Gbps, the fundamental frequency of the 0101b pattern is 1,5 GHz and the bit clock frequency is 3 GHz)(see 3.1.13).

3.1.16 bit error ratio (BER): The number of logical bits output from a receiver circuit that differ from the correct transmitted logical bits, divided by the number of transmitted logical bits. The BER is usually expressed as a coefficient and a power of 10 (e.g., 2 erroneous bits out of 100 000 bits transmitted would be 2 out of 10^5 or 2×10^{-5}).

3.1.17 broadcast primitive processor (BPP): An object within an expander function that manages broadcast primitives. See 4.6.5.

3.1.18 burst time: The part of an OOB signal (see 3.1.129) where ALIGN primitives (see 3.1.141) are being transmitted. See 6.6.

3.1.19 byte: A sequence of eight contiguous bits considered as a unit. A byte is encoded as a character (see 3.1.20) using 8b10b coding (see 6.2).

3.1.20 character: A sequence of ten contiguous bits considered as a unit. A byte (see 3.1.19) is encoded as a character using 8b10b coding (see 6.2).

3.1.21 class: A description of a set of objects (see 3.1.126) that share the same attributes (see 3.1.8), operations (see 3.1.130), relationships, and semantics. Classes may have attributes and may support operations.

3.1.22 class diagram: A diagram that shows a collection of classes (see 3.1.21) and their contents and relationships. See 3.5.

3.1.23 clock data recovery (CDR): The function is provided by the receiver circuit responsible for producing a regular clock signal from the signal (i.e., the recovered clock) and for aligning this clock to the symbols (i.e., bits) being transmitted with the signal. The CDR uses the recovered clock to recover the bits.

3.1.24 command descriptor block (CDB): A structure used to communicate a command from a SCSI application client to a SCSI device server. See SAM-3.

3.1.25 compliance point: An interoperability point where interoperability specifications are met. See 5.3.1.

3.1.26 compliant jitter tolerance pattern (CJTPAT): A test pattern for jitter testing. See 5.3.6.4 and A.2.

3.1.27 configurable expander device: An expander device that contains an expander route table that is configured with expander route entries. See 4.1.5.

3.1.28 confirmation: A message passed from a lower layer state machine to a higher layer state machine, usually responding to a request (see 3.1.153) from that higher layer state machine, and sometimes relaying a response (see 3.1.155) from a peer higher layer state machine. See 3.6.

3.1.29 connection: A temporary association between a SAS initiator port and a SAS target port. See 7.12.

3.1.30 connection rate: The effective rate of dwords through the pathway between a SAS initiator phy and a SAS target phy, established through the connection request.

3.1.31 connector: Electro-mechanical components consisting of a receptacle and a plug that provide a separable interface between two transmission 1 media segments. Connectors may introduce physical disturbances to the transmission path due to impedance mismatch, crosstalk, etc. These disturbances may introduce jitter and other forms of signal degradation under certain conditions.

Summary of Comments on Serial Attached SCSI 1.1 (SAS-1.1) Standard

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3.1.132 pathway: A set of physical links between a SAS initiator phy and a SAS target phy being used by a connection. See 4.1.9.

3.1.133 pathway blocked count: The number of times the port has retried this connection request due to receiving OPEN_REJECT (PATHWAY BLOCKED).

3.1.134 phy: A object in a device that is used to interface to other devices (e.g., an expander phy (see 3.1.65) or a SAS phy (see 3.1.170)). See 4.1.2.

3.1.135 phy reset sequence: An OOB sequence (see 3.1.128) followed by a speed negotiation sequence (see 3.1.211). See 4.4.

3.1.136 physical link: Two differential signal pairs, one pair in each direction, that connect two physical phys. See 4.1.2.

3.1.137 physical phy: A phy (see 3.1.134) that contains a transceiver (see 3.1.240) and electrically interfaces to a physical link to communicate with another physical phy. See 4.1.2.

3.1.138 port: A SAS port or an expander port. Each port contains one or more phys. See 4.1.3.

3.1.139 potential pathway: A set of physical links between a SAS initiator phy and a SAS target phy. See 4.1.9.

3.1.140 power on: Power being applied.

3.1.141 primitive: A dword containing a 7Ch or BCh control byte followed by three data bytes, or a K28.3 or K28.5 control character with correct disparity followed by three data characters with correct disparity. See 7.2.

3.1.142 primitive sequence: A set of primitives treated as a single entity. See 7.2.4.

3.1.143 probability density function (PDF): A histograph of the jitter event population.

3.1.144 programmed maximum physical link rate: The maximum operational physical link rate of a phy (e.g., as programmed via the SMP PHY CONTROL function (see 10.4.3.10) or the Phy Control and Discover subpage (see 10.2.7.2.3)).

3.1.145 programmed minimum physical link rate: The minimum operational physical link rate of a phy (e.g., as programmed via the SMP PHY CONTROL function (see 10.4.3.10) or the Phy Control and Discover subpage (see 10.2.7.2.3)).

3.1.146 rate: Data transfer rate of a physical link (e.g., 1,5 Gbps or 3,0 Gbps).

3.1.147 rate change delay time (RCDT): The time between rates during the speed negotiation sequence (see 6.7.4.2).

3.1.148 read data: Data transferred to the application client's data-in buffer from the device server, as requested by the Send Data-In transport protocol service (see 10.2.1.6).

3.1.149 receiver circuit: An electronic circuit that converts an analog serial input signal to a logic signal.

3.1.150 receiver device (Rx): The device downstream from an IR or CR compliance point containing a portion of the physical link and a receiver circuit (see 3.1.149).

3.1.151 reflection coefficient (ρ): The reflection coefficient of the transmission 1 ~~media~~ 2 (i.e., the ratio of the reflected voltage divided by the voltage applied to the transmission 3 ~~media~~ 4).

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Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:07:13 PM

Sequence number: 2
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:07:21 PM
segment

Sequence number: 3
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:07:39 PM

Sequence number: 4
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:07:45 PM
segment

3.1.247 transport protocol service response: A message passed from the application layer to the transport layer (i.e., from the SCSI device server to the SSP target port) that completes the SCSI transport protocol service.

3.1.248 TxRx connection: The complete simplex signal path between the transmitter circuit (see 3.1.241) and receiver circuit (see 3.1.149), over which a bit error ratio (BER) of < 10^{-12} is achieved. See 5.3.3.

3.1.249 TxRx connection segment: That portion of a TxRx connection (see 3.1.248) delimited by separable connectors or changes in ~~media~~. See 5.3.3.

3.1.250 unit interval (UI): The normalized, dimensionless, nominal duration of a signal transmission bit (e.g., $666,\overline{6}$ ps at 1,5 Gbps and $333,\overline{3}$ ps at 3,0 Gbps). Unit interval is a measure of time that has been normalized such that 1 UI is equal to 1/baud seconds.

3.1.251 valid character: A character that is a control character (see 3.1.34) or a data character (see 3.1.39).

3.1.252 valid dword: A dword that is a data dword (see 3.1.40) or a primitive (see 3.1.141).

3.1.253 virtual phy: A phy (see 3.1.134) that interfaces to another virtual phy inside the same device. See 4.1.2.

3.1.254 wide link: A group of physical links that attaches a wide port to another wide port. See 4.1.3.

3.1.255 wide port: A port that contains more than one phy. See 4.1.3.

3.1.256 write data: Data transferred from the application client's data-out buffer to the device server, as requested by the Request Data-Out transport protocol service (see 10.2.1.8).

3.2 Symbols and abbreviations

See 2.1 for abbreviations of standards bodies (e.g., ISO). Units and abbreviations used in this standard:

Abbreviation	Meaning
AA	ATA application layer (see 10.3)
A.C.	alternating current
ACK	acknowledge primitive (see 7.2.6.1)
AIP	arbitration in progress primitive (see 7.2.5.1)
ATA	AT attachment (see 3.1.9)
ATAPI	AT attachment packet interface
ATA/ATAPI-7	AT Attachment with Packet Interface - 7 standard (see 2.3)
AWG	American wire gauge
AWT	arbitration wait time
BCH	Bose, Chaudhuri and Hocquenghem code (see 4.2.3)
BER	bit error ratio (see 3.1.16)
BIST	built in self test
BPP	broadcast primitive processor (see 3.1.17)
CDB	command descriptor block (see 3.1.24)
CDF	cumulative distribution function (see 3.1.35)
CDR	clock data recovery (see 3.1.23)
CJTPAT	compliant jitter tolerance pattern (see 3.1.26)
CRC	cyclic redundancy check (see 3.1.36)

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Sequence number: 1
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:08:36 PM

Sequence number: 2
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:47:07 PM
the conductive material that carries the TxRx signal

SAS target device signal assignments, except for the addition of the secondary physical link when present, are in the same locations as they are in a SATA device. On cable assemblies, backplanes, or any other ~~connection media~~, the Tx signal from one internal connector pair shall be connected to the corresponding Rx signal of the other internal connector pair (i.e., the TP+ signal pin of connector 1 shall connect to the RP+ signal pin of connector 2) if there is an internal connector at both ends of the ~~transmission media~~.

The TP+, TP-, RP+, and RP- signals are used by the primary physical link. The TS+, TS-, RS+, and RS- signals are used by the secondary physical link.

5.2.3.3 SAS external connectors

5.2.3.3.1 SAS external connectors overview

SAS external cables shall use either the SAS external cable plug connector (see 5.2.3.3.2) or the SAS external compact cable plug connector (see 5.2.3.3.5).

SAS devices and expander devices with external ports shall use either the SAS external receptacle connector (see 5.2.3.3.3) or the SAS external compact receptacle connector (see 5.2.3.3.6).

5.2.3.3.2 SAS external cable plug connector

The SAS external cable plug connector is defined in SFF-8470 as the four lane free (plug) connector with jack screws. The SAS external cable plug connector shall not include keys and may include key slots. Key slots are not defined by this standard. The SAS external cable plug connector attaches to a SAS external receptacle connector, providing contact for up to four physical links.

Table 24 (see 5.2.3.3.4) defines the pin assignments.

Figure 61 shows the SAS external cable plug connector.

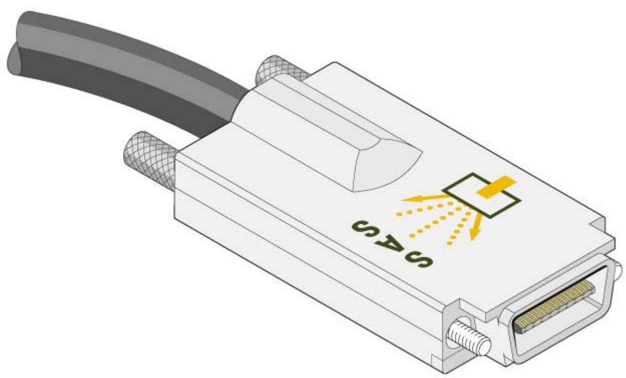

Figure 61 — SAS external cable plug connector

See 5.2.4.2 for icon recommendations for the connectors on each end of a SAS external cable.

5.2.3.3.3 SAS external receptacle connector

The SAS external receptacle connector is defined in SFF-8470 as the four lane fixed (receptacle) connector with jack screws. The SAS external receptacle connector shall not include keys and may include key slots. Key slots are not defined by this standard. The SAS external receptacle connector attaches to a SAS external cable plug connector, providing contact for up to four physical links.

A SAS external receptacle connector may be used by one or more SAS devices (e.g., one SAS device using physical links 0 and 3, another using physical link 1, and a third using physical link 2).

A SAS external receptacle connector shall be used by only one expander device at a time, and all physical links shall be used by the same expander port (i.e., all the expander phys shall have the same routing attribute (e.g., subtractive or table) (see 4.6.2)).

Table 24 (see 5.2.3.3.4) defines the pin assignments.

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Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:15:50 PM

Sequence number: 2
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:16:36 PM
conductive material that carries the TxRx electrical signal

Sequence number: 3
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:18:58 PM

Sequence number: 4
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:19:09 PM
TxRx connection segment

5.2.6 Impedance and ~~media~~ specifications

Table 30 defines impedance ~~and media~~ requirements for internal cables and backplanes.

Table 30 — Impedance ~~and media~~ requirements for internal cables and backplanes

Requirement [a]	Units	1,5 Gbps	3,0 Gbps
Maximum TDR rise time 20 % to 80 % [b]	ps	100	50
~~Media (backplane or cable)~~			
Differential impedance [c, d]	ohm	100 ± 10	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 15	
Maximum differential impedance imbalance [c, d, e]	ohm	5	

[a] All measurements are made through mated connector pairs.

[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.

[c] The ~~media~~ impedance measurement identifies the impedance mismatches present in the ~~media~~ when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the ~~media~~, when present, but includes any intermediate connectors or splices. The mated connectors measurement applies only to the mated connector pair at each end, as applicable.

[d] Where the ~~media~~ has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the impedance.

[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.

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Sequence number: 1
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:21:08 PM

Sequence number: 2
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:21:16 PM
TxRx connection segment

Sequence number: 3
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:48:08 PM

Sequence number: 4
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:23:35 PM

Sequence number: 5
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:23:56 PM

Sequence number: 6
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:24:23 PM
Backplane or Bulk Cable

Sequence number: 7
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:40:45 PM

Sequence number: 8
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:27:06 PM

Sequence number: 9
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:40:50 PM
conductive material that carries the TxRx electrical signal

Sequence number: 10
Author: coxa

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5.2.6 Impedance and ~~media~~ specifications

Table 30 defines impedance ~~and media~~ requirements for internal cables and backplanes.

Table 30 — Impedance ~~and media~~ requirements for internal cables and backplanes

Requirement [a]	Units	1,5 Gbps	3,0 Gbps
Maximum TDR rise time 20 % to 80 % [b]	ps	100	50
~~Media (backplane or cable)~~			
Differential impedance [c, d]	ohm	100 ± 10	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 15	
Maximum differential impedance imbalance, [c, d, e]	ohm	5	

[a] All measurements are made through mated connector pairs.

[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.

[c] The ~~media~~ impedance measurement identifies the impedance mismatches present in the ~~media~~ when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the ~~media~~, when present, but includes any intermediate connectors or splices. The mated connectors measureme[11]pplies only to the mated connector pair at each end, as applicable.

[d] Where the [12]~~edia~~ has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall [13]used to determine the impedance.

[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.

Subject: Cross-Out
Date: 5/8/2005 9:39:30 PM

Sequence number: 11
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:39:34 PM
TxRx connection segment

Sequence number: 12
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:39:02 PM

Sequence number: 13
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:39:14 PM
TxRx connection segment

Table 31 defines ~~impedance and media~~ requirements for external cables.

Table 31 — ~~impedance and media~~ requirements for external cables

Requirement [a]	Units	1,5 Gbps	3,0 Gbps
Maximum TDR rise time 20 % to 80 % [b]	ps	70	
~~Media (cable)~~			
Differential impedance [c, d]	ohm	100 ± 5	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 10	
Cable assembly			
Maximum insertion loss [f]	dB	16	
Maximum near-end crosstalk from aggressor pairs offset by one position (i.e., adjacent) [f, h]	dB	-30	
Maximum near-end crosstalk from aggressor pairs offset by two positions [f, h]	dB	-36	
Maximum near-end crosstalk from aggressor pairs offset by more than two positions [f, h]	dB	-40	
Maximum near-end crosstalk from aggressor pairs offset by one position (i.e., adjacent) [g, h]	dB	-24	
Maximum near-end crosstalk from aggressor pairs offset by two positions [g, h]	dB	-30	
Maximum near-end crosstalk from aggressor pairs offset by more than two positions [g, h]	dB	-40	
Maximum rise time [h, i]	ps	150	
Maximum ISI [j]	ps	60	
Maximum intra-pair skew [h, k]	ps	20	

[a] All measurements are made through mated connector pairs.

[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.

[c] The ~~media~~ impedance measurement identifies the impedance mismatches present in the ~~media~~ when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the ~~media~~, when present, but includes any intermediate connectors or splices. The mated connectors measurement applies only to the mated connector pair at each end, as applicable.

[d] Where the ~~media~~ has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the impedance.

[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.

[f] The range for this frequency domain measurement is 10 MHz to 2 250 MHz.

[g] The range for this frequency domain measurement is 2 250 Mhz to 4 500 MHz.

[h] The far end of the mated cable assembly shall be terminated in its characteristic impedance. Insertion loss variations (i.e., cable length) may change the measurement result.

[i] Connect the TDR step impulse response generators to the near end of the cable assembly and measure the output rise time at the far end. The input rise time shall be no higher than 35 ps.

[j] Measured DJ at the far end of the cable assembly under test using a lone bit pattern at 3,0 Gbps.

[k] The procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the intra-pair skew.

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Sequence number: 1
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:36:17 PM

Sequence number: 2
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:36:24 PM
electrical

Sequence number: 3
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:36:34 PM

Sequence number: 4
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:36:40 PM
Electrical

Sequence number: 5
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:36:46 PM

Sequence number: 6
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:36:57 PM
Bulk Cable

Sequence number: 7
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:28:28 PM

Sequence number: 8
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:41:39 PM

Sequence number: 9
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:40:34 PM
conductive material that carries the TxRx electrical signal

Sequence number: 10
Author: coxa

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Table 31 defines impedance and media requirements for external cables.

Table 31 — Impedance and media requirements for external cables

Requirement [a]	**Units**	**1,5 Gbps**	**3,0 Gbps**
Maximum TDR rise time 20 % to 80 % [b]	ps	70	
Media (cable)			
Differential impedance [c, d]	ohm	100 ± 5	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 10	
Cable assembly			
Maximum insertion loss [f]	dB	16	
Maximum near-end crosstalk from aggressor pairs offset by one position (i.e., adjacent) [f, h]	dB	-30	
Maximum near-end crosstalk from aggressor pairs offset by two positions [f, h]	dB	-36	
Maximum near-end crosstalk from aggressor pairs offset by more than two positions [f, h]	dB	-40	
Maximum near-end crosstalk from aggressor pairs offset by one position (i.e., adjacent) [g, h]	dB	-24	
Maximum near-end crosstalk from aggressor pairs offset by two positions [g, h]	dB	-30	
Maximum near-end crosstalk from aggressor pairs offset by more than two positions [g, h]	dB	-40	
Maximum rise time [h, i]	ps	150	
Maximum ISI [j]	ps	60	
Maximum intra-pair skew [h, k]	ps	20	

[a] All measurements are made through mated connector pairs.

[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.

[c] The media impedance measurement identifies the impedance mismatches present in the media when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the media, when present, but includes any intermediate connectors or splices. The mated connectors measuremen [11] pplies only to the mated connector pair at each end, as applicable.

[d] Where the [12] dia has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall b [13] used to determine the impedance.

[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.

[f] The range for this frequency domain measurement is 10 MHz to 2 250 MHz.

[g] The range for this frequency domain measurement is 2 250 Mhz to 4 500 MHz.

[h] The far end of the mated cable assembly shall be terminated in its characteristic impedance. Insertion loss variations (i.e., cable length) may change the measurement result.

[i] Connect the TDR step impulse response generators to the near end of the cable assembly and measure the output rise time at the far end. The input rise time shall be no higher than 35 ps.

[j] Measured DJ at the far end of the cable assembly under test using a lone bit pattern at 3,0 Gbps.

[k] The procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the intra-pair skew.

Subject: Cross-Out
Date: 5/8/2005 9:29:36 PM

Sequence number: 11
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:30:02 PM
TxRx connection segment

Sequence number: 12
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:31:26 PM

Sequence number: 13
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:31:48 PM
TxRx connection segment

Table 32 defines impedance and media requirements for internal wide cables.

Table 32 — Impedance and media requirements for internal wide cables

Requirement [a]	Units	1,5 Gbps	3,0 Gbps
Maximum TDR rise time 20 % to 80 % [b]	ps	70	
Media (cable)			
Differential impedance [c, d]	ohm	100 ± 10	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 15	
Maximum differential impedance imbalance [c, d, g]	ohm	5	
Cable assembly			
Maximum insertion loss [c, d]	dB	6	
Maximum near-end crosstalk on the following (adjacent) signal pairs: RX0/TX0, TX0/RX1, RX1/TX1, RX2/TX2, TX2/RX3, and RX3/TX3 [f, g]	dB	-33	
Maximum near-end crosstalk on the following signal pairs: RX0/RX1, RX0/TX1, TX0/TX1, RX2/RX3, RX2/TX3, and TX2/TX3 [f, g]	dB	-45	
Maximum near-end crosstalk on all other signal pairs [f, g]	dB	-50	
Maximum intra-pair skew	ps	10	

[a] All measurements are made through mated connector pairs.
[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.
[c] The media impedance measurement identifies the impedance mismatches present in the media when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the media, when present, but includes any intermediate connectors or splices. The mated connectors measurement applies only to the mated connector pair at each end, as applicable.
[d] Where the media has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the impedance.
[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.
[f] The range for this frequency domain measurement is 10 MHz to 4 500 MHz.
[g] The far end of the mated cable assembly shall be terminated in its characteristic impedance. Insertion loss variations (i.e., cable length) may change the measurement result.

5.3 Transmitter and receiver device electrical characteristics

5.3.1 Compliance points

Signal behavior at separable connectors requires compliance with signal characteristics defined by this standard only if the connectors are identified as compliance points by the supplier of the parts that contain or comprise the candidate compliance point.

Signal compliance is measured at physical positions denoted as probe points inside a test load (see 5.3.2). Probe points identify the position in the test load where the signal properties are measured but do not imply that physical probing is used for the measurement. Physical probing may be disruptive to the signals and should not be used unless verified to be non-disruptive.

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electrical

Sequence number: 3
Author: coxa
Subject: Cross-Out
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Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:43:27 PM
Electrical

Sequence number: 5
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:43:34 PM

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Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:43:42 PM
Bulk Cable

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Author: coxa
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Author: coxa
Subject: Cross-Out
Date: 5/8/2005 9:43:56 PM

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Author: coxa
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conductive material that carries the TxRx electrical signal

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Author: coxa

Comments from page 132 continued on next page

Table 32 defines impedance and media requirements for internal wide cables.

Table 32 — Impedance and media requirements for internal wide cables

Requirement [a]	Units	1,5 Gbps	3,0 Gbps
Maximum TDR rise time 20 % to 80 % [b]	ps	70	
Media (cable)			
Differential impedance [c, d]	ohm	100 ± 10	
Maximum differential impedance imbalance [c, d, e]	ohm	5	
Common-mode impedance [c, d]	ohm	32,5 ± 7,5	
Mated connectors			
Differential impedance [c, d]	ohm	100 ± 15	
Maximum differential impedance imbalance [c, d, g]	ohm	5	
Cable assembly			
Maximum insertion loss [c, d]	dB	6	
Maximum near-end crosstalk on the following (adjacent) signal pairs: RX0/TX0, TX0/RX1, RX1/TX1, RX2/TX2, TX2/RX3, and RX3/TX3 [f, g]	dB	-33	
Maximum near-end crosstalk on the following signal pairs: RX0/RX1, RX0/TX1, TX0/TX1, RX2/RX3, RX2/TX3, and TX2/TX3 [f, g]	dB	-45	
Maximum near-end crosstalk on all other signal pairs [f, g]	dB	-50	
Maximum intra-pair skew	ps	10	

[a] All measurements are made through mated connector pairs.
[b] Filtering may be used to obtain the equivalent rise time. The filter consists of the two-way launch/return path of the test fixturing, the two-way launch/return path of the test cable, and the software or hardware filtering of the TDR scope. The equivalent rise time is the rise time of the TDR scope output after application of all filter components. When configuring software or hardware filters of the TDR scope to obtain the equivalent rise time, filtering effects of test cables and test fixturing shall be included.
[c] The media impedance measurement identifies the impedance mismatches present in the media when terminated in its characteristic impedance. This measurement excludes mated connectors at both ends of the media, when present, but includes any intermediate connectors or splices. The mated connectors measurement applies only to the mated connector pair at each end, as applicable.
[d] Where the media has an electrical length of > 4 ns the procedure detailed in SFF-8410, or an equivalent procedure, shall be used to determine the impedance.
[e] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.
[f] The range for this frequency domain measurement is 10 MHz to 4 500 MHz.
[g] The far end of the mated cable assembly shall be terminated in its characteristic impedance. Insertion loss variations (i.e., cable length) may change the measurement result.

5.3 Transmitter and receiver device electrical characteristics

5.3.1 Compliance points

Signal behavior at separable connectors requires compliance with signal characteristics defined by this standard only if the connectors are identified as compliance points by the supplier of the parts that contain or comprise the candidate compliance point.

Signal compliance is measured at physical positions denoted as probe points inside a test load (see 5.3.2). Probe points identify the position in the test load where the signal properties are measured but do not imply that physical probing is used for the measurement. Physical probing may be disruptive to the signals and should not be used unless verified to be non-disruptive.

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Sequence number: 11
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TxRx connection segment

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Author: coxa
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Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:44:50 PM
TxRx connection segment

5.3.2.3 TCTF test load

Figure 93 shows the TCTF test load.

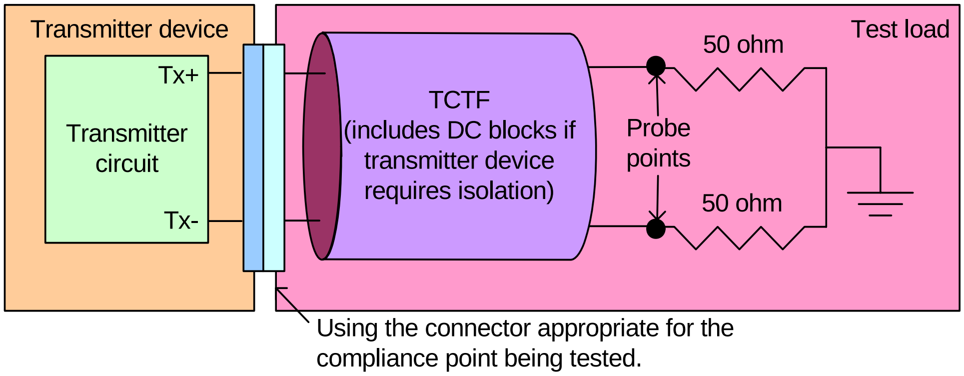

Figure 93 — TCTF test load

The TCTF test load shall meet the media requirements in table 30 (see 5.2.6). The nominal impedance shall be the target impedance.

The TCTF is defined by a set of S-parameters (see B.9). Only the magnitude of $S_{DD21}(f)$ (i.e., insertion loss) is specified by this standard.

For testing a 3,0 Gbps transmitter device at IT, the TCTF test load shall comply with the following equations for the magnitude of $S_{DD21}(f)$ (denoted as $|S_{DD21}(f)|$):

For 50 MHz < f <= 3,0 GHz:

$|S_{DD21}(f)| \le -20 \log_{10}(e) \times ((6{,}5 \times 10^{-6} \times f^{0{,}5}) + (2{,}0 \times 10^{-10} \times f) + (3{,}3 \times 10^{-20} \times f^2))$ dB

and for 3,0 GHz < f <= 5,0 GHz:

$|S_{DD21}(f)| \le -10{,}884$ dB

and, specifying a minimum ISI loss:

$((|S_{DD21}(f = 300 \text{ MHz})|$ of TCTF test load$) - (|S_{DD21}(f = 1\,500 \text{ MHz})|)$ of TCTF test load$)) > 3{,}9$ dB

where:

f is the signal frequency in Hz.

For testing a 3,0 Gbps transmitter device at CT, the TCTF test load shall comply with the following equations for the magnitude of $S_{DD21}(f)$ (denoted as $|S_{DD21}(f)|$):

For 50 MHz < f <= 3,0 GHz:

$|S_{DD21}(f)| \le -20 \log_{10}(e) \times ((1{,}7 \times 10^{-5} \times f^{0{,}5}) + (1{,}0 \times 10^{-10} \times f))$ dB

and for 3,0 GHz < f <= 5,0 GHz:

$|S_{DD21}(f)| \le -10{,}694$ dB

and, specifying a minimum ISI loss:

$|S_{DD21}(f = 300 \text{ MHz})| - |S_{DD21}(f = 1\,500 \text{ MHz})| > 3{,}9$ dB

where:

f is the signal frequency in Hz.

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impedance

Figure 95 shows the allowable $|S_{DD21}(f)|$ and minimum ISI loss of a TCTF test load and the $|S_{DD21}(f)|$ of a sample TCTF test load at 1,5 Gbps.

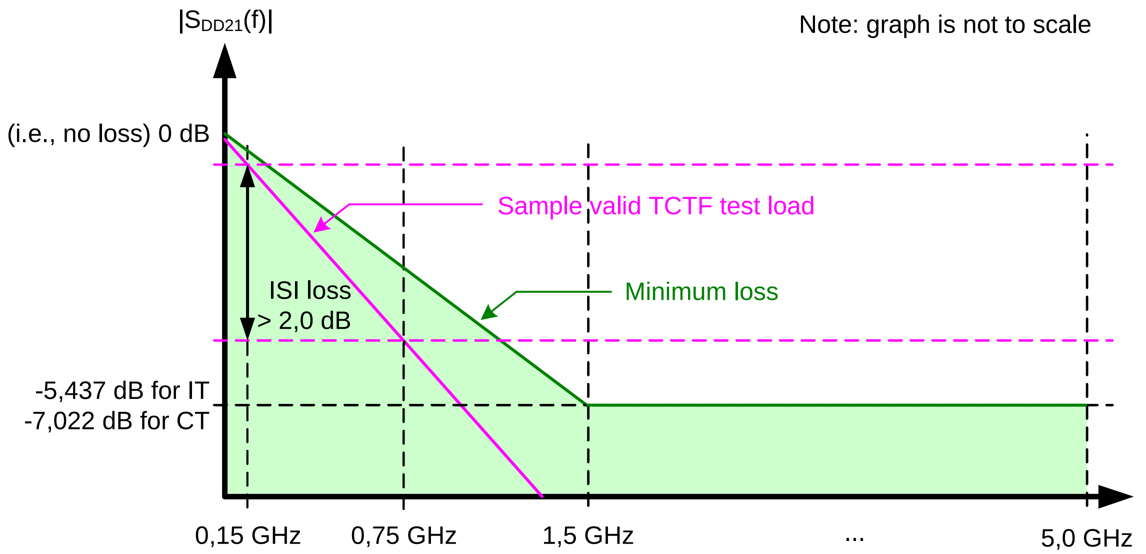

Figure 95 — TCTF test load S_{DD21} and ISI loss requirements at 1,5 Gbps

5.3.2.4 Low-loss TCTF test load

Figure 96 shows the low-loss TCTF test load.

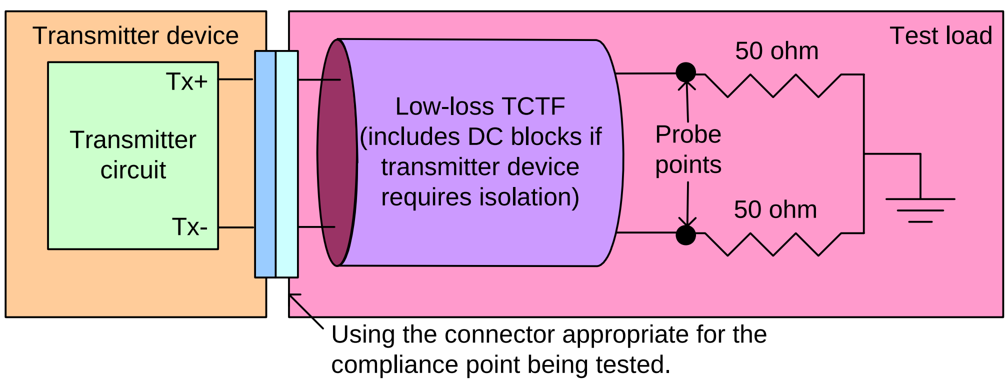

Figure 96 — Low-loss TCTF test load

The low-loss TCTF test load shall meet the media requirements for internal cables and backplanes in table 30 (see 5.2.6). The nominal impedance shall be the target impedance.

The low-loss TCTF is defined by a set of S-parameters (see B.9). Only the magnitude of $S_{DD21}(f)$ (i.e., insertion loss) is specified by this standard.

The low-loss TCTF test load shall comply with the following equations for the magnitude of $S_{DD21}(f)$ (denoted as $|S_{DD21}(f)|$):

For 50 MHz < f <= 5,0 GHz:

$$|S_{DD21}(f)| \le -20 \log_{10}(e) \times ((3{,}85 \times 10^{-6} \times f^{0,5}) + (1{,}1 \times 10^{-10} \times f) + (1{,}82 \times 10^{-20} \times f^{2}))\ \text{dB}$$

and, specifying a minimum ISI loss:

$$|S_{DD21}(f = 300\ \text{MHz})| - |S_{DD21}(f = 1\,500\ \text{MHz})| > 2{,}15\ \text{dB}$$

where:

f is the signal frequency in Hz.

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impedance

Figure 97 shows the allowable $|S_{DD21}(f)|$ and minimum ISI loss of a low-loss TCTF test load and the $|S_{DD21}(f)|$ of a sample low-loss TCTF test load at 3,0 Gbps.

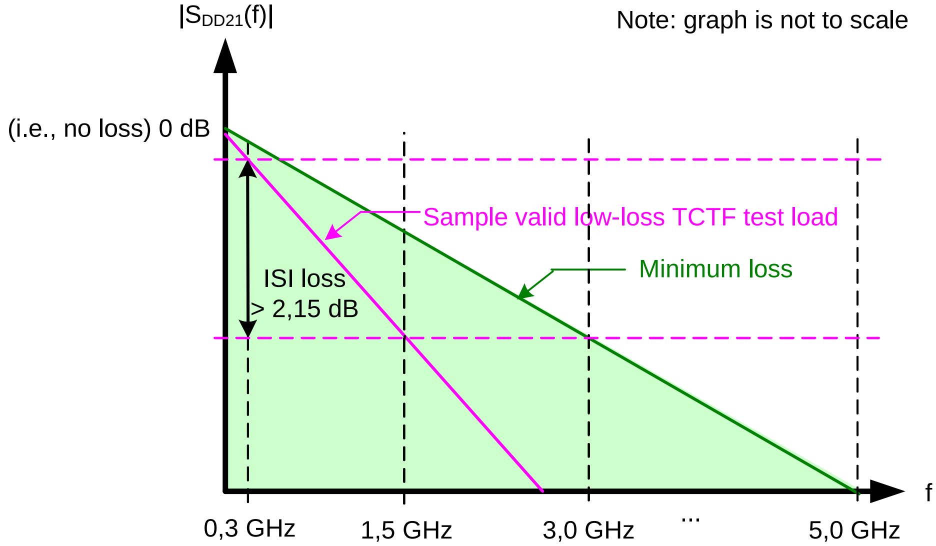

Figure 97 — Low-loss TCTF test load S_{DD21} and ISI loss requirements at 3,0 Gbps

5.3.3 General electrical characteristics

A TxRx connection is the complete simplex signal path between the transmitter circuit (see 3.1.241) and receiver circuit (see 3.1.149), over which a bit error ratio (BER) of < 10^{-12} is achieved.

A TxRx connection segment is that portion of a TxRx connection delimited by separable connectors or changes in media.

This standard defines the electrical requirements of the signal at the compliance points IT, IR, CT, and CR in a TxRx connection. Each compliant phy shall be compatible with these electrical requirements to allow interoperability within a SAS environment.

The TxRx connection shall exceed the BER objective of 10^{-12}. The parameters specified in this standard support meeting this requirement under all conditions including the minimum input and output amplitude levels.

The TxRx connection shall be designed such that its loss characteristics are less than:

a) the loss of the TCTF test load plus ISI (see figure 94 and figure 95 in 5.3.2.3); or
b) the loss of the low-loss TCTF test load plus ISI (see figure 97 in 5.3.2.4), if the system supports SATA devices using Gen2i levels (see SATA2-PHY) but the receiver device does not support SATA Gen2i levels through the TCTF test load.

The TxRx connection shall meet the delivered signal specifications in table 40 (see 5.3.8.2).

NOTE 14 - A TxRx connection is constructed from multiple components. It is possible that a TxRx connection does not meet the delivered signal requirements of table 40 (see 5.3.8.2) when the combined losses and noise introduced by those components is considered, even if each individual component is compliant with the requirements of this standard. Such a TxRx connection is not compliant with this standard.

For external cables, these electrical requirements are consistent with using good quality passive cable assemblies constructed with shielded twinaxial cable with 24 gauge solid wire up to 6 meters in length.

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conductive material that carries the TxRx electrical signal

Table 34 defines the general electrical characteristics.

Table 34 — General electrical characteristics

Characteristic	Units	1,5 Gbps	3,0 Gbps
Physical link rate	MBps	150	300
Bit rate (nominal)	Mbaud	1 500	3 000
Unit interval (UI)(nominal)	ps	666,$\overline{6}$	333,$\overline{3}$
Differential media impedance (nominal)	ohm	100	
A.C. coupling capacitor, maximum [a]	nF	12	
Maximum noise during OOB idle time [b]	mV(P-P)	120	

[a] The coupling capacitor value for A.C. coupled transmit and receive pairs.
[b] With a measurement bandwidth of 1,5 times the highest supported baud rate (i.e., 4,5 GHz for 3,0 Gbps), no signal level during the idle time shall exceed the specified maximum differential amplitude.

Table 35 defines the transmitter device general electrical characteristics.

Table 35 — General transmitter device electrical characteristics

Characteristic	Units	1,5 Gbps	3,0 Gbps
Physical link rate tolerance at IT and CT	ppm	± 100	
Transmitter device transients, maximum [a]	V	± 1,2	
Transmitter device source termination			
Differential impedance [b]	ohm	60 min/115 max	
Maximum differential impedance imbalance [b, c]	ohm	5	
Common-mode impedance [b]	ohm	15 min/40 max	

[a] See 5.3.4 for transient test circuits and conditions.
[b] All transmitter device termination measurements are made through mated connector pairs.
[c] The difference in measured impedance to ground on the plus and minus terminals on the interconnect, transmitter device, or receiver device, with a differential test signal applied to those terminals.

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TxRx connection

A mode transition is an event that may result in a measurable transient due to the response of the transmitter device or receiver device. The following conditions constitute a mode transition:

a) enabling and disabling driver circuitry;
b) enabling and disabling receiver common-mode circuitry;
c) hot plug event;
d) adjusting driver amplitude;
e) enabling and disabling pre-emphasis (i.e., de-emphasis); and
f) adjusting terminator impedance.

The maximum transmitter and receiver device transients are measured at nodes V_P and V_N with respect to GROUND on the test loads shown in figure 98 (for the transmitter device) and figure 99 (for the receiver device) during all power state and mode transitions. Test conditions shall include power supply power on and power off conditions, voltage sequencing, and mode transitions.

Figure 98 shows the test circuit attached to IT or CT to test transmitter device transients.

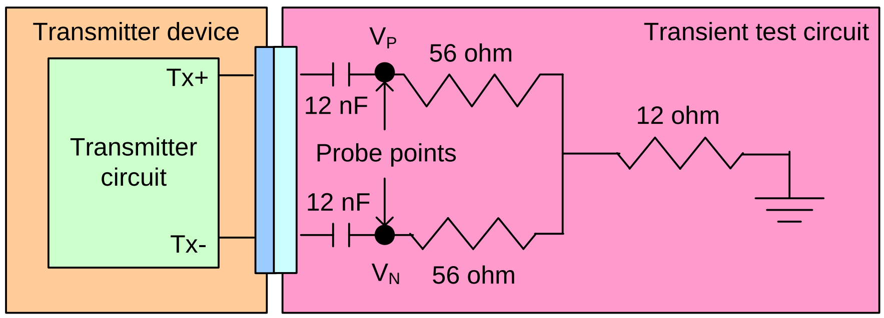

Figure 98 — Transmitter device transient test circuit

Figure 99 shows the test circuit attached to IR or CR to test receiver device transients.

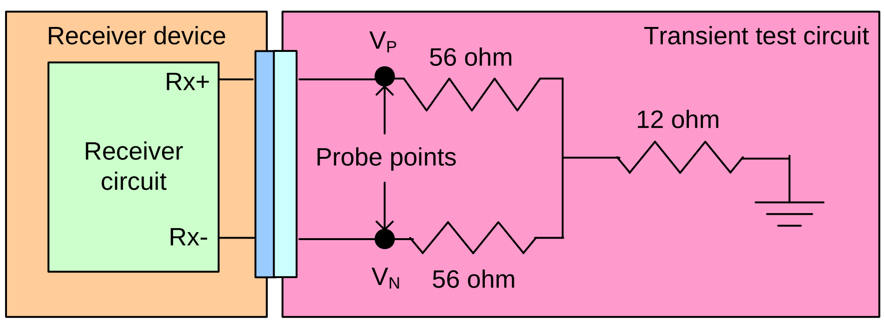

Figure 99 — Receiver device transient test circuit

5.3.5 Electrical TxRx connections

TxRx connections may be divided into TxRx connection segments. In a single TxRx connection individual TxRx connection segments may be formed from differing media and materials, including traces on printed wiring boards and optical fibers. This subclause applies only to TxRx connection segments that are formed from electrically conductive media.

Each electrical TxRx connection segment shall comply with the impedance requirements detailed in 5.2.6 for the media from which they are formed. An equalizer network, if present, shall be considered part of the TxRx connection.

TxRx connections that are composed entirely of electrically conducting media shall be applied only to homogenous ground applications (e.g., between devices within an enclosure or rack, or between enclosures interconnected by a common ground return or ground plane).

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Sequence number: 3
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 9:59:28 PM
conductive material that carries the TxRx electrical signal

Sequence number: 4
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 10:00:35 PM

Sequence number: 5
Author: coxa
Subject: Inserted Text
Date: 5/8/2005 10:00:51 PM
conductive material

Sequence number: 6
Author: coxa
Subject: Cross-Out
Date: 5/8/2005 10:01:51 PM
