ANSI X3T9.2 SCSI COMMITTEE PLENARY MEETING
St. Petersburg, Florida

SCSI-2 CABLE TESTING SUMMARY REPORT

Supplemental results as of 4/22/89

Hi - Density Flat Cables & Round Cables

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Test Equipment

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6. Hewlett Packard 6023A Power Supply

ABSTRACT

At last February's Plenary, Sun presented a Preliminary Test Report concerning the validity of the proposed SCSI-2 Cable and connector proposals from AMP and 3M. This supplement details the remainder of the testing that SUN has performed for the committee.

The intent of the tests were to characterize, as completely as possible, whether the samples of cable/interconnect from various manufactures would function satisfactorily in a SCSI environment while subjected to different Cluster configurations, when one put the maximum number of SCSI devices on the bus. Testing concentrated upon Synchronous data transfers of 4.0 Mbytes/Sec or higher.

To accomplish these goals, SUN utilized two separate test platforms: 1) Adaptec SDS-3 Synchronous SCSI Test System, and 2) Sun's own systems, some with synchronous capabilities. The Adaptec test system was used to verify that synchronous transfers could be performed on devices that were clustered on the SCSI bus. While the Sun systems were used to verify operations in an actual multi-user, multitasking environment with various peripherals devices in different cluster configurations.

During the testing with the Adaptec, it was decided that varying the applied voltage to TERMPWR could provide some form of margin characterization across the different cluster configurations. The voltage supplied at the iniator node (one end of the bus) was dropped from 5.25 Volts until failure.

Test results are tabulated. Data was compared for the various configurations tested, and final conclusions and recommendations were drafted. See Section IV.

Adaptec Cluster Testing

Testing consisted of running the Adaptec SDS-3 with two stand-alone test programs written to perform Asynchronous and Synchronous data transfers of 1.5 and 5.0 MHz. respectively, on the SCSI Bus. The target drives were Imprimis (CDC) Wren IV, Quantum 3.5" P105S and Micropolis 1684 devices, each with Synchronous transfer capability. The Adaptec was programmed for a maximum offset of 7 and a transfer period of 200 nS, to negotiate with during synchronous data transfers. The Imprimis drive very nearly matched the negotiation, while the Quantum and Micropolis drives negotiated to 4.0 MHz. data transfers. The Adaptec uses their AIC 6250 SCSI protocol controller in the SDS-3.

Term power was varied from 5.25 Volts down to failure of the SCSI Bus. Upon failure, the voltage was raised again and operated for 90 minutes of error free prior to reducing it back to the error level and re-verifying the same SCSI Bus error conditions. The voltage of the farthest device was checked to determine total line loss during testing.

Three separate cluster arrangements were implemented during testing. See Cluster Configurations. Measurements were made at each cluster node with scope shots taken of the worst case signals. Testing was performed using both cable configurations, 6 meter, single impedance cable and the combination internal/external cable set.

Cluster Configurations

Synchronous Data Transfers

A. Cluster A, SCSI-2 internal and SCSI-1 external cable, impedance 93/100
B. Cluster B, SCSI-2 internal and SCSI-1 external cable, impedance 93/100
C. Cluster C, SCSI-2 internal and SCSI-1 external cable, impedance 93/100
D. Cluster D, SCSI-1 internal and SCSI-1 external cable, impedance 110/100
E. Cluster E, SCSI-2, 20 ft. cable, impedance 93
F. Cluster F, SCSI-1, 20 ft. cable, impedance 110

Asynchronous Data Transfers

G. Cluster G, SCSI-2 internal and SCSI-1 external cable, impedance 93/100

DATA: Adaptec Cluster Testing

Scope Shots - 2/4 node versions

Synchronous Data Transfers

Configuration A: SCSI-2 internal and SCSI-1 external Cables

1. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 200 mV
2. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 200 mV

Configuration B: SCSI-2 internal and SCSI-1 external Cables

1. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 325 mV
2. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 325 mV

Configuration C: SCSI-2 internal and SCSI-1 external Cables

1. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV
2. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV
3. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV
4. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV

Configuration D: SCSI-1 internal and SCSI-1 external Cables

1. Test Point One, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
2. Test Point Two, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
3. Test Point One, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
4. Test Point Two, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV

Configuration E: SCSI-2, 20 ft. continuous flat cable

1. Test Point One, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
2. Test Point Two, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
3. Test Point One, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV
4. Test Point Two, SD1 communicating, Sync data transfers, term power voltage drop = 250 mV

Configuration F: SCSI-1, 20 ft. continuous flat cable

1. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 250 mV
2. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 250 mV

Asynchronous Data Transfers

Configuration G: SCSI-2 internal and SCSI-1 external Cables

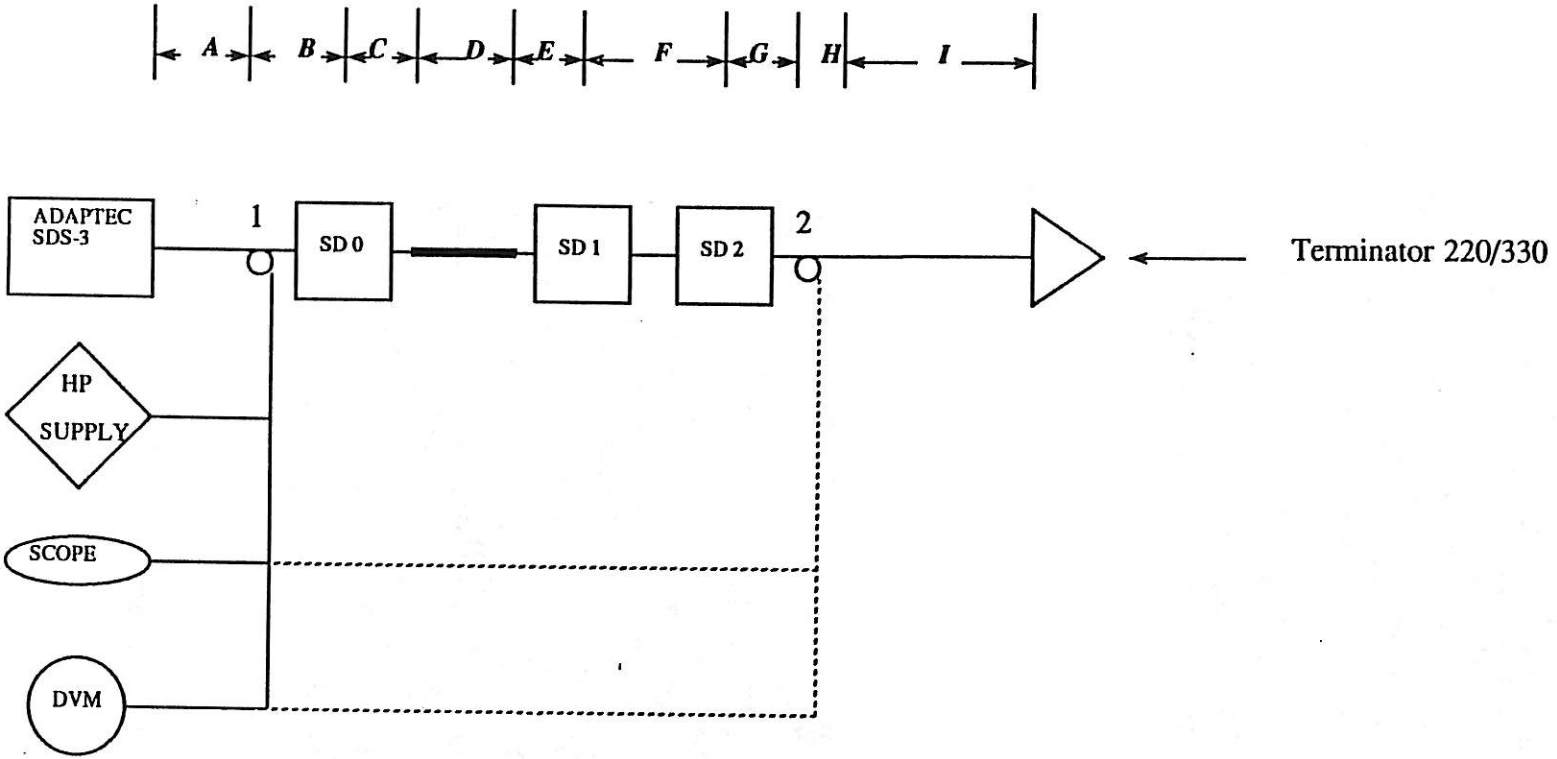
1. Test Point One, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV
2. Test Point Two, SD0 communicating, Sync data transfers, term power voltage drop = 425 mV

**Note: Scope shots have the following Orientation:*

Upper Trace = **REQ**
Lower Trace = **ACK**

CONFIGURATION A

O - Test Point Location



Distances

A = 10 inches
B = 11 inches
C = 21 inches
D = 14.5 inches
E = 12 inches
F = 12 inches
G = 10 inches
H = 4 inches
I = 14.5 inches

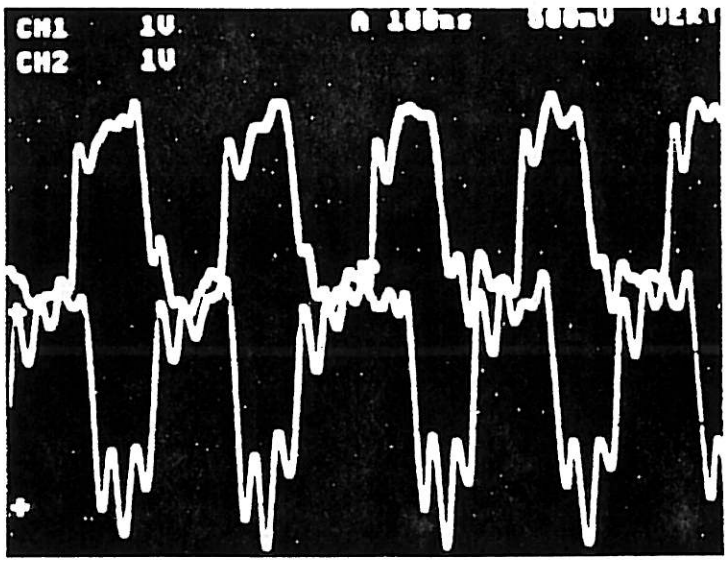
Total Length of Cable = 9.08 ft.

CABLE TYPE

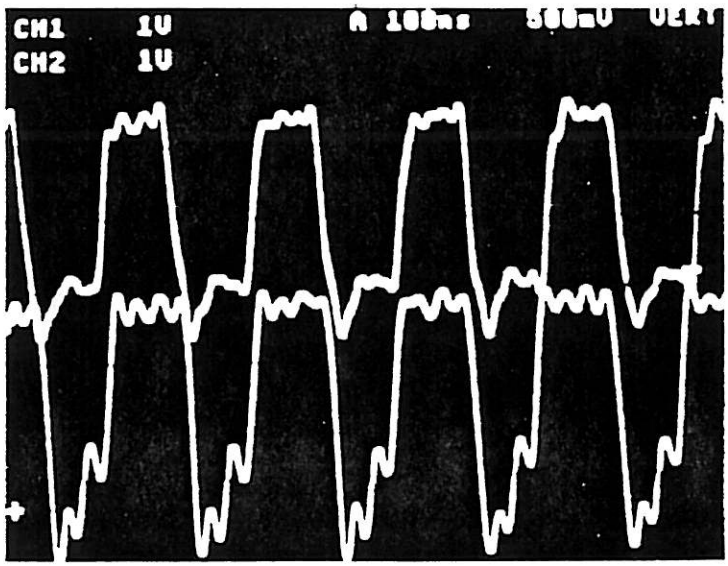
AMP, SCSI-2, Flat Ribbon Cable Sections, Impedance equals 93 Ohms

Madision, SCSI-1, External Twisted Pair Round Cable Sections, with characteristic Impedance of 100 Ohms.

SECTION A SCOPE SHOT #1

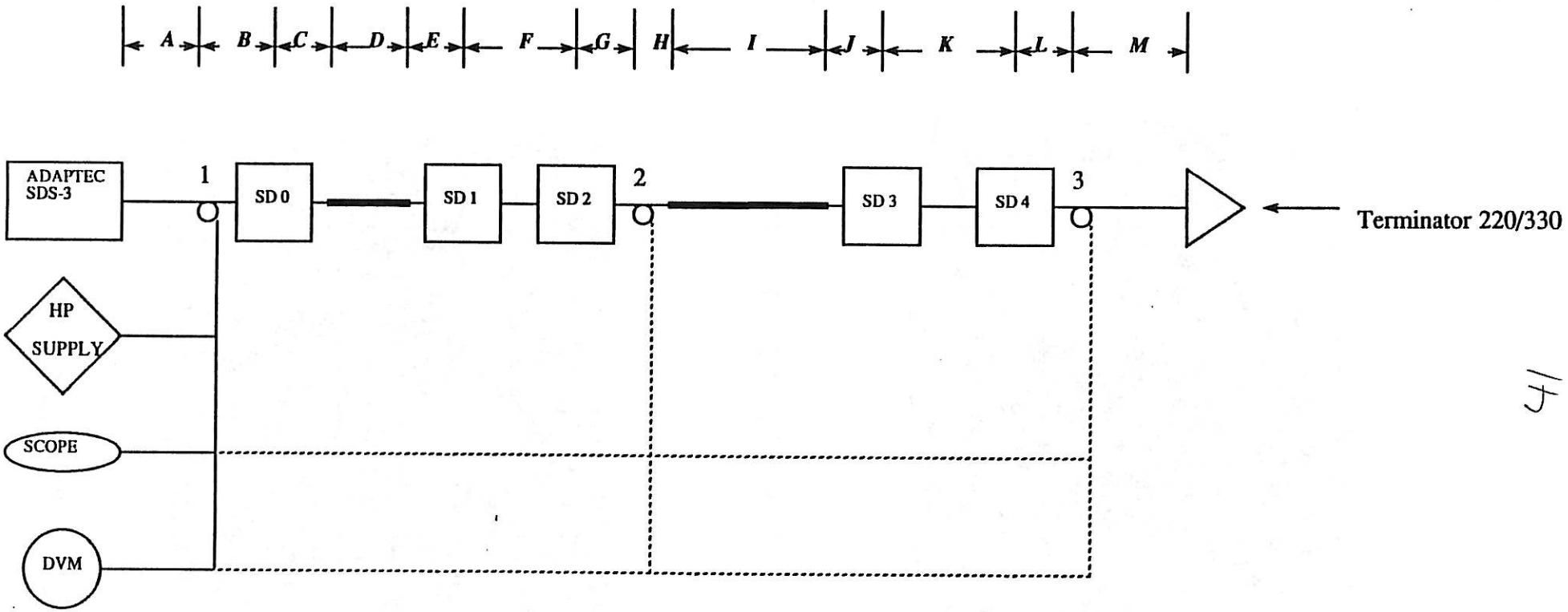


SECTION A SCOPE SHOT #2



CONFIGURATION B

○ - Test Point Location



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Distances

A = 10 inches
B = 11 inches
C = 21 inches
D = 14.5 inches
E = 12 inches
F = 12 inches
G = 10 inches
H = 4 inches
I = 48 inches
J = 11 inches
K = 12 inches
L = 8 inches
M = 14.5 inches

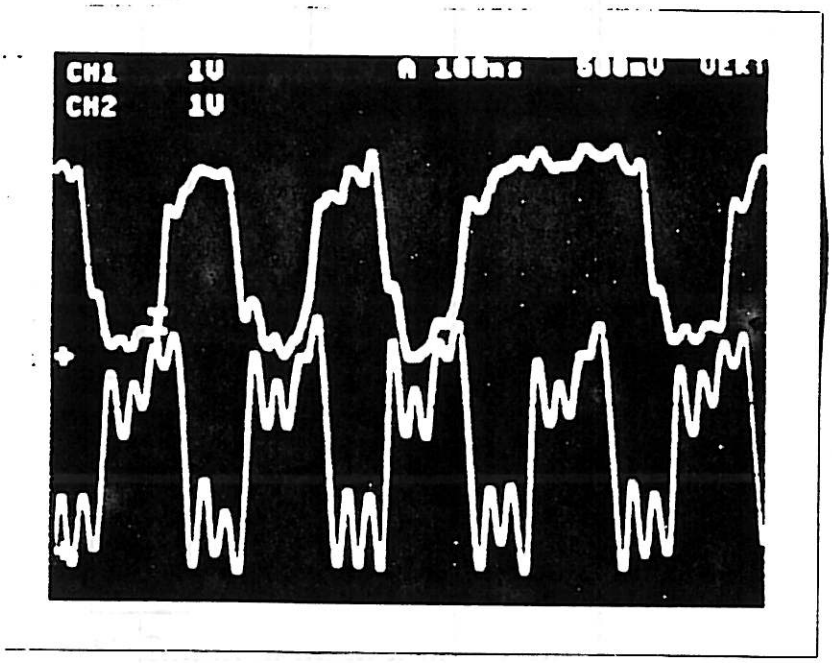
Total Length of Cable = 15.67 ft.

CABLE TYPE

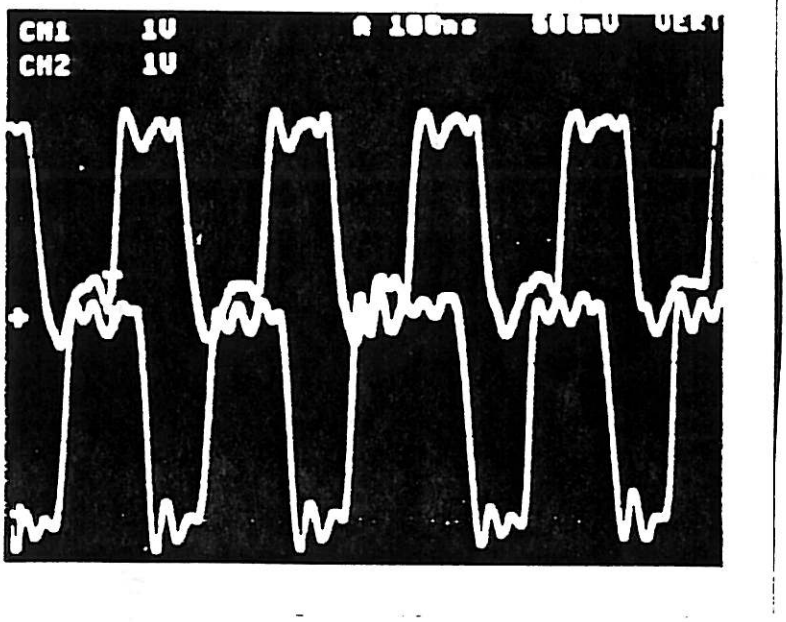
AMP, SCSI-2, Flat Ribbon Cable Sections, Impedance equals 93 Ohms

Madision, SCSI-1, External Twisted Pair Round Cable Sections, with characteristic Impedance of 100 Ohms.

SECTION B SCOPE SHOT #1

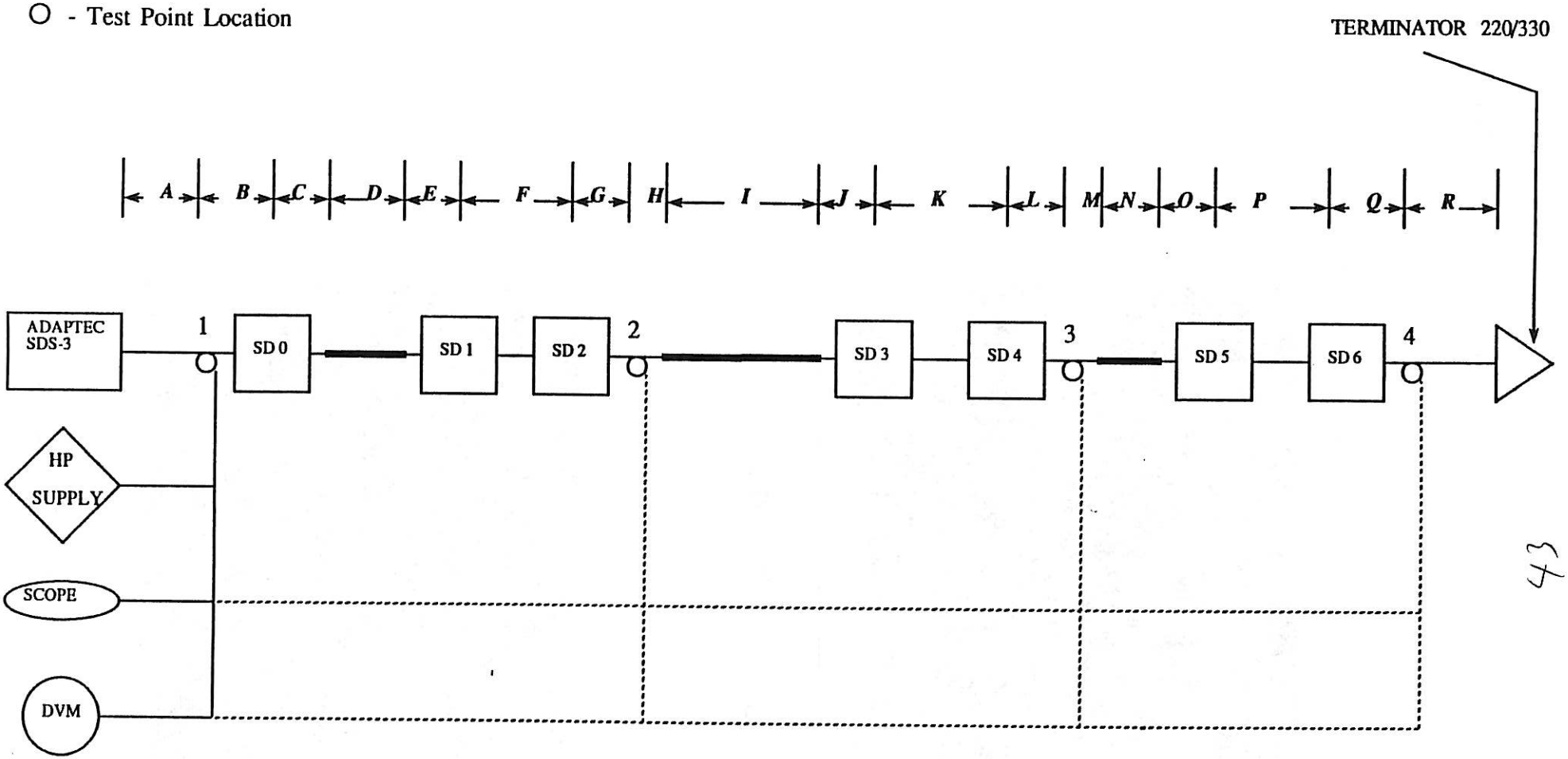


SECTION B SCOPE SHOT #2



CONFIGURATION C

O - Test Point Location



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Distances

A = 10 inches
B = 11 inches
C = 21 inches
D = 14.5 inches
E = 12 inches
F = 12 inches
G = 10 inches
H = 4 inches
I = 48 inches
J = 11 inches
K = 12 inches
L = 8 inches
M = 4.5 inches
N = 14.5 inches
O = 12 inches
P = 12 inches
Q = 11 inches
R = 3.5 inches

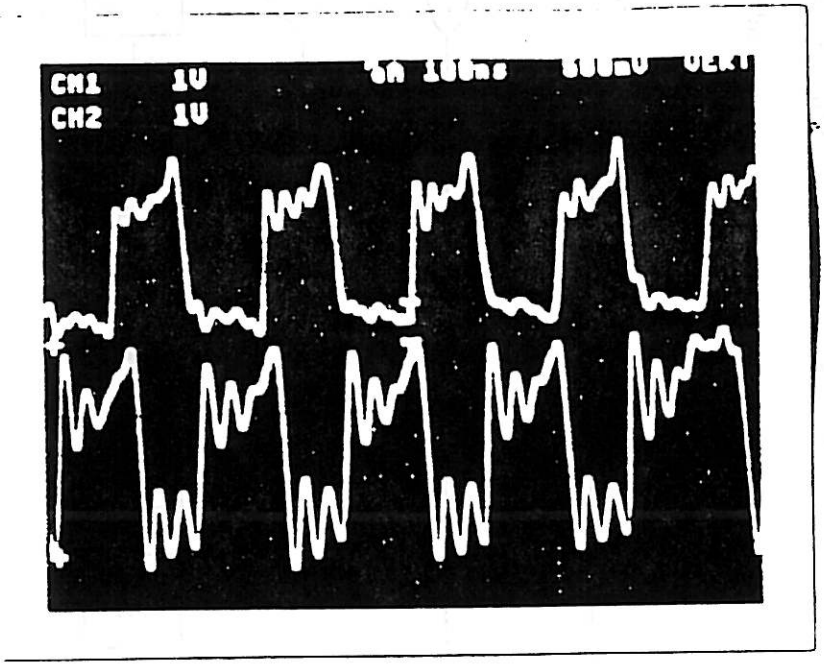
Total I ength of Cable = 20 ft.

CABLE TYPE

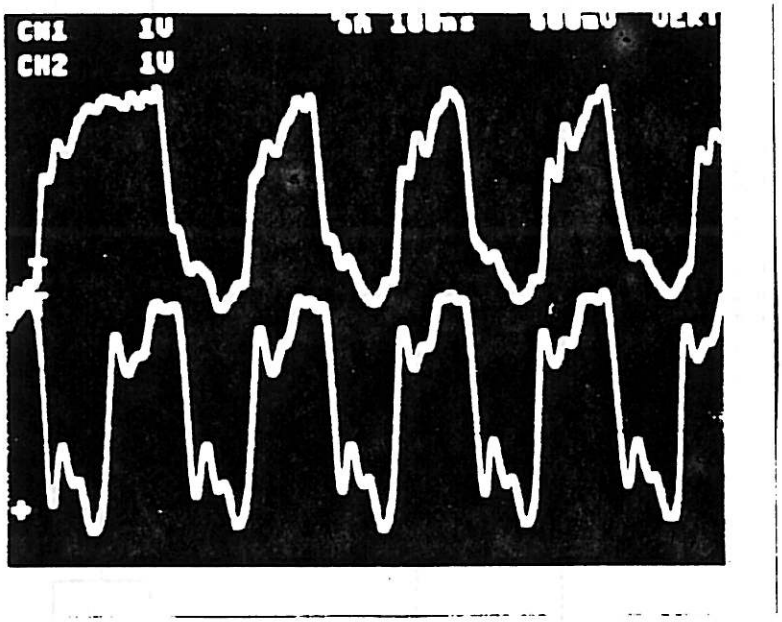
AMP, SCSI-2, Flat Ribbon Cable Sections, Impedance equals 93 Ohms

Madision, SCSI-1, External Twisted Pair Round Cable Sections, with characteristic Impedance of 100 Ohms.

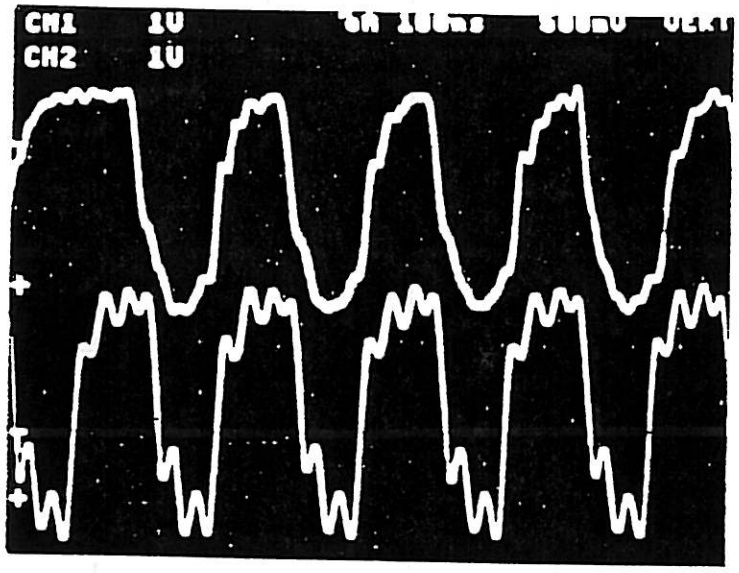
SECTION C SCOPE SHOT #1



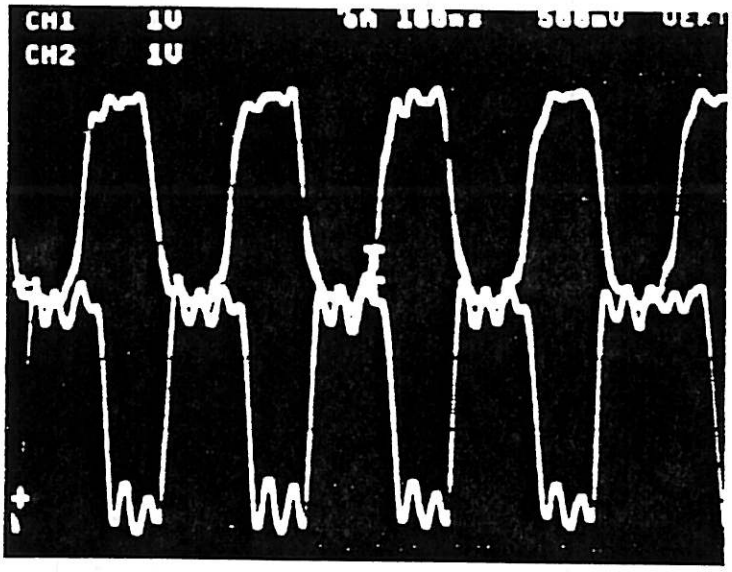
SECTION C SCOPE SHOT #2



SECTION C SCOPE SHOT #3

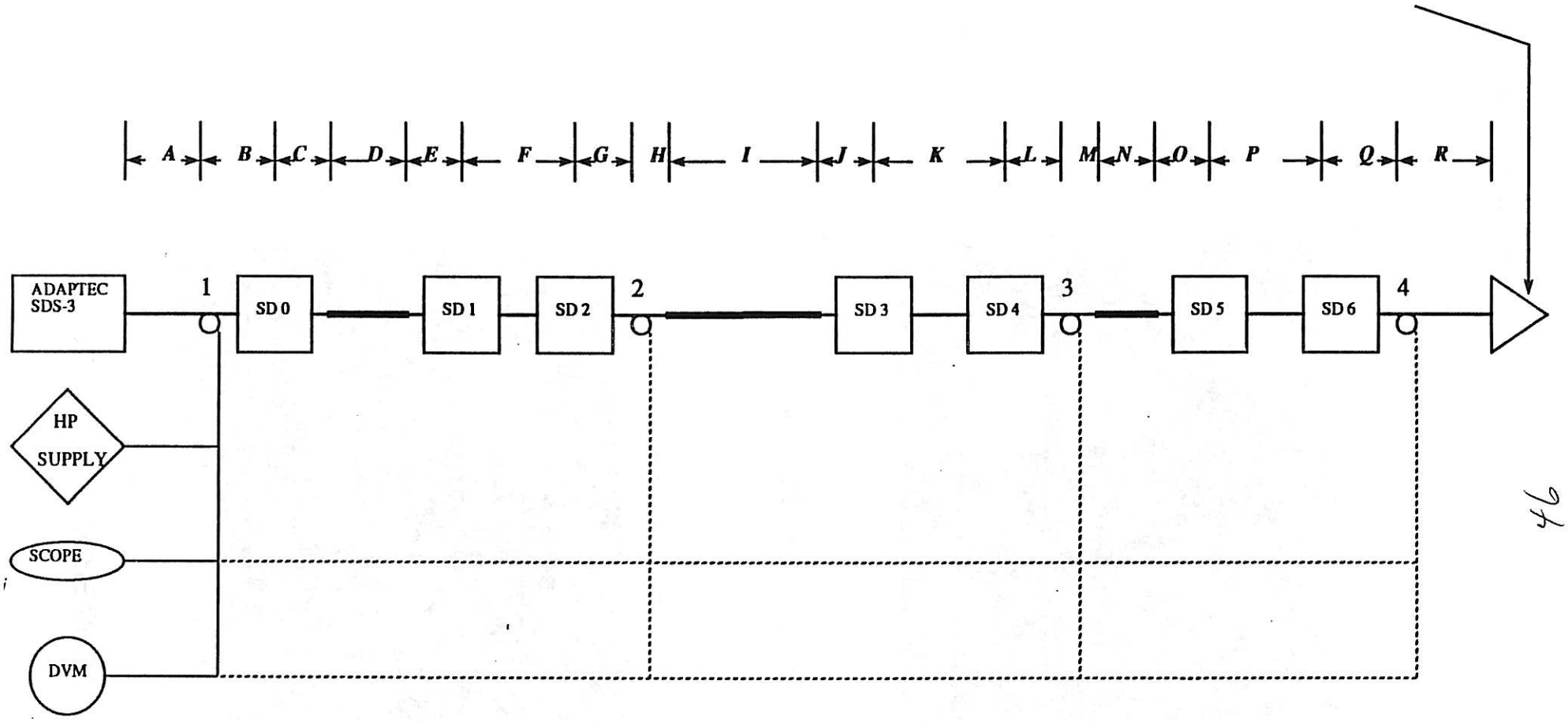


SECTION C SCOPE SHOT #4



CONFIGURATION D

O - Test Point Location



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Distances

A = 10 inches
B = 11 inches
C = 21 inches
D = 14.5 inches
E = 12 inches
F = 12 inches
G = 10 inches
H = 4 inches
I = 48 inches
J = 11 inches
K = 12 inches
L = 8 inches
M = 4.5 inches
N = 14.5 inches
O = 12 inches
P = 12 inches
Q = 11 inches
R = 3.5 inches

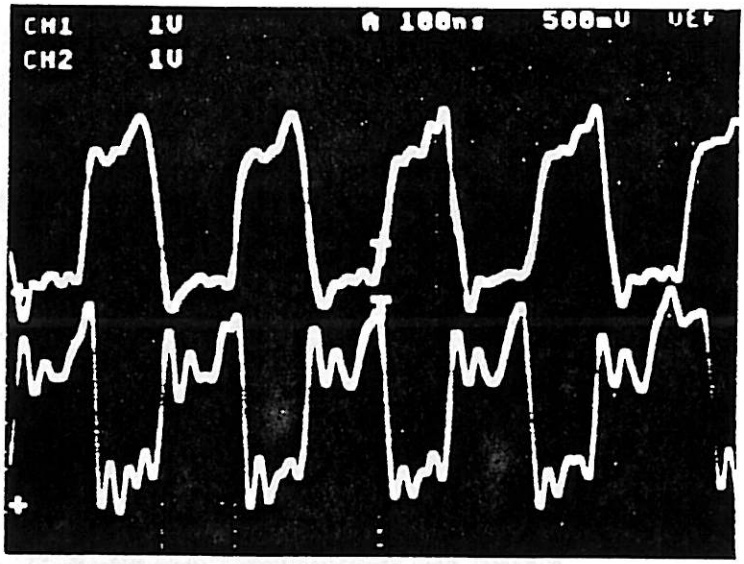
Total Length of Cable = 20 ft.

CABLE TYPE

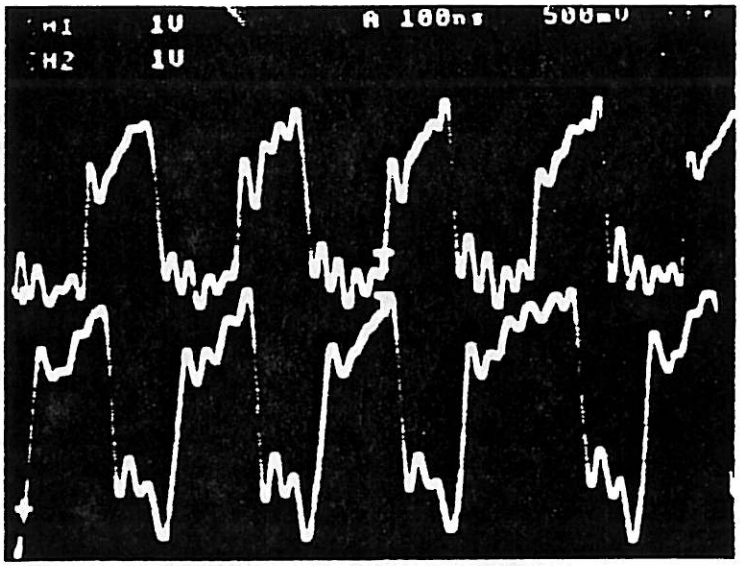
3M, SCSI-1, Flat Ribbon Cable Sections, Impedance equals 110 Ohms

Madision, SCSI-1, External Twisted Pair Round Cable Sections, with characteristic Impedance of 100 Ohms.

SECTION D SCOPE SHOT #1



SECTION D SCOPE SHOT #2



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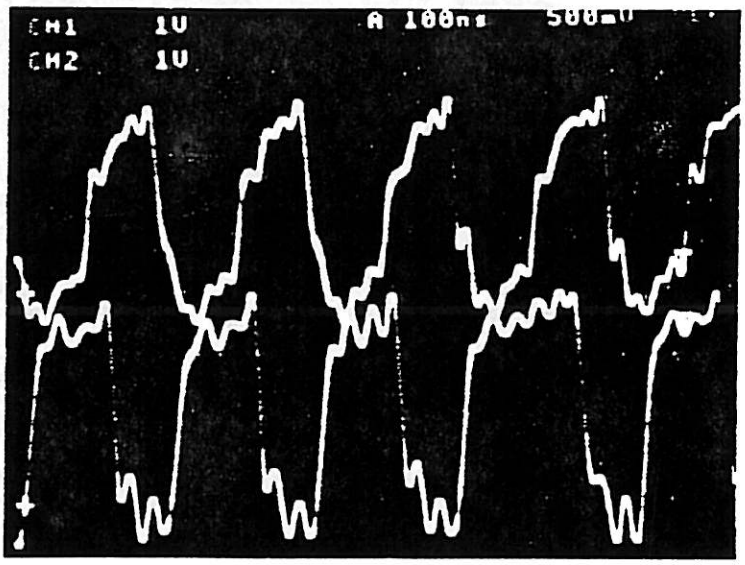
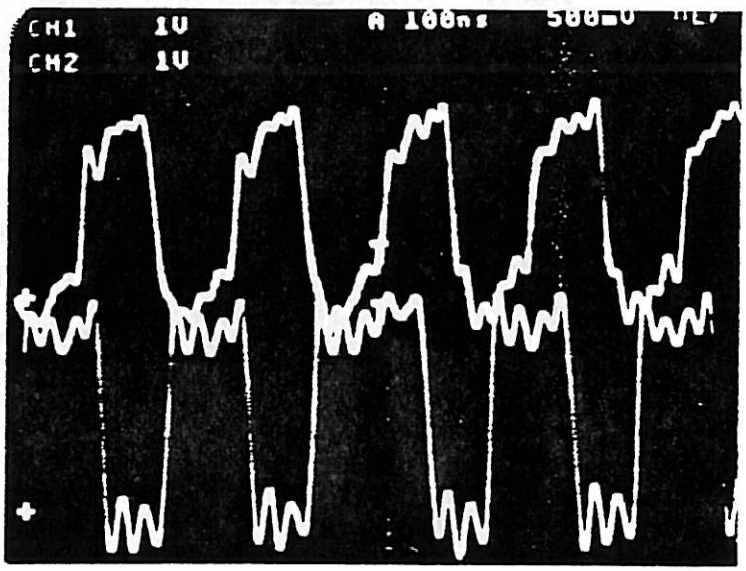
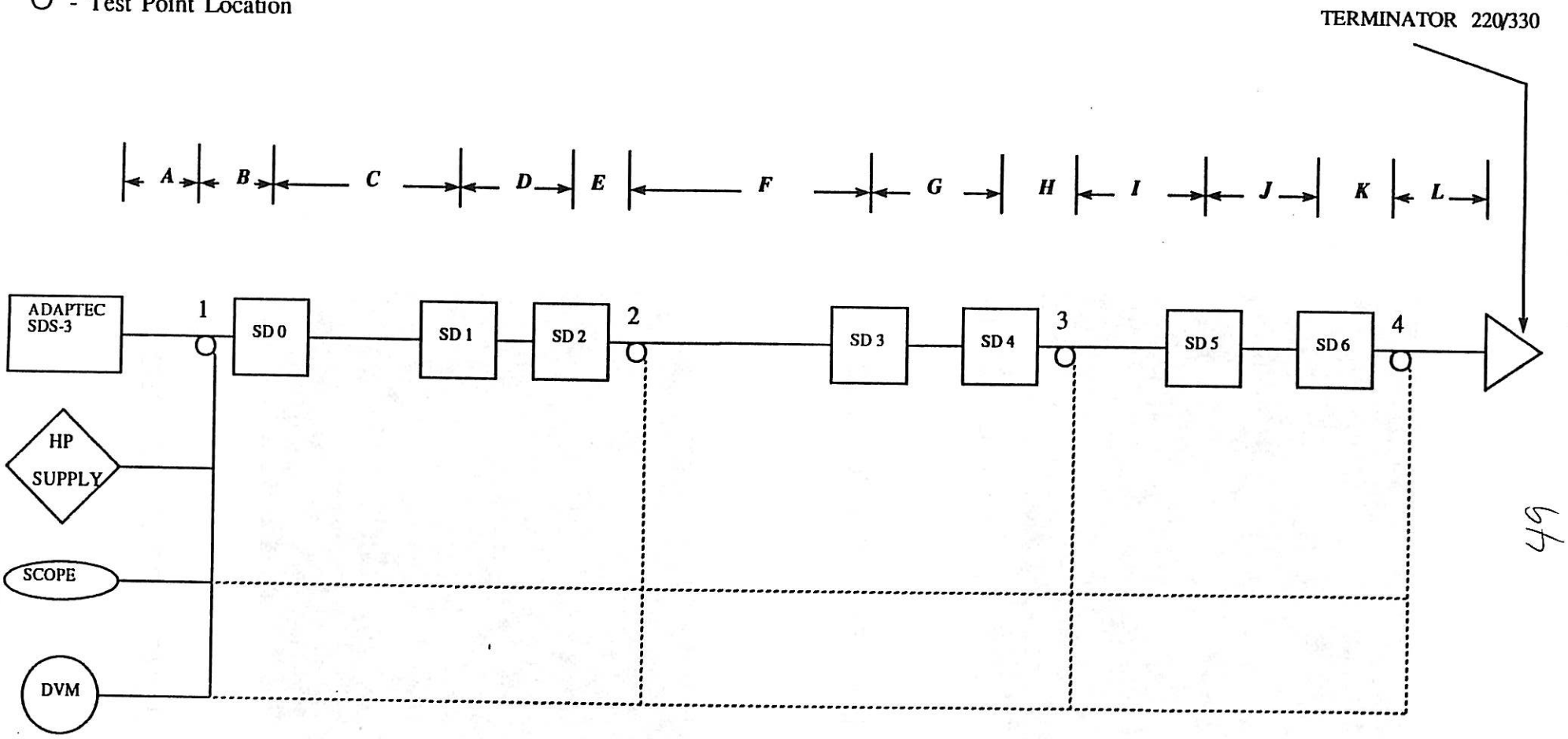


SECTION D SCOPE SHOT #4



CONFIGURATION E

○ - Test Point Location



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Distances

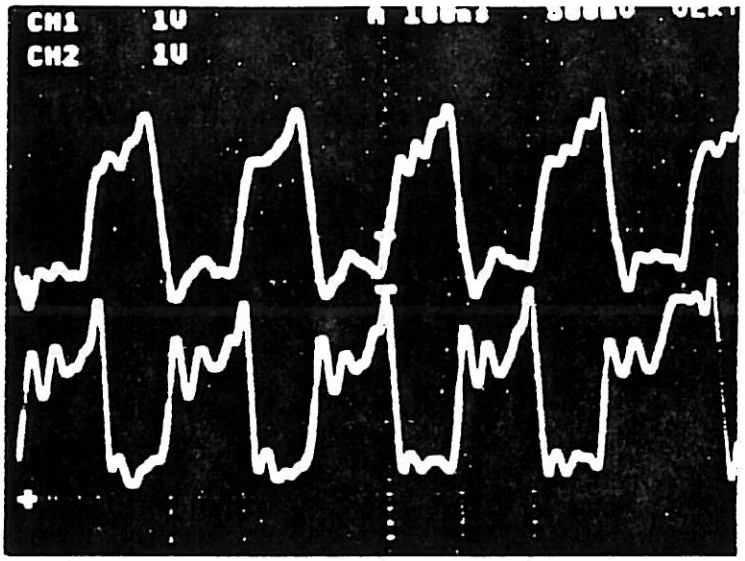
A = 1 ft.
B = 1 ft.
C = 3 ft.
D = 1 ft.
E = 1 ft.
F = 5 ft.
G = 1 ft.
H = 2 ft
I = 2 ft.
J = 1 ft.
K = 1 ft.
L = 1 ft.

Total Length of Cable = 20 ft.

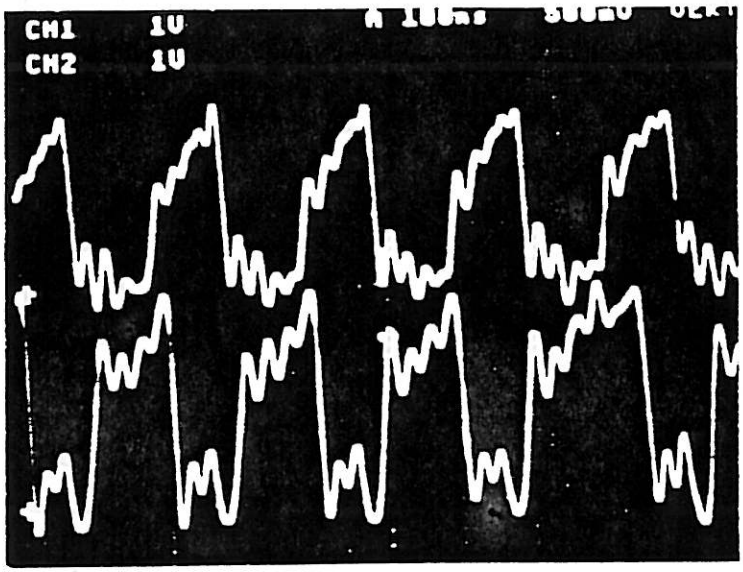
CABLE TYPE

AMP, SCSI-2, 20 ft. Flat Ribbon Cable
Impedance = 93 Ohms

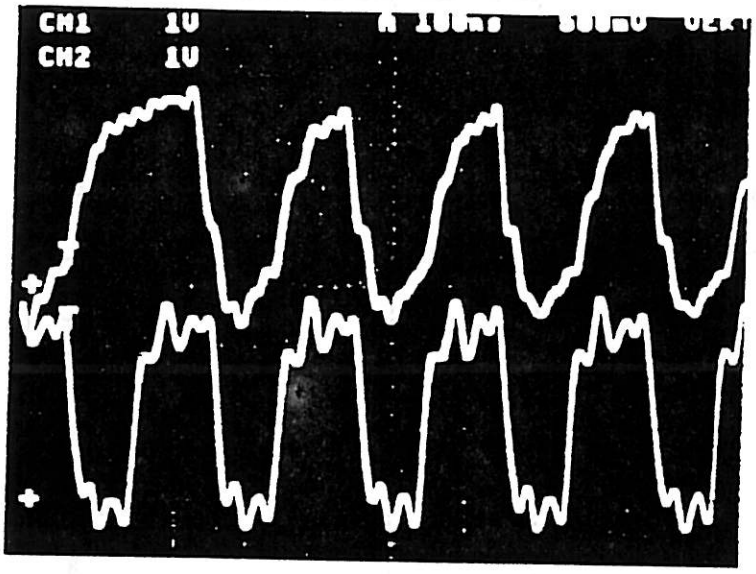
SECTION E SCOPE SHOT #1



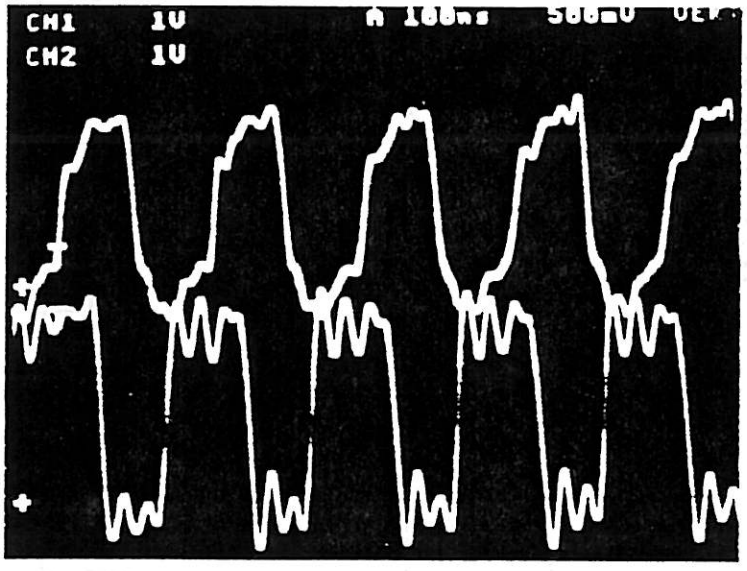
SECTION E SCOPE SHOT #2



SECTION E SCOPE SHOT #3

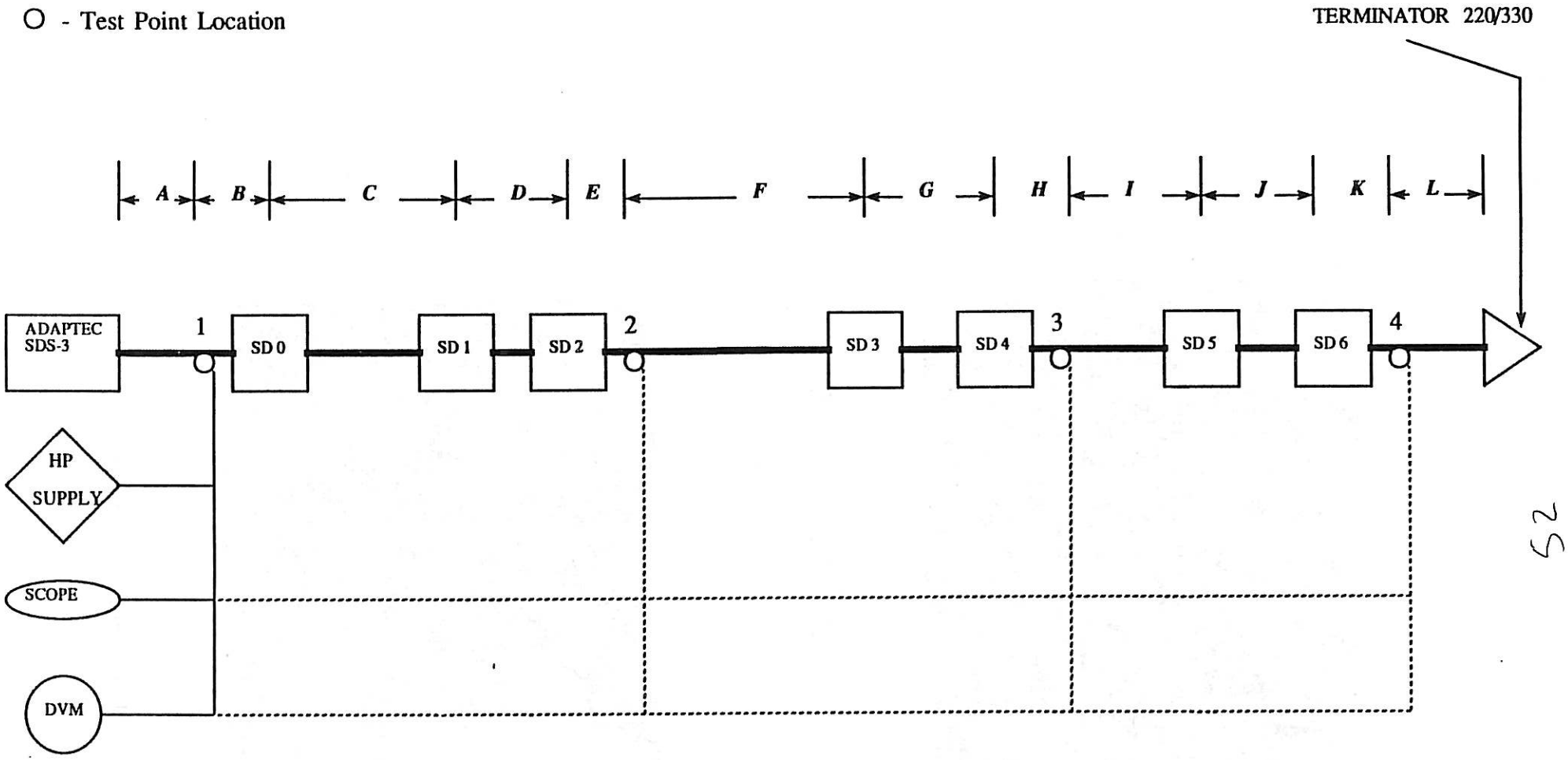


SECTION E SCOPE SHOT #4



CONFIGURATION F

O - Test Point Location



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Distances

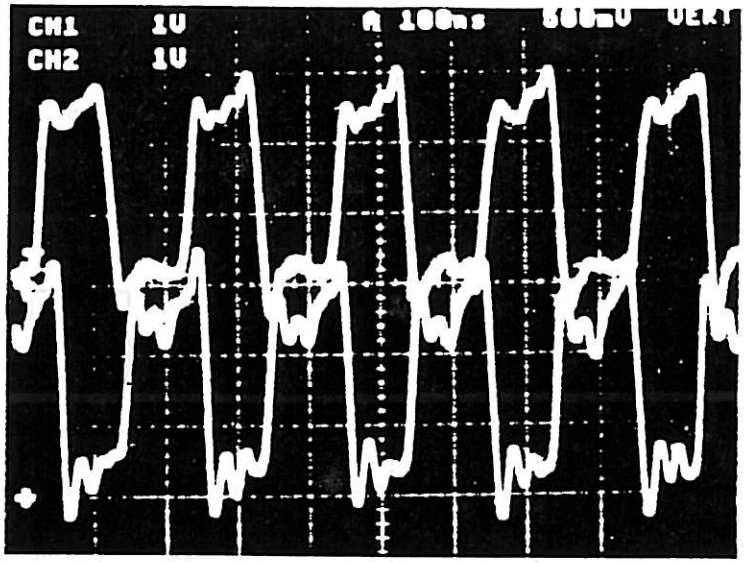
A = 1 ft.	G = 1 ft.
B = 1 ft.	H = 2 ft
C = 3 ft.	I = 2 ft.
D = 1 ft.	J = 1 ft.
E = 1 ft.	K = 1 ft.
F = 5 ft.	L = 1 ft.

Total Length of Cable = 20 ft.

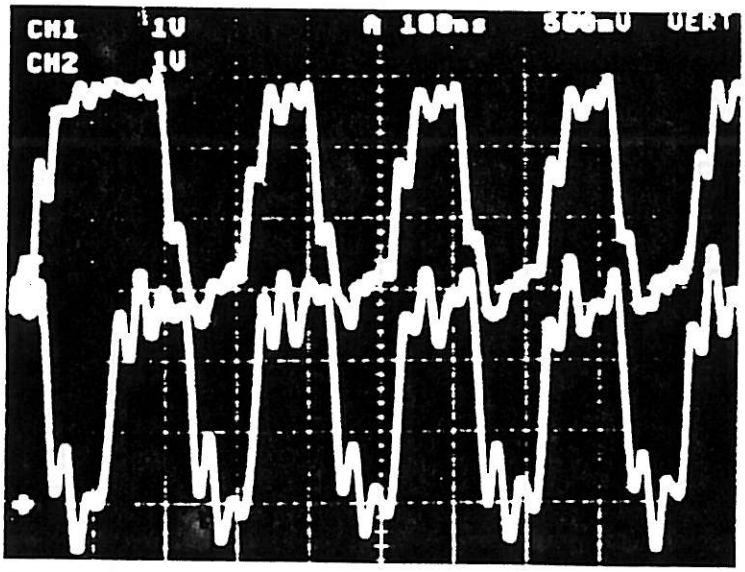
CABLE TYPE

AMP, SCSI-1, 20 ft. Flat Ribbon Cable
Impedance = 93 Ohms

SECTION F SCOPE SHOT #1

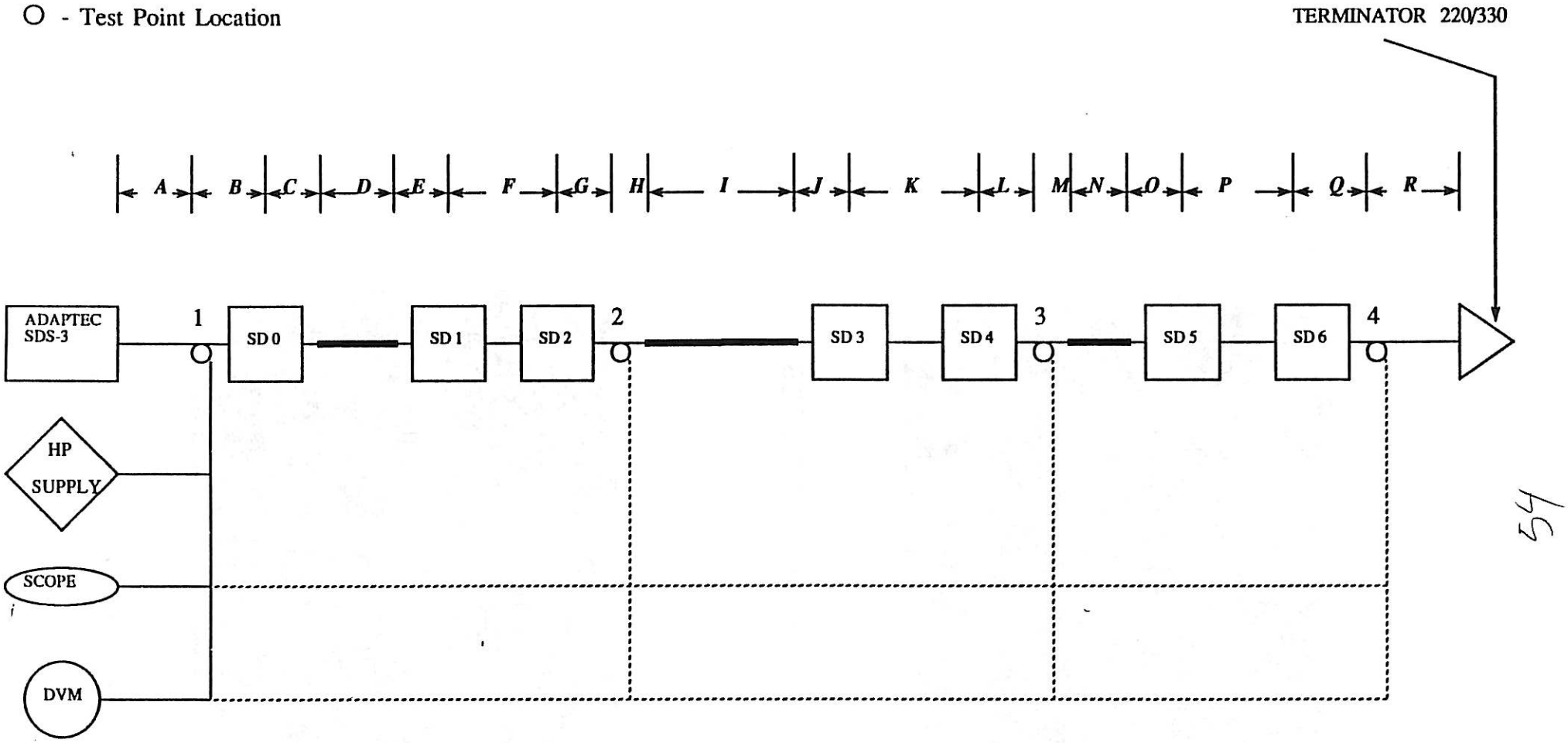


SECTION F SCOPE SHOT #2



CONFIGURATION G

O - Test Point Location



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Distances

A = 10 inches	G = 10 inches	M = 4.5 inches
B = 11 inches	H = 4 inches	N = 14.5 inches
C = 21 inches	I = 48 inches	O = 12 inches
D = 14.5 inches	J = 11 inches	P = 12 inches
E = 12 inches	K = 12 inches	Q = 11 inches
F = 12 inches	L = 8 inches	R = 3.5 inches

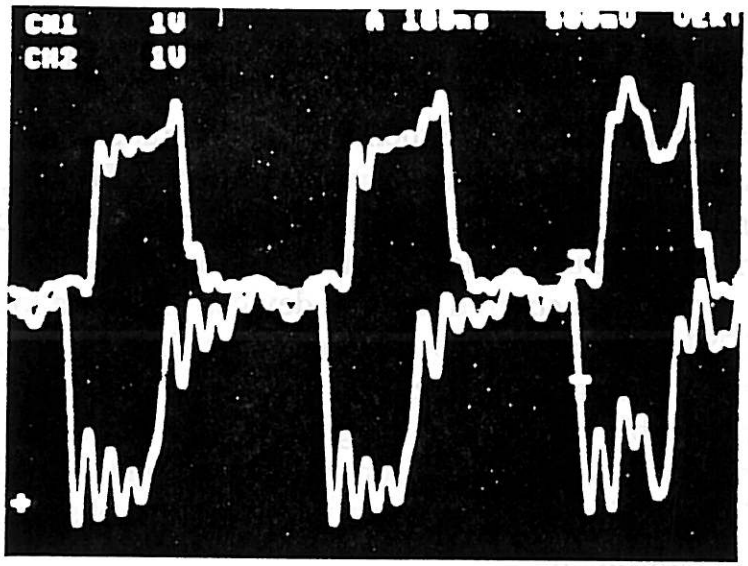
Total Length of Cable = 20 ft.

CABLE TYPE

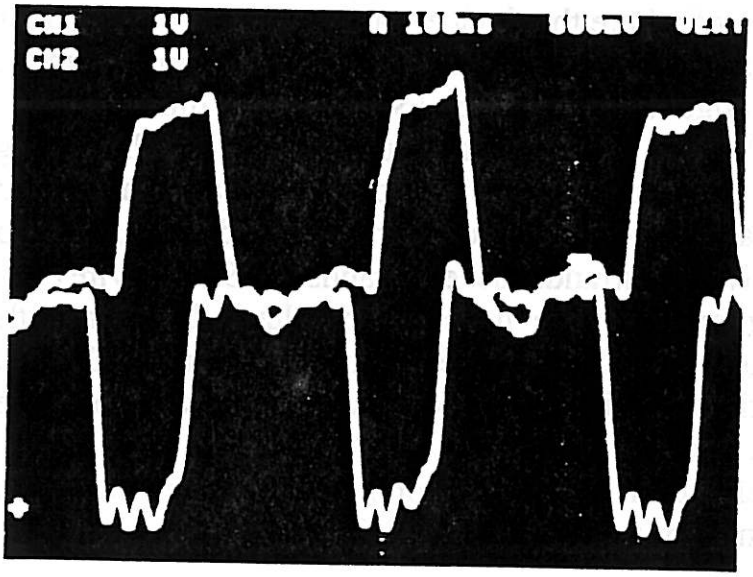
AMP, SCSI-2, Flat Ribbon Cable Sections, Impedance equals 93 Ohms

Madision, SCSI-1, External Twisted Pair Round Cable Sections, with characteristic Impedance of 100 Ohms.

SECTION G SCOPE SHOT #1



SECTION G SCOPE SHOT #2



Observations/Analysis

This section will try to identify the conditions under which the different cable configurations failed to operate.

*Note: Term Pwr measurements were made on the last device physically on the bus.

When Configuration A was tested, the following condition were exhibited:

1. All errors occurred during Synchronous data transfers
2. Error Conditions that appeared were: **Timeouts During Arbitration**
3. Errors were not restricted to any particular SCSI device. Rather it was a function of where the device was located physically on the cable.
4. Most of the errors occurred to SCSI devices that were located on either side of the SCSI-1 external cable. (See drawing, dimension D)
5. Term Power voltage was measured at 4.55V. The Voltage drop is a function of cable length. The longer the cable the higher the voltage drop.
6. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.

When Configuration B was tested, the following conditions were exhibited:

1. All errors occurred during Synchronous data transfers
2. Error Conditions that appeared were: **Timeouts During Arbitration**
3. Errors were not restricted to any particular SCSI device. Rather it was a function of where the device was located physically on the cable.
4. Most of the errors occurred to SCSI devices that were located on either side of the longer SCSI-1 cable. (See drawing, dimension I)
5. Term Power voltage was measured at 4.41V. The Voltage drop is a function of cable length. The longer the cable the higher the voltage drop. This is a direct response to having a high density, flat cable where the the individual strands (seven strands of 39 awg wire) that compose the 28 awg term pwr line have a high voltage drop across them.
6. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.
7. The Reflections at the initiator are more severe due mainly to the very fast Fall times of the Adaptec AIC 6250 Chip.

8. Errors would manifest themselves at any point during testing. Sometimes they would appear minutes or hours into testing, while at other times they wouldn't appear at all. .

When Configuration C was tested, the following conditions were exhibited

1. All errors occurred during Synchronous data transfers
2. Error Conditions that appeared over 99% of the test time were:
   Timeouts During Arbitration
   The other 1% of the error was **Synchronous Data Error.** These conditions only appeared twice throughout the entire length of testing.
3. Errors were not restricted to any particular SCSI device. Rather it was a function of where the device was located physically on the cable.
4. Most of the errors occurred to the SCSI device that was physically positioned last on the bus, near the Terminator.
5. Term Power voltage was measured at 4.31V. The Voltage drop is a function of cable length. The longer the cable the higher the voltage drop. This is a direct response to having a high density, flat cable where the the individual strands (seven strands of 39 awg wire) that compose the 28 awg term pwr line have a high voltage drop across them.
6. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.
7. The Reflections at the initiator are more severe due mainly to the very fast Fall times of the Adaptec AIC 6250 Chip.
8. Errors would manifest themselves at any point during testing. Sometimes they would appear minutes or hours into testing, while at other times they wouldn't appear at all. .

When Configuration D was tested, the following conditions were exhibited

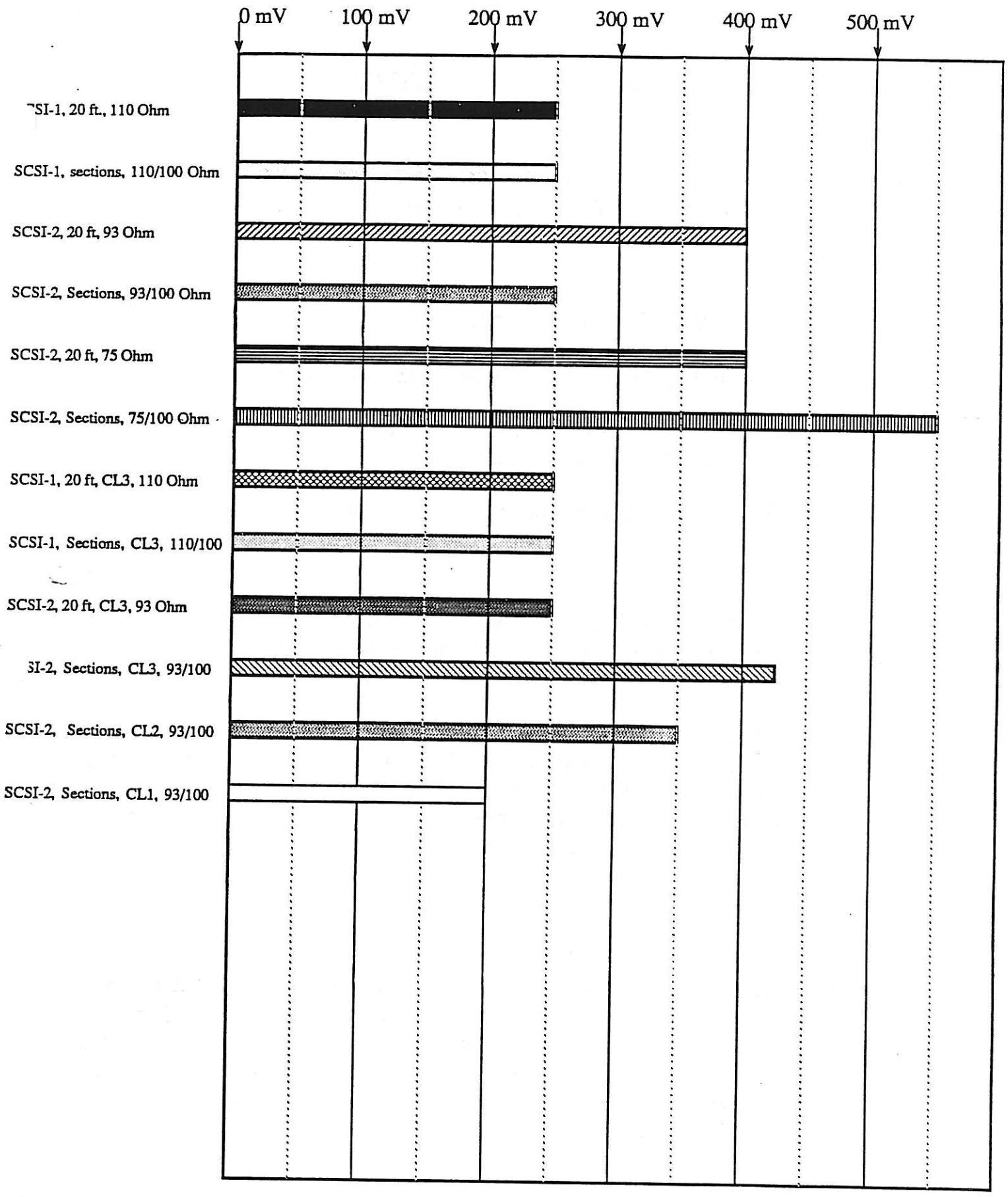
1. No errors occurred during Synchronous data transfers
2. Term Power voltage was measured at 4.50 V.
3. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.
4. Testing of this cable configuration logged in over 12 hours with NO errors encountered.

When Configuration E was tested, the following conditions were exhibited

1. All errors occurred during Synchronous data transfers
2. Error Conditions that appeared were: **Timeouts During Arbitration**
3. Errors were not restricted to any particular SCSI device. Rather it was a function of where the device was located physically on the cable.
4. Most of the errors occurred to the SCSI device that was physically positioned last on the bus, near the Terminator.
5. Term Power voltage was measured at 4.50 V. The Voltage drop is a function of cable length. The longer the cable the higher the voltage drop. This is a direct response to having a high density, flat cable where the the individual strands (seven strands of 39 awg wire) that compose the 28 awg term pwr line have a high voltage drop across them.
6. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.
7. The Reflections at the initiator are more severe due mainly to the very fast Fall times of the Adaptec AIC 6250 Chip.
8. Errors would manifest themselves at any point during testing. Sometimes they would appear minutes or hours into testing, while at other times they wouldn't appear at all. .

When Configuration F was tested, the following conditions were exhibited

1. No errors occurred during Synchronous data transfers
2. Term Power voltage was measured at 4.25 V.
3. The worst Reflections were observed to occur on the SCSI device closest to the initiator, while best looking waveforms were observed at the SCSI device nearest the terminator.
4. Testing of this cable configuration logged in over 12 hours with NO errors encountered.


0 mV
100 mV
200 mV
300 mV
400 mV
500 mV
SI-1, 20 ft., 110 Ohm
SCSI-1, sections, 110/100 Ohm
SCSI-2, 20 ft, 93 Ohm
SCSI-2, Sections, 93/100 Ohm
SCSI-2, 20 ft, 75 Ohm
SCSI-2, Sections, 75/100 Ohm
SCSI-1, 20 ft, CL3, 110 Ohm
SCSI-1, Sections, CL3, 110/100
SCSI-2, 20 ft, CL3, 93 Ohm
SI-2, Sections, CL3, 93/100
SCSI-2, Sections, CL2, 93/100
SCSI-2, Sections, CL1, 93/100

Recommendations

All information assumes single-ended SCSI implemented with synchronous data transfers up to 5 MHz rates. No testing done with differential drivers/receivers.

Recommendations:

- maintain term power >4.75 Volts

- use a Schottky diode with fuse to supply power to bus

- all devices along the bus should source term power as above if long cables (near spec limit) are used

- SCSI-2 cables should be specified at as high a characteristic impedance as possible, driving towards spec. > 100 ohms, preferably 110 ohms

- Decrease Slew Rate on driver chips to maintain a Fall time of 8-10 nS. In addition, incorporate Schmitt triggers that exhibit good centering level Hysteresis characteristics.

- changing the termination Thevenin equivalent impedance and/or implementing an active network still needs testing in an attempt to improve upon design margins using low (<93 ohm) impedance cables (put into SCSI-2 as an alternate term network for long bus lengths when using single-ended drivers/receivers?)

Bottom Line: If the System designer is planning to incorporate the SCSI-2 Cabling scheme in his/her product then testing of their unique cluster configuration must be made. This will insure that no problems exist in their product that are directly related to Reflections, line loss, etc. that would greatly negate system performance.

APPENDIX A

VENDOR CONTACT LIST

For C&M 100 ohm shielded cable with AMP and Honda connectors, passive and active terminators:

Amphenol Corporation
Interconnect Products Division
Endicott, NY
Bill Sopchak, Product manager (607)786-4307

QuadRep, Inc.
Richard Somers, V.P. (408)432-3300

For Furukawa 70 ohm shielded cable with AMP connectors and for high density terminators, 75 and 93 ohm hi-density cable with Modu-50 and SCSI-2 connectors:

AMP Incorporated
Intercom Division
Harrisburg, PA
Robert Whiteman, Product Manager (717)780-7481
Charles Brill, Computer Standards, (717)561-6198

For 100 +/- 10 ohm shielded cable:

Astro Wire and Cable
Worcester, MA
Peter Blackford, Chief Engineer, (800)447-1128, (508)754-3281

For 110 ohm +/- 10 % differential cable

Icontec Incorporated
Manufacturing and Assembly,
Milpitas, CA
Allen Haigh, V.P. (408)945-7766

For connectors, terminators, and Furukawa cable contact:

Fujitsu Components of America, Inc.
Santa Clara, CA
Joel Urban, Marketing Manager, (408)562-1722
Bob Thornton, Product Engineer, (408)562-1735

For 105 +/- 7 ohm and 120 +/- 10 ohm shielded cable:

Madison Cable
Worcester, MA
John Osborne, Product Manager, (508)752-7320

For inline and end-of-line terminators:

Methode Electronics
Chicago, IL
John Cannon, Product Manager, (312)867-9600 x 371
Bob Masterson, Applications Engineering Manager,(303)695-1333
Roger Fontenot, Sales Engineer, (408)262-3812

For providing Astro or Madison cable:

Quintec Interconnect
San Jose, CA
Greg Sulger, Sales Engineer, (408)272-8000

For providing 75 and 93 ohm hi-density cables with private interconnect:

3M Company
Electronic Products Division
Austin, TX
Bob Herron, Product Manager, (512)984-6807