Refining TDECQ

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Introduction

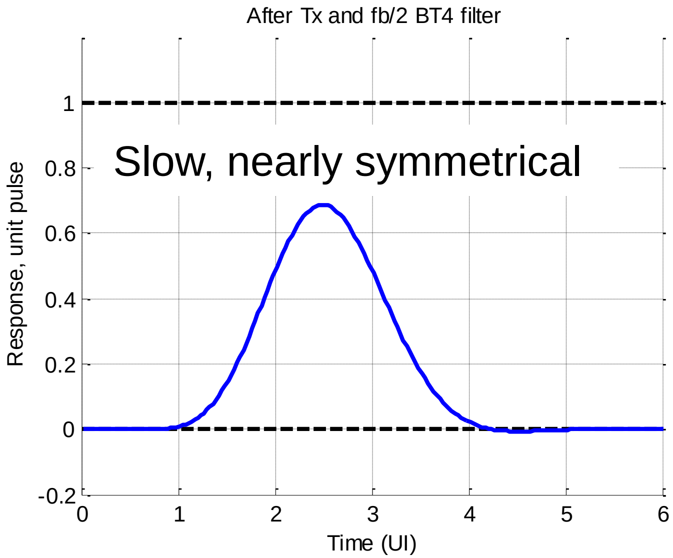
- A simple reference receiver will reduce cost in measurement (search time for TDECQ) but also in some real receiver implementations, as explained in sun_3cd_01a_0118, which showed that more than two precursor taps is not necessary
- This presentation looks at whether 0, 1 and 2 precursors are all desirable in a reference equalizer
- Also, starts to consider how to ensure transmitter quality

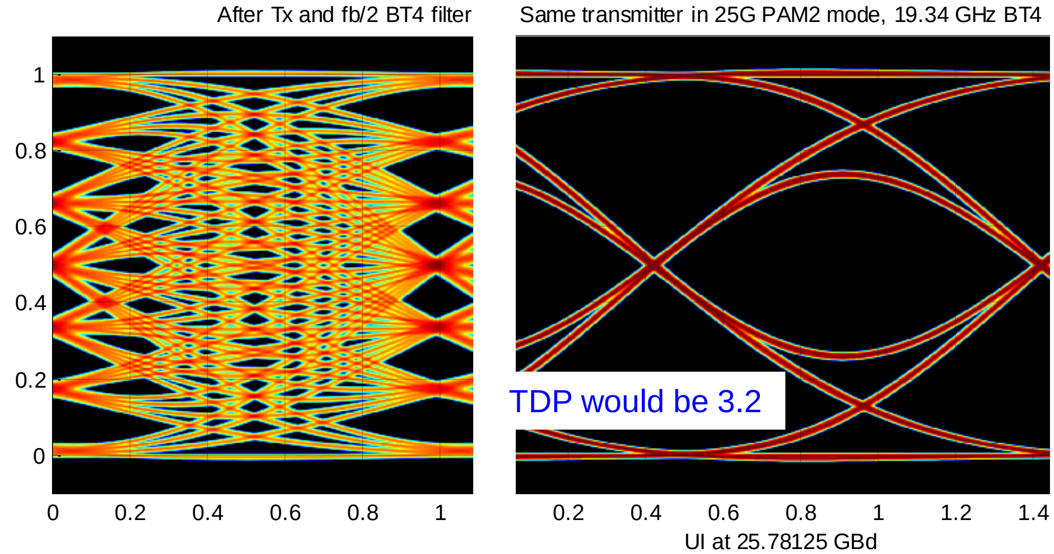
Slides 1 to 10 are the almost the same as dawe_022818_3cd_adhoc

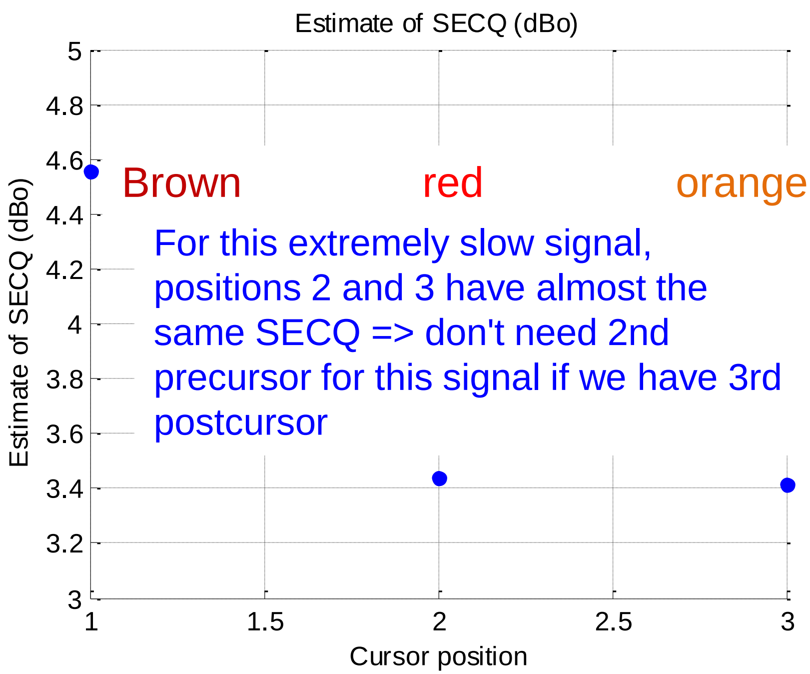
Slowest time-symmetric SMF signal

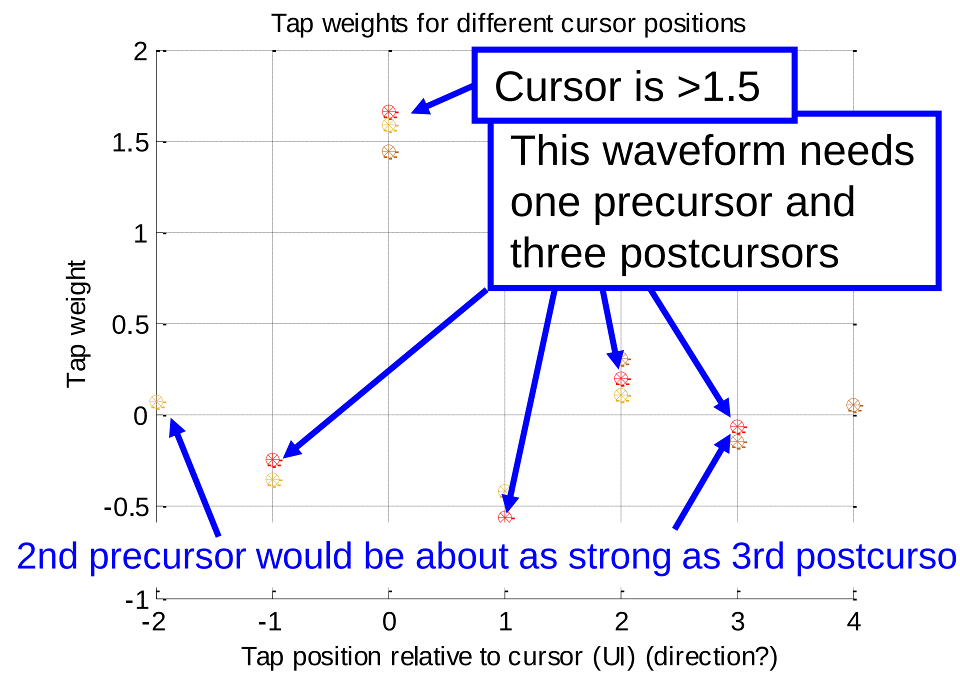
- A simulated signal is created with a fourth-order Bessel-Thomson filter, bandwidth chosen to set SECQ to 3.4 dB (the highest spec limit for any SMF PMD in 802.3bs or P802.3cd)
- No noise, jitter, distortion or emphasis. Any reasonable signal must be faster than this to make room for noise, jitter and distortion. This includes 100G/s/lane signals, relative to the unit interval
- If this were a 100GBASE-LR4 signal, its TDP would be 3.2 dB: too slow (spec is 2.2 dB for 100GBASE-LR4, 2.5 dB for 100GBASE-ER4)
  - So we expect that real 50G/s/lane signals will be faster than this anyway
- Most other possible responses (filter types) would have a relatively faster attack and slower decay than the time-symmetric signal
  - See later for discussion of chromatic and modal dispersion

BT4 filter as Tx, as slow as allowed for SMF

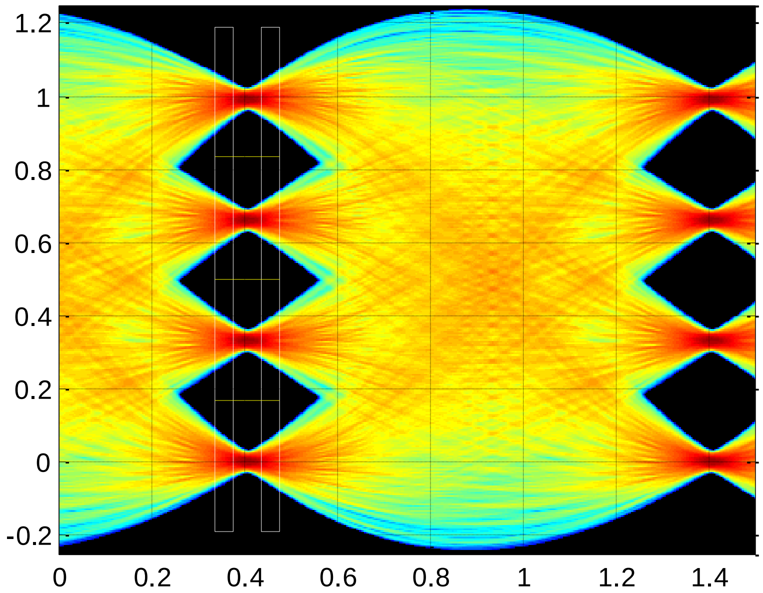


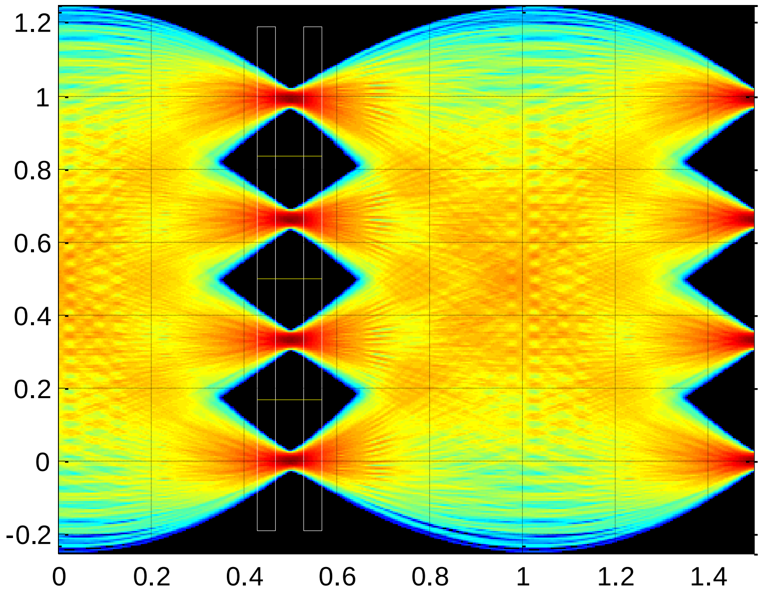






Eyes after reference equalizer





Cursor at position 2 Cursor at position 3

Real signals are faster than this and not so clean

Corrected histogram windows; showing thresholds

Other worst-case waveforms

- A first order filter (faster attack than decay) gave the same conclusion
- Even slower waveforms with moderate 2-tap Tx FFE – same conclusion

- Would any of these waveforms have been acceptable with the original T/2-spaced equalizer?

Chromatic dispersion?

- Could a signal be that slow AND have enough chirp on some edges (not necessarily rising vs. falling), enough to make it significantly asymmetric after the fb/2 BT4 filter? A DML?
- High chirp goes with fast edges, so such a transmitter would have a high chromatic dispersion penalty if used in a PAM2, non-equalised link
- Reasonable, or a corner case the standard and the receivers don't need to go out of their way to support?

What about MMF, with its higher TDECQ limit?

- Also, modal dispersion
  - Contained by the fibre and modal launch specs
  - Modal bandwidth is significantly more than the reference bandwidth in the receiver
- Not addressed here – for further study

What about the opposite: fast but "dirty" signals?

- While (OMA-TDECQ) controls the net useful signal strength,
- TDECQ doesn't control the net signal quality
- Conceptually – TDECQ with C_{eq} fixed to a constant, would
- We need something to ensure that the small opening in the eye is a reasonable proportion of the signal size – to do the job of the VEC spec in C2M

- There is a related problem with strongly over-emphasised signals that would require "inverting" FFE settings that no copper equalizer would need
- A simple way to mitigate this problem is a minimum cursor tap weight spec, e.g. 0.9

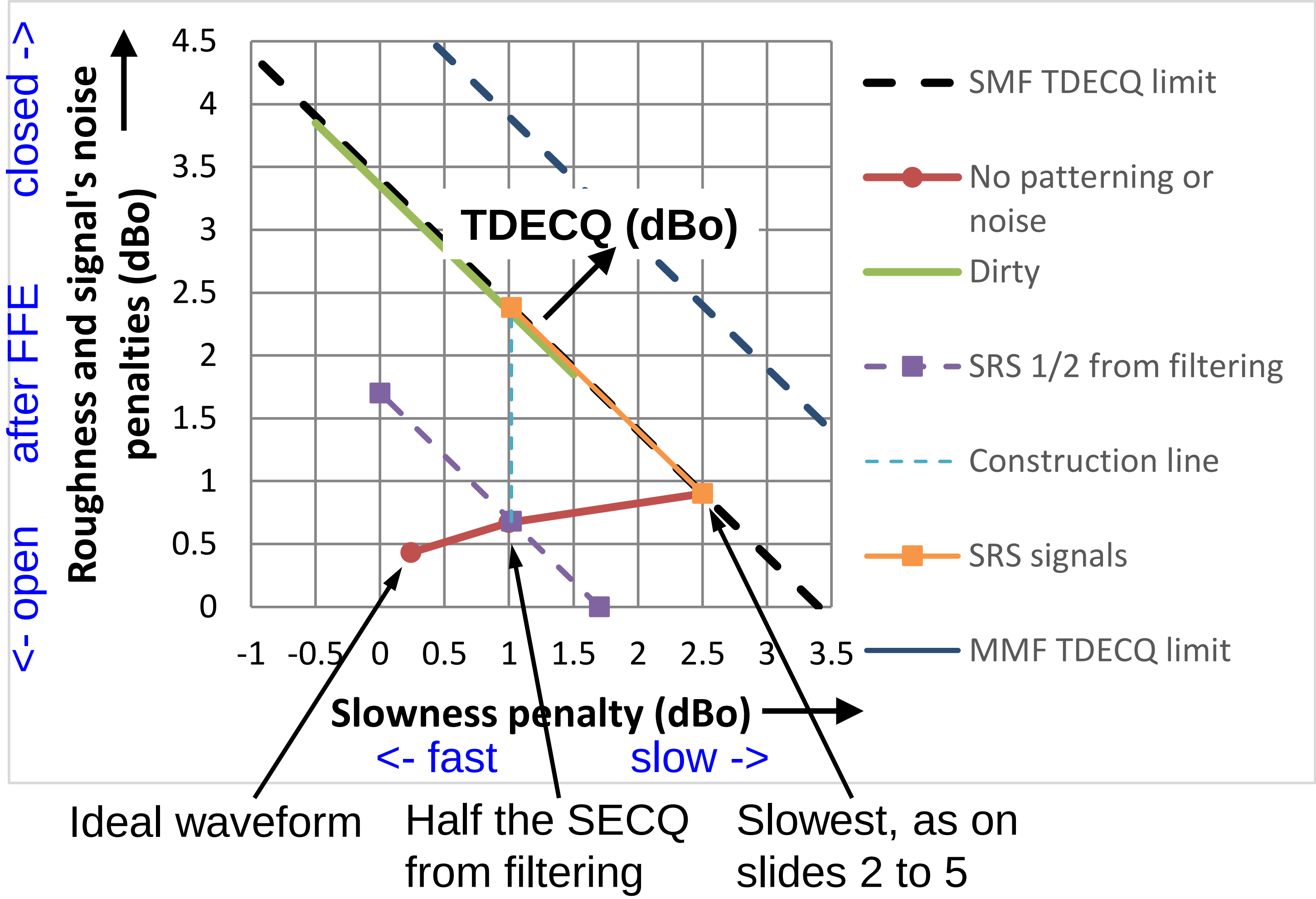
Conclusion so far

- The reference equalizer for SMF should not include the case with two precursor taps (cursor in third position) because it would be expensive to provide in some real equalizer architectures, would add search time to TDECQ measurement, and does not benefit reasonable waveforms
  - There might be some super-slow waveforms (which would have failed e.g. 100GBASE-LR4) that might get slightly worse TDECQ; marking them down will help the standard and real receivers

Other maximum-TDECQ signals

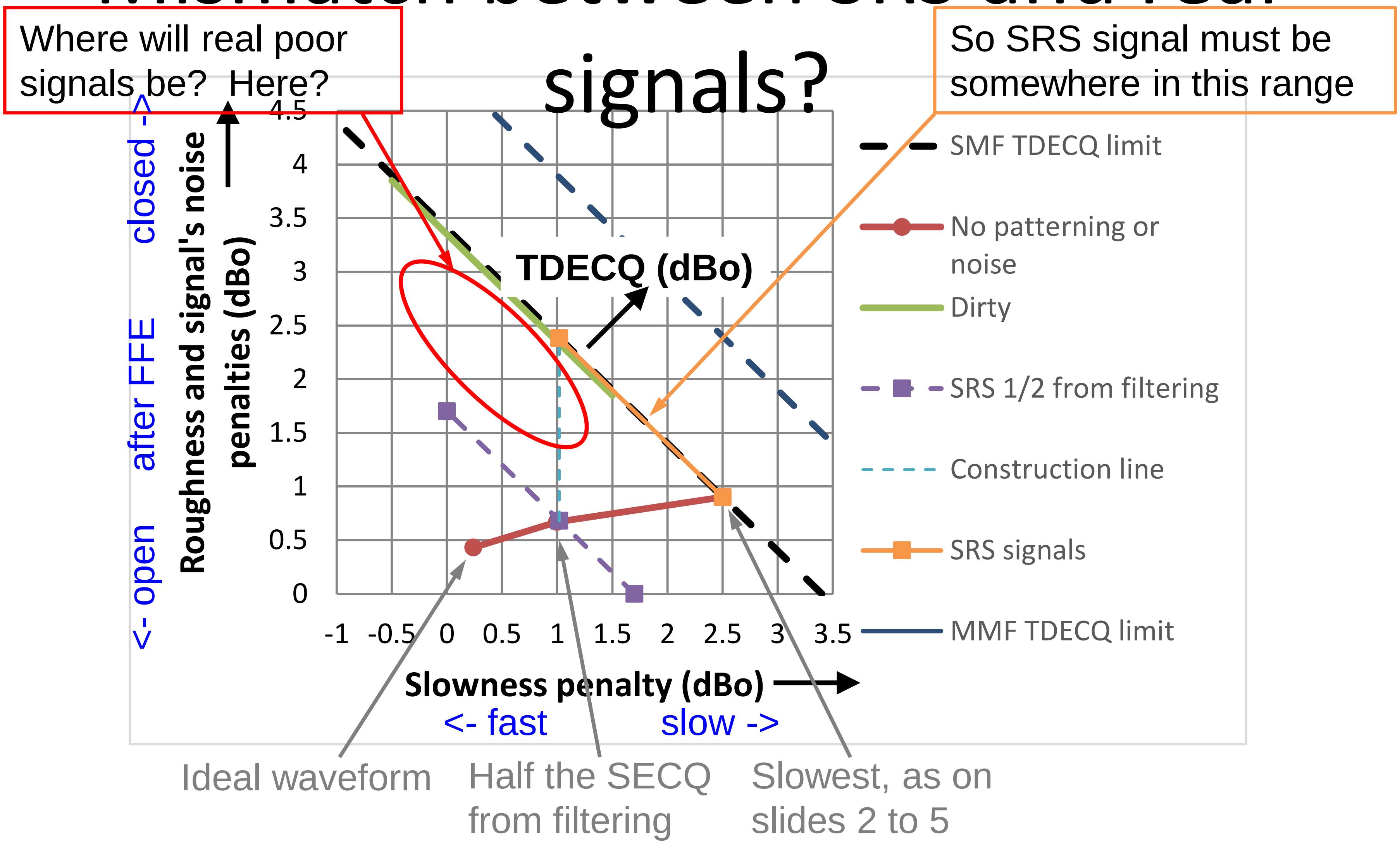
- Next, looking at the variety of bad signals and considering where the limits of compliance should be

TDECQ map



<- open after FFE closed ->
Roughness and signal's noise penalties (dBo)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
TDECQ (dBo)
Slowness penalty (dBo)
<- fast
slow ->
SMF TDECQ limit
No patterning or noise
Dirty
SRS 1/2 from filtering
Construction line
SRS signals
MMF TDECQ limit
Ideal waveform
Half the SECQ from filtering
Slowest, as on slides 2 to 5

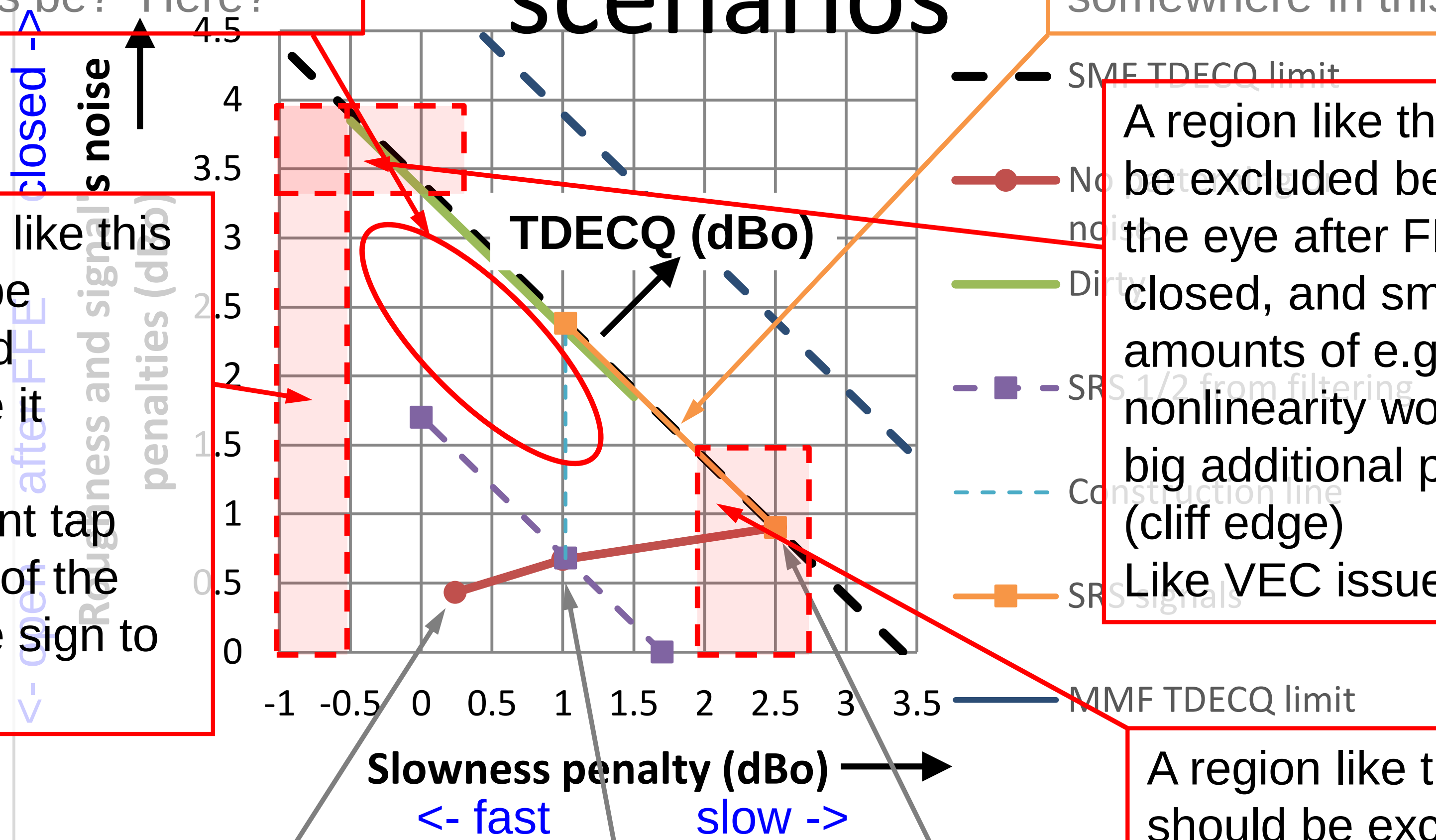
Mismatch between SRS and real signals?



Don't support unrealistic bad scenarios

Where will real poor signals be? Here?

So SRS signal must be somewhere in this range



A region like this should be excluded because it requires significant tap weights of the opposite sign to normal

A region like this should be excluded because the eye after FFE is very closed, and small amounts of e.g. nonlinearity would cause big additional penalties (cliff edge)
Like VEC issue in C2M

A region like this should be excluded because it requires strong tap weights not useful in practice

Ideal waveform

Half the SECQ from filtering

Slowest, as on slides 2 to 5

"Exclusion" could be by giving signals in the red boxes worse TDECQ scores, or by "hard" pass-fail rules

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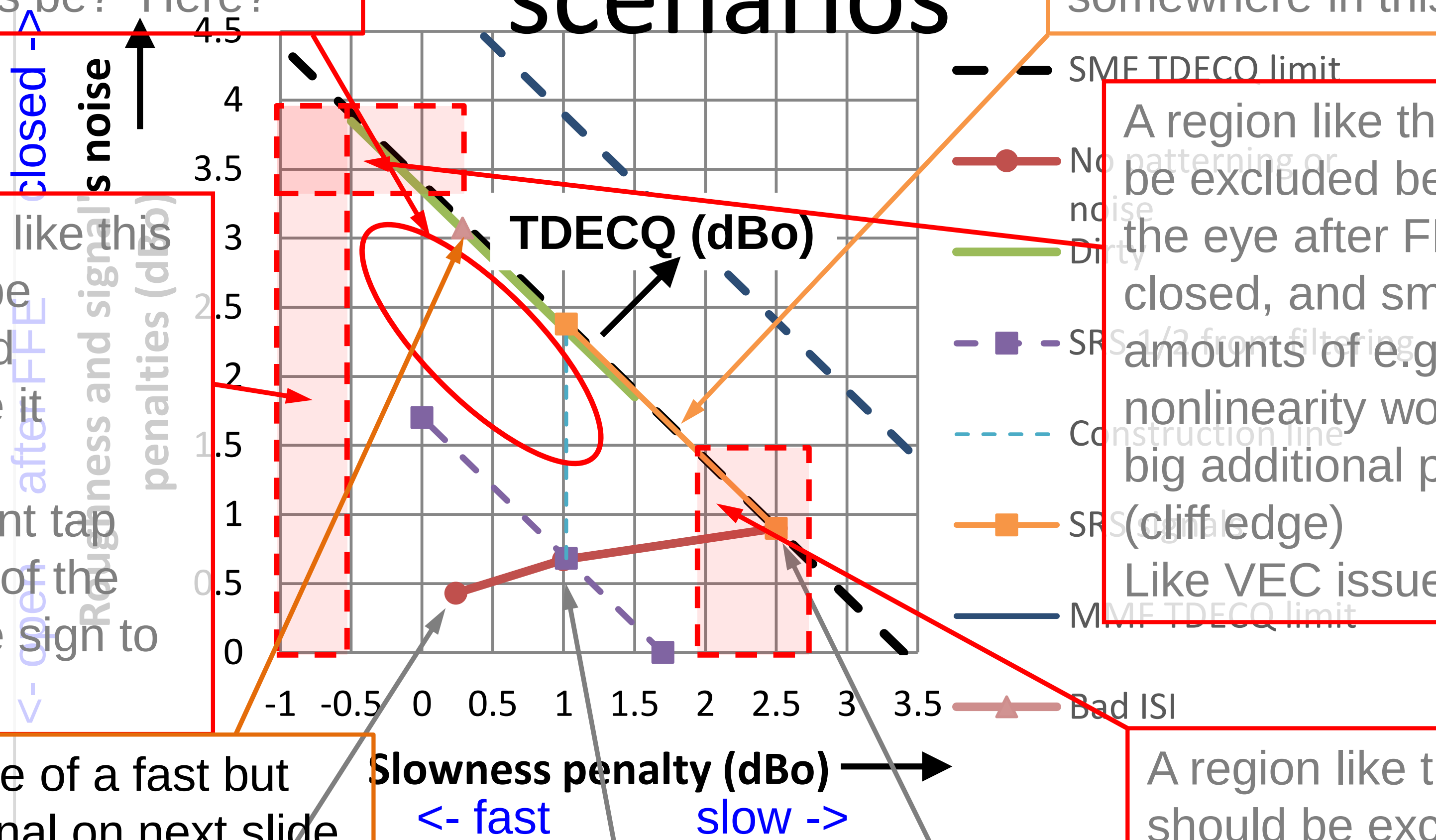

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Example of a fast but bad signal on next slide

Ideal waveform

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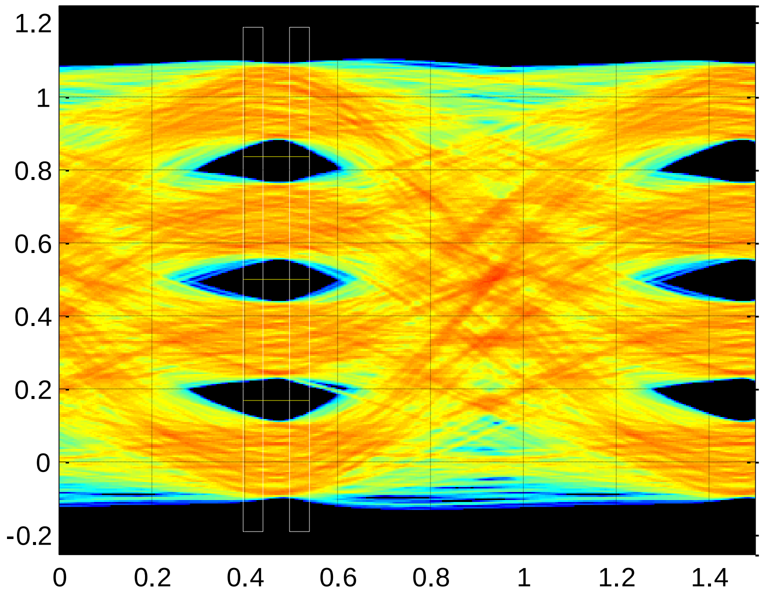
A tidy-looking fast bad eye after reference equalizer



Like the earlier bad signal, this one needs only one precursor tap

- Compare slide 5 – vertical eye opening is half as much here, although both signals have same SECQ, 3.4 dB
- Worse signals are allowed by Draft 3.1 (up and to the left on the map), even for SMF
- Worse again for MMF where the draft TDECQ limit is 4.9 dB