TEXAS INSTRUMENTS

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MEMORANDUM -- 16 Aug 1990

TO: John Lohmeyer, Chairman, X3T9.2

FROM: Bill Spence, TI

SUBJECT: S/E Cable Test Report No. 2

THE BOTTOM LINE

1. Using regulated 110-ohm terminators and quasi-coaxial 93-ohm single-ended (S/E) cables, a system was constructed with 8 devices strung out along a SCSI bus of about 21 m (69') total length. As expected, it ran perfectly, with very good waveforms.

2. Cables of the same length made with Madison 4099 cable (as representative of top quality solid-dielectric twisted-pair SCSI cables), pinned out to provide good isolation of the REQ- and ACK- lines, were substituted into the above system. Again, it ran perfectly, and (as not expected by me) with REQ- and ACK- waveforms pretty close to those above.

CABLE ASS'Y DESIGN

The Madison 4099 25-pair shielded cable employs solid polypropylene isulation and has a dielectric buffer wrap under the shield. The layup of the cable and the pinout used in these tests was as follows (Shielded Low-Density Connectors --old Alternative 2):

Layer	Pair	Colors	Grounded Pin	Signal Pin	Signal
Core	1	white/tan	24	49	-REQ
"	2	white/brown	19	44	-ACK
"	3	white/pink	17	42	GROUND
Middle	4	white/orange	15	40	GROUND
"	5	white/yellow	11	36	GROUND
"	6	white/green	10	35	GROUND
"	7	white/blue	13	38	TERMPWR
"	8	white/violet	20	45	-RST
"	9	white/gray	14	39	RESERVED
"	10	tan/brown	12	37	RESERVED
"	11	tan/pink	18	43	-BSY
"	12	tan/orange	22	47	-SEL

Outer	13	tan/yellow	16	41	-ATN
"	14	tan/green	23	48	-C/D
"	15	tan/blue	25	50	-I/O
"	16	tan/violet	21	46	-MSG
"	17	tan/gray	1	26	-DB(0)
"	18	brown/pink	2	27	-DB(1)
"	19	brown/orange	3	28	-DB(2)
"	20	brown/yellow	4	29	-DB(3)
"	21	brown/green	5	30	-DB(4)
"	22	brown/blue	6	31	-DB(5)
"	23	brown/violet	7	32	-DB(6)
"	24	brown/gray	8	33	-DB(7)
"	25	pink/orange	9	34	-DB(P)

It will be seen that during data transfers, all the signals in the middle layer are stationary, thus providing a shield layer between the -REQ/-ACK lines and the -DB lines. (The same objective can be achieved with pinout schedules which provide possibly easier manufacturability, and these may be used in the future.)

PHYSICAL LAYOUT

The bus layout is given in the following diagram:

```
 _____________            _______           _______           _______
|          |  |          |   |   |         |   |   |         |   |   |
|    H/A   |D0|          |D1 |D2 |         |D3 |D4 |         |D5 |D6 |
|_____T____|__|          |___|___|         |___|___|         |___|___|
|     1|____|||          |||_|||           |||_|||           |||_|||
|___________||           ||___||           ||___||           ||___||
            |____________|   2|____________|   3|____________|4   T
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The digits 1, 2, 3, 4 identify the locations where the waveforms which follow were taken.

There are 4 enclosures containing the host and 7 disks, as shown. The host adapter (H/A) includes a regulated 110-ohm terminator (T). Another is at the other end of the bus, applied externally. The bus is daisy-chained through each enclosure by some 2+ ft of regular unshielded, flat, 50-conducter by .050 ribbon cable. The shielded external cables are approximately 20 ft long each. Total bus length is about 69 ft--21 m. (This is a test system, not an example of how TI systems are configured.) The testing of a 21 m S/E bus, vs the 6 m arbitrary limit in the standard, was done both to expand the differences which might be found between cable types AND to illustrate the large performance margin available in S/E SCSI when the cables and terminators are properly chosen.

TEST DESIGN

The waveforms to follow are for read operations on disk D6. All disks except D5 and D6 are synchronous-capable and are so operated. At various times in the testing, all disks were in operation, and in some tests disks were interchanged so that the end disks were operating with synchronous data transfer. The slower non-synchronous operations with D6 permit better observation of the bus waveform behavior, however.

As a control, waveforms were taken with the same 3M pleated foil (PFS) cables reported on in my X3T9.2/89-148. In that paper, waveforms were also presented using the standard shielded SCSI cables originally procured by TI, with little specification of electromagnetic transmission properties. The waveforms were grotesque in comparison with those achieved with the PFS cables, suffering particularly from a slow upward waveform rise after signal de-assertion, providing extended opportunity for double clocking on the -REQ and -ACK lines.

The tests were run with an F0 0F F0 0F .... data pattern, providing a maximum disturbance to the other signals in the bus. The waveforms observed on the -REQ and -ACK lines were no different from those observed with a 00 00 00 .... data pattern, demonstrating the isolation achieved.

RESULTS

The startling (to me) evidence in the waveform pictures to follow is that these twisted-pair cables perform so similarly to the PFS cables. Only in regard to crosstalk among the data lines do they display their lack of true signal-to-signal isolation. Their step voltages (as discussed in my X3T9.2/90-123) are perceptibly lower in some cases than the PFS cables, but they are still quite good. It seems that their effective S/E characteristic impedance must be at least in the low 80's.

The waveforms of both cable types show considerable noise-type components, as would be expected from the 6 transitions between external shielded cables and internal unshielded ribbon cables (S/E impedance reportedly in the low 100's) and from the 8 stubs for the 8 devices on the bus. Possibly our scope technique introduces additional noise elements. But the observable waveforms make generally clean transitions through the standard-defined transition region between 0.8 and 2.0 v--unlike waveforms taken with our original cables. The 0.8 v and 2 v levels are marked at the edges of the waveform photos.

NOTES RE WAVEFORMS

The -ACK waveforms are on the first page. The -ACK waveforms for the PFS cables are in the top row and are designated PAn, where n is the location as given in the bus layout above. The corresponding -ACK waveforms for the twisted-pair cables are in the second row and are designated TAn.

The -REQ waveforms are on the second page. The -REQ waveforms for the PFS cables are in the top row and are designated PRn, where n is the location as given in the bus layout above. The corresponding -REQ waveforms for the twisted-pair cables are in the second row and are designated TRn.

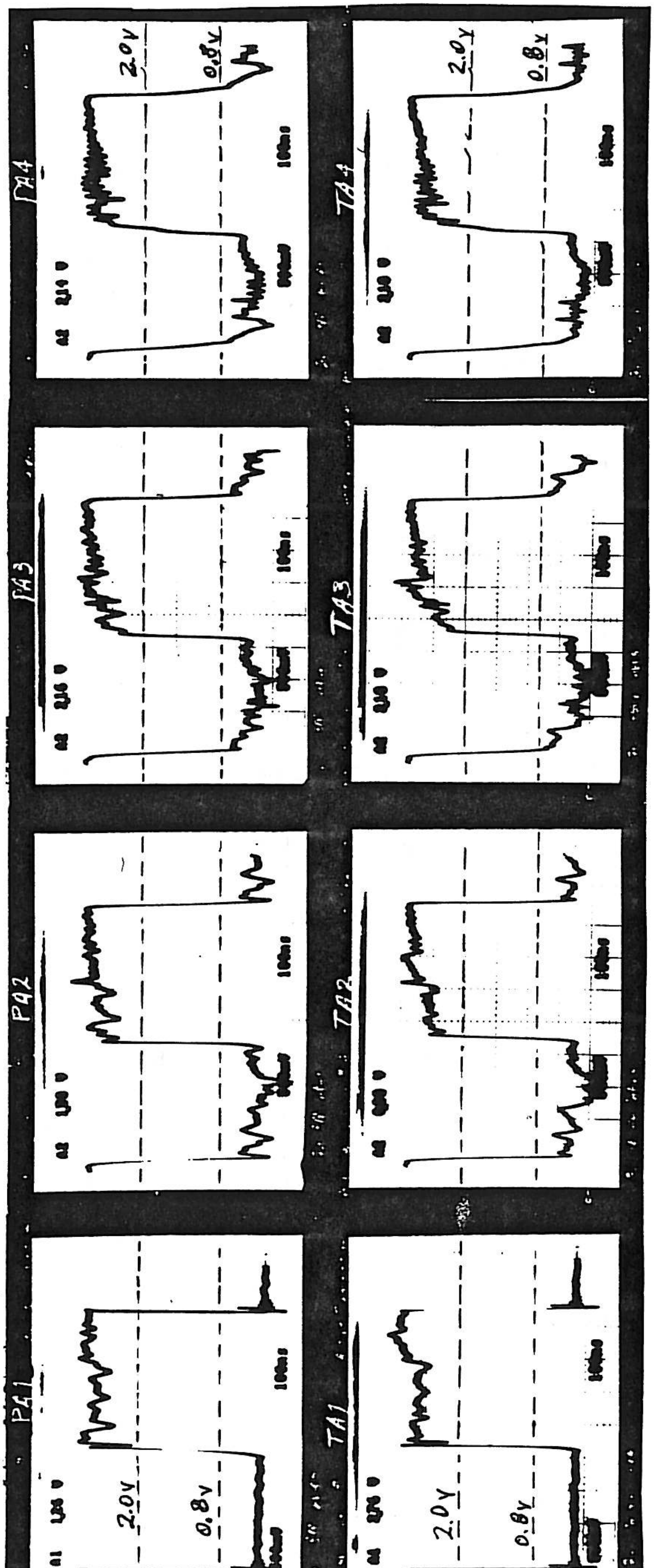
Noise and signal degredation mask the step effect in many cases, but the step effect is quite obvious in TA1, TA2, TR3, and TR4. Comparison with the corresponding PFS waveforms above gives testimony to the somewhat lower characteristic impedance of the twisted-pair cables. This difference is also seen e.g. between TA4 and PA4, and between TR2 and PR2. Nonetheless, all these signals clear the 2 v level satisfactorily. The only signals which have an unsatisfactory appearance are falling (assertion) edges in PR2, PR3, TR2, and TR3. The causes have not been investigated yet. But since they are -REQ signals generated by disk D6, the only one who reads them is the host, where they are good. There is no significant problem at any location with the assertion waveforms of the -ACK signals generated by the host. Still, this problem in the -REQ waveforms at the intermediate locations needs study.

To illustrate the effect of crosstalk, the bottom row of waveforms on the second page shows -DB(3) at the 4 locations. There is no intervening pair between -DB(3) and -DB(4). -DB(3) is driven low for a data byte 0F; -DB(4) is driven low for a data byte F0. The time span is doubled in the -DB(3) waveforms, compared to the -REQ waveforms, so as to show 2 transfer cycles and thus both 0F and F0 data bytes. The spikes induced in -DB(3) by the assertion of -DB(4) are very obvious. But, since the data is being clocked only after the crosstalk transients have subsided, the spike coupling in these lines does no harm.

(Interestingly, these waveforms seem to bear out Jim Fiala's discovery that at the frequencies and impedancies involved here, the capacitive component of crosstalk coupling is negligible. If the coupling were primarily capacitive, the spike polarities in -DB(3)1 and -DB(3)2 would have to be reversed. But if the coupling is primarily inductive, they may be of either polarity pattern, just depending on how the lay of the twist of the two pairs lines up with each other. In -DB(3)3, the opposite polarity pattern appears to be present. In in -DB(3)2 and -DB(3)4, the size of the spikes seems diminished from the other two waveforms. It seems possible that two pairs could be so laid with respect to each other that they would experience a crosstalk null with respect to each other. If so, some crosstalk measurements may turn out to be unrepeatable from sample to sample and therefore meaningless.)

FOOTNOTE

My presumption--that Madison's super-grade twisted-pair cable would perform about midway between economy-grade cables and the pleated foil cables--having been shaken, I would be interested to develop results for other cables. Obviously, the testing and waveform capture is a little time-consuming and costly to TI. We express our gratitude to Madison and Tessco for having made the 4099 cables available for test. To make other test results meaningful, the tests would have to be made with cable assy's essentially identical in length, pinout scheme, etc. If anyone is willing to furnish cable assy's for further testing, I will be happy to furnish copies of the cable ass'y spec.



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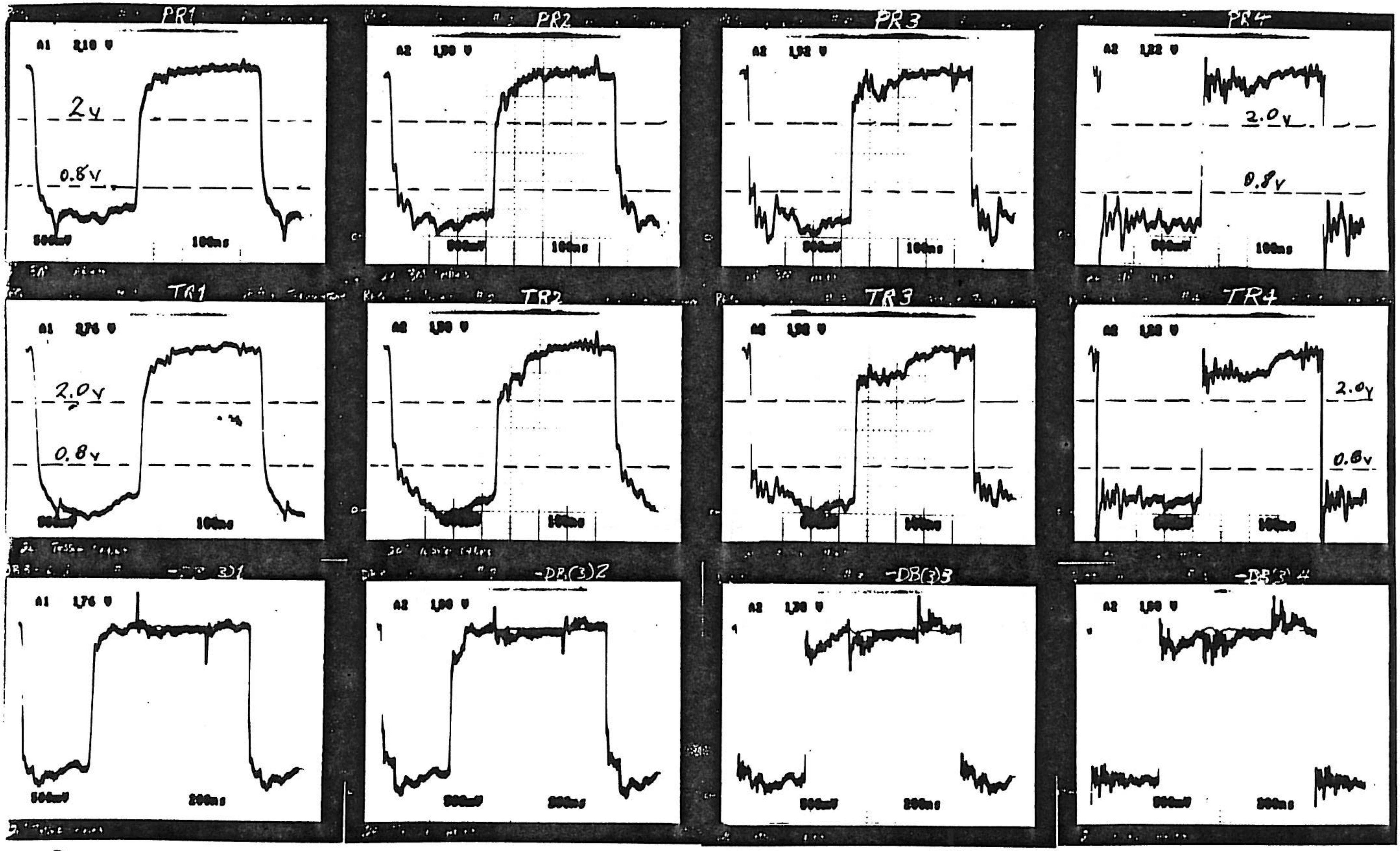
PR1
A1 2.10 V
2V
0.8V
500mV
100ns
PR2
A2 1.90 V
100ns
PR3
A2 1.92 V
100ns
PR4
A2 1.22 V
2.0V
0.8V
100ns
TR1
A1 2.76 V
2.0V
0.8V
500mV
100ns
TR2
A2 1.90 V
TR3
A2 1.90 V
TR4
A2 1.20 V
2.0V
0.8V
A1 1.76 V
500mV
200ns
-DB(3)2
A2 1.90 V
500mV
200ns
-DB(3)3
A2 1.30 V
500mV
200ns
A2 1.90 V
500mV
200ns

144

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