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X3T9.2/90-91

6/13/90



To: Larry J. Lamers, Maxtor Corporation
Chairman X3T9.2 cable working group

From: Jim Fiala, 3M Corporation

Subject: Crosstalk, capacitance testing of 25 pair twisted pair cable to determine the best and worst wire combinations when cable is used in the single ended mode (1 wire of each pair grounded).

The background:

The cable working group attempted to correlate the performance of various cable assemblies in a SCSI simulation setup, with the crosstalk performance of these cables. A determination was made that the group did not know how the cables were wired to the connectors (what wire combinations were used) and therefore didn't know if they were fairly comparing one cable assembly to another.

The difficulty here is that the cables are being used single ended (1 wire of each pair connected to ground). In this configuration a 50 conductor 25 pair cable has 25 signal and 25 ground wires plus the shield. There are volumes of information on twisted pair cable crosstalk and performance characteristics when used balanced (both wires of a pair ungrounded), however there is little or no information on balanced cable when used single ended.

The problem with previous crosstalk tests was that it was performed on only a few wire combinations, however in a cable with 25 signal wires there are 300 possible ways to hook up the 25 wires. Since crosstalk testing of 300 possible combinations would be very laborious and time consuming, a hypothesis was made that there might be a direct relationship between the wire to wire capacitance and crosstalk. It was expected that a rise in capacitance would indicate a corresponding rise in crosstalk. Since wire to wire capacitance could be measured far more rapidly than crosstalk, then all 300 combinations of a cable could be measured and the data used to select the best possible wiring configuration.

The testing:

We undertook the task of testing and used some Madison 25 pair IPI cable, since we had not yet received SCSI samples. Pages 12 to 15 show the wire to wire capacitance test results of all 300 possible combinations. Page 16 is important because we wanted to show the correlation between increasing capacitance and forward or backward crosstalk. We selected wire combinations that represented the range from lowest to highest capacitance in pF/20 ft and then measured the crosstalk on those combinations. Much to our surprise, as you can see from the chart, there is no correlation at all between wire to wire capacitance and crosstalk.

Note that crosstalk can be high and capacitance low or crosstalk low and capacitance high or vice a versa. In a final attempt to use capacitance as a crosstalk gauge we looked at the capacitance from each wire to ground as a possible factor. Our thinking was that wires close to the shield might have lower crosstalk. The last two columns show the capacitance to ground of each wire in the combination. Again as with wire to wire capacitance there is no correlation with crosstalk. From the foregoing testing we concluded that because of the single ended connection of twisted pair cable, unlike flat cable, unknown phenomena was controlling crosstalk.

We bite the bullet:

In order not to keep the working group hanging, we decided to test the newly arrived piece of Madison SCSI for all 300 possible combinations of wire to wire crosstalk. This crosstalk testing provided much more meaningful and exciting results. Pages 5 to 9 show all 300 possible combinations for both forward and backward crosstalk.

Page 4 shows the typical waveforms observed by the scope operator. Figure 1 shows the input to wire A and figures 2 to 6 show typical outputs on wire B. The test results are generally self explanatory. The "x" indicates that the tester observed traces as shown in figures 4, 5 and 6. Note that the backward crosstalk in figure 4 shows the classical backward waveform, however figure 5 shows the effects of multiple delays in interfering wires.

Figures 2 and 3 show crosstalk indicated by an "<" in the charts. These pictures show a crosstalk of about 50mv or 1% the highest in the < category. Many wire combinations showed no bump at all in the trace, until the sensitivity of the scope was increased to 10mv/ division.

We plan to test 2 additional cables which were received after the Madison cables, and present the results at the next general meeting. This crosstalk data should be useful in determining the performance levels of various cables, and to determine the best wiring combinations taking into consideration the susceptible wire criteria as outlined by Bill Spence and Bob Snively.

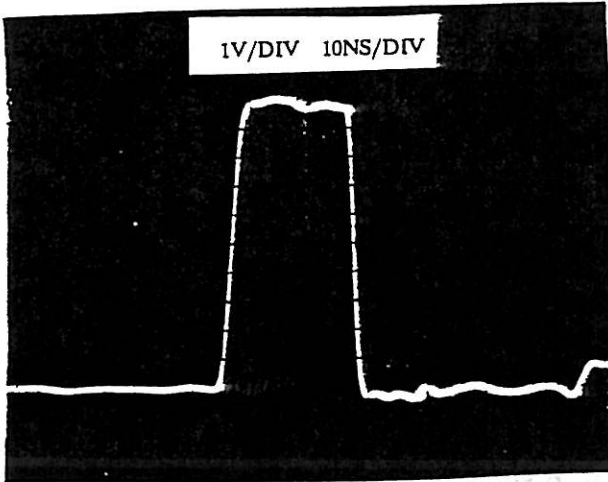


Fig. 1 Driven line input, 5V, 2.5ns rise time, 20ns wide

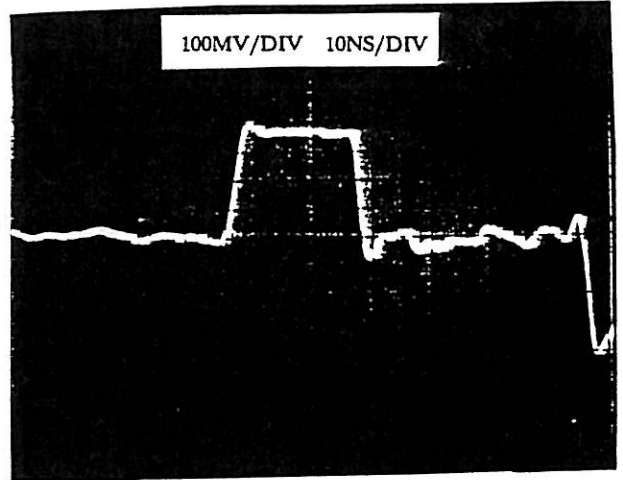


Fig. 4 High level backward crosstalk "X" on chart

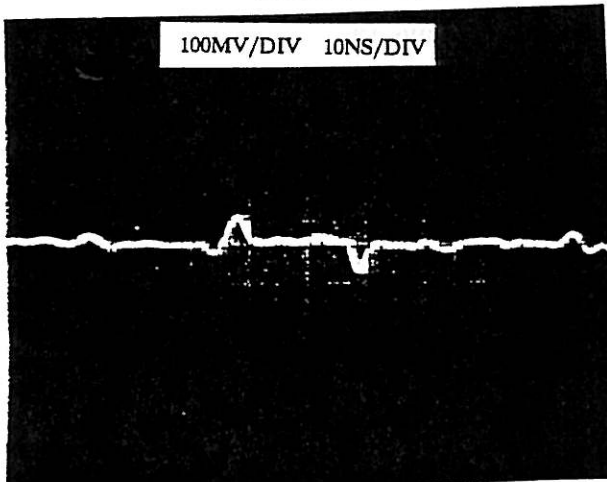


Fig. 2 50mv low level backward crosstalk on quiet line

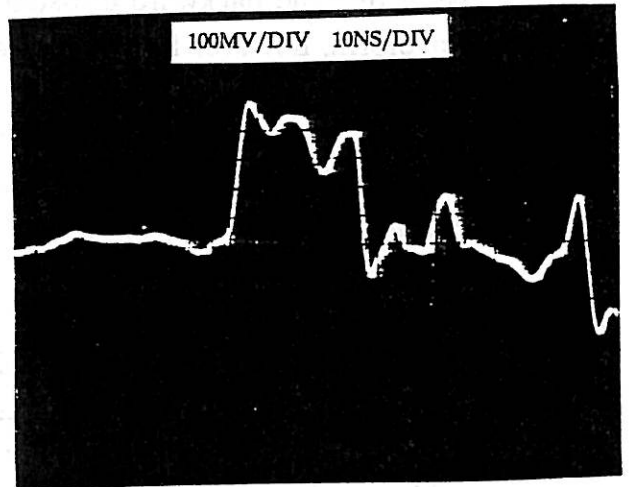


Fig. 5 High level backward crosstalk "X" on chart, with multiple interference

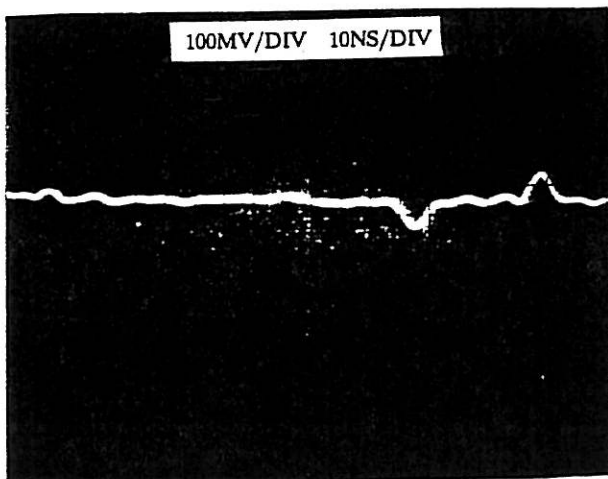


Fig. 3 50mv low level forward crosstalk on quiet line

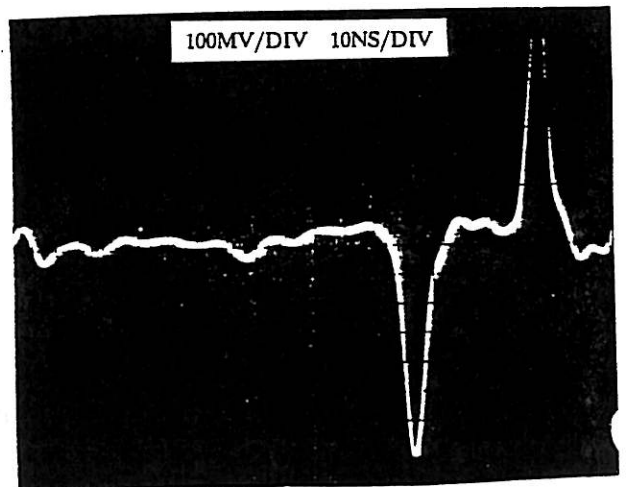


Fig. 6 High level forward crosstalk "X" on chart

CROSSTALK TEST RESULTS

Madison SCSI cable 4099 P/N 505 DK 00016 50 wire 25 pair round twisted pair cable connected in the single ended mode. Wire A was connected to a pulse generator with a 5 volt 2.5ns 20ns wide output. An oscilloscope was used to measure the forward (far end) crosstalk and backward (near end) crosstalk on wire B. X indicates the operator saw a good solid crosstalk coupling between the test wires. < means the crosstalk was below 50mv or 1%. > means the crosstalk was above 50mv with the number following indicating the observed value.

WIRE COMBINATION				WIRE COMBINATION			
A	B	F	B	A	B	F	B
1-2	X	>280	>200	2-19		<	<
1-3		<	<	2-20		<	<
1-4		<	<	2-21		<	<
1-5		<	<	2-22		>100	>75
1-6		<	<	2-23	X	>150	>150
1-7		<	<	2-24	X	>350	>250
1-8		<	<	2-25		<	<
1-9		>120	>80				
1-10		<	<	3-4	X	>300	>280
1-11		<	<	3-5		<	>100
1-12		<	>70	3-6		>100	>75
1-13		<	<	3-7		>100	>100
1-14		<	<	3-8		<	<
1-15		<	>60	3-9	X	>300	>300
1-16	X	>150	>200	3-10	X	>200	>190
1-17		<	<	3-11		<	<
1-18		<	<	3-12		<	<
1-19		<	<	3-13		<	<
1-20		<	<	3-14		<	<
1-21		<	<	3-15		<	<
1-22		<	<	3-16		<	<
1-23	X	>250	>200	3-17		<	<
1-24	X	>300	>300	3-18		<	<
1-25		<	<	3-19		<	<
				3-20		<	<
2-3	X	>300	>200	3-21		<	<
2-4		>75	>125	3-22		<	<
2-5		<	<	3-23		<	<
2-6		<	<	3-24	X	>150	>100
2-7		<	<	3-25		<	<
2-8		<	<				
2-9	X	>225	>300	4-5	X	>300	>250
2-10		>125	<	4-6		>125	>125
2-11		>90	>75	4-7		>125	>100
2-12		<	<	4-8		<	<
2-13		<	<	4-9	X	>300	>275
2-14		<	<	4-10	X	>360	>350
2-15		<	>75	4-11		>150	>100
2-16		<	>100	4-12		<	<
2-17		<	<	4-13		<	<
2-18		>75	<	4-14		<	<

WIRE
COMBINATION

A	B	F	B
4-15		<	<
4-16		>100	>60
4-17		>75	>75
4-18		>150	>125
4-19		>60	>75
4-20		>75	>60
4-21		<	<
4-22		<	<
4-23		>100	>90
4-24		>100	>100
4-25		>100	>100
5-6	X	>350	>250
5-7		<	<
5-8		<	<
5-9		>125	>100
5-10	X	>350	>250
5-11	X	>290	>325
5-12		<	>75
5-13		<	<
5-14		>75	>90
5-15		<	<
5-16		<	<
5-17		>120	>160
5-18	X	>200	>190
5-19		>140	>170
5-20		>100	>125
5-21		<	<
5-22		<	<
5-23		>100	>100
5-24		>75	>90
5-25		>150	>190
6-7	X	>275	>250
6-8		<	<
6-9		>65	>80
6-10	X	>260	>190
6-11	X	>400	>275
6-12		<	>95
6-13		<	>75
6-14		<	<
6-15		<	<
6-16		<	<
6-17		>90	>95
6-18		>90	>100
6-19	X	>200	>190
6-20		<	>75
6-21		<	<
6-22		<	<
6-23		<	<
6-24		<	>75

WIRE
COMBINATION

A	B	F	B
6-25		>90	>125
7-8		<	>75
7-9		>80	>125
7-10		>150	>160
7-11	X	>300	>225
7-12		<	>120
7-13		<	<
7-14		<	<
7-15		<	<
7-16		<	<
7-17		>90	>90
7-18		>90	>100
7-19	X	>350	>300
7-20		>100	>150
7-21		<	<
7-22		<	<
7-23		>65	>75
7-24		>95	>95
7-25	X	>325	>350
8-9		>150	>150
8-10		>60	>130
8-11		>125	>150
8-12		>65	>140
8-13		>80	>130
8-14		>65	>90
8-15		>75	>120
8-16		>80	>125
8-17	X	>390	>325
8-18	X	>325	>275
8-19		>90	>110
8-20		>60	>105
8-21	X	>200	>200
8-22	X	>300	>250
8-23	X	>325	>275
8-24	X	>275	>275
8-25		>100	>100
9-10	X	>375	>375
9-11		>125	>200
9-12		>75	>125
9-13		<	>80
9-14		<	>90
9-15		>75	>90
9-16		<	>65
9-17		>100	>100
9-18	X	>350	>275
9-19		<	>95
9-20		<	>75
9-21		<	<

WIRE
COMBINATION

A	B	F	B
9-22		<	>75
9-23		>75	>95
9-24	X	>325	>300
9-25		>100	>100
10-11	X	>325	>300
10-12		<	<
10-13		<	<
10-14		<	<
10-15		<	<
10-16		<	<
10-17		>120	>90
10-18	X	>325	>250
10-19		<	>100
10-20		<	>75
10-21		<	<
10-22		<	<
10-23		>65	>85
10-24		>65	>100
10-25		>80	>115
11-12		<	>100
11-13		<	<
11-14		<	<
11-15		<	<
11-16		<	>85
11-17	X	>325	>250
11-18	X	>350	>275
11-19	X	>275	>300
11-20		<	<
11-21		<	<
11-22		<	<
11-23		<	>75
11-24		<	>100
11-25		>65	>110
12-13	X	>250	>200
12-14		<	<
12-15		<	<
12-16		<	<
12-17		<	>125
12-18		<	>110
12-19		>125	>105
12-20	X	>300	>275
12-21	X	>225	>190
12-22		<	<
12-23		>75	>75
12-24		>75	>90
12-25	X	>225	>175
13-14	X	>300	>350

WIRE
COMBINATION

A	B	F	B
13-15		<	>135
13-16		<	>115
13-17		>100	>175
13-18		>75	>175
13-19		>100	>190
13-20	X	>300	>250
13-21	X	>350	>250
13-22	X	>200	>210
13-23		>100	>135
13-24		<	>125
13-25		>100	>150
14-15	X	>170	>210
14-16		<	<
14-17		>75	>140
14-18		<	>130
14-19		<	>100
14-20		>85	>90
14-21	X	>300	>290
14-22	X	>380	>400
14-23		>75	>100
14-24		<	>90
14-25		<	>100
15-16	X	>225	>230
15-17		<	<
15-18		>75	>60
15-19		>90	>75
15-20		>95	>75
15-21	X	>210	>225
15-22	X	>375	>400
15-23	X	>300	>310
15-24		<	<
15-25		>75	>95
16-17		<	>75
16-18		<	>100
16-19		<	<
16-20		<	<
16-21		<	<
16-22	X	>175	>210
16-23	X	>275	>260
16-24		>75	>125
16-25		<	<
17-18	X	>400	>310
17-19	X	>300	>300
17-20	X	>275	>310
17-21	X	>175	>250
17-22		>100	>135
17-23		>65	>120

WIRE
COMBINATION

A	B	F	B
17-24		>90	>140
17-25	X	>175	>220
18-19	X	>220	>250
18-20		>80	>190
18-21		<	>120
18-22		<	>140
18-23		>130	>160
18-24	X	>360	>250
18-25		>130	>210
19-20	X	>375	>275
19-21		<	>75
19-22		<	<
19-23		>75	>85
19-24		<	>90
19-25	X	>400	>300
20-21	X	>275	>280
20-22		<	>150
20-23		<	>120
20-24		<	>125
20-25	X	>360	>270
21-22	X	>420	>375
21-23		>75	>160
21-24		<	>85
21-25		<	<
22-23	X	>300	>440
22-24	X	>100	>200
22-25		<	>90
23-24	X	>450	>325
23-25		>125	>130
24-25		>125	>125

UNDESIRABLE WIRE COMBINATIONS

1-2 BROWN/PINK-BROWN/ORANGE
1-16 BROWN/PINK-TAN/GRAY
1-23 BROWN/PINK-WHITE/PURPLE
1-24 BROWN/PINK-WHITE/GRAY
2-3 BROWN/ORANGE-BROWN/YELLOW
2-9 BROWN/ORANGE-BROWN/TAN
2-23 BROWN/ORANGE-WHITE/PURPLE
2-24 BROWN/ORANGE-WHITE/GRAY
3-4 BROWN/YELLOW-BROWN/GREEN
3-9 BROWN/YELLOW-BROWN/TAN
3-24 BROWN/YELLOW-WHITE/GRAY
4-9 BROWN/GREEN-BROWN/TAN
4-10 BROWN/GREEN-TAN/PINK
5-6 BROWN/BLUE-BROWN/PURPLE
5-10 BROWN/BLUE-TAN/PINK
5-11 BROWN/BLUE-TAN/ORANGE
5-18 BROWN/BLUE-WHITE/PINK
5-25 BROWN/BLUE-RED/PINK
6-7 BROWN/PURPLE-BROWN/GRAY
6-10 BROWN/PURPLE-TAN/PINK
6-11 BROWN/PURPLE-TAN/ORANGE
6-19 BROWN/PURPLE-WHITE/ORANGE
7-11 BROWN/GRAY-TAN/ORANGE
7-19 BROWN/GRAY-WHITE/ORANGE
7-25 BROWN/GRAY-RED/PINK
8-17 BROWN/WHITE-WHITE/TAN
8-18 BROWN/WHITE-WHITE/PINK
8-21 BROWN/WHITE-WHITE/GREEN
8-22 BROWN/WHITE-WHITE/BLUE
8-23 BROWN/WHITE-WHITE/PURPLE
8-24 BROWN/WHITE-WHITE/GRAY
9-10 BROWN/TAN-TAN/PINK
9-18 BROWN/TAN-WHITE/PINK
9-24 BROWN/TAN-WHITE/GRAY
10-11 TAN/PINK-TAN/ORANGE
10-18 TAN/PINK-WHITE/PINK
11-17 TAN/ORANGE-WHITE/TAN
11-18 TAN/ORANGE-WHITE/PINK
11-19 TAN/ORANGE-WHITE/ORANGE
12-13 TAN/YELLOW-TAN/GREEN
12-20 TAN/YELLOW-WHITE/YELLOW
12-21 TAN/YELLOW-WHITE/GREEN
12-25 TAN/YELLOW-RED/PINK
13-14 TAN/GREEN-TAN/BLUE
13-20 TAN/GREEN-WHITE/YELLOW
13-21 TAN/GREEN-WHITE/GREEN
13-22 TAN/GREEN-WHITE/BLUE
14-15 TAN/BLUE-TAN/PURPLE
14-21 TAN/BLUE-WHITE/GREEN
14-22 TAN/BLUE-WHITE/BLUE
15-16 TAN/PURPLE-TAN/GRAY
15-21 TAN/PURPLE-WHITE/GREEN

15-22 TAN/PURPLE-WHITE/BLUE
15-23 TAN/PURPLE-WHITE/PURPLE
16-22 TAN/GRAY-WHITE/BLUE
16-23 TAN/GRAY-WHITE/PURPLE
17-18 WHITE/TAN-WHITE/PINK
17-19 WHITE/TAN-WHITE/ORANGE
17-20 WHITE/TAN-WHITE/YELLOW
17-21 WHITE/TAN-WHITE/GREEN
17-25 WHITE/TAN-RED/PINK
18-19 WHITE/PINK-WHITE/ORANGE
18-24 WHITE/PINK-WHITE/GRAY
19-20 WHITE/ORANGE-WHITE/YELLOW
19-25 WHITE/ORANGE-RED/PINK
20-21 WHITE/YELLOW-WHITE/GREEN
20-25 WHITE/YELLOW-RED/PINK
21-22 WHITE/GREEN-WHITE/BLUE
22-23 WHITE/BLUE-WHITE/PURPLE
22-24 WHITE/BLUE-WHITE/GRAY
23-24 WHITE/PURPLE-WHITE/GRAY

TEST CABLE COLOR CODES

Madison SCSI cable 4099 P/N 505 DK 00016 50 wire 25 pair round twisted pair cable.

WIRE NUMBER	COLOR CODE
1	brown/pink
2	brown/orange
3	brown/yellow
4	brown/green
5	brown/blue
6	brown/purple
7	brown/gray
8	brown/white
9	brown/tan
10	tan/pink
11	tan/orange
12	tan/yellow
13	tan/green
14	tan/blue
15	tan/purple
16	tan/gray
17	white/tan
18	white/pink
19	white/orange
20	white/yellow
21	white/green
22	white/blue
23	white/purple
24	white/gray
25	red/pink

NOTE Brown is dark and tan is light.

TEST CONDITIONS

25 pair twisted pair cable (Madison P/N 5473009 IPI cable) 20 ft long. 1 wire of each pair grounded to shield. Wire to wire capacitance measured at 100 KHz with shield and ground floating. Capacitance measured from 1 wire pair to another wire pair using an HP 4275A digital LCR meter.

WIRE COMBINATION		WIRE TO WIRE CAP	WIRE COMBINATION		WIRE TO WIRE CAP
A	B	pF/20 ft	A	B	pF/20 ft
1-2		240.0	2-21		231.6
1-3		255.2	2-22		228.1
1-4		206.7	2-23		229.5
1-5		206.6	2-24		214.5
1-6		206.9	2-25		231.2
1-7		226.5			
1-8		206.2	3-4		211.0
1-9		224.6	3-5		210.2
1-10		221.8	3-6		209.7
1-11		209.7	3-7		230.8
1-12		225.6	3-8		209.6
1-13		223.3	3-9		228.7
1-14		207.4	3-10		238.3
1-15		208.0	3-11		212.1
1-16		217.3	3-12		229.8
1-17		217.0	3-13		228.2
1-18		208.5	3-14		210.1
1-19		205.6	3-15		211.8
1-20		234.6	3-16		209.4
1-21		226.5	3-17		215.8
1-22		222.4	3-18		228.1
1-23		223.6	3-19		210.7
1-24		209.6	3-20		225.2
1-25		225.4	3-21		229.6
			3-22		226.3
2-3		244.2	3-23		227.8
2-4		212.2	3-24		213.0
2-5		211.7	3-25		229.3
2-6		232.6			
2-7		211.2	4-5		195.5
2-8		230.3	4-6		210.1
2-9		228.4	4-7		211.8
2-10		213.9	4-8		195.0
2-11		211.4	4-9		209.7
2-12		231.4	4-10		208.6
2-13		229.1	4-11		197.5
2-14		211.6	4-12		211.2
2-15		213.2	4-13		209.6
2-16		212.8	4-14		210.2
2-17		228.2	4-15		199.3
2-18		217.4	4-16		201.3
2-19		210.9	4-17		208.3
2-20		227.8	4-18		211.5

WIRE COMBINATION		WIRE TO WIRE CAP	WIRE COMBINATION		WIRE TO WIRE CAP
A	B	pf/20 ft	A	B	pf/20 ft
4-19		206.2	6-21		212.2
4-20		207.2	6-22		209.7
4-21		210.5	6-23		210.0
4-22		207.5	6-24		198.6
4-23		208.8	6-25		211.1
4-24		197.4			
4-25		210.2	7-8		212.4
			7-9		231.3
5-6		203.1	7-10		228.5
5-7		213.9	7-11		214.4
5-8		212.1	7-12		241.3
5-9		215.0	7-13		230.6
5-10		208.1	7-14		214.0
5-11		198.2	7-15		227.5
5-12		211.6	7-16		211.2
5-13		209.4	7-17		211.6
5-14		208.6	7-18		213.6
5-15		197.6	7-19		212.5
5-16		194.1	7-20		227.6
5-17		194.0	7-21		232.3
5-18		195.3	7-22		228.7
5-19		194.0	7-23		230.6
5-20		207.7	7-24		231.5
5-21		211.7	7-25		235.6
5-22		209.5			
5-23		226.9	8-9		227.7
5-24		213.9	8-10		207.8
5-25		224.1	8-11		212.9
			8-12		210.8
6-7		212.1	8-13		208.7
6-8		209.5	8-14		198.4
6-9		208.7	8-15		195.3
6-10		207.5	8-16		195.2
6-11		212.9	8-17		194.8
6-12		210.9	8-18		194.9
6-13		208.8	8-19		193.5
6-14		210.4	8-20		208.1
6-15		196.3	8-21		213.1
6-16		206.4	8-22		219.4
6-17		197.9	8-23		216.0
6-18		196.3	8-24		198.2
6-19		194.6	8-25		211.7
6-20		208.0			
			9-10		226.1

WIRE COMBINATION		WIRE TO WIRE CAP	WIRE COMBINATION		WIRE TO WIRE CAP
A	B	pf/20 ft	A	B	pf/20 ft
9-10		226.1	11-21		213.0
9-11		214.9	11-22		223.7
9-12		230.0	11-23		212.2
9-13		227.7	11-24		198.8
9-14		210.7	11-25		213.0
9-15		211.9			
9-16		209.2	12-13		242.7
9-17		209.5	12-14		212.8
9-18		211.0	12-15		229.8
9-19		209.2	12-16		210.0
9-20		225.3	12-17		210.8
9-21		230.7	12-18		213.0
9-22		239.3	12-19		218.5
9-23		241.4	12-20		226.8
9-24		213.5	12-21		231.6
9-25		230.2	12-22		228.1
			12-23		229.5
10-11		209.7	12-24		216.6
10-12		220.1	12-25		231.3
10-13		238.4			
10-14		207.9	13-14		210.2
10-15		209.6	13-15		214.5
10-16		206.8	13-16		208.3
10-17		208.6	13-17		209.1
10-18		224.1	13-18		213.5
10-19		215.4	13-19		225.2
10-20		222.6	13-20		224.2
10-21		227.0	13-21		229.0
10-22		223.7	13-22		225.5
10-23		225.0	13-23		226.4
10-24		210.8	13-24		212.4
10-25		226.6	13-25		228.2
11-12		213.0	14-15		211.6
11-13		211.2	14-16		195.2
11-14		197.3	14-17		195.1
11-15		196.9	14-18		197.3
11-16		211.9	14-19		201.3
11-17		196.8	14-20		207.1
11-18		196.8	14-21		211.4
11-19		194.9	14-22		208.6
11-20		216.0	14-23		210.6
			14-24		212.6

WIRE COMBINATION		WIRE TO WIRE CAP
A	B	pf/20 ft
14-25		212.5
15-16		194.6
15-17		195.2
15-18		197.8
15-19		211.1
15-20		208.4
15-21		212.4
15-22		209.5
15-23		211.1
15-24		213.2
15-25		213.3
16-17		210.5
16-18		196.0
16-19		193.1
16-20		221.6
16-21		214.4
16-22		208.5
16-23		208.6
16-24		196.1
16-25		209.6
17-18		211.7
17-19		195.0
17-20		209.0
17-21		211.2
17-22		208.1
17-23		209.0
17-24		196.4
17-25		210.2
18-19		211.5
18-20		208.4
18-21		213.3
18-22		209.2
18-23		210.4
18-24		198.0
18-25		211.8
19-20		205.8
19-21		209.6
19-22		206.7

WIRE COMBINATION		WIRE TO WIRE CAP
A	B	pf/20 ft
19-23		207.5
19-24		196.7
19-25		209.1
20-21		239.3
20-22		222.9
20-23		223.1
20-24		209.2
20-25		224.4
21-22		239.5
21-23		227.6
21-24		213.0
21-25		229.1
22-23		225.0
22-24		210.1
22-25		225.8
23-24		213.8
23-25		238.2
24-25		229.4

WIRE COMBINATIONS SELECTED FOR COMPARISON OF CROSSTALK VS WIRE TO WIRE CAPACITANCE.

TEST CONDITIONS

25 pair twisted pair cable (Madison P/N 5473009 IPI cable) 20 ft long. 1 wire of each pair was grounded to shield. Each remaining ungrounded wire of each pair was resistor terminated. A 5 volt 2.5ns rise time 20ns wide signal was applied to the wire listed first in the following chart. An oscilloscope was used to measure the forward (far end) crosstalk and backward (near end) crosstalk on the second wire listed in the following chart. An assortment of combinations were selected for test, going from lowest to highest wire to wire capacitance.

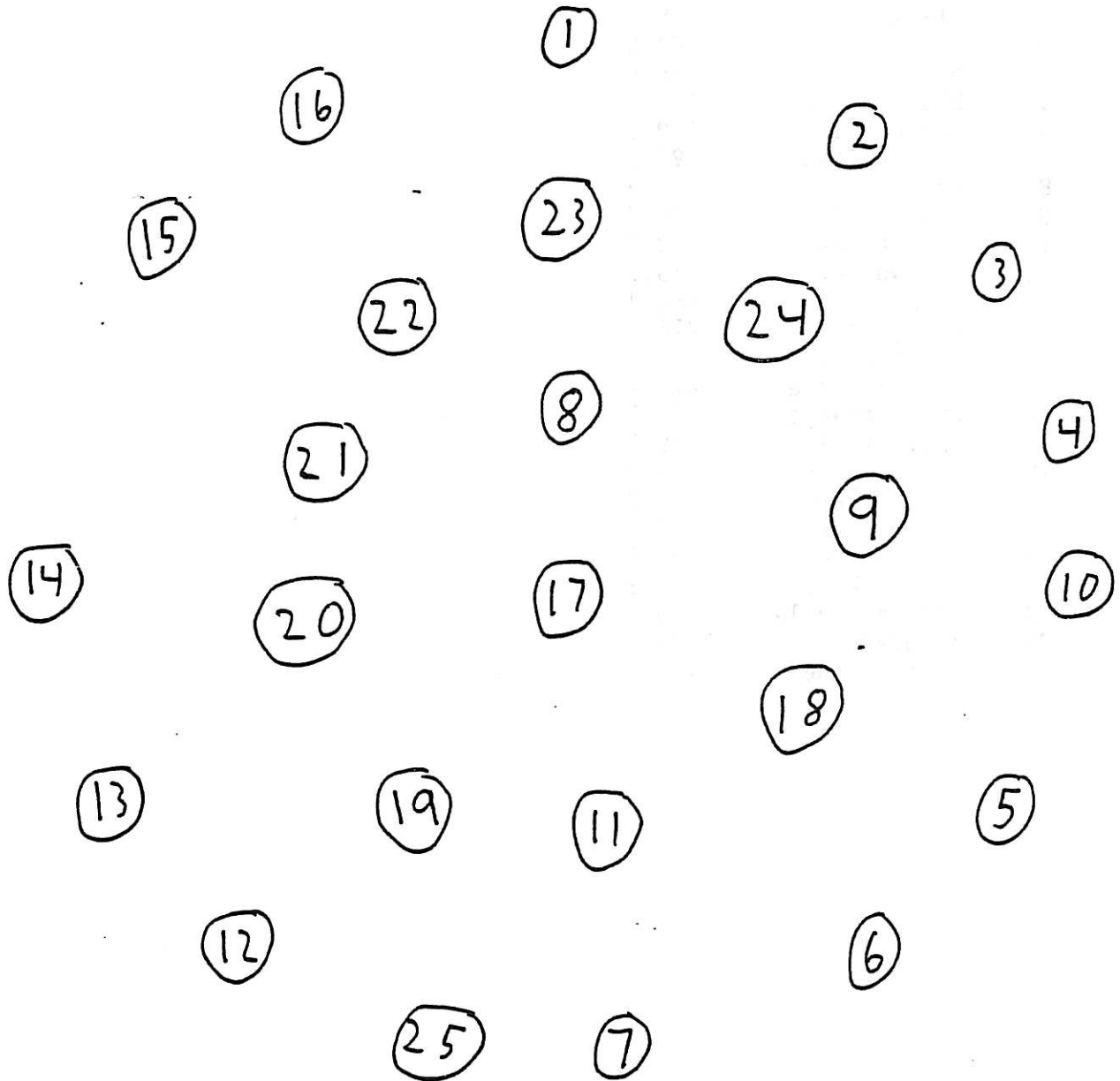
WIRE COMB.	WIRE TO WIRE CAPACITANCE	FORWARD CROSSTALK	BACKWARD CROSSTALK	CAP TO GROUND WIRE A	WIRE B
A B					
16-19	193.1	35mv	100mv	407.7	408.2
14-19	201.3	400mv	220mv	408.2	407.7
4-19	206.2	380mv	210mv	408.9	408.2
3-5	210.2	35mv	38mv	480.5	412.6
8-22	219.4	360mv	220mv	410.6	471.8
9-25	230.2	40mv	20mv	480.7	483.2
12-21	231.6	30mv	70mv	486.4	485.7
9-23	241.4	300mv	200mv	480.7	476.8
1-3	255.2	110mv	140mv	464.2	480.5

TEST CONDITIONS

25 pair twisted pair cable (Madison P/N 5473009 IPI cable) 20 ft long. 1 wire of each pair grounded to shield. Wire to ground capacitance measured at 100 KHz with shield and 1 wire of each pair grounded. Capacitance measured using an HP 4275A digital LCR meter.

WIRE NUMBER	COLOR CODE	CAP TO GROUND pf/20 ft
1	black/red	464.2
2	black/orange	486.9
3	black/green	480.5
4	black/yellow	408.9
5	black/white	412.6
6	brown/blue	409.5
7	brown/orange	490.2
8	brown/white	410.6
9	brown/yellow	480.7
10	red/yellow	470.7
11	red/white	419.9
12	red/blue	486.4
13	red/green	476.4
14	red/purple	411.4
15	white/purple	416.4
16	white/orange	407.7
17	white/yellow	409.7
18	white/green	415.2
19	white/blue	408.2
20	yellow/purple	467.2
21	yellow/green	485.7
22	yellow/blue	471.8
23	orange/purple	476.8
24	orange/green	421.5
25	orange/blue	483.2

PROBABLE WIRE LAYOUT OF MADISON
SCSI CABLE 4099 MATCHED TO
COLOR CODE CHART ON PAGE 11



PROBABLE WIRE LAYOUT OF MADISON
SCSI CABLE 409A

PLOT OF UNDESIRABLE WIRE COMBINATIONS
FROM PAGES 9 AND 10

