Agilent Technologies

Thunderbolt Transmitter & Receiver (Tx/Rx) Compliance Test

Test Solution Overview Using the Agilent E5071C ENA Option TDR

Last Update 2013/06/18 (TH)

Purpose

• This slide will show how to make return loss measurements of **Thunderbolt Compliance Tests** by using the Agilent E5071C ENA Option TDR.

• The DUT includes:
  • Host/Device Transmitter (Return Loss)
  • Host/Device Receiver (Return Loss)

Reference Document

- Thunderbolt Interconnect Specification Revision 0.9.
- Thunderbolt Transmitter, Receiver, and Return Loss Compliance Testing Method of Implementation (MOI) Using Agilent Instrumentation Revision 0.9 (provided by Granite River Labs Inc.)

Thunderbolt Tx/Rx Compliance Test Solution

Solution Overview

•The ENA Option TDR performs measurements in both time and frequency domains.

Traditional Solution

New Solution

Frequency Domain
•Differential Return Loss (Sdd11, Sdd22)

Time Domain
•Differential Impedance (Informative, Tdd11, Tdd22)

Vector Network Analyzer (VNA)

TDR Scope

•**ALL** parameters can be measured with **ENA Option TDR**

One-box Solution !!

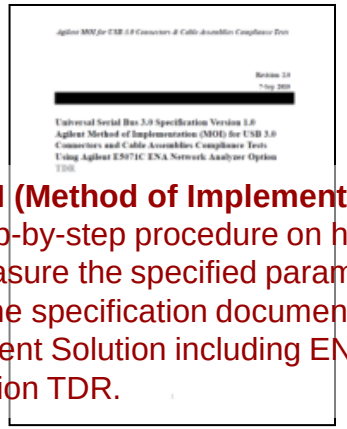
Thunderbolt Tx/Rx Compliance Test Solution

ENA Option TDR Solution

- ENA Mainframe
  - E5071C-480: 4-port, 9 kHz to 8.5 GHz
  - E5071C-485: 4-port, 100 kHz to 8.5 GHz
  - E5071C-4D5: 4-port, 300 kHz to 14 GHz
  - E5071C-4K5: 4-port, 300 kHz 20 GHz
- Enhanced Time Domain Analysis Option (E5071C-TDR)
- ECal Module
  - N4431B for E5071C-480/485
  - N4433A for E5071C-4D5/4K5

- Method of Implementation (MOI) document and state files for the E5071C-TDR is available (*) for easy setup and measurements of compliance testing.

* Contact Agilent sales representative for more detail.

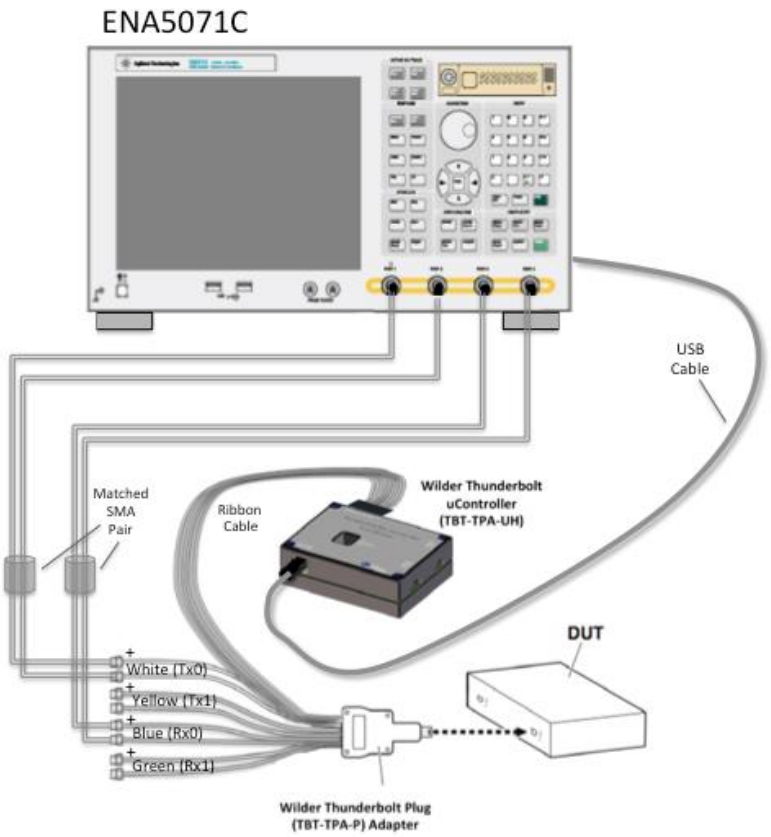


MOI (Method of Implementation)
Step-by-step procedure on how to measure the specified parameters in the specification document using Agilent Solution including ENA Option TDR.

ENA Option TDR Compliance Page: www.agilent.com/find/ena-tdr_compliance

Thunderbolt Tx/Rx Compliance Test Solution

Test Setup of Return Loss Measurements



Test Fixture

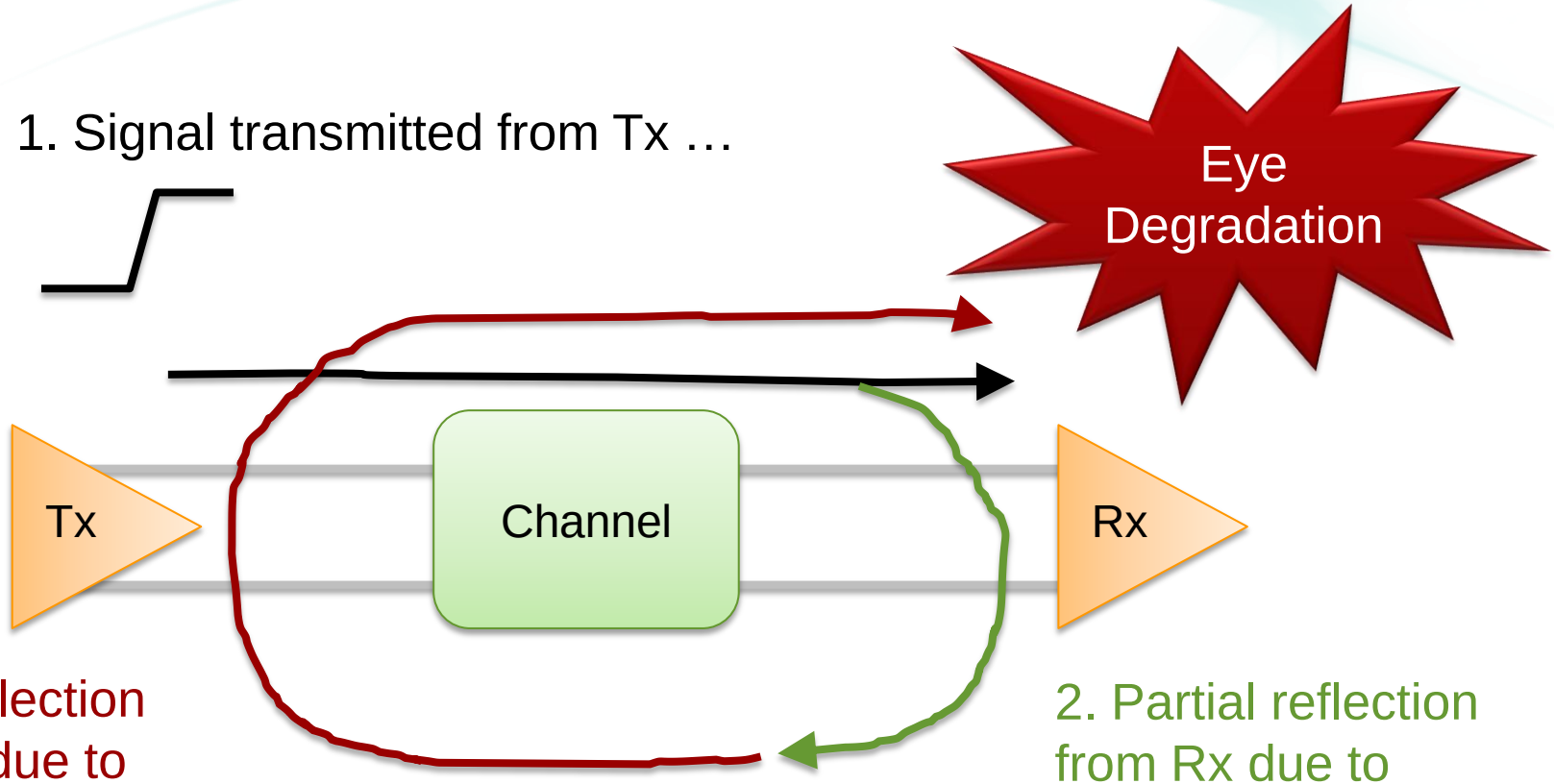
A Wilder TF-TB-TPA-P Thunderbolt Plug Test Adapter and two sets of low loss 50-Ohm matched pair cables are used, one pair for each transmit lane. Wilder test fixtures are available from www.wilder-tech.com.

Micro-Controller Board

A Wilder TF-TB-TPA-PU Thunderbolt Micro-Controller Board is used to communicate with the DUT and put it in the proper test mode.

Hot TDR Measurements

Why Measure?

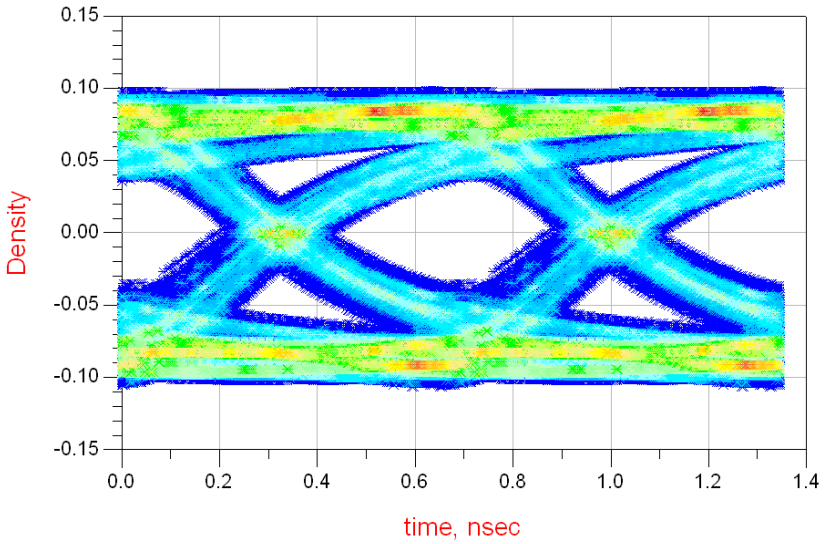


•Typically, impedance of device in OFF state and ON state (Hot TDR) is significantly different.

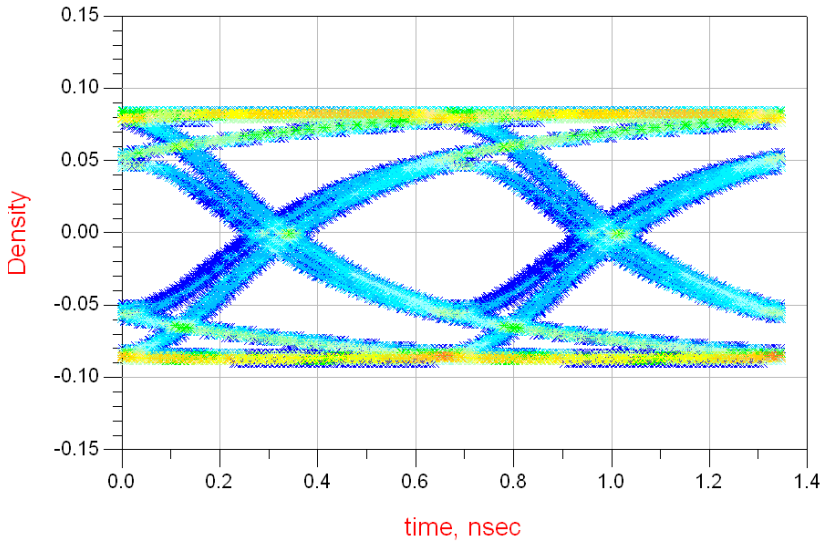
Hot TDR Measurements

Why Measure?

Source Termination Effects



Source Impedance **NOT** Matched



Source Impedance Matched

Hot TDR Measurements

Thunderbolt

4.6.1 Host/Device Transmitter Compliance Specifications

•The Thunderbolt Host/Device Transmitter must be driving **PRBS31** pattern during the compliance testing.

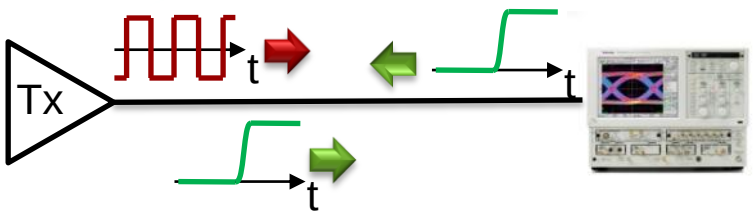
4.8.2 Dongle Transmitter Compliance Specifications

•The Thunderbolt dongle transmitter must be driving **PRBS31** test pattern during the compliance testing.

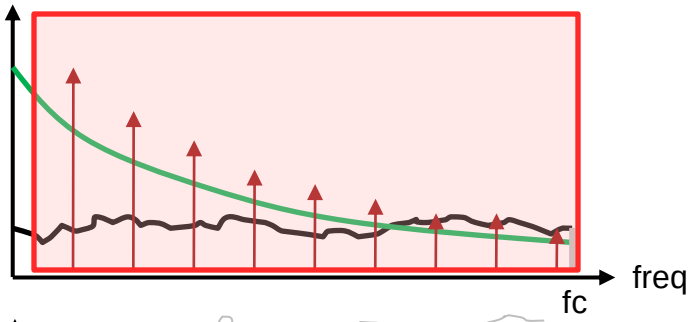
Advantages of ENA Option TDR for Hot TDR

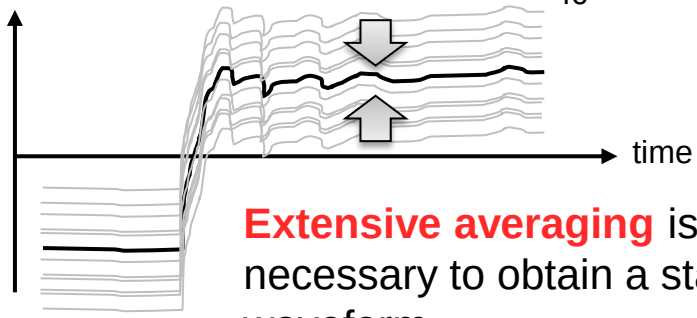
Fast and Accurate Measurements

TDR Scopes



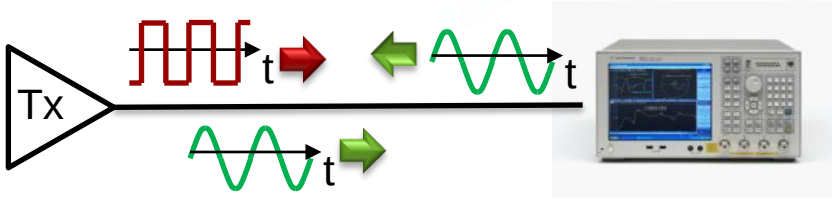
•**wideband receiver** captures all of the signal energy from the transmitter



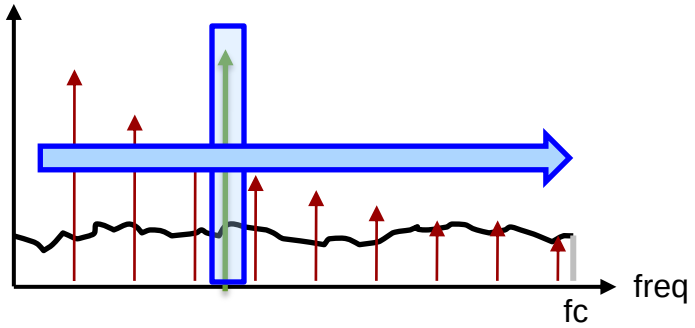


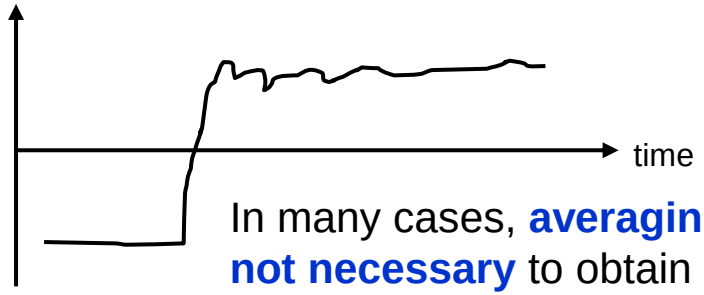
Extensive averaging is necessary to obtain a stable waveform.

ENA Option TDR



•**narrowband receiver** minimizes the effects of the data signal from the transmitter





In many cases, **averaging is not necessary** to obtain a stable waveform.

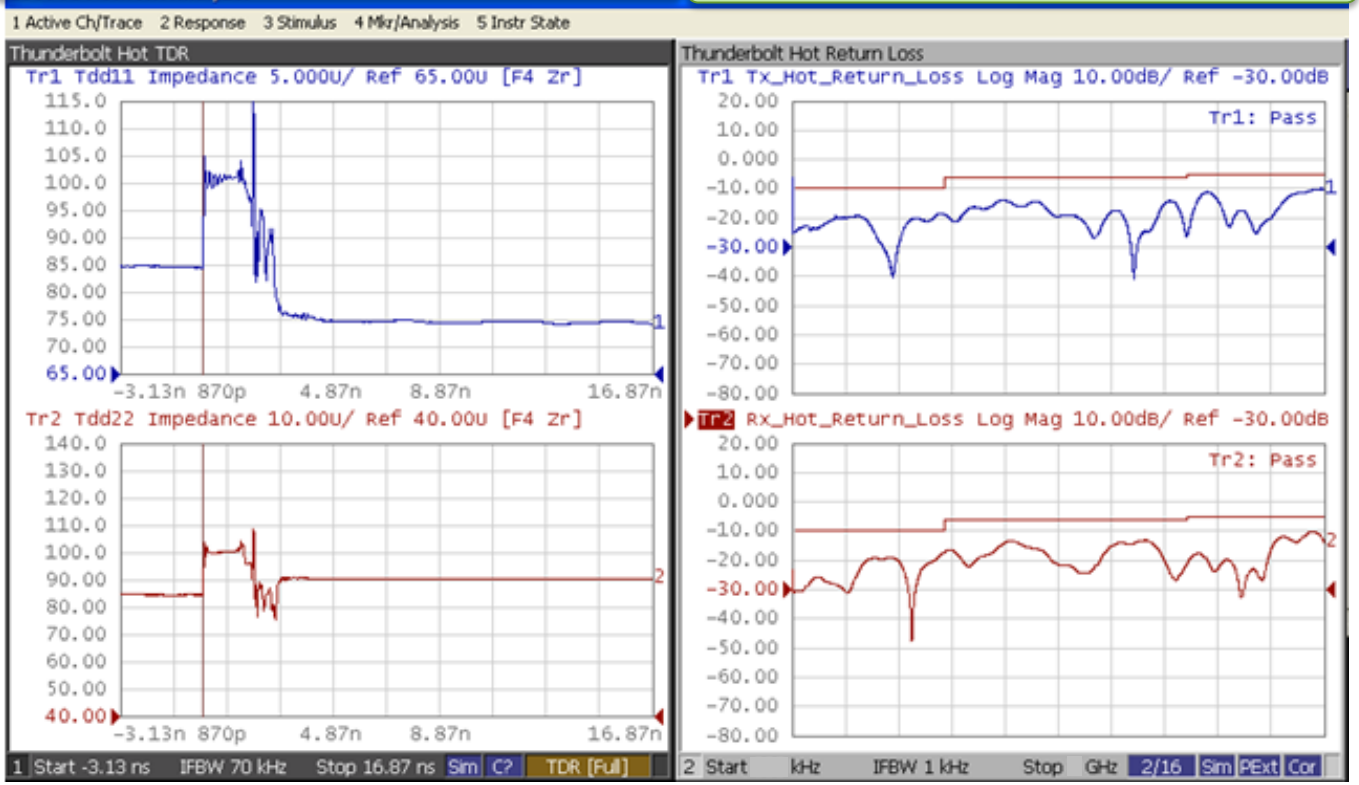
Thunderbolt Tx/Rx Compliance Test Solution

Measurement Parameters

ENA Option TDR Compliance Testing Solution is one-box solution which provides complete characterization of interconnects (time domain, frequency domain.)

Time Domain

Frequency Domain



ENA Option TDR Compliance Test Solution

Certified MOIs

Compliance test solutions (i.e. Certified MOIs) with the ENA Option TDR are available at:
www.agilent.com/find/ena-tdr_compliance

Cable / Connector

- SuperSpeed USB — Time & Frequency
- HDMI — Frequency
- SATA — Time & Frequency
- DisplayPort — Time & Frequency
- 10GBASE-T — Time & Frequency
- MHL — Time & Frequency
- PCI Express — E5071C ENA Network Analyzer with Option TDR

More Standards Currently Under Investigation

Transmitter/Receiver (Hot TDR)

- SATA — Time & Frequency
- MIPI Alliance — Time & Frequency
- Thunderbolt — Time & Frequency *

* Contact Agilent sales representative for more detail about Thunderbolt compliance test solution using the ENA Option TDR.

ENA Option TDR Compliance Test Solution

Certified Test Centers using ENA Option TDR

Test Centers Support ENA Option TDR

ENA Option TDR is used world wide by certified test centers of USB, HDMI, DisplayPort, MHL, Thunderbolt and SATA.

Thunderbolt Tx/Rx Compliance Test Solution
Summary

ENA Option TDR Compliance Testing Solution is ….

- ***One-box solution*** which provides complete characterization of high speed digital interconnects (time domain, frequency domain, eye diagram)
- ***Fast and Accurate*** output impedance measurements of transmitters in operating mode **(Hot TDR / Hot Return Loss)**
- Adopted by test labs worldwide

Additional Resources

- **Method of Implementation (MOI)**

www.agilent.com/find/ena-tdr_compliance

- **ENA Option TDR Reference Material**

www.agilent.com/find/ena-tdr

- Technical Overview (5990-5237EN)
- Application Notes
  - Correlation between TDR oscilloscope and VNA generated time domain waveform (5990-5238EN)
  - Comparison of Measurement Performance between Vector Network Analyzer and TDR Oscilloscope (5990-5446EN)
  - Effective Hot TDR Measurements of Active Devices Using ENA Option TDR (5990-9676EN)
  - Measurement Uncertainty of VNA Based TDR/TDT Measurement (5990-8406EN)
  - Accuracy Verification of Agilent's ENA Option TDR Time Domain Measurement using a NIST Traceable Standard (5990-5728EN)

Questions?

Agilent VNA Solutions

Performance

PNA-X, NVNA
Industry-leading performance
10 M to 13.5/26.5/43.5/50/67 GHz
Banded mm-wave to 2 THz

PNA
Performance VNA
10 M to 20, 40, 50, 67, 110 GHz
Banded mm-wave to 2 THz

PNA-L
World's most capable value VNA
300 kHz to 6, 13.5, 20 GHz
10 MHz to 40, 50 GHz

Mm-wave solutions
Up to 2 THz

PNA-X receiver
8530A replacement

PNA Series

E5072A
Best performance ENA
30 kHz to 4.5, 8.5 GHz

E5071C
World's most popular economy VNA
9 kHz to 4.5, 8.5 GHz
300 kHz to 20.0 GHz

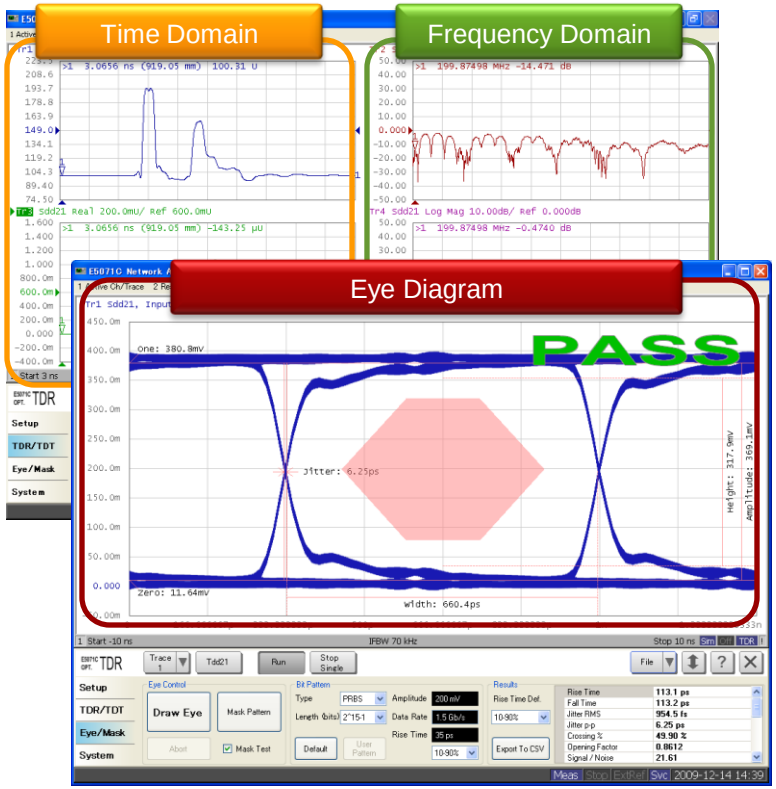
E5061B
NA + ZA in one-box
5 Hz to 3 GHz
Low cost RF VNA
100 k to 1.5/3.0 GHz

ENA Series

FieldFox
Handheld RF Analyzer
5 Hz to 4/6 GHz

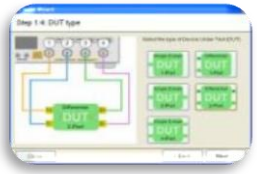
What is ENA Option TDR?

The ENA Option TDR is an application software embedded on the ENA, which provides an **one-box solution** for high speed serial interconnect analysis.

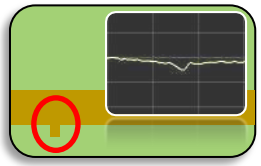


3 Breakthroughs

for Signal Integrity Design and Verification



Simple and Intuitive Operation



Fast and Accurate Measurements

ESD Robustness

What is ENA Option TDR?

[Video]

Agilent ENA Option TDR

Changing the world of Time Domain Reflectometry (TDR) Measurements

- www.youtube.com/watch?v=hwQNlyyJ5hI&list=UUAJAjd97CfnCehC4jZAfkxQ&index=20&feature=plcp
- www.agilent.com/find/ena-tdr

Additional Resources

•ENA Option TDR Reference Material

www.agilent.com/find/ena-tdr

•Technical Overview (5990-5237EN)

•Application Notes

- •Correlation between TDR oscilloscope and VNA generated time domain waveform (5990-5238EN)
- •Comparison of Measurement Performance between Vector Network Analyzer and TDR Oscilloscope (5990-5446EN)
- •Effective Hot TDR Measurements of Active Devices Using ENA Option TDR (5990-9676EN)
- •Measurement Uncertainty of VNA Based TDR/TDT Measurement (5990-8406EN)
- •Accuracy Verification of Agilent's ENA Option TDR Time Domain Measurement using a NIST Traceable Standard (5990-5728EN)

•Method of Implementation (MOI) for High Speed Digital Standards

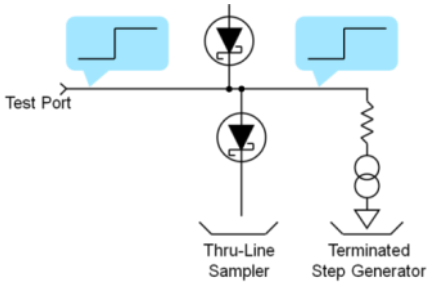
www.agilent.com/find/ena-tdr_compliance

Advantages of ENA Option TDR for Hot TDR

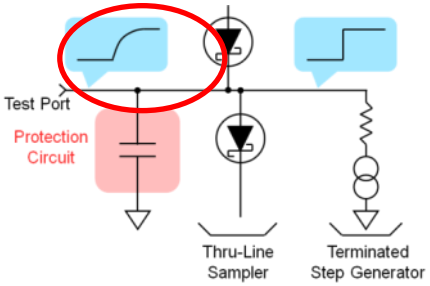
ESD Robustness

TDR Scopes

TDR scopes are sensitive to ESD.



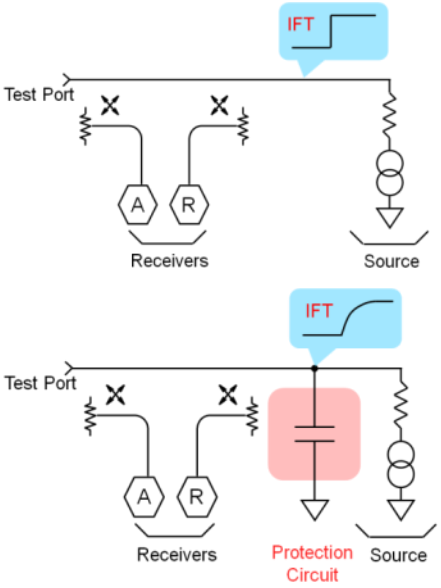
Implementing a protection circuit is difficult, because it will slow down the rise time of the step stimulus.

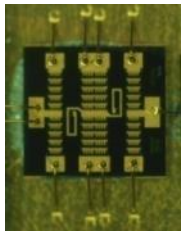


ENA Option TDR

ENA Option TDR has higher robustness against ESD, because protection circuits can be implement more easily.

ENA Option TDR measures the vector ratios of the transmitted and received signals. Therefore, the effects of the protection circuit will be canceled out.





Proprietary ESD protection chip significantly increase ESD robustness, while at the same time maintaining **excellent RF performance** (22ps rise time for 20GHz models).