Accuracy Verification of Agilent's ENA Option TDR Time Domain Measurement using a NIST Traceable Standard

Application Note

Introduction

With the increase in bit rates and lower supply voltages, issues not seen in traditional digital systems arise. In order to solve these issues, more accurate measurements are required and vector network analyzer (VNA) based time domain reflectometry (TDR) measurements are gaining attention due to its wide dynamic range. The Agilent ENA Option TDR (E5071C-TDR) is application software embedded in the ENA network analyzer, which offers VNA based time domain analysis. The purpose of this application note is to verify the measurement accuracy of the E5071C-TDR by comparing the measurement result of the E5071C-TDR with the simulation results based on the NIST traceable data.

Description

The E5071C is a network analyzer, which provides a response of the device as a function of frequency. The TDR application software running on the E5071C converts the frequency response into a time response by computing the inverse fast Fourier transform.

Advanced Design System (ADS) is electronic design automation software for RF, microwave, and signal integrity applications. ADS can simulate the time domain waveform based on the characteristics of the system components. In order to compare the time domain responses extracted from E5071C-TDR and ADS, the 25 Ω air line from Agilent 85053B Verification Kit is used. This verification kit includes measurement data and uncertainties which are traceable to National Institute of Standards and Technology (NIST). Based on this NIST traceable data, the time domain waveform is generated in ADS.

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Measurement and Simulation

The E5071C with a frequency range up to 20 GHz was selected for this comparison. A full 2-port calibration was performed using the N4433A electronic calibration module. For the calibration, a male to female adapter was used to accommodate the difference in connector gender between the calibration module and the 25 Ω air line. In order to remove the adapter characteristic from the calibration plane, the adapter removal feature was used. The risetime (10-90%) was set to 50 psec.

The ADS simulation was done based on the configuration shown in Figure 1. A CITI file that provides the frequency characteristics of the 25 Ω air line was loaded for the device, and VtPulse was used as a step pulse generator. The edge shape of the step pulse was set to Error Function Transition to recreate a finite risetime. The risetime was set to 111 psec, which corresponds to 50 psec for 10-90% risetime. In order to interpolate between the data points, the Cubic Spline or 1 model was used, which is a similar model employed on the E5071C.

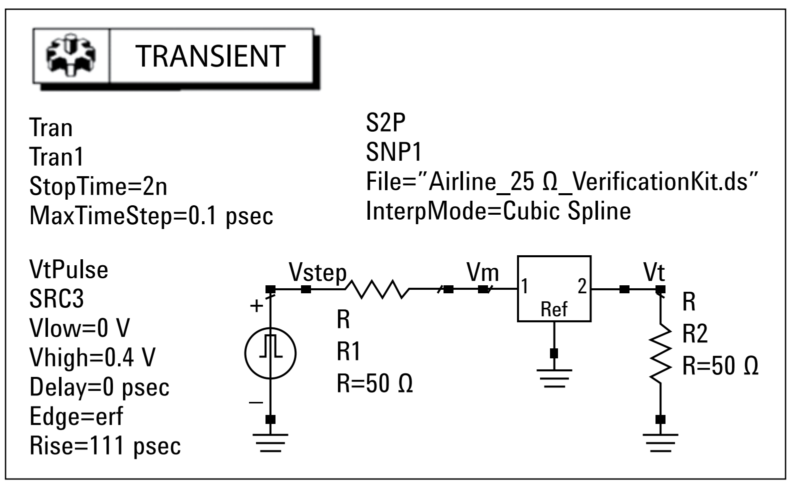

Figure 1. Configuration for ADS simulation

Results

Figure 2 shows the reflection waveforms extracted from the E5071C-TDR and ADS simulation. The two methods are highly comparable. The magnitude difference between the measured data and the simulation results are within 0.1 Ω in the range of 1.5 to 3.5 psec, which corresponds to the 25 Ω air line section.

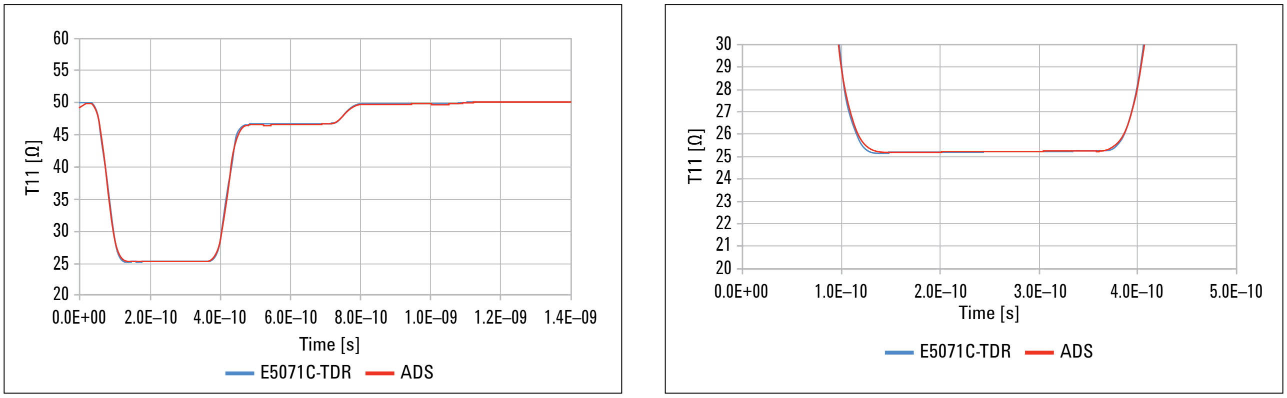

Figure 2. Reflection (TDR) waveform; overall view (left) and magnified view (right)

The transmission waveforms also matched well as shown in Figure 3. Comparisons are done in terms of voltage. The magnitude difference is within 2 mV, which is equivalent to 1% of full scale stimulus level.

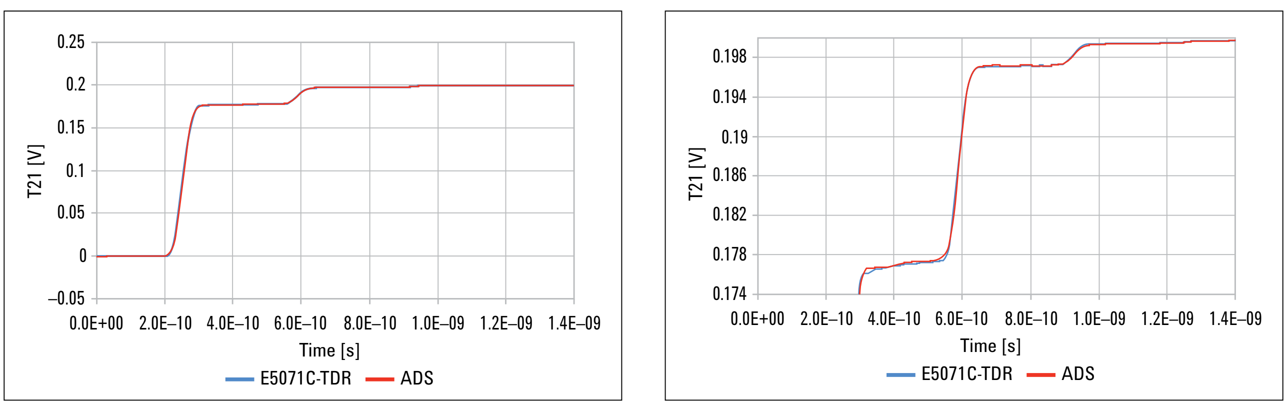

Figure 3. Transmission (TDT) waveform; overall view (left) and magnified view (right)

Figure 4 shows the eye diagrams from the E5071C-TDR and ADS. They are highly comparable as well as the TDR/TDT waveforms. The simulated eye diagrams were drawn by convolving transmission waveforms in Figure 3 with an internally generated bit pattern. The same bit pattern was used for comparison, which was pseudorandom binary sequence (PRBS) of 2^7-1 bit lengths, and the bit rate was set to 1 Gbps

1. *The TDT step amplitude setting is not the actual stimulus level input to the device, but is a normalization coefficient of the inverse Fourier transform calculation.*

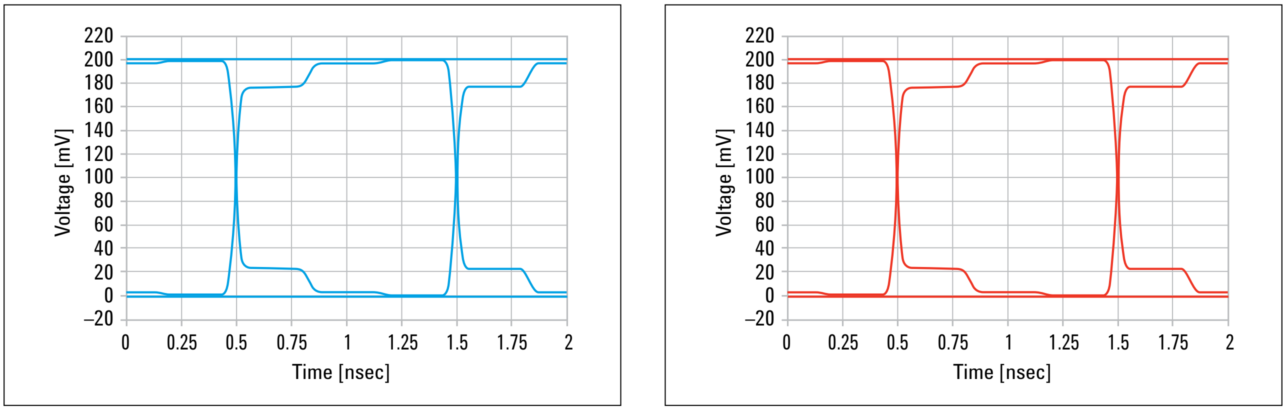

Figure 4. Simulated eye diagram; E5071C-TDR (left) and ADS (right)

Summary

In this application note, the time domain waveforms extracted from the E5071C-TDR and the ADS were compared using a device which is traceable to NIST. Both reflection and transmission waveforms measured by the E5071C-TDR are consistent with the simulation results obtained from the ADS, verifying the measurement accuracy of E5071C-TDR for time domain analysis.

Additional Resources

E5071C ENA Option TDR
www.agilent.com/find/ena-tdr

Advanced Design System
www.agilent.com/find/ads

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