TDECQ versus real receiver slope.

Authors:
Marco Mazzini – Cisco
Matt Traverso – Cisco
Jonathan King – Finisar
Marlin Viss - Keysight

Background

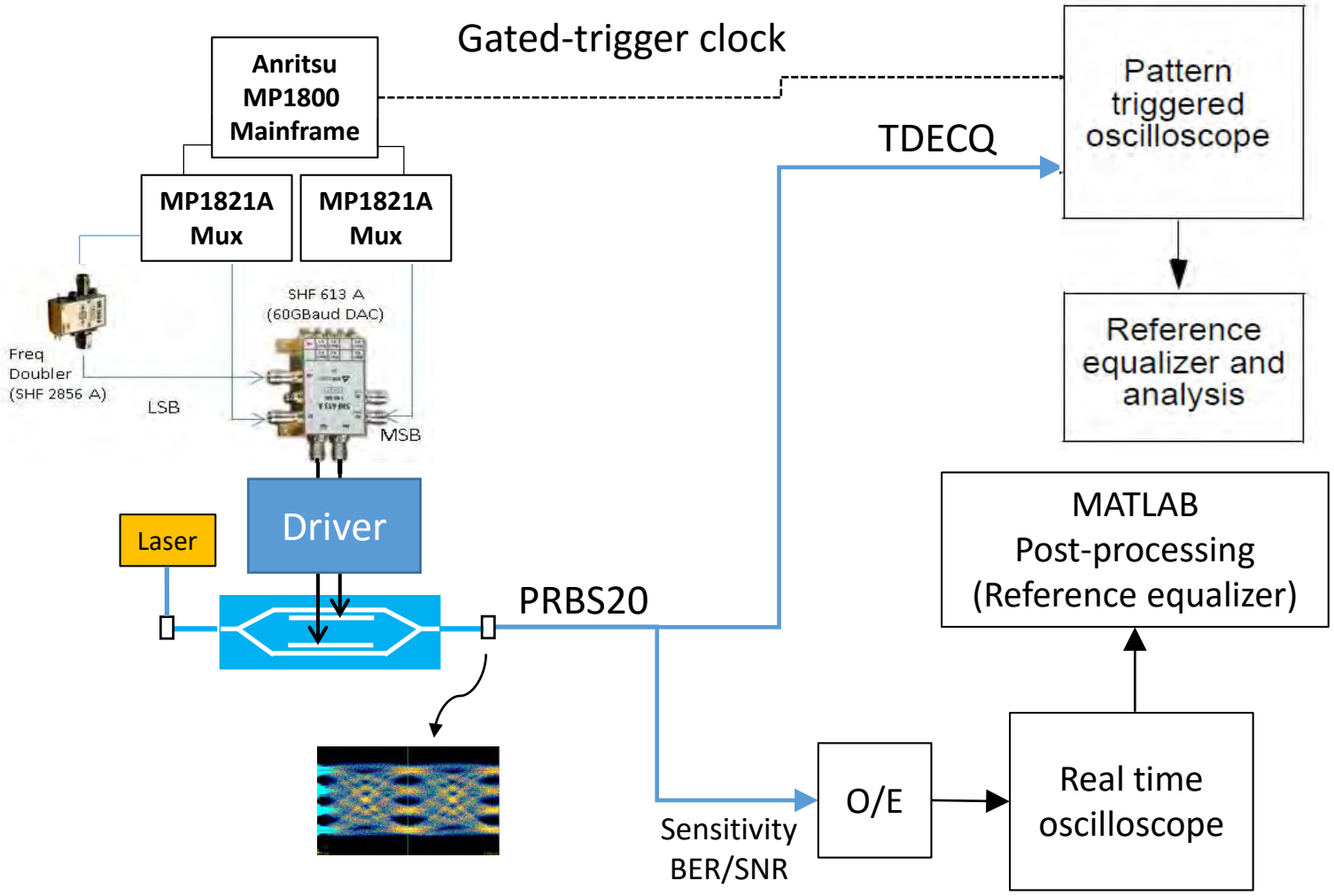
- Transmitter and dispersion eye closure (TDECQ) setup and methods are defined into 802.3bs.

- Recent agreement managed the concept of ideal TX with SECQ ≠ 0, as well as TDECQ slope versus reference receiver bandwidth.

- Here we would like also to focus the attention about TDECQ versus real receiver slope.
  - Into current 802.3cd/bs link budgets, 1dB TDECQ corresponds to 1dB OMAouter sensitivity.
  - Some previous contributions however, shown closed links with very high TDECQ transmitters.
  - For this we wanted to investigate with our set-up whenever the 1dB to 1dB relationship is true.

53GBaud PAM 4 TX/RX : sensitivity and TDECQ set-up.

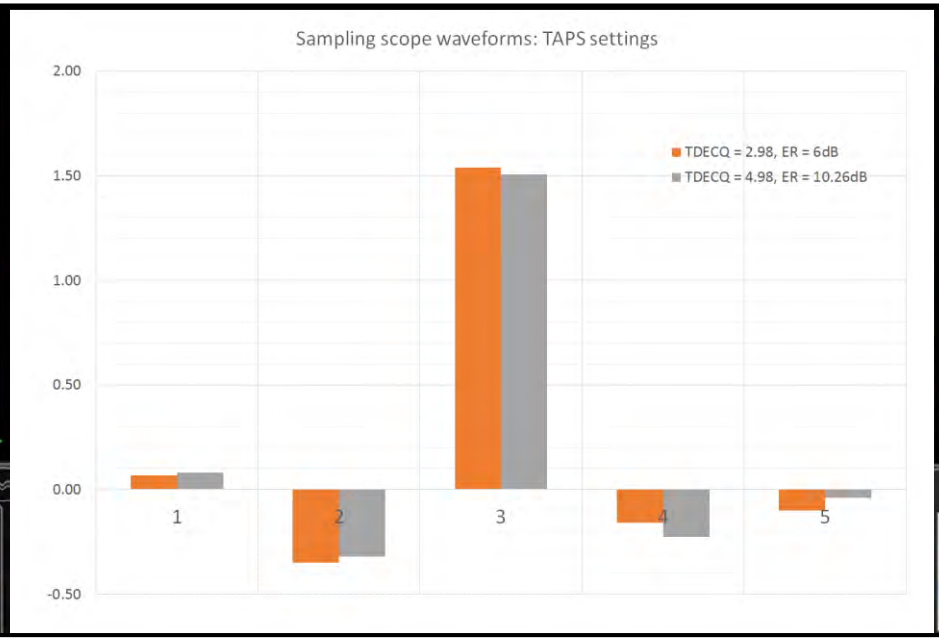
1. Different Driver settings allow to change over different TX characteristics.
2. The TX PRBS20 pattern is given to both sampling scope and real time scope (after O/E conversion).
3. The same reference 5T receiver equalizer is used when run the TDECQ algorithm and the sensitivity test.
4. We then calculated delta TDECQ and delta sensitivity results over two different TX waveforms.



Notes:

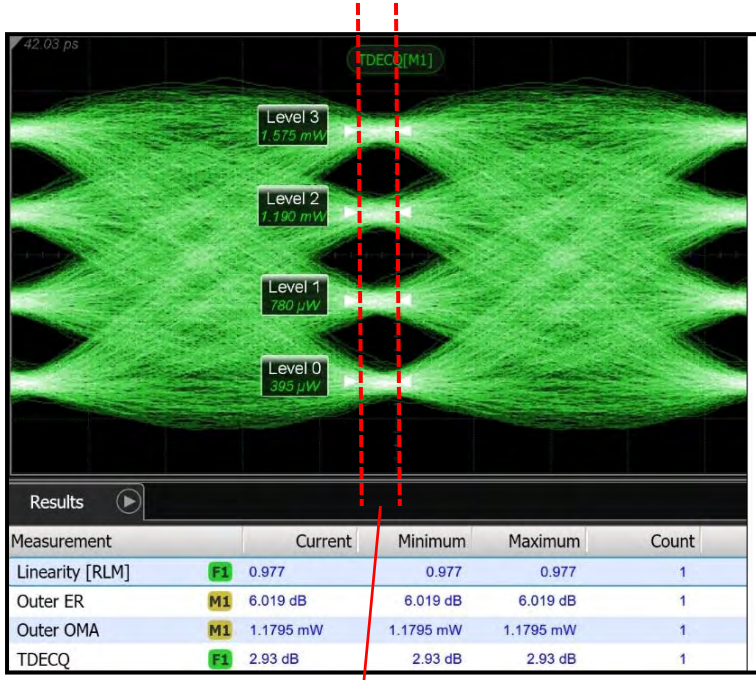
- Not currently able to generate SSPRQ pattern on our set-up.
- TDECQ algorithm applied with no fiber.
- Overall O/E BW of ≈30GHz.

Transmitter results over two reference settings: PRBS20.



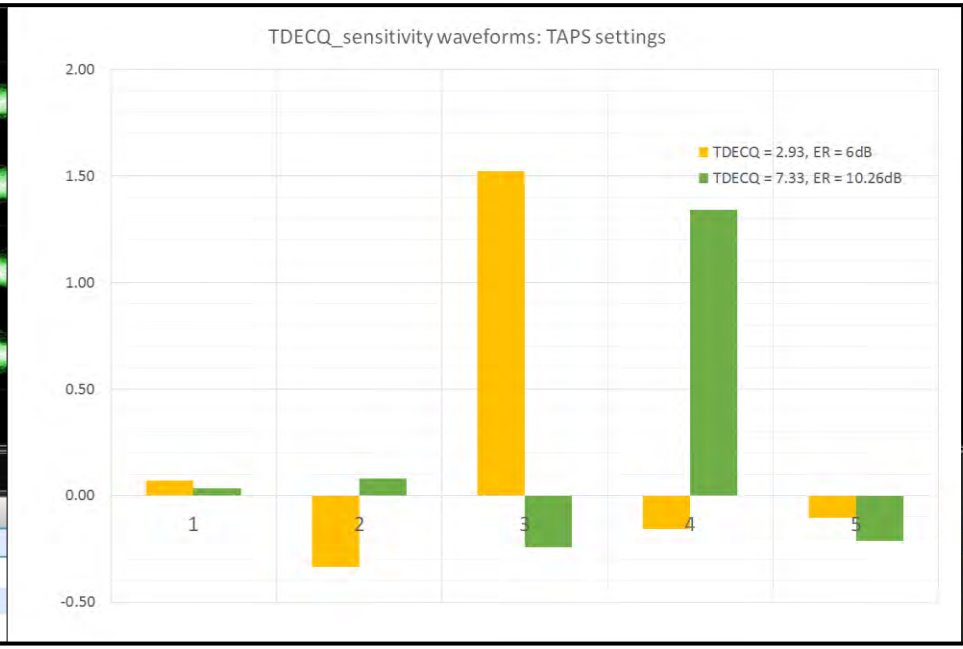
Two PRBS20 waveforms were aquired with Keysight DCA-M N1092A scope, then TDECQ algorithm (latest beta P.05.70.614 SW) was run on both of them.
The reference equalizer return similar taps weights, the 6dB transmitter show better TDECQ (2.98dB) than the 10.26dB transmitter (TDECQ = 4.98dB).

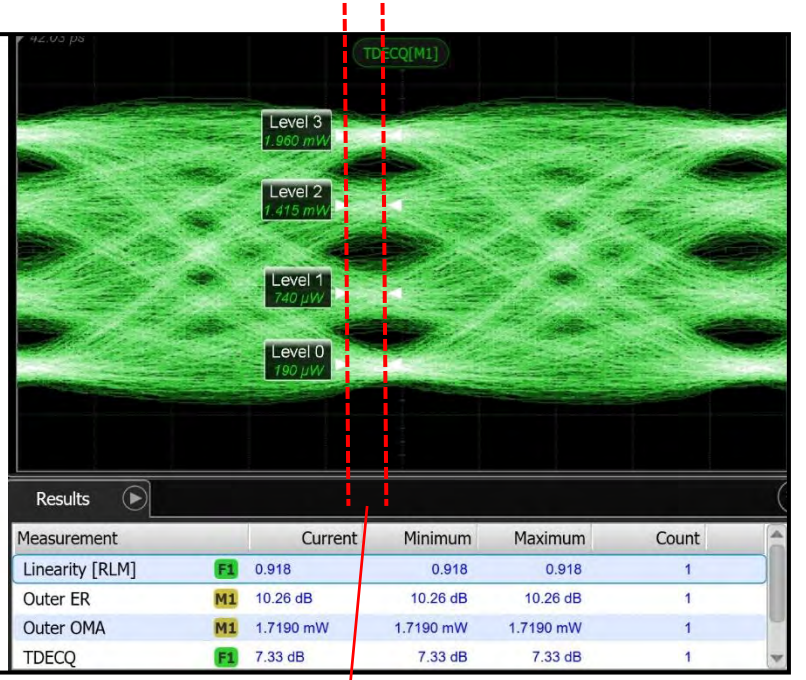
Transmitter results over two reference settings: PRBS11.



Results

Measurement		Current	Minimum	Maximum	Count
Linearity [RLM]	F1	0.977	0.977	0.977	1
Outer ER	M1	6.019 dB	6.019 dB	6.019 dB	1
Outer OMA	M1	1.1795 mW	1.1795 mW	1.1795 mW	1
TDECQ	F1	2.93 dB	2.93 dB	2.93 dB	1





Results

Measurement		Current	Minimum	Maximum	Count
Linearity [RLM]	F1	0.918	0.918	0.918	1
Outer ER	M1	10.26 dB	10.26 dB	10.26 dB	1
Outer OMA	M1	1.7190 mW	1.7190 mW	1.7190 mW	1
TDECQ	F1	7.33 dB	7.33 dB	7.33 dB	1

Centered vertical histogram

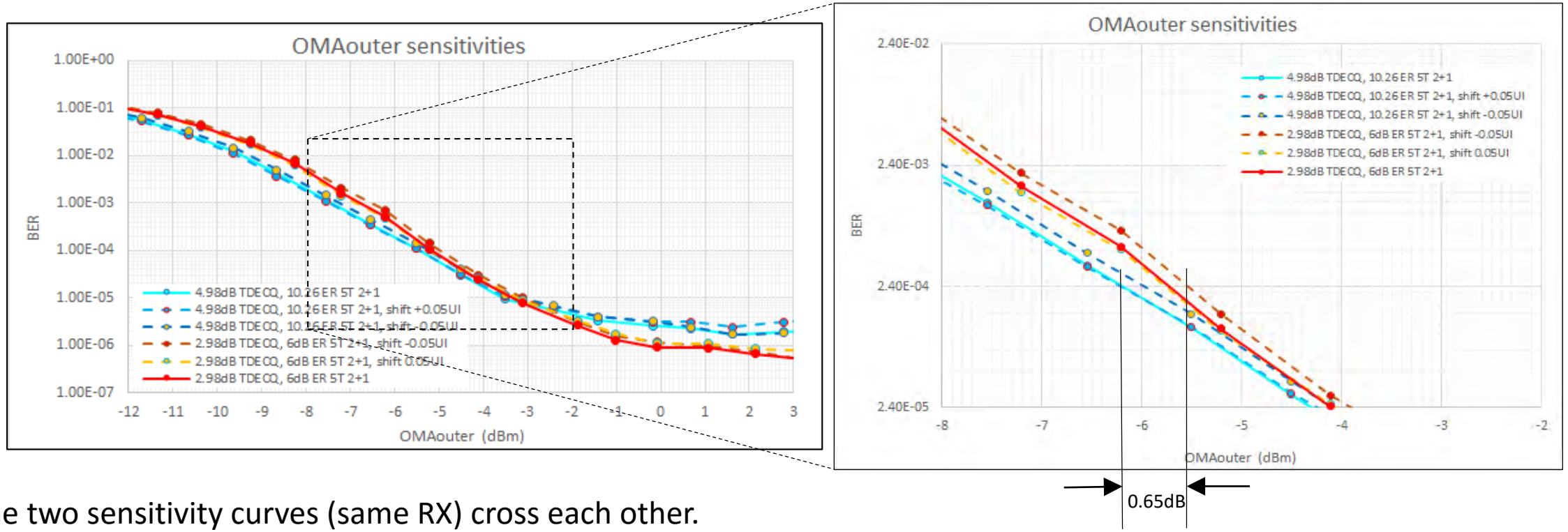
Offset vertical histogram !

Using same driver settings, PRBS11 waveforms were also aquired and then post-processed using same TDECQ algorithm.
The reference equalizer taps weights returned after iterative optimization are now different for the same two cases.

The 6dB transmitter still show similar TDECQ (2.93dB), but the 10.26dB transmitter is optimized with 3 pre-cursors taps, and exhibits TDECQ = 7.33dB.
For same TX, inner eye appear more closed by forcing the equalizer with 2 pre-cursors (returned TDECQ = 11.7dB).

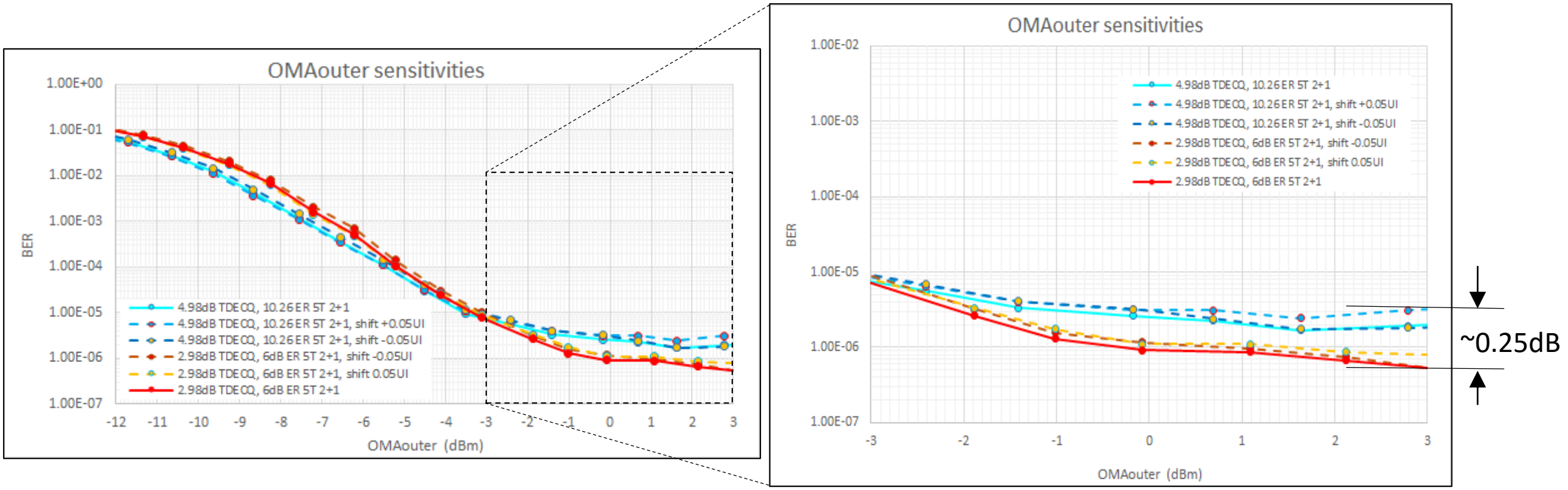
Different TDECQ: Delta Sensitivity at 2.4E-4 BER.

PRBS20 sensitivity tests were done over the same two driver settings.
The acquired waveforms were post-processed with 5T equalizer, 2 pre-cursor taps.
The sampling phase was offset by +/-0.05UI, so to have in principle similar TDECQ impact.



The two sensitivity curves (same RX) cross each other.
Over these two particular case, we observed an inversion of the trend between sensitivity and TDECQ (best TDECQ case of 2.98dB shows 0.65dB worse sensitivity than 4.98dB TDECQ case).
Next slide showing analysis done around BER ‘flat’ region.

Different TDECQ: Delta Sensitivity considering BER floor.



Assuming deltaOMA from deltaBER (deltaSNR) as deltaOMA = deltaSNR/2, we calculate around 0.25dB equivalent deltaOMA. Still assuming the delta sensitivity at floor then, also this case shows no 1:1 correlation between delta sensitivity and dTEDCQ (2dB).

Comments (1)

- Some previous contributions shown closed links with very high TDECQ transmitters.
- Current TDECQ algorithm returns considerably different values for different PRBS over same transmitter.
- Looking at our results (with slide's 3 caveats), seems there's no correlation between delta-TDECQ and delta-Sensitivity.

- *For this, we would like to ask if any other contributor can run similar experiments and verify (or not) same findings*.
- In the meanwhile, we are available to share PRBS20 waveforms used to calculate TDECQ to everyone requesting these, as well as PRBS20 sensitivities captures can be made available too.

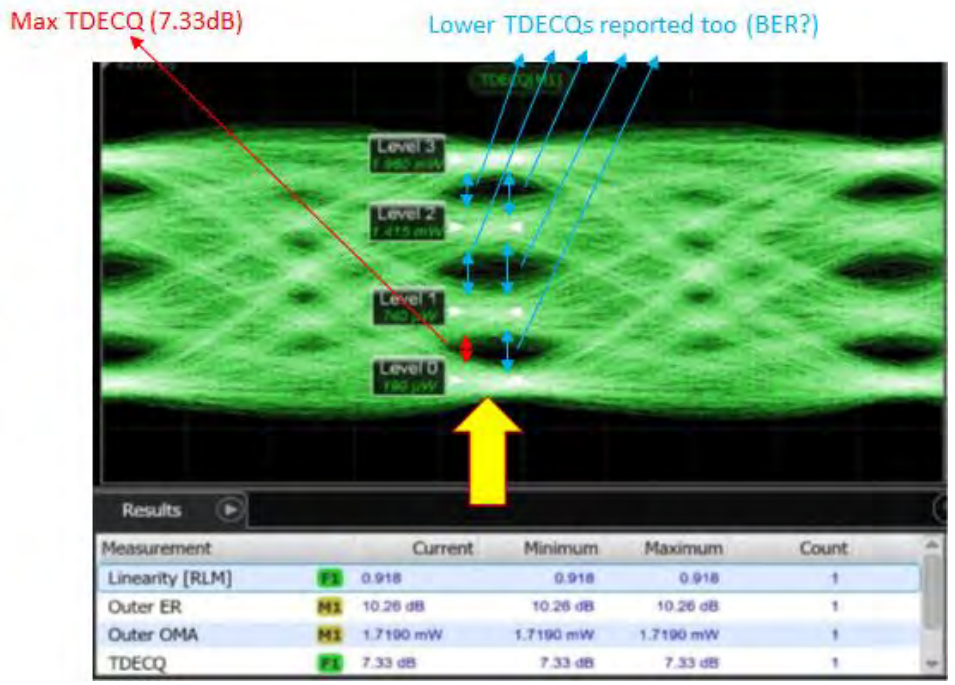
- NEXT: plan is to implement SSPRQ pattern generator.

Comments (2)

There's room to make TDECQ method more stable and helpful for developers.
Below (and Slide 5) diagram used as example for TDECQ time center eye optimization, as per Jonathan King late comment.

As further improvement, it would be good to have reported the TDECQ values of each of the six points of the eye diagram as table (UI/time, value) – <u>not meant to be added into the IEEE TDECQ method</u>.

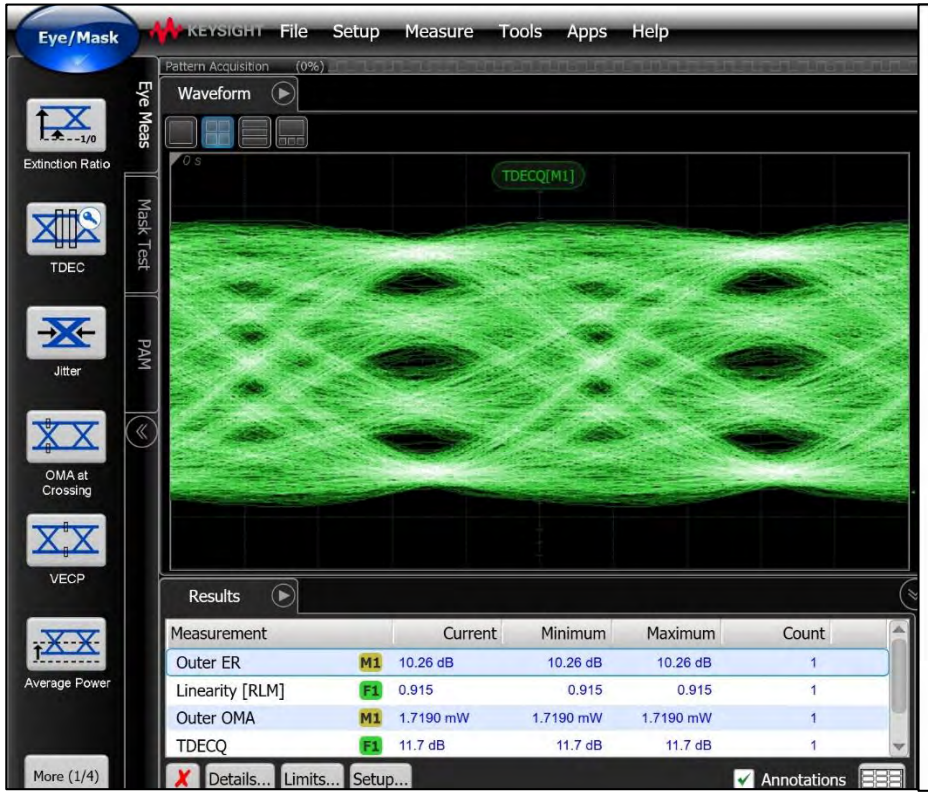
- Yellow arrow
  - shows where the time-centre of the eye is calculated to be, based on the current definition.
  - Allowing the left and right histograms to shift to the right would reduce TDECQ, and would be representative of the capabilities of T spaced and T/2 spaced equalizers.
- Red arrow showing the (guessed) position of the higher TDECQ eye/UI.
- Blue arrows showing the suggested improvement for TX eye optimization – target for developers would be to optimize towards same TDECQ values on each phase points of the three sub-eyes.

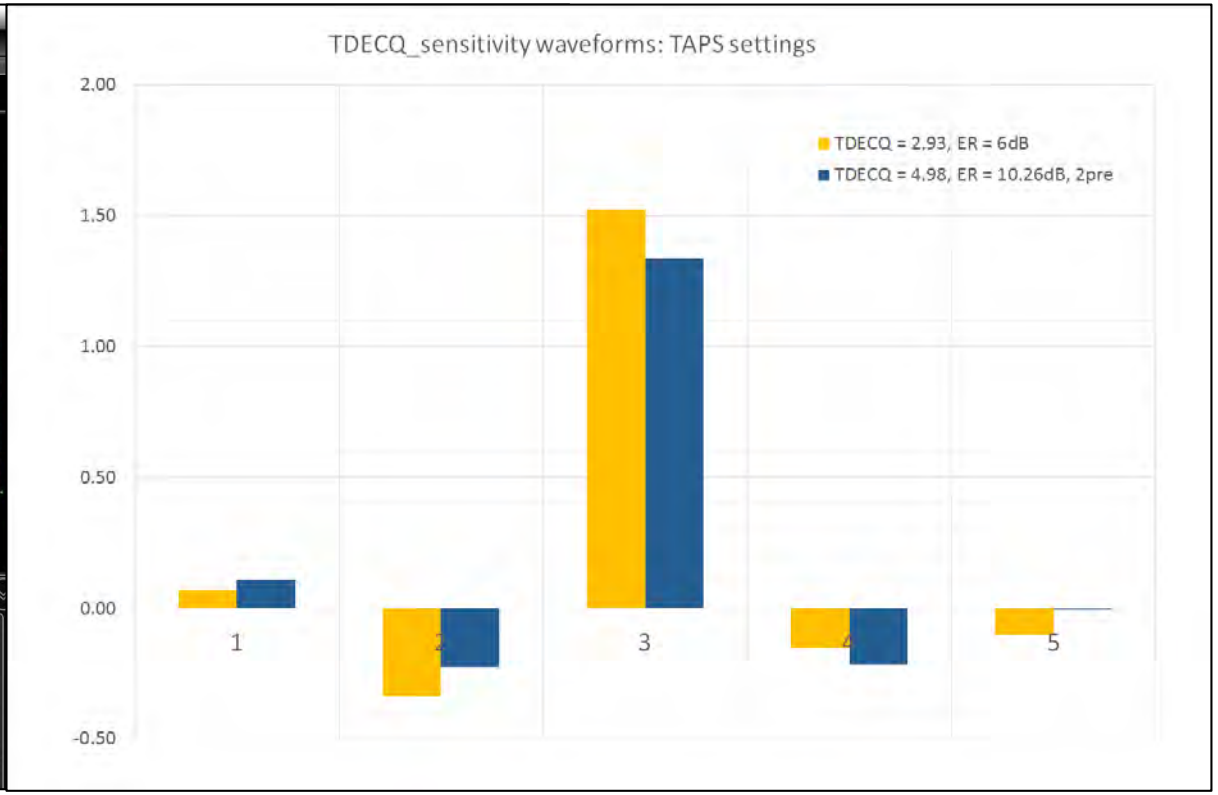


THANK YOU

BACK-UP

10.26dB transmitter optimized with 2 pre-cursors taps.

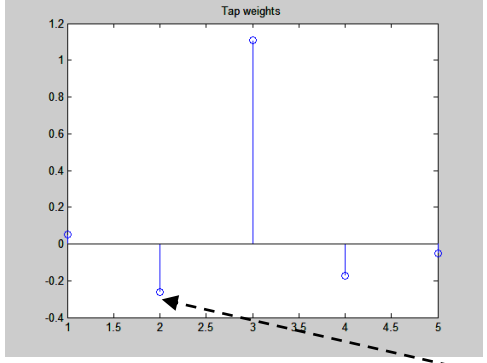




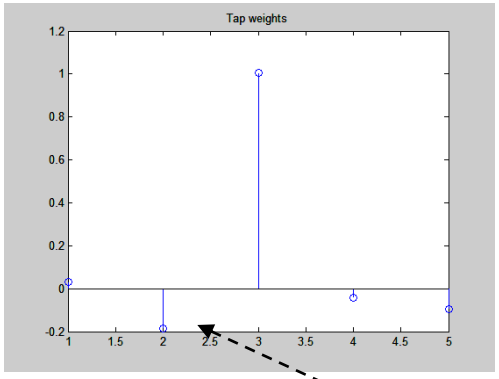
Processed signal BW.

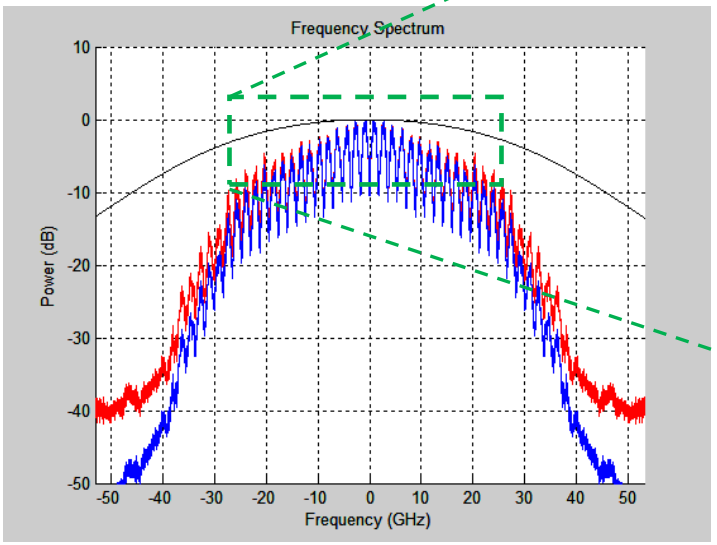
We also post-processed the same saved waveforms including a 4th order BT filter, to understand if any strong difference between TDECQ and sensitivity occours because the actual receiver BW.

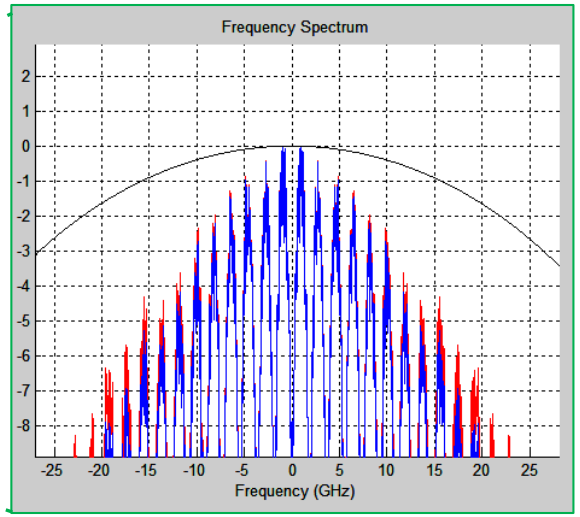
5T, m3, 0UI
Calc SNR (dB) = 20.204



5T, m3, 0UI
Calc SNR (dB) = 20.199

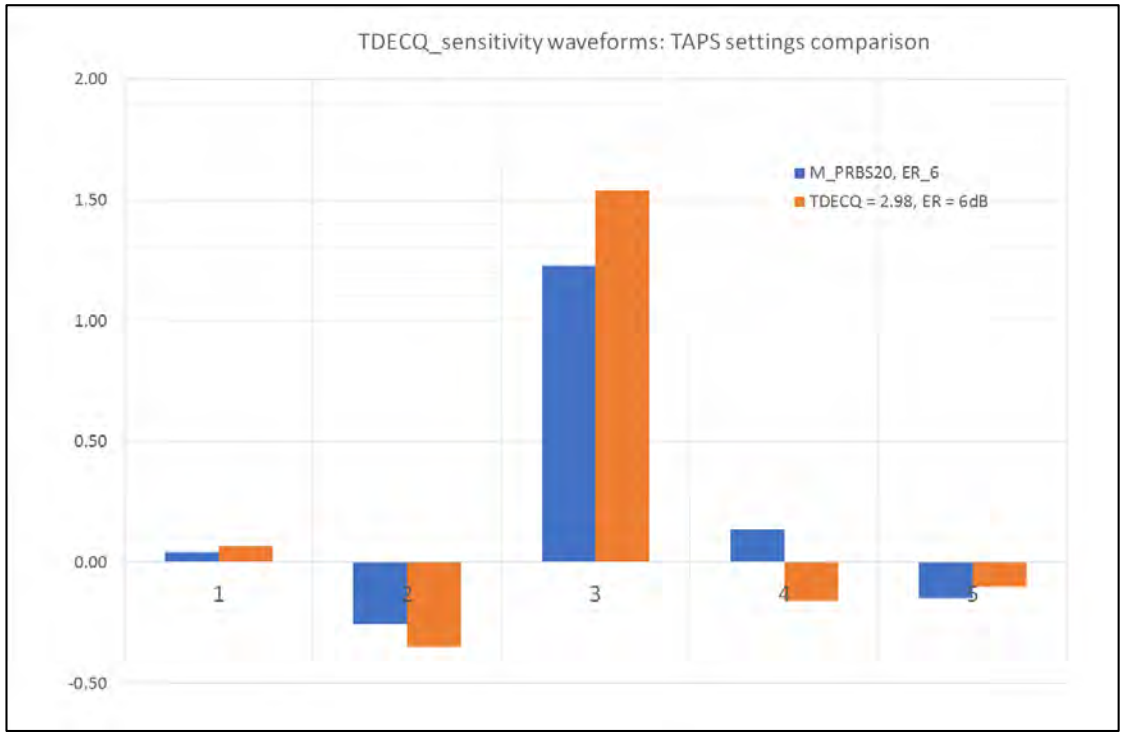


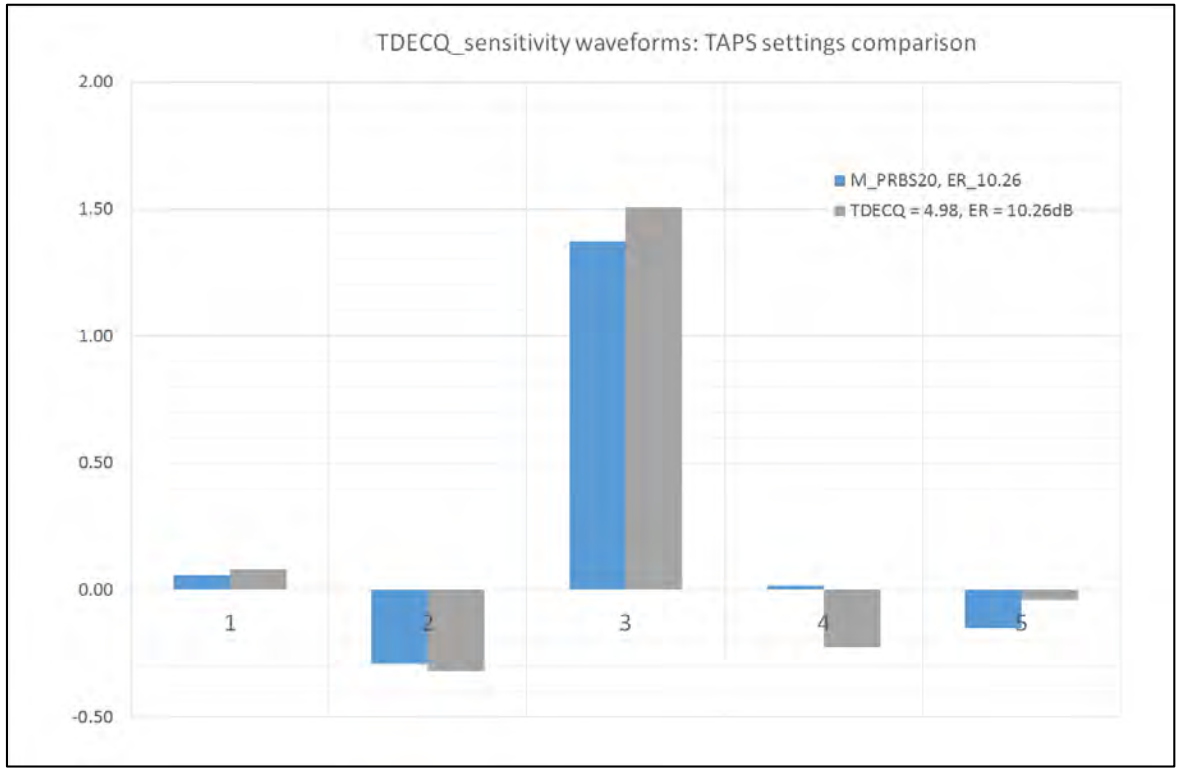




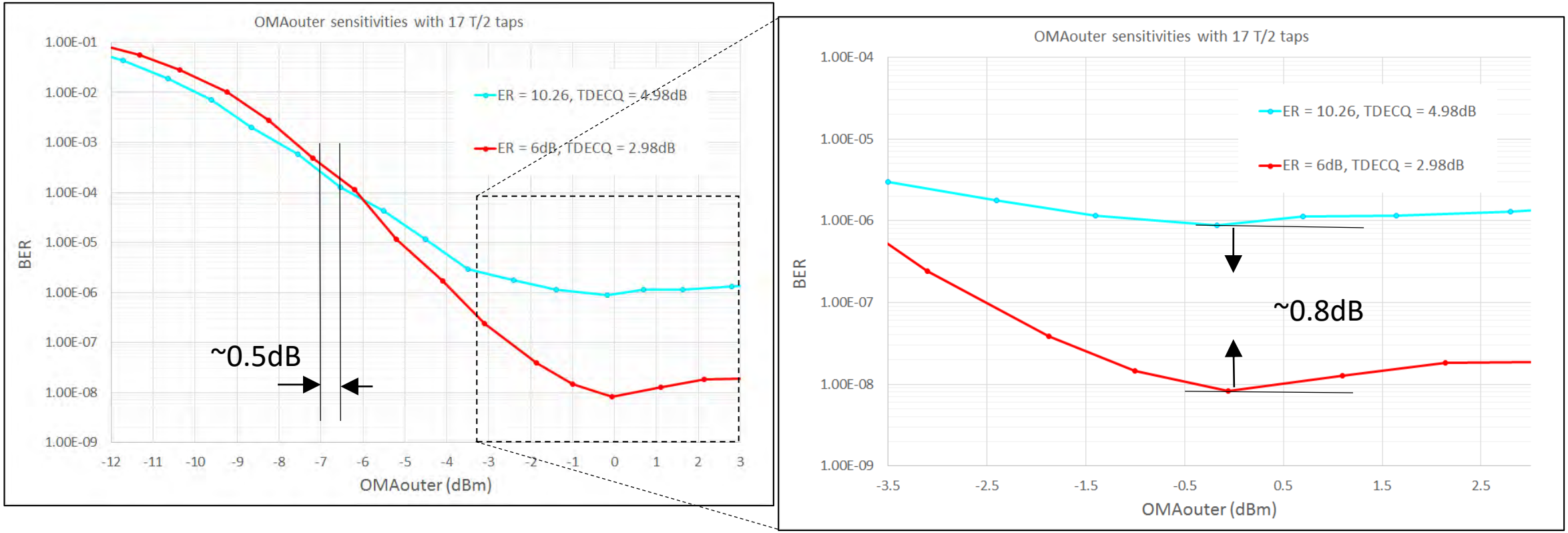
The 26.56GHz 4th order BT filtering has a small effect over the signal shape, tap weight at 1UI and calculated SNR.
Sensitivity results with and without filter are almost the same.

Taps weights comparisons.





Different TDECQ: Delta Sensitivity considering BER @2.4E-4 and floor with longer equalizer (17 T/2 taps).



Sensitivity delta @2.4E-4 leads into same comments as per slide 6.
On BER floor, calculating deltaOMA from deltaBER (deltaSNR) as deltaOMA = deltaSNR/2, we have now around 0.8dB equivalent deltaOMA.
Also in this case is shown no 1:1 correlation between delta sensitivity and dTEDCQ (2dB delta against 0.8dB delta).