10GEPON Jitter Budget

Contributors

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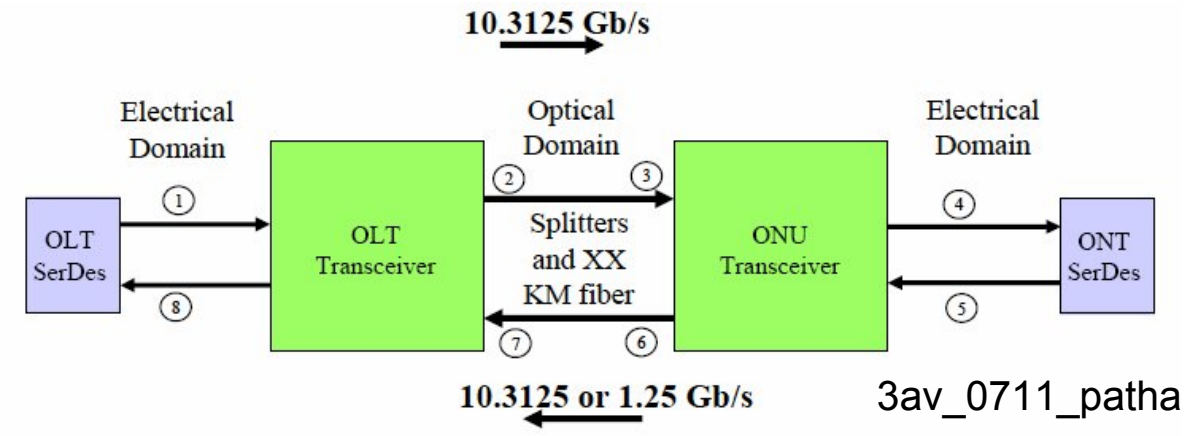
Jitter Dependencies

- Considering very small jitter budget available , it is important to examine sources of jitter and
  - Establish relevance of particular jitter to the application
  - Define methods to measure jitter (to be discussed)
  - Leverage system features
- Examples
  - Optical domain : Significant jitter is introduced during laser turn on/off which is not relevant to the application and therefore can be ignored
  - Systems using FEC may leverage BER limit to specify jitter . For example jitter can be specified as xx ps@ BER=1E-3 and yy ps @ BER= 1E-12

Jitter reference model

- Upstream jitter budget may define relevant ‘time window’



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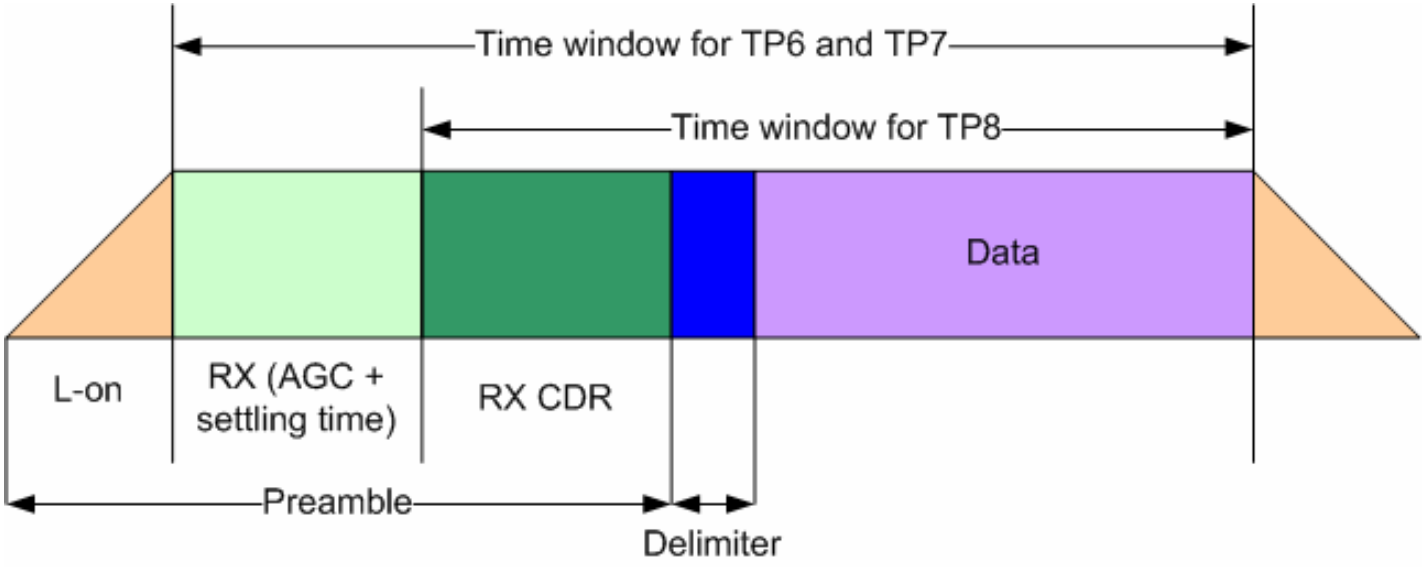

Effect of Co-existence

- Possibilities of different data rates in U/S and D/S directions requires a simplified scheme to specify jitter at various test points . Many options are possible
  - Option 1: Retain 1GEPON format of TP1- TP4 and specify multiple tables to indicate link direction and data speed
  - Option 2: Define 4 additional test points TP5-TP8 for up stream direction and an additional identifier for data rate
    - 10G downstream jitter at OLT = TP1_10
    - 10G upstream jitter at ONU = TP5_10
  - Other options :

We recommend Option 2

Conclusion

- Comments have been submitted for Clause 91 Draft 1.1
- Managing small jitter budget will require attention to detail and avoid double counting by using relevance and context .
- System features like FEC might allow little relaxation in jitter budgets
- Measurement conditions and definitions are equally necessary to drive standardization in component specifications

Supporting Slides for Comments Submitted to Draft 1.1

Jitter Corner Frequency

- Comment: #1047 and #1053

52.8.1 Sinusoidal jitter for receiver conformance test

The sinusoidal jitter is used to test receiver jitter tolerance. Sinusoidal jitter may vary over a magnitude range as required to accurately calibrate a stressed eye per 52.9.9. The range is limited by the constraints of Table 52–19.

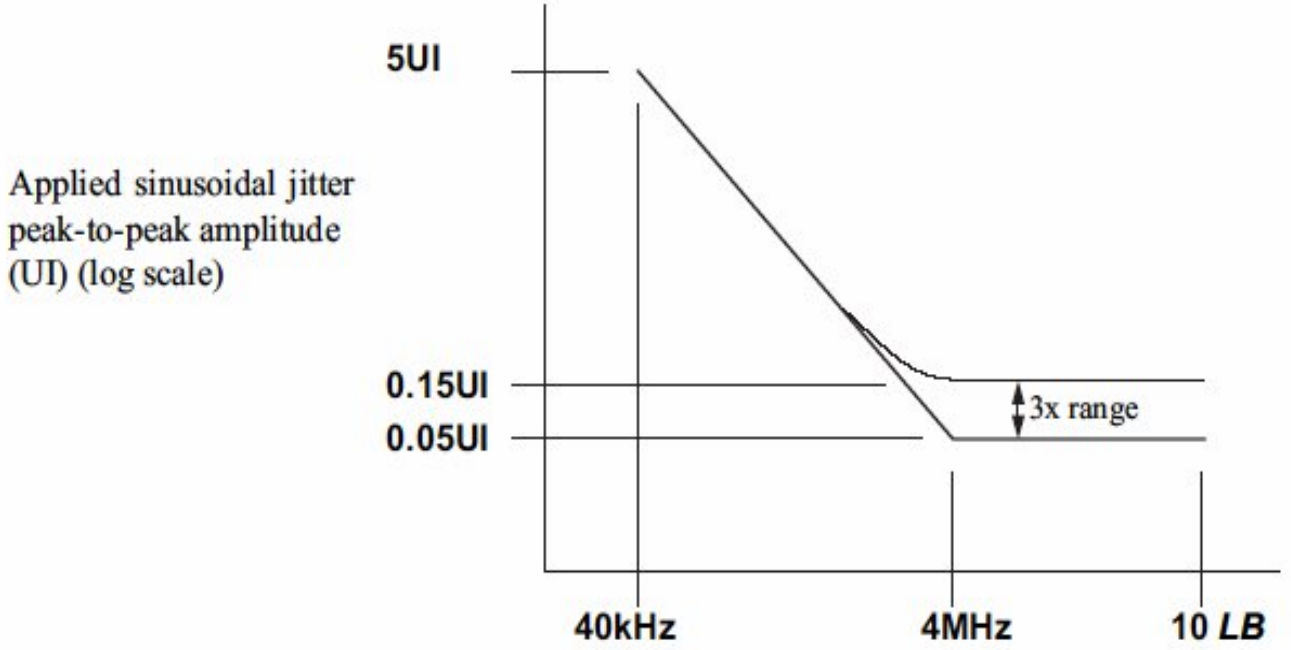

Figure 52–4—Mask of the sinusoidal component of jitter tolerance (informative)

OLT PMD Transmit Eye

- Comment: #1051

Table 52–7—10GBASE-S transmit characteristics

Description	10GBASE-SW	10GBASE-SR	Unit
Signaling speed (nominal)	9.95328	10.3125	GBd
Signaling speed variation from nominal (max)	± 20	± 100	ppm
Center wavelength (range)	840 to 860		nm
RMS spectral width[a] (max)	See footnote[b]		
Average launch power (max)	See footnote[c]		
Average launch power[d] (min)	–7.3		dBm
Launch power (min) in OMA	See footnote[b]		
Average launch power of OFF transmitter[e] (max)	–30		dBm
Extinction ratio (min)	3		dB
$RIN_{12}OMA$ (max)	–128		dB/Hz
Optical Return Loss Tolerance (max)	12		dB
Encircled flux	See footnote[f]		
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}		
Transmitter and dispersion penalty[g] (max)	3.9 dB		dB

[a]RMS spectral width is the standard deviation of the spectrum.
[b]Trade-offs are available between spectral width, center wavelength and minimum optical modulation amplitude. See Figure 52–3 and Table 52–8.
[c]The 10GBASE-S launch power shall be the lesser of the class 1 safety limit as defined by 52.10.2 or the average receive power (max) defined by Table 52–9.
[d]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.
[e]Examples of an OFF transmitter are: no power supplied to the PMD, laser shutdown for safety conditions, activation of a PMD_global_transmit_disable or other optional transmitter shut down conditions.
[f]The encircled flux at 19 μm shall be greater than or equal to 86% and the encircled flux at 4.5 μm shall be less than or equal to 30% when measured into Type A1a (50/125 μm multimode) fiber per ANSI/TIA/EIA-455-203-2001.
[g]TDP(max) and OMA(min) are at the respective wavelength and spectral width as specified in Table 52–8.

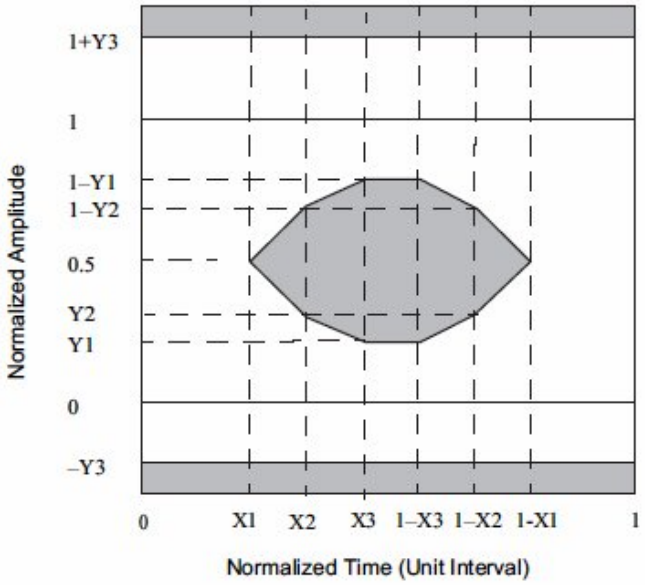

Figure 52–8—Transmitter eye mask definition

- Comment: #1049

ONU Receiver Stressed Eye

Table 52–9—10GBASE-S receive characteristics

Description	10GBASE-S	Unit
Signaling speed (nominal) 10GBASE-SR 10GBASE-SW	 10.3125 9.95328	GBd
Signaling speed variation from nominal (max)	± 100	ppm
Center wavelength (range)	840 to 860	nm
Average receive power[a] (max)	–1.0	dBm
Average receive power[b] (min)	–9.9	dBm
Receiver sensitivity (max) in OMA[c]	0.077 (–11.1)	mW (dBm)
Receiver Reflectance (max)	–12	dB
Stressed receiver sensitivity in OMA[d] [e](max)	0.18 (–7.5)	mW (dBm)
Vertical eye closure penalty[f] (min)	3.5	dB
Stressed eye jitter[g] (min)	0.3	UI pk-pk
Receive electrical 3 dB upper cutoff frequency (max)	12.3	GHz

[a]The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the average receive power (max) plus at least 1 dB.
[b]Average receive power (min) is informative and 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 is informative.
[d]Measured with conformance test signal at TP3 (see 52.9.9.2) for BER = 10^{-12}.
[e]The stressed sensitivity values in the table are for system level BER measurements which include the effects of CDR circuits. It is recommended that at least 0.4 dB additional margin be allocated if component level measurements are made without the effect of CDR circuits
[f]Vertical eye closure penalty is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.
[g]Stressed eye jitter is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

- Comment: #1048

Receiver Conformance Test

58.7.11.4 Sinusoidal jitter for receiver conformance test

The sinusoidal jitter is used to test receiver jitter tolerance. Sinusoidal jitter may vary over a magnitude range as required to accurately calibrate a stressed eye per 58.7.11.2. The range is limited by the constraints of Table 58–13 as illustrated in Figure 58–10, where f2, SJ1 and SJ2 are specified in the appropriate receiver table: Table 58–4, Table 58–6, Table 59–6, Table 59–8, Table 60–5, Table 60–6 or Table 60–9. The frequency f2 is specified as "Jitter corner frequency" in the receiver tables. SJ1 and SJ2 are defined as "sinusoidal jitter limits for stressed receiver conformance test (min, max)" in e.g. Table 58–4.

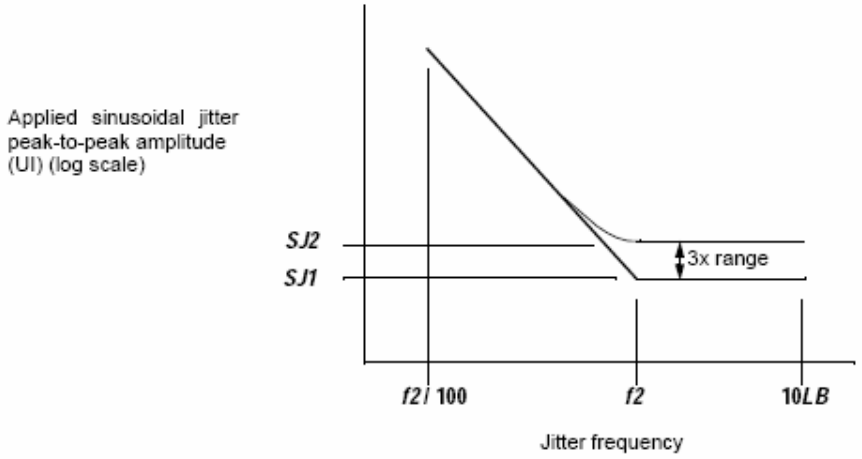

Figure 58–10—Mask of the sinusoidal component of jitter tolerance (informative)

Table 58–13—Applied sinusoidal jitter

Frequency range	Sinusoidal jitter (UI pk-pk)
$f < f2 / 100$	N/A
$f2 / 100 < f \le f2$	$0.05 \times f2 / f + S - 0.05$[a]
$f2 < f < 10 \times LB$[b]	$SJ1 \le S \le SJ2$[a]

[a] S is the magnitude of sine jitter actually used in the calibration of the stressed eye per the methods of 58.7.11.2.
[b] LB = Loop Bandwidth; Upper frequency bound for added sine jitter should be at least 10 times the loop bandwidth of the receiver being tested.

Table 58–4—100BASE-LX10 receive characteristics *(continued)*

Description	Type B1.1, B1.3 SMF	Unit
Average received power[a] (max)	–8	dBm
Receiver sensitivity (max)	–25	dBm
Receiver sensitivity as OMA (max)	–24.8 (3.3)	dBm (μW)
Receiver reflectance[b] (max)	–12	dB
Stressed receiver sensitivity[c]	–20.1	dBm
Stressed receiver sensitivity as OMA (max)	–19.9 (10.2)	dBm (μW)
Vertical eye-closure penalty[d] (min)	3.7	dB
Stressed eye jitter (min)	0.25	UI pk-pk
Jitter corner frequency	20	kHz
Sinusoidal jitter limits for stressed receiver conformance test (min, max)	0.05, 0.15	UI
Signal detect threshold (min)	–45	dBm

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the average received power (max) plus at least 1 dB.
[b] See 1.4 for definition of reflectance.
[c] The stressed receiver sensitivity is optional.
[d] Vertical eye closure penalty and the jitter specifications are test conditions for measuring stressed receiver sensitivity. They are not required characteristics of the receiver.

- Comment: #1054 and #1055

Jitter gain curve (Jitter transfer)

- Jitter transfer corner frequency was chosen to be double of jitter corner frequency of receiver
  - RX: 637 kHz > Transfer: 1274 KHz
  - RX: 4MHz > Transfer: 8MHz

$$\text{Jitter Transfer} = 20\log_{10}\left[\frac{\text{Jitter on upstream signal (UI)}}{\text{Jitter on downstream signal (UI)}}\right] \qquad (60\text{-}2)$$

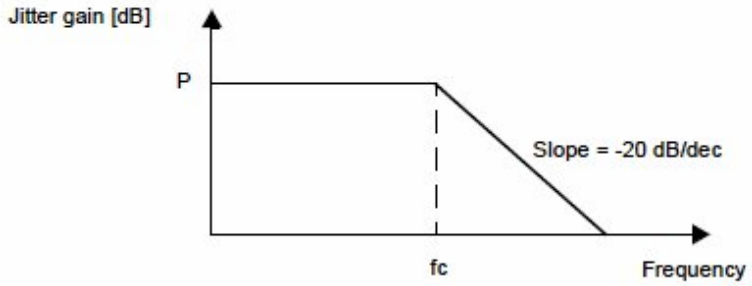

Figure 60–5—Jitter gain curve values for 1000BASE-PX10-U and 1000BASE-PX20-U

Table 60–12—Jitter gain curve values for 1000BASE-PX10-U and 1000BASE-PX20-U

	Value	Unit
P	0.3	dB
fc	1274	kHz