

TDECQ Limit and DFE Tap Weight Limit

Vancouver, March 2026

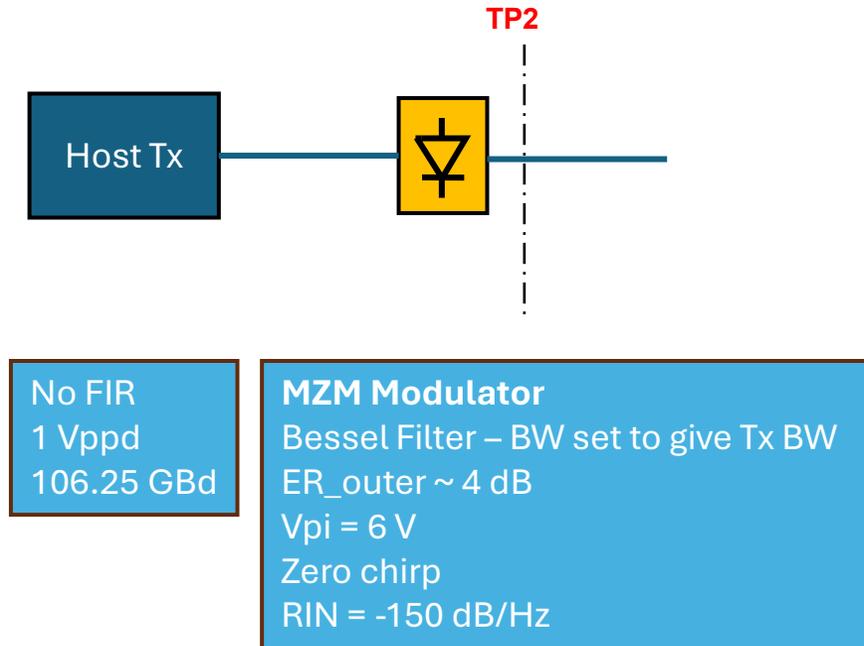
Supporters

- Adee Ran (Cisco)
- Norman Swenson (Nokia, Point2)

Overview

- IEEE802.3dj agreed to introduce a DFE tap into the Reference Receiver for TP2
- This has many implications that need addressing and were not considered or addressed in the proposal to add a DFE tap
- This presentation reviews some of the system implications of adding a DFE tap

Simulation Setup 1

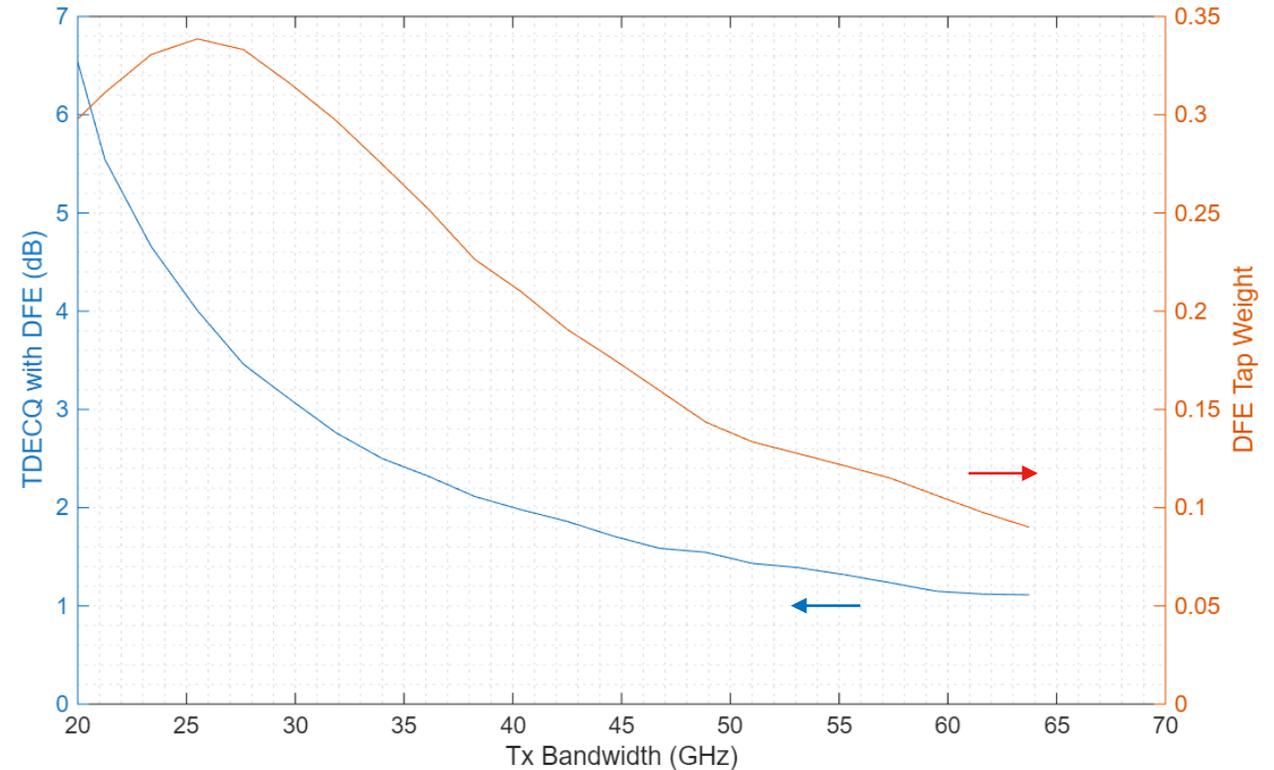


- Simulation to investigate Tx bandwidth impact on TDECQ with a DFE tap in the Reference Receiver
- MZM modulator sets Tx BW
- Represents the **combined** effects of
 - DSP Tx BW
 - TxFIR equalization
 - Driver BW
 - Modulator BW
 - Interconnect BW

Consequence of DFE tap weight

- The DFE tap weight allows very low bandwidth transmitters to be passed
- As the DFE tap weight increases, the lowest bandwidth Tx decreases
 - Lower bandwidth Tx's suffer a larger noise penalty and the DFE reduces the noise penalty
- As the DFE reduces the noise penalty, the Ceq aspect of TDECQ is reduced
 - Low Ceq Tx's (high bandwidth Tx's) do not benefit from the addition of a DFE

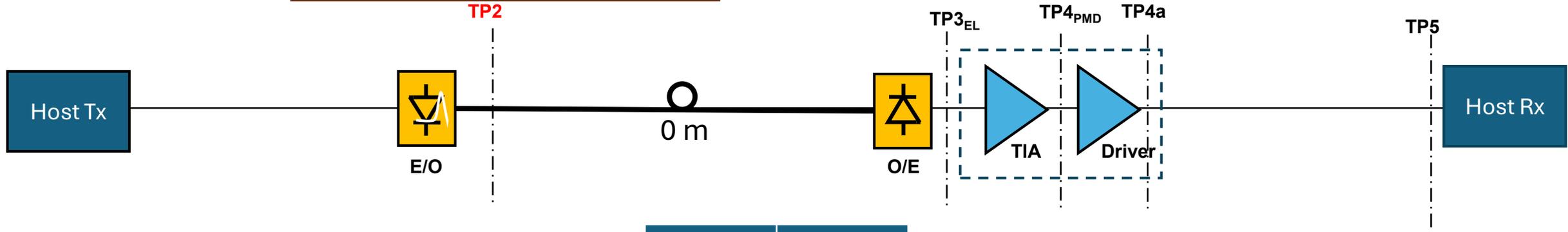
DFE	Tx BW	TDECQ w/ DFE
0.0	-	-
0.1	61 GHz	1.2 dB
0.2	41 GHz	2.0 dB
0.3	31.5 GHz	2.8 dB



Simulation Setup 2

TP2 Reference Rx
 TDECQ - 15 taps FFE
 TDECQ + DFE - 15 taps FFE + 1 tap DFE

System
 PRBS15Q
 BER - 50 frames PRBS15Q
 (1.638 M symbols)



1 Vppd
 60 GHz Bessel BW
 106.25 GBd
 No Tx FIR

Modulator
 Bessel Filter to set Tx Bandwidth
 ER_{outer} ~4 dB
 V_{pi} = 6 V
 Zero chirp
 RIN = -150 dB/Hz
 Electrical Xtalk added

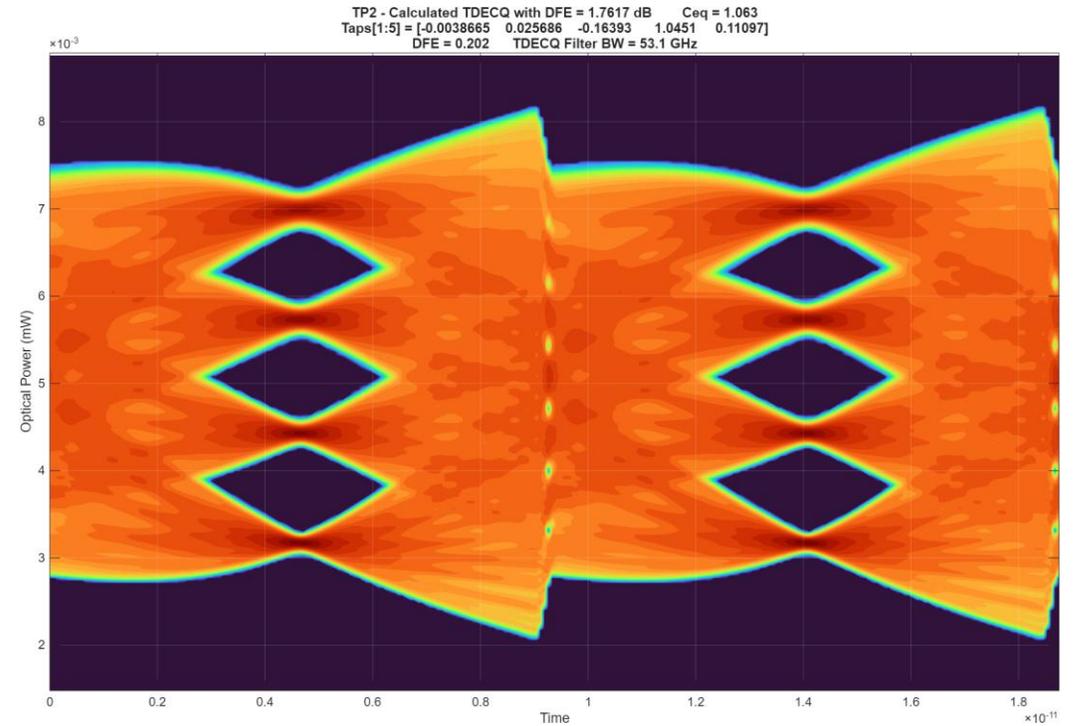
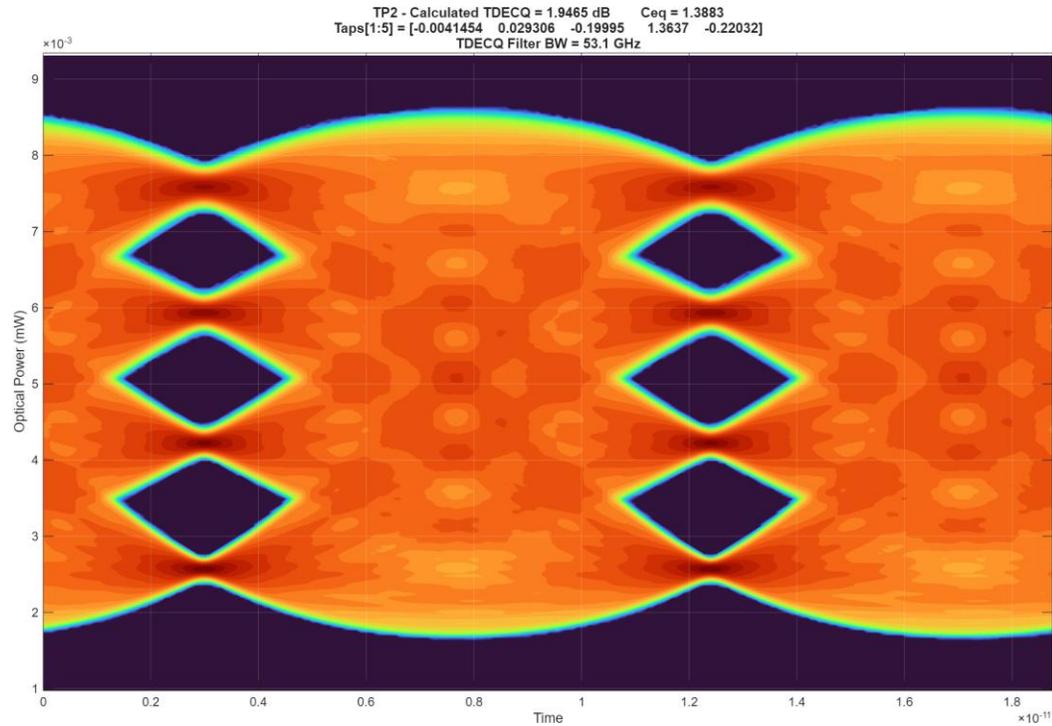
MZM BW	Nett Tx BW
60 GHz	42.4 GHz
55 GHz	40.5 GHz
50 GHz	38.4 GHz
45 GHz	36.0 GHz
40 GHz	33.3 GHz
35 GHz	30.2 GHz
30 GHz	26.8 GHz

PD + TIA
 Responsivity = 0.7 A/W
 60 GHz Bessel filter
 T_z = 3 kohms max
 Noise = 15 pA/rtHz
 Rx Xtalk ~ -40 dB
 Electrical Xtalk added

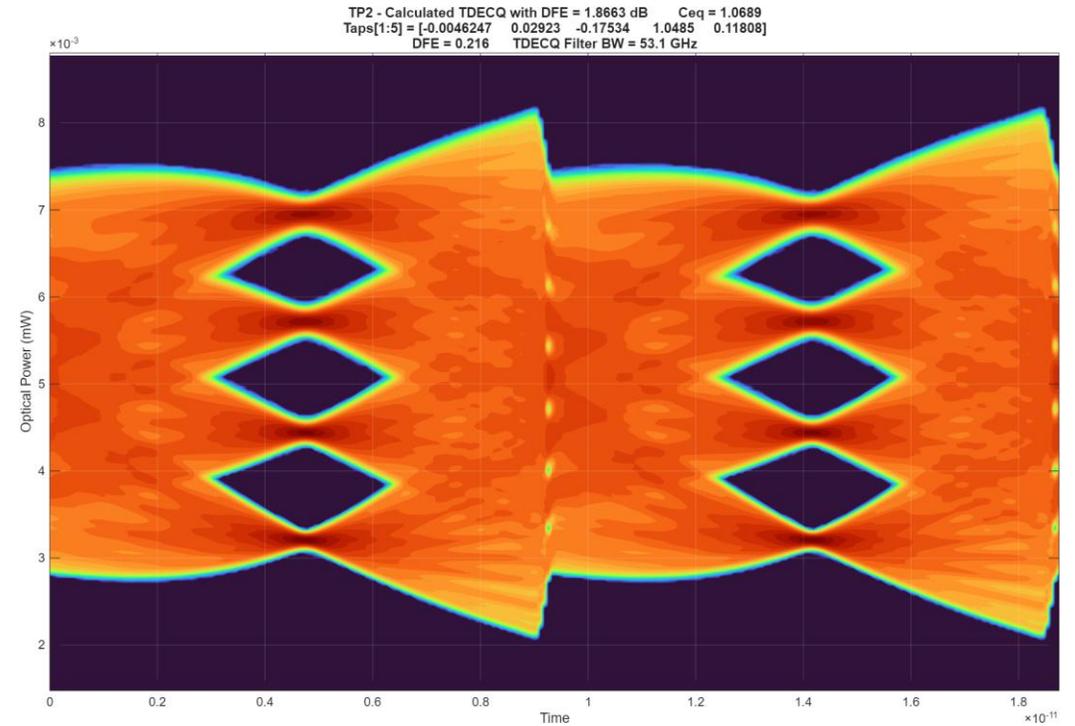
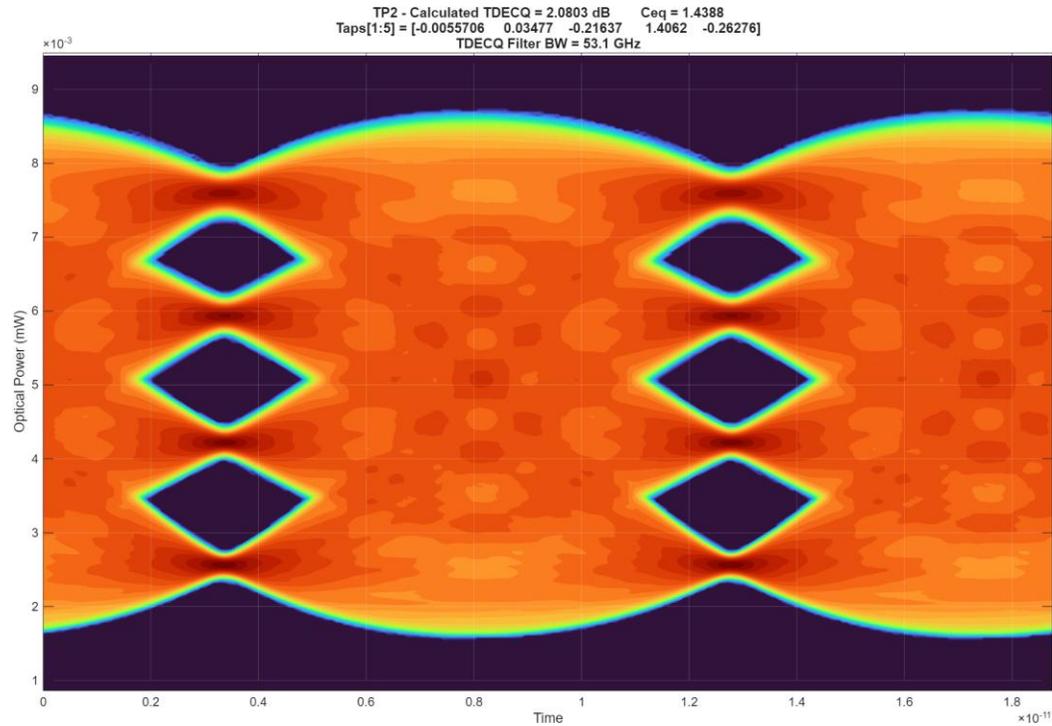
DSP Rx
 FFE - 30 taps (4 pre)
 DFE - 1 tap
 No MLSE

- Simulation to investigate the effect of nett Tx bandwidth on TDECQ (measured with and without DFE) and system BER performance
- Note that this simulation setup has a more complex Tx configuration so results show minor differences to the prior simulations

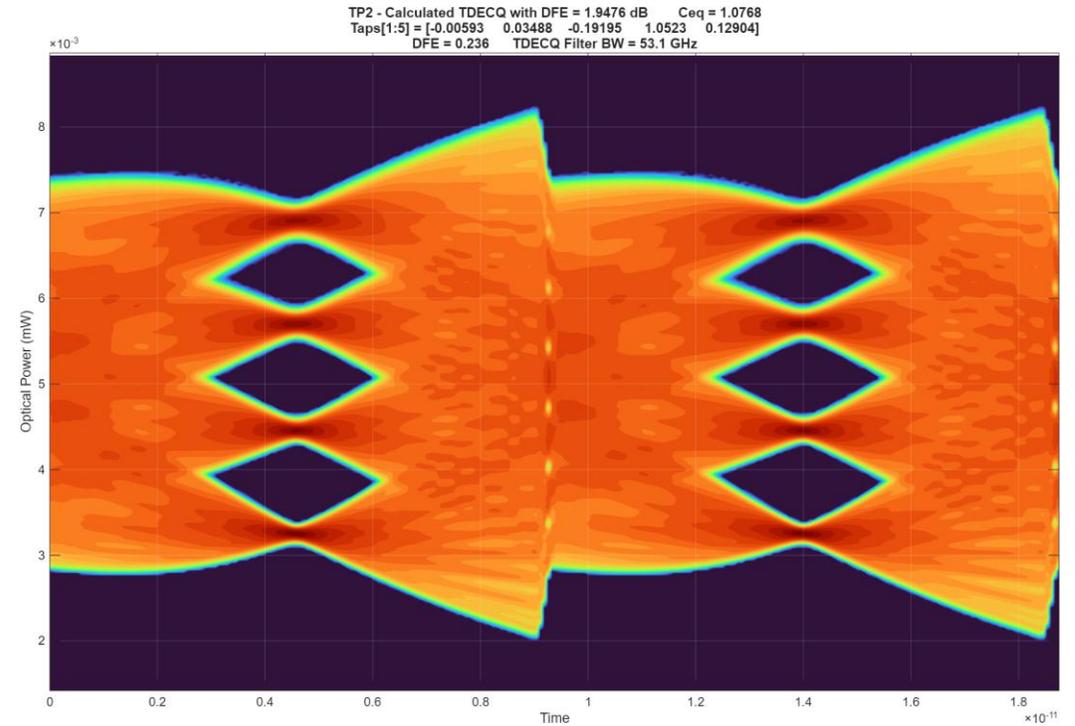
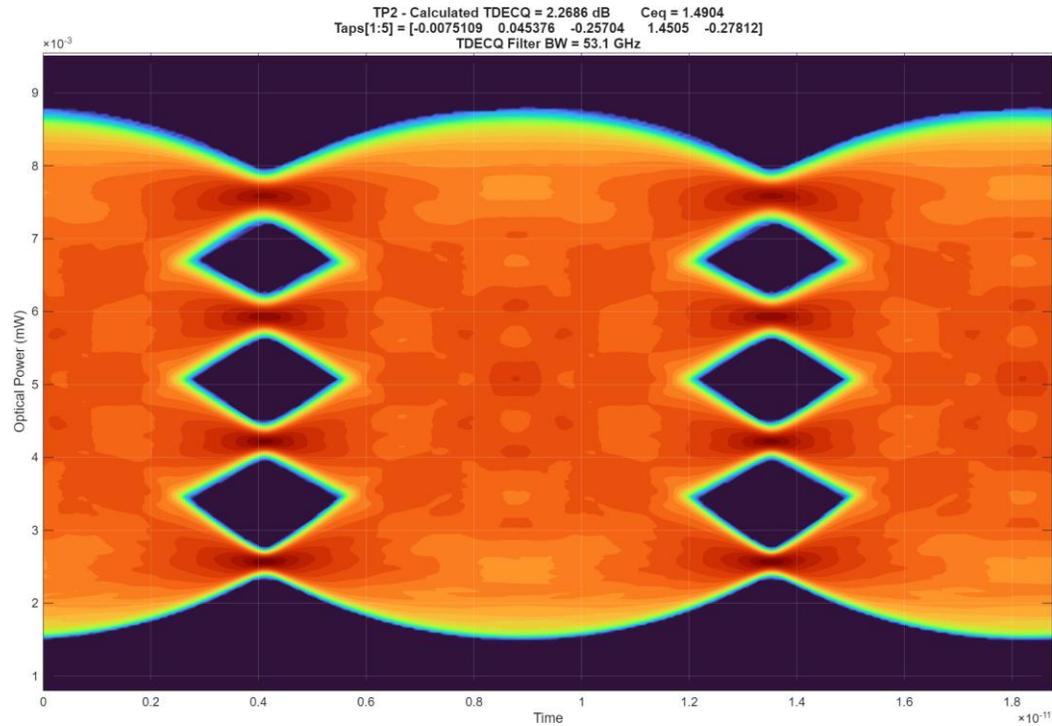
60 GHz DSP and 60 GHz MZM



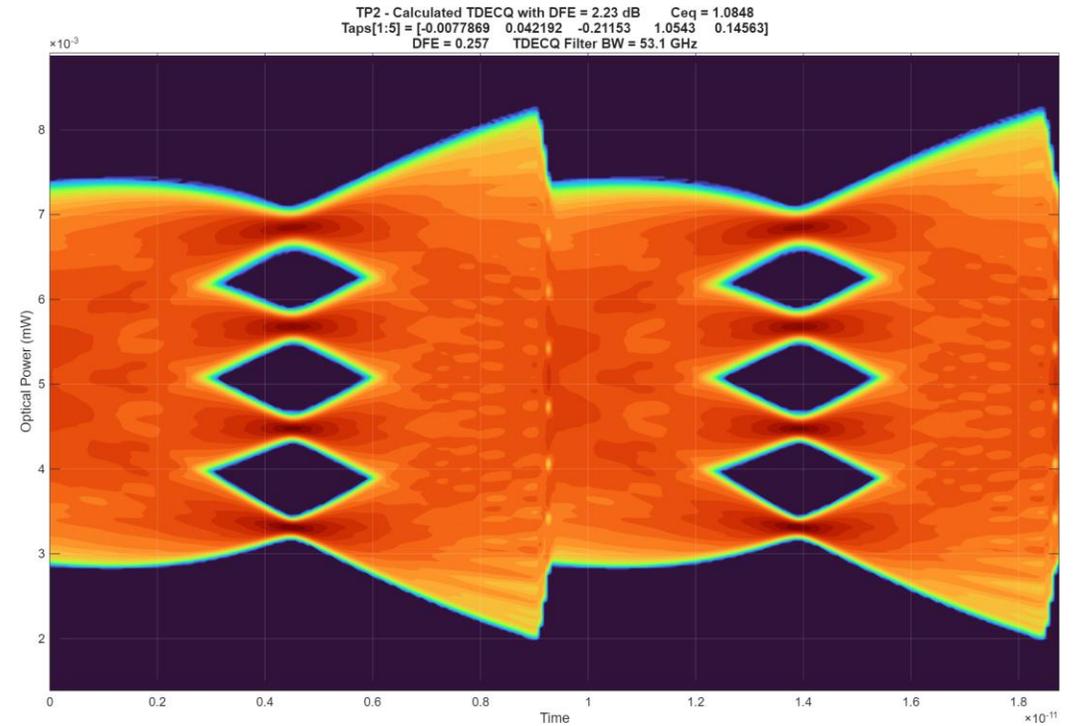
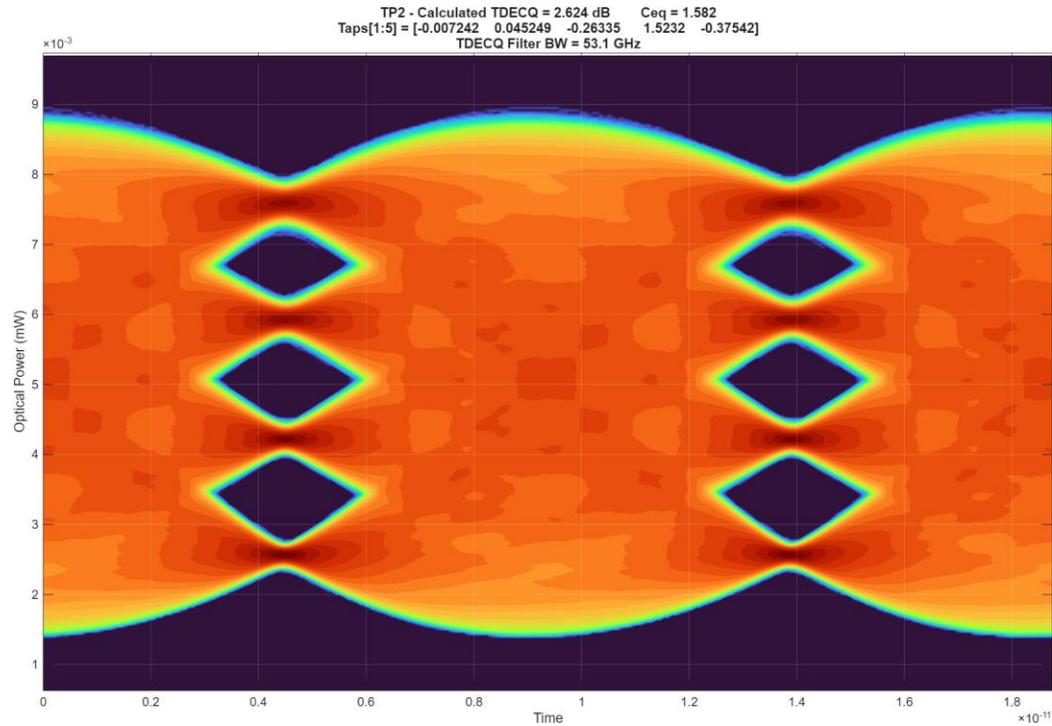
60 GHz DSP and 55 GHz MZM



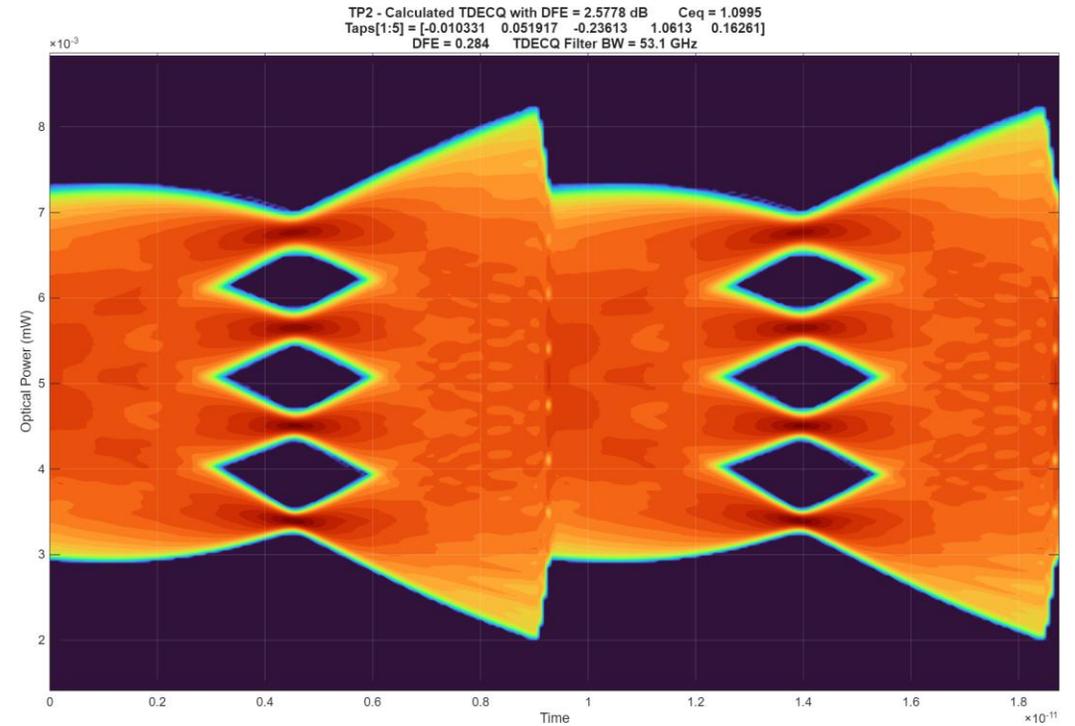
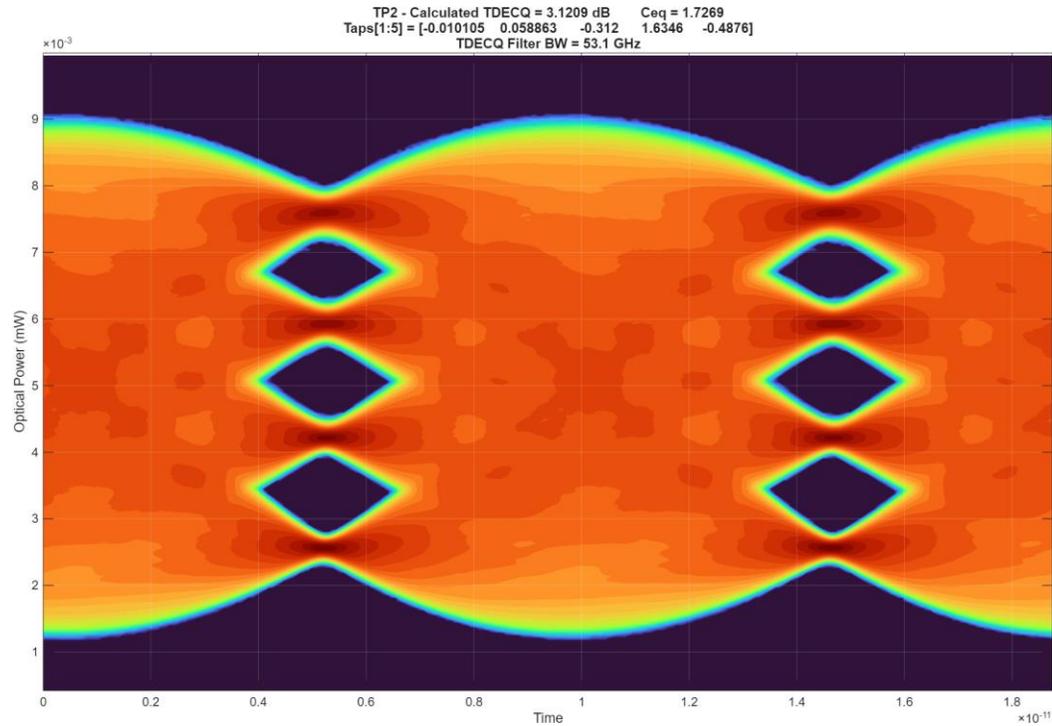
60 GHz DSP and 50 GHz MZM



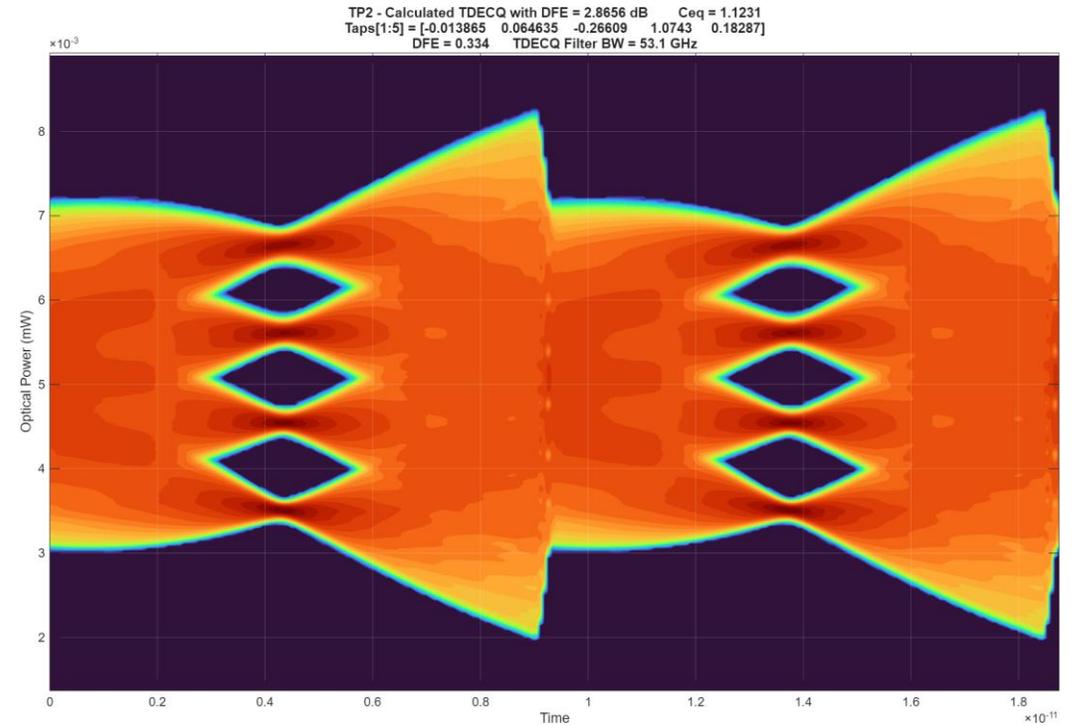
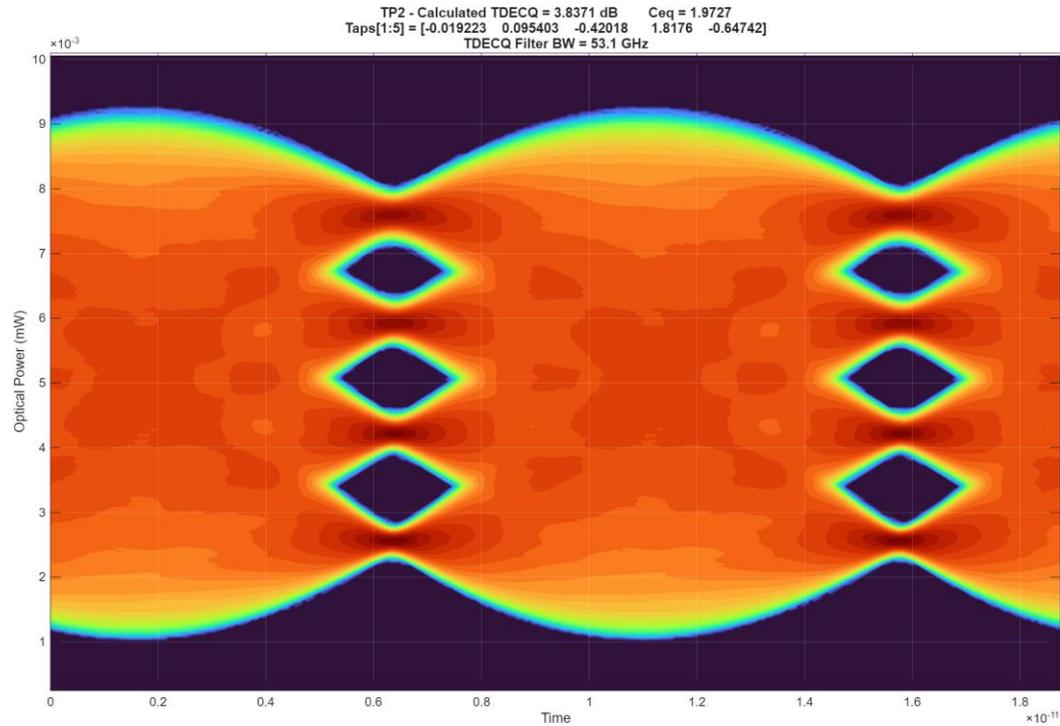
60 GHz DSP and 45 GHz MZM



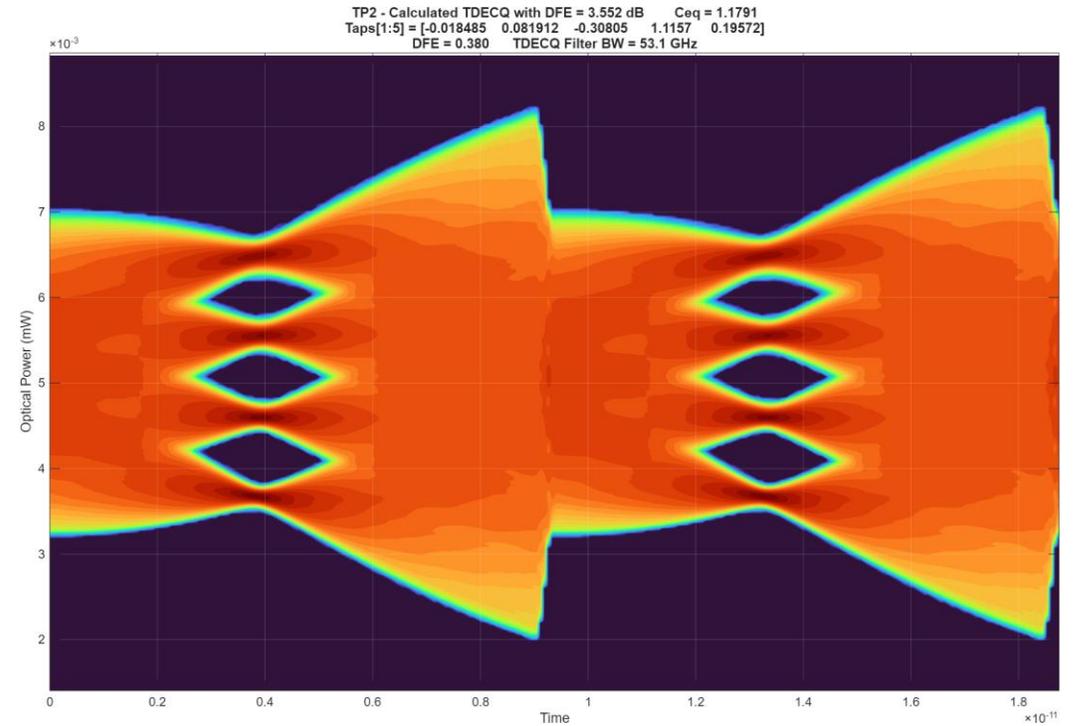
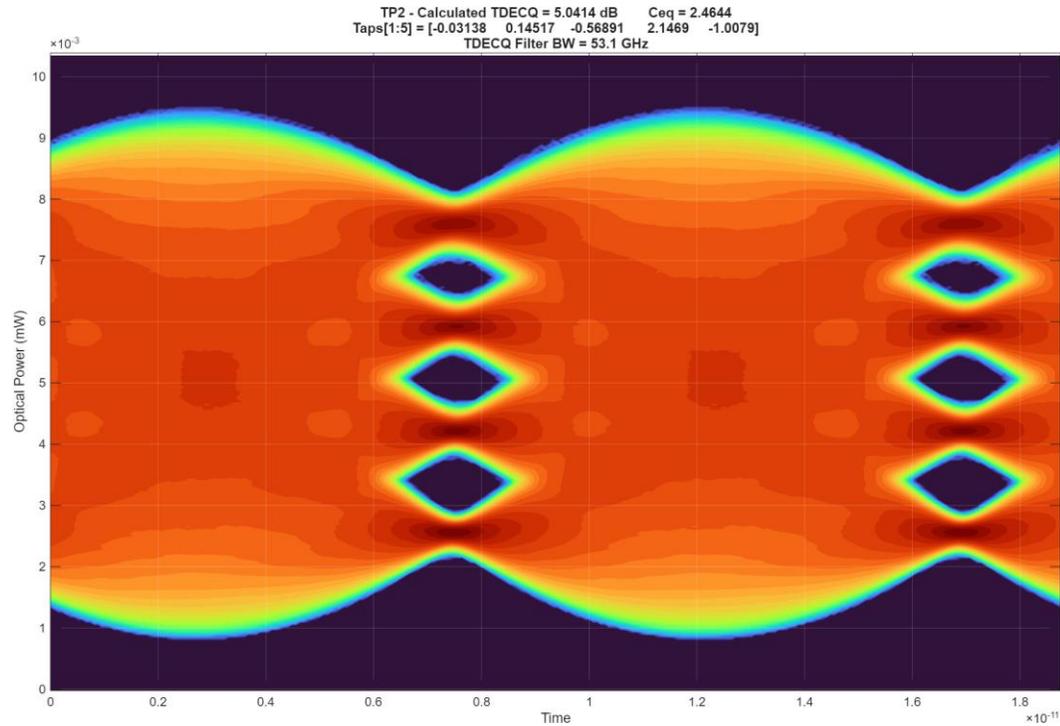
60 GHz DSP and 40 GHz MZM



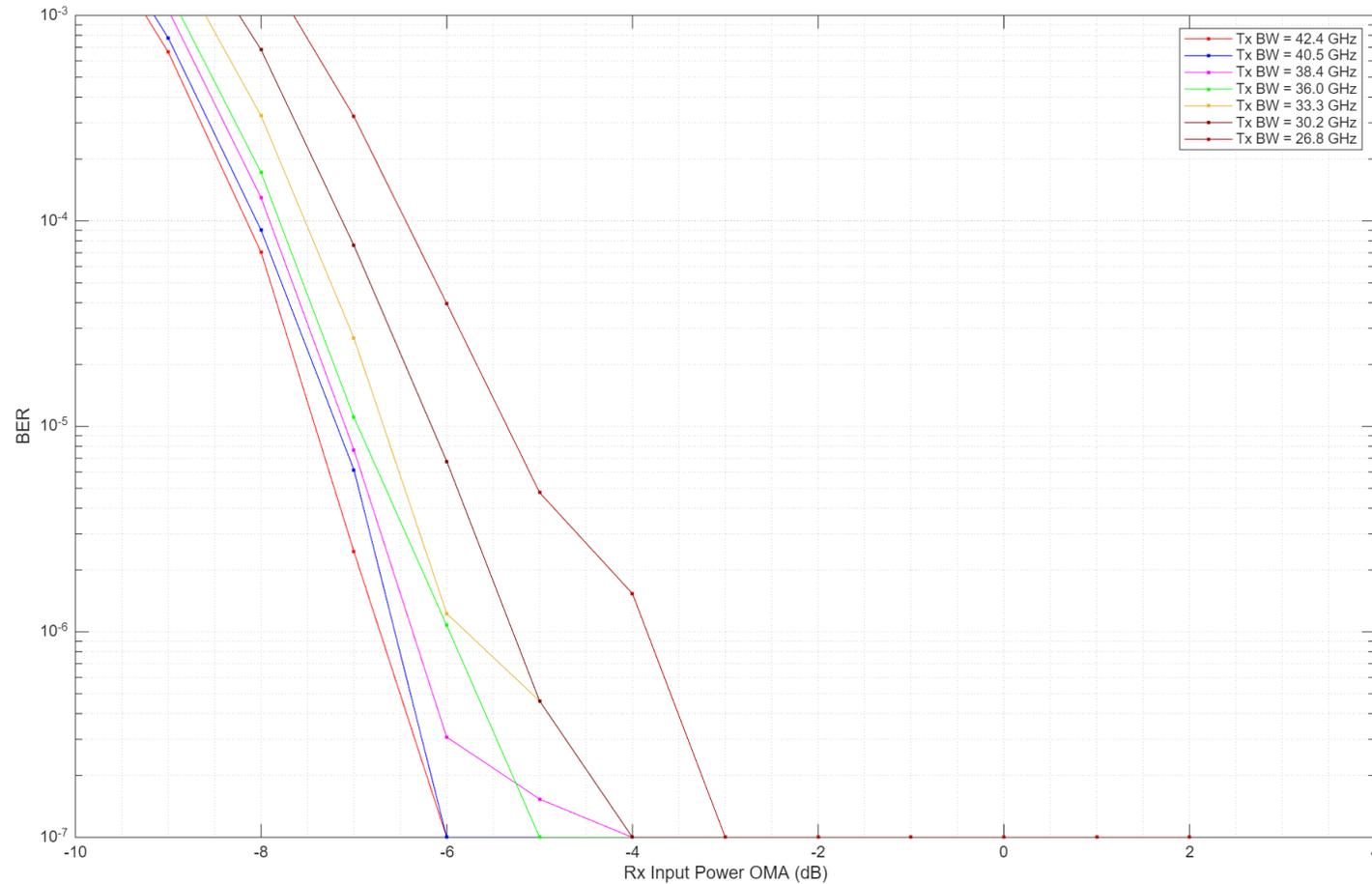
60 GHz DSP and 35 GHz MZM



60 GHz DSP and 30 GHz MZM

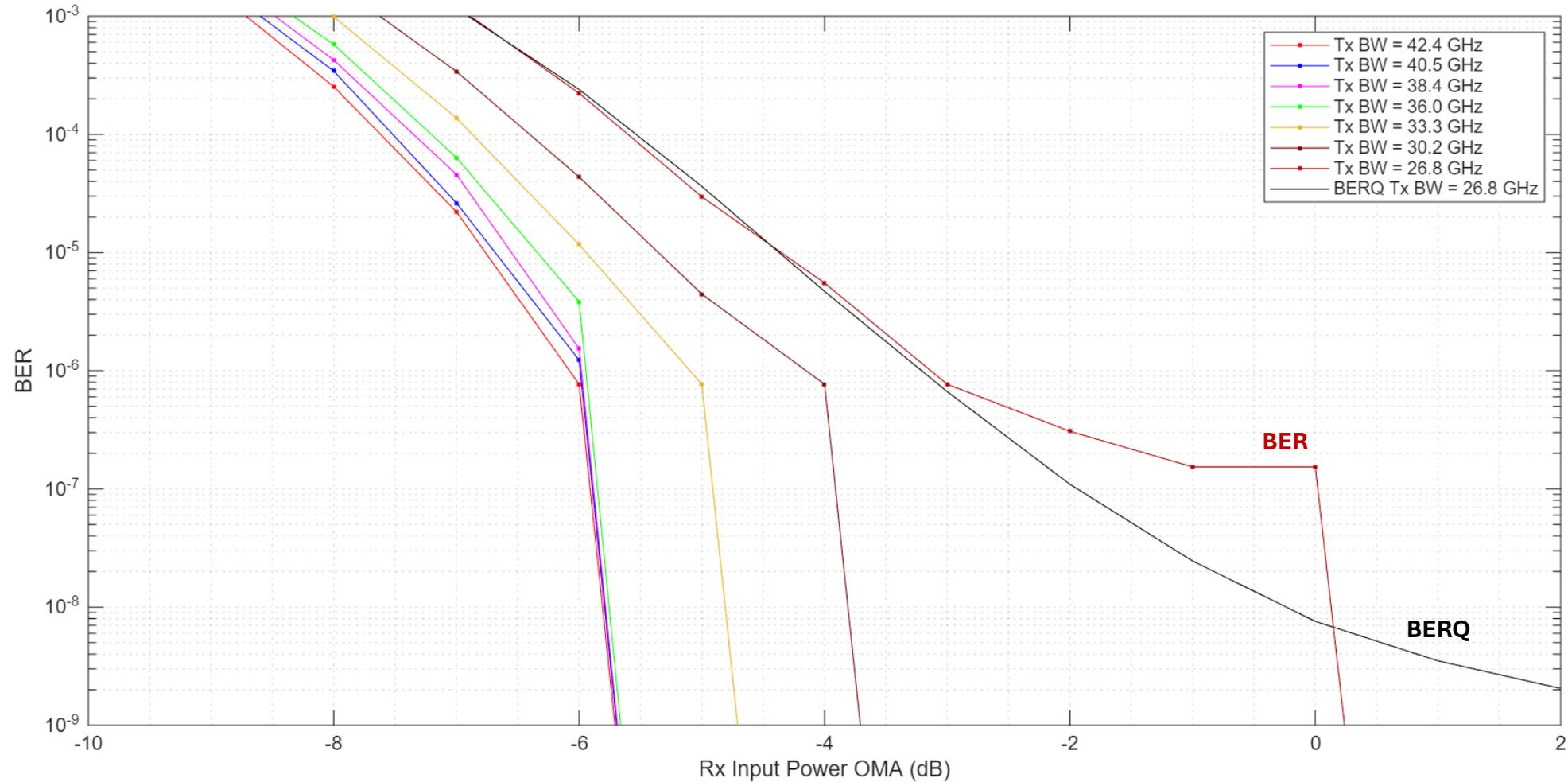


BER



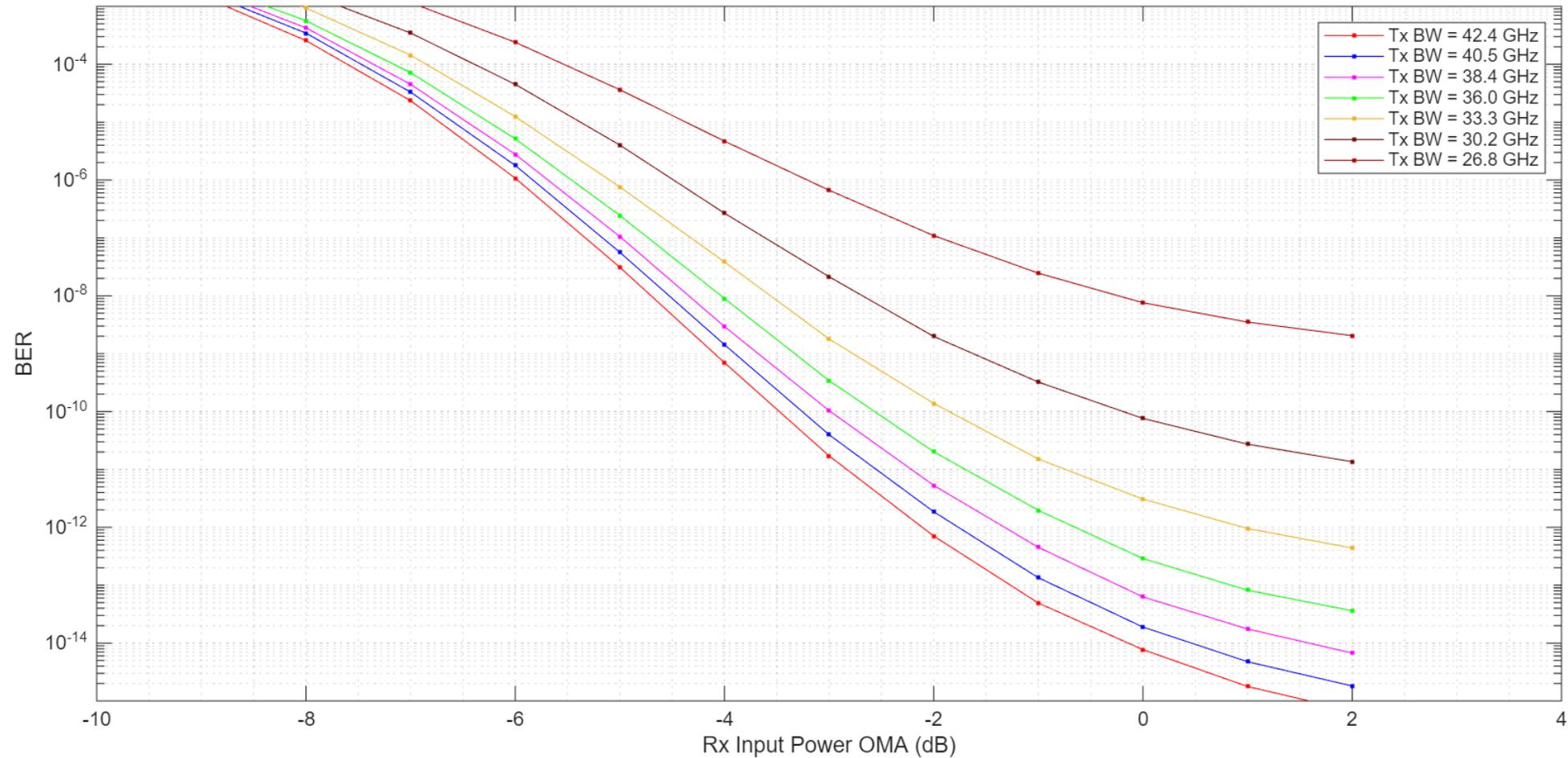
Tx BW (GHz)	BER(Q) @ 0 dBm
42.4	8E-15
40.5	3.4E-14
38.4	1.23E-13
36.0	5.9E-13
33.3	3.85E-12
30.2	7.81E-11
26.8	3.09E-09

BER



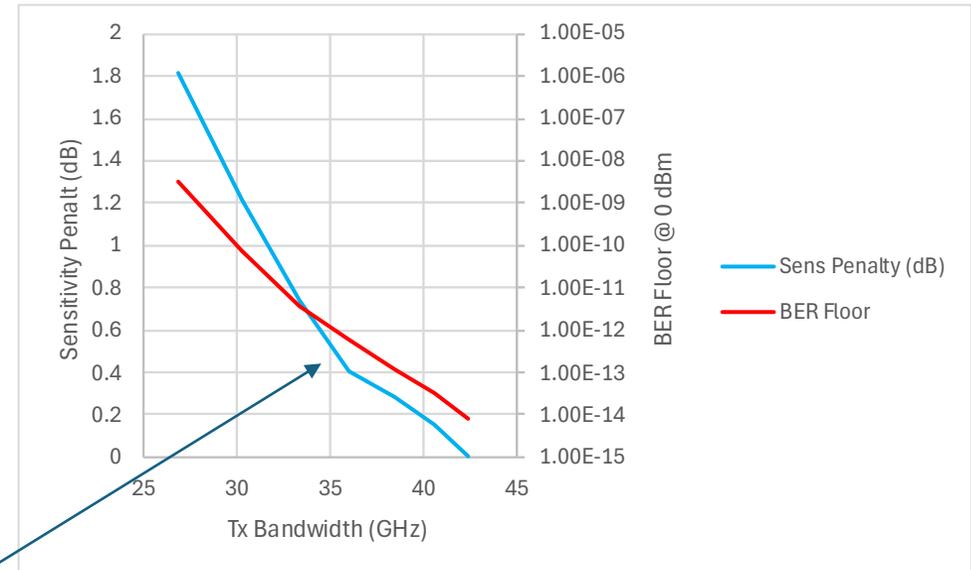
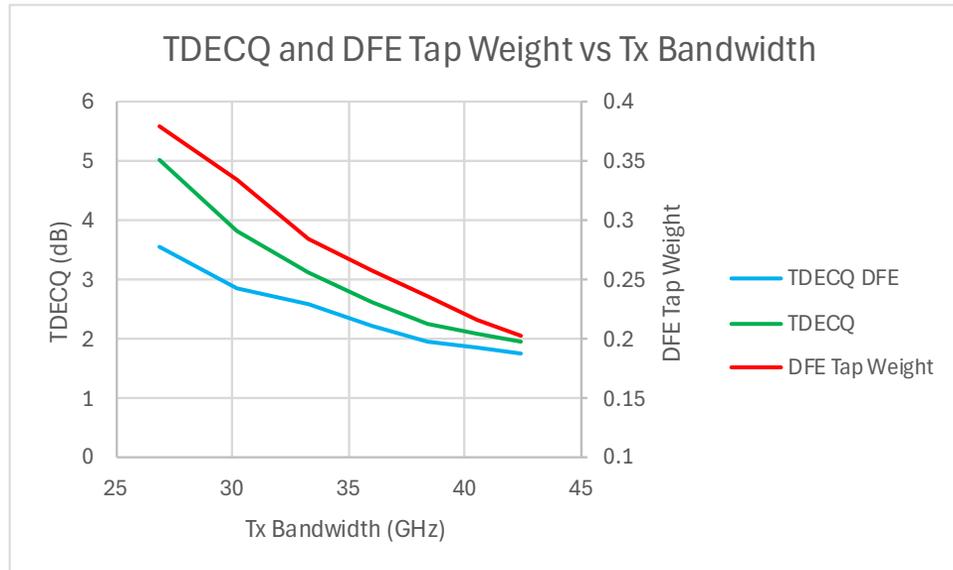
BERQ underestimates the BER floor by ~ 1 -2 decades due to ISI

BER based on Q showing error floor impact



BER floor will be worse when ISI is accounted for

Effect of Transmitter Bandwidth on TDECQ and BER



Sensitivity penalty is relative to 42 GHz Tx

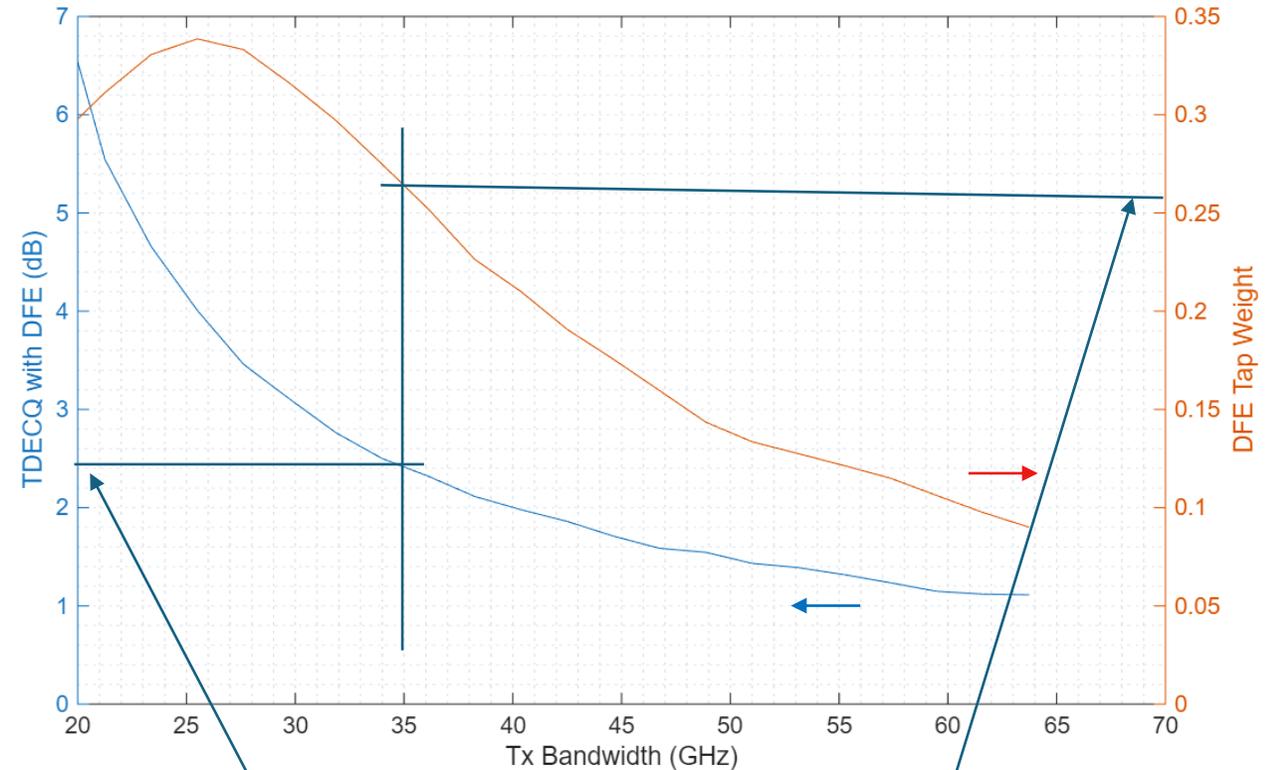
Recommend limiting Tx BW to 35 GHz (min)

- Sensitivity penalty ~0.5 dB compared to high BW Transmitters

Consequence of DFE tap weight

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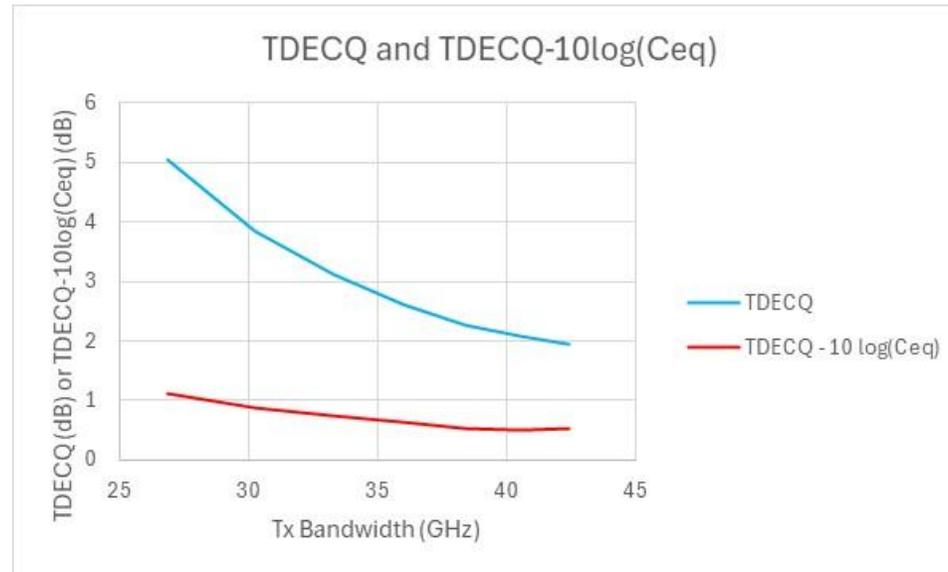
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TDECQ with DFE ≤ 2.5 dB

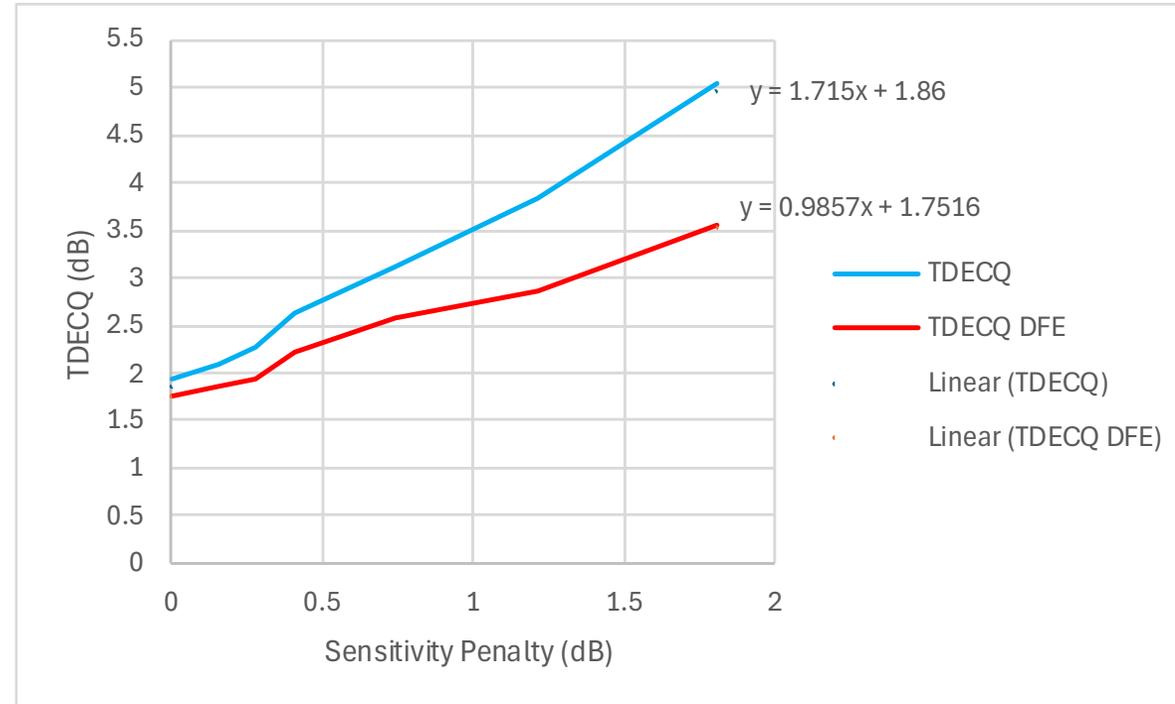
DFE ≤ 0.25

Does TDECQ – 10 log(Ceq) add benefit



- TDECQ – 10*log(Ceq) is very insensitive to the bandwidth impairment
 - BW impairments are largely Ceq related in these simulations
- Small change is hard to measure
- TDECQ is more sensitive and more useable

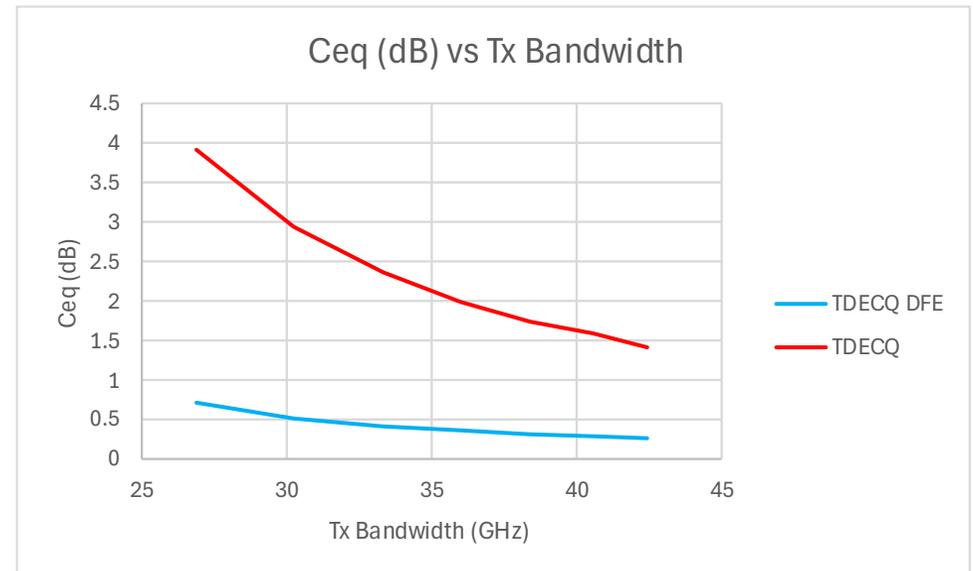
Comparison of TDECQ versus Sensitivity Penalty



- Sensitivity penalty is relative to 42 GHz Tx
- DFE addition gives 1:1 correlation between TDECQ and Sensitivity Penalty

Ceq Measurement

- With a DFE in place then Ceq has no meaning and is always set 1 (0dB)
- Could measure after the FFE (before the DFE)
 - Not sure of the benefit of this as Ceq variation is small compared TDECQ with FFE only



Summary

- Simulation shows that the use of TDECQ with a DFE tap allows low bandwidth transmitters unless
 - DFE tap weight is constrained
 - TDECQ limit is reduced
- Low bandwidth transmitters impact on receiver sensitivity and BER floor
 - Even when the Rx has a DFE tap
- The current TDECQ (FFE only) limit (3.4 dB) allows for about 1 dB sensitivity penalty due to Tx bandwidth
- To maintain the same sensitivity penalty when screening transmitters using TDECQ + DFE (compared to FFE only) then need to
 - Limit TDECQ to 2.5 dB
 - Limit DFE tap weight to 0.25

Recommendations

- Set DFE tap weight limit to 0.25
 - Set lower limit on Tx bandwidth
 - Avoid Tx taking too much margin from Rx and creating high noise floors
- Set TDECQ (max) limit to 3.0 dB
 - Gives additional 0.5 dB to the Tx for non-bandwidth impairments compared to the situation before the DFE was added
- Give 0.4 dB to the Rx sensitivity in the link budget
- Apply to Clauses 180 (DR), 181 (FR4-500) and 182 (DR-2)
- Clause 183 (FR4 and LR4) needs further work to understand impact of dispersion but would also in general benefit from higher bandwidth transmitters

Thank you