Application Note AN-2017-1

How to test IEEE 1394b Firewire Cables with the Mohr CT100B and Mohr TS-4 Adapter

The Mohr CT100B TDR Cable Tester with a Mohr TS-4 Adapter can be used to find faults in IEEE 1394B (Firewire) cables, inspect installations, check the quality of cables and connectors, and verify correct termination of the data pairs. This document describes how to perform these tasks.

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MOHR Test & Measurement LLC
2105 Henderson Loop, Richland, WA 99354
(888)852-0408 sales@mohrtm.com

Introduction

The Mohr TS-4 Adapter converts the single-ended signal of the Mohr CT100B into a differential signal. A single-ended test signal is a single electrical pulse going down one wire. A differential signal is two opposite pulses, one negative and one positive, going down a pair of wires. Single-ended and differential signals have different impedances, are affected by noise differently, and interact with other electrical components differently.

Differential cables, such as IEEE 1394b bus, use differential signals to send data. Differential cables are better investigated with a differential TDR, because the signal from the tester behaves the same as the data signals on the bus.

Prerequisites

The reader should be familiar with the basic operation of the Mohr CT100B TDR Cable Tester. In particular, the reader should know how to take a complete scan of a cable, move cursors, switch between cursors, read the measurements at the selected cursor, and change Vp.

See "Mohr Step-by-Step 1001: Scanning a Cable" for detailed instructions, and the "Mohr CT100B Operator's manual" for basic operation of the CT100B.

If using Mohr CT Viewer 2 software for Windows, the reader should be familiar with the basic operation of CT Viewer 2, including transferring saved traces from the CT100B.

Tools Needed

Mohr CT100B TDR

Mohr CT100B Metallic TDR Cable Tester is the highest performance portable TDR available. The original CT100 was the successor to the Tektronix 1502C; the CT100B is the latest generation of this product line.

Mohr TS-4 Firewire Adapter

The Mohr TS-4 1394B Balanced Firewire Switching Adapter converts an ordinary single-ended TDR test signal into a true differential TDR test signal on 1394B data pairs. A button toggles the adapter between the two Firewire data pairs. See Figure 1 for a picture of the Mohr TS-4.

Figure 1 Mohr TS-4 Firewire Adapter for IEEE 1394b

Mohr CT Viewer 2

Mohr CT Viewer is software for Microsoft Windows that is provided free with every CT100B. CT Viewer allows reviewing and storing saved traces and generating reports on a PC.

The screenshots in this document are from CT Viewer, however the CT100B is capable of performing every measurement on its own. CT Viewer is not a requirement for this process, although it makes viewing the results easier.

Example Configuration

For the examples and screen shots used in this document our test configuration consists of the following: a 30 foot Firewire cable, a six foot Firewire cable, a short Firewire coupler, and a Firewire computer card. The two cables are connected via the coupler and the terminating computer card is connected to the end of the six foot cable. See Figure 2 for a photo of the setup.

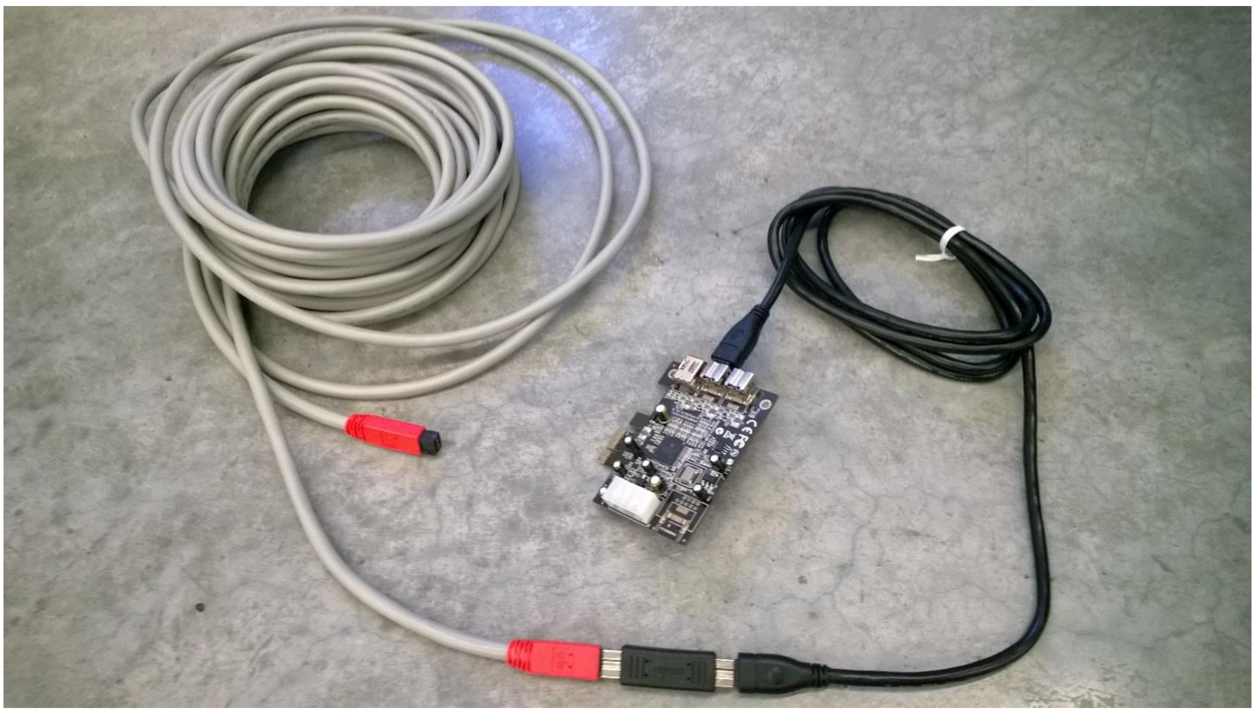

Figure 2 Test setup used for most of this document. A 30 foot cable is connected to a six foot cable, which terminates in a Firewire computer card. The test equipment, including the Mohr CT100B TDR and the Mohr TS-4 Adapter, are not shown.

Overview of a Firewire TDR Trace

See Figure 3 for an overview of a TDR trace of our test setup.

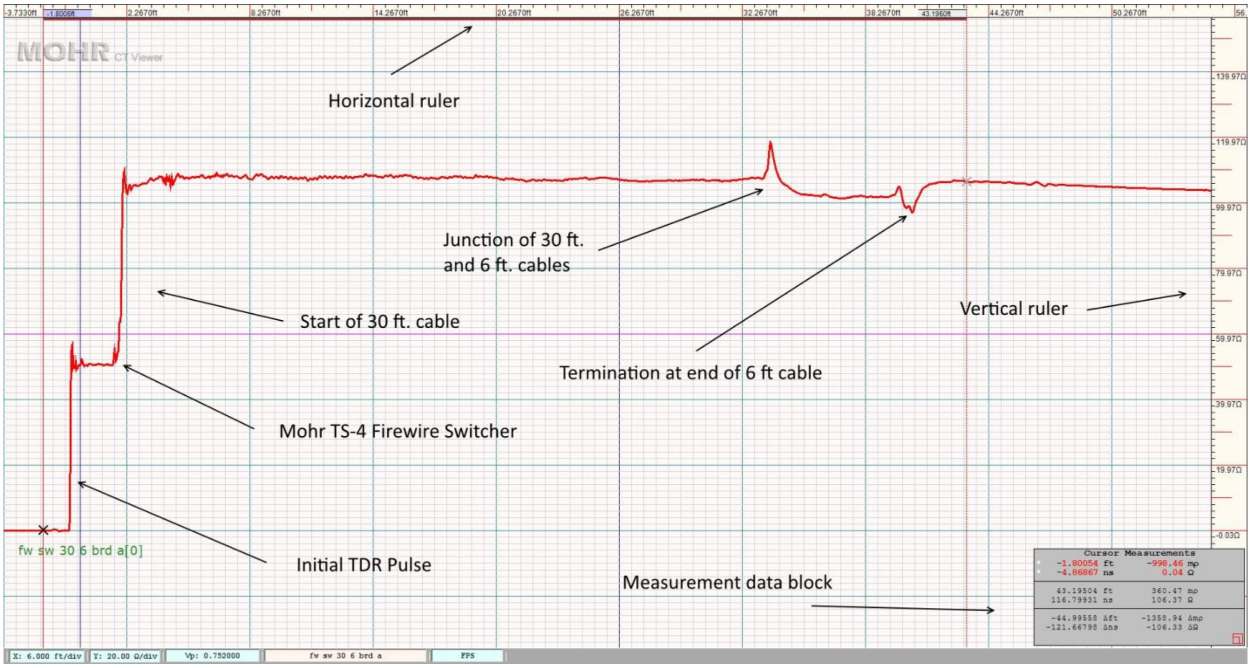

Figure 3 Overview of TDR Trace of the 30 ft to 6 ft Firewire setup.

Use Differential TDR to test the entire data pair at once

Data in a Firewire cable travels as a differential pulse down twisted pair conductors. With the TS-4 adapter, the CT100B creates a differential TDR test signal on a twisted pair that is similar to the Firewire data pulse. The resulting TDR trace will show problems on either conductor in the twisted pair. There's no need to test each conductor individually.

Save scans of the entire cable.

When inspecting a cable with the Mohr CT100B, save a scan of the entire cable.

1. Move one cursor to the left of the initial rise, and the other cursor well past the end of the cable run (as demonstrated in Figure 2).
2. Set the resolution to "Normal" from the main menu.
3. Press the SCAN button to go to the scan menu, and set the scan mode to "Cursor".
4. Start the scan.

For Firewire, the end of the run will either be a small reflection if the bus is terminated, or will be a large rising edge if the bus is disconnected.

Inspect both data pairs

A 1394B Firewire cable has two data pairs. Each of the two pairs of wires must be inspected independently. Use the button on the TS-4 Adapter to switch between the two pairs of a connected Firewire cable, and scan the full cable.

The result will be two separate scans, one for each Firewire data pair.

Inspecting Connections

Connectors, adapters, and splices will cause a small reflection in the TDR Trace. The larger the reflection, the greater the possibility it will interfere with Firewire data signals. The reflection shown in Figure 4 is from the mating adapter between the 30 foot and 6 foot Firewire cables.

Figure 4 Reflection at connector between 30 ft and 6 ft cables. The height of the reflection is about 11 ohms above the baseline. A damaged or poor connector would have a bigger reflection.

The Measurement

The critical measurement for a connection is the change in impedance from the incoming cable to the peak of the reflection. To measure this value, position one cursor at the peak of the reflection, and the other cursor on the cable before the connection. The delta Ohms reading will give the change in impedance from before the reflection to its peak.

Check the connector on both pairs of conductors.

Setting Criteria

Criteria for inspecting connections should be generated from scans of known good configurations. A criterion for a connector should therefore be a maximum allowable change in impedance to the peak of the reflection.

The proper criterion for a given reflection depends on the position of that reflection in the TDR trace. Any TDR reflection will weaken with distance, as the test signal is gradually attenuated along a cable. A connector will cause a larger reflection if it is closer to the TDR. See Figure 5 for a comparison of reflections from the same connector, one in which the connector is 6 feet from the TDR, while it is 30 feet from the TDR in the other.

Note that the reflection closer to the TDR is not only larger, but also is more detailed. This phenomenon occurs in all electrical cables and effects all TDR measurements. For more information, please see Mohr document XXXXX "Distance and Attenuation in TDR Signals".

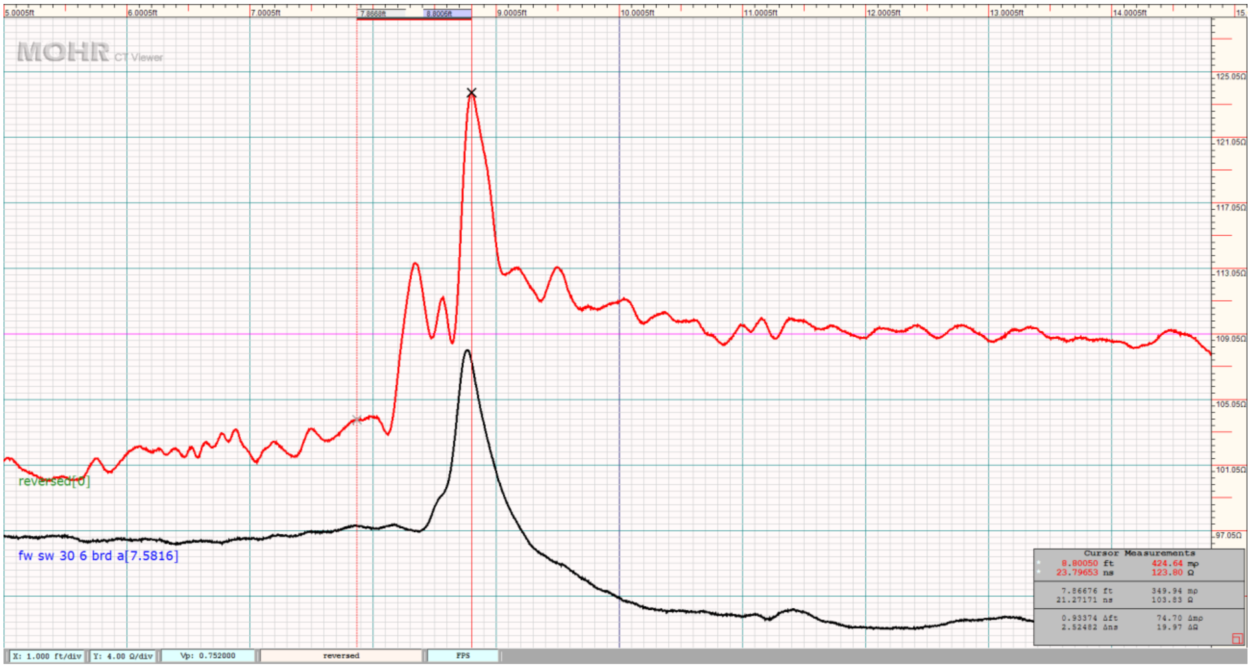

Figure 5 The red trace is reversed, with the 6 ft. cable connecting to the 30 ft. cable. The connector between the cables is closer to the TDR, leading to a larger, more detailed reflection.

Compare with Reference Scan

The most straight forward way to check a reflection is to compare it directly to a reflection from a reference scan created from a known good connection.

A connector with too much of reflection may be damaged, may be loose, or may be a poor quality connector.

Measuring Differential Impedance

Use the Mohr CT100B with the Mohr TS-4 Adapter to take a scan of the cable. Position a cursor in the middle of the trace of the cable. The impedance given at the cursor is the differential impedance. See Figure 6 for an example of an impedance measurement using CT Viewer.

Check the impedance of both Firewire data pairs.

There may be more than one cable in a cable run, as in the example configuration. Measure the impedance for each cable in the run separately. Their impedances are independent of each other.

The specified differential impedance for Firewire is 110 Ohms. Typical commercial cables can vary from 100 to 120 ohms.

Figure 6 Measurement of the differential impedance of the 30 ft. cable.

Checking Bus Termination

By specification, a 1394B Firewire bus should be terminated at 110 Ohms. The termination can, for example, be inside the computer that is the master of the 1394B bus. See Figure 7 for a TDR trace of the termination in a computer.

Figure 7 The region between the two cursors represents the end of the 6 ft. cable going through a connector into the termination in the computer card.

The termination will always generate a small reflection. The smaller reflection, the better. If a termination is properly impedance matched, then the TDR trace will return to near the specified impedance quickly after the reflection.

To verify a good termination, check the change in ohms from before the reflection to the peak of the reflection, as with a connector. Criteria for reflection impedance will depend on the length of cable from the

Measure the impedance after the reflection. Position the cursor immediately after the TDR trace recovers from the correction. 110 Ohms +- 10 Ohms is our preliminary criterion for termination impedance.

Check the termination for both Firewire data pairs, as they are independent of each other.

Measuring Distance to Fault

Use the Mohr CT100B TDR Cable Tester and the Mohr TS-4 Firewire Adapter to measure the distance to faults in Firewire cables.

1. Set Vp, or pulse velocity of the cable. Commercial Firewire cables tested at MOHR had a Vp of 0.75.
2. Identify the fault in the trace. Faults appear as major deviations from the expected line in the trace. The deviation will depend on the type of fault. Some types of faults are described below.
3. Position a cursor at the start of the fault. The distance reading for the cursor will be the length of cable from the test port to the fault.

See “Mohr Step-by-Step 1002: Distance to Fault” for more detailed instructions.

Measuring Cable Vp

The error on a distance measurement to a fault can be no better than the error in the Vp setting of the TDR. Therefore, setting Vp is a critical step when measuring the distance.

Specified Vp can sometimes be found on web sites or data sheets. Vp can also be measured from a known length of cable:

1. Find and measure the physical distance of a section of cable, using ruler, measuring tape, etc.
2. Scan the cable with the Mohr CT100B TDR.
3. Position one cursor at the start of the cable, and the other at the end of the cable.
4. Change Vp until the delta distance between the two cursors matches the physical distance. The final value is the Vp of the cable.

See “Mohr Step-by-Step 1008: Velocity of Propagation (Vp)” for more detailed instructions.

Comparison with Single Ended TDR Measurements

Testing Firewire equipment without the Mohr TS-4 adapter has several drawbacks when compared with a differential measurement using the TS-4 adapter. See Figure 8 for a visual comparison.

- The reflection from the connection between the 30 ft. cable and the 6 ft. cable has a long tail in the single ended TDR trace that does not appear in the differential trace. This tail is so long that it obscures the entire trace for the 6 ft. cable.
- Differential signals are less noisy than single ended signals. The single ended TDR trace has multiple spikes picked up from local noise sources that are missing in the differential trace.
- The single ended trace cannot give a good impedance measurement for a differential cable. The impedances calculated with a single ended trace cannot be related to differential impedance, but the differential TDR trace measures the impedance directly.
- Because the single ended impedance is not the same as the differential impedance, the single ended TDR trace may show a large impedance change at the cable termination, even though the termination is good.

The Mohr TS-4 Firewire Adapter turns the single ended trace of the Mohr CT100B into a differential TDR trace.

Figure 8 Comparison of a differential TDR trace to a single ended TDR trace using the setup of Firewire cables. On the single ended trace, note the elongated tail for the connection between the cables, the extra noise, and the grossly innacurate impedance values

Checking 1394A

1394A is a slower Firewire specification than 1394B. 1394A commercial systems usually use the 6-pin Firewire connector. The TS-4 adapter has a 9-pin 1394B connector. A 9-pin to 6-pin adapter or launch cable can be used to attach to a 1394A bus.

The same techniques for testing 1394B can be applied to 1394A.