TDECQ changes and consequent spec limits

802.3bs SMF ad hoc, 27th June 2017

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Intro: Link budget, OMA_{outer} and TDECQ

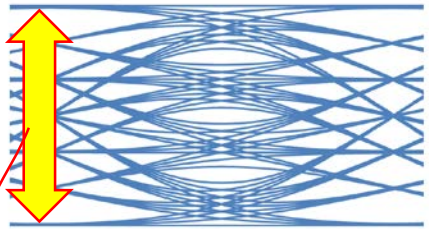
- Power budget (Tx output minus Rx stressed sensitivity) written in terms of OMA_{outer}
- TDECQ connects OMA_{outer} specs and transmitter and dispersion penalties to ensure that the OMA link budget closes
- SECQ (used to calibrate the SRS test source) is the same basic measurement as TDECQ but without the worst case channel
- SECQ connects expected transmitter performance over a worst case channel to the stressed receiver sensitivity test

Changes to TDECQ in 802.3bs draft 3.2

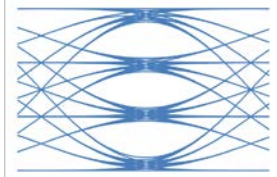
- Reference EQ replaced with 5 tap T spaced FFE and a lower (~Nyquist) bandwidth reference receiver
  - More representative of expected 50Gb/s and 100Gb/s PAM4 receivers with digital EQ implementations
    - The lower bandwidth reference receiver can be thought of as anti-aliasing filter - it filters high frequency noise and signal components which are not addressable with a T spaced EQ
  - Precise roll off is not critically important
- The changes to TDECQ introduced in draft 3.2 will increase TDECQ values (~0.9 dB) for the same transmitter waveforms. This should be accommodated by:
  - an appropriate increase of TDECQ and SECQ specs for each PMD
  - a similar decrease in the OMA_{outer} minus TDECQ spec
    - so that min Tx OMA_{outer} at max TDECQ is the same as draft 3.1
  - no changes to the OMA_{outer} spec for SRS test
    - A decrease in the informative receiver sensitivity (unstressed receiver sensitivity)

TDECQ old TDECQ new

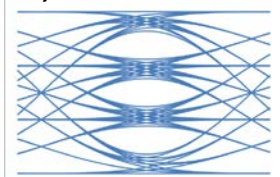
Just compliant
Tx waveform



Equalized eye
5xT/2, 0.75xBaud rate



Equalized eye
5xT, 0.5xBaud rate

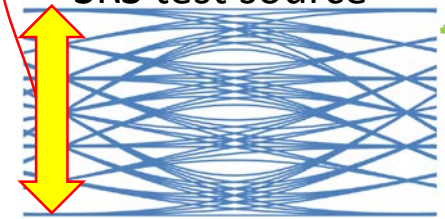


Tx OMA_{outer}

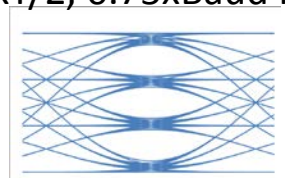
Changing the TDECQ methodology doesn't change the transmitter characteristics, it's the same transmitter, but it's TDECQ is measured as larger for D3.2 TDECQ

SRS OMA_{outer}

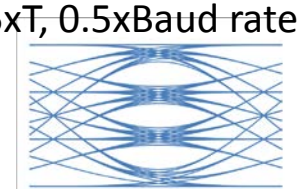
SRS test source



Calibrated SRS test eye
5xT/2, 0.75xBaud rate

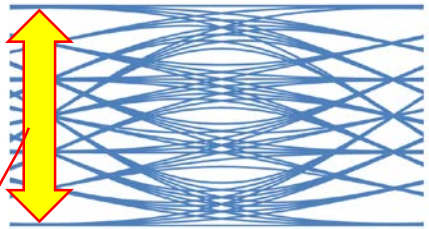


Calibrated SRS test eye
5xT, 0.5xBaud rate



TDECQ old TDECQ new

Just compliant
Tx waveform



Equalized eye
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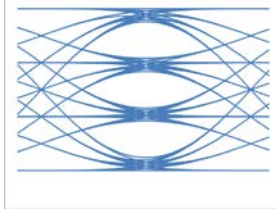
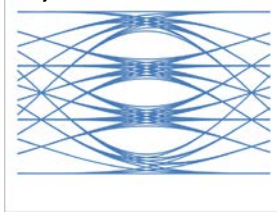


Equalized eye
5xT, 0.5xBaud rate



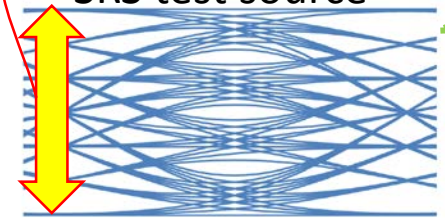
Tx OMA_{outer}

Changing the TDECQ methodology doesn't change the transmitter characteristics, it's the same transmitter, but it's TDECQ is measured as larger for D3.2 TDECQ

*The change to SECQ doesn't change the stress applied to the SRS test source, but it's SECQ is **measured** as larger for the D3.2 SECQ.*

SRS OMA_{outer}

SRS test source



Calibrated SRS test eye
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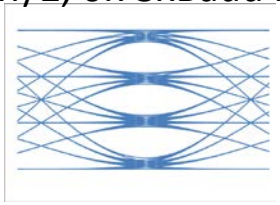

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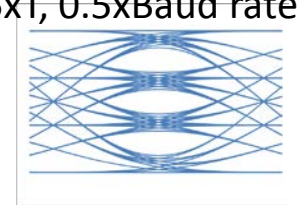
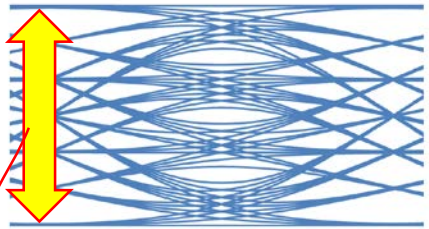


TDECQ old TDECQ new

Just compliant
Tx waveform



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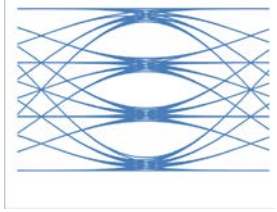

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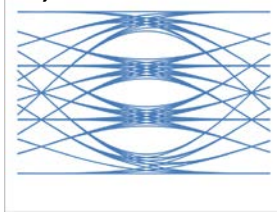


Tx OMA_{outer}

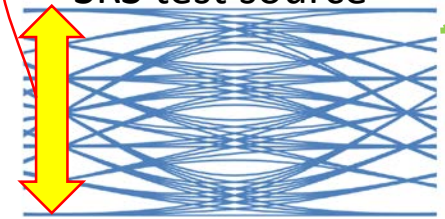
*Changing the TDECQ methodology doesn't change the transmitter characteristics, it's the same transmitter, but it's TDECQ is **measured** as larger for D3.2 TDECQ.*

The change to SECQ doesn't change the stress applied to the SRS test source, but it's SECQ is measured as larger for the D3.2 SECQ.

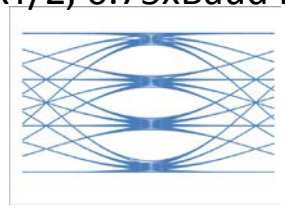
A specific receiver implementation isn't changed by the D3.2 SECQ - it's still the same receiver. If it could equalize and close the link with the SRS test source calibrated with D3.1 SECQ, it will still close link with D3.2 SECQ, without needing to change the input OMA to the receiver.

SRS OMA_{outer}

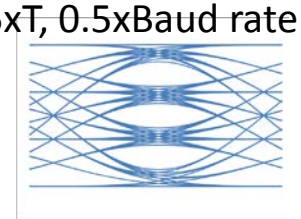
SRS test source



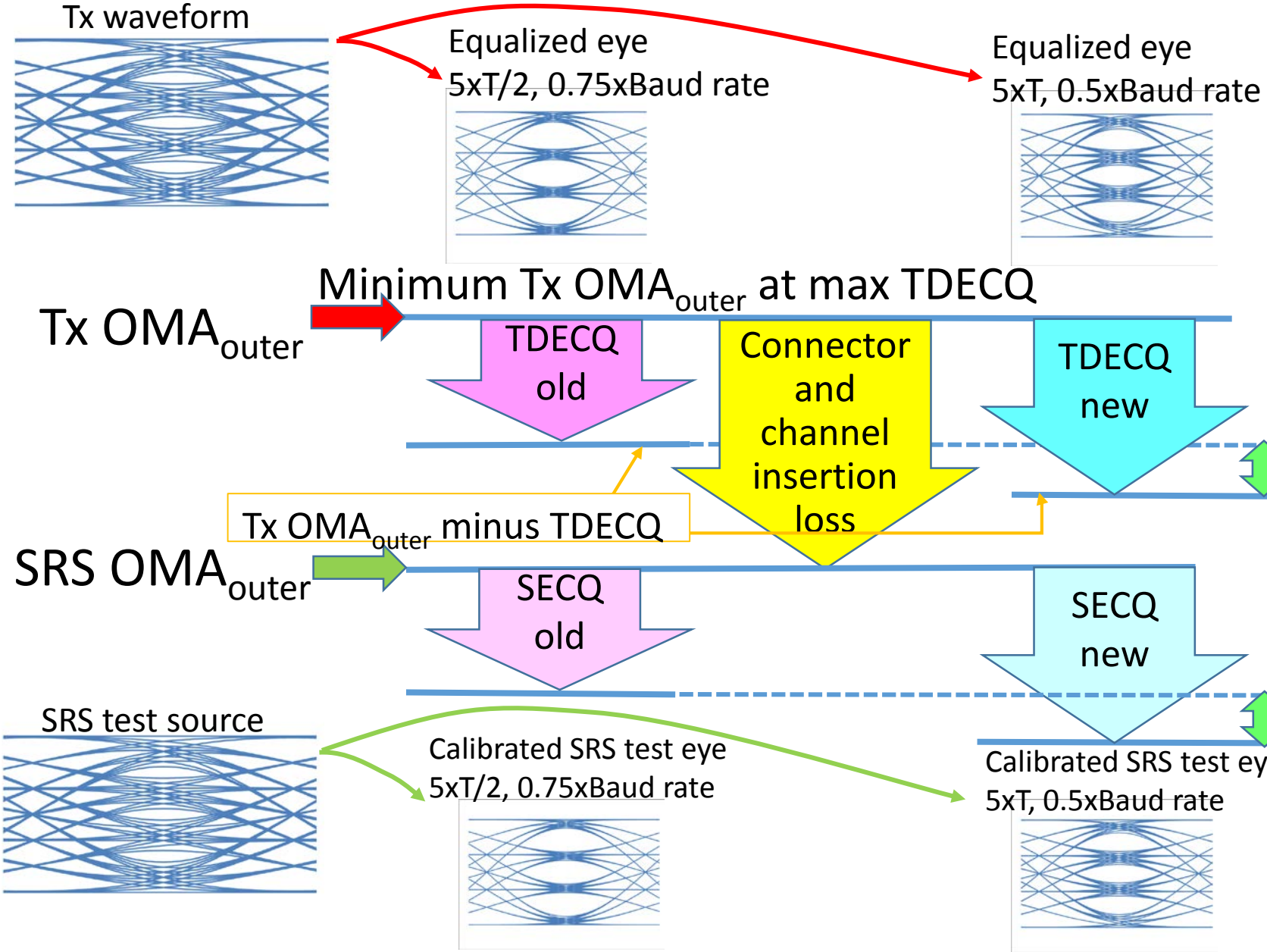
Calibrated SRS test eye
5xT/2, 0.75xBaud rate



Calibrated SRS test eye
5xT, 0.5xBaud rate



TDECQ old TDECQ new



Why no change to the SRS OMA test limit?

- Changing the TDECQ methodology doesn't change the transmitter characteristics, it's the same transmitter, but the penalty is *measured* as larger.
- Likewise, the change in SECQ wouldn't change the stress applied to the SRS test source, but the applied stress would be *measured* as larger for the D3.2 version of SECQ.
- And finally a specific receiver implementation isn't changed by the D3.2 SECQ - it's still the same receiver. If it could equalize and close the link with the SRS test source with D3.1 SECQ , it will still close link with D3.2 SECQ, without needing to change the input OMA to the receiver.

Unstressed receiver sensitivity - notes

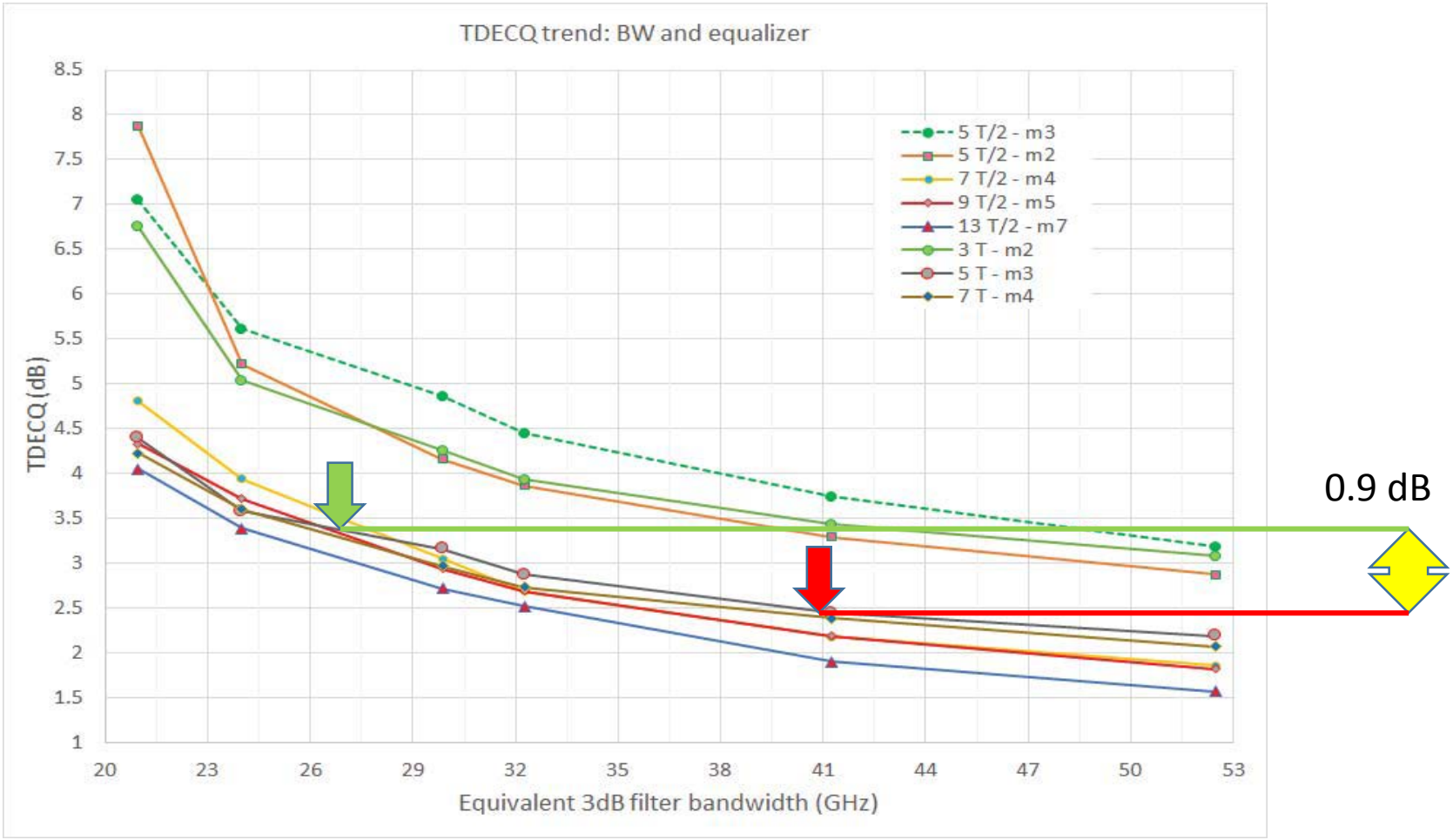
- The OMA_{outer} spec value for receiver sensitivity is never seen with compliant transmitters and links.
- Expectations for sensitivity for an ideal receiver with a bandwidth of 50% and 75% of symbol rate:
  - For constant input referred noise density, reducing receiver noise bandwidth from 75% to 50% of symbol rate would reduce total RMS noise by 0.9 dB.
- Test transmitter for measuring receiver sensitivity
    - TDECQ aims to avoid the need for a reference transmitter, but it seems likely that some will still want to measure “unstressed receiver sensitivity” for the nice fuzzy warm feeling it gives ☺
  - One way to arrive at an equivalent “unstressed receiver sensitivity” is to subtract the measured SECQ of the test transmitter from the receiver sensitivity measured with it.
  - The changes to D3.2, to the reference EQ and Rx bandwidth for SECQ, increase SECQ values by 0.9 dB.
  - So equivalent unstressed receiver sensitivity for a particular receiver should decrease (compared to D3.1) for D3.2 SECQ.

Summary – example for clause 121

- For the same transmitter waveforms, the change from D3.1 to D3.2 to the TDECQ reference EQ and Rx bandwidth will increase TDECQ values by 0.9 dB.
- For clause 121 (200GBASE-DR4) this could be accommodated by:
  - An increase of 0.9 dB for TDECQ and SECQ spec
  - A decrease of 0.9 dB for "OMA_{outer} minus TDECQ spec
    - so that min Tx OMA_{outer} at max TDECQ is the same as draft 3.1
    - no change to the OMA_{outer} spec for SRS test
    - change note b (Table 121-6) to say "Even for TDECQ < 1.9 dB, the OMA_{outer} (min) must exceed this value."
  - A decrease of 0.9 dB in the informative "Receiver sensitivity" spec
    - And add to note c (Table 121-7): "Receiver sensitivity is defined for a transmitter with SECQ = 0 dB"
    - Or leave the informative receiver sensitivity spec value unchanged
      - And add to note c (Table 121-7): "Receiver sensitivity is defined for a transmitter with SECQ = 0.9 dB"
    - Or remove the informative receiver sensitivity spec completely
  - An increase of 0.9 dB in "Power budget (for max TDECQ)" in Table 121-8
  - An increase of 0.9 dB in "Allocation for penalties (for max TDECQ)" in Table 121-8

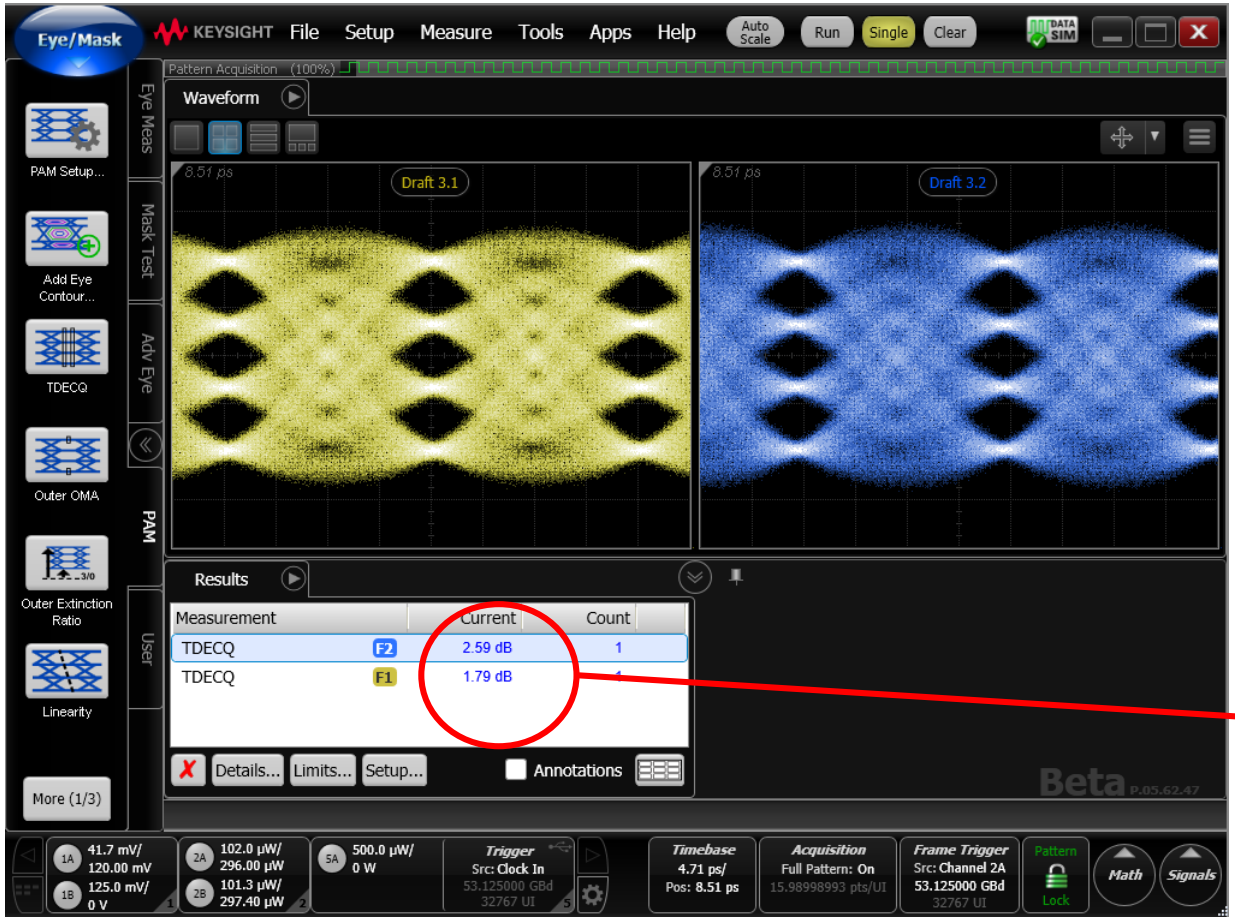
Back up

TDECQ plots from Mazzini_01a_0517_smf



Example simulated waveforms from Keysight

Result of simulated waveforms with a modest amount of ISI and RIN included. The increase of TDECQ from draft 3.1 to draft 3.2 is about 0.8 dB for this configuration.



0.8 dB difference

BER plots from Mazzini_01a_0517_smf