Updating Link Budget with Addition of 1T DFE

(Comments 132, 134, 135, 136, 137, 138, 139, 140, and 141)

Ali Ghiasi - Ghiasi Quantum/Marvell

IEEE 802.3dj Interim Meeting

Minneapolis

Sept 15, 2025

Overview

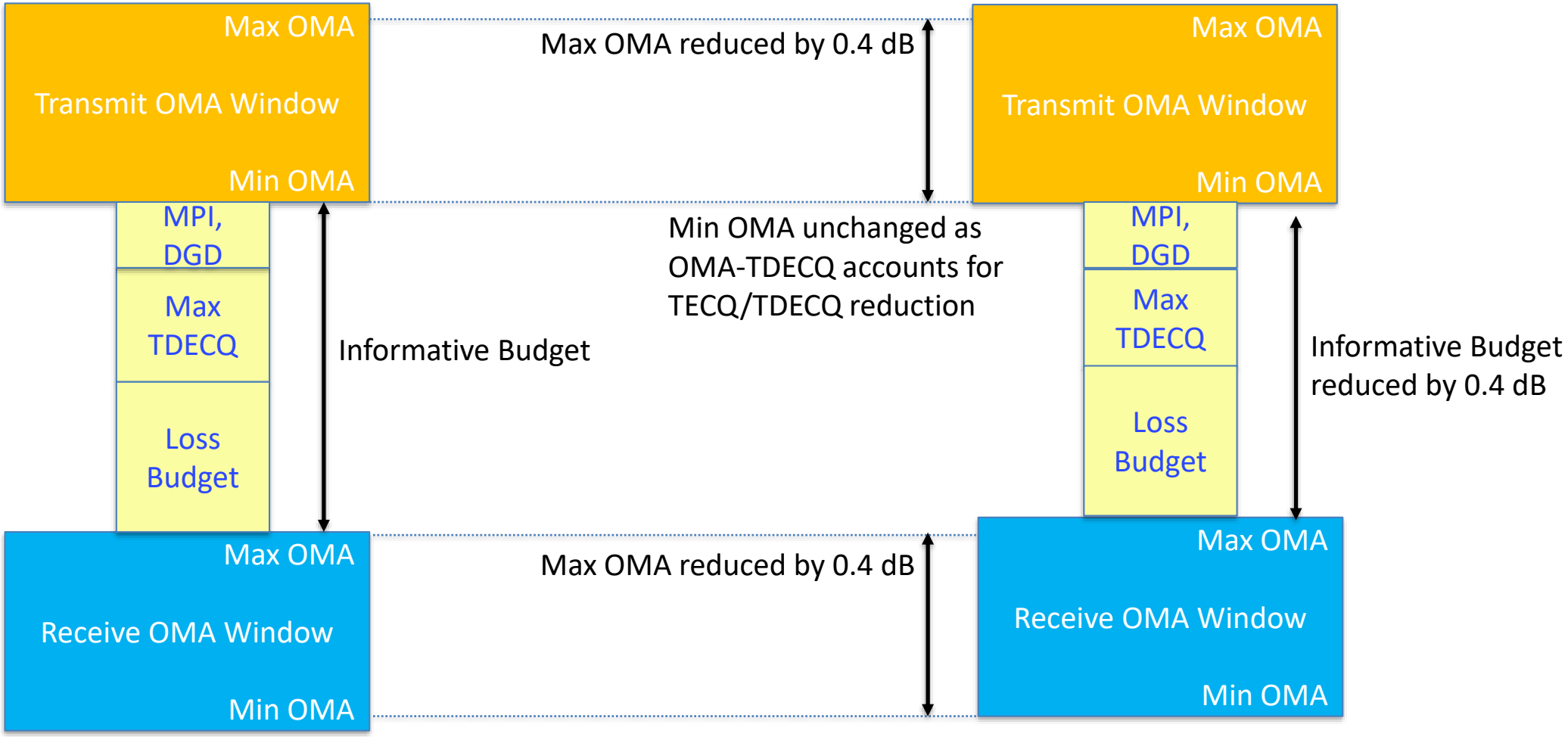
- **Background**
- **Splitting the TDECQ gain as result of 1T DFE**
- **Summary of optical link budget adjustment**
- **Illustrative link budgets**
  - DR-500 PMDs
  - 800GBASE-FR4 PMD
  - DR PMDs
  - 800GBASE-FR4/LR4 PMDs
- **Summary.**

Background

- **In Madrid 1T DFE was added to the TDECQ equalizer but due to limited time TDECQ limit and overshoot/undershoot limits were not addressed**
  - With 1T DFE providing ~ 1dB of equalizer gain the TDECQ limits need to be reduced
    - By enabling 1T DFE in TDECQ significant margin has shifted from receive DSP to transmitter, unless TDECQ limit is lowered the receive DSP will be left with no margin
  - Another key reason 1T DFE was proposed and adopted was to reduce reliance on overshoot/undershoot where TDECQ doesn't capture compression and clipping effects and higher overshoot can result in pre/post FEC BER degradation
    - It has been reported that transmitter with less overshoot and more linear response but with higher TDECQ have better BER
- **Ghiasi_3dj_01a_2509 proposes to reduce TDECQ/TECQ from 3.4 dB to 3 dB for DR, and FR4, and reduce TDECQ/TECQ from 3.9 dB to 3.5 dB for LR4**
  - A byproduct of enabling 1T DFE and reducing TECQ/TDECQ by 0.4 dB allow reducing illustrative link budget by 0.4 dB
  - This proposal reduces transmit Max OMA, Max average power, and Min average power by 0.4 dB
    - Max OMA and Max average power are identical to transmitter power levels
    - Min average power is "Min Tx power – passive loss budget".

Adjustment to Link Budget Based on TDECQ Reduction

- **0.4 dB TDECQ reduction benefit is split between transmitter and receiver**



Summary of Optical Budget as Result of TDECQ Reduction by 0.4 dB

	Clause 180 DRn		Clause 181 FR4-500		Clause 182 DRn-2		Clause 183 FR4		Clause 183 LR4	
PMD Parameters	DJ D2.1	This proposal	DJ D2.0	This proposal	DJ D2.0	This proposal	DJ D2.1	This proposal	DJ D2.1	This proposal
Illustrative link budget		Δ=0 dB		Δ=0 dB		Δ=-0.4 dB		Δ=-0.4 dB		Δ=-0.4 dB
Power budget (for max TDECQ)	6.7	6.7	7.5	7.5	7.7	7.3	7.7	7.3	7.7	7.3
Allocation for penalties (for max TDECQ)	3.7	3.7	4.0	4.0	3.8	3.7	3.8	3.7	3.8	3.7
Transmitter characteristics										
Average launch power, dBm (min)	-3.1	-3.1	-2.1	-2.1	-3.1	-3.1	-2.2	-2.2	-1.1	-1.1
Average launch power, dBm (max)	4.0	4.0	4.9	4.9	4.0	3.6	4.9	4.5	5.5	5.1
Transmit (OMAouter), each lane (max)	4.2	4.2	4.8	4.8	4.2	3.8	4.8	4.4	5.7	5.3
Outer Optical Mod. Amp. (OMAouter), dBm each lane (min) for max(TECQ, TDECQ) < 0.9 dB for 0.9 dB < max(TECQ, TDECQ) < 3.0 dB for 0.9 dB < max(TECQ, TDECQ) < 3.5 dB	-0.1 -1.0+max()	-0.1 -1.0+max()	0.9 max()	0.9 max()	-0.1 -1.0+max()	unchanged	0.8 -0.1+max()	unchanged	1.9 0.5+max()	unchanged
Receiver characteristics										
Average receive power, each lane (min)	-6.1	-6.1	-5.6	-5.6	-7.1	-7.1	-6.2	-6.2	-7.4	-7.4
Average receive power, each lane (max)	4.0	4.0	4.9	4.9	4.0	3.6	4.9	4.5	5.5	5.1
Receive (OMAouter), each lane (max)	4.2	4.2	4.8	4.8	4.2	3.8	4.8	4.4	5.7	5.3
Receiver sens. (OMAouter) dBm, (max) for TECQ < 0.9 dB for 0.9 dB < TECQ < SECQ for TECQ < 1.4 dB for 1.4 dB < TECQ < SECQ (dBm)	-3.4 -4.3+TECQ	-3.4 -4.3+TECQ	-3.2 -4.1+TECQ	-3.2 -4.1+TECQ	-4.4 -5.3+TECQ	unchanged	-3.7 -4.6+TECQ	unchanged	-5.5 -6.9+TECQ	unchanged
Stressed receiver sensitivity (OMAouter), each lane (max) (dBm)	-0.9	6.7	-0.7	-0.7	-1.9	unchanged	-1.2	unchanged	-1.0	unchanged

Clause 182 Link Budget Reduction as Result of TDECQ Reduction (Comments 132, 138, 139)

- **Reduce allocation for penalties by 0.4 dB**
  - Also update Figure 182-3 OMAmax and 182-5 OMAmax

Table 182–9—Illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)	~~7.7~~ 7.3 dB	dB
Operating distance	2000	m
Channel insertion loss[a, b]	4	dB
Maximum discrete reflectance	–35	dB
Allocation for penalties[c] (for max TDECQ)	~~3.7~~ 3.3 dB	dB
Additional insertion loss allowed	0	dB

Clause 183 Link Budget Reduction as Result of TDECQ Reduction FR4 (Comments 133, 140, 141)

- **Reduce allocation for penalties by 0.4 dB**
  - Also update Figure 183-3 OMAmax and 183-5 OMAmax

Table 183–8—800GBASE-FR4 and 800GBASE-LR4 illustrative link power budgets

Parameter	800GBASE-FR4	800GBASE-LR4	Unit
Power budget (for maximum TDECQ)	~~7.9~~ 7.5 dB	~~11.3~~ 10.9 dB	dB
Operating distance	2	10	km
Channel insertion loss[a]	4[b]	6.3[c]	dB
Maximum discrete reflectance	–35	–35	dB
Allocation for penalties[d] (for maximum TDECQ)	~~3.9~~[e] 3.5 dB	~~5~~[f] 4.6 dB	dB

Summary

- **TDECQ with 1T DFE reduces slow transmitters TDECQ by 1-1.5 dB see Ghiasi_3dj_01_2509 where Max(TECQ,TDECQ) are reduced by 0.4 dB**
  - The reduction of TECQ/TDECQ reduces illustrative link budget by 0.4 dB
  - With the reduction of illustrative link budget by 0.4 dB then Transmit Max OMA, Max Average power, and Min Average Power are reduced by 0.4 dB
  - Receive Max OMA and Max Average power are the same as transmit power
  - Receive Min Average power is “Transmit Min Average power-Passive loss budget”
- **Transmit OMA Min and receive sensitivity are unchanged as these parameters are as function of TECQ.**

Thank You!