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Refine the Rx Sensitivity/Tx OMA for DR/FR4-500/FR4

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TeraHop

Supporters

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Background

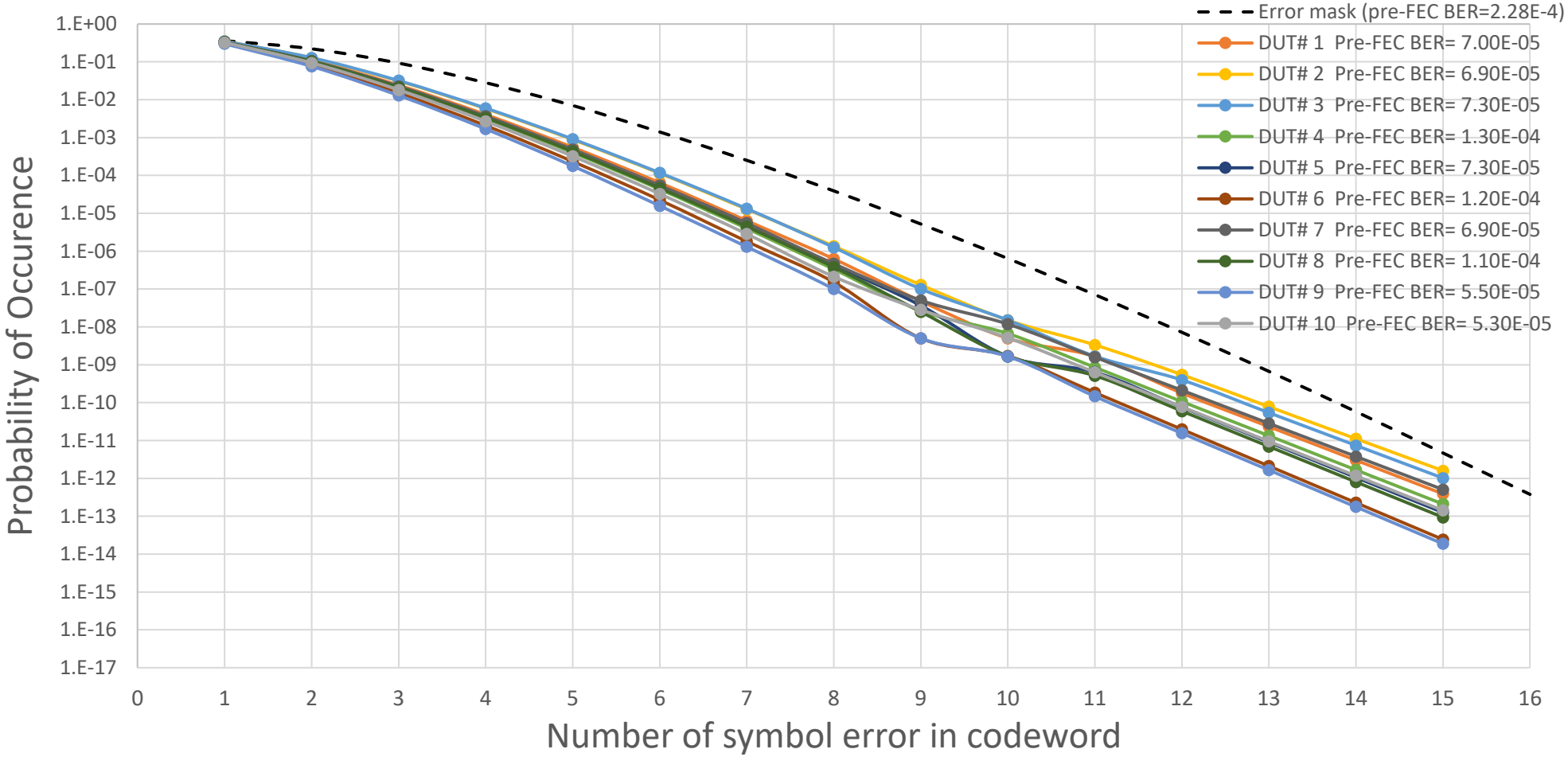
- The 802.3dj PMD baseline for 800GBASE FR4 and 800GBASE FR4-500 was proposed by welch_3dj_04_2309 and welch_3dj_01a_2401 respectively

- Rx sens data was shown in rodes_3dj_01a_2311, welch_3dj_01a_2401 as supporting evidence before large number of product samples were built and tested.

- Industry now have cumulated significant amount of test data over large number of samples. Based on these newly available test data, we propose to adjust/refine Tx_OMA_min and Rx_sens OMA_max spec to optimize product with lower power dissipation and lower cost.

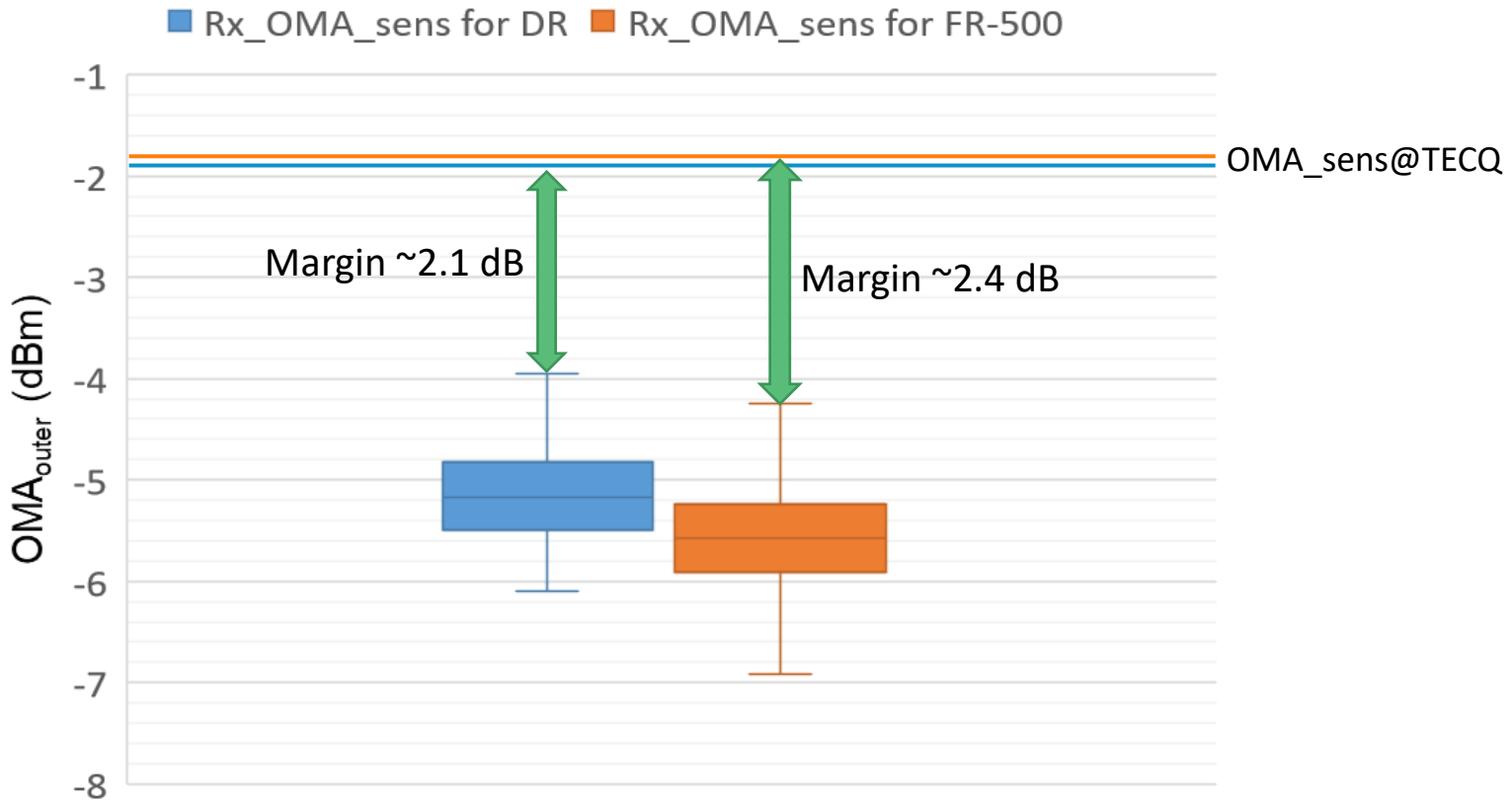
Correlation of Error Histogram Threshold and Pre-FEC BER

- The required pre-FEC BER for error histogram threshold is not a fixed level. Our results (after linear extrapolation) show it's in range of 5E-5 to 1.3E-4. To be simplified, we choose **2E-5 pre-FEC** BER as error histogram threshold replacement for Rx sensitivity.



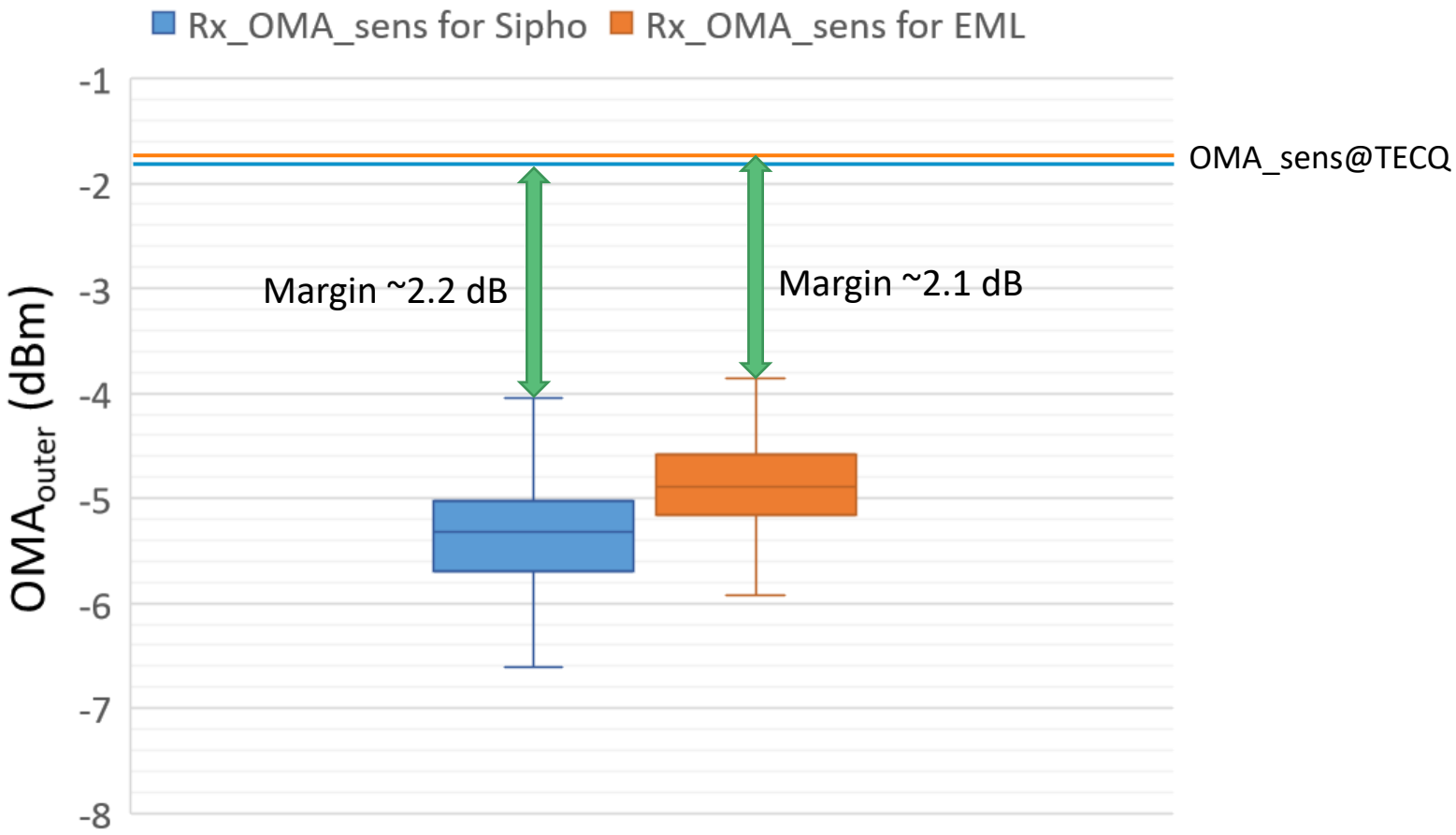
Rx_sens_OMA$_{outer}$ Distribution (DR & FR4-500)

- The Rx DUTs are Sipho based **1.6T 2xDR4 & 2xFR4-500**, the TECQ of the test Tx is in range of **2.4-2.9 dB & 2.3-2.7 dB**, respectively
- Rx sensitivities were tested **@ pre-FEC BER 2E-5**, which should be adequate for receiver error mask
- The distribution covers more than 2k data samples (86pcs x 8ch x 3-temp) and two main DSP suppliers. The upper control limit (99.3%) keeps **~2.1 dB** margin for DR spec @TECQ=2.4dB(min), and **~2.4 dB** margin for FR4-500 spec @TECQ=2.3dB(min)



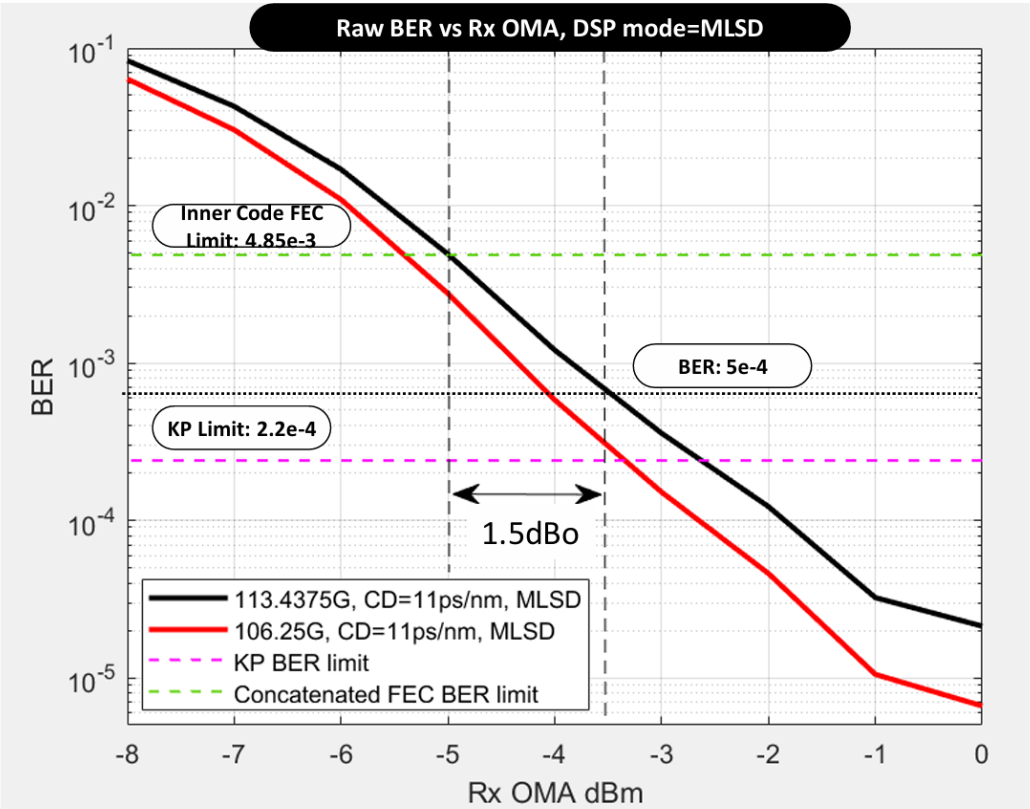
Comparison of Rx_sens_OMA$_{outer}$ (Siph vs EML)

- Both the Siph and the EML transceivers being tested are based on the same DSP and TIA.
- Siph based module WLs are normal FR4, while EML wavelengths only cover negative dispersion part of FR4
- The difference of margin between Siph and EML is almost negligible



Additional margin w/ Inner FEC for FR4

- The simulation results in [parthasarathy_3dj_01_2303] show ~1.5dB coding gain with Inner FEC



Proposed updates for 802.3dj Optical PMD Tx/Rx_sens OMA_{outer} Specs

Current Specs	DRx	FR4-500	DRx-2	FR4	LR4	Unit
Tx OMA_{outer}, each lane (min) for TECQ ≤ 0.9 dB	-0.1	0.9	-0.1	0.8	1.9 (TECQ ≤ 1.4dB)	dBm
Rx sensitivity (OMAouter), each lane (max) for TECQ ≤ 0.9 dB	-3.4	-3.2	-4.4	-3.7	-5.5 (TECQ ≤ 1.4dB)	dBm

↓ 0.6 dB ↓ 0.8 dB ↓ 0.7 dB

Proposed Specs	DRx	FR4-500	DRx-2	FR4	LR4	Unit
Tx OMA_{outer}, each lane (min) for TECQ ≤ 0.9 dB	-0.7	0.1	-0.1	0.1	1.9 (TECQ ≤ 1.4dB)	dBm
Rx sensitivity (OMA_{outer}), each lane (max) for TECQ ≤ 0.9 dB	-4.0	-4.0	-4.4	-4.4	-5.5 (TECQ ≤ 1.4dB)	dBm

Summary

- We presented large number of product samples data showing Rx Sensitivity with good margin (>2 dB) vs. baseline Rx_Sens_OMA_max specification

- For high-speed optical transceivers, majority of power dissipation and cost are from maintaining transmitter output power with acceptable quality. Shifting Rx_sens_OMA_max and Tx_OMA_min. to lower level is doable and worthwhile to reduce module power dissipation and cost

- We propose to
  - Reduce **0.6dB** for Rx_sens_OMA_max & Tx_OMA_min for DR
  - Reduce **0.8dB** for Rx_sens_OMA_max & Tx_OMA_min for FR4-500
  - Reduce **0.7dB** for Rx_sens_OMA_max & Tx_OMA_min for FR4

Suggested remedy for DR Tx (reduce 0.6dB)

Table 180–7—200GBASE-DR1, 400GBASE-DR2, 800GBASE-DR4, and 1.6TBASE-DR8 transmit characteristics

Description	Reference	200GBASE-DR1	400GBASE-DR2 800GBASE-DR4 1.6TBASE-DR8	Unit
Signaling rate, each lane (range)	—	106.25 ± 50 ppm		GBd
Modulation format	—	PAM4		—
Lane wavelength (range)	180.9.3	1304.5 to 1317.5		nm
Side-mode suppression ratio (SMSR), each lane (min)	180.9.3	30		dB
Average launch power, each lane (max)	180.9.4	4		dBm
Average launch power, each lane[a] (min)	180.9.4	~~-3.1~~[b] -3.7		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (max)	180.9.5	4.2		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) < 0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB	180.9.5		~~-0.1~~ -0.7 -1.6 ~~-1~~ + max(TECQ, TDECQ)	dBm dBm

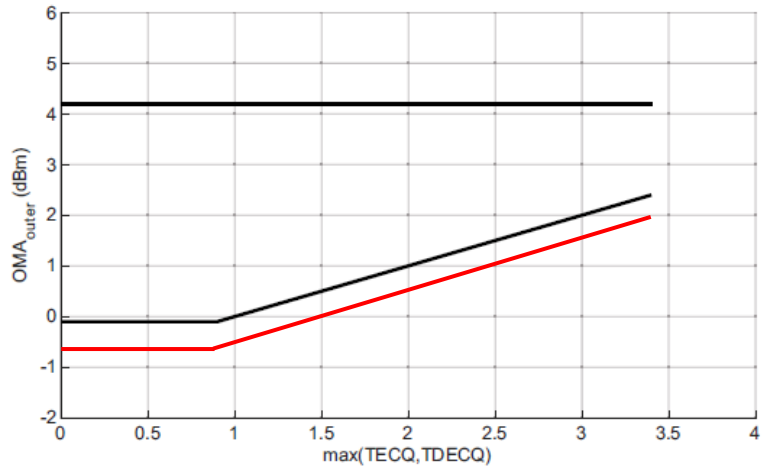


Figure 180–3—OMA_{outer} each lane (max) and OMA_{outer} each lane (min) versus max(TECQ, TDECQ)

Suggested remedy for DR Rx (reduce 0.6dB)

Table 180–8—200GBASE-DR1, 400GBASE-DR2, 800GBASE-DR4, and 1.6TBASE-DR8 receive characteristics

Description	Reference	Value	Unit
Signaling rate, each lane (range)	—	106.25 ± 50 ppm	GBd
Modulation format	—	PAM4	—
Lane wavelengths (range)	180.9.3	1304.5 to 1317.5	nm
Damage threshold[a], each lane	—	5	dBm
Average receive power, each lane (max)	—	4	dBm
Average receive power, each lane[b] (min)	—	~~-6.1~~ -6.7	dBm
Receive power (OMA_{outer}), each lane (max)	—	4.2	dBm
Receiver reflectance (max)	—	–26	dB

Description	Reference	Value	Unit
Receiver sensitivity (OMA_{outer}), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ	180.9.15	 ~~-3.4~~ -4.0 -4.9 ~~-4.3~~ + TECQ	dBm
Stressed receiver sensitivity (OMA_{outer}), each lane[c] (max)	180.9.16	~~-0.9~~ -1.5	dBm
Conditions of stressed receiver sensitivity test[d]:			
Stressed eye closure for PAM4 (SECQ), lane under test	—	3.4	dB
OMA_{outer} of each aggressor lane[e]	—	4.2	dBm

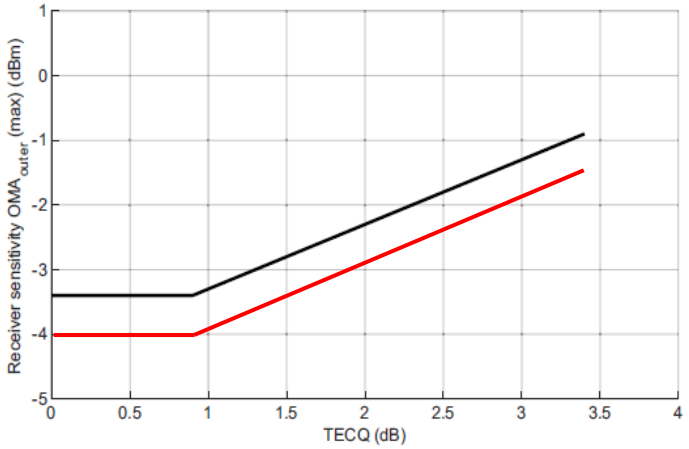


Figure 180–4—Receiver sensitivity (OMA_{outer}), each lane (max)

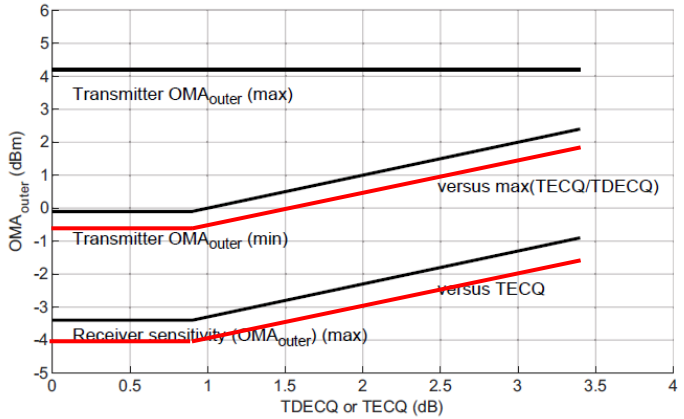


Figure 180–5—Transmitter OMA_{outer} each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA_{outer}) each lane versus TECQ

Suggested remedy for FR4-500 Tx (reduce 0.8dB)

Table 181–5—800GBASE-FR4-500 transmit characteristics

Description	Reference	800GBASE-FR4-500	Unit
Signaling rate, each lane (range)	—	106.25 ± 50 ppm	GBd
Modulation format	—	PAM4	—
Lane wavelengths (range)	181.9.3	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Side-mode suppression ratio (SMSR), each lane (min)	181.9.3	30	dB
Total average launch power (max)	181.9.4	10.9	dBm
Average launch power, each lane (max)		4.9	dBm
Average launch power, each lane[a] (min)		~~−2.1~~[b] -2.9	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (max)	181.9.5	4.8	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) <0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB		 ~~0.9~~ 0.1 -0.8 + max(TECQ, TDECQ)	 dBm dBm

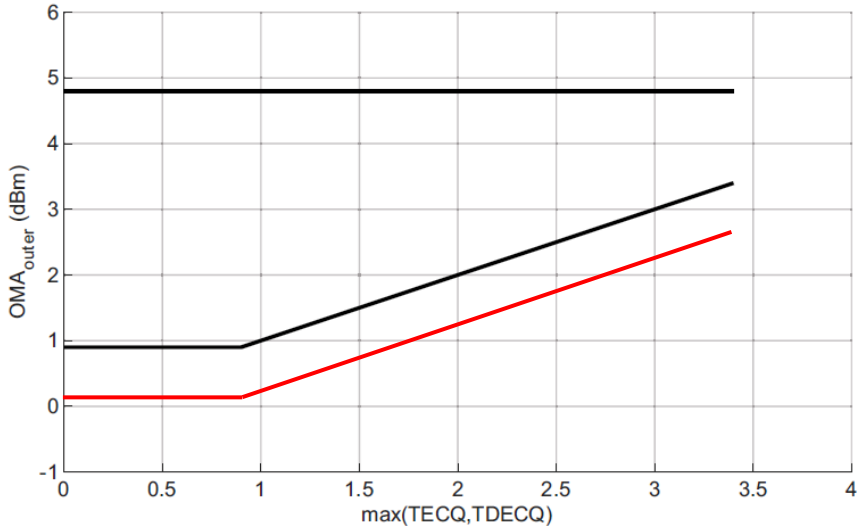


Figure 181–3—OMA_{outer} each lane (max) and OMA_{outer} each lane (min) versus max(TECQ, TDECQ)

Suggested remedy for FR4-500 Rx (reduce 0.8dB)

Table 181–6—800GBASE-FR4-500 receive characteristics

Description	Reference	800GBASE-FR4-500	Unit
Signaling rate, each lane (range)	—	106.25 ± 50 ppm	GBd
Modulation format	—	PAM4	—
Lane wavelengths (range)	181.9.3	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Damage threshold[a], each lane	—	5.9	dBm
Average receive power, each lane (max)	—	4.9	dBm
Average receive power, each lane[b] (min)	—	~~–5.6~~ -6.4	dBm
Receive power (OMA_{outer}), each lane (max)	—	4.8	dBm
Difference in receive power between any two lanes (OMA_{outer}) (max)	—	4.1	dB
Receiver reflectance (max)	—	–26	dB
Receiver sensitivity (OMA_{outer}), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ	181.9.15	 ~~–3.2~~ -4.0 -4.9 ~~–4.1~~ + TECQ	 dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane[c] (max)	181.9.16	~~–0.7~~ -1.5	dBm
Conditions of stressed receiver sensitivity test:[d]			
Stressed eye closure for PAM4 (SECQ), lane under test	—	3.4	dB
OMA_{outer} of each aggressor lane	—	1.3	dBm

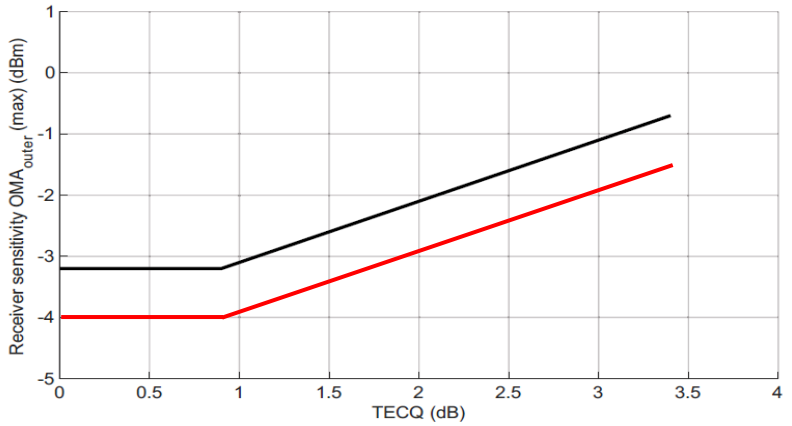


Figure 181–4—Receiver sensitivity (OMA_{outer}), each lane (max)

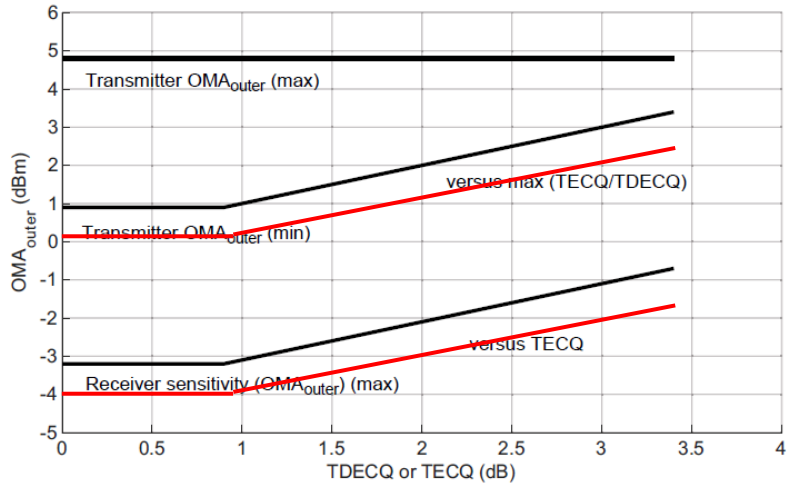


Figure 181–5—Transmitter OMA_{outer} each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA_{outer}) each lane versus TECQ

Suggested remedy for FR4 Tx (reduce 0.7dB)

Table 183–6—800GBASE-FR4 and 800GBASE-LR4 transmit characteristics

Description	Defined in	800GBASE-FR4	800GBASE-LR4	Unit
Signaling rate, each lane (range)	—	113.4375 ± 50 ppm		GBd
Modulation format	—	PAM4		—
Lane wavelengths (range)	183.9.3	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	1294.53 to 1296.59 1299.02 to 1301.09 1303.54 to 1305.63 1308.09 to 1310.19	nm
Side-mode suppression ratio (SMSR), each lane (min)	183.9.3	30		dB
Total average launch power (max)	183.9.4	10.9	11.5	dBm
Average launch power, each lane (max)	183.9.4	4.9	5.5	dBm
Average launch power, each lane[a] (min)	183.9.4	~~−2.2~~[b] -2.9	−1.1[c]	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (max)	183.9.5	4.8	5.7	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) <0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB for max(TECQ, TDECQ) <1.4 dB for 1.4 dB ≤ max(TECQ, TDECQ) ≤ 3.9 dB	183.9.5	 ~~0.8~~ 0.1 ~~Equation (183–1)~~ -0.8 + max(TECQ, TDECQ)	 — — 1.9 ~~Equation (183–2)~~ 0.5 + max(TECQ, TDECQ)	 dBm dBm dBm dBm

~~0.1 + max(TECQ, TDECQ)~~ ~~(183–1)~~

~~0.5 + max(TECQ, TDECQ)~~ ~~(183–2)~~

The values for OMA_{outer} each lane (min) in Table 183–6 vary with max(TECQ, TDECQ). The relationships are illustrated in Figure 183–3 along with the values for OMAouter each lane (max).

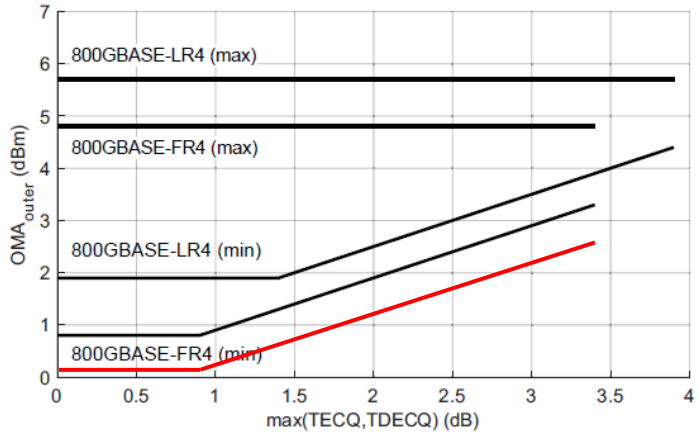


Figure 183–3—OMAouter each lane (max) and OMAouter each lane (min) versus max(TECQ, TDECQ) for 800GBASE-FR4 and 800GBASE-LR4

Suggested remedy for FR4 Rx (reduce 0.7dB)

Table 183–7—800GBASE-FR4 and 800GBASE-LR4 receive characteristics

Description	Defined in	800GBASE-FR4	800GBASE-LR4	Unit
Signaling rate, each lane (range)	—	113.4375 ± 50 ppm		GBd
Modulation format	—	PAM4		—
Lane wavelengths (range)	183.9.3	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	1294.53 to 1296.59 1299.02 to 1301.09 1303.54 to 1305.63 1308.09 to 1310.19	nm
Damage threshold[a], each lane	—	5.9	6.5	dBm
Average receive power, each lane (max)	—	4.9	5.5	dBm
Average receive power, each lane[b] (min)	—	~~–6.2~~ -6.9	–7.4	dBm
Receive power (OMA_{outer}), each lane (max)	—	4.8	5.7	dBm
Difference in receive power between any two lanes (OMA_{outer}) (max)	—	4.1	3.3	dB
Receiver reflectance (max)	—	–26		dB
Receiver sensitivity (OMA_{outer}), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ for TECQ < 1.4 dB for 1.4 dB ≤ TECQ ≤ SECQ	183.9.15	~~–3.7~~ -4.4 -5.3 ~~–4.6~~ + TECQ — —	— — –5.5 –6.9 + TECQ	dBm dBm dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane[c] (max)	183.9.16	~~–1.2~~ -1.9	–3	dBm
Conditions of stressed receiver sensitivity test:[d]				
Stressed eye closure for PAM4 (SECQ), lane under test	—	3.4	3.9	dB
OMA_{outer} of each aggressor lane	—	0.8	0.3	dBm

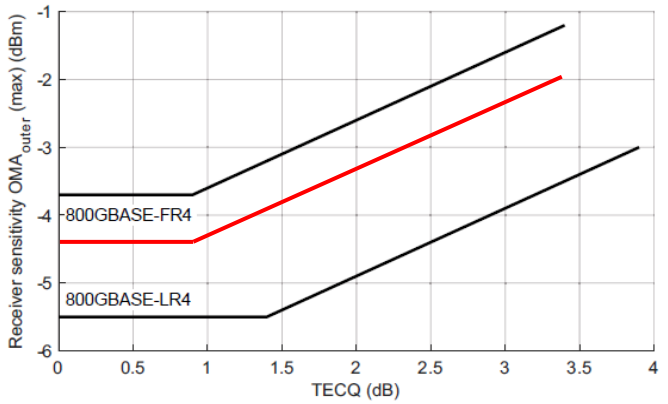


Figure 183–4—Receiver sensitivity (OMA_{outer}), each lane (max) for 800GBASE-FR4 and 800GBASE-LR4

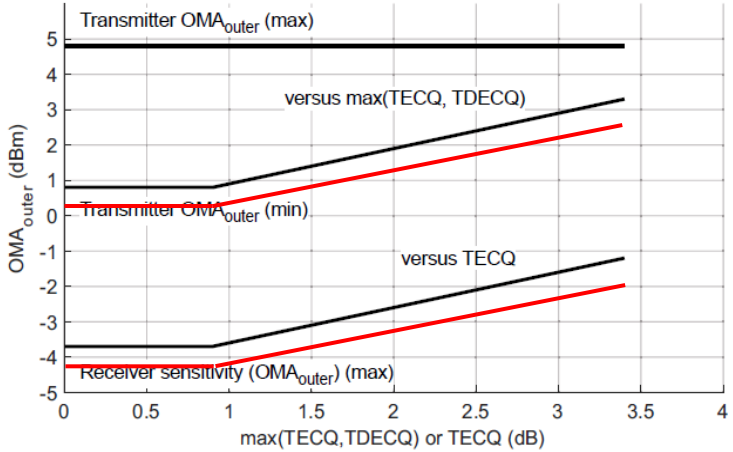


Figure 183–5—Transmitter OMA_{outer} each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA_{outer}) each lane versus TECQ for 800GBASE-FR4

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THANK YOU