Entertainment Services and Technology Association

DMX512 Over Category 5 Cable

Task Group Report

Part Three

Category 5 vs. Belden 9842 Cable Impedance Mismatch
Rosco/ET Talkback Evaluation

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NOTICE and DISCLAIMER

Introduction

In response to a perceived industry requirement for lower cost DMX512 cable installations, the DMX-over-Category 5 Cable Task Group was formed by ESTA's Control Protocols Working Group (CPWG) at the January 1998 TSP meetings in Dallas. The Task Group's mission was to employ an independent laboratory to carry out a series of comparison tests between a typical cable presently used for hardwired DMX512 installations, and conventional Category 5 data cable. The goal of this testing was to establish whether Category 5 cable, or "generic premises cable" as it has become known, could be used as a low cost substitute in permanently wired DMX512 installations.

Two series of lab tests were conducted in July and November of 1998 at MPB Technologies in Airdrie, Alberta. Additional tests were conducted in December of 1999

Part 1 of this report (CP/2000-1024.1) describes the first series of tests which compared the DMX512 handling characteristics of a typical EIA-422 rated data cable with those of a standard Category 5 unshielded twisted pair (UTP) cable. Radiated emissions tests were also done. Results of these tests indicated that Category 5 UTP cable performed as well as conventional DMX512 cable.

Part 2 of this report (CP/2000-1024.2) describes the second series of tests which were carried out with Category 5 shielded twisted pair (STP) cable, and also included radiated and induced signal immunity tests to current IEC standards on all cable types.

This section (Part 3 - CP/2000-1024.3) of the report describes the third series of tests which were conducted to determine the effect of combining different types of cable (i.e., Category 5 and EIA-485) on the same wire run. At this time, tests were also done with Rosco/ET IPS equipment to determine whether the use of Category 5 cable caused any timing problems with their talkback data.

Test Conditions & Equipment

MPB Technologies supplied a HP54510A 250MHz Digital Storage Oscilloscope and HP7475 pen plotter to generate the attached oscillograph plots. Radiated emissions and immunity tests were carried out in one of the largest of their five anechoic chambers, and data was acquired by a HP8566B Spectrum Analyzer with HP85685A pre-selector. To generate the required sweep frequencies, a HP8340A Synthesized Sweep Generator was used; this was driven by a HP43314A Function Generator. MPB used a custom software interface to format the output of the Spectrum Analyzer for laser printing. For induced immunity testing, a Velonex V-3300 fast transient burst generator, in conjunction with an MPB-constructed induction clamp conforming to IEC1000-4-4, was employed.

Gray Interfaces supplied the following equipment to facilitate the various tests:

- Goddard Design Li'l DMX'ter (used for DMX512 source and error checking)
- Gray DMX Repeater (isolated 1-in, 6-out buffer unit)
- Tektronix TDS 220 Oscilloscope
- Fluke DSP-100 LANMeter c/w smart remote
- Custom-wired transceiver unit with various EIA-485 transceiver types and switchable termination values
- Custom pulse generator

300 meters (1000 feet) of each of the following cable types was purchased for testing:

- EIA-485 (120 ohm) cable (2-pair with overall shield): Belden 9842
- Category 5 unshielded twisted pair (UTP) cable: Prestolite D0424 COU BL R-2
- Category 5 unshielded twisted pair (UTP) cable: Alpha 9504C

Test Equipment

- 330 meters ALPHA 9504C Category 5 UTP cable
- 130 Meters Belden 9842 low capacitance EIA-485 cable
- Tektronix TDS 220 Oscilloscope
- Fluke DSP-100 LAN Meter C/W Smart Remote
- Custom Pulse generator

Rosco Entertainment Technology Horizon 512 Interface Module and a Rosco Entertainment Technology IPS-DS-1206 dimmer strip.

Investigation

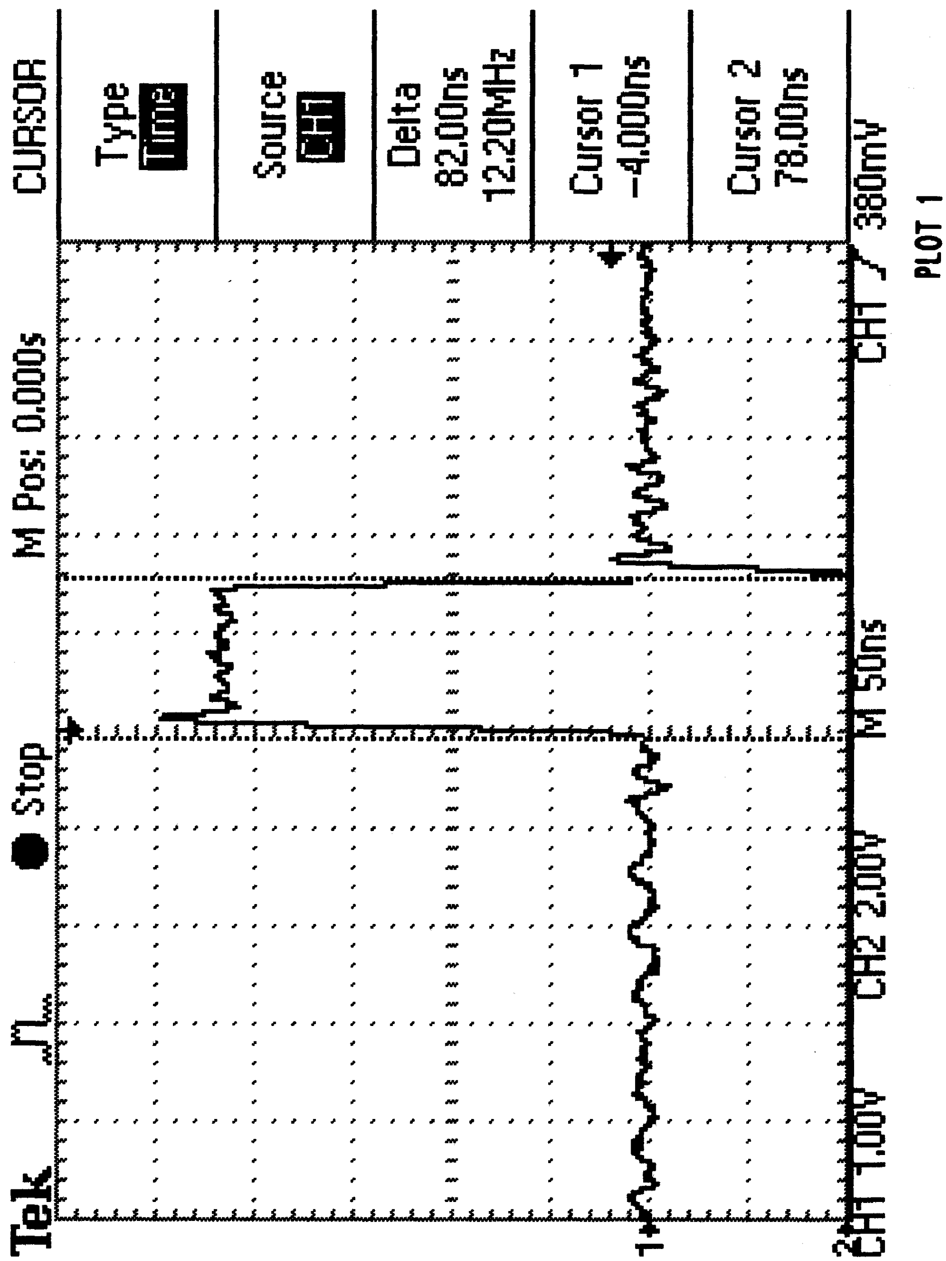
The parameters for these tests were twofold. The first was to examine the effects upon a DMX signal of a transition between cable types of different characteristic impedances. The second was to verify that Category 5 cable would pass both DMX data and IDS Talkback data simultaneously with no signal degradation or interference to either signal.

The impedance mismatch testing was performed using Time Domain Spectroscopy techniques. This involves injecting a short duration fast rise time pulse into the cable under test. The effect on the cable is measured with an oscilloscope. The injected pulse radiates down the cable and at the point where the cable ends some portion of the signal pulse is reflected back to the injection point. The amount of the reflected energy is a function of the condition at the end of the cable. If the cable is in an open condition the energy pulse reflected back is a significant portion of the injected signal in the same polarity as the injected pulse. If the end of the cable is shorted to ground or to the return cable, the energy reflected is in the opposite polarity to the injected signal. If the end of the cable is terminated into a resistor with a value matching the characteristic impedance of the cable, all of the injected energy will be absorbed by the terminating resistor and no reflection will be generated. Should the cable be terminated by some value different from the characteristic impedance of the cable the amount of energy reflected back to the cable start point would be the portion of the pulse not absorbed by the termination. Also any change in the cable impedance due to a connection, major kink or other problem will generate a reflection in addition to the reflection from the end of the cable. By timing the delay between the original pulse and the reflection it is possible to discern the point on the cable length where an anomaly exists. The speed at which the pulse travels along the wire is a fraction of the speed of light in a vacuum. The cable type governs this signal propagation speed. In the case of both the Category 5 and Belden 9842, the propagation speed is 66% the speed of light. By using this propagation speed and allowing for the fact that the pulse must travel to the end of the cable and back it is possible to accurately determine the absolute length of the cable and the position of any anomalies along the cable.

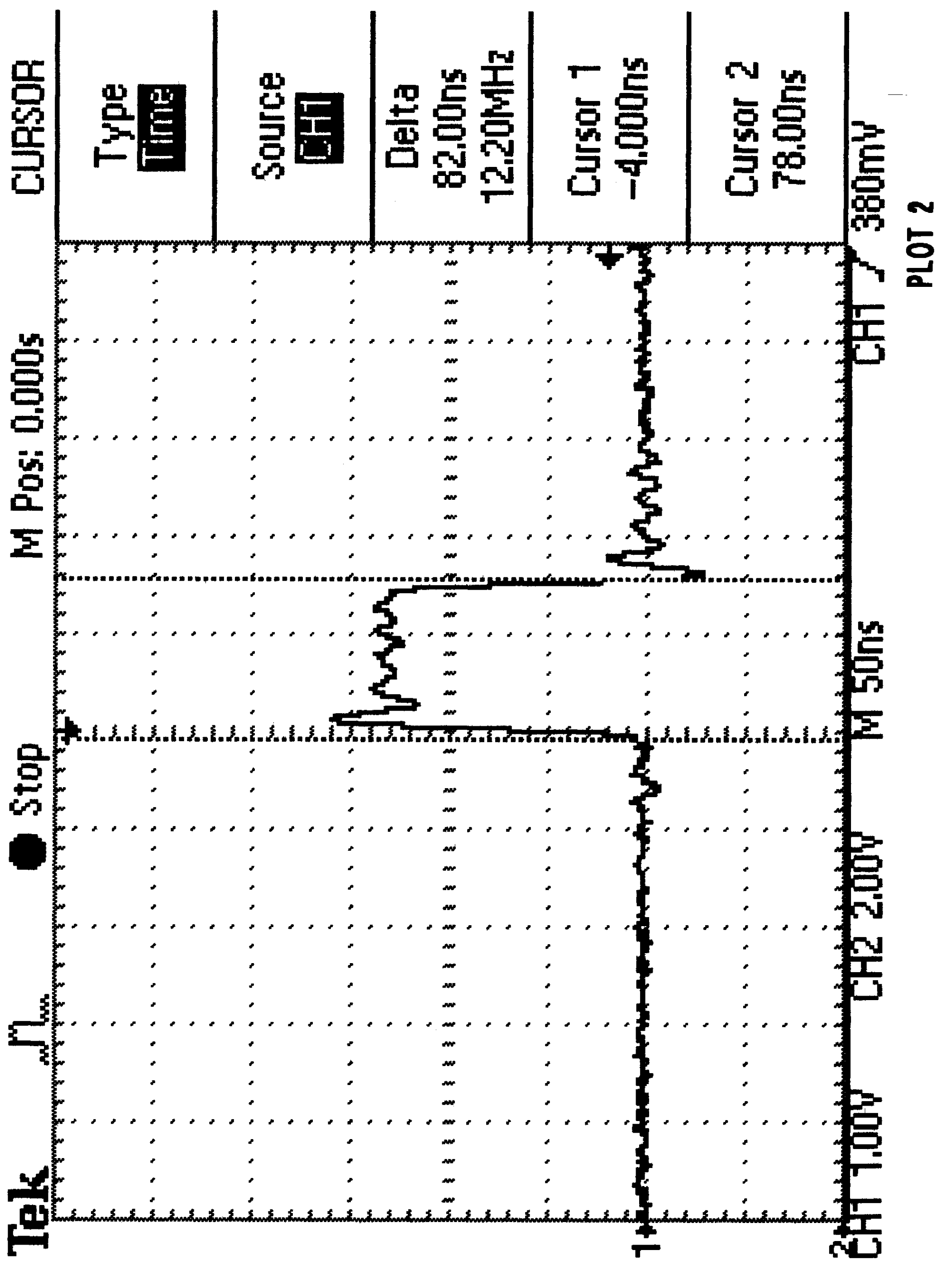
This is the methodology we employed to measure any discontinuities that might be caused by transitions from 100 ohm Category 5 cable to 120 ohm Belden 9842.

Oscillograph Plot Description

#1 Reference pulse from pulse generator 75nS wide 4.25 volts amplitude, used in all tests (this pulse does not appear in all plots).

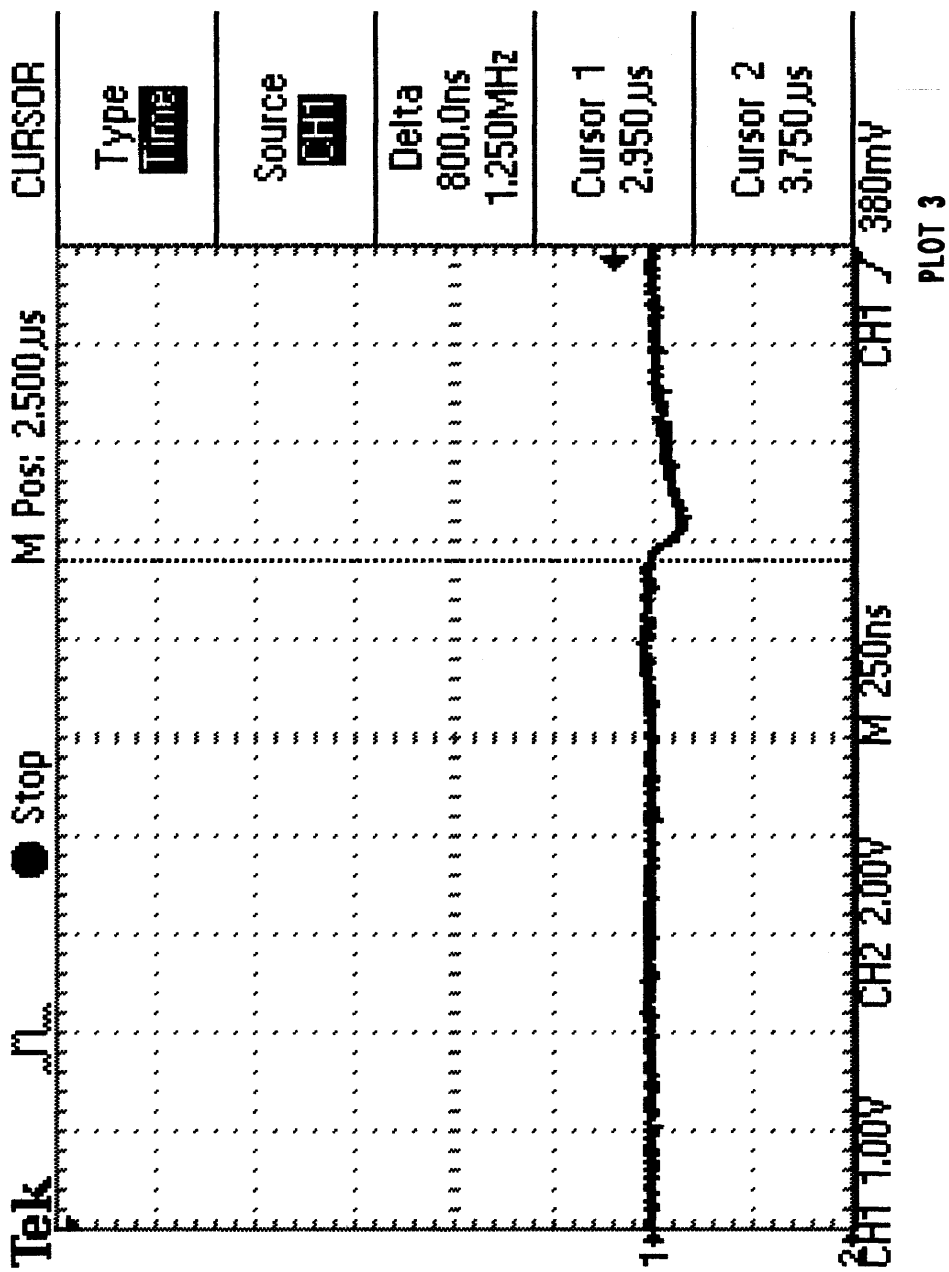


#2 Pulse from pulse generator with 300 meters Category 5 cable attached; 75nS wide 2.75 volts amplitude.



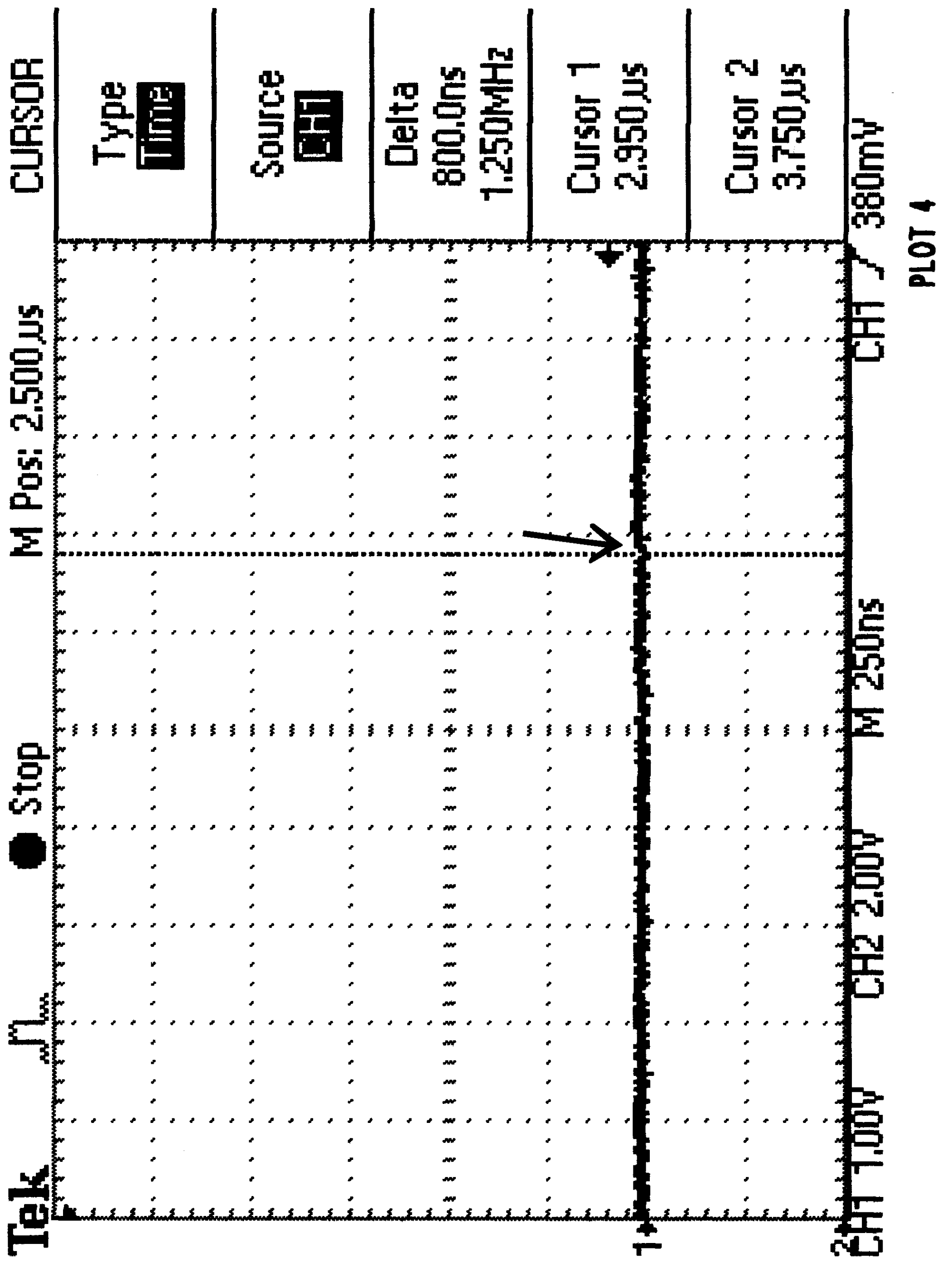
#3 300 meters Category 5 cable end shorted

Note 0.3 volt dip at 3.1µS is the cable end.



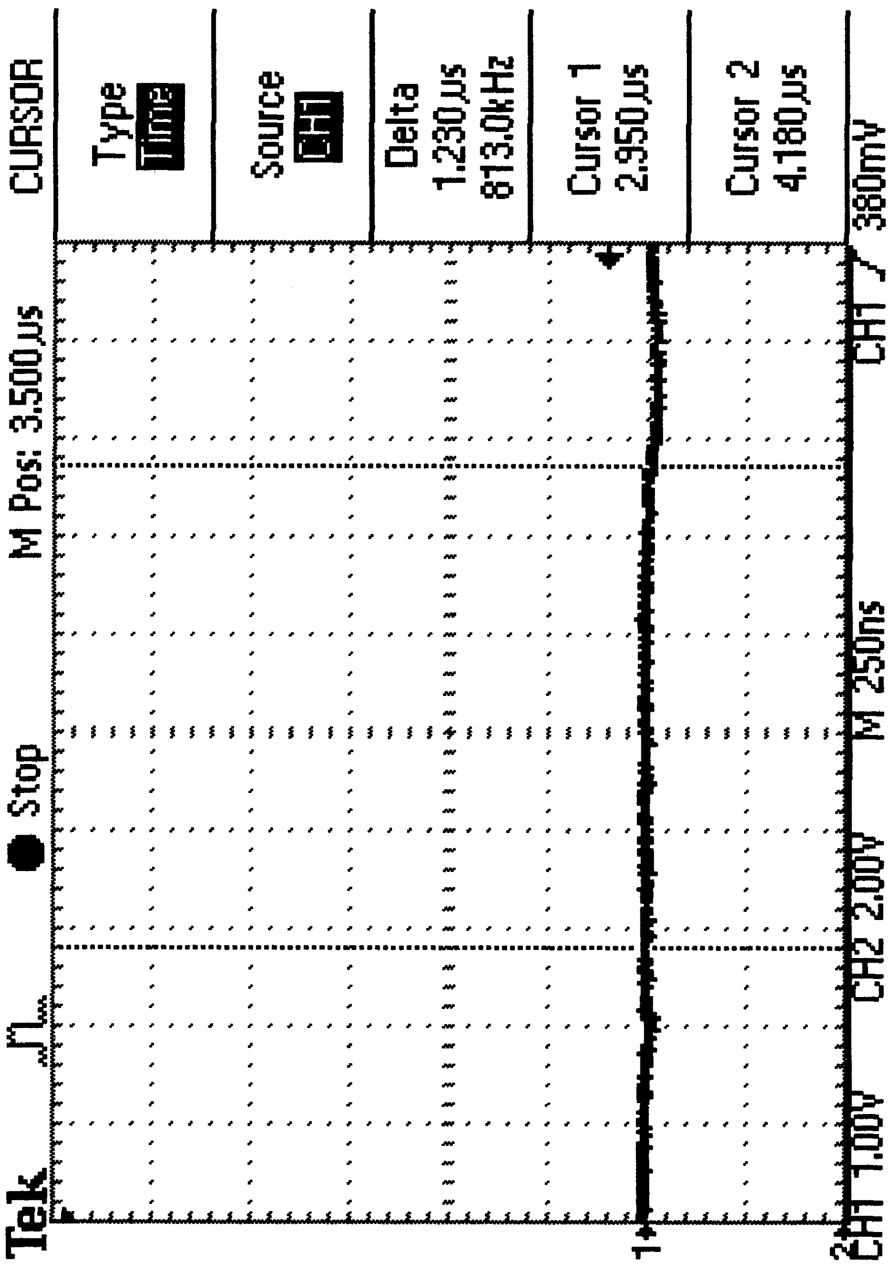
#4 300 meters Category 5 cable end open

Note tiny rise starting at 2.950µS shows cable end.



#5 300 meters Category 5 cable joined to 130 meters Belden 9842 end shorted.

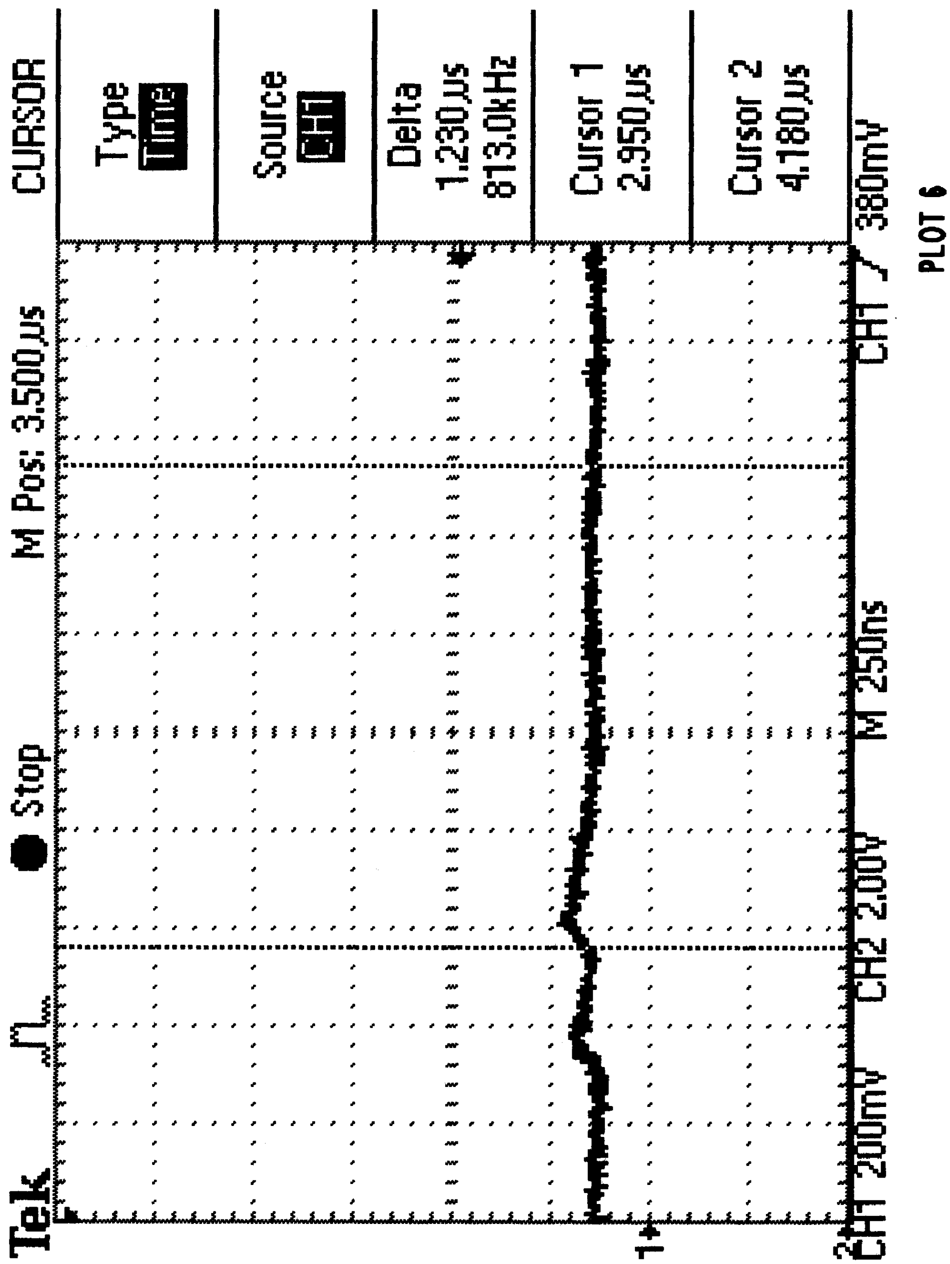
Note slight dip at 4.1 µS is cable end.



PLOT 5

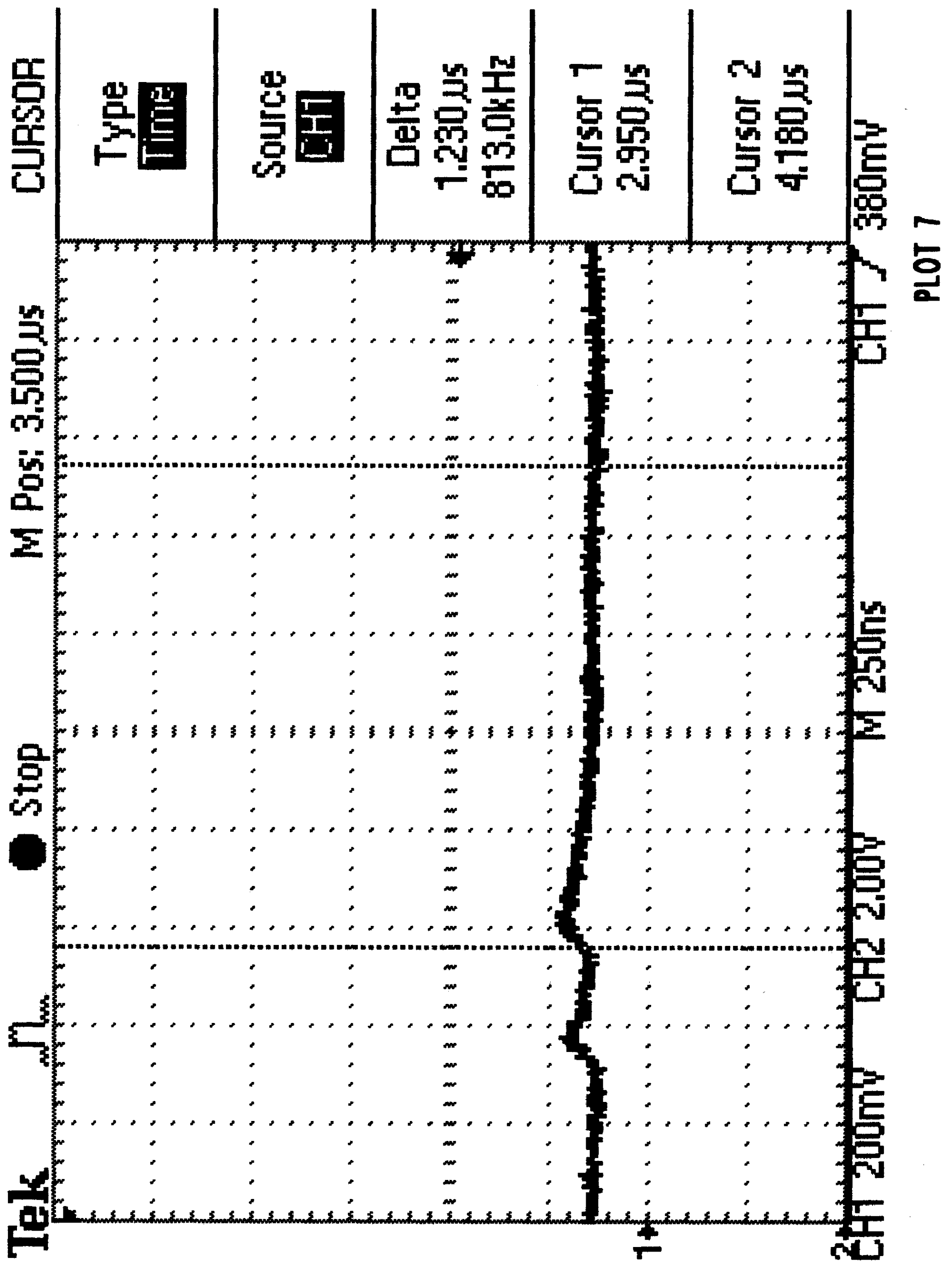
#6 300 meters Category 5 cable end complete with RJ45 connector open.

Note the voltage scale change. Also note the double "hump" between 2.6 and 2.75 µS due to the RJ45 connector. This is followed by the rise starting at 2.950µS showing the cable end.



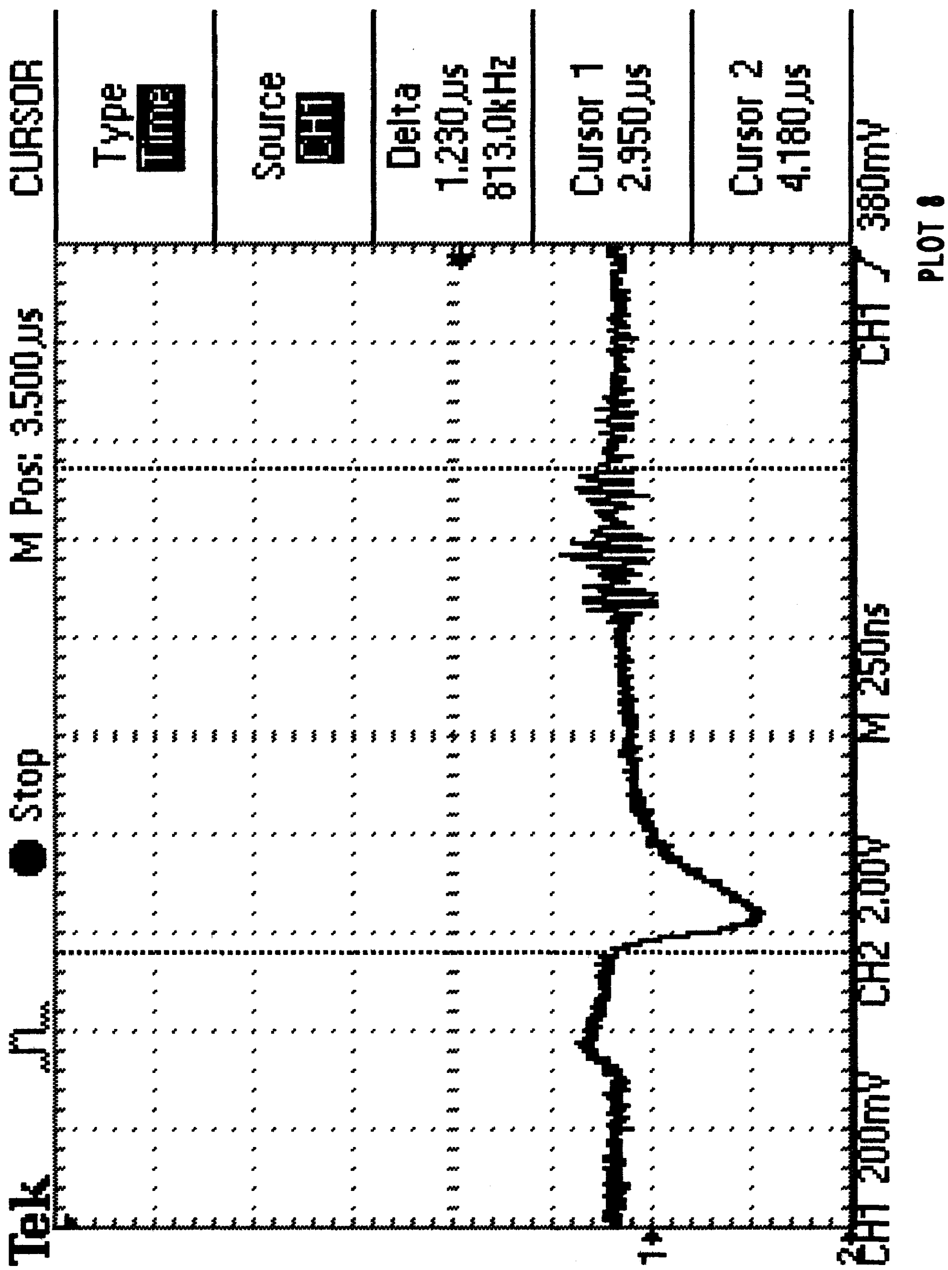
#7 300 meters Category 5 cable end complete with RJ 45 to 5 Pin XLR transition connector open.

Note the double "hump" between 2.6 and 2.75 µS is slightly larger than with just the RJ 45 alone. This is followed by the rise starting at 2.950 µS showing the cable end.



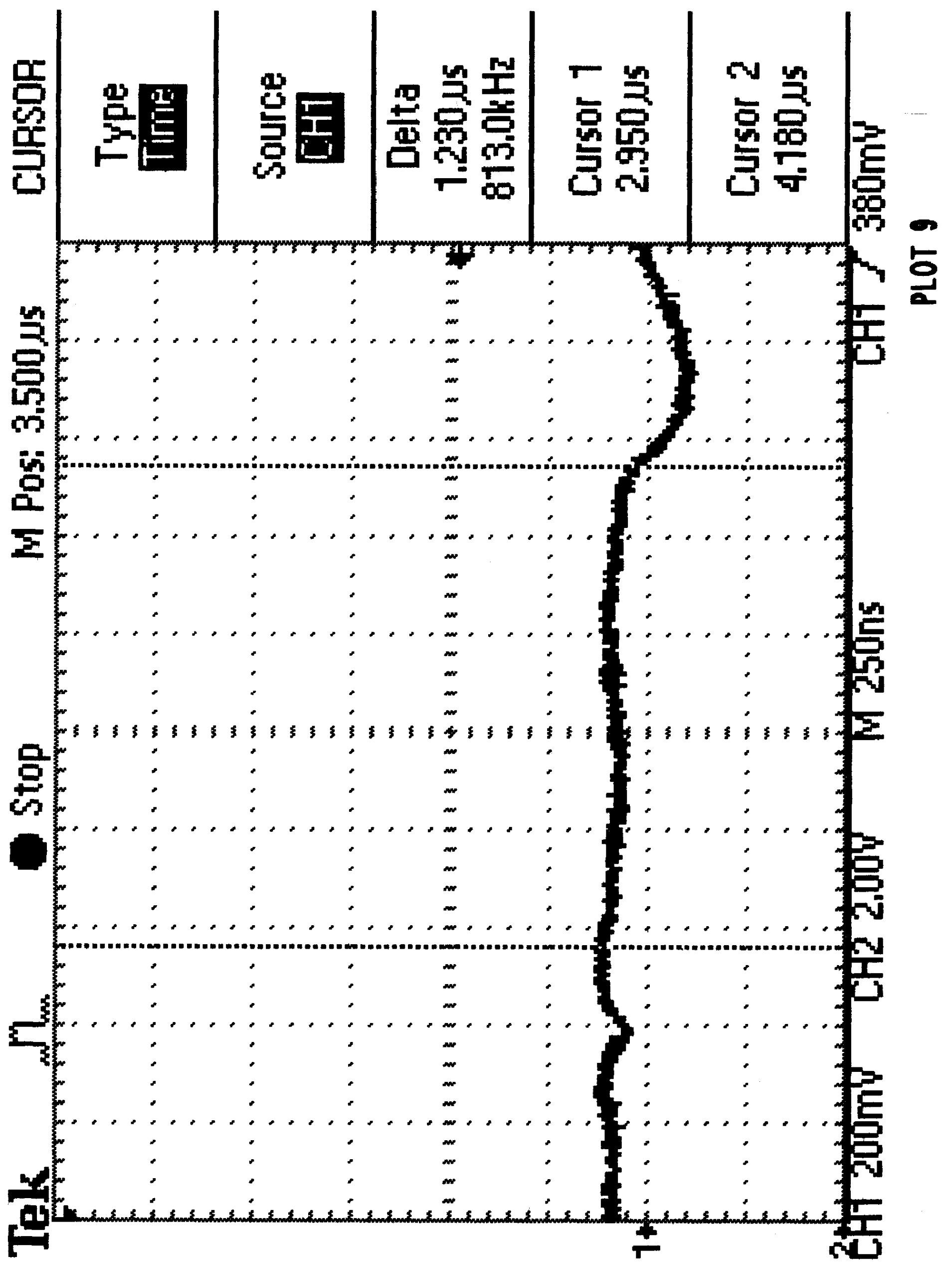
#8 300 meters Category 5 cable end complete with RJ45 to 5 pin XLR transition connector shorted.

Note the single "hump" between 2.6 and 2.75µS showing the RJ45 transition connector. This is followed by the sharp dip starting at 2.950µS indicating the cable end.



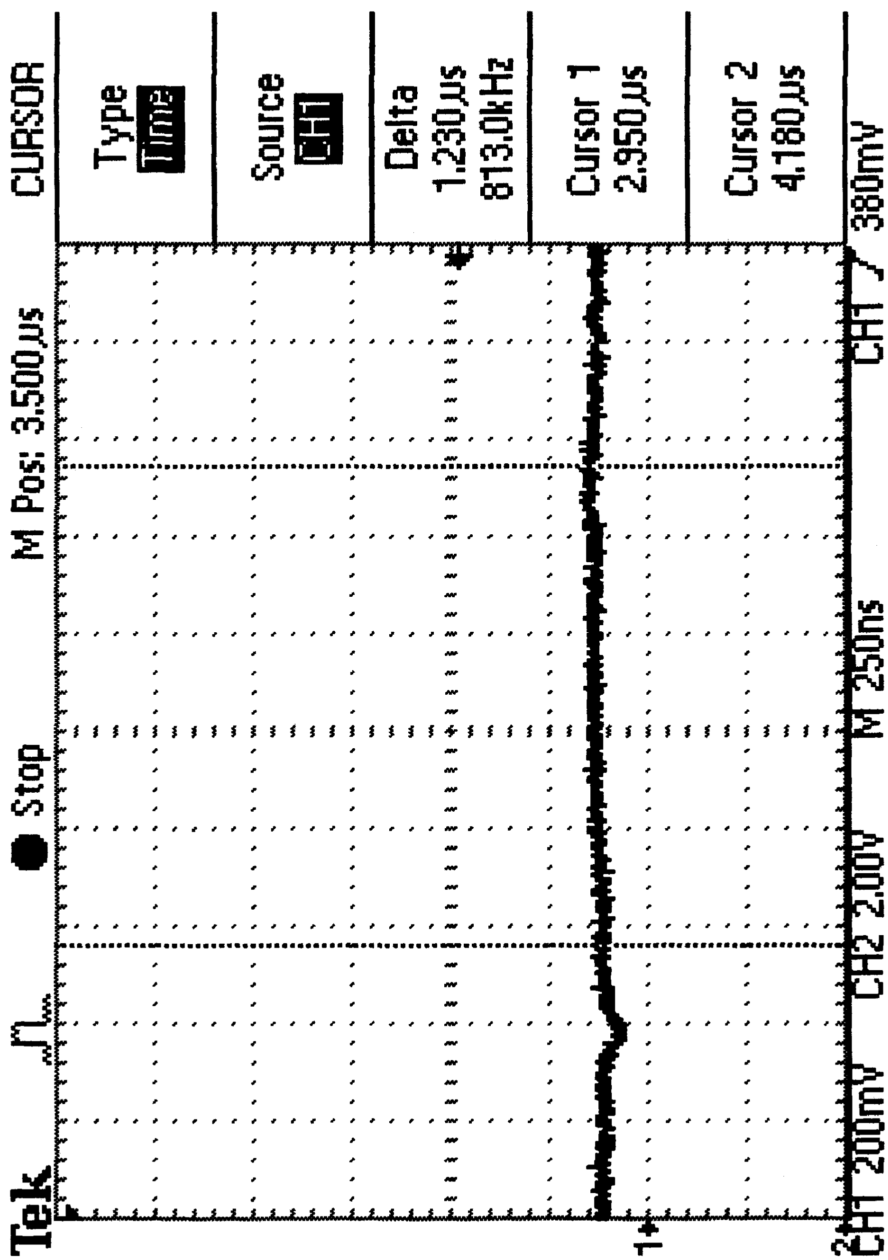
#9 300 meters Category 5 cable end complete with RJ45 to 5 pin XLR transition connector and 130 Meters Belden 9842 shorted.

Note the single "hump" between 2.60 and 2.75µS showing the RJ45 transition connector followed by the slight dip and rise denoting the change in impedance from ~107 ohms to 120 ohms (nominal). This is followed by the dip starting at 4.180µS indicating the Belden 9842 cable end.



#10 300 meters Category 5 cable end complete with RJ45 to 5 pin XLR transition connector and 130 Meters Belden 9842 terminated into 100 ohms.

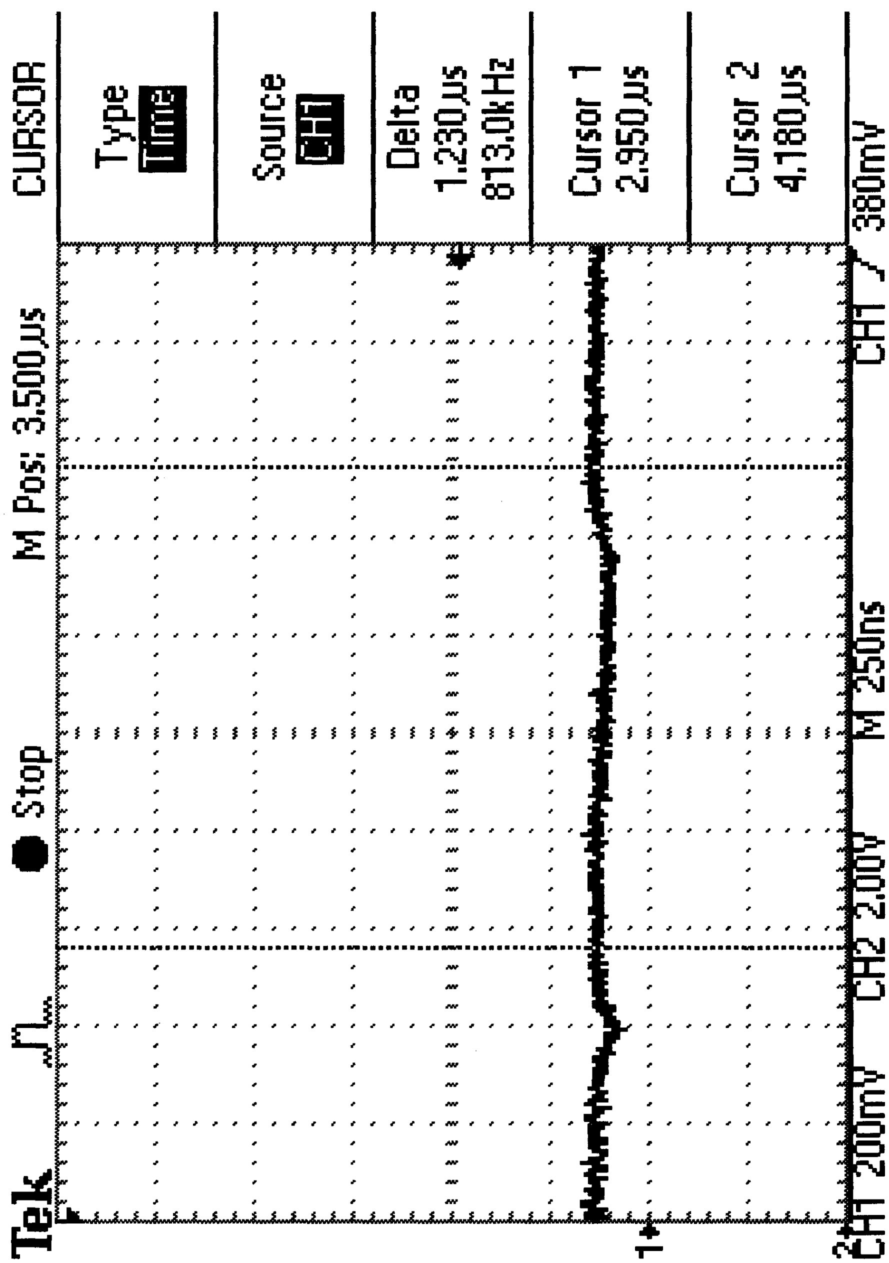
Note the single “hump” and dip between 2.60 and 2.75 µS showing the RJ45 transition connector have been smoothed out, followed by the almost flat response of the Belden cable (note that the 9842 does show an almost imperceptible rise to the termination at the cable end.



PLOT 10

#11 300 meters Category 5 cable end complete with RJ 45 to 5 Pin XLR transition connector and 130 meters Belden 9842 terminated into 120 ohms.

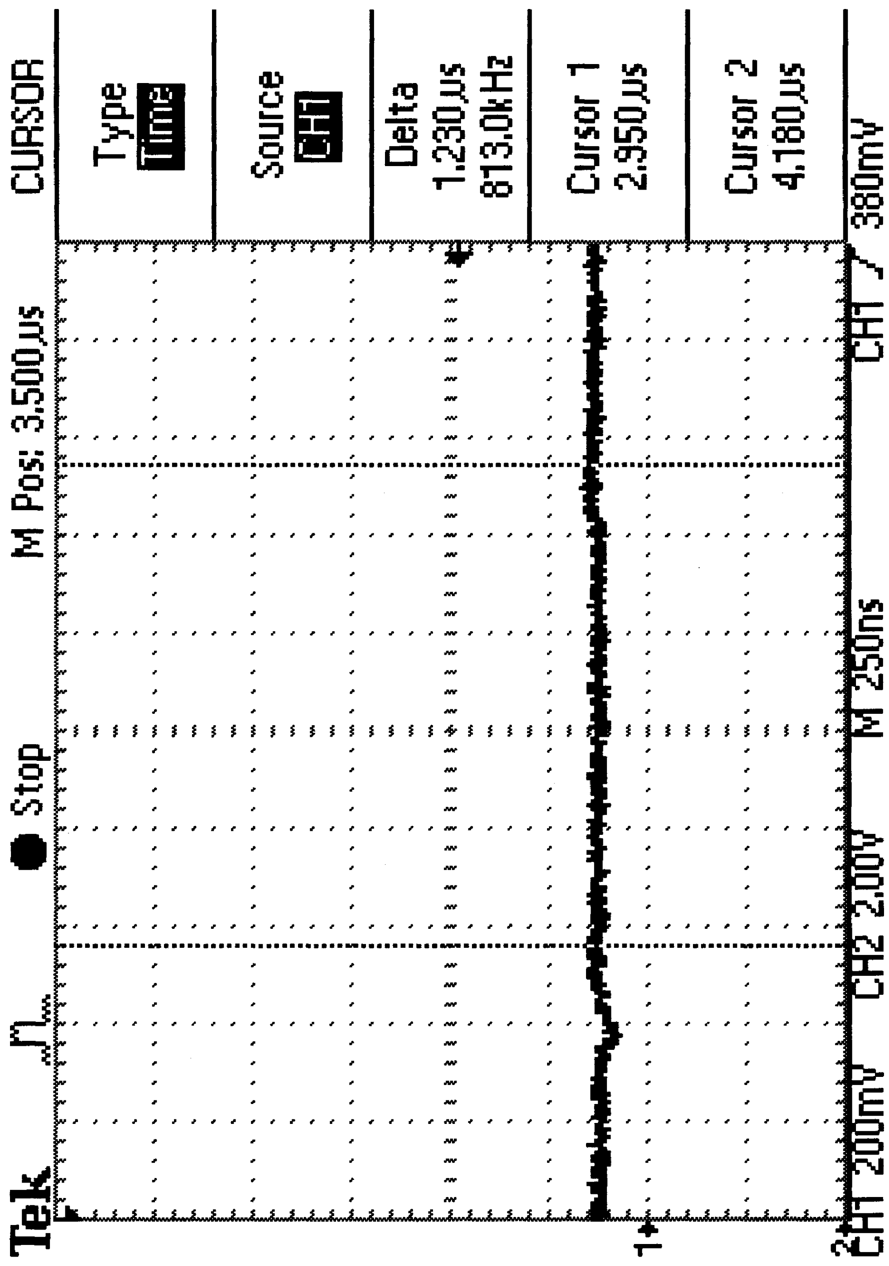
Note the single "hump" and dip between 2.60 and 2.75µS showing the RJ45 transition connector have been smoothed out. This is followed by the slightly descending response to 4.10µS where there is a slight rise showing a mismatch between the 120 ohm termination and the cable.



PLOT 11

#12 300 meters Category 5 cable end complete with RJ45 to 5 pin XLR transition connector and 130 meters Belden 9842 terminated into 110 ohms.

Note the single “hump” and dip between 2.60 and 2.75µS showing the RJ45 transition connector are almost completely gone. This is followed by the flat response to 4.10µS where there is a very slight rise showing a mismatch between the 110 ohm termination and the cable.



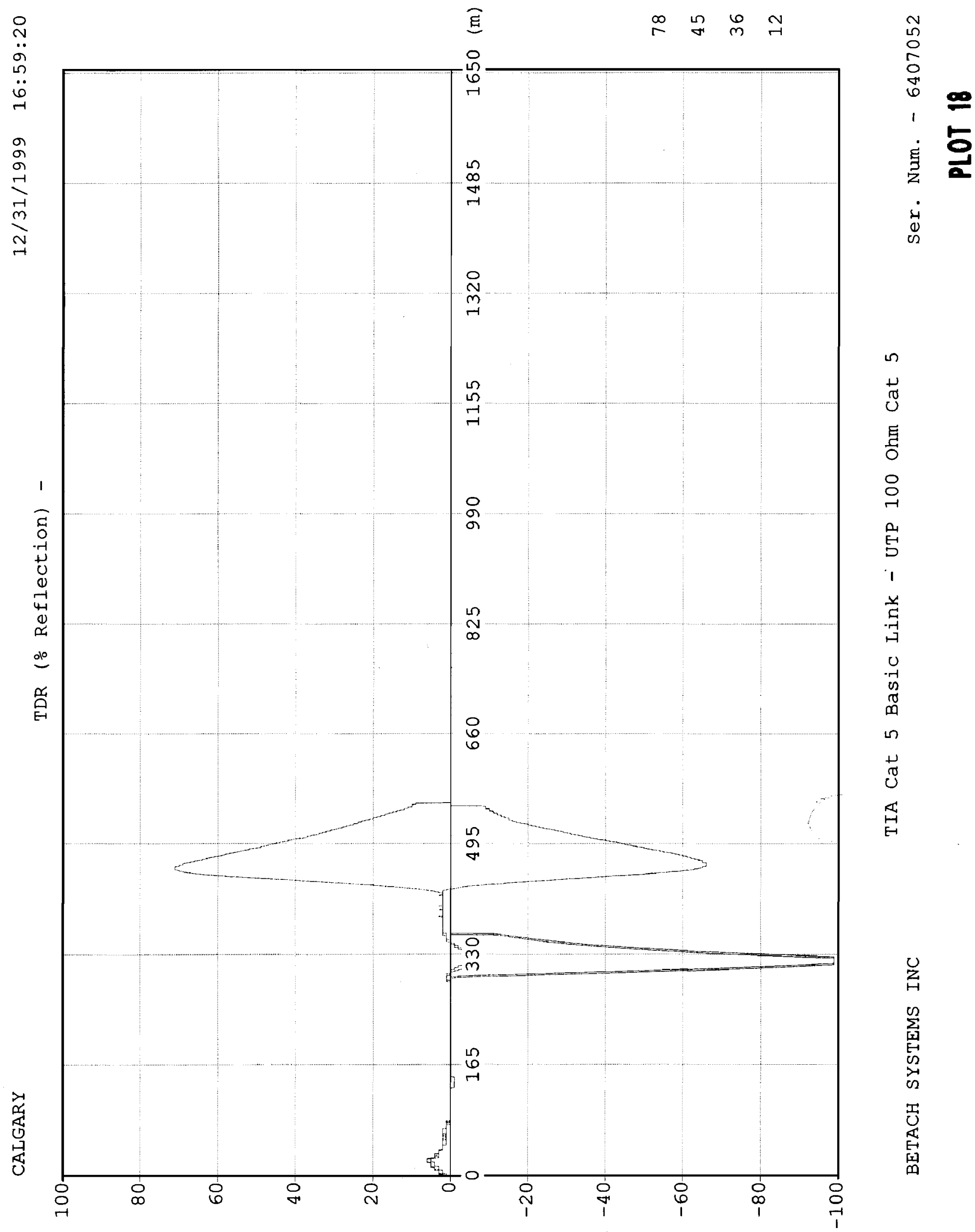
PLOT 12

Plots #13 - #17 do not reveal any distortions of significance and are not included in this report.

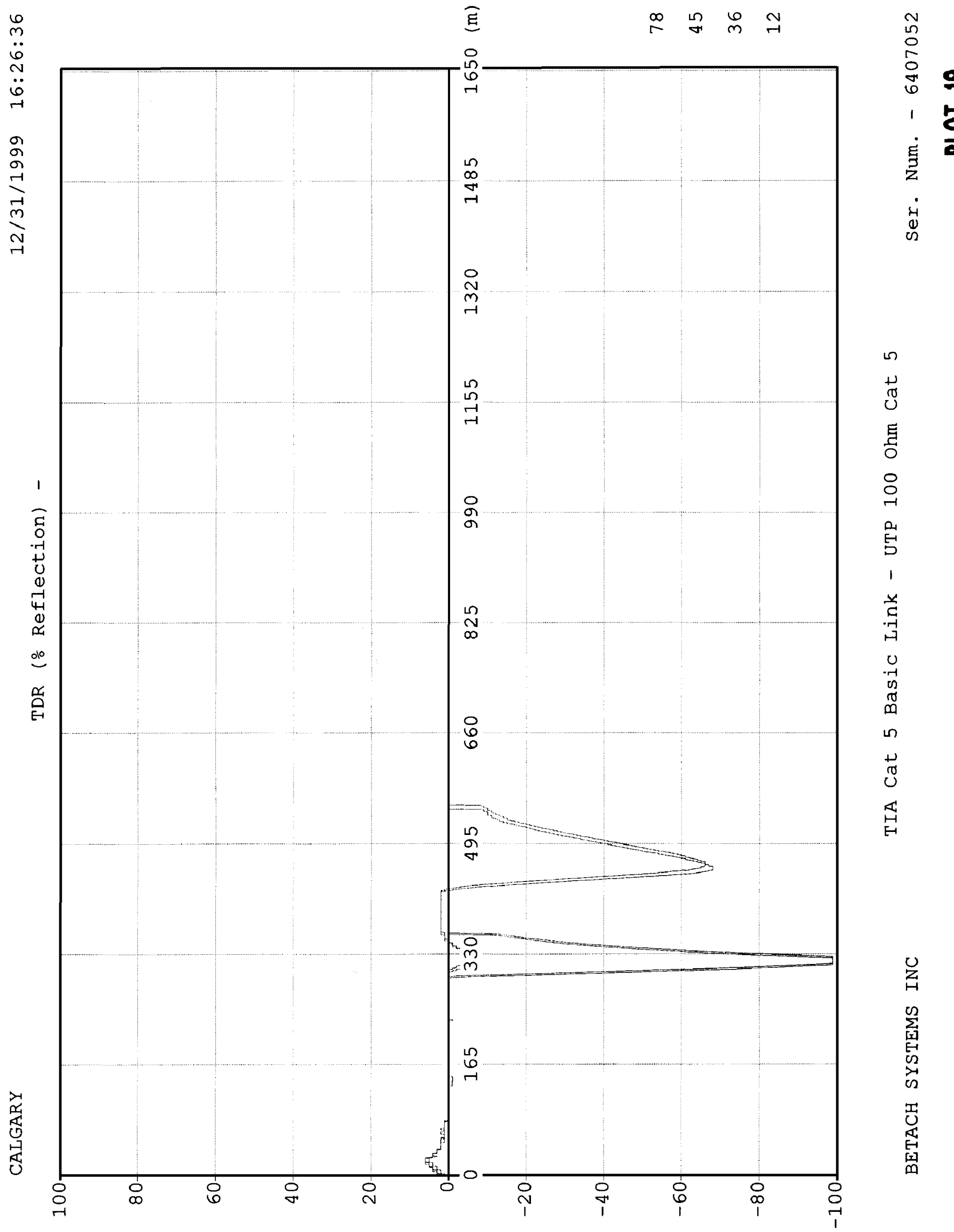
#18 TDR plot showing 300 meters Category 5 cable connected to 130 meters Belden 9842.

- Category 5 pairs 3,6 and 7,8 shorted
- Category 5 pairs 4,5 and 1,2 connected to Belden 9842 pairs.
- Pair 4,5 open
- Pair 1,2 shorted

The large dip centered at 310 meters show the shorted Category 5 pairs. The small dip inside the large dip shows the connection point between the Category 5 and Belden 9842. The large rise and dip at 480 meters show the Belden cable ends open and shorted respectively. The dip at 310 meters shows a decrease in the impedance of the system at the connection point between the two wire types. This reflection is 6% of the injected signal pulse at its peak. The impedance change is due primarily to the RJ11 connector and transition board. The cable beyond the transition point exhibits a constant 2% positive reflection for its entire length until the open or shorted end is encountered. This positive reflection is characteristic of the slightly higher impedance of the 9842 cable in comparison to the Category 5 cable.



#19 TDR plot identical to plot 18 with the exception that both pairs of the Belden 9842 cable are shorted. This plot also demonstrates the 2% reflection along the length of the 9842 cable.



Other Notes and Measurements

- It should be noted that while the nominal impedance of Category 5 cable is normally quoted as 100 ohms this is referenced to signals in the 10 to 100 MHz range. The Category 5 cable is also specified as having an impedance of 107 ohms at 256 KHz. This has been verified in our measurements.
- The test condition of 250 KHz is in fact twice the nominal rate of state changes per second that the cable will experience with 250 Kbps DMX signals. If the Alpha cable specification can be relied upon to be representative of Category 5 cables, the effective impedance of the cable at the equivalent DMX frequency of 125 KHz will be 115 ohms.
- Near end cross talk with the Category 5 cable at 300 KHz is 97dB
- Near end cross talk at 300 KHz is 65dB worst case, measured at the 9842 end of the 9842/Category 5 system.
- This would indicate that cross talk between pairs is of no practical concern at even the exaggerated cable lengths and test frequencies as used in this example.

Conclusion

It can be suggested that the minimal reflection from the transition between Category 5 and low capacitance 120 ohm EIA-485 cable is too small to be of any noticeable effect in DMX512 transmission and reception. In fact, since EIA-422 (100 ohm) cable is commonly mixed with 120 ohm cable in many DMX512 applications, it can be further suggested that this arrangement is potentially more problematic than where Category 5 cable is mixed with either of the conventional types.

IDS Talkback

Concerns have been expressed that impedance mismatches in mixed Category 5 and EIA-485 cable installations could adversely affect IDS Talkback timing tolerances and cause data errors. We believe that the previously described findings about Category 5 cable impedances should answer these concerns.

It has also been suggested that cross talk between DMX512 and pairs may be a factor when utilizing DMX512-based talkback schemes with DMX over Category 5 cable. In previous tests conducted in July of 1998, this concern was addressed with a number of tests where a 250 KHz signal was placed 90 degrees out of phase with the primary signal on an adjacent pair in the Category 5 cable.

Plot #20 (from the first round of tests done in July 1998) illustrates the cross talk that might be expected under worst case conditions.

This observation was borne out in our most recent tests where a Near End Crosstalk measurement was made with the Fluke DSP-100, as listed above.

To verify the test observations we ran the following tests with a Rosco Entertainment Technology Horizon 512 Interface Module and a Rosco Entertainment Technology IPS-DS-1206 dimmer strip.

We connected the Horizon unit to the IPS strip through the following cable lengths and configurations:

- 330 meters Category 5 cable C/W XLR 5 style connectors
- 130 meters Belden 9842
- 330 meters Category 5 cable and 130 meters Belden 9842
- 130 meters Belden 9842 and 330 meters Category 5 cable

In none of the above cases were any errors noted in either the DMX dimmer information or the returned talkback data over several hours of continuous testing. Conversely, our testing indicated that the Rosco/ET talkback scheme is fairly robust in terms of timing tolerances.

– End Part Three –