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# TDR Measurements of FTM to Port Card Cable and Connectors

Summary:

The purpose of this study is to determine several of the characteristic impedances of the FIB-TM to Port Card control cable including the common-mode impedance of a differential pair of conductors, which is not specified by the manufacturer. This study was conducted using a sixty-foot long 25-mil pitch, 50-conductor shielded ribbon cable (3M part number 90101) very similar to the one being used in the production version (3M part number 90201). The only difference between the two cables is the construction of the outer jacket (PVC in the 90101 and TPE in the 90201). One end of the cable ends in a single AMP Amplimite 786090-5 50-pin receptacle, which is similar to the AMP 787190-5 50-pin shielded receptacle that will be used in the production system. This was mated to an AMP 787190-5 boardmount connector. The other end of the cable was split in half and terminated with two 3M 10126-6000EC 26-pin MDR IDC cablemount plugs, which were mated to a pair of 3M10226-6212VC boardmount 26-pin shielded receptacles. Again, these are the production system connectors.

Time-Domain Reflectometry (TDR) measurements were made with a Tektronix 11801B oscilloscope with a single SD-24 TDR head in the channel 7/8 expansion slot. The results shown were all conducted while all cablemount connectors and their associated boardmount connectors were attached. All measurements were conducted from the 50-pin connector end of the cable. This impedance information indicates that a single 30-35 ohm resistor will be adequate to terminate the common-mode return current line.

Procedure:

- Differential Pair TDR

This measurement will be compared to the manufacturer's specifications for the differential (balanced) characteristic impedance between two signal conductors with the shield floating. In verifying the manufacturer specification, the TDR impedance measurement procedure is validated. This procedure can then be used to obtain a valid measurement of the common-mode impedance of a single conductor.

This measurement was taken using pins 4 and 29 on the 50-pin AMP connector, corresponding to the adjacent conductors carrying the differential signal C0 on the ribbon cable. On the 3M 26-pin connector pins 3 and 17 correspond to the same adjacent conductors carrying signal C0. The shield was left floating. Differential TDR probes were soldered to pins 4 and 29 on the 50-pin boardmount connector, the scope was set to differential mode with both channels active, and the measurement was conducted. See Figures 1 and 2 below.

The measured characteristic impedance of the adjacent differential pair of conductors was 104 +/- 2.5 ohms. This concurs with the manufacturer specification of 104 ohms balanced for characteristic impedance.

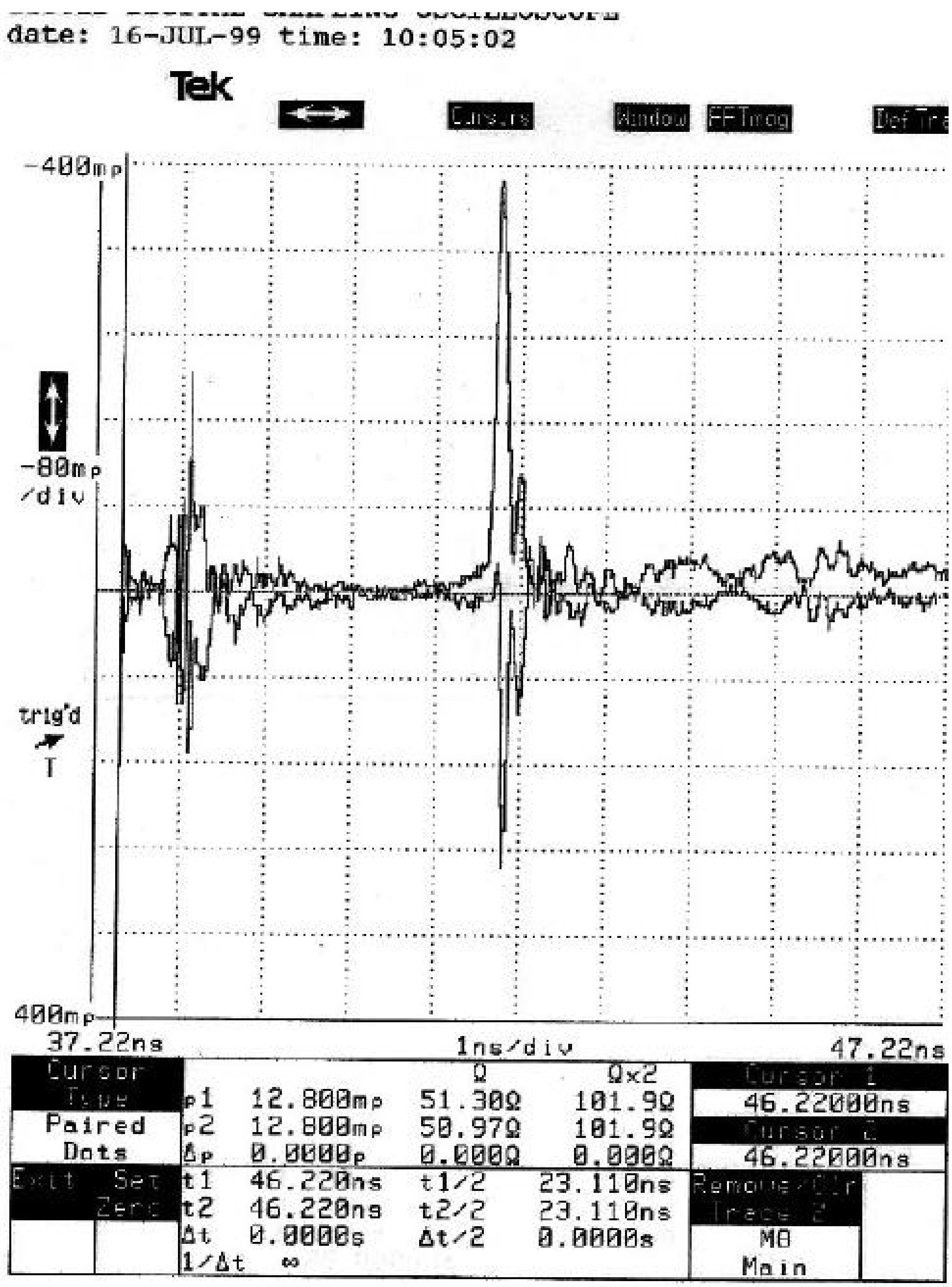


**Figure 1: Here you can clearly see the first TDR return, corresponding to the differential probe connection with the 50-pin AMP cablemount connector, and the larger return near the center of the scope indicating the connector/cable junction. Characteristic impedance measurements for the cable itself were taken at the far right of the screen. The reflection for the discontinuity at the end of the cable is off screen and therefore not visible.**

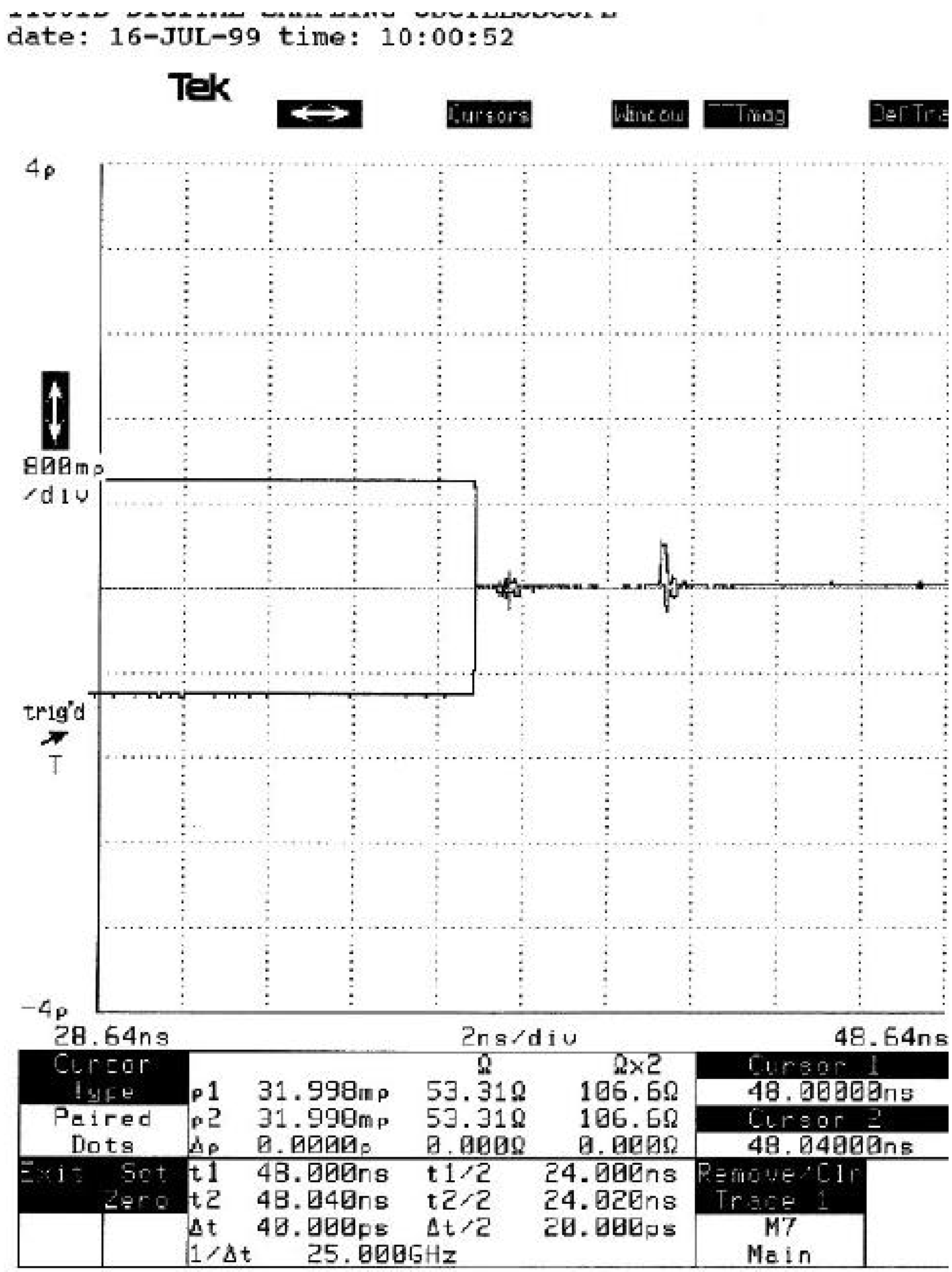


**Figure 2: Same as figure 1, but with a more zoomed-out view. Impedance measurements were taken further to the right, near the end of the cable to verify the impedance measurement taken close to the beginning of the cable in figure 1. Again, the discontinuity at the end of the cable is not visible due to screen limitations (the entire TDR from time zero to the reflection from the cable end would not fit on one screen).**

- Single-Line (Coax Mode) TDR

This measurement will also be compared to the manufacturer's specification to validate the methodology with which we will make the common-mode impedance measurement. For this measurement a single pin, pin 4 on the 50-pin AMP connector was driven by the TDR. Pins 28 and 29, corresponding to the conductors on either side of the line being driven (pin 4), and the shield were tied to ground. The scope was set to use single channel TDR, and measurements were taken. See figure 3 below.

The single-line characteristic impedance was measured to be approximately 59 ohms, which is close to the manufacturer specification of 53 ohms.

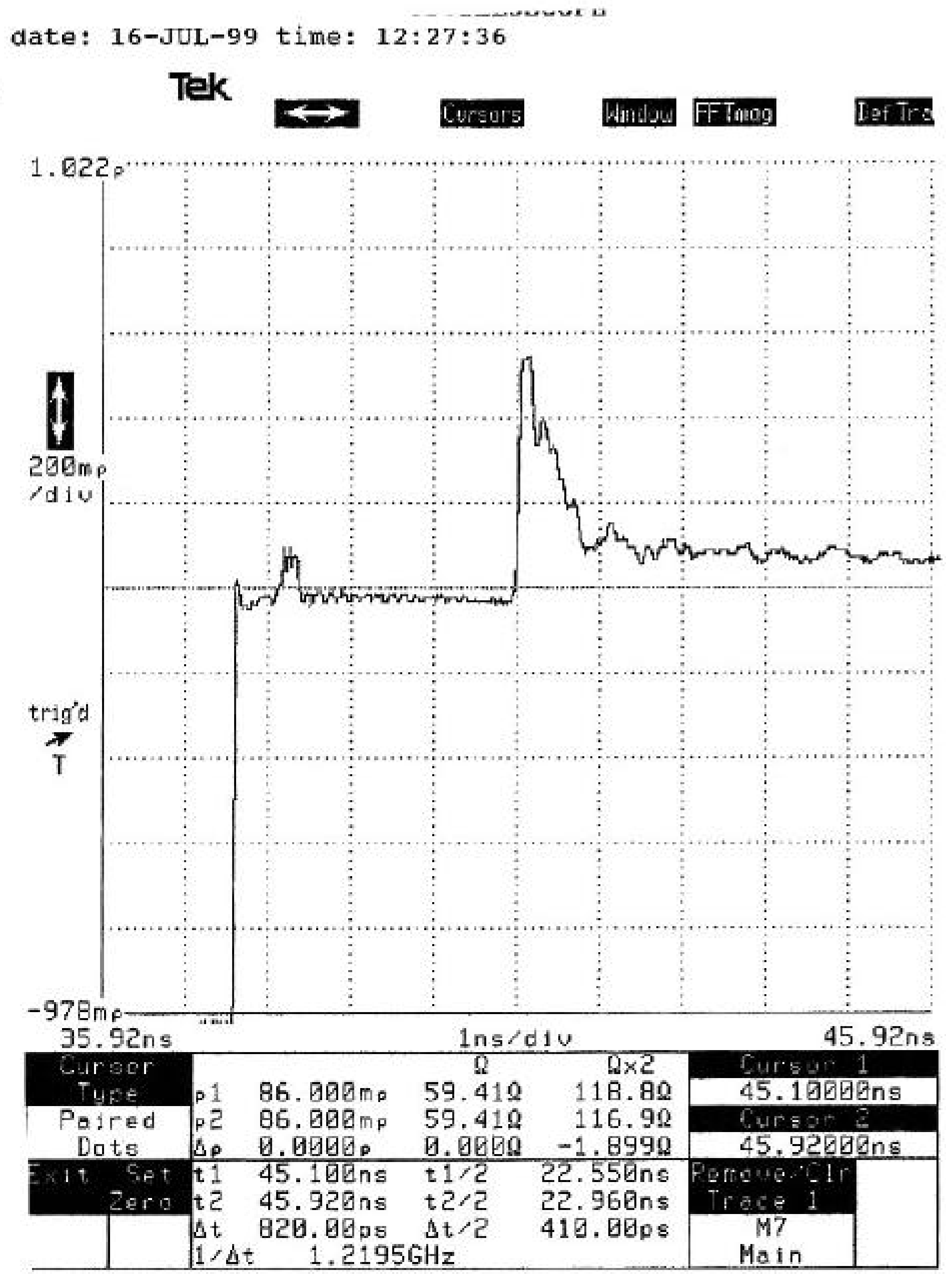


**Figure 3: This waveform shows the TDR pulse, a small ripple at the probe connection, and a large ripple at the connector/cable junction. Measurements for the cable's impedance were taken at the far right of the screen.**

- Common-Mode TDR

A single-ended probe was connected to both pins 1 and 26 on the 50-pin AMP connector. These pins correspond to the adjacent pair of differential signal conductors. The shield was connected to the other end of the TDR probe. TDR measurements were taken (see figure 4 below), yielding a characteristic impedance value of 31 +/- 3 ohms.

Pin 13 was then shorted to the shield. Pins 1 and 26 are the first two conductors on one end of the cable, and pin 13 corresponds to the conductor furthest from that differential pair of conductors, but still on the same side of the cable split (in the same group of 25 conductors). TDR measurements indicated no change in cable impedance.

The single ended probe was then soldered to pins 12 and 37, leaving pin 13 shorted to the shield. Pins 12 and 37 correspond to the differential conductor pair adjacent to each other and also adjacent to the shorted conductor (pin 13) on the ribbon cable. A slight change in characteristic impedance was noticed (see figure 5 below), yielding a value of 34 +/- 3 ohms.

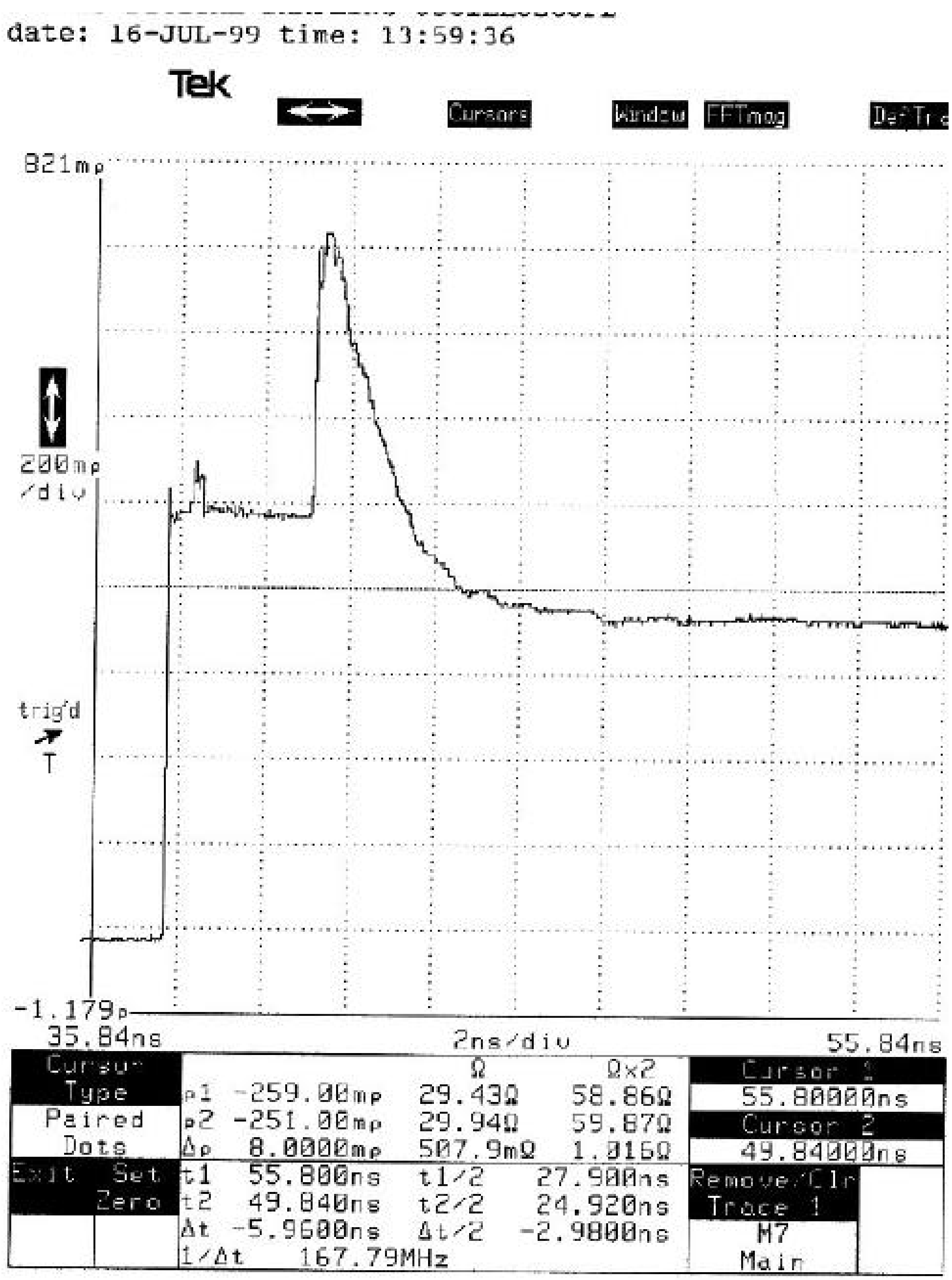


**Figure 4: This figure shows the common-mode impedance measurement of a differential pair of conductors without the end conductor (pin 13) being shorted. The large reflection indicates the connector/ribbon cable boundary. The cable's characteristic impedance measurements were taken to the far right of the screen.**

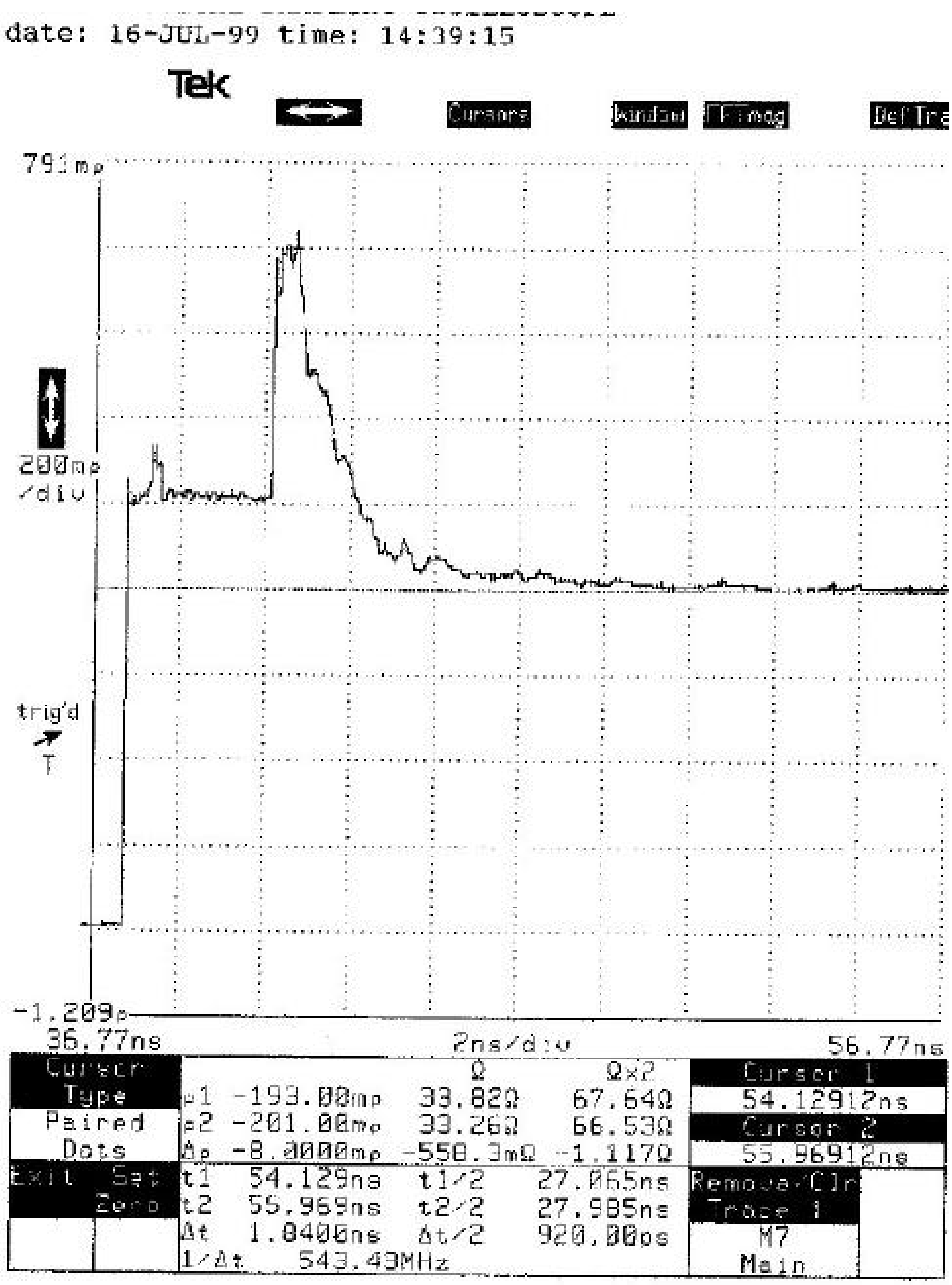


**Figure 5: This figure clearly shows the common-mode characteristic impedance of the differential pair of conductors adjacent to the shorted conductor. Compare this with figure 4, which shows a very similar TDR measurement for the differential pair furthest from the conductor shorted to the shield.**

Results:

The differential TDR of two adjacent conductors produced a differential impedance measurement of approximately 104 +/- 2.5 ohms. The manufacturer's specification is 104 ohms. As expected, no change in characteristic impedance was observed when the 26-pin connector pins carrying the differential signal were terminated with a 100-ohm resistor.

The impedance measurement of the single conductor being driven against the shield and adjacent conductors was approximately 59 ohms. The manufacturer's specification is 53 ohms.

The manufacturer does not specify the common-mode impedance. The common-mode impedance for a differential pair of conductors and the shield was measured to be 31 ohms, +/- 3 ohms. No change in impedance for this measurement was noticed when the end-conductor (pin 17) for that group of 25 conductors (at the split cable end) was shorted to the shield. This is a conductor in the cable that can be used to carry ground reference or shield current.

When the closest differential-pair of conductors to this shorted end-conductor (pin 17) were driven against it, a small change in the range of +3 to 4 ohms was indicated, giving a characteristic impedance of 34 ohms +/- 3 ohms. This change is visible when comparing figures 4 and 5 above.

Conclusions:

1. The validity of our TDR measurements is proven by the fact that our characteristic impedance measurements for differential conductor pairs (balanced) and single-conductor (unbalanced) agree with manufacturer specifications.
2. A single resistor in the range of 30-35 ohms should be adequate to terminate the common-mode current return line to the differential driver.