95.7.2 100GBASE-SR4 receive optical specifications

Table 95–7—100GBASE-SR4 receive characteristics

Description	Value	Unit
Conditions of stressed receiver ~~sensitivity~~ conformance test:[d]		

(Note to reader: red, green and purple and yellow highlighting show text of interest, teal and magenta show insertions and deletions)

95.8.8 Stressed receiver sensitivity

Stressed receiver sensitivity shall be within the limits given in Table 95–7 if measured using the method defined by 95.8.8.1 and 95.8.8.5, with the stressed receiver ~~conformance~~ test signal at TP3 as described in 95.8.8.2.

~~Stressed receiver sensitivity is defined with all transmit and receive lanes in operation. Pattern 3 or Pattern 5, or a valid 100GBASE-SR4 signal, is sent from the transmit section of the PMD under test. The signal being transmitted is asynchronous to the received signal. The interface BER of the PMD receiver is the average of the BER of all receive lanes while stressed and at the specified receive OMA.~~

95.8.8.1 Stressed receiver conformance test block diagram

A block diagram for the stressed receiver conformance test is shown in Figure 95–5. The patterns used for the stressed receive~~d~~r test ~~compliance~~ signal are specified in Table 95–10. The ~~optical~~ stressed receiver test signal is conditioned (stressed) using the stressed receiver methodology defined in 95.8.8.2, and has sinusoidal jitter applied as specified in 95.8.8.5. A suitable test set is needed to characterize and verify that the signal used to test the receiver has the appropriate characteristics.

~~The fourth-order Bessel-Thomson filter has~~ For stress conditioning, a 3 dB bandwidth for the fourth-order Bessel-Thomson filter of approximately 19 GHz is suitable. The low-pass filter is used to create ISI. The low-pass filter, when combined with the E/O converter, should have a frequency response that results in at least the ~~appropriate~~ level of stressed eye closure (SEC) given in 95.8.8.2 before the sinusoidal terms (see below) are added.

The sinusoidal amplitude interferer 1 causes jitter that is intended to emulate instantaneous bit shrinkage that can occur with DDJ. This type of jitter cannot be created by simple phase modulation. The sinusoidal amplitude interferer 2 causes additional eye closure, but in conjunction with the finite edge rates from the limiter, also causes some jitter. The sinusoidally jittered clock represents other forms of jitter and also verifies that the receiver under test can track low-frequency jitter. The sinusoidal amplitude interferers may be set at any frequency between 100 MHz and 2 GHz, although care should be taken to avoid harmonic relationships between the sinusoidal interferers~~, the sinusoidal jitter~~, the signaling rate, and the pattern repetition rate. The Gaussian noise generator, the amplitude of the sinusoidal interferers, and the low-pass filter are adjusted so that the SEC, stressed eye J2 Jitter, and stressed eye J4 Jitter specifications given in Table 95–7 are met simultaneously while also passing the stressed receiver eye mask in Table 95–7 according to the methods specified in 95.8.7 (the random noise effects such as RIN, or random clock jitter, do not need to be minimized).

For improved visibility for calibration, all elements in the signal path (cables, DC blocks, E/O converter, etc.) should have wide and smooth frequency response, and linear phase response, throughout the spectrum of interest. Baseline wander and overshoot and undershoot should be minimized.

The stressed receiver ~~conformance~~ test signal verification is described in 95.8.8.4.

Stressed receiver sensitivity is defined with all transmit and receive lanes in operation. Each receive lane is tested in turn while all aggressor receive lanes are operated as specified in Table 95–7. Pattern 3 or Pattern 5, or a valid 100GBASE–SR4 signal is sent from the transmit section of the ~~receiver~~ interface under test. The signal

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Comment [PD1]: Name of the test, and test block diagram, underlined in green. 5 instances should be consistent (one or two terms). Comme r02-21.

Comment [PD2]: Name of the signal in underlined in red. I have marked about 12 instances, not sure I have found them all. They should be consistent (same term every time). Comment r02-20.

Comment [PD3]: Text in yellow is duplicated. It's a bit detailed to be here in the introductory subclause. Maybe it should go in the "now we ar calibrated, do the test" section at the bottom of 95.8.8.2, although the choice of pattern should b combined with the reference to Table 95-10 in 95.8.8.1.

Comment [PD4]: See comment PD3 above.

Comment [PD5]: Using "the signal" as shorthand for "the mouthful signal" is fair enoug but if we pick a short name such as " "stressful signal" we should look at the two or so plain "signal"s. Comment r02-20.

Comment [PD6]: Which of the two fourth-or Bessel-Thomson filters? Comment r02-22.

Comment [PD7]: Which is what? Comments r02-23, r02-32

Comment [PD8]: This is repeated later. Comment r02-29.

Comment [PD9]: If the SJ is swept, is it reasonable to avoid a harmonic relationship between it and all those other things? OTOH, on probably should when calibrating.

being transmitted is asynchronous to the received signal. If Pattern 3 is used with a common clock for the transmit ~~and~~ or receive lanes not under test, there is at least 31 UI delay between the PRBS31 patterns ~~generated~~ on one lane and any other lane.

For 100GBASE-SR4 the relevant BER is the interface BER at the PMD service interface. The interface BER is the average of the four BER of the receive lanes when stressed and at the specified receive OMA: see 95.8.1.1.

If present, the RS-FEC sublayer can measure the lane symbol error ratio at its input. The lane BER can be assumed to be one tenth of the lane symbol error ratio. If each lane is stressed in turn, the PMD interface BER is the average of the BERs of all the lanes when stressed: see 95.8.1.1.

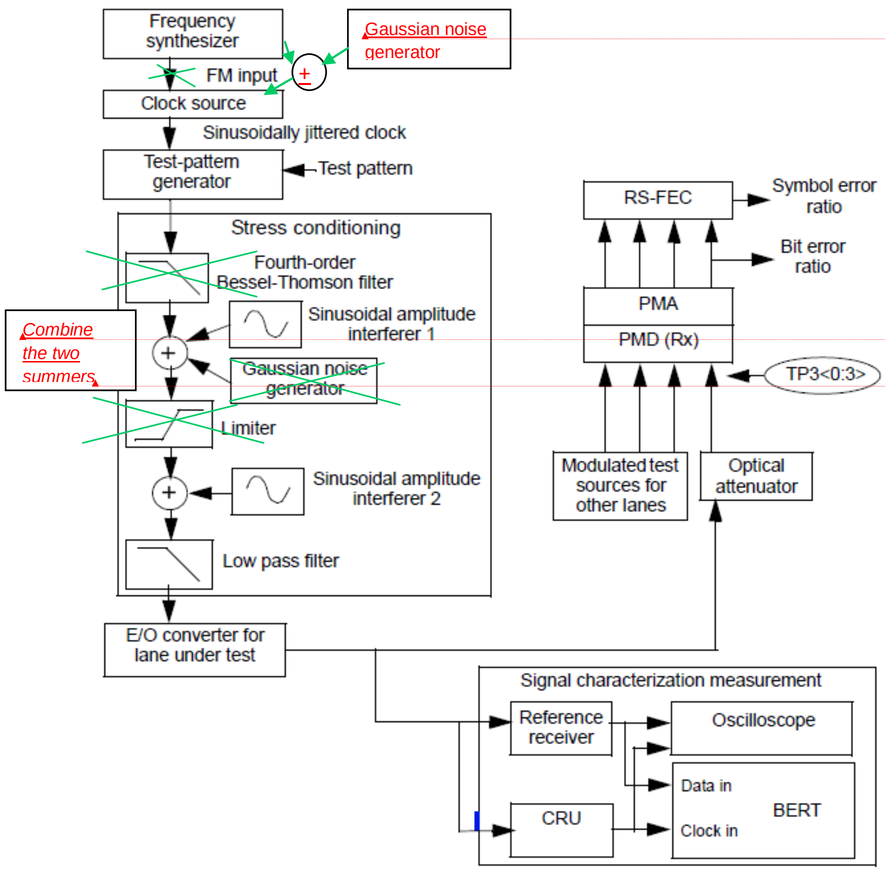

Figure 95–5—Stressed receiver conformance test block diagram

95.8.8.2 Stressed receiver ~~conformance~~ test signal characteristics and calibration

The stressed receiver ~~conformance~~ test signal is used to validate that the PMD receiver of the lane under test meets BER requirements with near worst-case waveforms at TP3.

The primary parameters of the stressed receiver ~~conformance~~ test signal are its stressed eye closure (SEC), stressed eye J2 Jitter and stressed eye J4 Jitter. The SEC of the stressed receiver ~~conformance~~ test signal is measured according to 95.8.5, except that the combination of the O/E and the oscilloscope used to measure the waveform has a fourth-order Bessel-Thomson filter response with a bandwidth of 19.34 GHz, and the value of

Comment [PD10]: Four lanes so should these signals be plural?

Comment [PD11]: Not consistent with rules f pattern 3 elsewhere. Comment r02-24.

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Comment [PD12]: Do lanes have receivers or vice versa? Comment r02-25.

M1 and M2 in Equation (95–3) ~~is~~ are set to zero. Stressed eye J2 Jitter and stressed eye J4 Jitter are defined in 95.8.8.3.

An example stressed receiver conformance test setup is shown in Figure 95–5, however any approach that modulates or creates the appropriate levels and frequencies of the SEC and jitter components is acceptable.

The following steps describe a possible method for setting up and calibrating a stressed ~~eye~~ receiver ~~conformance~~ test signal when using a stressed receiver conformance test setup as shown in Figure 95–5:

1) Set the signaling rate of the test pattern generator to meet the requirements in Table 95–7.

2) With the sinusoidal jitter, sinusoidal interferers, ~~sinusoidal jitter,~~ and Gaussian noise generator turned off, set the extinction ratio of the E/O to approximately the minimum specified in Table 95–6.

3) The required values of SEC, J2 Jitter and J4 Jitter of the stressed receiver ~~conformance~~ test signal are given in Table 95–7.

With sinusoidal jitter, sinusoidal amplitude interferer 1, sinusoidal amplitude interferer 2, ~~sinusoidal jitter,~~ and the Gaussian noise generator turned off, at least 2.5 dB of SEC should be created by the selection of the appropriate bandwidth for the low-pass filter. Any remaining SEC must be created with a combination of sinusoidal jitter, sinusoidal interference, and Gaussian noise.

Sinusoidal jitter is added as specified in Table 95–11. When calibrating the conformance signal, the sinusoidal jitter frequency should be ~~within~~ between ~~the 10~~ 50 MHz ~~to~~ and 10 times LB as defined in Table 95–11, avoiding harmonic relationships between the sinusoidal jitter, the sinusoidal interferers, the signaling rate, and the pattern repetition rate. Sinusoidal jitter amplitude may be calibrated by measuring the jitter on the oscilloscope, while transmitting the square wave pattern, and using a clean clock in place of the CRU to trigger the oscilloscope.

~~The sinusoidal amplitude interferers may be set at any frequency between 100 MHz and 2 GHz, although care should be taken to avoid harmonic relationships between the sinusoidal interferers, the sinusoidal jitter, the signaling rate, and the pattern repetition rate.~~ The ~~instantaneous bit shrinkage~~ jitter introduced by sinusoidal amplitude interferer 1 or sinusoidal interferer 2 should be ~~no more than~~ between 0.05 UI and 0.15 UI each.

Iterate the adjustments of sinusoidal interferers and Gaussian noise generator and extinction ratio until the values of SEC, stressed eye J2 Jitter and stressed eye J4 Jitter meet the requirements in Table 95–7, the extinction ratio is approximately the minimum specified in Table 95–6, and sinusoidal jitter is as specified in Table 95–11.

Each receiver lane is conformance tested in turn. The source for the lane under test is adjusted to supply a signal at the input to the receiver under test at the "Stressed receiver sensitivity (OMA), each lane (max)" specified in Table 95–7, and the test sources for the other lanes is set to the "OMA of each aggressor lane" specified in Table 95–7.

95.8.8.3 J2 Jitter and J4 Jitter

J2 Jitter is defined as the time interval at the average optical power level that includes all but 10^{-2} of the jitter distribution, which is the time interval from the 0.5th to the 99.5th percentile of the jitter histogram. J2 Jitter is defined using a clock recovery unit as in 95.8.7. If measured using an oscilloscope, the histogram should include at least 10 000 hits, and should be taken over about 1% of the signal amplitude. If measured by plotting BER vs. decision time, J2 is the time interval between the two points with a BER of 2.5×10^{-3}.

Comment [PD13]: Comment r02-33 recommends deletion. Comment r02-18 recommends a change.

Comment [PD14]: These two? in purple shou be consistent with whatever we choose for mouthful signal. Comment r02-20.

Comment [PD15]: This is too wide. Compare 95.8.5 " The method described in 95.8.5.1 and 95.8.5.2 is the reference measurement method. Other equivalentmeasurement methods may be used with suitable calibration." Comment r02-26

Comment [PD16]: Order of stressors: D3.1 comment 88, D3.2 comment 27.

Comment [PD17]: Not consistent with the la sentence of 95.8.8.1. Comment r02-34.

Comment [PD18]: At 10 MHz, CRU will partia track the SJ, degrading the calibration. Comment r02-28.

Comment [PD19]: This is where we should a to avoid a harmonic relationship involving the SJ. And see r02-29.

Comment [PD20]: This has been stated earli Comment r02-29.

Comment [PD21]: Duplicate text, as comme r02-29 points out.

Comment [PD22]: Instantaneous bit shrinka does not seem measurable: comment r02-35. W about sinusoidal amplitude interferer 2? comme r02-30.

Comment [PD23]: Number. Comment 31.

Comment [PD24]: Newly spotted: should be Jitter" not "J2".

J4 Jitter is defined as the time interval at the average optical power level that includes all but 10^{-4} of the jitter distribution. J4 Jitter is defined using a clock recovery unit as in 95.8.7. If measured using an oscilloscope, the histogram should include at least 1 000 000 hits, and should be taken over about 1% of the signal amplitude. If measured by plotting BER vs. decision time, J4 is the time interval between the two points with a BER of 2.5×10^{-5}.

95.8.8.4 Stressed receiver ~~conformance~~ test signal verification

The stressed receiver ~~conformance~~ test signal can be verified using an optical reference receiver with an ideal fourth-order Bessel-Thomson response with a reference frequency f_r of 19.34 GHz. Use of G.691 tolerance filters may significantly degrade this calibration. The clock output from the clock source in Figure 95–5 is modulated with the sinusoidal jitter. To use an oscilloscope to calibrate the final stressed eye J2 Jitter and stressed eye J4 Jitter that includes the sinusoidal jitter component, a clock recovery unit (CRU of Figure 95–5) is required.

Care should be taken when characterizing the stressed receiver test signal because excessive noise/jitter in the measurement system would result in a~~n~~ stressed receiver test ~~input~~ signal that does not fully stress the receiver under test. Running the receiver tolerance test with a signal that is under-stressed may result in the deployment of non-compliant receivers. Care should be taken to minimize the noise/jitter introduced by the reference O/E, filters and any BERT and/or to correct for this noise. ~~While t~~The details of a BER scan measurement and test equipment are beyond the scope of this standard.~~, i~~ It is recommended that the implementor fully characterize the test equipment and apply appropriate guard bands to ensure that the stressed receiver ~~conformance input~~test signal meets the stress and sinusoidal jitter specified in 95.8.8.2 and 95.8.8.5.

Comment [PD25]: What BERT? I suppose the might be one for doing BER bathtub measuremer for J4 (can BERT measure J2?). Maybe this should be "and any BERT". New comment.

Comment [PD26]: These recommendations should apply even if there is no BERT, so should b decoupled from the clause before.

95.8.8.5 Sinusoidal jitter for stressed receiver conformance test

The sinusoidal jitter is used to test receiver jitter tolerance. The amplitude of the applied sinusoidal jitter is dependent on frequency as specified in Table 95–11.

Table 95–11—Applied sinusoidal jitter

Frequency range	Sinusoidal jitter peak-to-peak (UI)
f < 100 kHz	Not specified
100 kHz < f <= 10 MHz	$5 \times 10^5/f$
10 MHz < f <= 10 *LB*[a]	0.05

[a]*LB* = loop bandwidth; upper frequency bound for added sinusoidal jitter should be at least 10 times the loop bandwidth of the receiver being tested.