100GBASE-BR40:
Updates to Tables

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Supporters

Overview

- During May meeting a request to show adopted and proposed values for 100GBASE-BR40 in the draft document tables.
- In addition, comments justifying or motivation for values is included on most table entries.
- ***Note:*** If group finds this useful, can do the same for 100GBASE-BR20 at July meeting.

Table 999-4 Signal Detect value definition *(page 6244)*

Receive conditions	SIGNAL_DETECT value
Average optical power at TP3 ≤ TBD dBm -20 (Note)	FAIL
[(Optical power at TP3 average receive power (min) Table 999–7) AND (compliant 100GBASE-BRx signal input)]	OK
All other conditions	Unspecified

Justification
Value must be lower than Rx avg power at TP3. Some projects used -15 dBm, which are for shorter reaches (higher Rx power) & the desire to include SiPh technology where the squelch was initiated by an MZM modulator.

*Note: 3dk_takahara_2404_1a.pdf proposed **-15 dBm**.*

Table 999–6—100GBASE-BRx transmit characteristics *(Page 6246)*

Description	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
100GBASE-BRx-D center wavelengths (range)	1308.1 to 1310.1			nm
100GBASE-BRx-U center wavelengths (range)	1303.6 to 1305.6			nm
Side-mode suppression ratio (SMSR), (min)	30		30	dB
Average launch power (max)	4.8		8.5	dBm
Average launch power[a] (min)	–1.9		2.7	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (max)	5		8.7	dBm
Outer Optical Modulation Ampli (min)[b]: for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	1.1 –0.3 + TDECQ		5.7 4.3 + TDECQ	dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	3.4		3.9	dB
TECQ (max)	3.4		3.9	dB
| TDECQ – TECQ | (max)	2.5		2.7	dB
Transmitter over/under -shoot (max)	22		22	%
Transmitter power excursion (max)	2.8		TBD 6.5	dBm
Average launch power of OFF transmitter (max)	–15		-15	dBm
Extinction ratio (min)	3.5		5.0	dB

Accommodate 3.4 & 3.9 values Use TDECQ (max)?

BR 40 Justification
Align with ITU-T G9608 Am 3, 100G BiDi wavelength plan (DS)—May 2023 Motion
Align with ITU-T G9608 Am 3, 100G BiDi wavelength plan (US)—May 2023 Motion
Consistent with other IEEE standards
March 2024, Motion #5.
Assumes ER=∞. *{Suggestions this is unlikely in practice. Alternate value?}*
March 2024, Motion #5. 8.7 gives 0.5dB of margin relative to 4.3+TDECQ=+8.2dBm
March 2024, Motion #5
March 2024, Motion #5
March 2024, Motion #5
March 2024, Motion #5
Same as P802.3cu, 100Gb/s per wavelength.
April presentation (3dk_takahara_2404_1a.pdf) proposed this value.
Same as P802.3cu, 100Gb/s per wavelength & P802.3cp, 50Gb/s BiDi.
March 2024, Motion #5

Table 999–6—100GBASE-BRx transmit characteristics *(continued)*

Description	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40	Unit
Transmitter transition time (max)	17		17	ps
$RIN_x OMA$ (max)[c]	-136		-136	dB/Hz
Optical return loss tolerance (max)	15.6		15.6 15	dB
Transmitter reflectance[d] (max)	-26		-26	dB

[a] Average launch power (min) is 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.
[b] The OMA_{outer} (min) requirement holds even if the TDECQ < 1.4 dB. Even though the representation of the OMA_{outer} requirement is different from that in Clause 139, they are consistent.
[c] In $RIN_x OMA$, "*x*" is the optical return loss tolerance (max) for the PHY under test.
[d] Transmitter reflectance is defined looking into the transmitter.

BR40 Justification
Consistent with P802.3cu, 100Gb/s per wavelength.
Consistent with P802.3cu, 100Gb/s per wavelength.
15.6 adopted in March Motion #5. Should it be **15**? Consistent with 50GBASE-ER/BR40?
Consistent with P802.3cu, 100Gb/s per wavelength & P802.3cp, 50GBASE-BR40

Table 999–7—100GBASE-BRx receive characteristics *(page 6248)*

Description	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40	Unit
Signaling rate (range)	53.125 ± 100 ppm			GBd
Modulation format	PAM4			—
100GBASE-BRx-D center wavelengths (range)	1303.6 to 1305.6			nm
100GBASE-BRx-U center wavelengths (range)	1308.1 to 1310.1			nm
Damage threshold[a]	5.8		TBD -0.5	dBm
Average receive power (max)	4.8		TBD -1.5	dBm
Average receive power[b] (min)	–8.2		-15.3	dBm
Receive power (OMA_{outer}) (max)	5		TBD -1.3	dBm
Receiver reflectance (max)	-26		-26	dB
Receiver sensitivity (OMA_{outer})[c] for TECQ < 1.4 dB for 1.4 dB ≤ TECQ ≤ 3.4 dB	–6.1 –7.5 + TECQ		-12.8 -14.2 + TECQ	dBm dBm
Stressed receiver sensitivity (OMA_{outer})[d] (max)	–4.1		TBD -10.3	dBm
Conditions of stressed receiver sensitivity test:[e]				
Stressed eye closure for PAM4 (SECQ)	3.4		3.9	dB

Accommodate 3.4 & 3.9 values Use TECQ (max)?

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.
[b] Average receive power (min) is not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.
[c] Receiver sensitivity (OMA_{outer}) (max) is optional and is defined for a transmitter with a value of SECQ up to 3 dB for 100GBASE-BR10 and 3.2 dB for 100GBASE-BR20, and 100GBASE-BR40.
[d] Measured with conformance test signal at TP3 (see 999.7) for the BER specified in 999.1.1.
[e] These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

BR40 Justification
Align with ITU-T G9608 Am 3, 100G BiDi wavelength plan (downstream)
Align with ITU-T G9608 Am 3, 100G BiDi wavelength plan (upstream)
+1 dB higher than max average receive power, e.g. P802.3cu/cn/cp standards (1)
Avg Tx (max) plus 10 dB IL (min) => +8.5 dBm – 10 dB = **-1.5 dBm (1)**
Avg Tx (min) plus 18 dB IL (max) => 2.7 dBm – 18 dB = **-15.3dBm**
Tx OMA (max) plus 10 dB IL (min) => 8.7 dBm – 10 dB = **-1.3dBm (1)**
Consistent with P802.3cu, 100Gb/s per wavelength & P802.3cp, 50GBASE-BR40
March 2024, Motion #5
-14.2 dBm (intrinsic sensitivity) + TECQ (3.9) = **-10.3 dBm (1)**
SECQ = TECQ

Note 1:
April presentation (3dk_takahara_2404_1a.pdf) proposed:

- Rx Damage threshold: -1.0 dBm
- Rx Power (AVG, max): -1.5 dBm
- Rx Power (OMA, max): -1.3 dBm
- Stressed Rx sensitivity (OMA, max): -10.3 dBm

Table 999–8—100GBASE-BRx illustrative link power budgets

(page 6249)

Adopted
March 2024

Parameter	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40	Unit
Power budget (for maximum TDECQ)	10.6		22.4	dB
Operating distance	10	20	40	km
Channel insertion loss	6.3[a]	10[a]	18[a]	dB
Maximum discrete reflectance	–35	See xxx.yy.zz	-35	dB
Allocation for penalties[b] (for maximum TDECQ)	4.3		4.4	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 999–5 for 100GBASE-BR10, 100GBASE-BR20 and 100GBASE-BR40 and fiber attenuation of 0.4 dB/km plus an allocation for connection and splice loss given in 999.10.2.1.

[b] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

BR40 Justification
IL = 18dB, 3.9dB = TDECQ, 0.5dB => (MPI + DGD((2)
P802.3cp has -26dB (?) whereas P802.3cn cites table.* Propose P802.3cn approach.

* **Table 139–14—Maximum value of each discrete reflectance**

Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance		
	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40
1	–22 dB	TBD	–19 dB
2	–29 dB		–27 dB
4	–33 dB		–32 dB
6	–35 dB		–35 dB
8	–37 dB		–37 dB
10	–39 dB		–39 dB

Note 2:
MPI & DGD penalties revisited (see back-up slides)

*Recommend using this table in the *.dk draft*

Copied from P802.3cn, 50GBASE-LR

Table 999-11—Transmitter compliance channel specifications *(page 6252)*

PMD type	Dispersion[a] (ps/nm)		Insertion loss[b]	Optical return loss[c]	Max mean DGD
	Minimum	Maximum			
100GBASE-BR10	$0.23 \times \lambda \times [1 - (1324 / \lambda)^4]$	$0.23 \times \lambda \times [1 - (1300 / \lambda)^4]$	Minimum	15.6	5
100GBASE-BR20	$0.46 \times \lambda \times [1 - (1324 / \lambda)^4]$	$0.46 \times \lambda \times [1 - (1300 / \lambda)^4]$	Minimum	TBD	TBD
100GBASE-BR40	~~$0.92 \times \lambda \times [1 - (1324 / \lambda)^4]$~~	~~$0.92 \times \lambda \times [1 - (1300 / \lambda)^4]$~~	Minimum	15 dB	0.8 ps

[a] The dispersion is measured for the wavelength of the device under test (λ in nm). The coefficient assumes 10 km for 100GBASE-BR10, 20 km for 100GBASE-BR20, and 40 km for 100GBASE-BR40. The link may be as short as 2 m, and the minimum or maximum dispersion may be 0.

[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.

BR40 Justification
Update with latest from Statistical Dispersion in P802.3dj. Optical Return Loss = Tx spec table. Max mean DGD = same as other specifications (this is Tx compliance spec, not fiber cable plant spec)

Table 999-12—Fiber optic cabling (channel) characteristics *(page 6259)*

Description	100GBASE-BR10	100GBASE-BR20	100GBASE-BR40	Unit
Operating distance (max)	10	20	40	km
Channel insertion loss[a, b] (max)	6.3	10	18	dB
Channel insertion loss (min)	0	0	10	dB
Positive dispersion[b] (max)	TBD/3.3		37	ps/nm
Negative dispersion[b] (min)	TBD/-12.1		-77	ps/nm
DGD_max[c]	5		TBD 4.9	ps
Optical return loss (min)	22		22 19	dB

[a] These channel insertion loss values include cable, connectors, and splices.
[b] Over the wavelength range ~~1260 nm to 1340 nm for 100GBASE-BR10 and 1281 nm to 1322 nm for 100GBASE-BR20 and 100GBASE-BR40~~ 1303.6 nm to 1310.1 nm.
[c] Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system is required to tolerate.

BR40 Justification
Update per progress in P802.3dj (?)
Update per progress in P802.3dj (?)
P802.3cp, BR40 has 10.3 psec. Leads to high penalty. Too conservative? (3)
P802.3cn, 50GBASE-ER has 19 dB. P802.3cp, 50G BiDi has 21 dB. Propose using the same methodology as other standards---assuming a table for discrete reflections is used. The first-row entry is for a *single connection* with the indicated RL => **19 dB** (3)

Note 3:
April presentation (3dk_takahara_2404_1a.pdf) proposed:

- DGD_max: 4.9 psec
- Optical return loss (min): 22 dB

Missing Table or Citation to table like this?

Table 139–13—Optical fiber and cable characteristics
{P802.3cn, 50GBASE-ER}

Description	Value	Unit
Nominal fiber specification wavelength	1310	nm
Cabled optical fiber attenuation (max)	0.43[a] or 0.5[b]	dB/km
Zero dispersion wavelength (λ_0)	$1300 \le \lambda_0 \le 1324$	nm
Dispersion slope (max) (S_0)	0.093	ps/nm^2 km

[a] The 0.43 dB/km at 1304.5 nm attenuation for optical fiber cables is derived from Appendix I of ITU-T G.695.
[b] The 0.5 dB/km attenuation is provided for Outside Plant cable as defined in ANSI/TIA 568-C.3. Using 0.5 dB/km may not support operation 10 km for 50GBASE-LR or 40 km for 50GBASE-ER.

- P802.3cp, 50Gb/s BiDi does not have this table, but has a citation (*see Note below*).
- P802.3cn 50GBASE-ER has this table.
- P802.3cu, 100Gb/s per lambda has this table
- P802.3df, nx100Gb/s lanes cites this table back to *.bs.
- P802.3dj, 200Gb/s will have it (or citation to it)

Note: P802.3cp, 50Gb/s BiDi

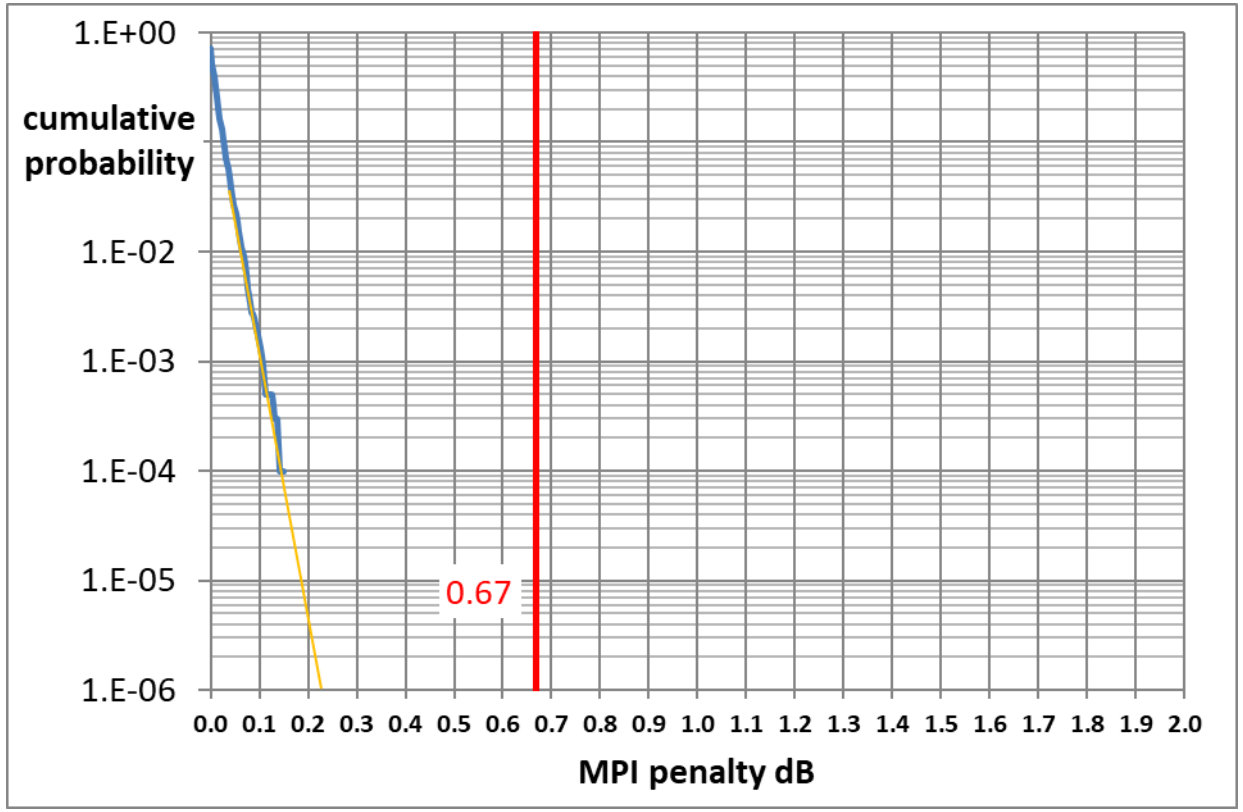
160.10.1 Optical fiber cable
The optical fiber cable requirements are satisfied by cables containing ITU-T G.652.B (dispersion unshifted), type G.652.D (low water peak, dispersion unshifted), or type G.657.A1 or type G.657.A2 (bend insensitive) fibers or the requirements in **Table 160–12 where they differ.**

Is this a correct reference? Should it refer to the optical fiber and cable characteristics (above)? Not the channel, which is the table on the preceding slide?

Thanks!

Back-Up Slides

MPI Penalty



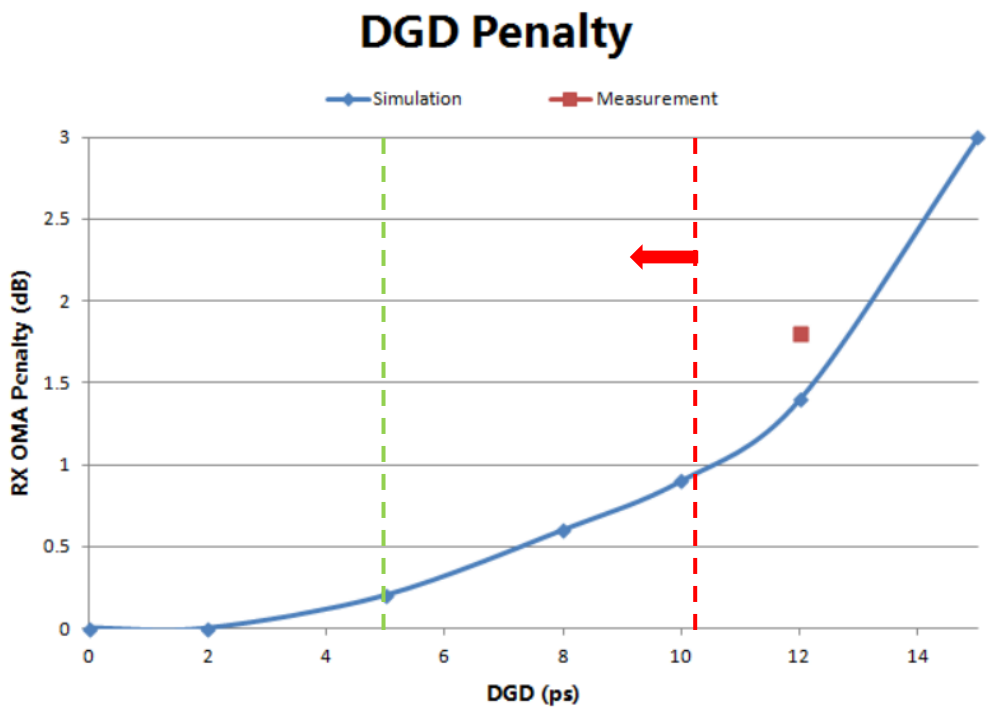
BER: 2.4E-4
Loss: 18 dB (40km)
ER: 5.0 dB
Connector: 6 @ 35 dB +4 @ 55 dB RL

Multi-Path Interference (MPI) penalty = **0.23 dB** *(99.9999%)*

RL = -15.7 dB (assuming single-pass, coherent addition)

DGD Penalty

- Most current standards use DGD_max = 10.3 psec.
  - Leads to unacceptably high penalty (see plot below)



From: shuai_3cu_adhoc_050119.pdf

- From anslow_3cu_01_0519.pdf
  - G.652.A and G.652.C with a maximum PMD_Q of 0.5 ps/√km
  - G.652.B and G.652.D with a maximum PMD_Q of 0.2 ps/√km

Vince Ferretti from Corning has helpfully pointed out a relevant publication:

JACOBS, S.A. et al., Statistical Estimation of PMD Coefficients for System Design. Electronics Letters, 1997, 33, pp. 619-621

This includes an analysis of 288 randomly selected scaled cabled fibers.

Equation 10 of this is:

$$X_Q = \frac{\left(2.004 + 0.975\sqrt{n \times 0.979}\right)}{\sqrt{n \times 48.6}}$$

For n = 20 (20 cable segments), this evaluates to X_Q = 0.203 ps/√km
For a 40 km link and with a ratio of "Max" DGD to mean DGD of 3.75, this is a DGD_max of **4.8 psec.** {close to April presentation of 4.9 psec}

From plot at left 4.8 psec => **0.25 dB penalty**