TEXAS INSTRUMENTS

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MEMORANDUM -- 14 Oct 1990

TO: John Lohmeyer, Chairman, X3T9.2

FROM: Bill Spence, TI

SUBJECT: S/E Cable Test Report No. 3

THE BOTTOM LINE

1. In our in-system performance measurements, Astro 52-107-C cable displayed essentially identical characteristics to Madison 4099/4197 and, with 110-ohm terminators, supported synchronous operation over a total bus length of at least 70 feet, fully loaded.

2. Characterization of a sample of "pick-up" cable in Jim Fiala's lab at 3M suggests that Impedance and Rise Time Degredation are key performance indicators.

3. Cable impedance determination may indeed be in need of standardization.

4. The improvements in bus performance caused by each of the 3 factors--better cable, lower impedance terminators, and controlled placement of the clocking and data conductors--are great enough to suggest that the adoption of any two of them may well provide trouble-free single-ended operation for total bus lengths of at least the "legal" 6 meters.

CABLE ASS'Y DESIGN

This test followed essentially exactly the test of the Madison cable reported in my S/E Cable Test Report No. 2, X3T9.2/90-124, 16 Aug 1990. The Astro cable uses Polyolefin wire insulation vs Madison's Polypropylene. Both have a buffer layer of dielectric inside the shield layers. The color code is different from the Madison cable but the same pinout scheme was followed in making the cable assy: -REQ and -ACK are in the core; the data and parity lines are in the outer layer.

ASTRO provided the cable and CMS made the cable assemblies for this test, and we express our gratitude to both.

PHYSICAL LAYOUT (This section is repeated from S/E Cable Test Report No. 2)

The bus layout is given in the following diagram:

```
 ____________              _______             _______             _______
|        |  |             |   |   |           |   |   |           |   |   |
|   H/A  |D0|             |D1 |D2 |           |D3 |D4 |           |D5 |D6 |
|____T___|__|             |___|___|           |___|___|           |___|___|
|    1|___|||             |||_|||             |||_|||             |||_|||
|_________ ||     20'     || _ ||     20'     || _ ||     20'     || _ ||
           |______________| 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 70 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.

RESULTS AND WAVEFORMS

As before, the 21-meter total bus length is indicative of the large performance margin offered by 110-ohm terminators and high-quality cables. As before, the system was operated with both asynchronous- and synchronous-data-transfer disks in the end location, and the system ran perfectly for the several hours that the test was continued.

For the purposes of this report, only the -ACK waveform generated at the host and the -ACK wavefrom received by the end disk are reproduced. On the waveform page, the top waveforms are again with the "standard"--3M's quasi-coaxial PFS cables--in use. The center waveforms are with the Astro 52-107-C cables in use. The bottom waveforms are again with the Madison 4099/4179 cables in use.

As before, the signal transitions through the transition region from 0.8 to 2.0 volts is clean, and some noise margin outside the transition region is maintained. The signal degredation from the left hand pictures to the right hand pictures is obvious but obviously not damaging. One item of interest: the rise time degredation appears to be considerably more than the 3.5 ns which Jim Fiala's recommendations would allow for 70 feet of good cable. It must be remembered that this 70 foot bus includes numerous transitions to PVC ribbon cable and back, with the total ribbon cable length in excess of 10 feet.

The waveforms provide evidence to support Jim Fiala's contention that differing methods of determining cable impedance can produce inconsistent values. The cable impedance is reflected in the height of the step in the first 200 ns after the rise of the left hand -ACK waveform. There is on average no significant difference between the Astro and Madison cables (this was true comparing other waveforms as well), whereas the 3M cable does show a significantly higher step. These results disagree with the nominal impedances given in the manufacturers' specs, however:

3M: Z = 93 ohms   Astro: Z = 90 ohms   Madison: Z = 79 ohms

Based on 93 ohms for the 3M cable, the waveforms would suggest a figure in the low to middle 80's for the core conductors in both Astro and Madison cables. It is our intention as we proceed to characterize all cables using the same test methods.

"PICK-UP" CABLE CHARACTERIZATION

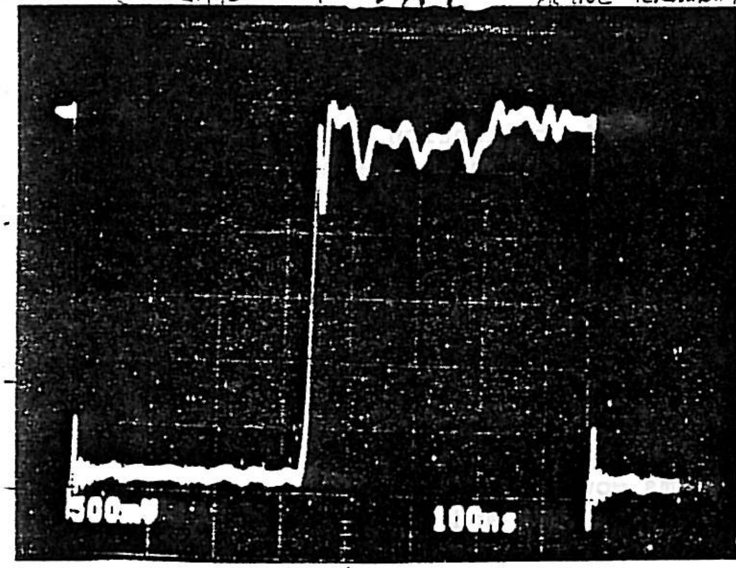
Some earlier waveforms I have presented were taken with 25-pair shielded cables which were chosen without emphasis on their transmission characteristics. Such cables do not adequately support fully-loaded bus operations with a total bus length of even the "legal" 6 meters. 3M and Jim Fiala graciously characterized a 20' sample of such cable, prepared according to Jim's exacting instructions. The results were as follows:

PARAMETER	JIM'S RECOMMENDATIONS	CABLE
Rise Time Degredation	less than 1 ns	3.5 ns
Square wave voltage) attenuation)	less than .75 v less than 15%	.5 v 10 %
Propagation delay	less than 33 ns	38.3 ns
Propagation skew	less than 1.5 ns	1.02 ns
Capacitance	less than 500 pf	841 pf
Capacitive "skew"	less than 100 pf	103 pf
Impedance	greater than 80 ohms	45 ohms

On examination, it appears that the "pick-up" cable characterics arose from two main differences from the "high-quality" cables: the conductors are AWG 26 instead of AWG 28, and the conductor insulation is PVC or similar, as opposed to a telephone-cable grade insulation like Polypropylene or Polyolefin. The larger conductors both lower the inductance and raise the capacitance of the conductors, with the noted disastrous effect on the cable impedance.

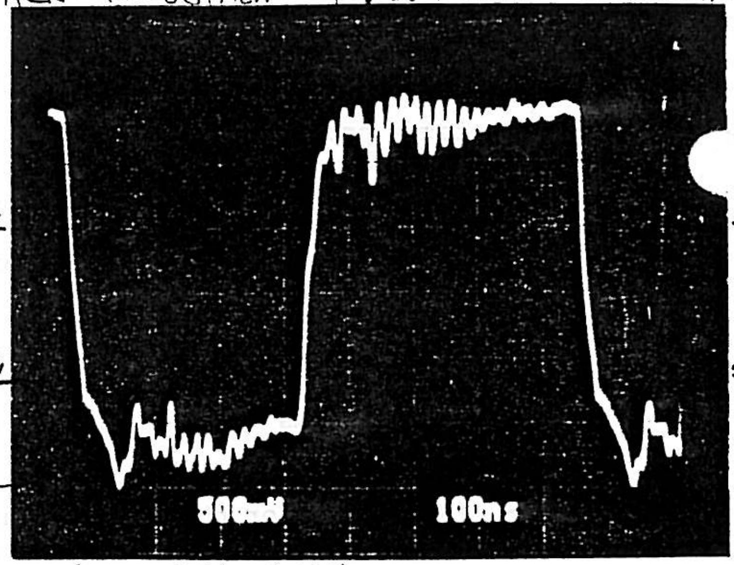
The super-low cable impedance by itself may explain this cable's deficiency in performance. Another factor is that its pinout was uncontrolled and is unknown. The only other parameter which really stands out is the 3.5 times factor of its rise time degredation over the recommended maximum.

ACK - @ location #1 PA1 ACTIVE TERMINATION



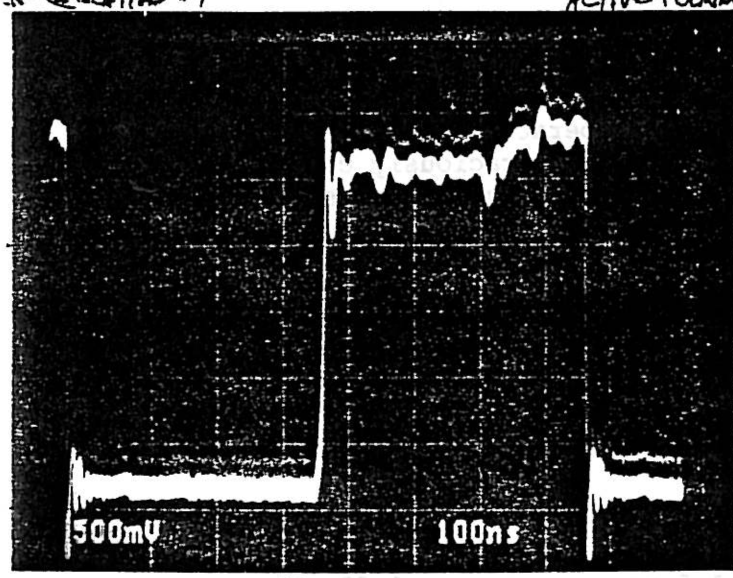
22' 3M Cables (PFS)

ACK - @ location #4 PA4 ACTIVE TERMINATION



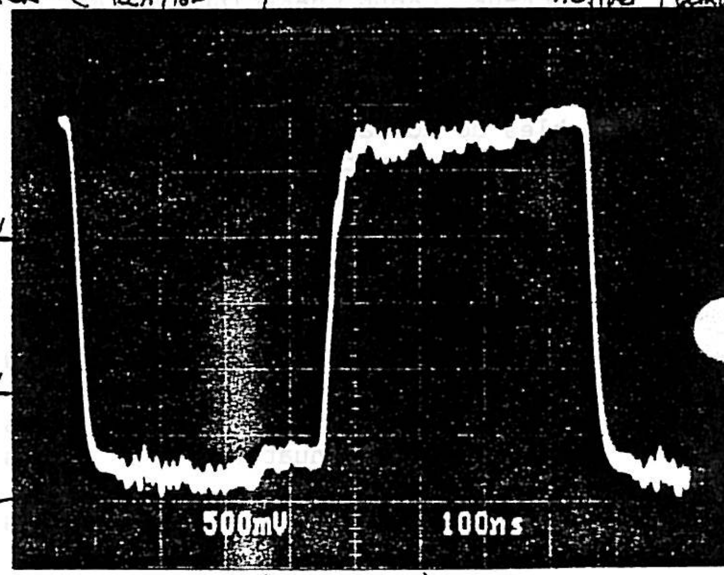
22' 3M Cables (PFS)

ACK - @ location #1 Active termination



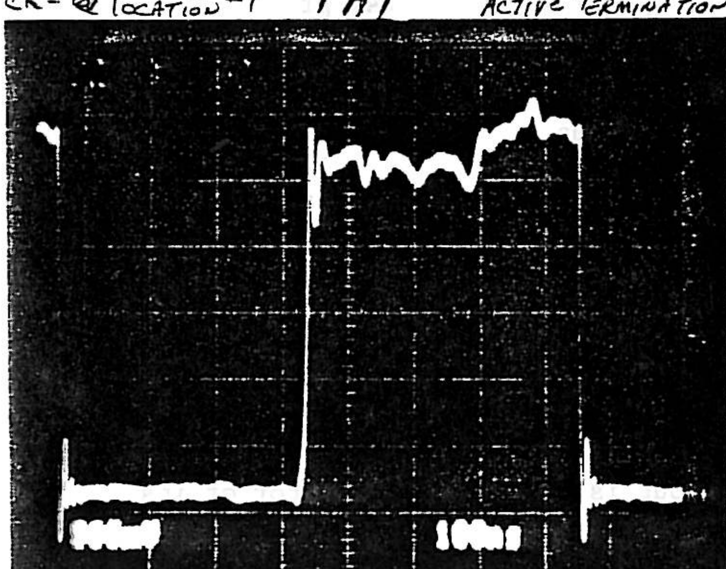
20' Astro Cable (52-107-C) - CMS

ACK - @ location #4 Active termination



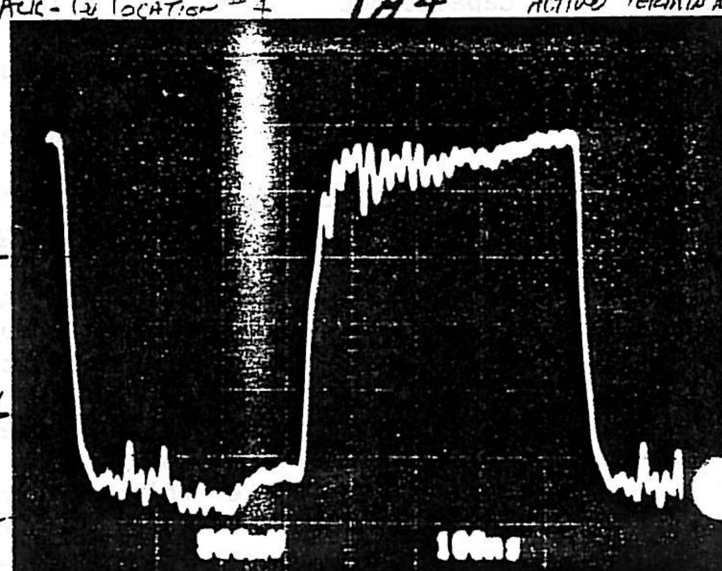
20' Astro Cable (52-107-C) - CMS

ACK - @ location #1 TA1 ACTIVE TERMINATION



20' Tessco Cables - Madison (4099/4197)

ACK - @ location #4 TA4 ACTIVE TERMINATION



20' Tessco Cables - Madison (4099/4179)