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Information Technology
SCSI Passive Interconnect Performance (PIP)

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1.0 Overview

In the past only the performance levels of the Bulk cable have been specified. Bulk cable provides only part of the electrical path in system applications. This document defines the electrical measurement techniques for various test parameters on a variety of media types, such as cable, various interconnects and printed circuit board designs.

This document specifies the details of the measurement methodology to minimize the error in results from different electrical testing laboratories. Details are given at each stage of testing from calibration, fixturing and sample preparation.

Several measurement parameters use a per unit length measurement in order to allow concatenation of different lengths of cable without exceeding the performance limits at maximum length.

1.1 Media types for consideration

This document will address the following types of test environments but other media may also be tested using similar procedures.

- Bulk cable:
  - Flat planar
  - Twisted and flat planar
  - Unshielded round
  - Shielded round
- Interconnect assemblies:
  - point to point:
    - two connector shielded
    - two connector unshielded
  - multi drop:
    - multi connector shielded (e.g. external daisy chain)
    - multi connector unshielded
  - stubs:
    - unshielded cable stubs
    - shielded cable stubs
- Printed circuit board assemblies:
  - printed circuit board of a SCSI device:
    - single connector
    - stubs
  - backplanes:
    - multi connector
    - stubs (including the length of conductor extending beyond a terminator)

Overall length and specific placement and properties of stubs are essential parts of the description of the construction. Note that the dimensions shall be measured in nanoseconds not meters.

In general the passive interconnects for SCSI are complex multi-port circuits whose performance must be considered from every connector in the media.

Each of the above will have measurement criteria assigned. These criteria are broken down into two levels of measurement requirements. See Section 1.3 below for more details.

1.2 SCSI passive interconnect as an N-port construction

SCSI interconnects are considered as an N'-port element where every connector constitutes the approximate location of the ports. Since SCSI is a parallel bus every connector contains a multiplicity of somewhat independent ports (one for every differential signal).

For purposes of the SCSI PIP, a lower case "N", n, refers to the number of the specific signal in a connector. An upper case "N'", N' refers to the number of a specific connector. Thus a SCSI passive interconnect is characterized by N' connectors and n signals. N' is used instead of N so that when referring to connectors or ports verbally there will be distinction. Typically n ranges from 1 to 27 for SCSI applications. N' is determined by the structure of the interconnect and ranges from 2 to 18 (16 devices + 2 terminators) in most cases.

Therefore, a SCSI passive interconnect many contain up to 18 x 27 = 486 ports. Each N'th port can be represented by a matrix of n ports. The structure of the matrix will be based on the names of the signals.

Each port is characterized by (1) the signal launched into the port and the signal reflected back from the launched signal (2) the signal transferred to the port from other ports in the cable assembly.

The signals delivered out of every port when the most degraded allowed signal is launched from every other port (one at a time), when the most aggressive noise sources are present on all other ports that can couple into the port under test, and when the resonant conditions are within acceptable bounds shall meet at least the minimum requirements for a received signal. This concept is termed signal degradation below.

1.3 Required versus diagnostic measurements

Several parameters are required to verify electrical performance levels. For the purpose of simplification, measurement of PIP media performance is broken down into two levels:

1. those used to verify performance for critical values associated with SPI-X performance demands, and
2. those needed to diagnose the causes of degraded performance but are not directly required for adequate operation of the interconnect.

Within each measured parameter, the applicability for testing certain media is assigned to help the user identify which parameters are required for each media. One additional application, modeling, is called out in Table 1 and Table 2 below. This application is specified to help those users who require additional information to properly build certain models to aid in building complete systems. Parameters used for modeling purposes, are not classified as Level 1 or Level 2.

Emphasis is placed on the Level 1 measurements and required performance levels (test). The Level 2 measurements are described in this document but no specific performance requirements are stipulated.

Level 1 measurements specified in this document:

- SE local impedance
- Diff local impedance
- Extended distance impedance (Diff)
- SE capacitance
- Diff capacitance
- Propagation time (time domain)
- Propagation time skew (time domain)
- Eye diagrams (signal degradation)
- Near-end crosstalk
- Far-end crosstalk
- [ZSD1]Common mode degradation
- D.C. leakage to ground
- HI-Pot
- D.C. resistance imbalance
- Dielectric constant variation with frequency

Level 2 measurements specified in this document:

- Common mode impedance
- Common mode capacitance
- Propagation time (frequency domain)
- Propagation time skew (frequency domain)
- Eye diagrams (signal degradation within the pair)

- Attenuation (within the pair)
- Attenuation skew (pair to pair)
- Rise time degradation
- Common mode noise
- Dielectric constant variation w/ frequency
- ACR (attenuation to cross talk ratio)
- Vector Network Analyzer (VNA) tests???

Some parameters are specified for both single ended and differential applications. Table 1 and Table 2 below summarizes the measurement requirements.

Methods detailed, use either frequency or time domain measurements as noted in Table 1 and Table 2 below. Attempts are made to cover as much of the entire performance range as defined by the application. Specifically, both local and extended distance parameters and the range of applicable frequencies are included.

This annex does not specify any construction requirements but rather relies solely on the measured performance results as the criteria for compliance.

Several measurement parameters use a per unit length measurement in order to allow concatenation of different lengths of cable without exceeding the performance limits at maximum length.

Bulk cable provides only part of the electrical path in system applications. The requirements in this annex only apply to Bulk cable performance in nominally uniform media.

Media constructions designed to be non-uniform for purposes of enabling connectorization are covered in this annex. An example of such media is unshielded round media that has areas where the conductors are constrained to be flat (in a line) for short distances so that an insulation displacement type of connector may be attached. These types of media are considered to be intrinsically part of a cable assembly (where connectors are attached) and the performance cannot be accurately assessed without also considering the connectors.

In system applications, effects not specified in this document, but nevertheless related to bulk cable, may affect the bus performance. For example, the use of bulk cable with different impedance values in the same bus should be avoided to minimize discontinuities and signal reflections. If one wishes to build construction of this type and treat the entire bus as a single media, then the specifications in this document maybe applied to the entire bus.

Other effects that may affect the performance of a complete SCSI bus segment:

- spacing of media conductors from other physical structures for non-shielded constructions (e.g. wires in other media, metallic walls, non-metallic surfaces)
- non uniform device loading across all of the SCSI signals for all parameters

- non uniform stub properties
- the population of devices
- data phase speed

The specifications in this document assume that all connectors have worse case devices attached.

1.4 Local neighborhood concepts

For signals, the basic idea is to not test for interactions that are insignificant to the port under test. For example in a flat cable signals removed from the signal under test by at least 5 signal pairs do not significantly couple into the signal under test and do not need to be considered. The level of interaction deemed to be significant is left to be defined. For physical constructions the dimensional precision within which the construction shall be considered identical is 1/10 of the rise length of the fastest signal to be used in the interconnect. This is approximately 1 inch for 1ns rise time signals in shielded twisted pair media. In other words, two connectors placed 0.5 inch apart may be treated identically regardless of which is actually tested. Similarly, the placement of connectors on nominally identical flat ribbon cables shall be considered identical if they are within 1 inch of being at the same position.

1.5 Local neighborhood concepts

The length of the interconnect needs to be understood. For example there are a few percent difference between different “length” parameters. For example it may require 103 feet of wire to produce a cable assembly with 100 feet overall connector to connector path length. (2-103 foot wires to produce a single 100 foot twisted pair). Cabling applied to a bundle of pairs (cable lay) also affects the total path length. The electrical length is also important where the propagation time is part of the interest for the specification. The following was proposed as the way that PIP will consider length issues:

That the length parameters be separated into two pieces both of which shall be specified:

(1) the physical length along the geometrical center line (e.g. center line of the jacket for round cables to the center line of the unmated connector) of the completed cable assembly (not necessarily the actual wire length for any specific conductor)

(2) the propagation time between electrical access points (typically connectors) in the cable assembly. Other lengths such as those internal to the media will NOT be used as descriptors in PIP. These internal lengths may be important for creating accurate models but are not essential to specify how to do proper measurements on cable assemblies and therefore do not belong in the PIP effort.

1.6 Interoperability points

Interoperability points are physical points in the system where separable connectors exist and where it is required that the components on either side of the connector may be supplied from different compliant vendors. Following is a list where interoperability might be expected in a SCSI segment. A "Y" following the position designation means that this will be considered an interoperability point for PIP purposes. Similarly, a "N" following the position designation means that the point will NOT be considered an interoperability point for PIP purposes.

Disk drive connector mounted directly on the disk drive (Y)

HBA connector external connector (Y)
HBA internal SCSI connector to internal cables (Y)
HBA internal SCSI connector to the mother board (N)

Motherboard SCSI connector where the mother board contains the HBA (in an ASIC) on board (Y)

Backplane connectors:

Any connector that directly accepts a disk drive or other SCSI device (Y)
Any connector that directly connects to an external cable assembly through an expander on the backplane (Y)

Any connector on an external cable assembly that connects to an external connector of an HBA (Y)

Any connector on an external cable assembly that connects to an external connector of a disk drive array containing an expander immediately behind the external connector (Y)

Any connector on an internal cable that directly connects to a diskdrive or other SCSI device. (Y)

The external connector to a box that has external cable assembly attached and an internal cable assembly attached internally to the same connector. (N)

Note: this means that one may NOT have a cable to cable connection at the bulkhead if interoperability is required.

1.7 Approach to concatenated constructions

There are two types of acceptable methods of concatenated constructions.

In the first method the SCSI passive interconnect performance is considered under the conditions where the bus segment interconnect consists of a single media type and construction.

For example, in this situation, two dissimilar (e.g. round to flat) cable assemblies connected together in series would not have an interoperability point at the point of common connection. Similarly, a backplane connected directly to a round shielded cable would NOT have an interoperability point at the backplane connector.

While the first method is relatively easy to construct performance requirements around, it leaves several important constructions without clear definition. Thus a second method is mentioned here.

The second method may consists of one of the following:

a) where a short cable assembly is used between the HBA and the bulkhead in a PC-like packaging
b) where a short cable assembly is used between the disk drive and the backplane
c) where an HBA is used between the external bulkhead and both internal and external cables
d) where an external cable is attached directly to a backplane

Each of these cases has the property that the performance at the connector is significantly affected by the details of the passive interconnect on BOTH sides of the connector. This complicates specifying unique performance requirements for the connector because of interactions on both sides.

Table 1 Summary table for level one test parameters for SCSI PIP

Test parameter	Level	Applicability (Bulk cable, PCB, modeling, etc.)	Section	Domain	Condition		Comments
SE local impedance		All	2.1	T	Rise time at 3ns		TDR i.e. Tektronix 11801 or equivalent
Diff local impedance		All	2.2	T	Rise times at 1 and 3ns		TDR i.e. Tektronix 11801 or equivalent
Extended Distance Impedance (Diff)		Bulk cable	2.3	F	sweep between 30MHz and 600MHz		HP 8753E network analyzer or equivalent
Capacitance (SE)		Bulk cable, interconnect assembly (L2), PCB, modeling	2.4	F	100KHz and 1MHz		LCR meter
Capacitance (Diff)		Bulk cable, PCB, modeling	2.5	F	100KHz and 1MHz		LCR meter
Propagation time		Bulk cable, interconnect assembly (L2), PCB, modeling	2.6	T	An S12*** measurement within the pair swept from 10MHz to 650MHz (normative measurement with no pass fail levels		HP 8753x network analyzer or equivalent
Propagation time SKEW		Bulk cable, interconnect assembly (L2), PCB, modeling	2.7	T	Difference between the minimum and maximum Tp of all pairs.		Pair to pair
Eye diagrams (signal degradation)	**1**	Interconnect assembly	2.8	T			All lines active
NEXT		Bulk cable, interconnect assembly, PCB, modeling	2.9	T	Single pulse, maximum allowed amplitude, minimum STD time		Tektronix 11801 with TDR or equivalent.
FEXT		Bulk cable, interconnect assembly, PCB, modeling	2.10	T			
Common mode degradation		Interconnect assembly, modeling	2.11	T			+ Signal to - signal balance within the pair (sum of the difference)
EMI		Interconnect assembly	2.12	F			Shielded versions only
D.C. leakage to ground		Interconnect assembly	2.13				[Impacts receiver bias / D.C. offset]
HI-Pot		Bulk cable, interconnect assembly, PCB	2.14				
D.C. resistance imbalance		Interconnect assembly	2.15				Within the pair
Dielectric constant variation w/ frequency		Bulk cable, PCB, modeling	2.16	F	Sweep between 300KHz and 600MHz		HP 8753x network analyzer or equivalent

**STD: Signal Transition Duration.
***S_{12} is a scattering parameter that relates the incident and transmitted voltage waves in a two-port circuit.

Table 2 Summary table for level two test parameters for SCSI PIP

Common mode impedance		Bulk cable, PCB, modeling	3.1	T			Treat each pair as a single conductor
Common mode capacitance		Bulk cable, PCB, modeling	3.2	F			
Propagation time		Bulk cable, modeling	3.3	F			Within the pair
Propagation time SKEW		Bulk cable, modeling	3.4	F			Pair to pair
Eye diagrams (signal degradation within the pair)		Interconnect assembly, modeling	3.5	T			One line active
Attenuation (within the pair)	**2**	Interconnect assembly, media, PCB	3.6	F			
Attenuation skew (pair to pair)		Interconnect assembly, media, PCBs	3.7	F			Difference in voltage transfer function between pairs
Rise time degradation		Interconnect assembly, modeling	3.8	F			The pair propagation velocity
Dielectric constant variation w/ frequency		Bulk cable, PCB, Modeling	3.9	F			
ACR (attenuation to cross talk ratio)		Bulk cable, Modeling	3.10	F			
Vector Network Analyzer (VNA) tests???		Modeling	3.11				All matter of S parameters.

2.0 Level one test

2.1 Single ended local impedance

2.1.1 Applicability

2.1.2 Sample preparation

2.1.3 Test fixture and measurement equipment

2.1.4 Calibration and verification procedure

2.1.5 Test procedure

2.1.6 Acceptable values

2.2 Differential local impedance

2.2.1 Applicability

2.2.2 Sample preparation

2.2.3 Test fixture and measurement equipment

2.2.4 Calibration and verification procedure

2.2.5 Test procedure

2.2.6 Acceptable values

2.3 Extended distance impedance

2.3.1 Applicability

2.3.2 Sample preparation

2.3.3 Test fixture and measurement equipment

2.3.4 Calibration and verification procedure

2.3.5 Test procedure

2.3.6 Acceptable values

2.4 Capacitance single ended

2.4.1 Applicability

2.4.2 Sample preparation

2.4.3 Test fixture and measurement equipment

2.4.4 Calibration and verification procedure

2.4.5 Test procedure

2.4.6 Acceptable values

2.5 Capacitance differential

2.5.1 Applicability

2.5.2 Sample preparation

2.5.3 Test fixture and measurement equipment

2.5.4 Calibration and verification procedure

2.5.5 Test procedure

2.5.6 Acceptable values

2.6 Propagation time

2.6.1 Applicability

2.6.2 Sample preparation

2.6.3 Test fixture and measurement equipment

2.6.4 Calibration and verification procedure

2.6.5 Test procedure

2.6.6 Acceptable values

2.7 Propagation time skew

2.7.1 Applicability

2.7.2 Test procedure

2.7.3 Acceptable values

2.8 Eye diagrams – signal degradation

2.8.1 Applicability

2.8.2 Sample preparation

2.8.3 Test fixture and measurement equipment

2.8.4 Calibration and verification procedure

2.8.5 Test procedure

2.8.6 Acceptable values

2.9 Near end cross talk

2.9.1 Applicability

2.9.2 Sample preparation

2.9.3 Test fixture and measurement equipment

2.9.4 Calibration and verification procedure

2.9.5 Test procedure

2.9.6 Acceptable values

2.10 Far end cross talk

2.10.1 Applicability

2.10.2 Sample preparation

2.10.3 Test fixture and measurement equipment

2.10.4 Calibration and verification procedure

2.10.5 Test procedure

2.10.6 Acceptable values

2.11 Common mode degradation

2.11.1 Applicability

2.11.2 Sample preparation

2.11.3 Test fixture and measurement equipment

2.11.4 Calibration and verification procedure

2.11.5 Test procedure

2.11.6 Acceptable values

2.12 Electromagnetic interference (EMI)

2.12.1 Applicability

2.12.2 Sample preparation

2.12.3 Test fixture and measurement equipment

2.12.4 Calibration and verification procedure

2.12.5 Test procedure

2.12.6 Acceptable values

2.13 D.C. leakage to ground

2.13.1 Applicability

2.13.2 Sample preparation

2.13.3 Test fixture and measurement equipment

2.13.4 Calibration and verification procedure

2.13.5 Test procedure

2.13.6 Acceptable values

2.14 HI-Pot testing

2.14.1 Applicability

2.14.2 Sample preparation

2.14.3 Test fixture and measurement equipment

2.14.4 Calibration and verification procedure

2.14.5 Test procedure

2.14.6 Acceptable values

2.15 D.C. resistance imbalance

2.15.1 Applicability

2.15.2 Sample preparation

2.15.3 Test fixture and measurement equipment

2.15.4 Calibration and verification procedure

2.15.5 Test procedure

2.15.6 Acceptable values

2.16 Dielectric constant variation with frequency

2.16.1 Applicability

2.16.2 Sample preparation

2.16.3 Test fixture and measurement equipment

2.16.4 Calibration and verification procedure

2.16.5 Test procedure

2.16.6 Acceptable values

3.0 Level two testing

3.1 Common mode impedance

3.1.1 Applicability

3.1.2 Sample preparation

3.1.3 Test fixture and measurement equipment

3.1.4 Calibration and verification procedure

3.1.5 Test procedure

3.1.6 Acceptable values

3.2 Common mode capacitance

3.2.1 Applicability

3.2.2 Sample preparation

3.2.3 Test fixture and measurement equipment

3.2.4 Calibration and verification procedure

3.2.5 Test procedure

3.2.6 Acceptable values

3.3 Propagation time

3.3.1 Applicability

3.3.2 Sample preparation

3.3.3 Test fixture and measurement equipment

3.3.4 Calibration and verification procedure

3.3.5 Test procedure

3.3.6 Acceptable values

3.4 Propagation time Skew

3.4.1 Applicability

3.4.2 Acceptable values

3.5 Eye Diagrams for signal degradation within the pair

3.5.1 Applicability

3.5.2 Sample preparation

3.5.3 Test fixture and measurement equipment

3.5.4 Calibration and verification procedure

3.5.5 Test procedure

3.5.6 Acceptable values

3.6 Attenuation with in the pair

3.6.1 Applicability

3.6.2 Sample preparation

3.6.3 Test fixture and measurement equipment

3.6.4 Calibration and verification procedure

3.6.5 Test procedure

3.6.6 Acceptable values

3.7 Attenuation skew pair to pair

3.7.1 Applicability

3.7.2 Sample preparation

3.7.3 Test fixture and measurement equipment

3.7.4 Calibration and verification procedure

3.7.5 Test procedure

3.7.6 Acceptable values

3.8 Rise time degradation

3.8.1 Applicability

3.8.2 Sample preparation

3.8.3 Test fixture and measurement equipment

3.8.4 Calibration and verification procedure

3.8.5 Test procedure

3.8.6 Acceptable values

3.9 Dielectric constant variation with frequency

3.9.1 Applicability

3.9.2 Sample preparation

3.9.3 Test fixture and measurement equipment

3.9.4 Calibration and verification procedure

3.9.5 Test procedure

3.9.6 Acceptable values

3.10 Attenuation to cross talk ratio (ACR)

3.10.1 Applicability

3.10.2 Sample preparation

3.10.3 Test fixture and measurement equipment

3.10.4 Calibration and verification procedure

3.10.5 Test procedure

3.10.6 Acceptable values

3.11 Vector network analyzer (VNA)

3.11.1 Applicability

3.11.2 Sample preparation

3.11.3 Test fixture and measurement equipment

3.11.4 Calibration and verification procedure

3.11.5 Test procedure

3.11.6 Acceptable values