Tx Headroom Budget for 400GBASE-LR4-6

Jan. 20, 2020

R. Okabe, H. Isono
Fujitsu Optical Components, Ltd.

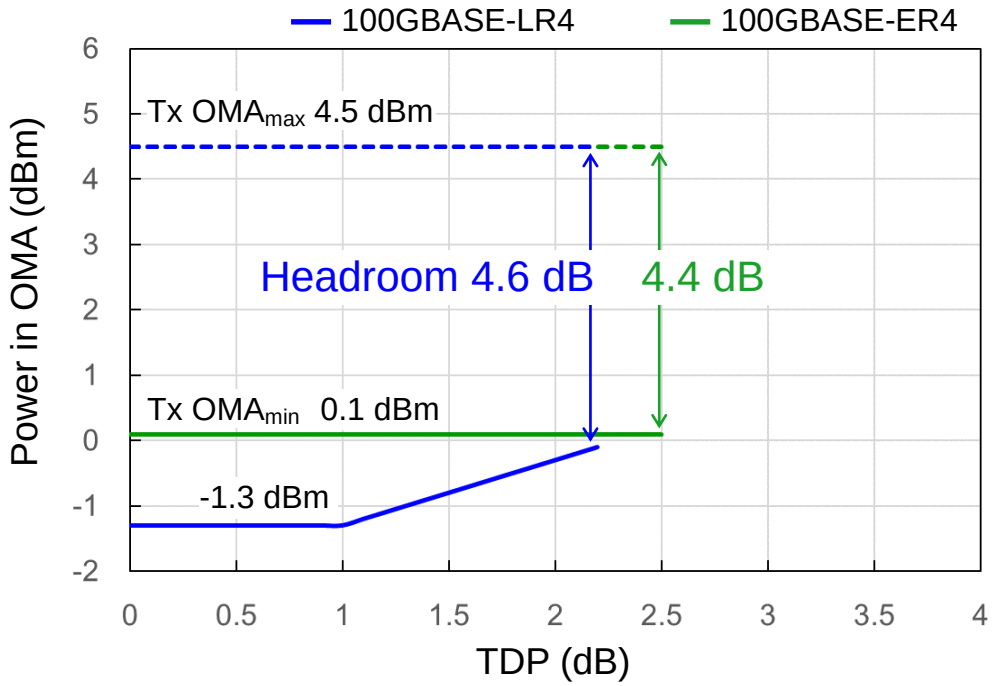
Preliminary Remarks

- This contribution will provide some thoughts on Tx headroom specification. By comparing the Tx headroom margin of 400GBASE-LR4-6 with 100BASE-LR4 & ER4, the margin for current 400GBASE-LR4-6 spec seems to be insufficient and refinement would be required. A reasonable margin will be highly expected for 400GBASE LR4-6 from a view point of basic elements for Tx headroom budget.
- This content is not be in time for the comments against D1.1, however it will be proposed for D2.X comment for further discussions. Discussion on Tx headroom is highly expected among the industry to define reasonable specification.

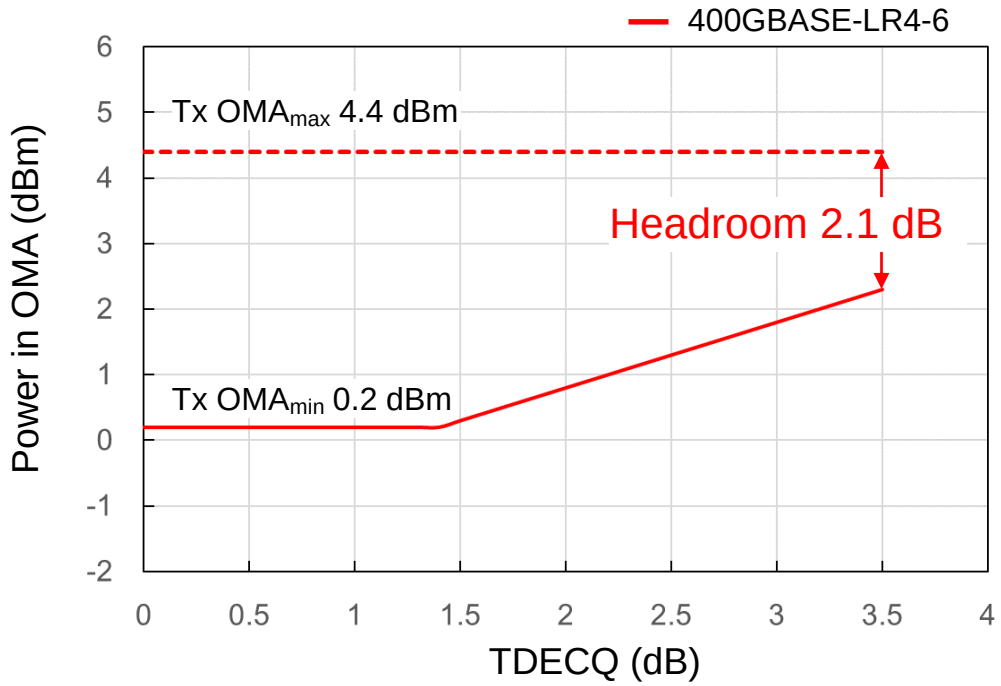
Tx Headroom Spec Comparison with 100GBASE-LR4 & ER4

- Tx headroom specification for 100GBASE-LR4 & ER4 is illustrated and compared with 400GBASE-LR4-6.
- Headroom for 100GBASE-LR4 & ER4 are 4.6 dB & 4.4 dB, respectively.
- Headroom for 400GBASE-FR4-6 is only 2.1 dB which is lower by ≥ 2.3 dB.

- 100GBASE-LR4 & ER4 (IEEE802.3-2018, table 88-7)



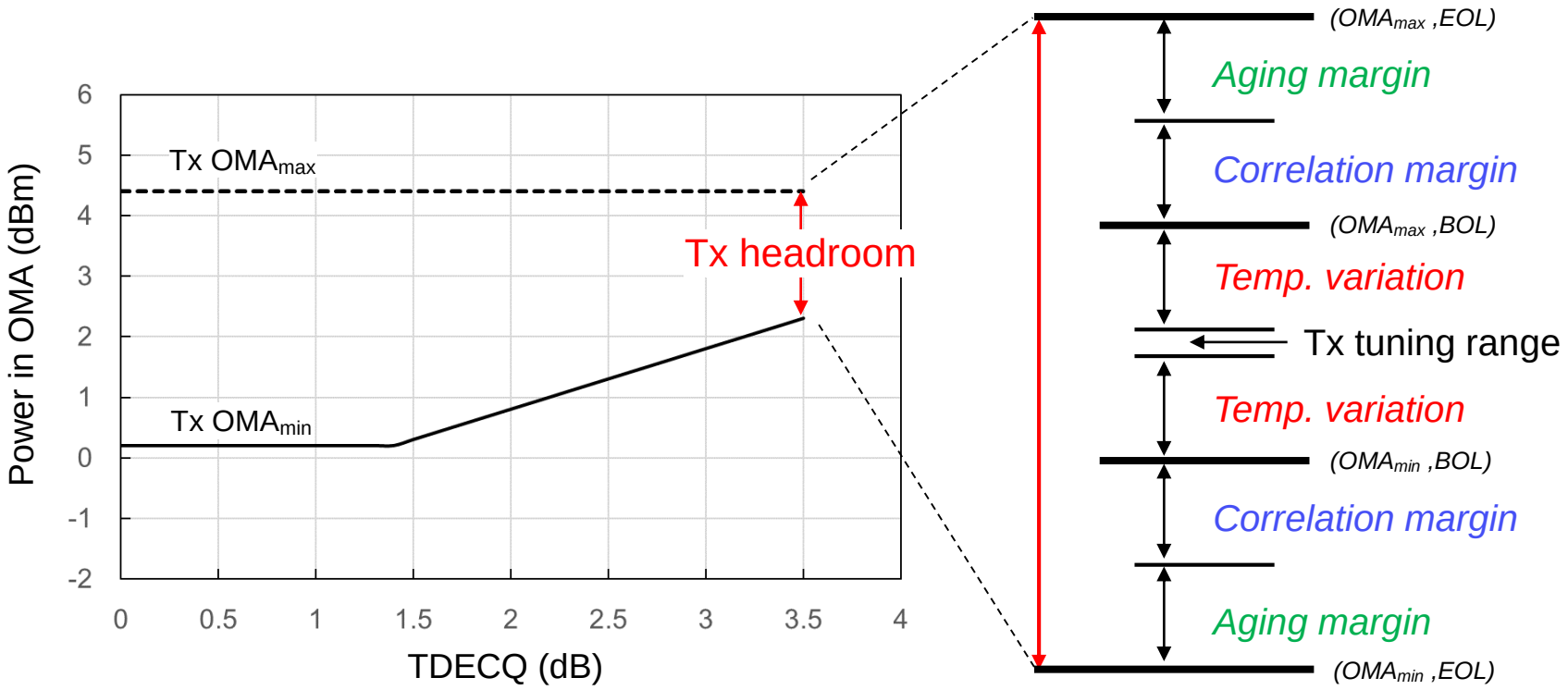
- 400GBASE-LR4-6 (IEEE802.3cu, table 151-7)



Tx Headroom Budget

- Manufacturing margins for Tx headroom consist of the following elements;
  - Tx tuning range
  - Temp. variation
  - Correlation margin
  - Aging margin

- ≥ 2.5-dB Tx headroom is required for manufacturing margin on 400GBASE-LR4-6 spec
- 0.4 dB enhancement is highly expected for Tx headroom (from 2.1 dB to 2.5 dB)



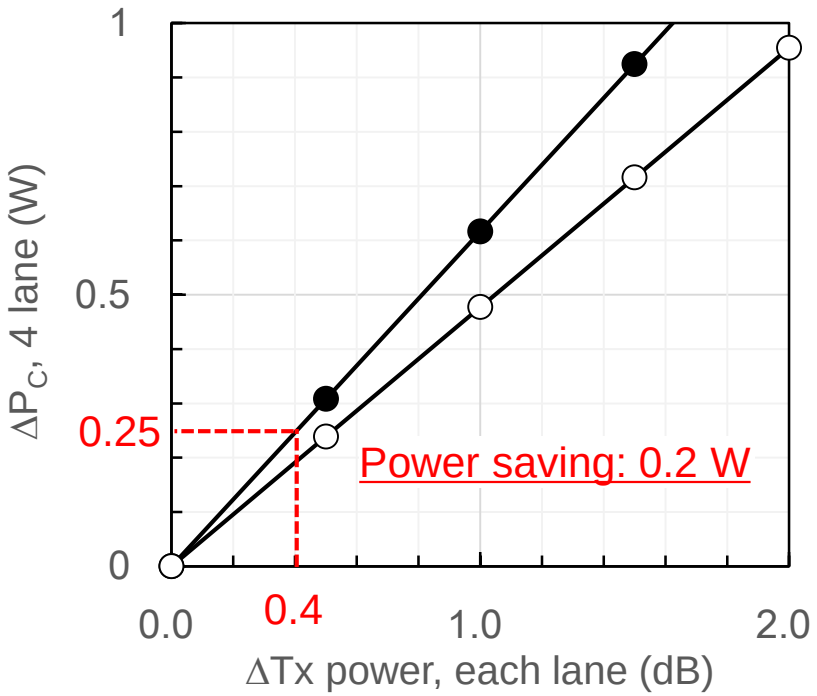
Items for each element

Temperature variation
Tracking error
Temp. variation of circuit
etc.
Correlation margin
Connector loss variation
Test equipment difference
etc.
Aging margin
Aging degradation

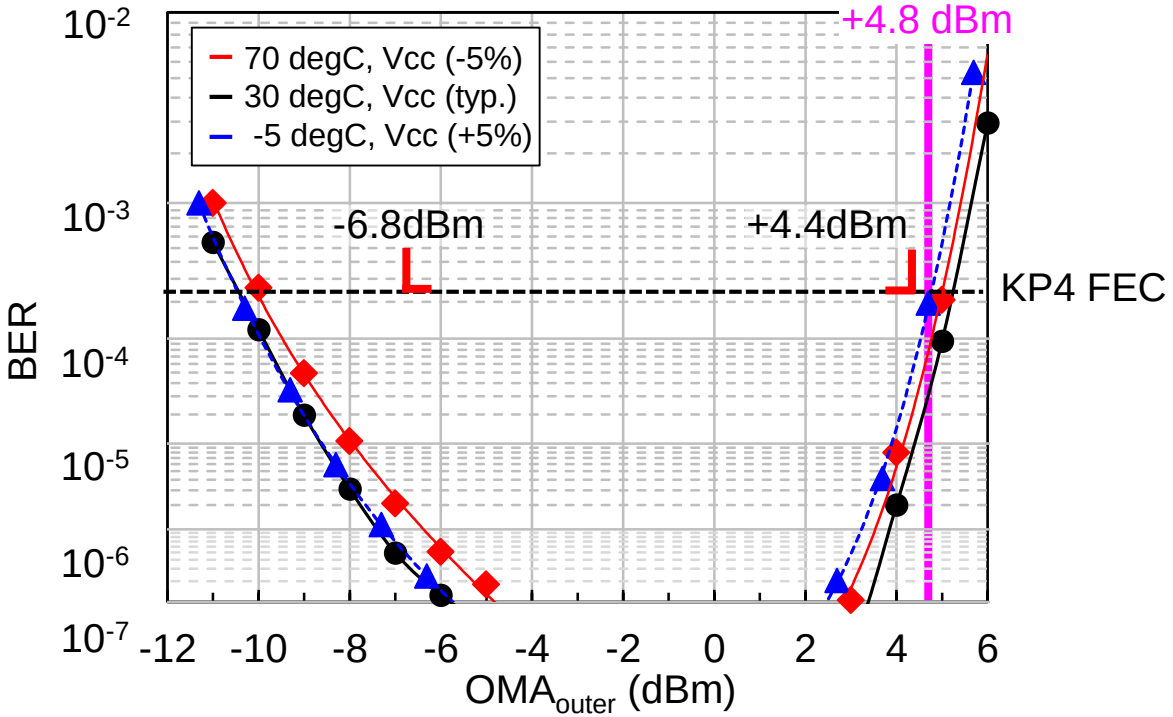
Possible Solution for Tx Headroom Enhancement

- Possible solutions will be as below;
  - Option-1: reduce Tx OMA_{min} from +0.2 to -0.2 dB by 0.4 dB
  - Option-2: increase Tx OMA_{max} from 4.4 to 4.8 dB by 0.4 dB
  - (Rx sensitivity should be changed for corresponding to the option-1 & option-2)
- Cons & pros for each option

Option-1: 0.25-W power saving



Option-2: overload issue for Rx sensitivity

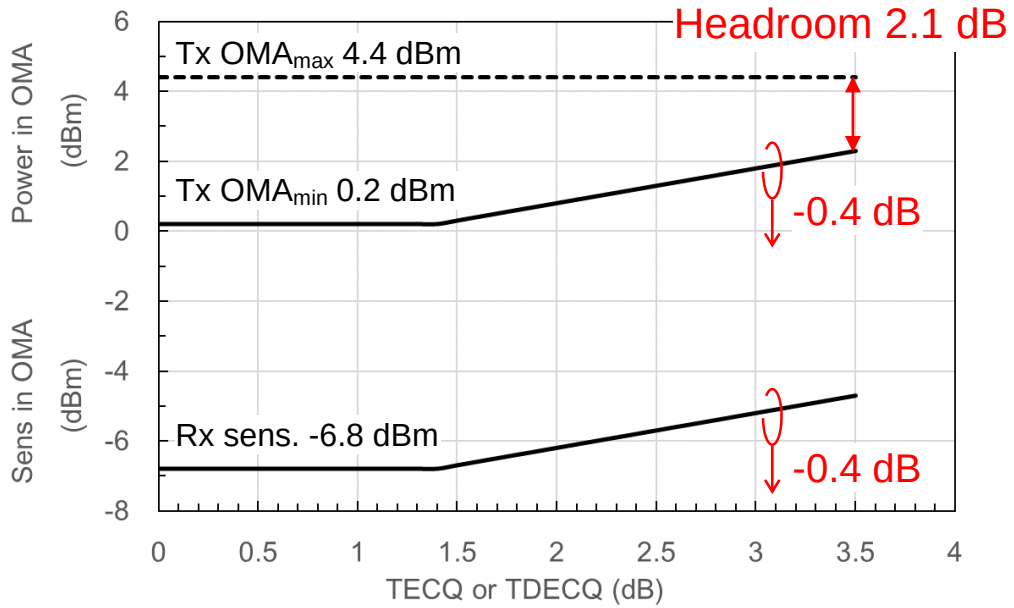


Reference: okabe_3cu_01_0719, Vienna plenary meeting (2019)

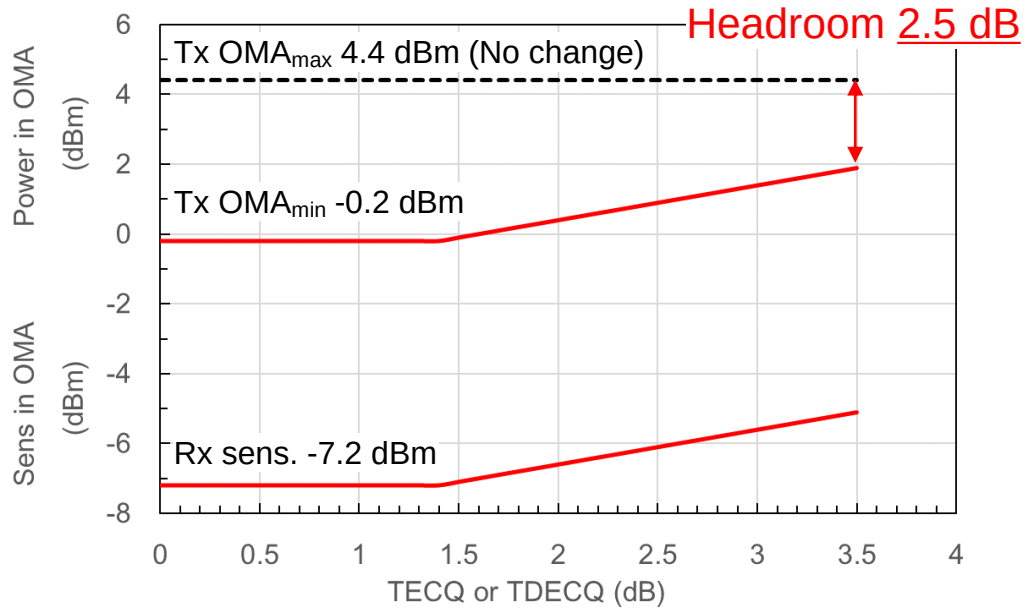
Summary & Proposed Changes for 400G-LR4-6

- Thoughts on Tx headroom budget for 400GBASE-LR4-6 was provided. Tx headroom of 2.5 dB is required for Tx tuning range, temp. variation, correlation and aging margin.
- To keep ≥ 2.5-dB Tx headroom for 400GBASE-LR4-6, 0.4-dB reduction for Tx OMA and Rx sensitivity is highly expected.

Tx OMA & Rx sens. (draft 1.1 based)



Tx OMA & Rx sens. (expected revision)



Proposed Changes:
Transmit & Receive Characteristics for 400G-LR4-6

- Proposed changes: 0.4-dB reduction for Tx OMA and Rx sensitivity
  - Tx changes: table151-7 “400GBASE-FR4 and 400GBASELR4-6 transmit characteristics”
  - Rx changes: equation (151-3) in the section of “151.8.10 Receiver sensitivity”

Table 151–7—400GBASE-FR4 and 400GBASE-LR4-6 transmit characteristics

Description	400GBASE-FR4	400GBASE-LR4-6	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm		GBd
Modulation format	PAM4		—
Lane wavelengths (range)	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), (min)	30		dB
Total average launch power (max)	9.5	11.6	dBm
Average launch power, each lane (max)	3.5	5.6	dBm
Average launch power, each lane[a] (min)	–3.3	~~–2.8~~ -3.2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min)[b]	–0.3	~~–0.2~~ -0.2	dBm
Difference in launch power between any two lanes (OMA_{outer}) (max)	4	4	dB

151.8.10 Receiver sensitivity

For 400GBASE-FR4, receiver sensitivity is informative and is defined for a transmitter with a value of SECQ up to 3.4 dB. Receiver sensitivity should meet Equation (151–1), which is illustrated in Figure 151–6.

For 400GBASE-LR4-6, receiver sensitivity is informative and is defined for a transmitter with a value of SECQ up to 3.5 dB. Receiver sensitivity should meet Equation (151–2), which is illustrated in Figure 151–6.

$$RS = \max(-4.6, SECQ - 6) \quad \text{(dBm)} \qquad (151\text{–}1)$$

$$RS = \max(\sout{-6.8}, SECQ - 8.2) \quad \text{(dBm)} \qquad (151\text{–}2)$$

-7.2

where

RS is the receiver sensitivity

SECQ is the SECQ of the transmitter used to measure the receiver sensitivity

Proposed Changes in Figure 151-6

- Proposed changes: 0.4-dB reduction for Tx OMA and Rx sensitivity
- Rx changes: Figure 151-6 “Illustration of receiver sensitivity for 400GBASE-FR4 and 400GBASE-LR4-6”

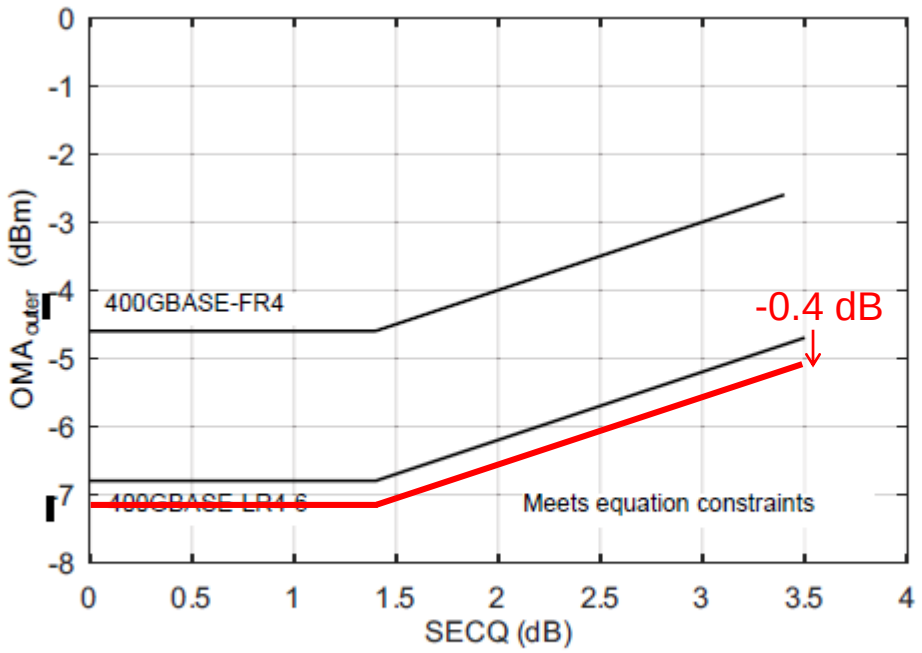


Figure 151–6—Illustration of receiver sensitivity for 400GBASE-FR4 and 400GBASE-LR4-6

Thank you