tests

- 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: test fiber + golden RX

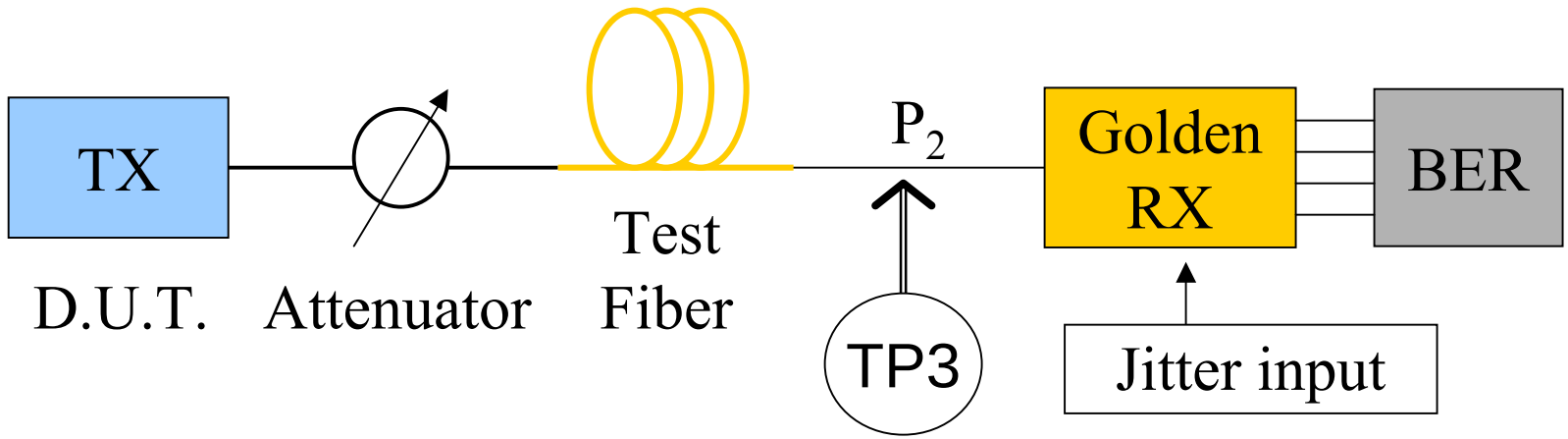
(In the following, * means that further work is needed)

Some definitions and parameters

Link insertion loss	IL	13	dB
Dispersion penalty (max)	DP_{max}	3	dB
Nominal sensitivity (OMA/2)	P_{sens}	-19.4	dBm
Link margin		2	dB
RMS Spectral width	redundant		nm
Extinction ratio (min)	ER_{min}	3	dB

In the following, all powers are measured in OMA/2

TX test at TP3 – dispersion penalty



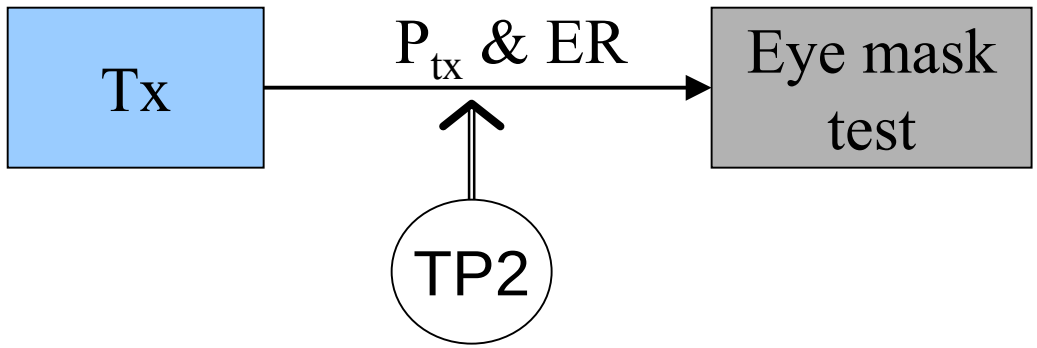
Measure P_{DUT} = (P_2 at TP3 for BER=10^{-12})

S = sensitivity (10^{-12}) of the golden RX

Pass condition:

– DP = max(P_{DUT} - S, 0) < DP_{max} = 3 dB

Transmitter test at TP2



Measure P_{tx}, ER (?) and eye mask (?)

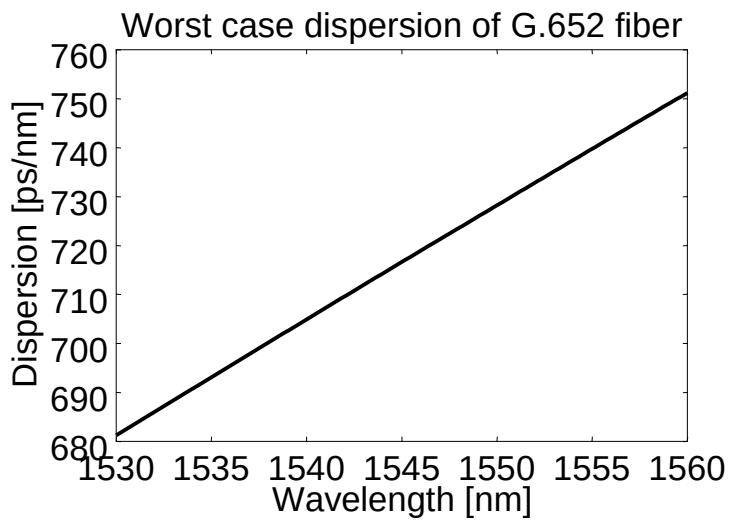
Pass conditions:

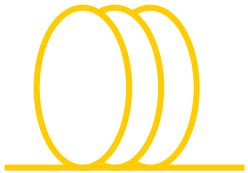
- $P_{tx} > P_{sens} + IL + DP + margin = -4.4\ dBm + DP$
- $ER > ER_{min}$
- ”eye mask pass” (might not be needed if jitter test is included in the dispersion test)

Test fiber characteristics

- A G.652 fiber with total dispersion larger than the worst-case 40km G.652 dispersion. The test fiber can be longer than 40km.
- 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.

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





How to make the test fiber

1. Get a fiber longer than 40 km
   - long should ensure that the total dispersion larger than required
2. Measure the dispersion of the fiber over the wavelength region of interest
3. If the total dispersion of the fiber is too large, cut back the fiber to lower the total dispersion
4. Verify that the total dispersion of the fiber is large enough
   - if necessary, return to step 3
5. Your fiber is ready to go !!

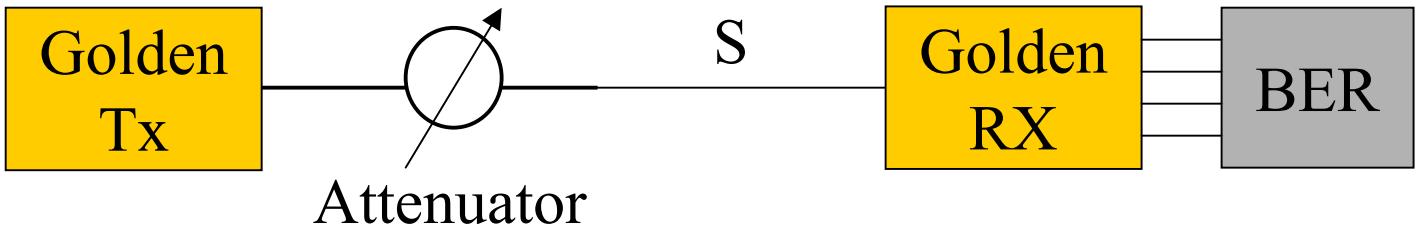
Golden RX

Golden receiver

- Reference receiver with clock recovery
- Sensitivity should be at least as good as the 10 GbE RX
- Decision threshold at average signal level
- (*) Bandwidth ??
- (*) Possibly with jitter input on the recovered clock.
  - Can this be implemented with commercially available equipment ??
- (*) Standard Bessel filter
  - another filter type might be more appropriate
  - the filter characteristic should be defined

Golden Rx

Golden Rx calibration



Measure the sensitivity S of the golden RX for BER=10^{-12}. (Without jitter input)

Golden Tx

Golden Tx

- High bandwidth (>15 GHz) modulator
- High quality eye, test for:
  - Symmetry and eye mask
  - Vertical eye closure < 0.5 dB in the center 20 % of the eye
  - (*) Rise/fall times < xx ps ??
  - (*) Vertical eye closure < yy dB ??
  - (*) Total jitter < zz dB ??
- Chirp unimportant
- Moderate power needed

Action points for this test ….

- Test pattern for the penalty measurement
  - PRBS 2^{23}-1
- (*) Golden RX filter characteristics
  - Not obvious what the desired characteristics are
- (*) Decide on the amount of jitter introduced in the golden RX for the transmitter test
  - Is the TX eye mask test necessary ??
- (*) Can we test other thing in the same test ??
- (*) Cut-off frequencies for the RX (upper, lower)

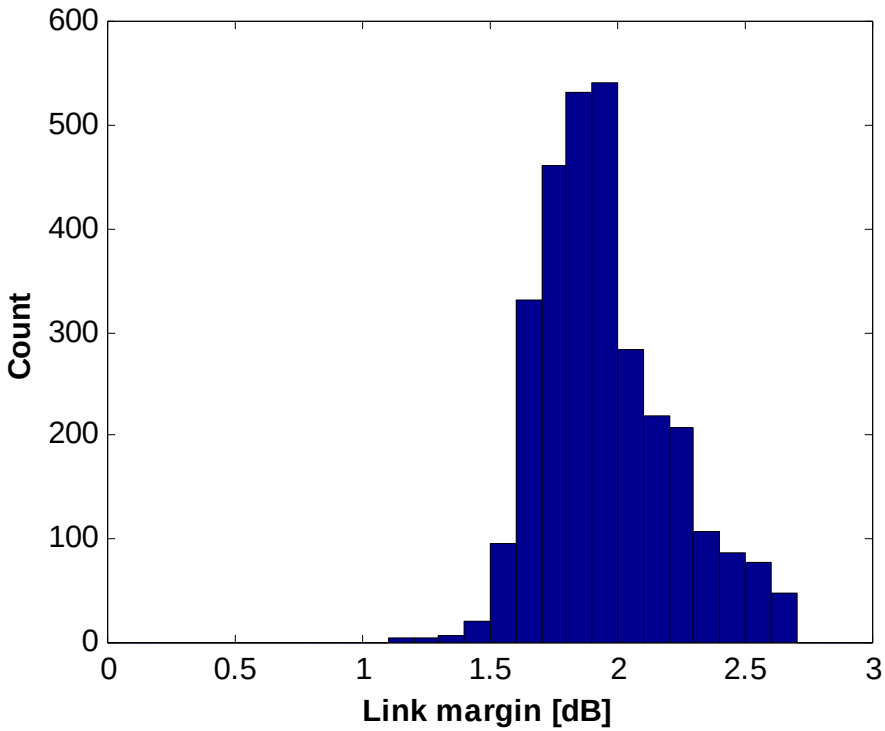
Things not covered by the test

- 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.
  - Polarization Mode Dispersion
- These degradations give penalties which have to be accounted for separately in the link budget

Simulation of compliance tests

- Vary chirp parameters of the TX
  - simple model of DFB-EA is used
- Vary bandwidth and filter order of RX
  - filter type is a bessel filter of order 1 – 4
  - bandwidth is 5.5 – 10.5 GHz
- Take TXs and RXs that barely pass the tests
- Test every TX with every RX over a 40 km link
- Calculate the link margin for each combination

Simulated link margin for ”good” components



- The mean link margin is close to 2 dB
- There is a spread, but few combinations give a margin < 1.5 dB

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

Why trade off dispersion penalty and output power ?

- 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 → $P_{tx} – \max(DP,0) > -3\ dBm$