Date: November 13, 2002
To: T10 Technical Committee
From: Alvin Cox (alvin.cox@seagate.com)
Subject: SAS Test Loads

The following changes to text and test load figure are made to aid the testing process by clarifying and defining the compliance interconnect test load and zero-length test load. The changes to the rev 0 version are significant and not highlighted in an effort to make this version more readable.
Revision 2 adds a statement explaining the purpose of compliance interconnect testing.
Revision 3 adds additional changes to section 5.7 as agreed upon during the face-to-face 11/4-11/5.
Revision 4 updates document number to match T10 voting minutes (no technical changes).

Change the title of section 5.7 to **Transmitter and receiver electrical characteristics**.

Change 5.7.1 as follows:

5.7.1 Compliance points

Signal behavior at separable connectors and integrated circuit package connections that satisfy the physical definition for an compliance point require compliance with transmitter and receiver characteristic tables only if the connectors or integrated circuit package connections are identified as compliance points by the supplier of the parts that contain or comprise the candidate compliance point. Table 23 lists the compliance points.

Table 23. Compliance points

Compliance point	Type	Description
IT	intra-enclosure	Drive connector; transmit serial port
IR	intra-enclosure	Drive connector; receive serial port
CT	inter-enclosure	External cabinet connector; transmit serial port
CR	inter-enclosure	External cabinet connector; receive serial port
XT	intra-enclosure	Expander or initiator phy; transmit serial port
XR	intra-enclosure	Expander or initiator phy; receive serial port

Delete section **5.7.2 Optional compliance points**. Combined with section 5.7.1

5.7.4.1 Eye masks overview

Delete Note 10.

5.7.4.2 Transmitted eye masks at IT, CT, and XT

Delete section. This section no longer needed due to compliance test methodology.

5.7.4.4 Jitter tolerance masks

Delete first two paragraphs of this section and figure 36. Tolerance masks do not apply to transmitters.

Figure 38 – Provide numbers for F_{NOM} at 1,5 and 3,0 Gbps (editorial).

5.7.5 Transmitted signal characteristics

Delete “and optional Tx compliance points” from the sentence immediately preceding table 26.

Replace table 26 with the following table:

Table 26. Transmitted signal characteristics at Tx compliance points

Compliance point	Signal characteristic	Units	1,5 Gbps	3,0 Gbps
IT, CT, XT	Skew[d]	ps	20	15
	Tx Off Voltage[c]	mV(P-P)	< 50	< 50
	Maximum rise/fall time[d]	ps	273	137
	Minimum rise/fall time[d]	ps	133	67

Notes:

a) All tests in this table shall be performed with the zero-length test load shown in figure 39.

b) The skew measurement shall be made at the midpoint of the transition with a repeating 0101b pattern on the physical link. The same stable trigger, coherent to the data stream, shall be used for both the Tx+ and Tx- signals. Skew is defined as the time difference between the means of the midpoint crossing times of the Tx+ signal and the Tx- signal.

c) The transmitter off voltage is the maximum A. C. voltage measured at compliance points IT, CT and XT when the transmitter is logically turned off or is unpowered.

d) Rise/fall times are measured from 20 % to 80 % of the transition with a repeating 0101b pattern on the physical link.

5.7.6 Received signal characteristics

Replace the first paragraph with the following text:

Table 27 defines the compliance point requirements of the delivered signal at the receiver end of a TxRx connection as measured into the test loads specified in figure 39.

Table 27:

Change skew values for IR, CR, and XR to 80 ps and 75 ps for 1,5 Gbps and 3,0 Gbps, respectively.

Delete SATA column from IR and CR table.

Add note flag to IR and note as follows:
If SATA devices are to be supported at the IR location, requirements of the SATA specification shall be met at that compliance point.

Change the skew note (IR, CR and XR tables) to the following:

The skew measurement shall be made at the midpoint of the transition with a repeating 0101b pattern on the physical link. The same stable trigger, coherent to the data stream, shall be used for both the Rx+ and Rx- signals. Skew is defined as the time difference between the means of the midpoint crossing times of the Rx+ signal and the Rx- signal.
Delete XR reference to note c and delete designation as optional compliance point.

5.7.7 Jitter

Delete the entire first paragraph of this section except for the first sentence.

Delete rows for IT, CT, and XT in table 28.
Delete notes a) and g) of table 28.

5.7.8 Jitter tolerance

Change first paragraph to:
Table 29 defines the minimum allowable jitter tolerance at the compliance points.

Delete CT, IT, and XT rowas from table 29.
Delete note g from table 29.

Change 5.7.11 and 5.7.12 to the following:

5.7.11 Transmitter requirements

For all inter-enclosure TxRx connections, the transmitter shall be A. C. coupled to the interconnect through a transmission network.

For intra-enclosure TxRx connections the expander transmitter shall be A. C. coupled to the interconnect. Other transmitters may be A. C. or D. C. coupled.

A combination of a zero-length test load and the transmitter compliance transfer function (TCTF) test load methodology is used for the specification of the initiator, expander or target device transmitter characteristics. This methodology specifies the transmitter signal at the test points on the required test loads. The transmitter shall use the same settings (pre-emphasis, voltage swing, etc.) with both the zero-length test load and the TCTF test load. The received signal specifications shall be met under each of these loading conditions.

The TCTF is the mathematical statement of the transfer function through which the transmitter shall be capable of producing acceptable signals as defined by a receive mask. The transmission magnitude response, $[S_{21}]$, of the TCTF in dB satisfies the following equation:

$$\left| S_{21} \right| \leq -20 \log (e) \{[6.5 \times 10^{-6}(f^{0.5})]+[2.0 \times 10^{-10}(f)]+[3.3 \times 10^{-20}(f^{2})]\} \text{ dB}$$

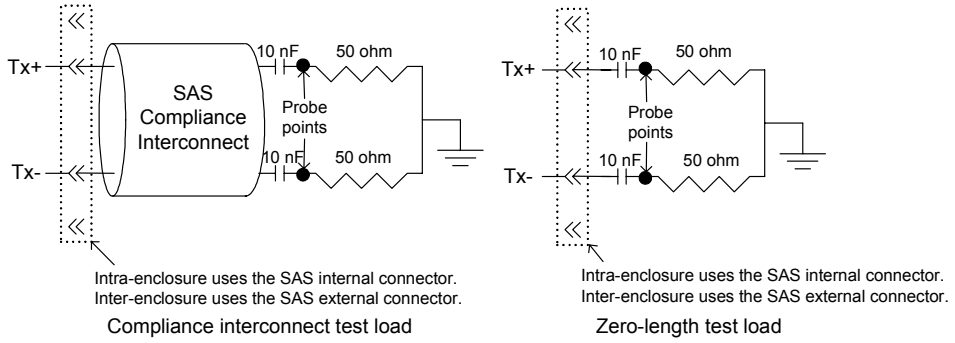
The TCTF is used to specify the requirements on transmitters that may or may not incorporate pre-emphasis or other forms of compensation. A compliance interconnect is any physical interconnect with equal or greater loss at all frequencies than that required by the TCTF.

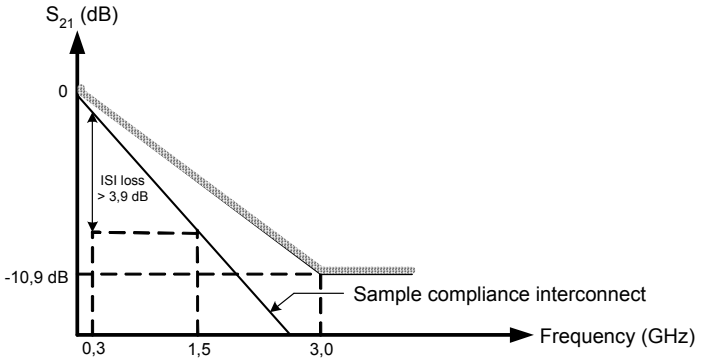
Compliance with the TCTF test load requirement shall be determined either (a) by measuring the signal produced by the transmitter through a physical compliance interconnect attached to the transmitter or (b) by mathematically processing through the TCTF the signal captured using a zero-length test load.

Compliance with the zero-length test load requirement shall be determined by measurement made across a load equivalent to the zero-length load shown in figure 39.

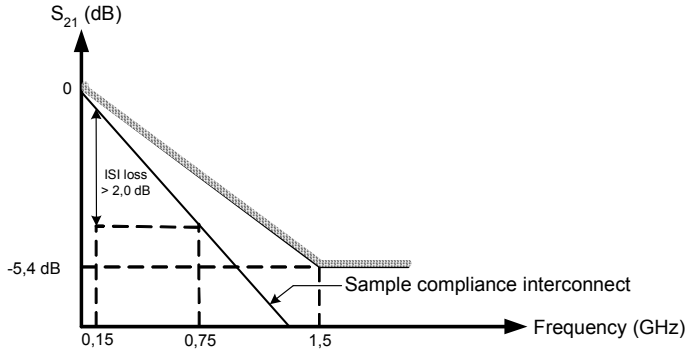
For both test load cases, the transmitter shall meet the output voltages and timing listed in table 25 and table 26 at the designated compliance points. The default mask shall be CR for inter-cabinet TxRx connections and IR for intra-cabinet TxRx connections. The eye masks are shown in 5.7.4.

The compliance interconnect magnitude response and ISI loss examples for 3 Gbps and 1,5 Gbps are shown in figure 39.





Compliance interconnect magnitude response and ISI loss example for 3,0 Gbps



Compliance interconnect magnitude response and ISI loss example for 1,5 Gbps

Figure 39 — Transmitter test loads

5.7.12 Receiver requirements

The receiver shall be A. C. coupled to the interconnect through a receive network. The receive network shall terminate the TxRx connection by a 100 ohm equivalent impedance as specified in table 28.

The receiver shall operate within a BER of 10^{-12} when a SAS signal with valid voltage and timing characteristics is delivered to the compliance point from a 100 ohm source. The delivered SAS signal shall be considered valid if it meets the voltage and timing limits specified in table 25 and table 26.

Additionally the receiver shall also operate within the BER objective when the signal at a receiving phy has the additional sinusoidal jitter present that is specified in the table 29. The jitter tolerance figure is given in 5.7.4.4 for all Rx compliance points in a TxRx connection. The figure given assumes that any external interference occurs prior to the point at which the test is applied. When testing the jitter tolerance capability of a receiver the additional 0,1 UI of sinusoidal jitter may be reduced by an amount proportional to the actual externally induced interference between the application point of the test and the input to the receiving phy. The additional jitter reduces the eye opening in both voltage and time.