TDP, mask and VECP

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  - Error caused by definition of VECP
- Gaussian transmitter
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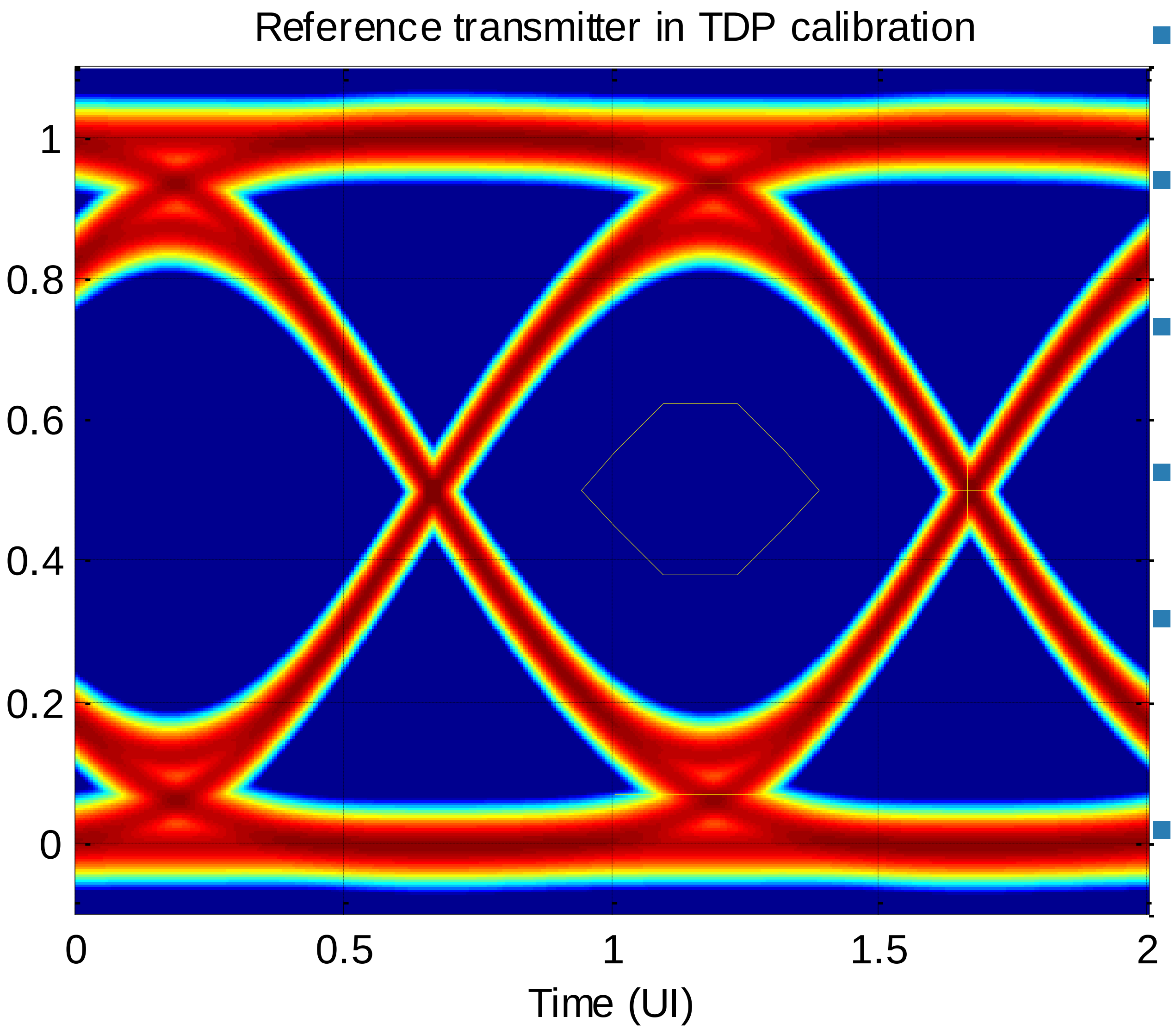
Blue text denotes either emphasis or updated material

Reference transmitter in TDP calibration



However, the following slides assume a faster reference transmitter with P=0.80 dB, VECP=1.42 dB: error of 0.62 dB (values for zero error also provided)
A lower noise reference transmitter would have a smaller VECP-induced error

- This is a 12 ps transmitter with RIN_OMA -133 dB/Hz as seen through the 12.6 GHz Bessel-Thomson reference receiver
- Deterministic ISI at -0.11 UI from eye centre
  - P_ISI = 1.57 dB
- Signal's penalty P
  - 1.30 dB
- VECP at all but 0.1%
  - 2.06 dB
- The "worst bit and noise" penalty (spreadsheet algorithm) would be
  - 1.61 dB
- VECP is a bad estimate of the signal's penalty
  - VECP – P = 2.06 – 1.30 = –0.79 dB
  - VECP is ~0.8 dB too large
- This error causes the TDP results this much higher than otherwise
- Worse, the error depends on the proportions of ISI and noise, and the details of the ISI
  - A simple correction factor won't fix this

Discussion

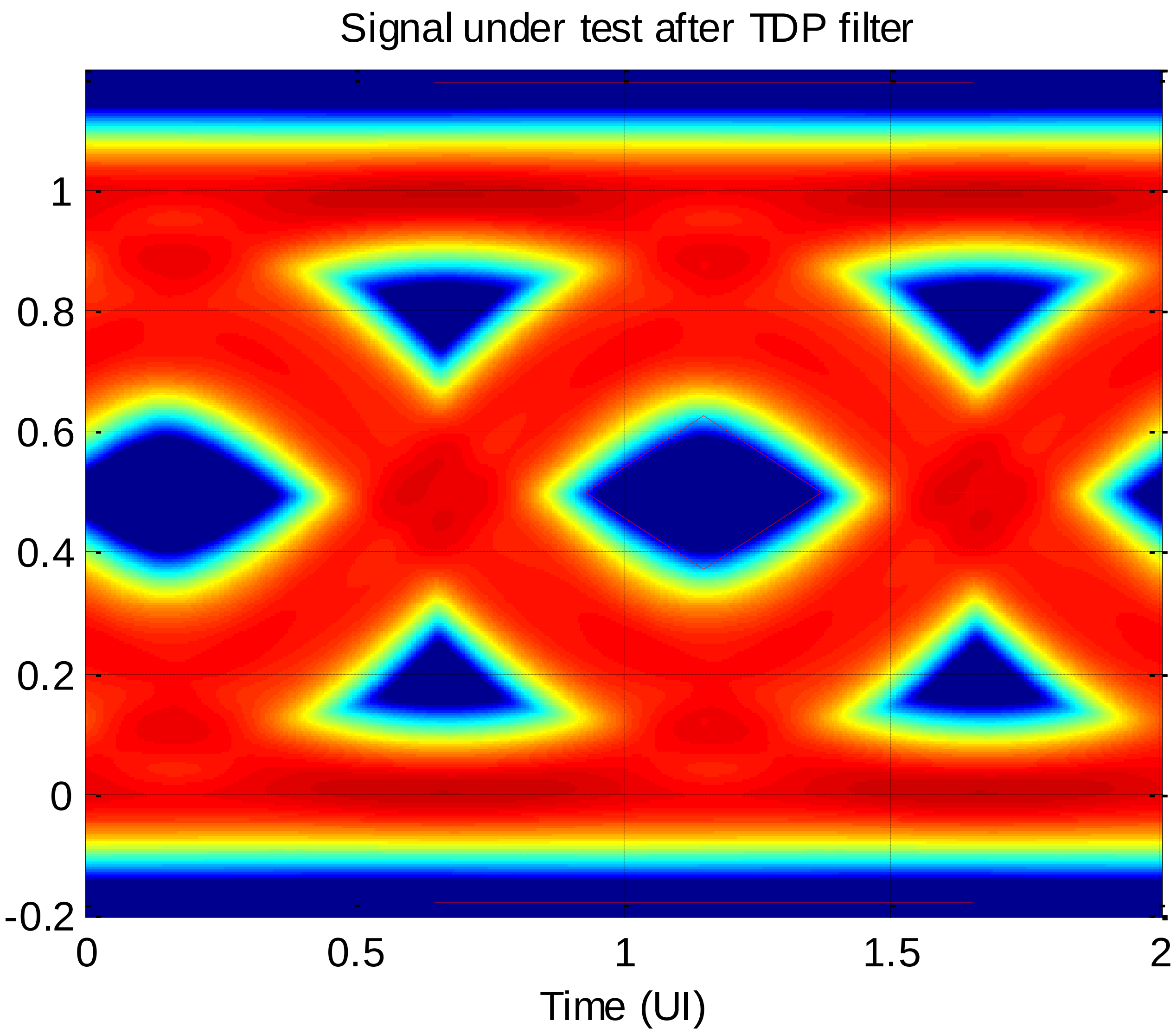
- In spite of its name, VECP is not a penalty
  - In 802.3ae, it is defined by all but 0.1% of the vertical distribution. This correlates well with penalty for BER = 1e-12
- For 100GBASE-SR4 with BER = 5e-5, we need to find the right proportion for "all but"
- This could be found by investigating reference transmitters with different mixes of ISI and noise

- However, there is a much larger VECP (with much larger error) in the stressed receiver spec
  - It would be better to investigate stressed eyes with different mixes of ISI and noise

Gaussian transmitter

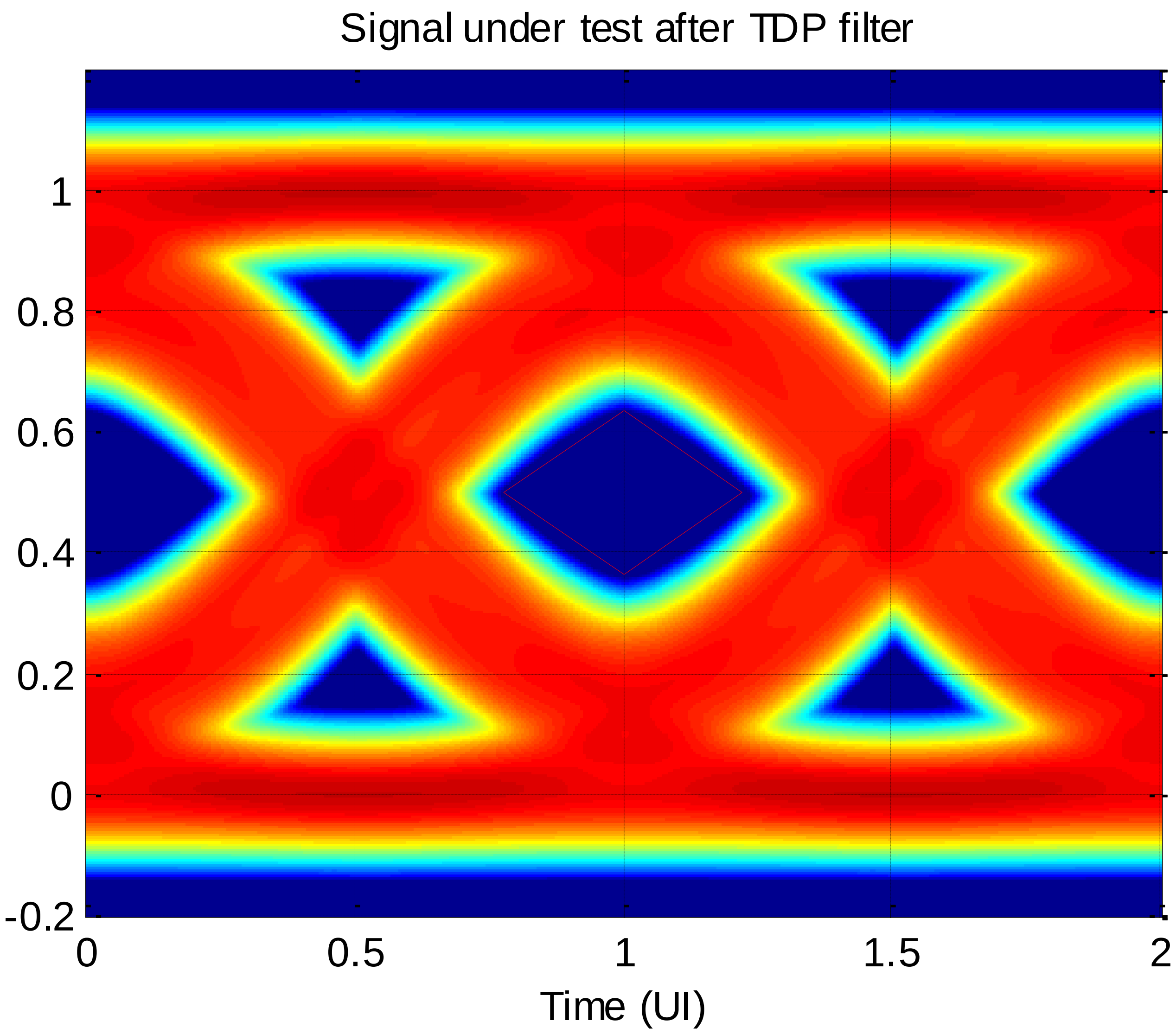
- Simulating a Gaussian transmitter with DJ and RJ
- Finding its TDP in 12.6 GHz as in D2.0, and in 16.2 GHz

Gaussian transmitter after 12.6 GHz TDP filter



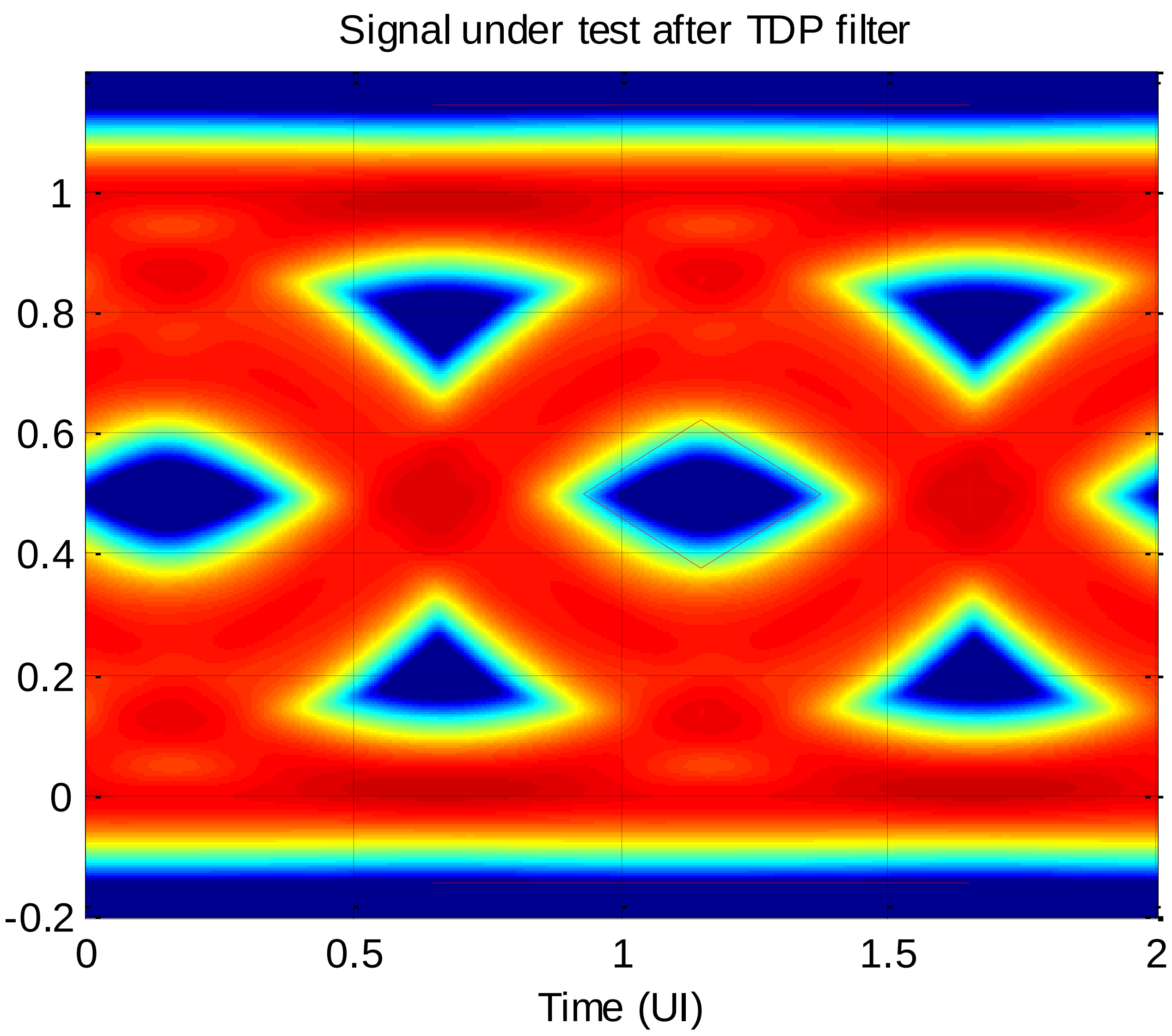
- 21 ps Gaussian transmitter
- 0.05 UI Even-Odd Jitter
- 0.247-0.05 = 0.197 UI SJ
- 0.00793 UI applied RJ
- TDP = 4.46 dB (3.64 dB without VECP error)
- Stressed receiver eye mask of Table 95-7 (red)

Gaussian transmitter after 16.2 GHz TDP filter



- As before but 16.2 GHz observation filter
- TDP(16.2) = 3.58 dB (2.89 dB without VECP error)

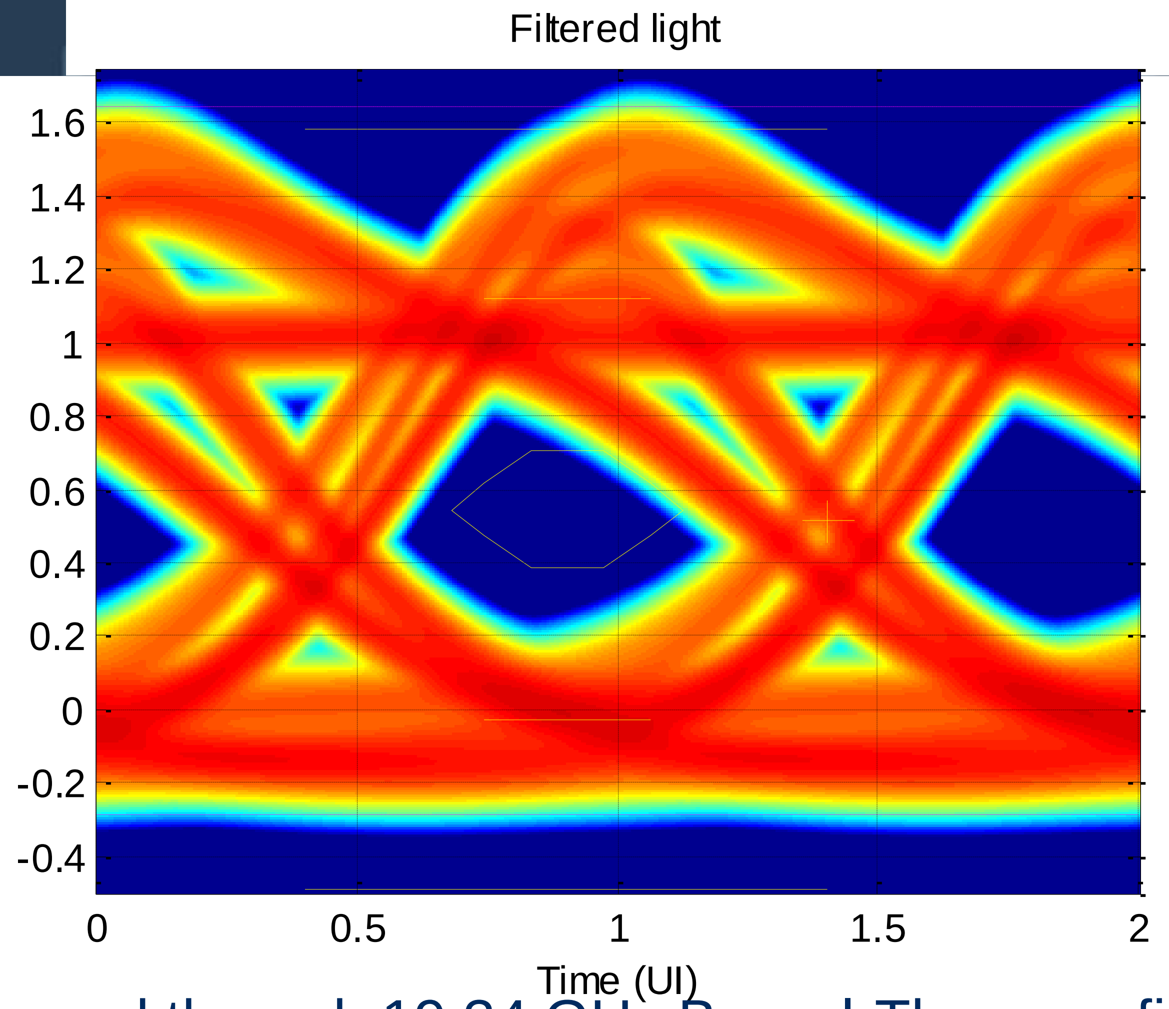
Slower Gaussian, moving towards max TDP

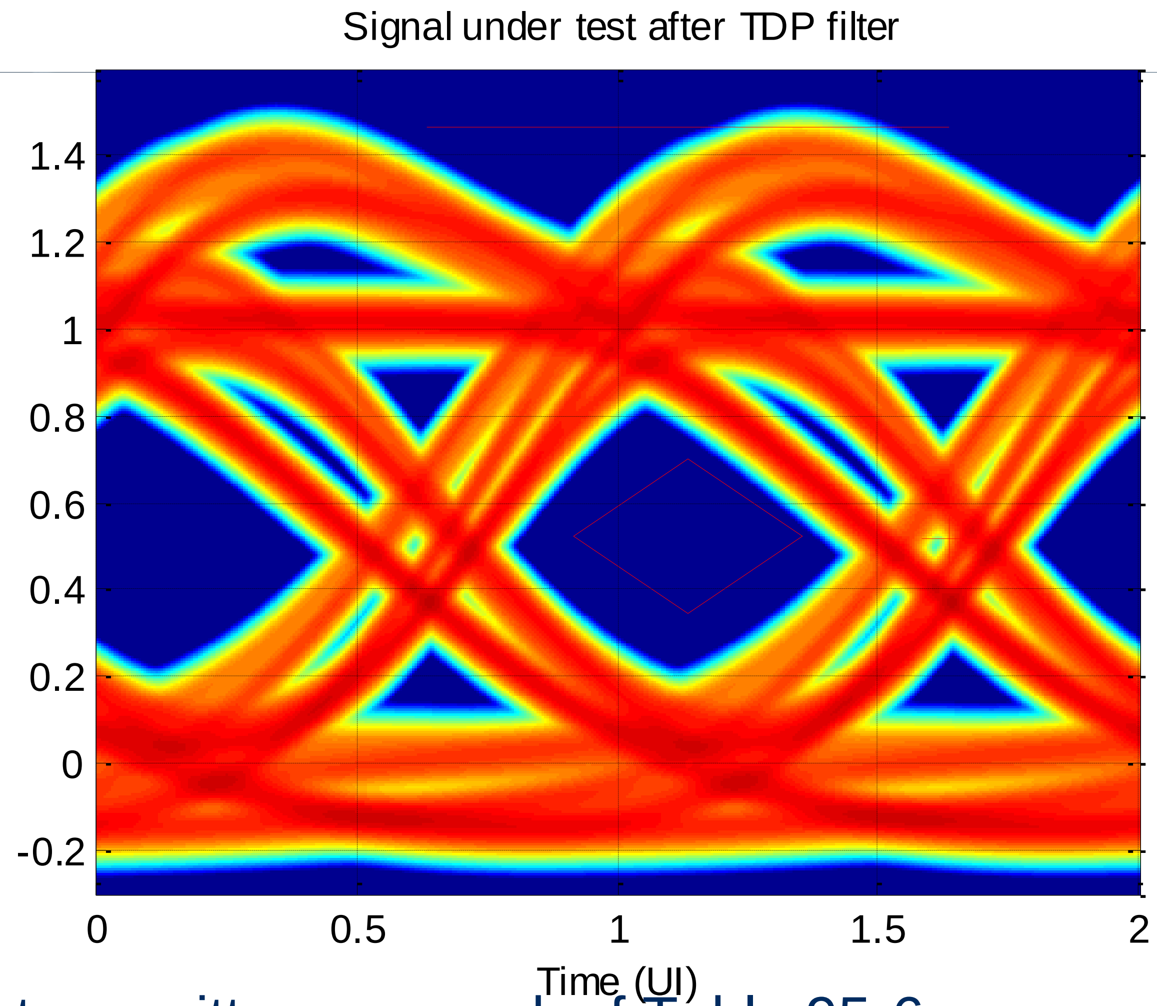


- 24 ps Gaussian transmitter
- 0.05 UI Even-Odd Jitter
- 0.247-0.05 = 0.197 UI SJ
- 0.00793 UI applied RJ
- TDP = 5.40 dB (4.51 dB without VECP error)
- Stressed receiver eye mask of Table 95-7 (red)

New slide

Realistic transmitter and eye mask



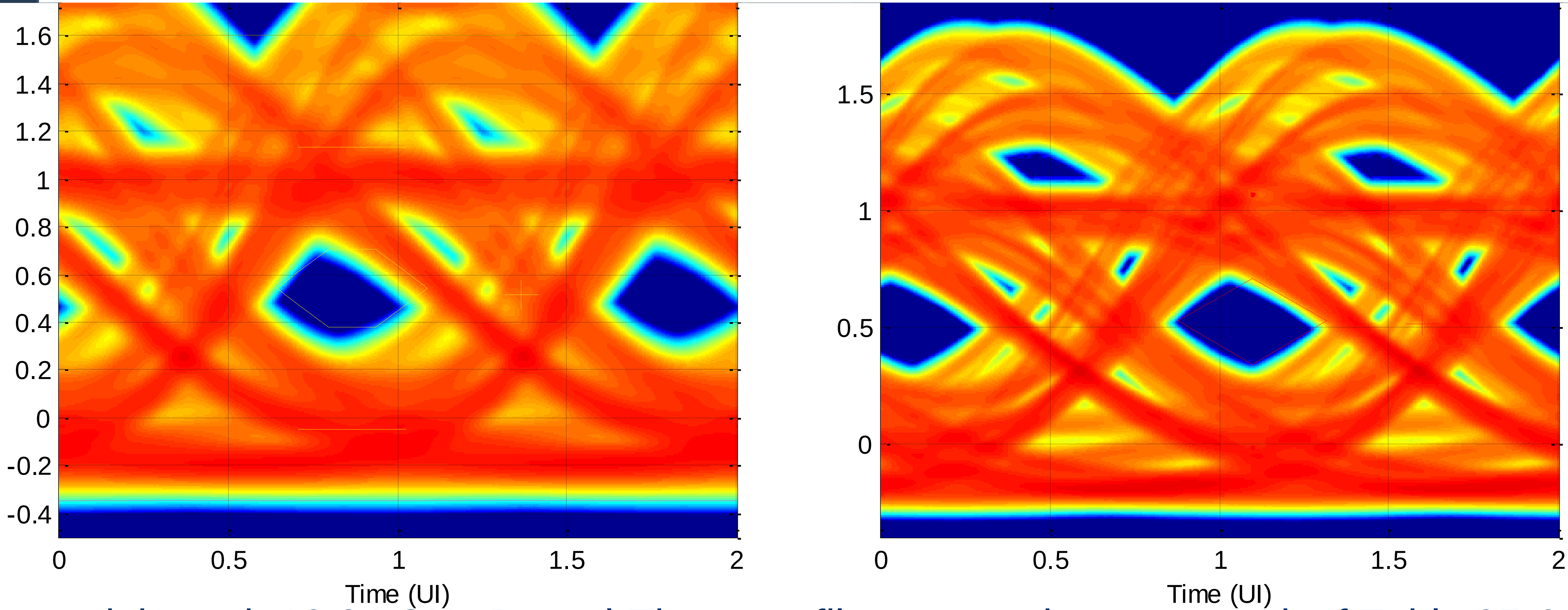


Left: observed through 19.34 GHz Bessel-Thomson filter, transmitter eye mask of Table 95-6

Right: observed through 12.6 GHz Bessel-Thomson filter, stressed receiver eye mask of Table 95-7

- This is a simulated laser eye with a TDP of 2.86 dB (2.07 dB without VECP error)
- The eye is barely passing the inner mask, but fails the outer mask (yellow mask, magenta shows extent of signal)
- A signal with a TDP of 5 dB could fail the mask by a large margin (see next slide)
- Mask needs to be made easier: both inner mask smaller (Y1, Y2) and outer mask larger (Y3)

Transmitter with ~4.2 dB TDP *New slide*



Left: observed through 19.34 GHz Bessel-Thomson filter, transmitter eye mask of Table 95-6

Right: observed through 12.6 GHz Bessel-Thomson filter, stressed receiver eye mask of Table 95-7

- This is a simulated laser eye with a TDP of 4.95 dB (4.16 dB without VECP error)
- The eye fails both inner mask and outer mask (yellow mask, magenta shows extent of signal)
  - Also it's difficult to get an accurate measure of OMA with PRBS9
- Mask needs to be made easier: both inner mask smaller (Y1, Y2) and outer mask larger (Y3)

Eye mask

- Eye mask is intended to be permissive: TDP is the primary measure of transmitter quality, almost all signals with adequate TDP should pass the eye mask spec
  - Th exception is a signal with more TP than the TDP limit
- The inner eye mask needs relaxation
  - Or very much tighter TDP, which would not be a cost effective choice
- A well chosen 10-sided mask correlates better to useful performance than a hexagonal mask
- The outer eye mask needs relaxation
  - Outer eye mask controls overshoot, partly for its own sake and partly in an attempt to control bounce-back into the middle of the eye that would cause a problem to a receiver with higher bandwidth than the reference 19.34 GBd
  - The smaller the inner eye mask is, the more bounce back can be tolerated by a compliant receiver
  - Over the generations of optical Ethernet, the inner eye mask has been relaxed; the outer eye mask has also been relaxed but has not kept up:

PMD type	Inner eye Y1, Y2		Outer eye Y3
1000BASE-SX	0.2	0.2	0.3
10GBASE-SR (A)	0.25	0.28	0.4
10GBASE-SR (B)	0.235	0.265	0.4
40GBASE-SR4	0.27	0.35	0.4
100GBASE-SR4	0.36	0.44	0.4

- This time we need to increase Y3 to keep up with changes in Y1, Y2. Increase Y3 to 0.55

5 dB TDP is too high anyway

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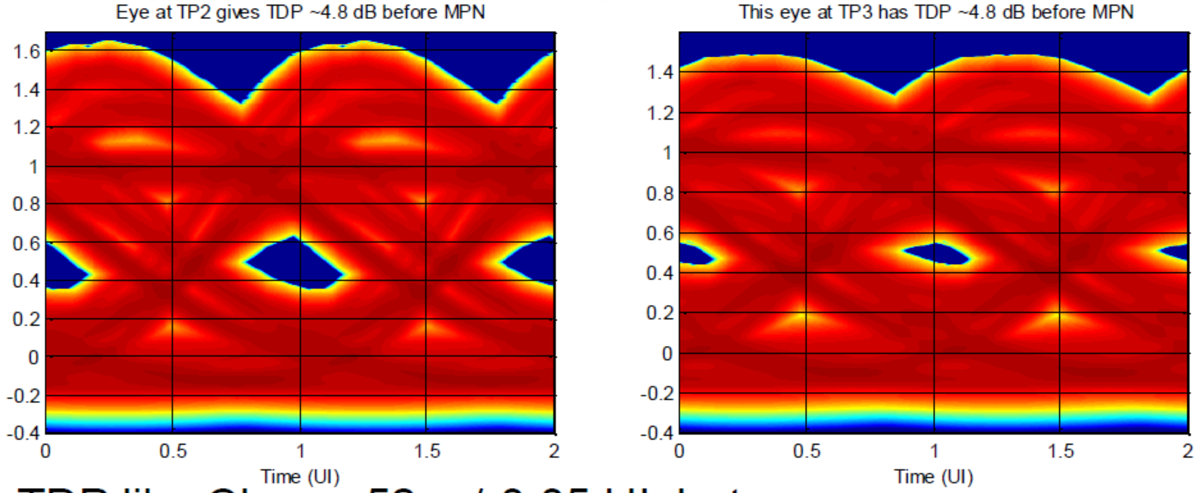
Simulated eye with TDP approaching 5 dB



- TDP like Clause 52: +/-0.05 UI, but:
  - BER = 5e-5
  - 100 m of OM4 modelled as a Gaussian filter, like spreadsheet model
  - Standard fourth-order Bessel-Thomson
- Includes ISI from chromatic dispersion but not MPN
- Is this on the cliff edge?

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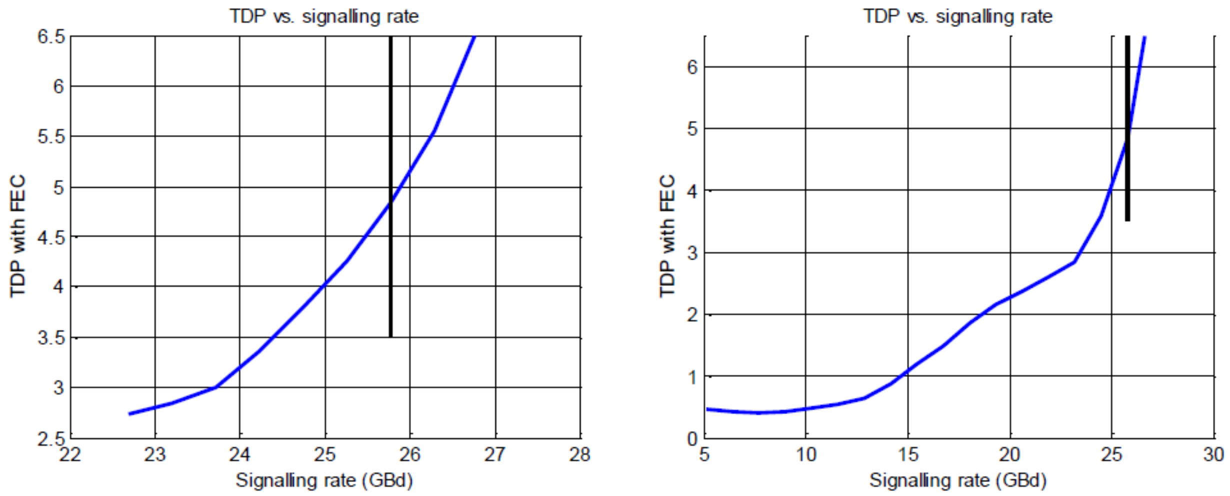
TDP vs. signalling rate



- IC bandwidths scaled with signalling rate, laser not scaled
- 2% rate change increases TDP by 0.7 dB – yes, cliff edge

- The colour scale here is not the same as previous slides
- Also we need to find an additional 0.2 dB in the budget for modal noise penalty (see dawe_04_0114_optx.pdf)
- This eye is on the "cliff edge": about to collapse. Widening the decision timing offsets has helped

- It seems that 5 dB TDP is too high anyway

Thank You