

TDR Tutorial

February 24, 2018

1 Single Ended TDR

1. Turn on the oscilloscope and put it into TDR Mode.

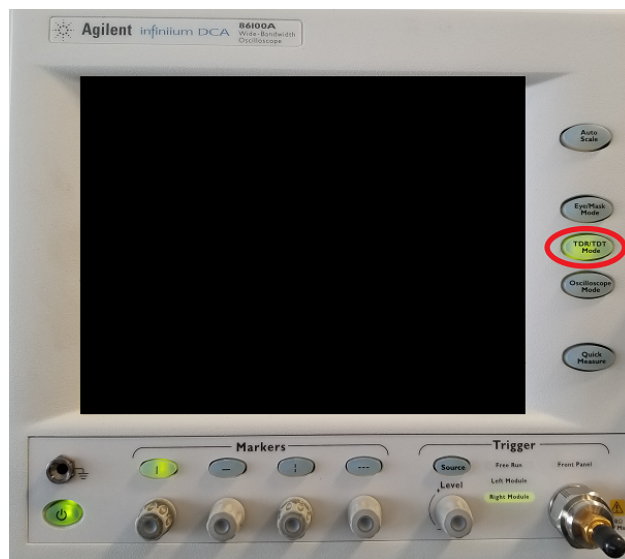


Figure 1:

2. Attach 3.5mm cable to channel 3 on the module on the right side of the oscilloscope.



Figure 2:

3. Select TDR/TRT setup. In the window that pops up. Ensure that stimulus is set to channel 3.
4. Add a marker to measure impedance and time delay. The time delay that is displayed with the marker is the round trip delay. In order to find the time it took the signal to reach that point, divide this time by two.

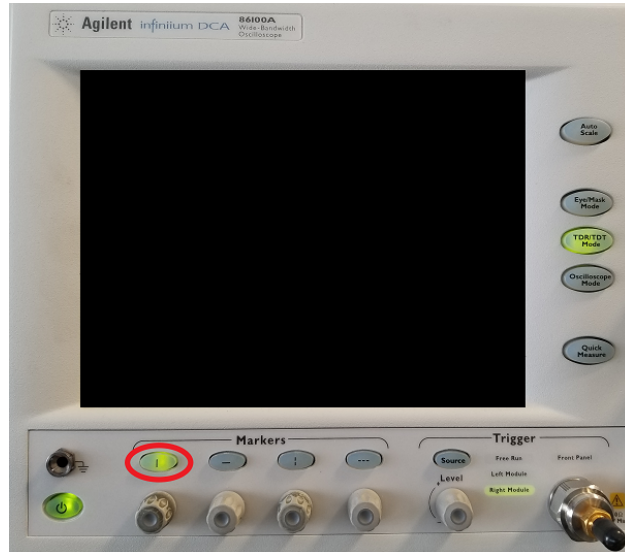


Figure 3:

2 Differential TDR

1. Turn on the oscilloscope and put it into TDR Mode.
2. Attach 3.5mm cable to both channels 3 and 4 on the module on the right side of the oscilloscope.
3. Select TDR/TRT setup. In the window that pops up, select “Common Mode” or “Differential”.
4. Add markers to measure impedance and time delay along the line. You can select either channel 3 or 4 to measure.

3 TDT

1. Turn on the oscilloscope and put it into TDR Mode.
2. Attach 3.5mm cable to both channels 3 and 4 on the module on the right side of the oscilloscope.
3. Select TDR/TRT setup. In the window that pops up, set stimulus to channel 3.
4. Set the destination to channel 4. This ensures the oscilloscope is prepared to receive a TDR pulse in channel 4.
5. Connect the cable from channel 3 to the input of your device, and channel 4 to the output of your device.
6. Add markers to measure impedance and time delay along the line. You can select either channel 3 or 4 to measure.

4 Saving Data

1. Insert 3.5in floppy disk into slot on the upper right of the machine.
2. Go to **File > Save > Waveform...**
3. Select the drop down icon next to “Look in:” and select “3.5 Floppy (A:)”.
4. Name your file.
5. Select which waveform to save (if 1-port TDR, most likely Channel 3).
6. Select file type as “Waveform Files(verbose)(*.txt)”
7. Press save.
8. This file contains a header with some information about the data that was taken. Important entries include points, XInc, and XOrg. These values correspond to the number of samples taken, the time step between each sample, and the time offset. Different measurements may have different time steps and time offsets so its important to adjust for that if plotting data in an external tool.

5 Example Single Ended TDR Measurements

5.1 Measurement of Non-Terminated Cable

It is important to first measure the cable we are using in order to find the time delay associated with it. We can use this measurement to calibrate out the effect of the cable in future measurements. Shown below is the plot of the measurement of the unterminated cable, including the offset in time specified in the .txt file. This result makes sense since the cable is naturally terminated with an open termination. An open termination results in a positive reflected wave, which adds to the original step function. Using the markers, we are able to determine the round trip delay of the cable to be $62.11ns - 51.56ns = 10.55ns$.

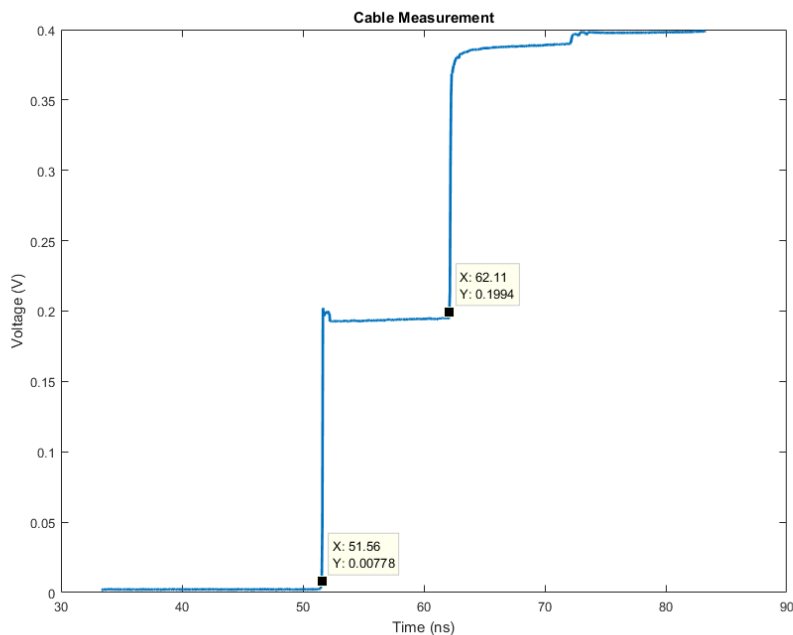


Figure 4: Cable Measurement

5.2 Measurement of a Terminated Cable

In this section we will show a measurement of the cable with different calibration standards attached. We see the expected behavior for each one: the open results in a positive reflected wave, the short results in a negative reflected wave that cancels the original, and the match results in no reflected wave.

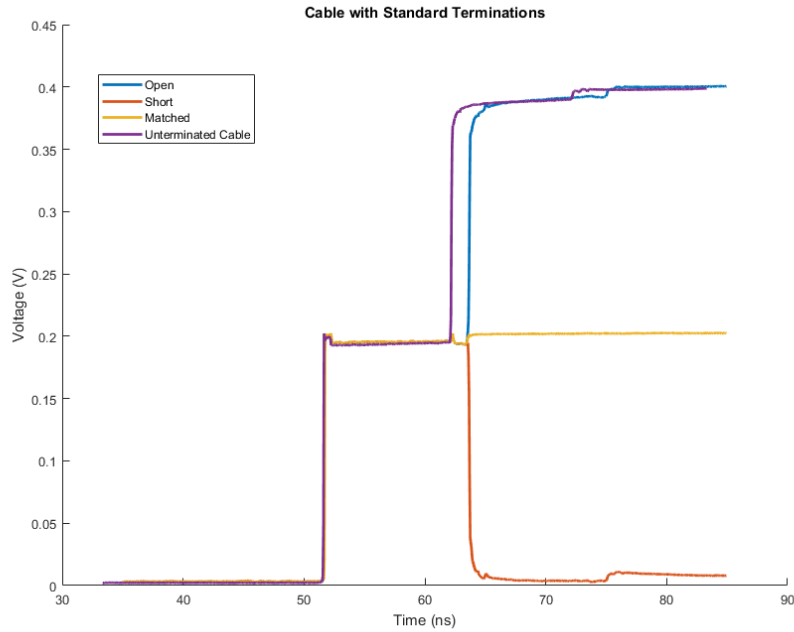


Figure 5: Cable with Standard Terminations

If we look closely, we can see that adding the termination creates a small spike in the responses in all three cases. This can be attributed to the connector. Another interesting observation is that the load itself seems to add a slight amount of delay to the response. This is because it contains a different dielectric that reduces the speed of the wave. The termination adds an extra $63.41ns - 62.06ns = 1.35ns$ of round trip time to the measurement.

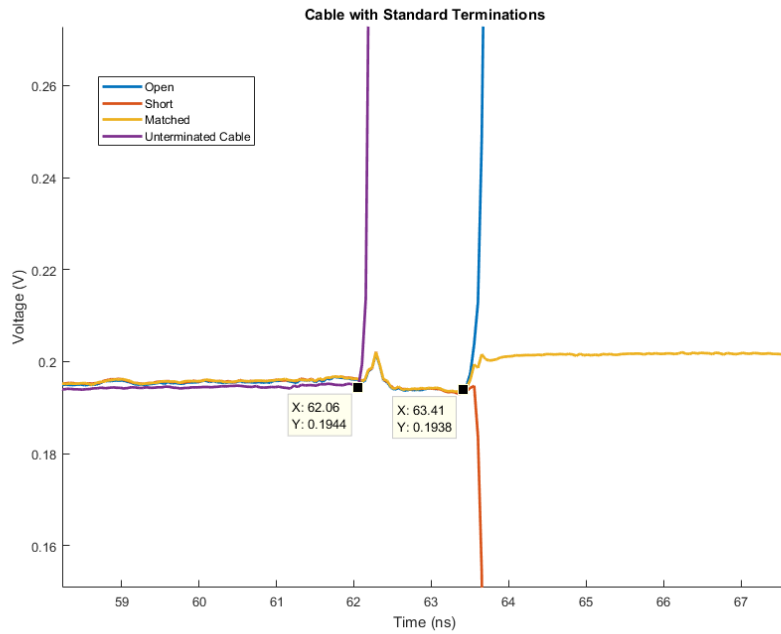


Figure 6: Cable Measurement with Emphasis on Termination Connection

5.3 Measurement of Line with Discontinuities

In this section we will show an example measurement for a line with discontinuities. A discontinuous line contains one or more abrupt changes in characteristic impedance. Each interface will create a reflection. Shown below is an image of the device under test and the measurement results.

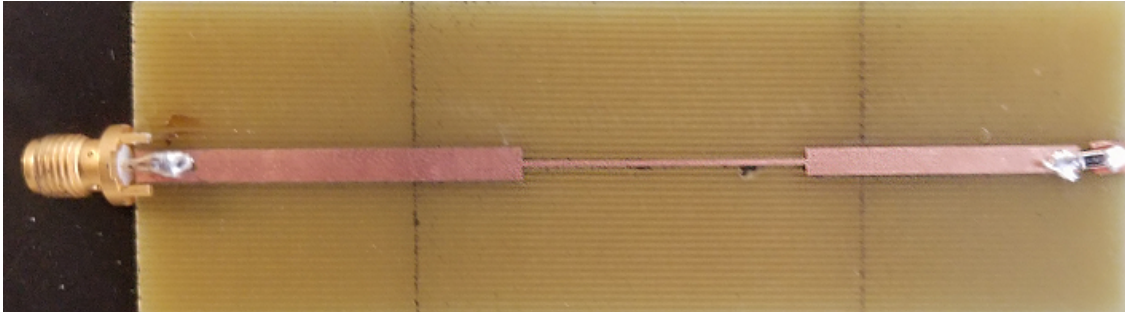


Figure 7: Image of DUT

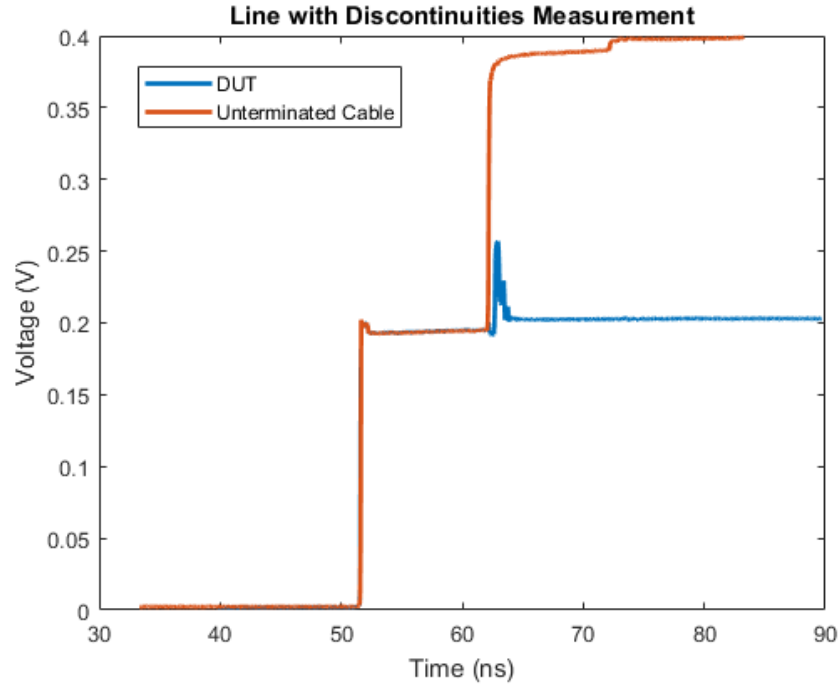


Figure 8: Line with Discontinuities Measurement

Below, there is a zoomed in and annotated plot of the measurement results. Important features of the measurement are indicated. Using this measurement, several things can be measured including the length of different segments of the transmission line (from time delay) and the impedance of each section (from reflected wave amplitude).

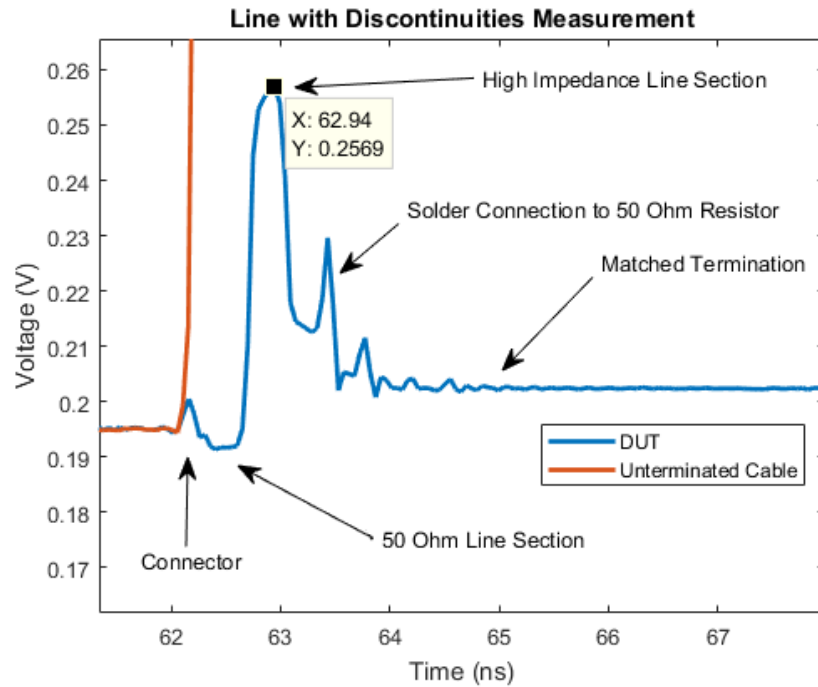


Figure 9: Line with Discontinuities Measurement with Emphasis on DUT