Passive interconnect performance working group (PIP) 01-019r0
December 12,13, 2000
Nashua, NH

Subject: Draft minutes for the SCSI passive interconnect performance working group, PIP, in Nashua, NH on December 12, 13, 2000

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

Previous approved minutes: 00-379r1

1. Introduction

In the absence of both Zane Daggett and Dave Chapman, Bill Ham, secy, opened the meeting, conducted the introductions, and reviewed the meeting purpose.

2. Attendance

The following folks were present:

Name	Organization	e-mail	Phone
			603-669-1656
Richard McMillan	Adaptec	Richard_mcmillan@adaptec.com	408-957-6025
Greg Vaupotic	Amphenol	Greg.vaupotic@snet.net	203-287-7425
Jie Fan	C&M Corp.	jfan@cmcorporation.com	860-779-4864
Bill Ham	Compaq	Bill_ham@ix.netcom.com	978-828-9102
Jason Chou	Foxconn	mailto:jasonc@foxconn.com	408-919-6141
Zane Daggett	Hitachi Cable	zdaggett@hcm.hitachi.com	603-669-4347 x.236
Bob Gannon	JPM	rgannon@jpmco.com	860-537-6800
Larry Barnes	LSI Logic	Larry.barnes@lsil.com	719-533-7432
Richard Uber	Quantum	Richard.uber@quantum.com	508-720-2568
Umesh Chandra	Seagate	Umesh_chandra@seagate.com	831-439-7264
Ken Plourde	Temp Flex	kplourde@tempflex.com	508-839-5987 x.232
Paul Aloisi	Texas Instruments	Paul.Aloisi@ti.com	603-429-8687

3. Agenda development

The agenda shown was that used (moved by Daggett / Vaupotic). Passed unanimously.

4. Approval of previous minutes

Bill Ham moved and Zane Daggett 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 has had its first meeting with the next meeting scheduled for T11 week in February.

8. Presentations on new topics

8.1 Ultra 320 cross talk analysis - 01-013r0, Umesh Chandra, Seagate

This presentation covered the cross talk performance of a specific kind of Amphenol twist and flat cable 8.1 inch twist 1.75 flat 30 AWG solid 207 feet.

This sample was cut to 12 meters to give a 3 dB attenuation at 80 MHz (this "attenuation" is different from the normal definition as it related the amplitude of the low frequency (d.c.) pulses to the amplitude of the complete pulses with an 80 MHz rep rate).

This data showed an extremely strong far end cross talk effect using actual U320 drivers (even without the most aggressive launched signals). The effects included serious jitter increase and (surprisingly) an overall amplitude increase for the particular configuration tested.

This observation will require that we add a far end signal test that is executed with neighboring lines active.

Umesh recommended that at least eye diagrams should be used in specifying the performance requirements for SCSI cable assemblies.

9. Effects of non-uniformities and/or periodic structures

9.1 Effects of periodic structures continued, Larry Barnes, LSI Logic

[not discussed in December]

Larry presented a spread sheet that reports the loaded impedance and velocity of propagation based on frequency, unloaded impedance, separation of loads, capacitance of loads assuming no stub length. Larry agreed to make this spreadsheet available on the web.

Larry Barnes is actioned to place his spreadsheet on the T10 web site.

10. Rationalization of existing attenuation data, all

[This table was not updated but a key factor in the disagreements between the Seagate results and the other measurements was noted.]

The table generated in the last meeting was re-examined. A summary of the data available at meeting time is given in the table below.

The data in the table is for cable assemblies or media only, media 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. Note that there are significant differences in the measurement methodologies and that direct comparisons may not be valid. Nevertheless, the data presented shows the magnitude of difference that has been reported. This framework will be used to compare the round robin data.

	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	Amphenol twisted pair ribbon (no flats) network analyzer with TP101 with 121Ω matching pads
Sample description	cable assys	cable media	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)		TPE 0.26dB/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)		TPE 0.46dB/m (11.5/25M)
28 strand	0.28/m (7 dB/m)	0.36/m (9/25m)	0.40/m (10/25m)	
28 solid			0.40/m (10/25m)	

Note that there are few direct comparisons and some minor inconsistencies in the data in the above table. 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.

It was noted that the Seagate data has backed out the d.c. contribution which is a couple of dB. This helps the agreement considerably.

11. Round robins

11.1 Cable media round robin 1 (Exploratory)

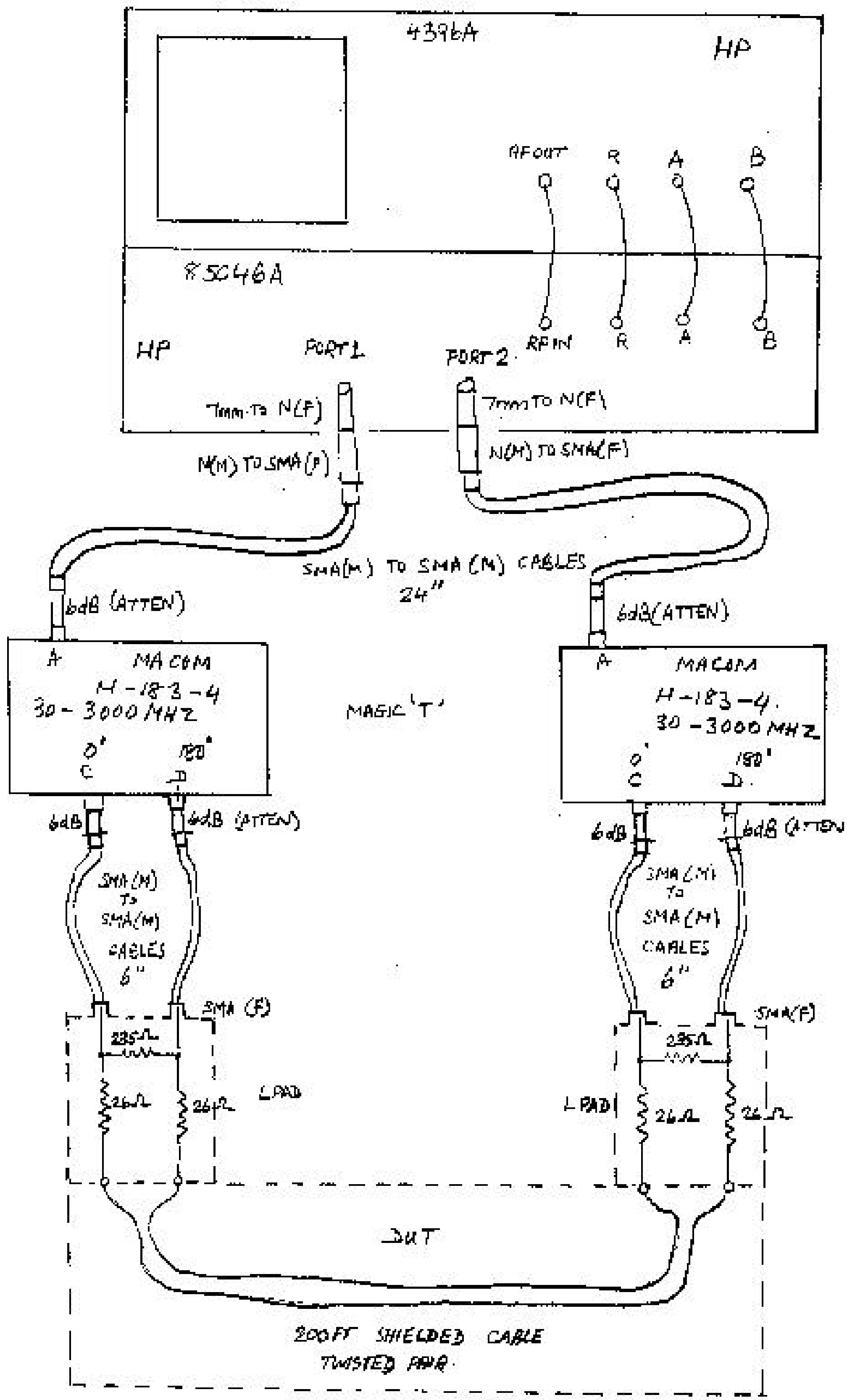
11.1.1 Progress report, Umesh Chandra, Seagate

[much of this material is retained for continuity – Madison data and a summary table was added]

The following samples have been collected:

- 30AWG solid round from Hitachi 57m (190 ft) [sample 1]
- 28AWG stranded round from Hitachi 57m (190 ft) [sample 2]
- 30 AWG solid twist and flat [sample 3]

A test procedure has been documented:



4396A
HP
RF OUT
R
A
B
8504GA
HP
PORT 1
PORT 2
RF IN
R
A
B
7mm TO N(F)
7mm TO N(F)
N(M) TO SMA(F)
N(M) TO SMA(F)
SMA(M) TO SMA(M) CABLES
24"
6dB (ATTEN)
6dB (ATTEN)
A
MACOM
H-183-4
30-3000 MHZ
0°
C
180°
D
MAGIC 'T'
A
MACOM
H-183-4
30-3000 MHZ
0°
C
180°
D
6dB
6dB (ATTEN)
6dB
6dB (ATTEN)
SMA(M) TO SMA(M) CABLES 6"
SMA(M) TO SMA(M) CABLES 6"
SMA (F)
SMA(F)
235Ω
26Ω
26Ω
L PAD
L PAD
235Ω
26Ω
26Ω
DUT
200 FT SHIELDED CABLE TWISTED PAIR

Test Procedure using HP4396A/45046A

- Apply ‘shorts’ (thru) (2) in place of DUT
- Set ‘SOURCE’ level to +20 dB, ‘START’ to 0.5 MHz ‘STOP’ to 300 MHz
- ‘CAL’ -> ‘Cal Menu’ -> ‘Response’ -> ‘Thru’ -> ‘Done’
- ‘SAVE’ -> ‘State’ -> ‘Done’
- Replace ‘shorts’ with the DUT (Cable under Test)
- Collect Data
- ‘SAVE’ -> ‘ASCII Save’ -> ‘Data Only (ASCII)’
- Import file into XL and create graph

Test results:

- 30 AWG Solid Hitachi #49557-068 SCSI3
- dc R = 20.5 OHMS
- CHANNEL: 1
- MEASURE TYPE: S21
- FORMAT TYPE: LOG MAG
- NUMBER of POINTS: 201
- SWEEP TIME: 70 ms
- SWEEP TYPE: LIN FREQ
- SOURCE POWER: 20 dBm
- IF BANDWIDTH: 40 kHz

Data summary from Seagate:

Attenuation at 200 MHz for sample 1 9.21 dB/25m [30AWG solid] average of some 2 pairs
Attenuation at 200 MHz for sample 2 10.82 dB/25m tan/white single pair [28AWG stranded]
Attenuation at 200 MHz for sample 3 the number is somewhat meaningless (partly due to making the measurement in a “bunched up” mode)

Hitachi data:

Test set up: same as SPI-3 except used 100 ohm baluns (350 MHz) and no matching pads

Attenuation at 200 MHz for sample 1 9.25 dB/25m [30AWG solid] average of all 34 pairs
Attenuation at 200 MHz for sample 2 10.39 dB/25m [28AWG stranded] average of all 34 pairs 10.60 dB/25m for the same pair as used by Seagate
Attenuation at 200 MHz for sample 3 not measured

Madison data:

Attenuation at 200 MHz for sample 1 [30 AWG solid] 9.22 dB/25m average for all 34 pairs ranging from 8.94 to 9.67 4 port VNA used for both samples

Attenuation at 200 MHz for sample 2 10.39 dB/25m average for all 34 pairs ranging from 9.83 to 11.03 [28 AWG stranded] tan/white was 10.77
Attenuation at 200 MHz for sample 3 not measured

Data summary:

company	sample 1 (dB/25m)	sample 2 (dB/25m)	sample 3 (dB/25m)
Seagate	9.21	10.82 tan/white	na
Hitachi	9.25	10.39 avg	na
Madison	9.22	10.39 avg 10.77 pair tan/white	na

Conclusions so far:

- One conclusion is that measuring either way gives very similar results.

- Another conclusion is that the pulse amplitude method used previously by Seagate does not match well the results from the network analyzer methods (although the difference is less when d.c. attenuation is accounted for).

The round robin will continue as planned. To those who have not yet reported their results: no fair adjusting the results because the answers are now available.

Umesh agreed to document the round robin activities and results. Umesh to create the draft document for the next meeting.

11.1.2 Testing methodology and parameters

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.

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.

11.1.3 Participating companies, all

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: Chuck Grant (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)

11.1.4 Present status

The following order was used:

Hitachi: Clint Heiser (603 669-4347 ext 362)
Seagate: Bruce Manildi (831 439-7229) [Coordinator]
Madison: Chuck Grant (508 752-2881 ext 306)

Samples just delivered to:
Amphenol Spectra-Strip: Greg Vaupotic (203 287-7425)
Adaptec: Lee Hearn

11.2 Cable media round robin 2 (Expanded parameter set), Greg Vaupotic, Amphenol Spectra Strip

Round robin 2 is based on a significantly more precise specification of the measurement details.

OBJECTIVE

For several characteristics, determine simplest measurement method which compares favorably to the best method. This is accomplished by measuring several samples using several methods, with results being compared later. Most Round-Robin participants will not be able to use all methods; each will do what they can.

DATA PRESENTATION

- Data presented in MS Excel spreadsheets, for later by compilation by coordinator. Participants not able to present electronically are, of course, permitted to present data as recorded.
- Graphs/plots presented prior to final compilation shall be 1 to 1000 MHz, log frequency, even though impedance data is only collected down to 10 MHz. This facilitates comparing data sets for resonance effects.
- Report impedance as differential Ohms. “Attenuation” shows gain as dB / meter.
- Report Propagation time Skew as measured (e.g.: 127 ps / 25 meter length) as table (Excel).

SAMPLES

All samples are 25 meter length. Unshielded samples (twisted pair ribbons) are to be suspended from ceiling, with minimum of crossovers and keeping sample as spread out as possible (to minimize crosstalk effects).

Sample 1 Round twisted pair cable having overall shield, 28 AWG 7-36 TC (Hitachi)

Measure pairs 1 (Heat shrink 1), 7 (Heat shrink 2), and 34 (Heat shrink 3) (each pair to be secured with heat shrink tubing)

Sample 2 Round twisted pair cable having overall shield, 30 AWG solid TC (Madison)

Measure pairs 1 (Heat shrink 1), 7 (Heat shrink 2), and 34 (Heat shrink 3) (each pair to be secured with heat shrink tubing)

Sample 3 Twisted pair ribbon having no flats. (Spectra-Strip)

Measure pairs 1, 3, and 5 (wires 1-2, 5-6, and 9-10)

Sample 4 Twisted pair ribbon having flats at TDB inch intervals (Hitachi)

Measure pairs 1, 3, and 5 (wires 1-2, 5-6, and 9-10)

ATTENUATION

Record S21 using log scale (really is gain). Use 30 Hz IF BW. Where possible, use 401 points. Record from 1 to 1000 MHz, log sweep. In addition to recording sweep, record actual values (using “markers”) at 80, 160, and 200 MHz.

Balun Methods, using fixture described in 00-339r0 (balun with matching resistors). For consistency, use matching network comprised of one 68 Ω shunt and two 47 Ω series resistors (1/8 W 5% carbon).

Method A Calibrate by storing fixture response. Then measure sample. Then remove fixture response. (“normalized”)

Method B Full 2-port calibration. Use 121 Ω ± 1% chip resistor (Panasonic EJR series) for “load”, for “short” solder test points of fixture together, for “open” position matching resistors as will be when measurement is made. For “thru”, attach both fixtures together.

4-port Network Analyzer Methods:
Method C Full 4-port calibration. Calibrate for 100 Ω environment.

Method D Full 4-port calibration. Calibrate for 122 Ω environment (software “corrects” for Z).

DIFFERENTIAL IMPEDANCE

Use 30 Hz IF BW. Where possible, use 401 points. Record from 10 to 1000 MHz, log sweep.

Hybrid Junction Method

Method E See Appendix 1 for outline regarding fixture and calibration.

4-port Network Analyzer Method

Method F Full calibration of one differential port. Calibrate for 100 Ω environment.

SKEW PAIR to PAIR

Per SPI-3 TDR method. Please record propagation time of each leg of each pair. Pair propagation time is the average of these two readings. Doing this allows us to examine within pair skew.

Pair #	Propagation time + signal	Propagation time - signal	Pair propagation time Average (+,-Sig)
1 (or shrink 1)			
3 (or shrink 2)			
5 (or shrink 3)			

LOGISTICS

Companies providing a sample will send to first name on below list. Round cable sample shall be on spools. Flat cable sample shall be on pads.

The first person on the list will send samples to second person. The second to the third, and so forth.

Company	Person	Address	
Amphenol Spectra-Strip	Greg Vaupotic (203) 287-8725	720 Sherman Ave Hamden CT 06410	greg.vaupotic@snet.net
Hitachi Cable	Zane Daggett (603) 669-4347	900 Holt Avenue Manchester NH 03109	zdaggett@hcm.hitachi.com
Madison Cable	Chuck Grant (508) 752-2884	125 Goddard Memorial Dr. Worcester MA 01603	cgrant@madisoncable.com
Seagate	Umesh Chandra (831) 439-7264	4585 Scotts Valley Drive Scotts Valley CA 95066	
Adaptec	Dave MacQuown		david_macquown@corp.adaptec.com
END Amphenol Spectra-Strip	Greg Vaupotic (203) 287-	720 Sherman Ave Hamden CT 06410	greg.vaupotic@snet.net

	8725		

TEST METHOD CAPABILITIES

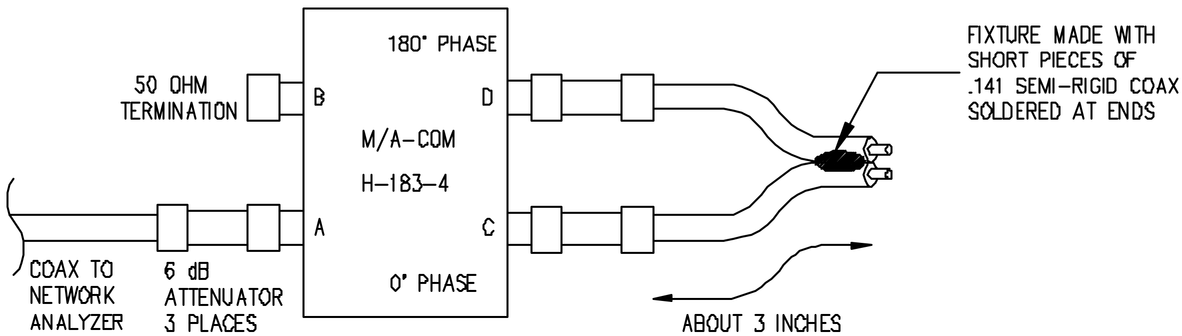
Table below shows anticipated test capabilities of participants.

Company	Balun A	Balun B	4-port C	4-port D	Hybrid E	“4-port” F
Amphenol	yes	yes	no	no	yes	no
Hitachi Cable			no	no		no
Madison Cable	Yes?	yes?	yes	yes		yes
Seagate	yes	yes	yes	yes	yes	yes

APPENDIX 1

Hybrid Junction Test Fixture

The hybrid junction converts an unbalanced 50 Ω input into two balanced 50 Ω outputs (two signals having 180° phase, 100 Ω differential). The selected hybrid junction is the M/A-COM H-183-4. This is specified from 30 MHz to 3 GHz. However, it may be used from 10 MHz to 3 GHz when used with a careful calibration.



OUTLINE for Calibration Procedure

Attach fixture to analyzer port 1. Semi-rigid coax strongly recommended.
Preset Network Analyzer to default condition. Then set analyzer to:
Power = 10 dBm Points = 401 Linear Sweep (??) Start = 10 MHz
Stop = 1 GHz
30 Hz IF BW

With attenuators attached, BUT with semi-rigid fixture removed, calibrate port 1. This is accomplished using precision standards attached to the two attenuators on the right.
Two sets of standards are required.

When finished calibrating port 1, attach semi-rigid coax fixture (which, having no sample attached, is an "open" circuit)

- Set analyzer to look at S11 Phase. Set phase scale to 10° per division.
- Enable port extensions
- Adjust port-1 extension for 0° across the frequency range (expected for an open circuit). This compensates for the fixture's propagation propagation time. Above 800 MHz, it will not be possible to achieve exactly 0°. This is because the fixture is not a perfect open circuit. The attachment stubs cause small undesired parasitics. (Port extension for above fixture is about 380 ps.)
- Set the analyzer to look at S11 Set Z Reflected = On Set scale = Linear

Important – The analyzer has been calibrated to 50 Ω. The actual impedance at the calibration plane was, in fact, 100 Ω differential. Multiply measurements by two for differential impedance.

Measurement using Open/Short Method

Two measurements are required for each pair that is examined. First, record the impedance of the pair with the far-end “open”. Then record again with the far end “shorted”. The impedance is then calculated with the following equation:

$$Z = \sqrt{(Z_{OPEN})(Z_{SHORT})}$$ This is the value to report.

11.3 Backplane round robin 1, Umesh Chandra, Seagate

[most of this is a carry over from the last meeting - some significant progress has been made however]

This effort is needed to add backplane testing methodology to the test suite. The basic idea is to acquire some small selection of SCSI backplanes and send these around for testing at different companies.

Umesh has a non-product backplane design that could be used. Bill Ham thinks that he may have some older backplanes that are not products that could be used.

Umesh is actioned to select 2 boards for use in the round robin.

Ham is actioned to select 2 boards for use in the round robin.

Umesh is actioned to propose a set of tests to be used including things like test fixtures and specific slots to be measured.

Participants include: Seagate, Compaq?, Adaptec?, IBM?, Quantum?,

Umesh has certain hardware that could be useful in exciting the interconect under test. The initial cut should focus on the “Data spewing” card (disk drive card) with a data interface through the SCA connector that allows programming of the data pattern through an HBA using the SCSI transport. Umesh is actioned to determine if/when the data spewing card could be made available to the industry for use in PIP applications.

Motion Ham / Umesh that PIP will document a cost effective eye diagram based test methodology for passive interconnect that will be part of a test suite for performance requirements.

Motion passes 10/0.

12. Proposed new round robins

12.1 Cable Assembly round robin 1, Martin O., Molex

Martin O. presented his view of the content and timing of this round robin. As there was not enough time to explore all the details in this meeting needed to structure a "good" round robin a reduced, two company round robin will be completed before February 2001. Martin agreed to structure a preliminary round robin intended to refine the parameters of the real cable assembly round robin 1. The companies that will deliver results to the February meeting are Molex and JPM.

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

Deferred (again) to February due to issues with obtaining the chemicals needed for calibration into the LSI Logic facility. (Material safety data sheets etc). This work is intended to use the HP polished probe method according to the following table.

Greg Vaupotic noted that data from the swept frequency slab method on partially processed material could be made available.

This discussion produced collaboration containing the following:

Polyethelyne samples to be provided by Spectra Strip	slab method	coax probe method
raw material processed into a slab	Spectra strip	LSI Logic
raw material extruded over single conductor 26 AWG with approximately 12 to 15 mils dielectric thickness	NA	LSI logic -- strip material off conductor and measure by inserting the probe through slit in the conductor to the opposite side (C-)
material removed from conductor processed into slab	Spectra strip	LSI Logic

The range of frequency will be at least 1 MHz to 1 GHz linear sweep.

The samples will be targeted to Larry by mid November 2000.

Greg Vaupotic and Larry Barnes are actioned to complete the work outlined in the above table.

14. Worst case vs spec numbers strategy

[This item was not discussed at this meeting but is still unresolved.]

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.

15. 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.

15.1 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.

15.2 Length measurements

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

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.

15.3 Interoperability points

[This section was discussed in earlier meetings but will be retained in the minutes until transferred into the PIP document. Bill Ham extracted this section and presented it at the last SCSI plenary, 00-404r0. A version suitable for use in the SSM document resulted.]

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)

15.4 Approach to concatenated constructions

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

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.

16. 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. The project number 1439-D. This numbering implies that PIP is a standard and not a technical report. Bill Ham is actioned to check this out.

Motion Ham/Vaupotic that the PIP ad hoc recommend to the T10 plenary that the PIP project be to develop a standard (if that is not already the case).

6 in favor, 0 opposed, 3 abstain.

17. 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.

17.1 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.

17.1.1 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)

17.1.2 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.

17.1.3 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?

17.1.4 Test types

The following table represents the present view of the candidate measurements

Table 1 Summary table for test parameters for SCSI PIP

Test parameter	Level	Applicability (cable media, backplane, modeling, etc.)	Section	Domain	Condition	Sample configuration	Comments
SE local impedance	**1**	All		T			
Diff local impedance		All					
Extended Distance Impedance (Diff)		Cable media		F			
Capacitance (SE)		Cable media, interconnect assembly (L2), backplane, modeling		F			
Capacitance (Diff)		Cable media, backplane, modeling		F			
Propagation time		Cable media, interconnect assembly (L2), backplane, modeling		T			Within the pair
Propagation time SKEW		Cable media, interconnect assembly (L2), backplane, modeling		T			Pair to pair
Eye diagrams (signal degradation)		Interconnect assembly		T			All lines active
NEXT		Cable media, interconnect assembly, backplane, modeling		T			
FEXT		Cable media, interconnect assembly, backplane, modeling		T			
EMI		Interconnect assembly		F			Shielded versions only
D.C. leakage to ground		Interconnect assembly					[Impacts receiver bias / D.C. offset]
HI-Pot		Cable media, interconnect assembly, backplane					
D.C. resistance imbalance		Interconnect assembly					Within the pair
Dielectric constant variation w/ frequency		Cable media, backplane, modeling		F			

Common mode impedance	**2**	Cable media, backplane, modeling		T			Treat each pair as a single conductor
Common mode capacitance		Cable media, backplane, modeling		F			
Propagation time		Cable media, modeling		F			Within the pair
Propagation time SKEW		Cable media, modeling		F			Pair to pair
Eye diagrams (signal degradation within the pair)		Interconnect assembly, modeling		T			One line active
Common mode degradation		Interconnect assembly, modeling		T		Need more discussion on whether this is level one or level two type test.	+ Signal to - signal balance within the pair (sum of the difference)
Attenuation (within the pair)		Interconnect assembly, media, backplane		F			
Attenuation skew (pair to pair)		Interconnect assembly, media, backplanes		F			Difference in voltage transfer function between pairs
Rise time degradation		Interconnect assembly, modeling		F			The pair propagation velocity
~~Common mode noise~~							
Dielectric constant variation w/ frequency		Cable media, backplane, Modeling		F			
ACR (attenuation to cross talk ratio)		Cable media, Modeling		F			
TBD							
Vector Network Analyzer (VNA) tests???		Modeling					All matter of S parameters.

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[0] Create a definition field for each “media” Cable media, Interconnect assembly, Backplane, Modeling, etc.

Interconnect assembly could include complete cable assembly or backplane with connectors.
Backplane is without connectors
Modeling in this table means results of these measurements maybe useful to users involved in model creation, model verification or other analysis. Modeling may or may not require some or all “media” to be tested.

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

17.1.5 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.

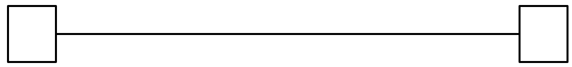
17.1.6 Acceptable performance values

All level 1 tests will have specific acceptable values proposed.

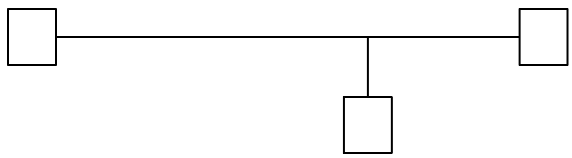
18. Starting point for specifying application of tests

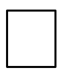
The following configurations were agreed to be used for the next steps in developing specifications for the application of the tests.

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.]

18.1 Definitions for the document - Barnes

Not addressed at this meeting.

19. 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.

20. Next meetings

Approved schedule:

February 20-21, 9AM to 5 PM 02/20; 9AM to 12PM 02/21, Cypress / Anaheim CA (Foxconn)

Requested schedule:

April 3-4, 2000 9AMPM to 5 PM 04/03; 9AM to 12PM 04/04 Worcester, MA (Madison)

21. Action Items:

21.1 Old action items from previous meetings

Larry Barnes to acquire data from the polished coax probe method for dielectric constant frequency variations.
Status: equipment now in hand, test results now expected before December meeting due to time availability

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 00-379r0

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

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

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

Greg and Jie to prepare a detailed proposal for samples, measurements to be performed, and logistics for round robin 2.
Status: done by Greg due to Jie changing jobs

Ham to select 2 boards for use in the backplane round robin.
Status: partly done carried over

Umesh to propose a set of tests to be used including things like test fixtures and specific slots to be measured.
Status: done 01-014r0 (Manildi)

Greg V to provide Larry with polyethylene samples per section 13.
Status: done

Bill Ham to create a document outlining the interoperability points issues for SCSI
Status: done 00-404r0 and presented to T10 plenary

Larry Barnes to place his spreadsheet for backplane on the T10 web site.
Status: done

Bruce Manildi to put the presentation from the extended set of cable media on the T10 web site.
Status: done 00-385r0

Umesh to create a draft document describing the details of and results from the cable media round robin 1 for the next meeting
Status: done 00-386r0

Martin to create a proposal for cable assembly round robin 1
Status: done

Larry Barnes to complete the work outlined in the table relating to the frequency dependence of dielectric constant.
Status: carried over

Bill Ham to extract this section on interoperability points for presentation at the next SCSI plenary meeting and to produce a version suitable for use in the SSM document.
Status: partially done - the SSM part is carried over
Umesh to select 2 boards for use in the round robin.
Status: carried over pending permission from the owners of the board designs

Ham to select 2 boards for use in the round robin.

Status: carried over pending permission from the owners of the board designs

Umesh to propose a set of tests to be used including things like test fixtures and specific slots to be measured.
Status: carried over

21.2 New actions from this meeting

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

Umesh to determine if/when the data spewing card could be made available to the industry for use in PIP applications.
Status: new