

# Proposed changes to 802.3cu D2.1 PMD specs (comment #8)

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# Background

During the May 5th 802.3cu ad-hoc conference call, several PMD spec changes were proposed in [cole 3cu adhoc 050520 v4](#)

A number of straw polls were taken and provided a consensus direction on the proposed changes ([minutes 3cu adhoc 050520](#))

The results of the straw polls can be summarized as follows.

Technical changes:

1. Change TDECQ(max), TECQ(max) and SECQ(max) for 400GBASE-LR4-6 from 3.5dB to 3.4dB
2. Change to a single extinction ratio range for the specification of TxOMA and Power Budget (at max TDECQ) for all PMDS, with values consistent with those defined for ER<4.5.
3. Use TECQ rather than SECQ when representing RS requirements.

Editorial changes:

4. Change how TxOMA requirements are represented in the “transmit characteristics” tables.
5. Change how RS requirements are represented in the “receive characteristics” tables.

# Straw Poll Results (5<sup>th</sup> May Ad Hoc)

## **Straw Poll #1:**

I would support changing the TDECQ(max), TECQ(max) and SECQ(max) values for 400GBASE-LR4-6 from 3.5dB to 3.4dB as proposed in slide 3 of cole\_3cu\_adhoc\_050520\_v4.

Yes: 19

No: 4

## **Straw Poll #2:**

I would support changing to a single extinction ratio range for the specification of TxOMA for 400GBASE-FR4 and 400GBASE-LR4-6, with values consistent with those defined for ER<4.5 in the D2.1 draft.

Yes: 17

No: 5

## **Straw Poll #3:**

I would support changing to a single extinction ratio range for the specification of TxOMA for 100GBASE-FR1 and 100GBASE-LR1, with values consistent with those defined for ER<4.5 in the D2.1 draft.

Yes: 16

No: 5

# Straw Poll Results (5<sup>th</sup> May Ad Hoc)

## **Straw Poll #4:**

For representing TxOMA requirements in the “transmit characteristics” tables, I would prefer:

- A. Editorial Alternative 1 in slide 4 of cole\_3cu\_adhoc\_050520\_v4
- B. Editorial Alternative 2 in slide 4 of cole\_3cu\_adhoc\_050520\_v4
- C. No strong opinion

A: 6 B: 14 C: 8

## **Straw Poll #5:**

For representing RS requirements in the “receive characteristics” tables, I would prefer:

- A. Editorial Alternative 1 in slide 5 of cole\_3cu\_adhoc\_050520\_v4
- B. Editorial Alternative 2 in slide 5 of cole\_3cu\_adhoc\_050520\_v4
- C. No strong opinion

A: 5 B: 16 C: 7

## **Straw Poll #6:**

For representing RS requirements in the “receive characteristics tables, I would prefer to use TECQ or SECQ in the tables:

- A. TECQ
- B. SECQ

A: 18 B: 8

# Overview

During offline consensus discussions following the May 5th ad-hoc call, a few minor issues were identified with some of the values in [cole\\_3cu\\_adhoc\\_050520\\_v4](#) (that don't change the intent or direction of the straw poll results).

This presentation captures a consolidated view of all the changes required to the P802.3cu D2.1 draft and is in support of comment #8 (changes from D2.1 are highlighted in blue text).

# Clause 140

# Changes to Table 140-6

Table 140-6—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 transmit characteristics

Description	Value 100GBASE-DR	100GBASE-FR1	100GBASE-LR1	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
Wavelength (range)	1304.5 to 1317.5			nm
Side-mode suppression ratio (SMSR), (min)	30			dB
Average launch power (max)	4	<u>4</u>	<u>4.8</u>	dBm
Average launch power <sup>a</sup> (min)	-2.9	<u>-2.9</u>	<u>-2-1.9</u>	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ) (max)	4.2	<u>4.2</u>	<u>5</u>	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ) (min) <sup>b</sup> : for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	-0.8	<u>-0.2</u> <u>-0.1</u> <u>-1.5 + TDECQ</u>	<u>±</u> <u>1.1</u> <u>-0.3 + TDECQ</u>	dBm dBm dBm
Launch power in OMA <sub>outer</sub> minus TDECQ (min): for extinction ratio ≥ 5 dB for extinction ratio < 5 dB for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	-2.2 -1.9 <u>—</u> <u>—</u>	<u>—</u> <u>—</u> <u>-1.6</u> <u>-1.5</u>	<u>—</u> <u>—</u> <u>-0.4</u> <u>-0.3</u>	dBm dBm dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	3.4	<u>3.4</u>	<u>3.4</u>	dB
TDECQ - 10log <sub>10</sub> (C <sub>eq</sub> ) (max) <sup>c</sup>	3.4	<u>—</u>	<u>—</u>	dB



# Changes to Table 140-6 (cntd)

Description	Value <u>100GBASE-DR</u>	<u>100GBASE-FR1</u>	<u>100GBASE-LR1</u>	Unit
<u>TECQ (max)</u>	—	<u>3.4</u>	<u>3.4</u>	<u>dB</u>
<u>  TDECQ - TECQ   (max)</u>	—	<u>2.5</u>	<u>2.5</u>	<u>dB</u>
Average launch power of OFF transmitter (max)	-15	<u>-15</u>	<u>-15</u>	dBm
Extinction ratio (min)	3.5	<u>3.5</u>	<u>3.5</u>	dB
Transmitter transition time (max)	17	<u>17</u>	<u>17</u>	ps
<u>Transmitter over/under-shoot (max)</u>	—	<u>22</u>	<u>22</u>	<u>%</u>
<u>Transmitter peak-to-peak power (max)</u>	—	<u>5</u>	<u>5.8</u>	<u>dBm</u>
<u>RIN<sub>15.5</sub>-OMA (max)</u> <u>RIN<sub>x</sub>-OMA (max), where x is the optical return loss tolerance (max)</u>	-136	<u>-136</u>	<u>-136</u>	dB/Hz
Optical return loss tolerance (max)	15.5	<u>17.1</u>	<u>15.6</u>	dB
Transmitter reflectance <sup>d</sup> (max)	-26	<u>-26</u>	<u>-26</u>	dB

<sup>a</sup>Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

<sup>b</sup>For 100GBASE-DR, Even if the TDECQ < 1.4 dB for an extinction ratio of ≥ 5 dB or TDECQ < 1.1 dB for an extinction ratio of < 5 dB, the OMA<sub>outer</sub> (min) must exceed this value. ~~For 100GBASE-FR1, or 100GBASE-LR1, even if the TDECQ < 1.4 dB for an extinction ratio of ≥ 4.5 dB or TDECQ < 1.3 dB for an extinction ratio of < 4.5 dB, the OMA<sub>outer</sub> (min) must exceed this value.~~

<sup>c</sup>C<sub>eq</sub> is a coefficient defined in 121.8.5.3, which accounts for the reference equalizer noise enhancement.

<sup>d</sup>Transmitter reflectance is defined looking into the transmitter.

# Changes to Table 140-7

Table 140-7—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 receive characteristics

Description	Value <u>100GBASE-DR</u>	<u>100GBASE-FR1</u>	<u>100GBASE-LR1</u>	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
Wavelengths (range)	1304.5 to 1317.5			nm
Damage threshold <sup>a</sup>	5	<u>5</u>	<u>5.8</u>	dBm
Average receive power (max)	4	<u>4</u>	<u>4.8</u>	dBm
Average receive power <sup>b</sup> (min)	-5.9	<u>-6.9</u>	<del>-8.3</del> -8.2	dBm
Receive power (OMA <sub>outer</sub> ) (max)	4.2	<u>4.2</u>	<u>5</u>	dBm
Receiver reflectance (max)	-26	<u>-26</u>	<u>-26</u>	dB
Receiver sensitivity (OMA <sub>outer</sub> ) <sup>e</sup> (max)	Equation (140-1) <sup>c</sup>	—	—	dBm
for <u>SECQTECQ</u> < 1.4 dB	—	<u>-4.5</u>	<u>-6.1</u>	<u>dBm</u>
for 1.4 dB ≤ <u>SECQTECQ</u> ≤ 3.4 dB	—	<u>-5.9 + SECQTECQ</u>	<u>-7.5 + SECQTECQ</u>	<u>dBm</u>
Stressed receiver sensitivity (OMA <sub>outer</sub> ) <sup>d</sup> (max)	-1.9	<u>-2.5</u>	<u>-4.1</u>	dBm
Conditions of stressed receiver sensitivity test: <sup>e</sup>				
Stressed eye closure for PAM4 (SECQ)	3.4	<u>3.4</u>	<u>3.4</u>	dB
SECQ - 10log <sub>10</sub> (C <sub>eq</sub> ) <sup>f</sup> (max)	3.4	—	—	dB

# Changes to Table 140-8

Table 140-8—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 illustrative link power budgets

Parameter	Value 100GBASE-DR	100GBASE-FR1	100GBASE-LR1	Unit
Power budget (for max TDECQ): for extinction ratio $\geq 5$ dB for extinction ratio $< 5$ dB <del>for extinction ratio <math>\geq 4.5</math> dB</del> <del>for extinction ratio <math>&lt; 4.5</math> dB</del>	6.5	<u>7.8</u>	<u>10.6</u>	dB
	6.8	=	=	dB
	=	<u>7.7</u>	<u>10.5</u>	<del>dB</del>
	=	<u>7.8</u>	<u>10.6</u>	<del>dB</del>
Operating distance	500	<u>2 000</u>	<u>10 000</u>	m
Channel insertion loss <sup>a,b</sup>	See 140.9	<u>4</u>	<u>6.3</u>	dB
Maximum discrete reflectance	-35	<u>See 140.10.2.2</u>	<u>See 140.10.2.2</u>	dB
Allocation for penalties <sup>c</sup> (for max TDECQ): for extinction ratio $\geq 5$ dB  for extinction ratio $< 5$ dB  <del>for extinction ratio <math>\geq 4.5</math> dB</del> <del>for extinction ratio <math>&lt; 4.5</math> dB</del>	6.5 minus max channel insertion loss per Table 140-12	<u>3.8</u>	<u>4.3</u>	dB
	6.8 minus max channel insertion loss per Table 140-12	=	=	dB
	=	<u>3.7</u>	<u>4.2</u>	<del>dB</del>
	=	<u>3.8</u>	<u>4.3</u>	<del>dB</del>
Additional insertion loss allowed	0	<u>0</u>	<u>0</u>	dB

# Changes to 140.7.9

The receiver sensitivity ( $OMA_{outer}$ ) shall be within the limits given in Table 140–7 for 100GBASE-FR1 and 100GBASE-LR1, if measured using a test pattern for receiver sensitivity in Table 140–10.

The conformance test signal at TP3 meets the requirements for a 100GBASE-FR1 or 100GBASE-LR1 transmitter followed by an attenuator.

The ~~SECQ-TECQ~~ of the conformance test signal is measured according to 140.7.5, except that the test fiber is not used. The measured value of ~~SECQTECQ~~ is then used to calculate the limit for receiver sensitivity ( $OMA_{outer}$ ) as specified in Table 140–7 and illustrated in Figure 140–5.

# Clause 151

# Changes to Table 151-7

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	10.2	dBm
Average launch power, each lane (max)	3.5	4.2	dBm
Average launch power, each lane <sup>a</sup> (min)	<del>-3.3</del> -3.2	<del>-2.8</del> -2.7	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ), each lane (min): for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	<del>-0.3</del> -0.2 -1.6 + TDECQ	<del>0.2</del> 0.3 -1.1 + TDECQ	dBm dBm
Difference in launch power between any two lanes (OMA <sub>outer</sub> ) (max)	4	4	dB
<del>Launch power in OMA<sub>outer</sub> minus TDECQ, each lane (min):</del> for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	<del>-1.7</del> -1.6	<del>-1.2</del> -1.1	dBm dBm

# Changes to Table 151-8

Table 151-8—400GBASE-FR4 and 400GBASE-LR4-6 receive 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
Damage threshold <sup>a</sup> , each lane	4.5	5.2	dBm
Average receive power, each lane (max)	3.5	4.2	dBm
Average receive power, each lane <sup>b</sup> (min)	<del>-7.3</del> -7.2	<del>-9.1</del> -9	dBm
Receive power (OMA <sub>outer</sub> ), each lane (max)	3.7	4.4	dBm
Difference in receive power between any two lanes (OMA <sub>outer</sub> ) (max)	4.1	4.3	dB
Receiver reflectance (max)	-26		dB
Receiver sensitivity (OMA <sub>outer</sub> ), each lane (max)	-4.6	-6.8	dBm
for SECQTECQ < 1.4 dB	-6 + SECQTECQ	-8.2 + SECQTECQ	dBm
for 1.4 dB ≤ SECQTECQ ≤ 3.4 dB	—	<del>-8.2 + SECQ</del>	<del>dBm</del>
for 1.4 dB ≤ SECQ ≤ 3.5 dB			
Stressed receiver sensitivity (OMA <sub>outer</sub> ), each lane <sup>c</sup> (max)	-2.6	<del>-4.7</del> -4.8	dBm
Conditions of stressed receiver sensitivity test: <sup>d</sup>			
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	<del>3</del> -3.4	dB
OMA <sub>outer</sub> of each aggressor lane	1.5	-0.4	dBm

# Changes to Table 151-9

**Table 151-9—400GBASE-FR4 and 400GBASE-LR4-6 illustrative link power budgets**

Parameter	400GBASE-FR4	400GBASE-LR4-6	Unit
Power budget (for maximum TDECQ):	7.8	10.5	
<del>for extinction ratio <math>\geq 4.5</math> dB</del>	<del>7.7</del>	<del>10.5</del>	<del>dB</del>
<del>for extinction ratio <math>&lt; 4.5</math> dB</del>	<del>7.8</del>	<del>10.6</del>	<del>dB</del>
Operating distance	2	6	km
Channel insertion loss	4 <sup>a</sup>	5 <sup>b</sup>	dB
Maximum discrete reflectance	See 151.11.2.2	See 151.11.2.2	dB
Allocation for penalties <sup>c</sup> (for maximum TDECQ):	3.8	4.2	dB
<del>for extinction ratio <math>\geq 4.5</math> dB</del>	<del>3.7</del>	<del>4.2</del>	<del>dB</del>
<del>for extinction ratio <math>&lt; 4.5</math> dB</del>	<del>3.8</del>	<del>4.3</del>	<del>dB</del>
Additional insertion loss allowed	0	1.3	dB

<sup>a</sup> The channel insertion loss is calculated using the maximum distance specified in Table 151-6 for 400GBASE-FR4 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 151.11.2.1.

<sup>b</sup> The channel insertion loss is calculated using the maximum distance specified in Table 151-6 for 400GBASE-LR4-6 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 151.11.2.1.

<sup>c</sup> Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.



# Changes to 151.8.12

## 151.8.12 Receiver sensitivity

The receiver sensitivity ( $OMA_{outer}$ ) of each lane shall be within the limits given in Table 151–8 for 400GBASE-FR4 and 400GBASE-LR4-6, if measured using a test pattern specified for receiver sensitivity in Table 151–11.

The conformance test signal applied at TP3 meets the requirements for a 400GBASE-FR4 or 400GBASE-LR4-6 transmitter followed by an attenuator. An optical demultiplexer may be used to separate the lane having the wavelength for the lane under test as specified in Table 151–8 for calibrating the  $SECQTECQ$ .

The  $SECQTECQ$  of the conformance test signal is measured according to ~~Table 151.8.5~~ 151.8.5, except that the test fiber is not used. The measured value of  $SECQTECQ$  is then used to calculate the limit for receiver sensitivity ( $OMA_{outer}$ ) as specified in Table 151–8 and illustrated in Figure 151–6 .

# Changes to Table 151-16

**Table 151-16—Channel insertion loss requirements for interoperation between 400GBASE-LR4-6 and 400GBASE-FR4**

Direction	Min loss	Max loss	Unit
400GBASE-LR4-6 transmitter to 400GBASE-FR4 receiver	0.7	4.5	dB
400GBASE-FR4 transmitter to 400GBASE-LR4-6 receiver	0	<del>6-16.2</del>	dB

# Backup

(clean version of changes)

# Clause 140

# Changes to Table 140-6 (clean)

Table 140-6—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 transmit characteristics

Description	Value 100GBASE-DR	100GBASE-FR1	100GBASE-LR1	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
Wavelength (range)	1304.5 to 1317.5			nm
Side-mode suppression ratio (SMSR), (min)	30			dB
Average launch power (max)	4	<u>4</u>	<u>4.8</u>	dBm
Average launch power <sup>a</sup> (min)	-2.9	<u>-2.9</u>	<u>-1.9</u>	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ) (max)	4.2	<u>4.2</u>	<u>5</u>	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ) (min) <sup>b</sup> : for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	-0.8	<u>-0.1</u> <u>-1.5 + TDECQ</u>	<u>1.1</u> <u>-0.3 + TDECQ</u>	dBm dBm
Launch power in OMA <sub>outer</sub> minus TDECQ (min): for extinction ratio ≥ 5 dB for extinction ratio < 5 dB	-2.2 -1.9	== ==	== ==	dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	3.4	<u>3.4</u>	<u>3.4</u>	dB
TDECQ - 10log <sub>10</sub> (C <sub>eq</sub> ) (max) <sup>c</sup>	3.4	==	==	dB

Table 140-6—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 transmit characteristics (continued)

Description	Value 100GBASE-DR	100GBASE-FR1	100GBASE-LR1	Unit
TECQ (max)	==	<u>3.4</u>	<u>3.4</u>	dB
TDECQ - TECQ  (max)	==	<u>2.5</u>	<u>2.5</u>	dB
Average launch power of OFF transmitter (max)	-15	<u>-15</u>	<u>-15</u>	dBm
Extinction ratio (min)	3.5	<u>3.5</u>	<u>3.5</u>	dB
Transmitter transition time (max)	17	<u>17</u>	<u>17</u>	ps
Transmitter over/under-shoot (max)	==	<u>22</u>	<u>22</u>	%
Transmitter peak-to-peak power (max)	==	<u>5</u>	<u>5.8</u>	dBm
RIN <sub>15,5</sub> OMA (max) RIN <sub>x</sub> OMA (max), where x is the optical return loss tolerance (max)	-136	<u>-136</u>	<u>-136</u>	dB/Hz
Optical return loss tolerance (max)	15.5	<u>17.1</u>	<u>15.6</u>	dB
Transmitter reflectance <sup>d</sup> (max)	-26	<u>-26</u>	<u>-26</u>	dB

<sup>a</sup>Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

<sup>b</sup>For 100GBASE-DR, even if the TDECQ < 1.4 dB for an extinction ratio of ≥ 5 dB or TDECQ < 1.1 dB for an extinction ratio of < 5 dB, the OMA<sub>outer</sub> (min) must exceed this value.

<sup>c</sup>C<sub>eq</sub> is a coefficient defined in 121.8.5.3, which accounts for the reference equalizer noise enhancement.

<sup>d</sup>Transmitter reflectance is defined looking into the transmitter.

# Changes to Table 140-7 (clean)

Table 140-7—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 receive characteristics

Description	Value <u>100GBASE-DR</u>	<u>100GBASE-FR1</u>	<u>100GBASE-LR1</u>	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
Wavelengths (range)	1304.5 to 1317.5			nm
Damage threshold <sup>a</sup>	5	<u>5</u>	<u>5.8</u>	dBm
Average receive power (max)	4	<u>4</u>	<u>4.8</u>	dBm
Average receive power <sup>b</sup> (min)	-5.9	<u>-6.9</u>	<u>-8.2</u>	dBm
Receive power (OMA <sub>outer</sub> ) (max)	4.2	<u>4.2</u>	<u>5</u>	dBm
Receiver reflectance (max)	-26	<u>-26</u>	<u>-26</u>	dB
Receiver sensitivity (OMA <sub>outer</sub> ) <sup>e</sup> (max)	Equation (140-1) <sup>c</sup>	—	—	dBm
for TECQ < 1.4 dB	—	<u>-4.5</u>	<u>-6.1</u>	<u>dBm</u>
for 1.4 dB ≤ TECQ ≤ 3.4 dB	—	<u>-5.9 + TECQ</u>	<u>-7.5 + TECQ</u>	<u>dBm</u>
Stressed receiver sensitivity (OMA <sub>outer</sub> ) <sup>d</sup> (max)	-1.9	<u>-2.5</u>	<u>-4.1</u>	dBm
Conditions of stressed receiver sensitivity test: <sup>e</sup>				
Stressed eye closure for PAM4 (SECQ)	3.4	<u>3.4</u>	<u>3.4</u>	dB
SECQ - 10log <sub>10</sub> (C <sub>eq</sub> ) <sup>f</sup> (max)	3.4	—	—	dB

# Changes to Table 140-8 (clean)

Table 140-8—100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1 illustrative link power budgets

Parameter	Value 100GBASE-DR	100GBASE-FR1	100GBASE-LR1	Unit
Power budget (for max TDECQ): for extinction ratio $\geq$ 5 dB	6.5	<u>7.8</u>	<u>10.6</u>	dB
	6.8	==	==	dB
Operating distance	500	<u>2 000</u>	<u>10 000</u>	m
Channel insertion loss <sup>a,b</sup>	See 140.9	<u>4</u>	<u>6.3</u>	dB
Maximum discrete reflectance	-35	<u>See 140.10.2.2</u>	<u>See 140.10.2.2</u>	dB
Allocation for penalties <sup>c</sup> (for max TDECQ): for extinction ratio $\geq$ 5 dB	6.5 minus max channel insertion loss per Table 140-12	<u>3.8</u>	<u>4.3</u>	dB
	6.8 minus max channel insertion loss per Table 140-12	==	==	dB
Additional insertion loss allowed	0	<u>0</u>	<u>0</u>	dB

<sup>a</sup>The channel insertion loss is calculated using the maximum distance specified in Table 140-5 for 100GBASE-DR and 100GBASE-FR1 and enabled optical-fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 140.10.2.1.

<sup>b</sup>The channel insertion loss is calculated using the maximum distance specified in Table 140-5 for 100GBASE-LR1 and fiber attenuation of 0.43 dB/km at 1304.5 nm plus an allocation for connection and splice loss given in 140.10.2.1.

<sup>c</sup>Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

# Changes to 140.7.9 (clean)

The receiver sensitivity ( $OMA_{outer}$ ) shall be within the limits given in Table 140–7 for 100GBASE-FR1 and 100GBASE-LR1, if measured using a test pattern for receiver sensitivity in Table 140–10.

The conformance test signal at TP3 meets the requirements for a 100GBASE-FR1 or 100GBASE-LR1 transmitter followed by an attenuator.

The TECQ of the conformance test signal is measured according to 140.7.5, except that the test fiber is not used. The measured value of TECQ is then used to calculate the limit for receiver sensitivity ( $OMA_{outer}$ ) as specified in Table 140–7 and illustrated in Figure 140–5.



# Clause 151

# Changes to Table 151-7 (clean)

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	10.2	dBm
Average launch power, each lane (max)	3.5	4.2	dBm
Average launch power, each lane <sup>a</sup> (min)	-3.2	-2.7	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ), each lane (min): for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	-0.2 -1.6 + TDECQ	0.3 -1.1 + TDECQ	dBm dBm
Difference in launch power between any two lanes (OMA <sub>outer</sub> ) (max)	4	4	dB
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4	3.4	dB
Transmitter eye closure for PAM4 (TECQ), each lane (max)	3.4	3.4	dB
TDECQ – TECQ   (max)	2.5	2.5	dB

# Changes to Table 151-8 (clean)

Table 151-8—400GBASE-FR4 and 400GBASE-LR4-6 receive 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
Damage threshold <sup>a</sup> , each lane	4.5	5.2	dBm
Average receive power, each lane (max)	3.5	4.2	dBm
Average receive power, each lane <sup>b</sup> (min)	-7.2	-9	dBm
Receive power (OMA <sub>outer</sub> ), each lane (max)	3.7	4.4	dBm
Difference in receive power between any two lanes (OMA <sub>outer</sub> ) (max)	4.1	4.3	dB
Receiver reflectance (max)	-26		dB
Receiver sensitivity (OMA <sub>outer</sub> ), each lane (max) for TECQ < 1.4 dB for 1.4 dB ≤ TECQ ≤ 3.4 dB	-4.6 -6 + TECQ	-6.8 -8.2 + TECQ	dBm dBm
Stressed receiver sensitivity (OMA <sub>outer</sub> ), each lane <sup>c</sup> (max)	-2.6	-4.8	dBm
Conditions of stressed receiver sensitivity test: <sup>d</sup>			
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	3.4	dB
OMA <sub>outer</sub> of each aggressor lane	1.5	-0.4	dBm

# Changes to Table 151-9 (clean)

**Table 151-9—400GBASE-FR4 and 400GBASE-LR4-6 illustrative link power budgets**

Parameter	400GBASE-FR4	400GBASE-LR4-6	Unit
Power budget (for maximum TDECQ):	7.8	10.5	
Operating distance	2	6	km
Channel insertion loss	4 <sup>a</sup>	5 <sup>b</sup>	dB
Maximum discrete reflectance	See 151.11.2.2	See 151.11.2.2	dB
Allocation for penalties <sup>c</sup> (for maximum TDECQ):	3.8	4.2	dB
Additional insertion loss allowed	0	1.3	dB

<sup>a</sup> The channel insertion loss is calculated using the maximum distance specified in Table 151-6 for 400GBASE-FR4 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 151.11.2.1.

<sup>b</sup> The channel insertion loss is calculated using the maximum distance specified in Table 151-6 for 400GBASE-LR4-6 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 151.11.2.1.

<sup>c</sup> Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

# Changes to 151.8.12 (clean)

## 151.8.12 Receiver sensitivity

The receiver sensitivity ( $OMA_{outer}$ ) of each lane shall be within the limits given in Table 151–8 for 400GBASE-FR4 and 400GBASE-LR4-6, if measured using a test pattern specified for receiver sensitivity in Table 151–11.

The conformance test signal applied at TP3 meets the requirements for a 400GBASE-FR4 or 400GBASE-LR4-6 transmitter followed by an attenuator. An optical demultiplexer may be used to separate the lane having the wavelength for the lane under test as specified in Table 151–8 for calibrating the TECQ.

The TECQ of the conformance test signal is measured according to 151.8.5, except that the test fiber is not used. The measured value of TECQ is then used to calculate the limit for receiver sensitivity ( $OMA_{outer}$ ) as specified in Table 151–8 and illustrated in Figure 151–6 .

# Changes to Table 151-16 (clean)

**Table 151-16—Channel insertion loss requirements for interoperation between 400GBASE-LR4-6 and 400GBASE-FR4**

Direction	Min loss	Max loss	Unit
400GBASE-LR4-6 transmitter to 400GBASE-FR4 receiver	0.7	4.5	dB
400GBASE-FR4 transmitter to 400GBASE-LR4-6 receiver	0	6.2	dB

Thanks !