Passive interconnect performance working group (PIP) 00-253r0
June 12-13, 2000
Lisle, IL

Subject: Draft minutes for the SCSI passive interconnect performance working group, SPIP, in Lisle, IL on June 12-13, 2000

Zane Daggett of Hitachi led the meeting. Bill Ham of Compaq, secretary, took these minutes. There was a good attendance from a broad spectrum of the industry. Martin Ogbuokiri of Molex hosted the meeting.

Previous approved minutes: 00-217r1

1. Introduction

Zane Daggett opened the meeting, conducted the introductions, and reviewed the meeting purpose.

2. Attendance

The following folks were present:

Name	Company	E-Mail
Paul Aloisi	TI	Paul_Aloisi@TI.com
Larry Barnes	LSI	larry.barnes@lsil.com
Vince Bastiani	Adaptec	bastiani@corp.adaptec.com
Bob Canniff	Hitachi	rcanniff@hcm.hitachi.com
Umesh Chandra	Seagate	umesh_chandra@notes.seagate.com
Dave Chapman	Amphenol	dave.chapman@aipc.fabrik.com
Zane Daggett	Hitachi	zdaggett@hcm.hitachi.com
Jie Fan	Madison Cable	jfan@madisoncable.com
Bob Gannon	JPM	rgannnon@jpmco.com
Glen Griessler	Molex	ggriessler@molex.com
Bill Ham	Compaq	bill_ham@ix.netcom.com
Clint Heiser	Hitachi	cheiser@hcm.hitachi.com
Thom Kreusel	HP	thom_kreusel@hp.com
David MacQuown	Adaptec	david_macquown@corp.adaptec.com
Bruce Maniloi	Seagate	Bruce_Maniloi@notes.seagate.com
Martin Ogbuokiri	Molex	mogbuokiri@molex.com
Greg Vaupotic	Amphenol Spectra-Strip	greg.vaupotic@snet.net

3. Agenda development

The agenda shown was that used (moved by Zane / seconded by Bruce M.)

4. Approval of previous minutes

Bill Ham moved and Paul Aloisi seconded that the draft minutes from the previous meeting be approved as modified. Motion passed unanimously.

The methodology for minutes uses the draft/approved minutes scheme with posting to the t10 web site of the minutes as the vehicle for publication. Postings are announced to the SCSI reflector after the posting is verified to be on the web site.

Minutes will be in .pdf format.

5. Review of action items

Action items were reviewed and the status is listed below in the action items section.

6. Administrative structure:

The present administrative structure is:

Chair: Zane Daggett, Hitachi
Vice Chair: Dave Chapman, Amphenol
Secretary: Bill Ham, Compaq

Document editors: Zane Daggett, editor in chief, Bill Ham, assistant editor, Greg Vaupotic, assistant editor, others welcome (but work is expected)

7. Review of industry activities

- Bill Ham briefly reviewed the T10, T11, and SFF activities relating to testing and modeling. He noted that the T11 modeling activity was not moving very fast.

8. Presentations

8.1 Attenuation measurements, Bruce Manildi, Seagate

Bruce presented data taken with a spectrum analyzer on a variety of different cable types and lengths. He showed significant variability and little agreement with the attenuation limits shown in published T10 standards. One issue was the lack of availability of baluns with the correct properties. Another was the use of non-uniform media such as twisted flat with flat sections for connectors. Yet another was the use of relatively short sections with connectors on each end (and possibly in the middle as well). In most cases the measured attenuation was significantly less than expected.

Another important point was that the attenuation vs frequency data did NOT follow the expected curve shape. This means that the attenuation at 80 MHz for example is NOT well predictable from the performance at 200 MHz. This invites a requirement to specify the attenuation at frequencies other than only 200 MHz.

The level of disagreement was quite significant and prompted a desire to create a round robin to determine more detail concerning the reasons for the differences.

Bruce agreed to take on the management of an attenuation round robin effort. A proposal for executing this round robin will be available before the next meeting.

8.2 Attenuation measurements, Zane Daggett, Hitachi

Zane reviewed an old document that has a lot of attenuation data on round cables: 97-213r0. This data more or less agreed with the requirements presented in the SPI-3 document and significantly disagreed with the Seagate data.

8.3 Attenuation data, Jie Fan, Madison

Jie presented data on 30 AWG stranded and on 28 AWG solid. This data appeared to be in rough agreement with the Hitachi data. A summary of the data available at meeting time is given in the table below.

Round cable only, media only, impedance varies in the 128-132 ohm range, data presented in units of dB/m, fail limit set at 12 dB @ 25m @ 200 MHz in SPI-3.

	Seagate HP 8110 pulse generator with clock-like pattern with slow edges, spectrum analyzer used for measuring outputs and inputs	Hitachi network analyzer with 100 ohm baluns	Madison 4-port network analyzer
Sample description	cable assys	cable media	cable media
80 MHz			
30 strand		0.32/m (8/25m)	0.31/m (7.75/25m)
30 solid	0.16/m?? (4/25m) media type not known for sure at time of writing	0.26/m (6.5/25m)	
28 strand	0.12/m (3/25m)	0.19/m (4.75/25m)	
28 solid			0.25/m (6.25/25m)

200 MHz			
30 strand		0.59/m (14.75/25m)	0.52/m (13/25m)
30 solid	0.38/m?? media type not known for sure at time of writing	0.44/m (11/25m)	
28 strand	0.28/m (7 dB/m)	0.36/m (9/25m)	0.34/m (8.5/25m)
28 solid			0.40/m (10/25m)

Note that there are very few direct comparisons and some inconsistencies in the data in the above table. For example the Madison data shows the 200 MHz attenuation to be smaller for stranded than for solid for 28 AWG. It seems very clear that there is considerably more than the wire gauge that influences the attenuation. Thus the wisdom of doing a performance rather than a physical description specification.

Nevertheless, the present specification of 12 dB @ 25m @ 200 MHz seems to be reasonable given the 11 dB/25m data for 30 AWG solid.

9. Exploratory round robin

In order to get a jump start on the round robin the following was suggested for a test process. There are a few important differences from that specified in SPI-3.

The details listed below are suggested for a quick round robin:

Test methods to be modified as follows:
[Following copied from SPI-3 and modified appropriately]
E.7.5 Measurement test fixture and measurement equipment
An instrument capable of supplying a sinusoidal signal is used as the signal source and an instrument capable of detecting the amplitude of a sinusoidal signal is used as the signal sink. Two measurement test fixtures are required: one for the source end and one for the sink end. Since most source and sink instruments capable of using variable frequency sinusoidal signals are single ended, a balun or a hybrid (M/A - Com) may be used between the instruments and the test fixtures. Impedance matching networks may be required.(Lpad). If a source or sink is used differential signals then no balun is required for the differential source or sink.

Action Item: Greg Vaupotic to supply details on how to build the interface circuit for attenuation testing.

Equipment Required: Network Analyzer (HP 87xx Series) or equivalent.

The test fixture having 61 ohm single ended paths for each signal line shown in SPI-3 will NOT be used for the tests. Samples shall be directly soldered to the Lpads. The opens, shorts, through calibration method shall be used.

The tested lines shall be terminated by using 122 ohm nominal resistors between the + signal and the - signal line. [some observations have indicated different results when using the terminations instead of keeping the untested line open as presently implied in SPI-3]. The question of whether to require this termination may be answered in subsequent testing.

Action item: Bruce M. to initiate collection of samples for testing

Companies agreeing to participate in this initial exploratory measurement effort: Seagate, Hitachi, Madison, Amphenol Spectra-Strip, Adaptec,

Contacts: Hitachi: Clint Heiser (603 669-4347 ext 362)
Seagate: Bruce Manildi (831 439-7229) [Coordinator]
Amphenol Spectra-Strip: Greg Vaupotic (203 287-7425)
Adaptec: Lee Hearn (?????????????)
Madison: Jie Fan (508 752-2881 ext 306)

Samples requested: all round shielded raw media 25 meters long, one sample of each from Hitachi and Madison of 28AWG solid, 28 AWG stranded, 30 AWG stranded, 30 AWG solid (total of 8 samples)

9.1 Frequency dependence of dielectric constant test methodology - Barnes, LSI Logic

Deferred (again) to August due to equipment delivery schedules.

10. Discussion of possible attenuation issues, Greg V.

Cable media with no intentional non-uniformities (for connectorization) generally follows the same general attenuation curve shape. Therefore typically three measurement points approximately determine the curve.

However, when the media contains non-uniformities such as flat regions for connectors then resonances at lower and middle frequencies and a sharper roll off at frequencies above approximately 200 MHz. These same effects would be seen if round cable had transition region added during assembly operations. Therefore, the frequency response may be more complex than found in uniform constructions.

Bill Ham noted that in the project proposal, which was accepted and forwarded to NCITS at the last T10 meeting, it mentions replacing attenuation with the more general concept of a voltage transfer function. This replacement of terms was noted by the group but it is still an open question concerning the terms to be used.

11. Worst case vs spec numbers strategy

This item is intended to address the basic issues created by using a collection of worst case component specifications instead of recognizing the typical integrated impact of a collection of real parts.

Worst case specifications frequently result in excessive demands to improve component performance. On the other hand, given a large population of components, there is some chance that end-to-end failures will be experienced unless the worst case component performance requirements are met.

Therefore, conditions for SCSI are approaching the point where some recognition of the overspecification that results from worst case methodologies is reflected in the component performance specifications. When the worst case numbers are added up for SPI-4 the SCSI segment will not work. Therefore, either the specification methodology or some component specifications need to change.

This is one reason why there is presently a focus on the interconnect specifications.

In any case there were no breakthroughs in this area at this meeting.

12. SCSI passive interconnect as an N-port construction - all

[This section was discussed in earlier meetings but will be retained in the minutes until transferred into the PIP document.]

It was previously agreed that the SCSI cable assembly will be 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 SPIP work 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.

12.1 Local neighborhood concepts

[This section was discussed in earlier meetings but will be retained in the minutes until transferred into the PIP document.]

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.

12.2 Length measurements

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:

(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.

12.3 Interoperability points

[This section was discussed in earlier meetings but will be retained in the minutes until transferred into the PIP document.]

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 disk drive or other SCSI device. (Y)

Question: should the external connector to a disk drive array that does not contain an expander be considered an interoperability point? The group agreed that this should NOT be an interoperability point until proven otherwise in the SSM group. (N)

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.

Question: should separable connectors that belong to terminators be considered interoperability points? The group agreed that these connectors should be included in the interoperability suite.(Y)

12.4 Approach to concatenated constructions

The group identified two basic situations:

In the first situation 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 situation is relatively easy to construct performance requirements around, it leaves several important constructions without clear definition.

Thus the second situation:

Four examples are described where interoperability is probably expected in common constructions:

- where a short cable assembly is used between the HBA and the bulkhead in a PC-like packaging

- where a short cable assembly is used between the disk drive and the backplane

- where an HBA is used between the external bulkhead and both internal and external cables

- 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 the connector because of interactions on both sides.

Because these are important practical applications, some approach is needed in the PIP work. This subject is left for further consideration by the modeling group and in future PIP efforts. Pending definition of a viable strategy for these situation 2 cases work in PIP will be focused on the situation 1 cases.

13. Project proposal for PIP - all

Bill Ham noted that the project proposal for PIP was approved at the T10 plenary in May. The project proposal is document number 00-238r0.

14. PIP documentation - Daggett

This working group will proceed to develop an internal committee document Titled: "SCSI Passive Interconnect Performance Requirements" whose schedule is independent from SPI-x standards schedule. Zane Daggett is editor, Bill Ham and Greg Vaupotic are assistant editors. The document will follow the same general format as 99-219rx.

The document number is 00-160rx.

14.1 Topics for consideration for the passive interconnect test document

[This section was discussed in earlier meetings and modified slightly in this meeting. It will be retained in the minutes until transferred into the PIP document.]

The material in this section was reviewed from the last meeting as possible candidates for consideration for the PIP document 00-160rx.

14.1.1 Components of passive interconnect

The following constitute the basic building blocks of passive interconnect:

media (wire and backplane)
connectors
transition regions (connector termination / comb out / lacing regions / vias)

14.1.2 Construction

The following physical constructions are part of PIP:

Point to point:
   two connector shielded
   two connector unshielded

Multidrop:
   multi connector shielded (e.g. external daisy chain)
   multi connector unshielded
   multi connector backplanes

Stubs:
   backplane stubs (length of conductor extending beyond a terminator)
   device circuit board stubs
   unshielded cable stubs
   shielded cable stubs

Overall length and specific placement and properties of stubs are essential parts of the description of the construction. Note that the length and position may not be measured in inches but rather in nanoseconds.

In general the passive interconnects for SCSI are complex multiport circuits whose performance must be considered from every connector in the interconnect.

14.1.3 Specific technical concentration areas

- Cable assembly design
    - Non uniform media issues (e.g. twisted flat)
    - Transition regions for cable assemblies

    - Connector performance specifications
    - Connector variations
    - Assembly construction variations
- Backplane design
    - Distance between connectors
    - Trace impedance
    - Overall backplane size constraints
    - Power and ground distribution
    - Routing restrictions (e.g. no traces over breaks in power/ground planes)
    - Holes for cooling air
    - Mechanical rigidity
    - EMC containment
    - Effect of vias
    - Effects of connector attachment scheme (vias, pads)
    - Proximity effects of extraneous materials near the signal paths
    - Et cetera
- EMC - reference SFF-8410 for CMPT and EMR for emissions - applies to shielded versions only
    - Susceptibility issue for backplanes?

14.1.4 Test types

The following tests are presently viewed as the candidate list

Local impedance
Extended distance impedance
Capacitance (SE, DF)
Frequency dependence of dielectric constant
Propagation time - differential signal for each signal pair
Propagation time skew - difference between pairs
+ signal to - signal balance - within the pair (balance degradation)
Attenuation (voltage transfer function) - within the pair
Attenuation skew (difference in voltage transfer function between pairs)
Eye diagrams (signal degradation)
Rise time degradation
Common mode (treat each pair as a single conductor) impedance
Common mode capacitance
Common mode noise
Near end crosstalk
Far end crosstalk
Attenuation to cross talk ratio (ACR)
EMC (CMPT, EMR) shielded versions only

The Level 1 and Level 2 approach described in SFF-8410 will be used. Level 1 is required for performance and has specific acceptable limits defined. Level 2 is diagnostic and has no specific limits defined.

There is some support for including additional swept frequency tests (possibly as level 1 tests) but these have not been defined. The issue of how to construct valid time domain signals from frequency domain measurements is part of this discussion. Also the of the choice of interoperability points significantly interacts with the test results and needs to be considered.

The initial cut at the frequency/time domain testing distribution is listed below:

- Local impedance (time domain)
- Extended distance impedance (frequency domain)
- Capacitance (SE, DF) (frequency domain)
- Frequency dependence of dielectric constant (frequency domain)
- Propagation time - differential signal for each signal pair (time domain and frequency domain – needs more work)
- Propagation time skew - difference between pairs (time domain and frequency domain – need more work)
- + signal to - signal balance - within the pair (balance degradation)
- Attenuation (voltage transfer function) - within the pair (frequency domain)
- Attenuation skew (difference in voltage transfer function between pairs) (frequency domain)
- Eye diagrams (signal degradation)
- Rise time degradation
- Common mode (treat each pair as a single conductor) impedance
- Common mode capacitance
- Common mode noise
- Near end crosstalk (time domain and frequency domain – needs more work)
- Far end crosstalk (time domain and frequency domain – needs more work)
- Attenuation to cross talk ratio (ACR) (frequency domain)
- EMC (CMPT, EMR) shielded versions only (frequency domain)

The following represents the present thinking on the division of tests between the level 1 and level 2 types.

Level 1

- Local impedance
- Extended distance impedance
- Propagation time - within the pair
- A.C. signal degradation - all pairs to clock (Full signal characterization - e.g. Eye diagrams)
- D.C. leakage to ground [impacts receiver bias / d.c. offset]
- A.C. balance degradation within the pair (+ signal to - signal balance /common mode)
- End to end d.c. resistance difference within the pair
- Capacitance (SE, DF)

- Near end crosstalk (for noise induced on wired-or signals)
- Far end crosstalk (for noise induced on wired-or signals)

- EMC (CMPT, EMR) shielded versions only

Level 2

- Signal degradation within the pair (Full signal characterization - e.g. Eye diagrams [note that the full set of signals with respect to the clock is the level 1 requirement – a single signal performance is not adequate (example being different jitter and proptime on different signals)]
- Rise time degradation
- Frequency dependence of dielectric constant
- Attenuation to cross talk ratio (ACR)
- Attenuation (voltage transfer function) - within the pair
- Attenuation skew (difference between voltage transfer function pairs) - pair to pair
- Propagation time skew - pair to pair

Problem areas needing future attention - not classified yet:

- Common mode impedance
- Common mode capacitance
- Common mode noise
- Resonance effects

14.1.5 Instrumentation / measurement methods:

- Baluns
- Eye diagram / signal degradation testing (including cross talk noise)
- Filtering schemes for eye pattern generation

These topics are in addition to other issues already identified for media.

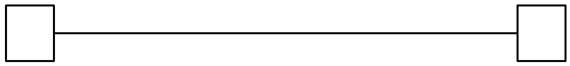
14.1.6 Acceptable performance values

All level 1 tests will have specific acceptable values proposed.

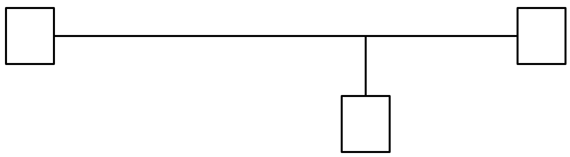
15. Starting point for specifying application of tests

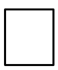
The following configurations were agreed to be used for the next steps in developing specifications for the application of the tests.

SIMPLEST POINT TO POINT



SIMPLEST MULTIDROP





UNMATED CONNECTOR

The point to point construction allows inclusion of connectors and transition regions, multiple line cross talk, resonance issues and other issues not previously considered in uniform cable media.

The simplest multidrop construction adds a single connector and greatly increases the number of possible interactions between lines as well as adding a known non-uniformity in addition to the connectors and transitions regions in the point to point construction.

Clearly these simple constructions do not have the desired complexity of some interesting applications. These more complex constructions, such as backplanes will be considered after we complete these initial constructions. [Note: the complexity for these simple constructions is significantly greater than that previously considered.]

15.1 Definitions for the document - Barnes

Not addressed at this meeting.

16. Architectural definitions

This refers to issues like defining the test points, nomenclature, and the like. It was decided to use the same conventions commonly used for modeling and transmission lines if possible. Larry B to propose a specific syntax for the next meeting.

All measurements will be through a mated connector. This means that the test fixturing specification will be critical since part of the tested interconnect will remain with the test environment and part will be removable with the IUT.

Zane is creating a summary table for all tests defined above and to start the document.

It was agreed that a special filtering function is needed for some tests to account for the filtering that may occur in the receivers. See 00-149r0 for more detail.

17. Next meetings

Approved schedule:

August 14-15, 2000 9AM to 5 PM 8/14 9AM to 12PM 8/14, Colorado Spgs (LSI Logic)

Requested schedule:

October 10-11, 2000 9AM to 5PM 10/12 9AM to 12:00PM 10/12, Santa Cruz, CA (Seagate)

18. Action Items:

18.1 Old action items from previous meetings

Larry Barnes to acquire data from the polished coax probe method for dielectric constant frequency variations.
Status: cable now in hand, test results now expected before August meeting due to lead time issues for the network analyzer from HP

Zane to provide data from the HP slab method for dielectric constant frequency variations
Status: carried over

Bill Ham to post the minutes to the T10 web site
Status: done 00-217r0

Zane to create a summary table for all tests defined above and to start the document.
Status: carried over

Bill Ham to create a project proposal for consideration at the next T10 meeting.
Status: done, submitted and approved by T10

Larry Barnes to look at list of proposed tests and suggest revisions / additions to incorporate possible frequency domain tests and design validation tests and production tests.
Status: carried over

18.2 New actions from this meeting

Bill Ham to post the minutes to the T10 web site
Status: new

Bill Ham to create a minutes framework that includes all the necessary boilerplate. The T11 format will be used as a starting point.
Status: new

Greg Vaupotic to supply details on how to build the interface circuit for attenuation testing.
Status: new

Bruce M. to initiate collection of samples for testing.
Status: new

Larry B to propose a specific syntax for defining the test points, nomenclature, and the like for the next meeting.
Status: new