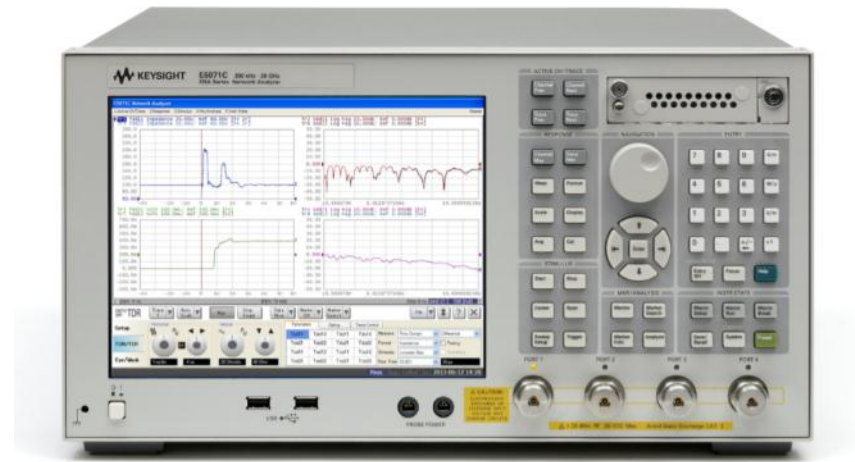# MIPI Tx/Rx Interface S-parameter & Impedance Measurements with ENA Option TDR

Component Test Division - Kobe

October 2014

KEYSIGHT
TECHNOLOGIES

Purpose

- This slide will show how to make measurements of MIPI Tx/Rx Interface S-parameter & Impedance Measurements Conformance Tests by using the Keysight E5071C ENA Option TDR.

Keysight Digital Standards Program

Our solutions are driven and supported by Keysight experts involved in international standards committees:

- Joint Electronic Devices Engineering Council (JEDEC)
- PCI Special Interest Group (PCI-SIG®)
- Video Electronics Standards Association (VESA)
- Serial ATA International Organization (SATA-IO)
- **High-Definition Multimedia Interface (HDMI)**
- USB-Implementers Forum (USB-IF)
- Mobile Industry Processor Interface (MIPI) Alliance
- Optical Internetworking Forum (OIF)
- Mobile High-Definition Link (MHL) Consortium

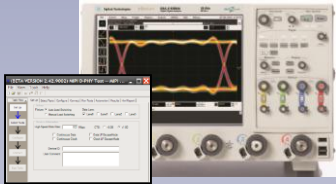We're active in standards meetings, workshops, plugfests, and seminars

Our customers test with highest confidence and achieve compliance faster

Keysight MIPI D-PHY and M-PHY Solution Coverage

Transmitter Characterization

DSAQ93204A Infiniium

U7238A D-PHY app
U7249A M-PHY app

InfiniiMax Probes

N2809A PrecisionProbe

Industry's highest analog bandwidth, lowest noise floor/sensitivity, jitter measurement floor with unique cable/probe correction

Receiver Characterization

N4903B JBERT

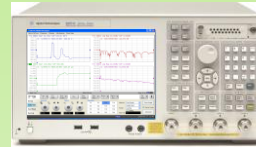Option A02 Receiver SER Analysis

81250A ParBERT
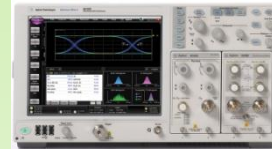

N5990A Automated characterization

Highest precision jitter lab source with automated compliance software for accurate, efficient, and consistent measurement

Impedance/Return Loss Validation

E5071C ENA Option TDR

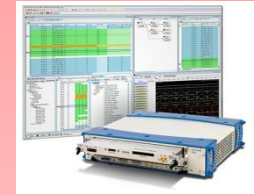DCA 86100D Wideband sampling oscilloscope

54754A TDR/TDT

Precision impedance measurements and S-Parameter capability

Protocol Stimulus and Analysis

U4421A CSI-2 / DSI Analyzer and Exerciser

Scope Protocol Decoder
N8802A CSI-2 / DSI
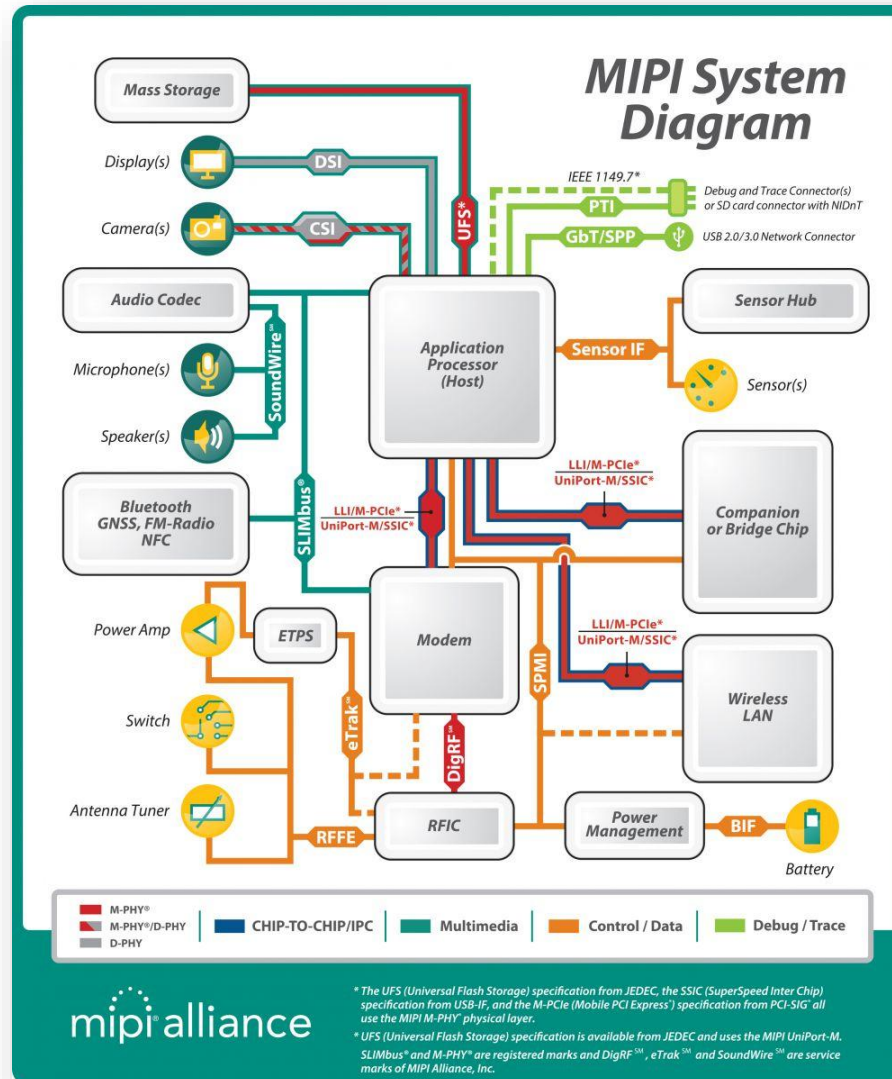N8807A DigRF v4
N8808A UniPro
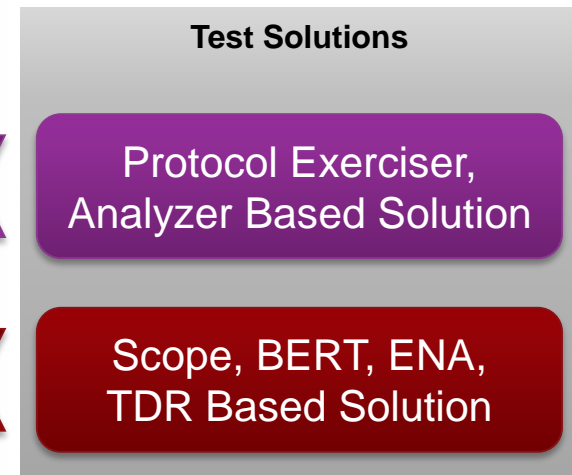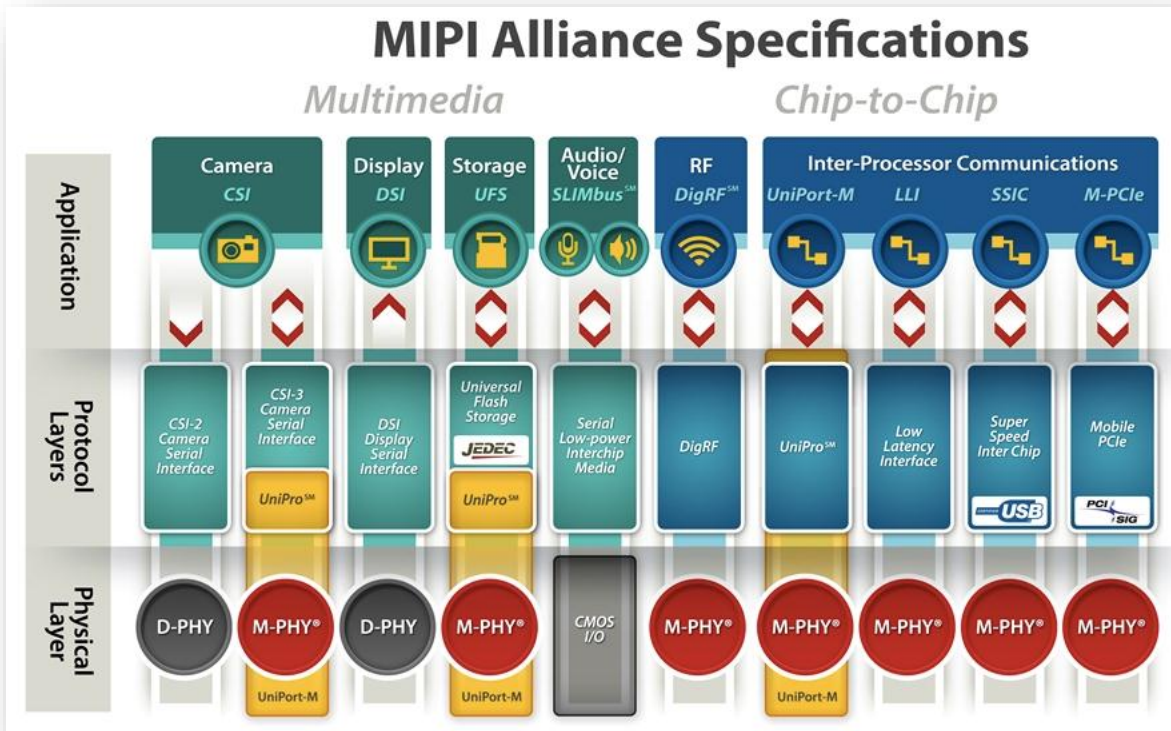N8818A UFS
N8809A LLI
N8824A RFFE

Fast upload and display, accurate capture, intuitive GUI and customizable hardware. Correlate physical and protocol layer.
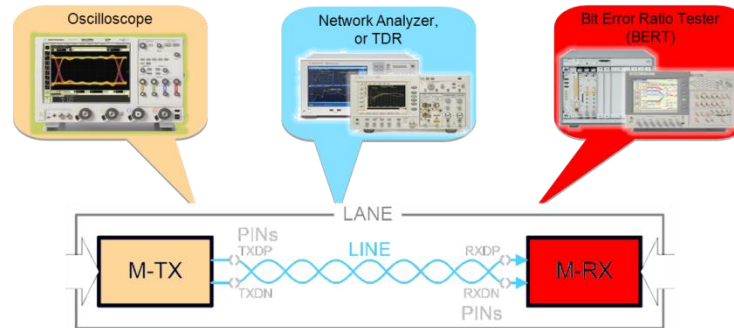
MIPI Interfaces in a Mobile Platform

MIPI Alliance Specifications and Test Solutions

PHY Conformance Test Suite(CTS) Requirements

Three test sections outlined in the CTS are:

- TX Timers and Signaling
  - Voltage, Eye-opening, Jitter, Rise/Fall time, Skew, Slew rate, etc

- RX Timers and Electrical Tolerances
  - Amplitude, Jitter, Termination, Skew tolerance, etc

- Interface S-parameters and Impedance
  - Return loss, impedance mismatch, etc

References

- MIPI Alliance Specification for M-PHY v3.0

- MIPI Alliance Conformance Test Suite for M-PHY Physical Layer v1.0

- MIPI Alliance Specification for D-PHY v1.1

- MIPI Alliance Conformance Test Suite for D-PHY Physical Layer v1.1 r03

KEYSIGHT
TECHNOLOGIES

Measurements for M-PHY

◆S-parameter Measurements

	Tx	Rx
Differential Return Loss	✓	✓
Common-mode Return Loss	✓	-

◆Impedance Measurements

	Tx	Rx
Single-Ended Output Resistance (DIF-N/DIF-P and Stall/Sleep state)	✓	-
Single-Ended Output Resistance Mismatch	✓	-
Differential Termination Resistance	-	✓

Measurement Equipment

DUT mounted on SMA-based Test Vehicle Board
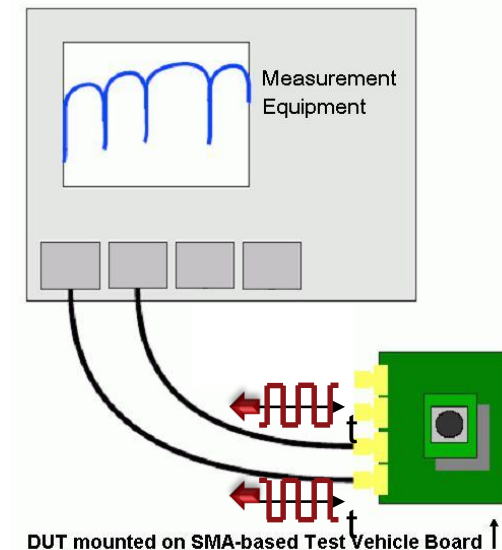
Power on and configure the DUT to force its M-TX into a continuously transmitting HS state, transmitting a continuous CRPAT repeating pattern.

Example Using ENA Option TDR

◆All Measurements in One Screen

VBA Macro automatically sets the limit lines for your desired parameters.

TDR application serves for trouble shooting with the simple and intuitive user-interface.
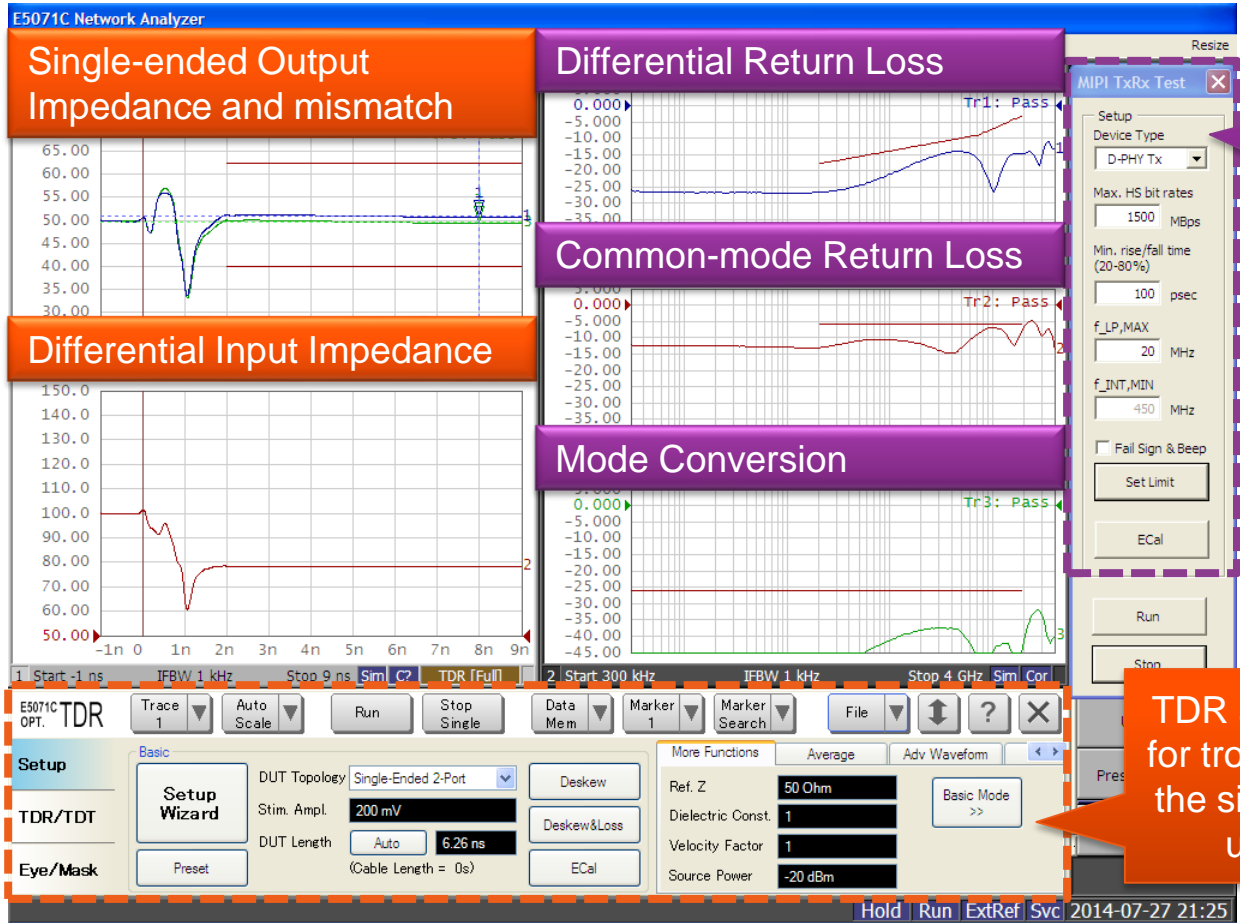
Measurements for D-PHY

◆S-parameter Measurements

	Tx	Rx
Differential Return Loss	✓	✓
Common-mode Return Loss	✓	✓
CMN-Diff Mode Conversion	✓	✓

◆Impedance Measurements

	Tx	Rx
Single-Ended Output Impedance	✓	-
Single-Ended Output Impedance Mismatch	✓	-
Differential Input Impedance	-	✓

KEYSIGHT
TECHNOLOGIES

Example Using ENA Option TDR

◆ All Measurements in One Screen

VBA Macro automatically sets the limit lines for your desired parameters.

TDR application serves for trouble shooting with the simple and intuitive user-interface.

KEYSIGHT
TECHNOLOGIES

MOIs & State Files are available from A.com

www.keysight.com/find/ena-tdr_compliance

Standards supported by E5071C-TDR

Standards		MOIs & State Files		Test Solution Overview
		Cable-Connector Assembly	Tx/Rx Impedance	
USB	USB2.0	Coming soon...	Coming soon...	Coming soon...
	USB3.0	Available	-	Available
	USB3.1	Coming soon...	-	Coming soon...
HDMI	HDMI 1.4b	Available	-	Available
	HDMI 2.0	(*2)	Available	Coming soon...
SATA		Available	Available	Available
DisplayPort		Available	-	Available
MIPI™	D-PHY	-	Available	Available
	M-PHY	-	Available	Available
Ethernet	100BASE-TX	Available	-	
	10GBASE-T	Available	-	Available
	10GBASE-KR / 40GBASE-KR4	Available (*3)	Available	
MHL		Available	Coming soon...	
PCIe®		Available	-	
Thunderbolt		-	Available (*1)	
BroadR-Reach		Available (*1)	-	
SD Card	UHS-II	-	Available (*1)	
Cfast		-	Available (*1)	

*1: Contact Keysight sales representative for more detail.
*2: HDMI 2.0 uses the same cable as HDMI 1.4b.
*3: Backplane interconnect tests

Download MOIs and test packages

Documents & Downloads

Agilent Method of Implementation (MOI) for MIPI M-PHY Conformance Tests 🔗   📕 PDF 918 KB
Agilent Method of Implementation (MOI) for MIPI M-PHY Conformance Tests Using Agilent E5071C ENA Network Analyzer Option TDR

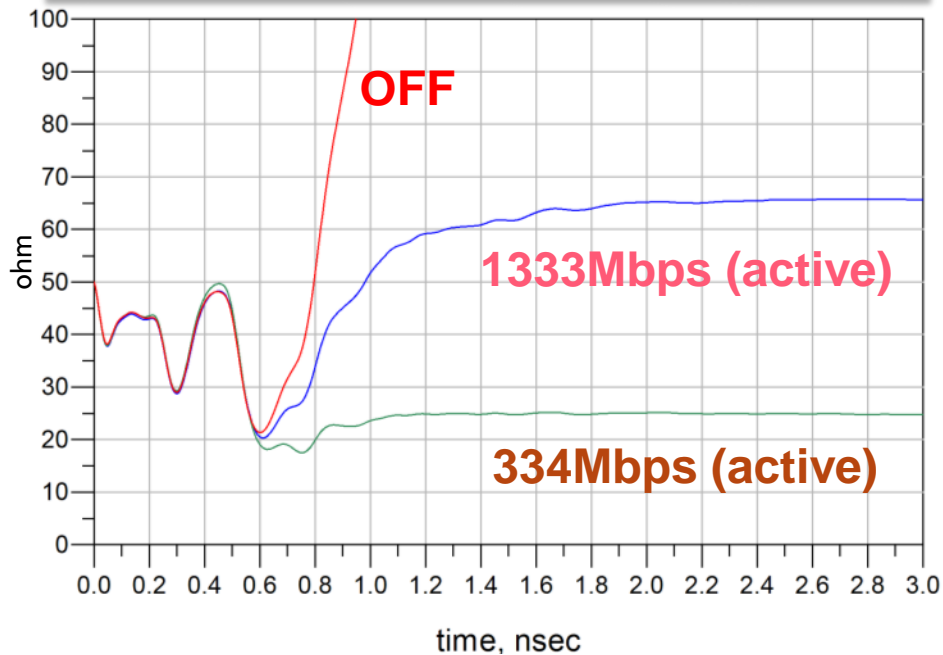*Application Note*   2011-12-01

E5071C-TDR Test Package for MIPI M-PHY Tx/Rx Devices   📀 ZIP 293 KB
This package includes the E5071C-TDR state files and vba macro software that support the measurements described in the MOI.
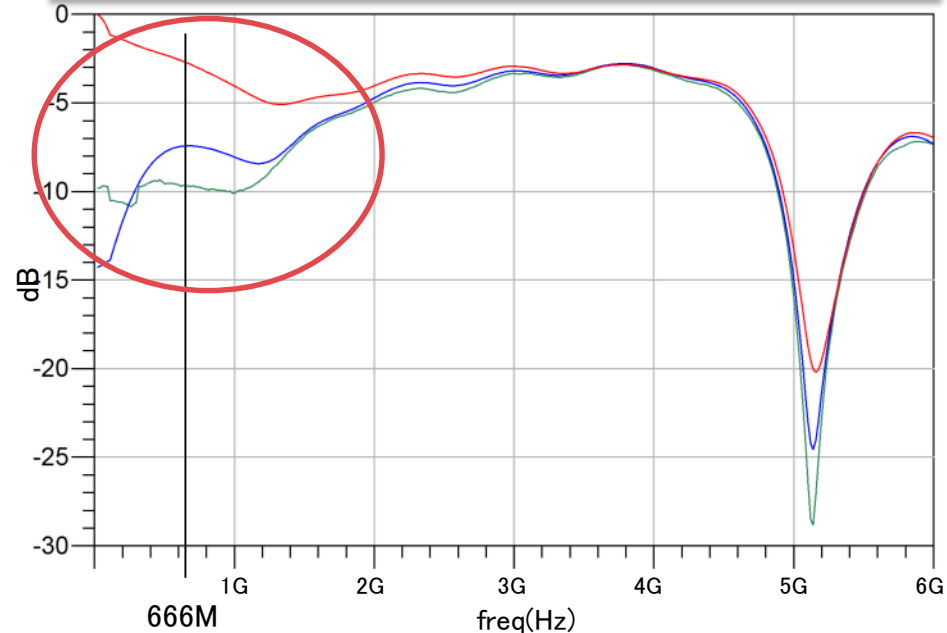
Programming Example   2011-12-01

KEYSIGHT TECHNOLOGIES

Hot TDR Measurements - Why Measure?

• **Hot TDR** measurement is the impedance analysis of active devices under actual operation conditions.

• Typically, impedance of the device in the OFF state and ON state (Hot TDR) is significantly different. Impedance may vary with the data rate as well.
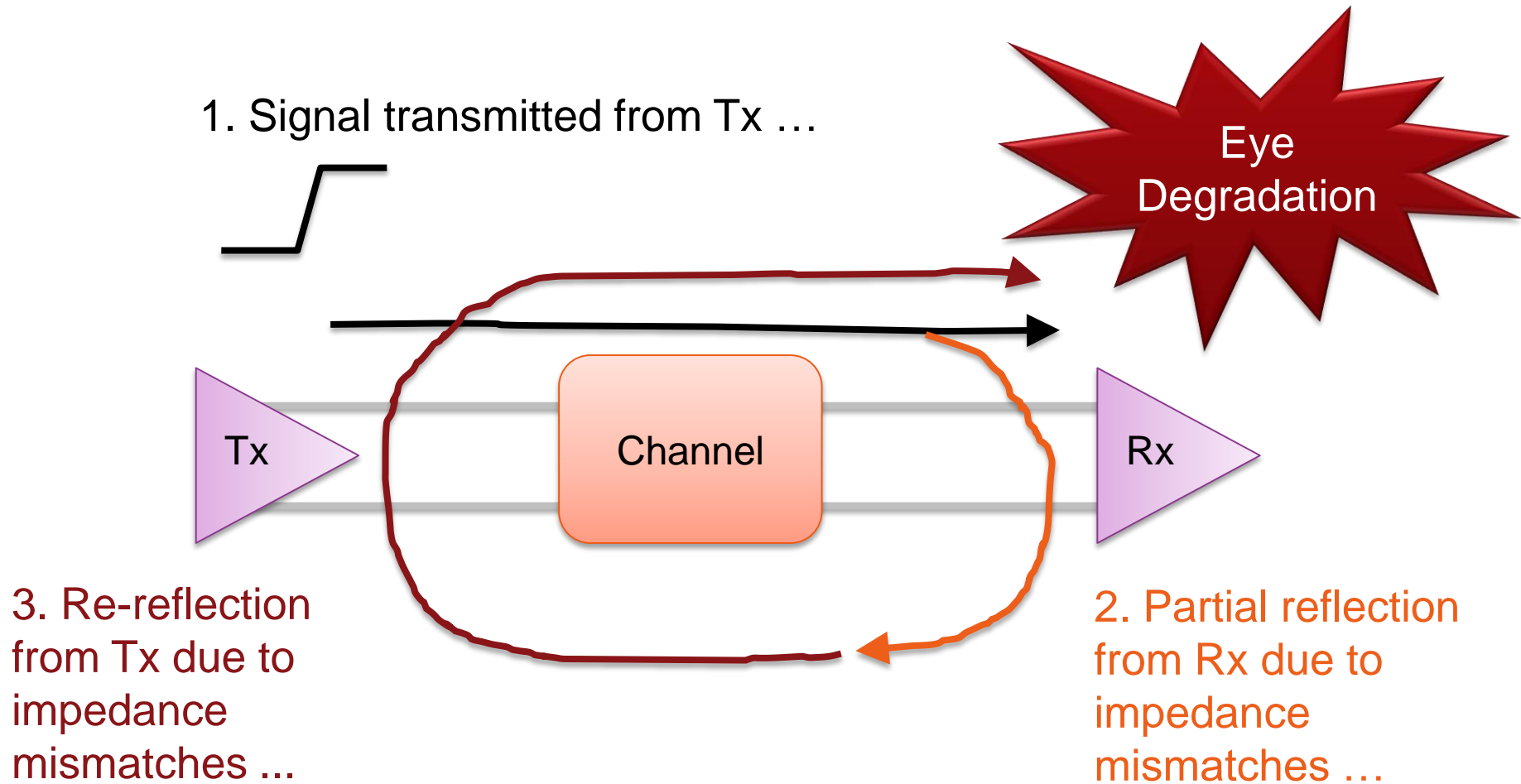
TDR(Time Domain)

OFF

1333Mbps (active)
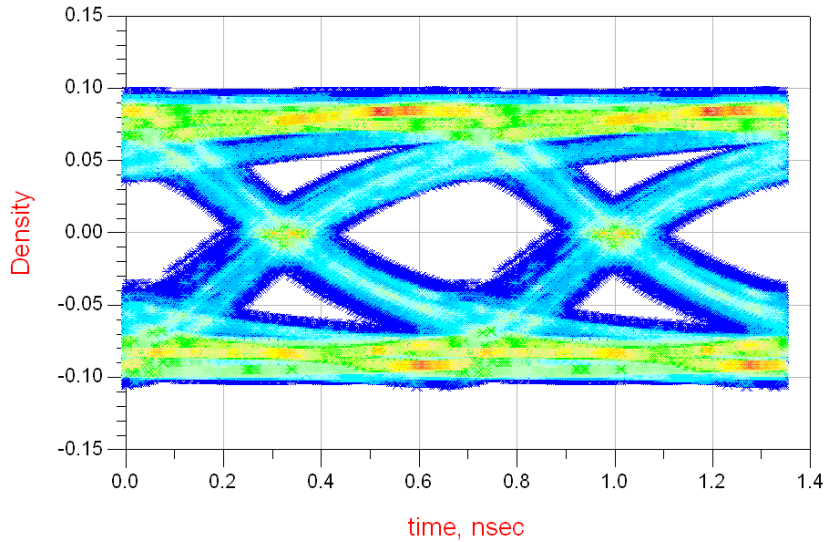
334Mbps (active)

time, nsec

Return Loss (Freq Domain)

dB

freq(Hz)

666M

KEYSIGHT
TECHNOLOGIES

Hot TDR Measurements - Why Measure?

1. Signal transmitted from Tx …

Eye Degradation

Tx

Channel

Rx

3. Re-reflection from Tx due to impedance mismatches ...

2. Partial reflection from Rx due to impedance mismatches …

KEYSIGHT
TECHNOLOGIES

Hot TDR Measurements - Why Measure?

Source Termination Effects

Source Impedance **NOT** Matched
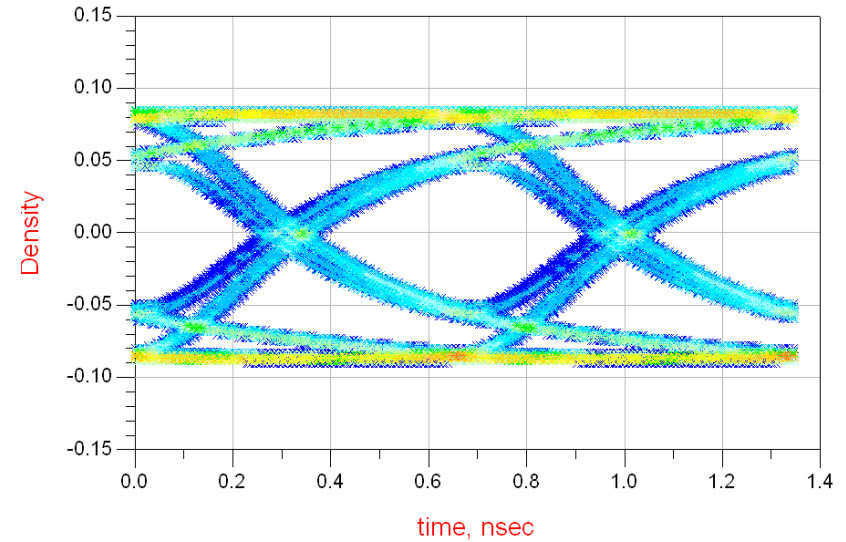
Source Impedance Matched

Advantages of VNA Based Solution
Fast and Accurate Measurements

Since the measurements must be performed while the device is turned on, data signals from the transmitter cause measurement error. ENA can resolve this trouble in a smart way.
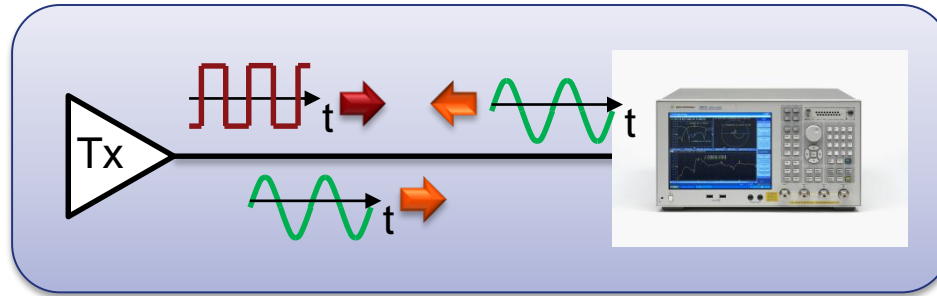
Narrowband receiver minimizes the effects of the data signal from the transmitter

S-parameter can be converted into TDR.
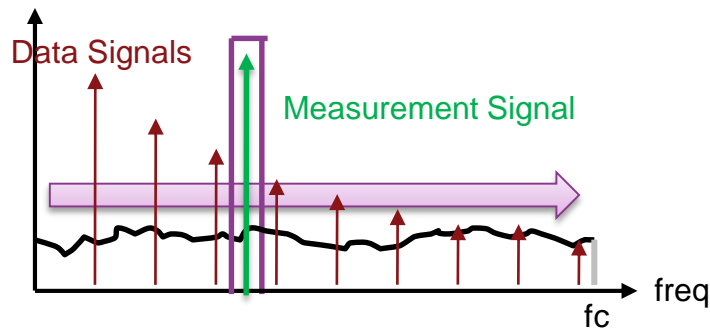
ENA sweeps across desired frequency range. The spurious frequencies can be avoided during the sweep.
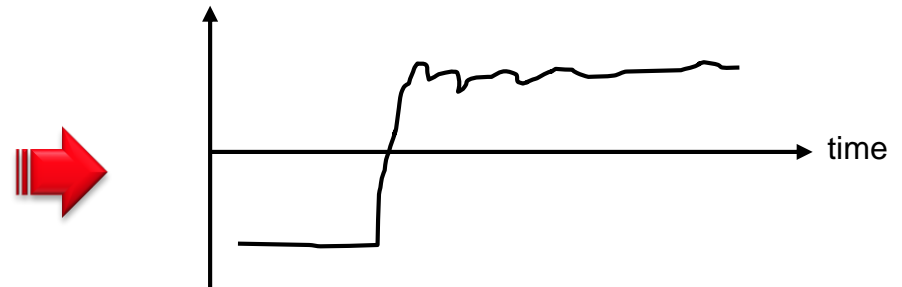
Averaging is not necessary to obtain a stable waveform.

Advantages of VNA Based Solution
ESD Robustness
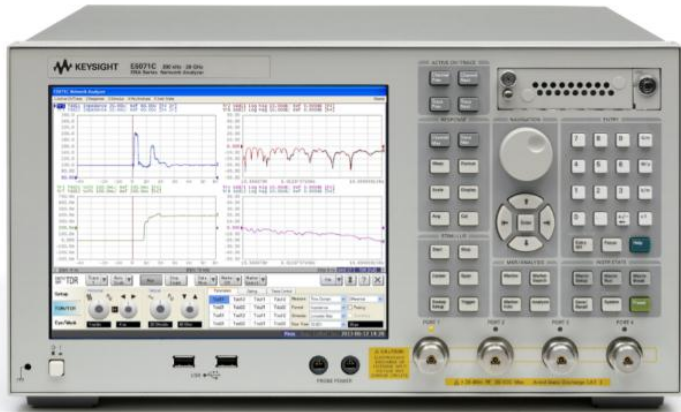
ENA has ESD protection circuits inside

ESD Survival:
IEC 801-2 Human Body Model. (150 pF, 330 Ω) RF Output Center
pins tested to **3,000 V**, 10 cycles
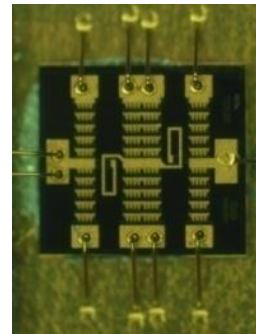
Proprietary ESD protection chip significantly increase ESD robustness, while at the same time maintaining **excellent RF performance** (22ps rise time for 20GHz models).

ENA Option TDR Compliance Test Solution

Certified MOIs available at www.keysight.com/find/ena-tdr_compliance

Cable/Connector/Interconnect

SUPERSPEED USB — Time & Frequency	**HDMI** — Frequency	**SERIAL ATA** — Time & Frequency
DisplayPort — Time & Frequency	**100BASE-TX** — Time & Frequency	**10GBASE-T** — Time & Frequency
10GBASE-KR — Time & Frequency	**MHL** — Time & Frequency	**PCI EXPRESS**
BroadR-Reach * — Time & Frequency		

Transmitter/Receiver (Hot TDR/Hot Return Loss)

SERIAL ATA — Time & Frequency	**mipi alliance** — Time & Frequency	**10GBASE-KR** — Frequency
MHL — Time & Frequency	(Thunderbolt) * — Time & Frequency	

More Standards Currently Under Investigation

* For more detail about Thunderbolt and BroadR-Reach compliance test solution using the ENA Option TDR, contact Keysight sales representative.

KEYSIGHT TECHNOLOGIES

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.

Questions?

Keysight 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

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

PNA-X receiver
8530A replacement

Mm-wave solutions
Up to 2 THz

PNA Series

ENA Series

FieldFox
Handheld RF Analyzer
5 Hz to 4/6 GHz

KEYSIGHT
TECHNOLOGIES

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.

Time Domain	Frequency Domain

Eye Diagram

PASS
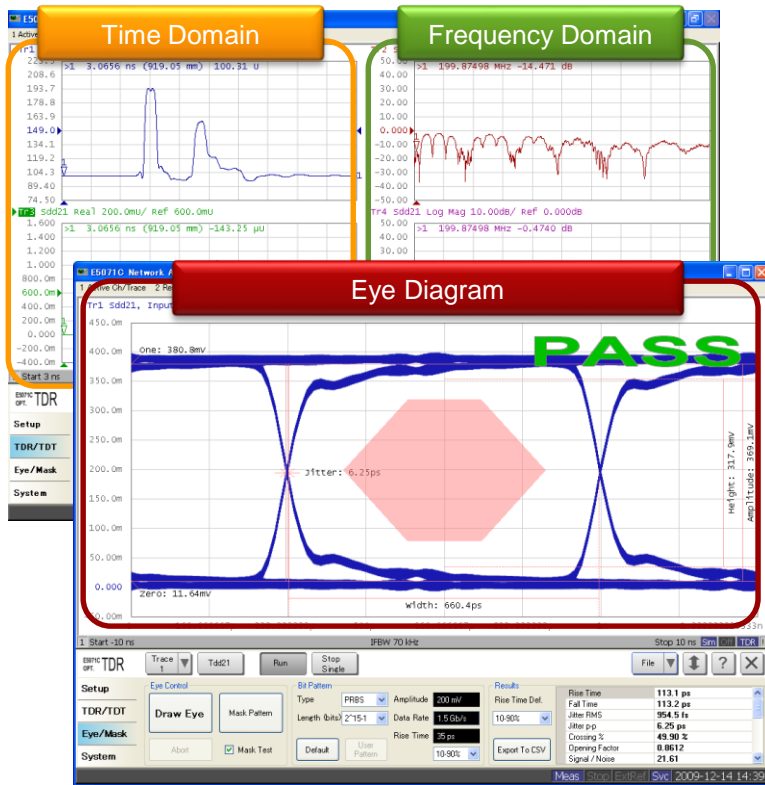
3 Breakthroughs

for Signal Integrity Design and Verification
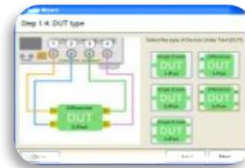
Simple and Intuitive Operation

Fast and Accurate Measurements

ESD protection inside
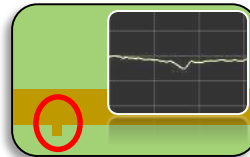
ESD Robustness

KEYSIGHT
TECHNOLOGIES

What is ENA Option TDR?

[Video]
Keysight ENA Option TDR
Change the world of Time Domain Reflectometry (TDR) Measurements

- youtu.be/uBHXkzk4lzk?list=PLG98L-F0jgVj-jeYUheKdpGhr5z1Jg4q_
- www.keysight.com/find/ena-tdr

Additional Resources

- **ENA Option TDR Reference Material**

www.keysight.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.keysight.com/find/ena-tdr_compliance

KEYSIGHT TECHNOLOGIES

Appendix

KEYSIGHT
TECHNOLOGIES
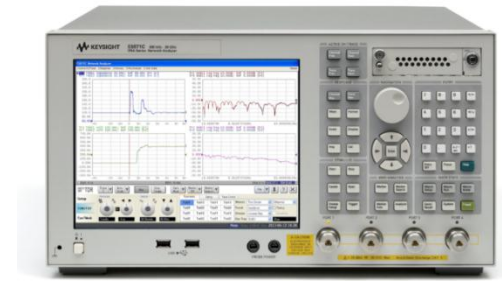
Advantages of ENA Option TDR
Fast and Accurate Measurements

For Hot TDR measurements, data signals from the transmitter cause measurement error...

TDR Scopes
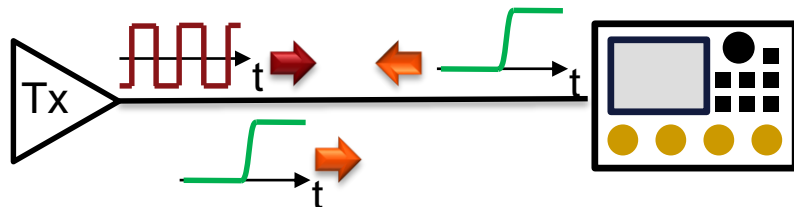
ENA Option TDR

•**wideband receiver** captures all of the signal energy from the transmitter
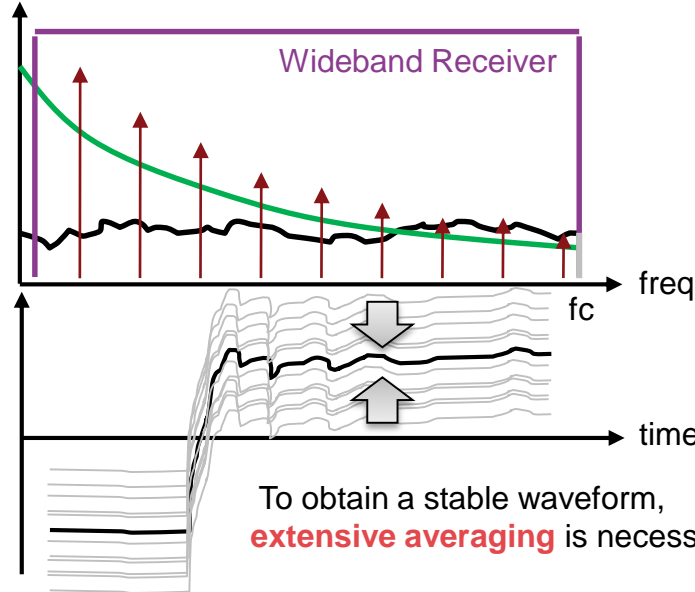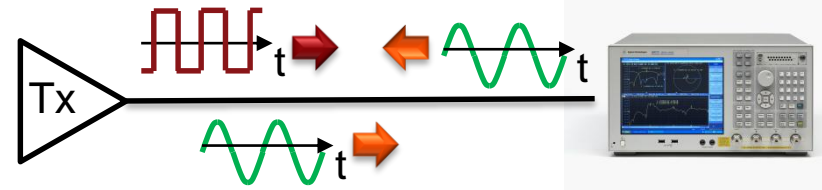
•**narrowband receiver** minimizes the effects of the data signal from the transmitter

Wideband Receiver

Narrowband Receiver
Sweeps across desired frequency range.
From the data rate (user input), spurious frequencies can be determined and avoided during the sweep.

freq
fc

freq
fc

time

time

To obtain a stable waveform, **extensive averaging** is necessary.

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

KEYSIGHT
TECHNOLOGIES
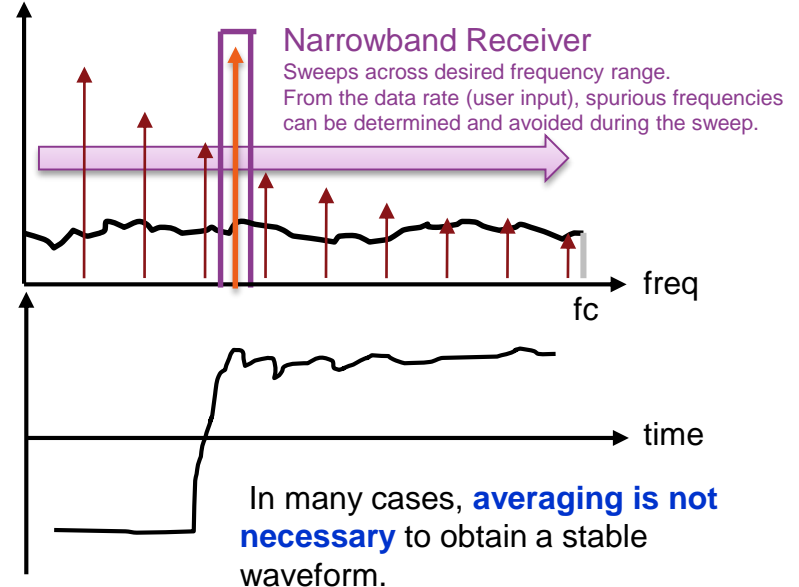
Advantages of ENA Option TDR
ESD Robustness

TDR Scopes

TDR scopes are sensitive to ESD.
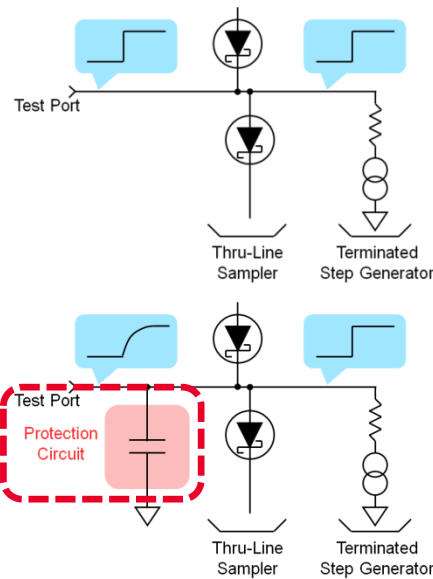
Implementing a protection circuit is difficult, because it will slow down the rise time of the step stimulus.

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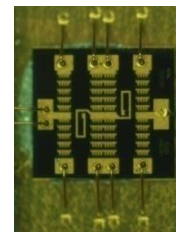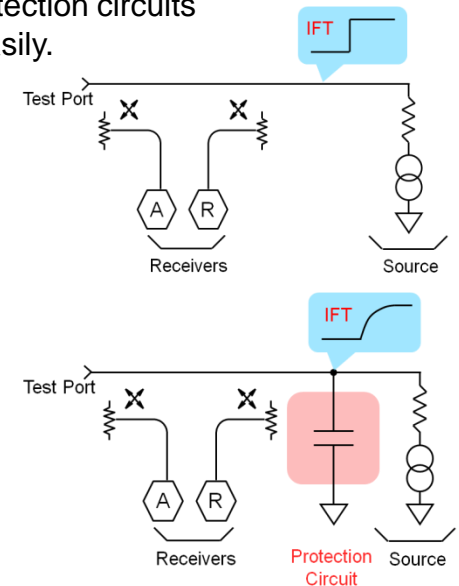
Proprietary ESD protection chip significantly increase ESD robustness, while at the same time maintaining **excellent RF performance** (22ps rise time for 20GHz models).

Advantages of ENA Option TDR
Fast and Accurate Measurements

Correlation between 86100C TDR oscilloscope and E5071C ENA Option TDR

TX-03 Differential Mode Return Loss

E5071C   86100C

TX-01 Pair Differential Impedance

E5071C   86100C

Time (sec)

M-PHY Tx Device

M-PHY Rx Device

D-PHY Tx Device

D-PHY Rx Device