In support of I-37, I-80, I-81, I-84, I-86, I-87, I-90 proposed resolution

David Lewis

Sept 15, 2020

IEEE P802.3cu 100 Gb/s and 400 Gb/s over SMF at 100 Gb/s per Wavelength Task Force

I-37: Missing compliance channels for 100GBASE-FR1 and –LR1

Cl 140 SC 140.7.5 P49 L42 # I-37

Lewis, David Lumentum Inc.

Comment Type T *Comment Status* D *measurement method*

There are no reference channels for TDECQ testing of 100GBASE-FR1 or 100GBASE-LR1 at the linked locations (121.8.5.2).

SuggestedRemedy

Change text from ".measured using the methods specified in 121.8.5.1, 121.8.5.2, and 121.8.5.3.." to ".measured using the methods specified in 121.8.5.1, 121.8.5.2 for 100GBASE-DR only, and 121.8.5.3..". Insert a new paragraph before 140.7.5.1: " 100GBASE-FR1 and 100GBASE-LR1 transmitters are tested using optical channels that meet the requirements in Table 140-10a. Insert the new Table 140-10a in the same format as Table 151-12 but with PMD types 400GBASE-FR4 replaced by 100GBASE-FR1 and 400GBASE-LR4-6 replaced by 100GBASE-LR1. Change the coefficient values for minimum and maximum dispersion of 100GBASE-LR1 from 0.138 to 0.23. Change footnotes with editorial license.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

The suggested remedy may not be the most efficient way to address the issue.

A presentation is expected capturing an alterenative set of changes to address the issue.

Pending presentation and task force discussion.

I-37: Proposed changes to for 140.7.5 TDECQ

140.7.5 Transmitter and dispersion eye closure for PAM4 (TDECQ)

Change the first paragraph of 140.7.5 (inserted by IEEE Std 802.3cd-2018 and changed by IEEE Std 802.3cn-2020) as follows:

~~The~~ TDECQ and for 100GBASE-DR only TDECQ – $10\log_{10}(C_{eq})$, shall be within the limits given in Table 140–6 if measured using the ~~methods~~ test setup specified in 121.8.5.1, with an optical channel specified in ~~121.8.5.2~~140.7.5.2, ~~and~~using the measurement method specified in 121.8.5.3, and using a reference equalizer as described in ~~140.7.5.1~~121.8.5.4, with the following exceptions:

- ~~The optical return loss of the transmitter compliance channel is 15.5 dB.~~
- The signaling rate of the test pattern generator is as given in Table 140–6 and uses a test pattern specified for TDECQ in Table 140–10.
- There are no interfering optical lanes and therefore the delay requirement of at least 31 UI between test pattern on one lane and any other lane, as specified in 121.8.5.1, is redundant.
- The combination of the O/E converter and the oscilloscope has a 3 dB bandwidth of approximately 26.5625 GHz with a fourth-order Bessel-Thomson response to at least 1.3 × 53.125 GHz and at frequencies above 1.3 × 53.125 GHz the response should not exceed –20 dB. Compensation may be made for any deviation from an ideal fourth-order Bessel-Thomson response.
- The normalized noise power density spectrum, $N(f)$ in Equation (121–9), is equivalent to white noise filtered by a fourth-order Bessel-Thomson response filter with a bandwidth of 26.5625 GHz.

I-37: Proposed changes to 140.7.5 TDECQ (cont'd)

Insert 140.7.5.2 after 140.7.5.1 as follows:

140.7.5.2 Channel requirements

The transmitter is tested using an optical channel that meets the requirements listed in Table 140–10a.

Table 140–10a—Transmitter compliance channel specifications

PMD type	Dispersion[a] (ps/nm)		Insertion loss[b]	Optical return loss[c]	Max mean DGD
	Minimum	Maximum			
100GBASE-DR	$0.011625 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.011625 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	15.5 dB	0.5 ps
100GBASE-FR1	$0.046 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.046 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	17.1 dB	0.8 ps
100GBASE-LR1	$0.230 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.230 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	15.6 dB	0.8 ps

[a] The dispersion is measured for the wavelength of the device under test (λ in nm). The coefficient assumes 500 m for 100GBASE-DR, 2 km for 100GBASE-FR1 and 10 km for 100GBASE-LR1.
[b] There is no intent to stress the sensitivity of the O/E converter associated with the oscilloscope.
[c] The optical return loss is applied at TP2.

A 100GBASE-DR, 100GBASE-FR1 or 100GBASE-LR1 transmitter is to be compliant with a total dispersion at least as negative as the "minimum dispersion" and at least as positive as the "maximum dispersion" columns specified in Table 140–10a for the wavelength of the device under test. This may be achieved with channels consisting of fibers with lengths chosen to meet the dispersion requirements.

To verify that the fiber has the correct amount of dispersion, the measurement method defined in IEC 60793-1-42 may be used. The measurement is made in the linear power regime of the fiber.

The channel provides an optical return loss specified in Table 140–10a. The state of polarization of the back reflection is adjusted to create the greatest RIN.

The mean DGD of the channel is to be less than the value specified in Table 140–10a.

I-80: SECQ still used for receiver sensitivity of 100GBASE-DR

Cl 140 *SC* 140.7.9 *P* 51 *L* 15 # I-80

Dawe, Piers J G Mellanox Technologies

Comment Type TR *Comment Status* D *measurement method*

Here, the penalty in the signal for RS testing is called SECQ, while in 140.6.3 and p52 line 7 it's TECQ. Rule says use the same name for the same thing, every time.

SuggestedRemedy

Options are:
Change to SECQ to align with base document. Consider repurposing SECQ to "signal eye closure (quaternary)"; or
Define ECQ "eye closure (quaternary)" for general use including when it's not necessarily of transmitted signal at TP2 (TECQ), dispersed signal at TP3 (TDECQ), or stressed signal at TP3 (SECQ).
Adjust 151 for consistency.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

100GBASE-DR receiver sensitivity is based on SECQ and changing it to TECQ for consistency with 100GBASE-FR1 and 100GBASE-LR1 is out of scope.

The three new paragraphs starting at page 52, line 1, apply to 100GBASE-FR1 and 100GBASE-LR1 only. The draft could be improved to make this clearer. A presentation is expected.

Pending presentation and task force discussion.

I-80: Proposed new text for 140.7.9 Receiver Sensitivity

140.7.9 Receiver sensitivity

Insert a new subclause heading 140.7.9.1 to contain the existing text and figure from 140.7.9 as follows:

140.7.9.1 Receiver sensitivity for 100GBASE-DR

Change the content of 140.7.9.1 (formerly the content of 140.7.9) as follows:

The r~~R~~eceiver sensitivity for 100GBASE-DR is informative and is defined for a transmitter with a value of SECQ up to 3.4 dB. Receiver sensitivity for 100GBASE-DR should meet Equation (140–1), which is illustrated in Figure 140–5. The normative requirement for the 100GBASE-DR receiver is stressed receiver sensitivity.

$$RS = \max(-3.9, SECQ - 5.3) \quad \text{(dBm)} \qquad (140\text{–}1)$$

where

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

I-80: Proposed new text for 140.7.9 Receiver Sensitivity (cont'd)

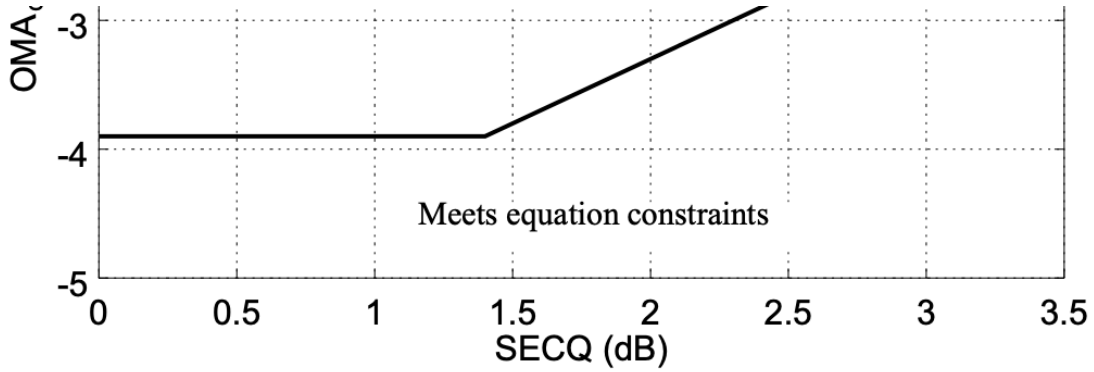

Figure 140–5—Illustration of receiver sensitivity

Insert a new subclause 140.7.9.2 as follows:

140.7.9.2 Receiver sensitivity for 100GBASE-FR1 and 100GBASE-LR1

The receiver sensitivity (OMA_{outer}) for 100GBASE-FR1 and 100GBASE-LR1 shall be within the limits given in Table 140–7 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 transmitter used to measure the receiver sensitivity 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.

I-81: SRS test signal should comply with Tx characteristics

Cl 140 *SC* 140.7.10 *P*52 *L*35 # I-81

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *measurement method*

Do we need to say that the stressed receiver conformance test signal obeys the rules for over/under-shoot and peak-to-peak power (if applicable)?

SuggestedRemedy

Add another item to the list saying so.
Also in 151.8.13.2.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

Pending presentation and task force discussion.

I-81: Proposed changes to 140.7.10 Stressed receiver sensitivity

140.7.10 Stressed receiver sensitivity

Change 140.7.10 (inserted by IEEE Std 802.3cd-2018 and changed by IEEE Std802.3cn-2020) as follows:

Stressed receiver sensitivity shall be within the limits given in Table 140–7 if measured using the method defined in 121.8.9, using the test pattern specified for SRS in Table 140–10, with the following exceptions:

- The SECQ of the stressed receiver conformance test signal is measured according to 140.7.5, except that the test fiber is not used. The transition time of the stressed receiver conformance test signal is no greater than the value specified in Table 140–6.
- With the Gaussian noise generator on and the sinusoidal jitter and sinusoidal interferer turned off, the $RIN_{\sout{15.5}x}OMA$ of the SRS test source (where x is the value for optical return loss tolerance from Table 140–6) should be no greater than the value specified in Table 140–6 for 100GBASE-DR, 100GBASE-FR1, and 100GBASE-LR1.
- An example stressed receiver conformance test setup is shown in Figure 139–7; however, alternative test setups that generate equivalent stress conditions may be used.
- The signaling rate of the test pattern generator and the extinction ratio of the E/O converter are as given in Table 140–6 using test patterns specified in Table 140–10.
- The required values of the "Stressed receiver sensitivity (OMA_{outer}) (max)", "Stressed eye closure for PAM4 (SECQ)", and for 100GBASE-DR only "SECQ – $10\log_{10}(C_{eq})$ (max)" are as given in Table 140–7.
- For 100GBASE-FR1 and 100GBASE-LR1 the values over/under-shoot and peak-to-peak power of the stressed receiver conformance test signal are within the limits specified in Table 140–6.

I-84: OMA difference between lanes needs changing

Cl 151 SC 151.7.1 P71 L23 # I-84

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *Tx characteristics*

The difference in launch power between any two lanes is limited to 4 dB here, while the rows above limit it to 3.9 or 4.1 dB.

SuggestedRemedy

Delete the row or tighten the limit e.g to 3 dB. Adjust the receive table in step.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

Pending presentation and task force discussion.

- Change OMA difference for –FR4 to 3.9 dB.
- Max OMA difference at TP3 = Max OMA difference at TP2 + Max differential loss between wavelengths through worst case fiber
- Using “Fibre_characteristics_V_3_0” excel spreadsheet, the max loss differences are:
  - For –FR4: 0.13 dB
  - For –LR4-6: 0.40 dB
- So aggressor levels are:
  - FR4: -2.6 + 3.9 + 0.13 = 1.43 (round to 1.4)
  - LR4-6: -4.8 + 4 + 0.4 = -0.4

I-84: Proposed changes to Table 151-7 and 151-8

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[a] (min)	–3.2	–2.7	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), 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_{outer}) (max)	~~4~~ 3.9	4	dB
Transmitter and dispersion eye closure for PAM4	3.4	3.4	dB

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[a], each lane	4.5	5.2	dBm
Average receive power, each lane (max)	3.5	4.2	dBm
Average receive power, each lane[b] (min)	–7.2	–9	dBm
Receive power (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Difference in receive power between any two lanes (OMA_{outer}) (max)	4.1	4.3	dB
Receiver reflectance (max)	–26		dB
Receiver sensitivity (OMA_{outer}), 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_{outer}), each lane[c] (max)	–2.6	–4.8	dBm
Conditions of stressed receiver sensitivity test:[d]			
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	3.4	dB
OMA_{outer} of each aggressor lane	~~1.5~~ 1.4	–0.4	dBm

I-85, I-86, I-87, I-90: Referencing subclauses versus duplicate material

Cl 151 SC 151.8.4 P79 L11 # I-85

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *measurement method*

Apart from the first two sentences, this is identical to 122.8.4.

SuggestedRemedy

Remove all but the first two sentences; refer to 122.8.4.

Proposed Response *Response Status* W

PROPOSED REJECT.

This short subclause is repeated for convenience to avoid the reader having to find the cross reference.

Cl 151 SC 151.8.9 P82 L26 # I-87

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *measurement method*

Too much duplication of over/under-shoot method.

SuggestedRemedy

Delete from line 31 and say it is analogous to 140.7.5b.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

Pending presentation and task force discussion.

Cl 151 SC 151.8.5 P79 L36 # I-86

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *measurement method*

Too much duplication of established TDECQ method. Also, contradictory: says specified in 121.8.5.1, 121.8.5.2, and 121.8.5.3 then repeats it all below.

SuggestedRemedy

Remove the duplicate material.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

Pending presentation and task force discussion.

Cl 151 SC 151.8.13 P83 L43 # I-90

Dawe, Piers J G Mellanox Technologies

Comment Type T *Comment Status* D *measurement method*

Too much duplication of stressed receiver sensitivity method. Figure wastes the reader's time - is it identical to Figure 122-8, if not what ddiffers?

SuggestedRemedy

Define 151's SRS by reference to 121 and 122, in the style of 140.7.10.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.

Pending presentation and task force discussion.

I-85 response – with references to CI 122

151.8.4 Outer Optical Modulation Amplitude (OMA_{outer})

The OMA_{outer} of each lane shall be within the limits given in Table 151–7 for 400GBASE-FR4 and 400GBASE-LR4-6. The OMA_{outer} is measured using a test pattern specified for OMA_{outer} in Table 151–11, using the measurement method in 122.8.4.

I-86 response – with references to CI 122

151.8.5 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The TDECQ of each lane shall be within the limits given in Table 151–7 for 400GBASE-FR4 and 400GBASE-LR4-6 if measured using the ~~methods~~ test setup specified in 122.8.5.1, with the optical channel specified in 151.8.5.1, the measurement method in 122.8.5.3, and the reference equalizer in 122.8.5.4, with the following exceptions:

— The signaling rate of the test pattern generator is as given in Table 140–6 and uses a test pattern specified for TDECQ in Table 140–10.

— The combination of the O/E converter and the oscilloscope has a 3 dB bandwidth of approximately 26.5625 GHz with a fourth-order Bessel-Thomson response to at least 1.3 × 53.125 GHz and at frequencies above 1.3 × 53.125 GHz the response should not exceed –20 dB. Compensation may be made for any deviation from an ideal fourth-order Bessel-Thomson response.

— The normalized noise power density spectrum, $N(f)$ in Equation (121–9), is equivalent to white noise filtered by a fourth-order Bessel-Thomson response filter with a bandwidth of 26.5625 GHz.

151.8.5.1 Channel requirements

I-87 response – with references to Cl 140

151.8.9 Transmitter over/under-shoot

The transmitter over/under-shoot percentage of each lane shall be within the limits given in Table 151–7 if measured using a test pattern specified for transmitter over/under-shoot in Table 151–11, using the measurement method in 140.7.5b.

151.8.10 Transmitter peak-to-peak power

The transmitter peak-to-peak power of each lane shall be within the limits given in Table 151–7 if measured using a test pattern specified for transmitter peak-to-peak power in Table 151–11, using the measurement method in 140.7.5c.

I-90 response – with references to Cl 122

151.8.13 Stressed receiver sensitivity

Stressed receiver sensitivity shall be within the limits given in Table 151–8 for 400GBASE-FR4 and 400GBASE-LR4-6 if measured using the method defined in 122.8.9 with the following exceptions:

— The SECQ of the stressed receiver conformance test signal is measured according to 151.8.5, except that the test fiber is not used. The transition time of the stressed receiver conformance test signal is no greater than the value specified in Table 151–7.

— With the Gaussian noise generator on and the sinusoidal jitter and sinusoidal interferer turned off, the $RIN_x OMA$ of the SRS test source (where x is the value for optical return loss tolerance from Table 151–7) shall be no greater than the value specified in Table 151–7 for 400GBASE-FR4 and 400GBASE-LR4-6.

— The signaling rate of the test pattern generator and the extinction ratio of the E/O converter are as given in Table 151–7.

— The required values of the "Stressed receiver sensitivity (OMA_{outer}), each lane (max)", "Stressed eye closure for PAM4 (SECQ), lane under test" and "OMAouter of each aggressor lane" are as given in Table 151–8.

— For 400GBASE-FR4 and 400GBASE-LR4-6 the values of over/under-shoot and peak-to-peak power of the stressed receiver conformance test signal are within the limits specified in Table 151–7.