High-Definition Multimedia Interface (HDMI) 2.0

Source/Sink Impedance Compliance Tests

Test Solution Overview Using the Agilent E5071C ENA Option TDR

Last update: 2014/06/02 (HK)

Purpose

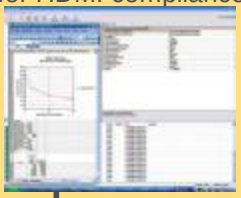
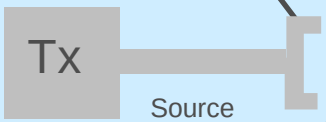
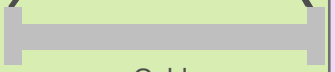
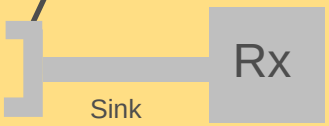
This slide will show how to make measurements of High-Definition Multimedia Interface (HDMI) 2.0 Source/Sink Impedance Compliance Tests using the Agilent E5071C ENA Option TDR.

Leadership in Developing Future Standards

- JEDEC, Board of Directors, Perry Keller
- PCI-SIG, Board of Directors, Rick Eads
- VESA, Board of Directors, Brian Fetz
- MIPI, Contributing Member, Roland Scherzinger
- HDMI, Contributing Member, Stefan Friebe
- USB, Contributing Member, Jim Choate
- Serial ATA (SATA), Contributing Member, Min-Jie Chong
- IEEE 802.3 Ethernet, Greg Le Cheminant
- OPT TRX WAN, Stefan Loefflar

Agilent experts helping define next generation standards, and solutions

HDMI 2.0 test solution overview from Agilent

	Source Test	Cable Assembly Test (HDMI 1.4b)	Sink Test (ParBERT)	Sink Test (AWG)	Protocol Test
SW	N5399C HDMI Electrical Compliance Test Software 		N5990A Automatic SW for HDMI compliance 	N5990A Automatic SW for HDMI compliance 	U4998A SW for HDMI compliance 
HW	DSO90000A Infiniium real time scope 13 GHz 	E5071C Option TDR ENA Network Analyzer 	 E4887A ParBERT TMDS Signal Generator	 M8190A AWG	U4998A (N5998A) HDMI 1.4 protocol analyzer/ generator 
Signal Condi-tioning			 new Cable Emulator		
Fixture	 BIT-1010-0200-0	 N1080B	 BIT-1010-0201-0	 BIT-1010-0201-0	
DUT	 Tx Source	 Cable	 Rx Sink	 Rx Sink	

Protocol Test on U4998A is supported up to HDMI 1.4b

For HDMI 2.0 third party protocol testers are supported in Valiframe SW

Reference Document

- High-Definition Multimedia Interface (HDMI) Specification Version 2.0
- High-Definition Multimedia Interface (HDMI) Version 2.0 Compliance Test Specification

HDMI 2.0 Compliance Test – TMDS Electrical Tests

HF1-9 (Source) and **HF2-4 (Sink)** **Differential Impedance** are measured with **TDR/TDT Network Analyzer**

- **Source TMDS Electrical 6G Tests**

1	V_L and V_{swing}
2	T_{RISE}, T_{FALL}
…	
9	Differential Impedance
…	

Other Source TMDS Electrical test items are measured with **Digital Oscilloscope**

- **Sink TMDS Electrical 6G Tests**

1	Min/Max Differential Swing Tolerance
2	Intra-Pair Skew
…	
4	Differential Impedance
…	

Other Sink TMDS Electrical test items are measured with **Signal Generator**

HDMI Source/Sink Impedance Compliance Test

Measurement Parameters

Time Domain Measurements

- HF1-9: Source TMDS Electrical – 6G – Differential Impedance
- HF2-4: Sink TMDS Electrical – 6G – Differential Impedance

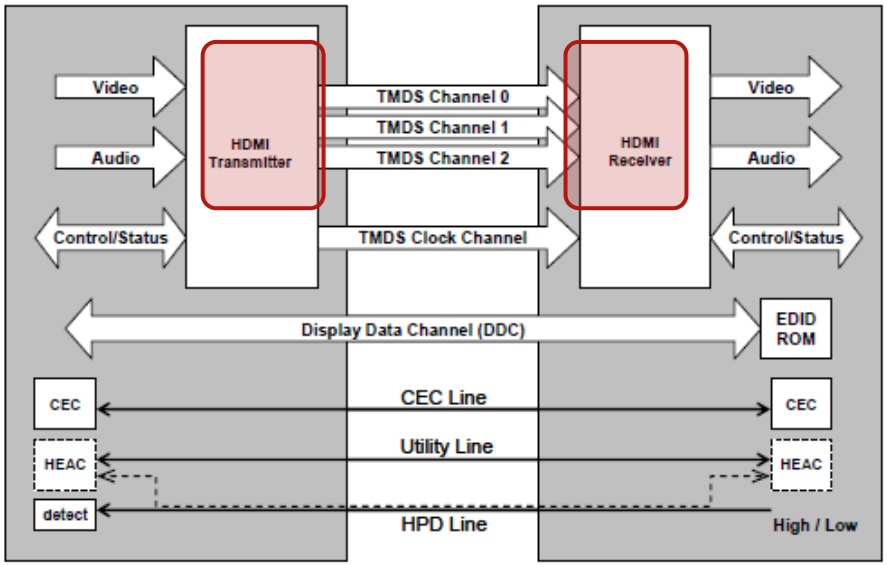
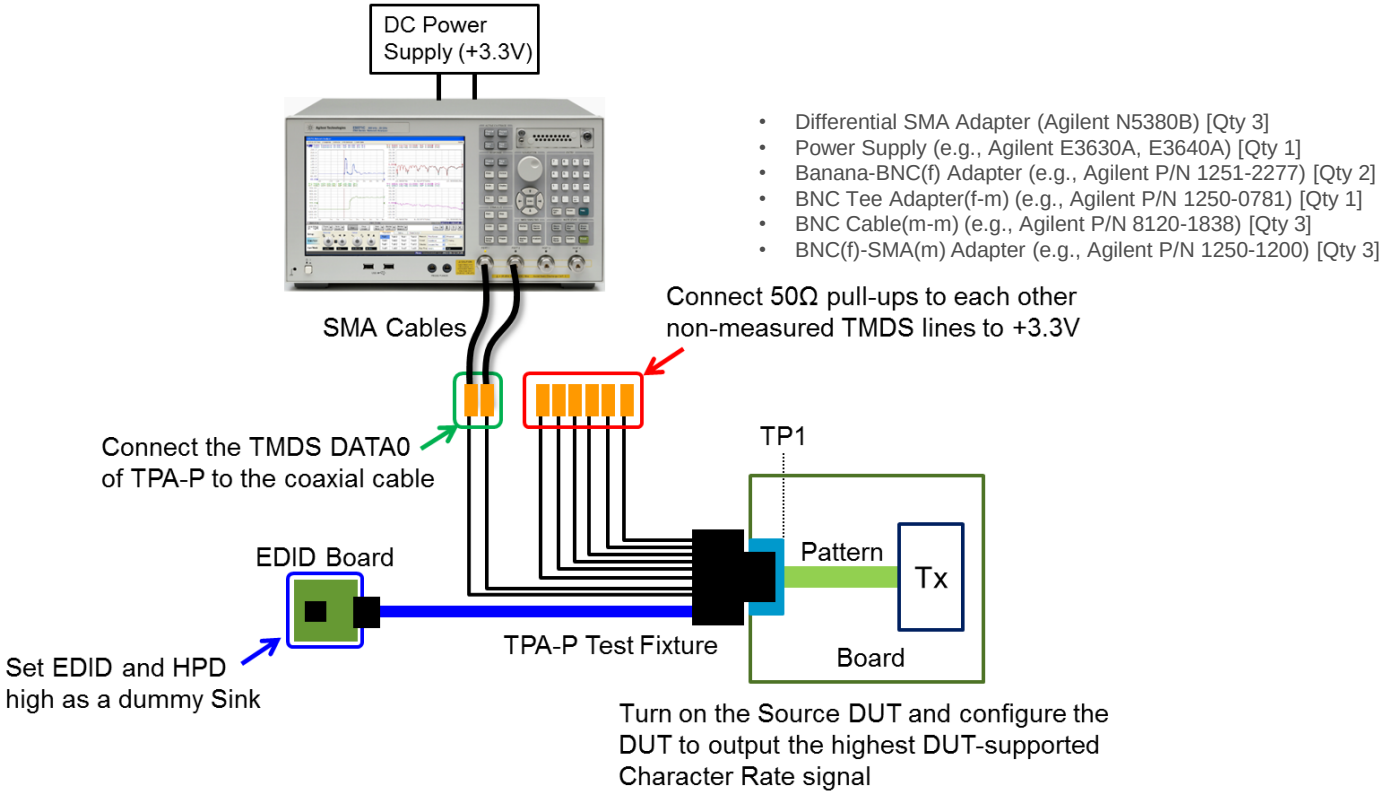


Figure 3-1 HDMI Block Diagram

HDMI Source/Sink Impedance Compliance Test

Test Setup Example - Source TMDS Differential Impedance Measurement

- Measure source impedance characteristics on each TMDS data differential pairs: D0, D1, and D2 under actual operating condition.



- Differential SMA Adapter (Agilent N5380B) [Qty 3]
- Power Supply (e.g., Agilent E3630A, E3640A) [Qty 1]
- Banana-BNC(f) Adapter (e.g., Agilent P/N 1251-2277) [Qty 2]
- BNC Tee Adapter(f-m) (e.g., Agilent P/N 1250-0781) [Qty 1]
- BNC Cable(m-m) (e.g., Agilent P/N 8120-1838) [Qty 3]
- BNC(f)-SMA(m) Adapter (e.g., Agilent P/N 1250-1200) [Qty 3]

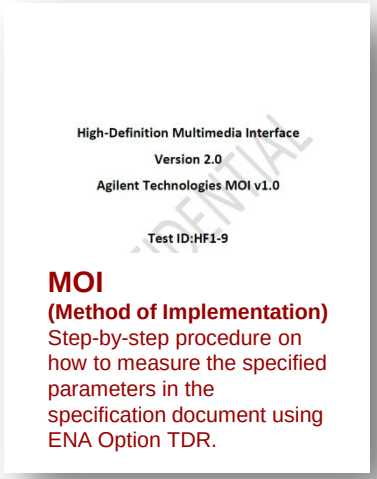
HDMI Source/Sink Impedance Compliance Test

Configuration

- ENA Mainframe (*1)
  - E5071C-285/485: 2/4-port, 100 k to 8.5 GHz
  - E5071C-2D5/4D5: 2/4-port, 300 k to 14 GHz
  - E5071C-2K5/4K5: 2/4-port, 300 k 20 GHz
- Enhanced Time Domain Analysis Option (E5071C-TDR)
- ECal Module
  - N4431B for E5071C-285/485
  - N4433A for E5071C-2D5/4D5/2K5/4K5

*1: Select one of test set options.
*2: The list above includes the major equipment required. Please contact our sales representative for configuration details.

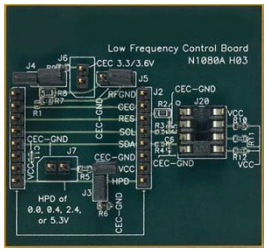
- Method of Implementation (MOI) document available for download on HDMI Adopter Extranet (you must be a current adopter).
- State files for the ENA Option TDR are available on Agilent Website.
- For more details: www.agilent.com/find/ena-tdr_hdmi-txrx



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

HDMI Test Fixtures

Agilent
- N1080B-H06 HDMI EDID Board



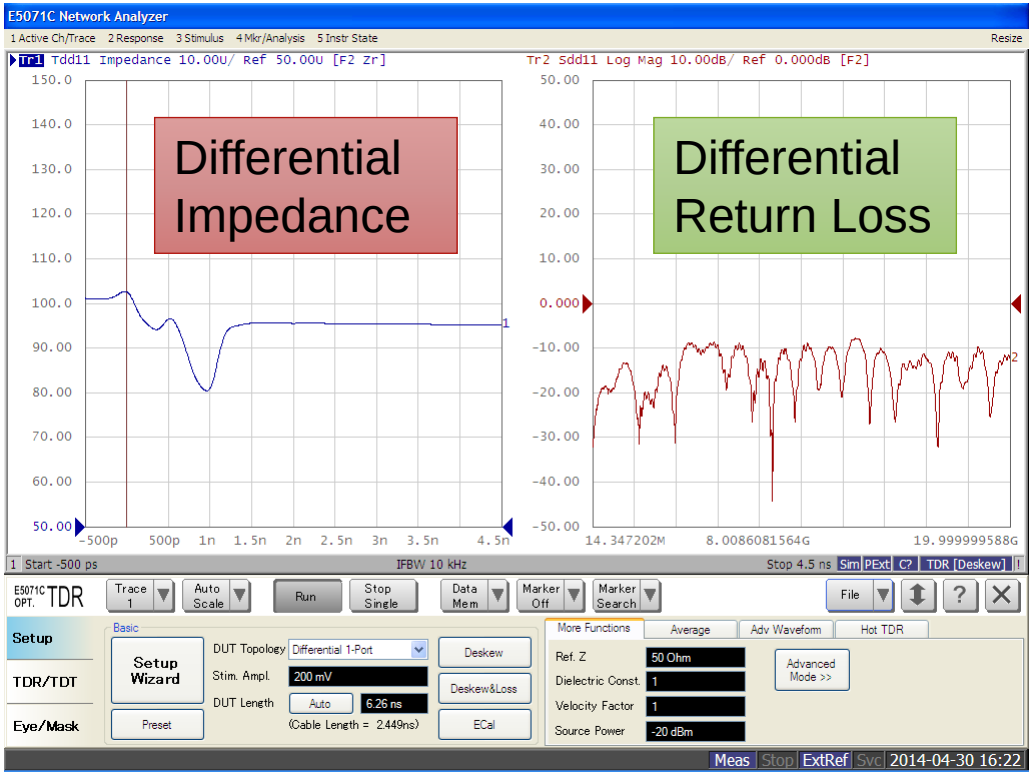
+

BitifEye (Type A or Type D)
- BitifEye Bit-1010-0200-0 HDMI 2.0 Type A Source Test Plug Adapter Kit
  or
- BitifEye Bit-1010-0275-0 HDMI 2.0 Type D Test Plug Adapter Kit

HDMI Source/Sink Impedance Compliance Test

Measurement Example

- Source differential impedance measurement example while the DUT outputs 6Gbps signal (actual operating condition).



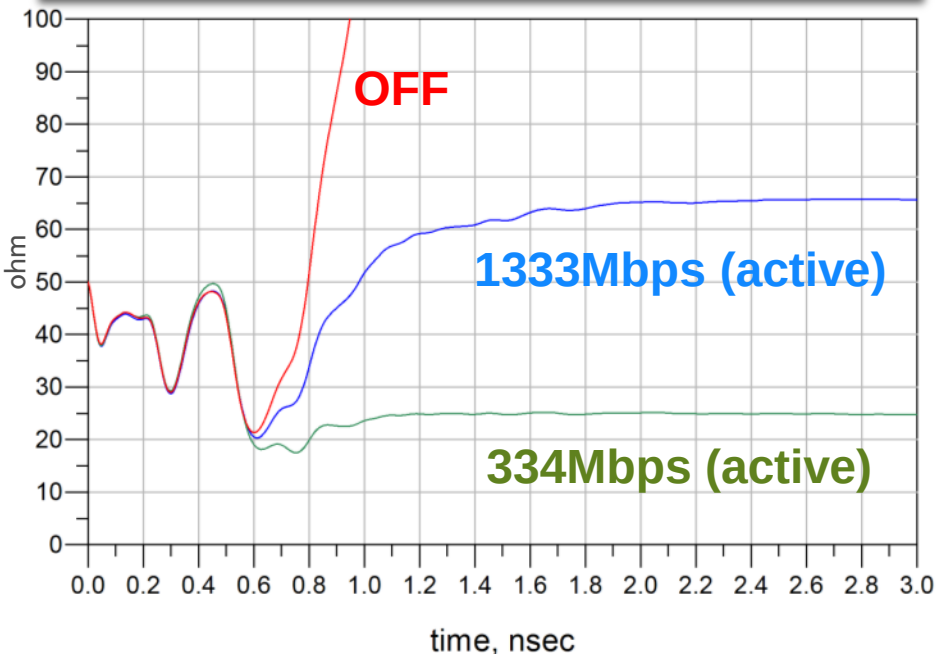
Hot TDR Measurements

Why Measure?

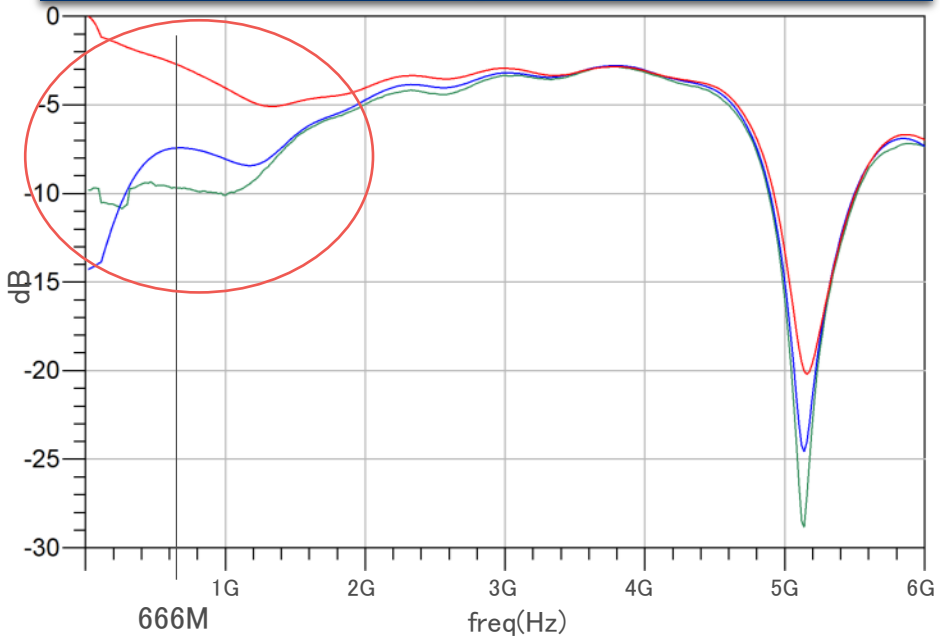
- **Hot TDR** measurement is the impedance analysis of active devices under actual operation conditions.

- 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)



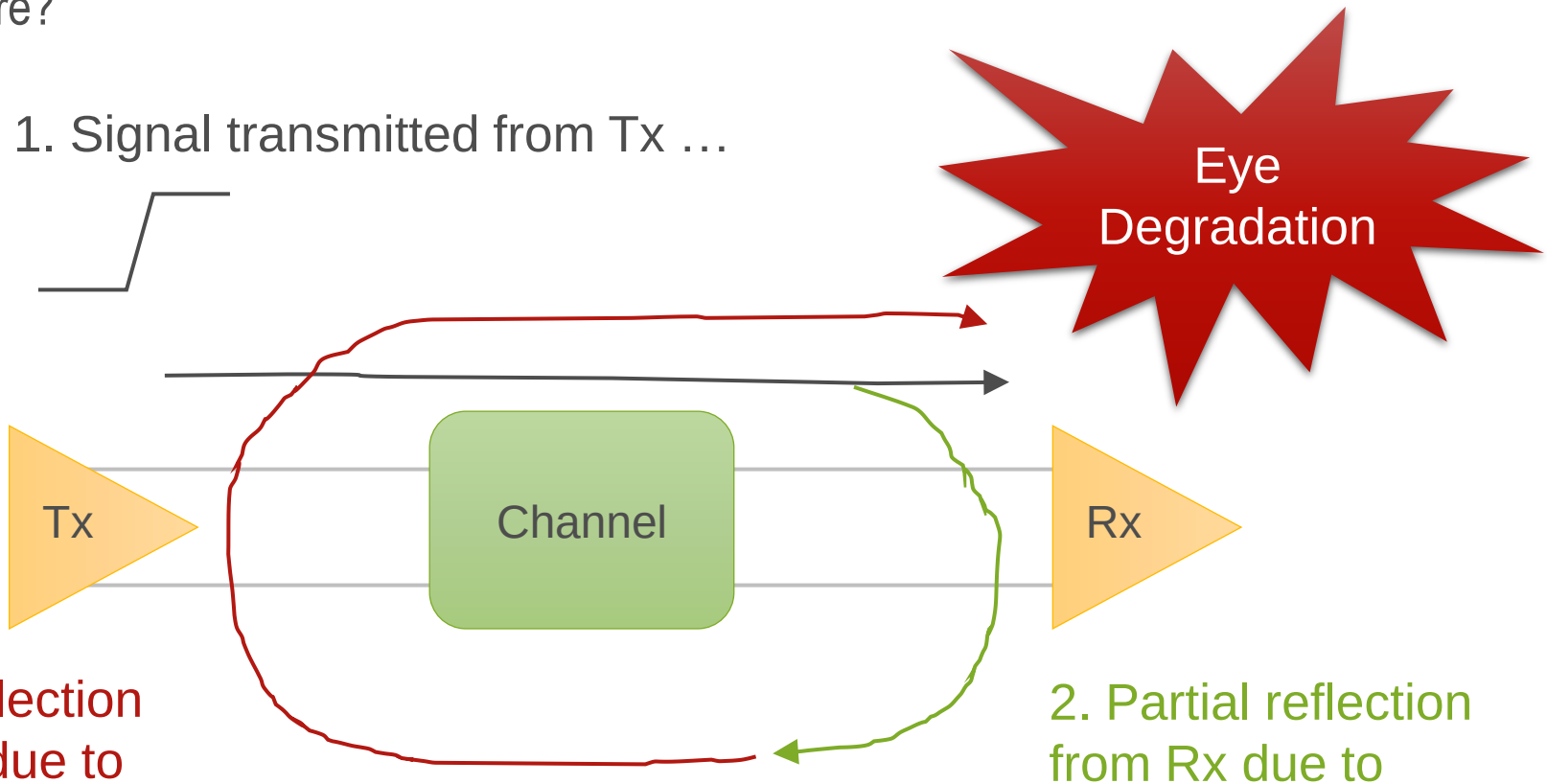
Return Loss (Freq Domain)



Hot TDR Measurements

Why Measure?

1. Signal transmitted from Tx …



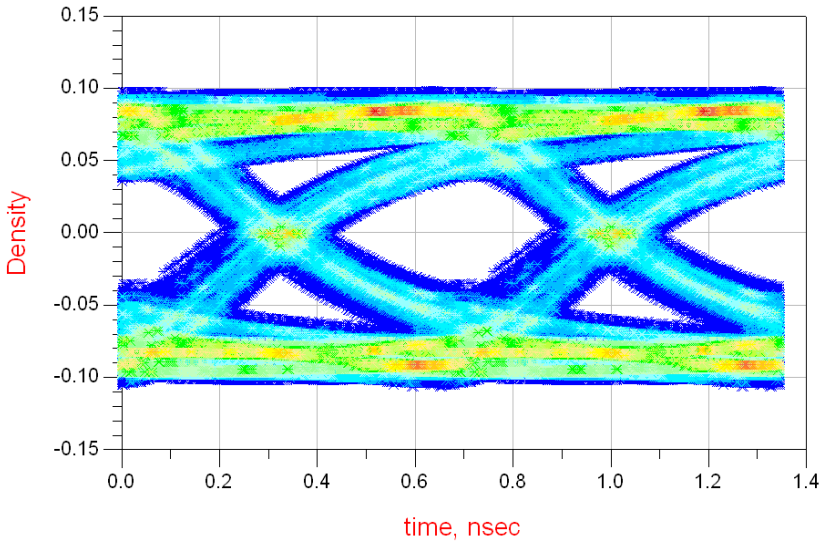
3. Re-reflection from Tx due to impedance mismatches ...

2. Partial reflection from Rx due to impedance mismatches …

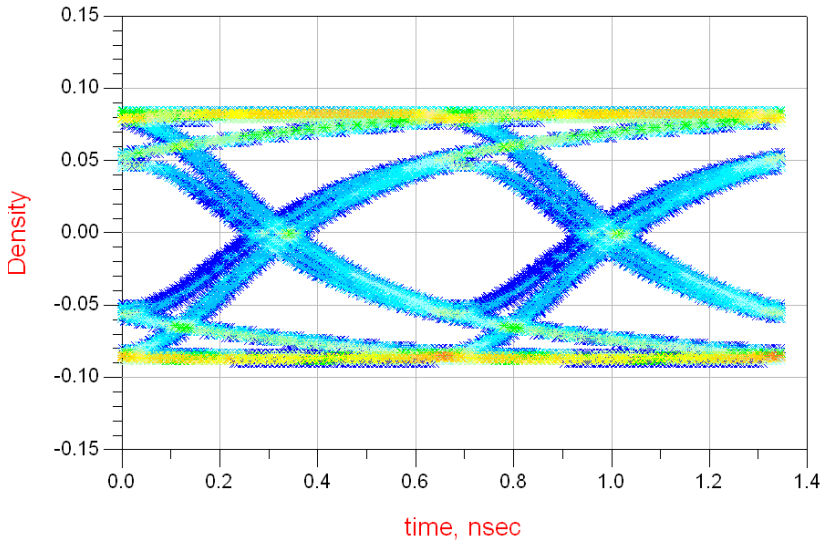
Hot TDR Measurements

Why Measure?

Source Termination Effects

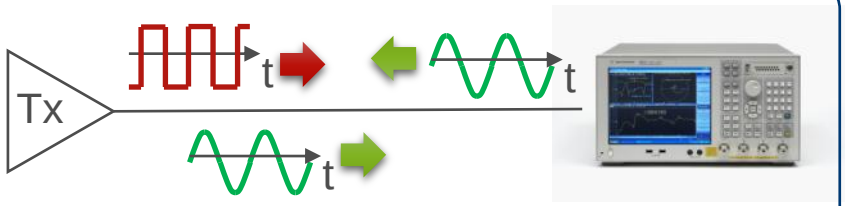


Source Impedance **NOT** Matched

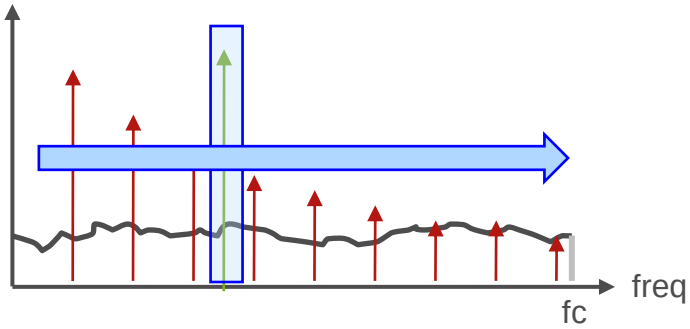


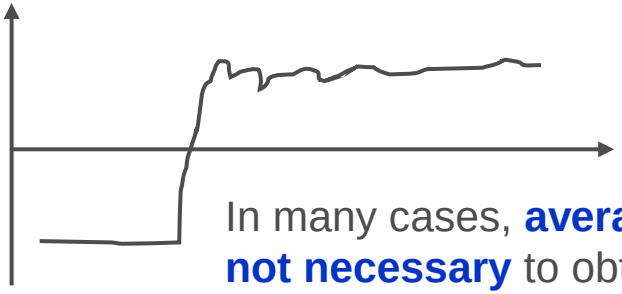
Source Impedance Matched

Advantages of VNA Based Solution



Narrowband receiver minimizes the effects of the data signal from the transmitter





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

Test signal level is adjustable.

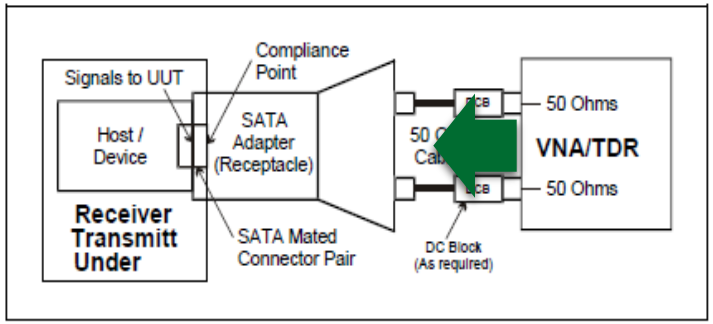
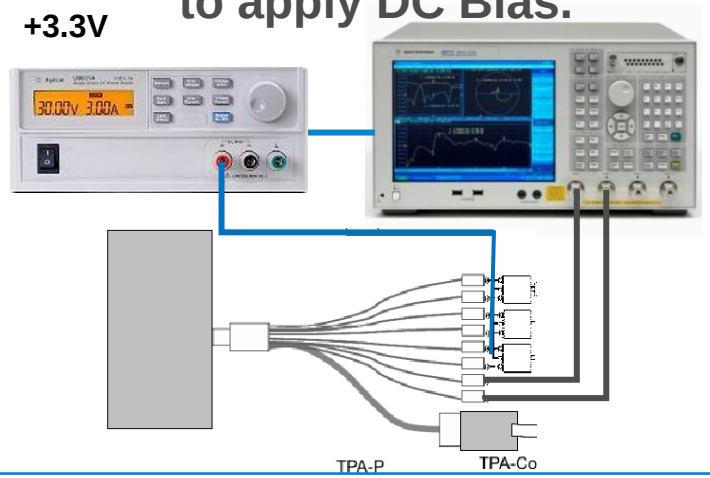


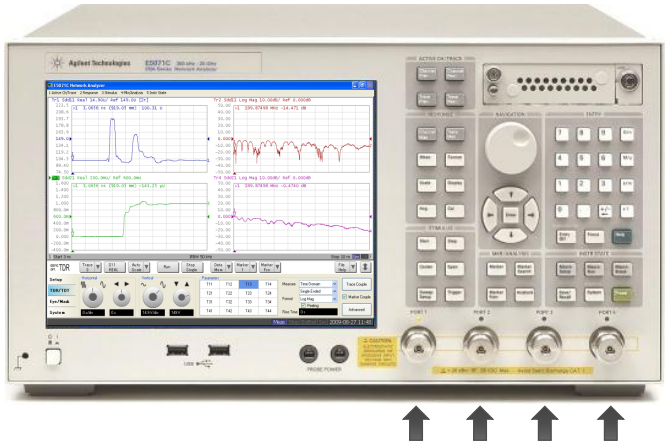
Figure 164 – Return Loss Test

Internal bias-tee is available to apply DC Bias.



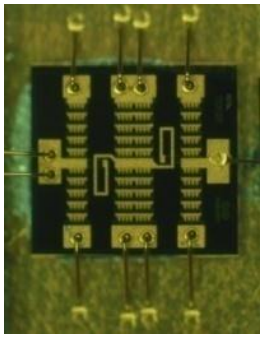
Advantages of VNA Based Solution

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).

Agilent HDMI Compliance Test Solutions

Electrical / Cable Assembly

Source/Sink (HDMI 2.0)

- **Digital Oscilloscope**
  Source Test (HF1-x)

DSO90000A Infiniium

- **TDR/TDT Network Analyzer**
  Source Test (HF1-9), and Sink Test (HF2-4)

E5071C ENA Option TDR

- **TMDS Signal Generator**
  Sink Test (HF2-x)

E4887A ParBERT

M8190A AWG

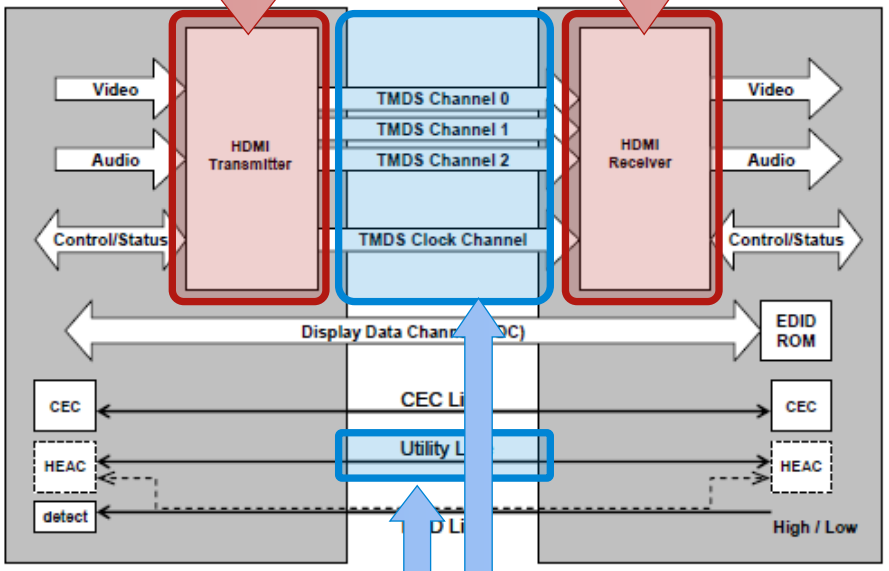


Figure 3-1 HDMI Block Diagram

Cable Assembly (HDMI 1.4b*)

- **TDR/TDT Network Analyzer**
  Cable Assembly Test

E5071C ENA Option TDR

* HDMI 2.0 features will work with existing HDMI cables (Category 2 cables defined in HDMI 1.4b).

ENA Option TDR Compliance Test Solution

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

Cable/Connector/Interconnect

- USB SuperSpeed — Time & Frequency
- HDMI — Frequency
- SATA — Time & Frequency
- DisplayPort — Time & Frequency
- 100BASE-TX — Time & Frequency
- 10GBASE-T — Time & Frequency
- 10GBASE-KR — Time & Frequency
- MHL — Time & Frequency
- PCI Express — E5071C ENA Network Analyzer with Option TDR
- BroadR-Reach — Time & Frequency *

Transmitter/Receiver (Hot TDR/Hot Return Loss)

- SATA — Time & Frequency
- MIPI Alliance — Time & Frequency
- 10GBASE-KR/ 40GBASE-KR4 — Frequency
- MHL — Time & Frequency
- Thunderbolt — Time & Frequency *
- HDMI — Time

More Standards Currently Under Investigation

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

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.

HDMI 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)

•Similar look-and-feel to traditional TDR scopes, providing ***simple and intuitive operation*** even for users unfamiliar to VNAs and S-parameters

•Adopted by test labs worldwide

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

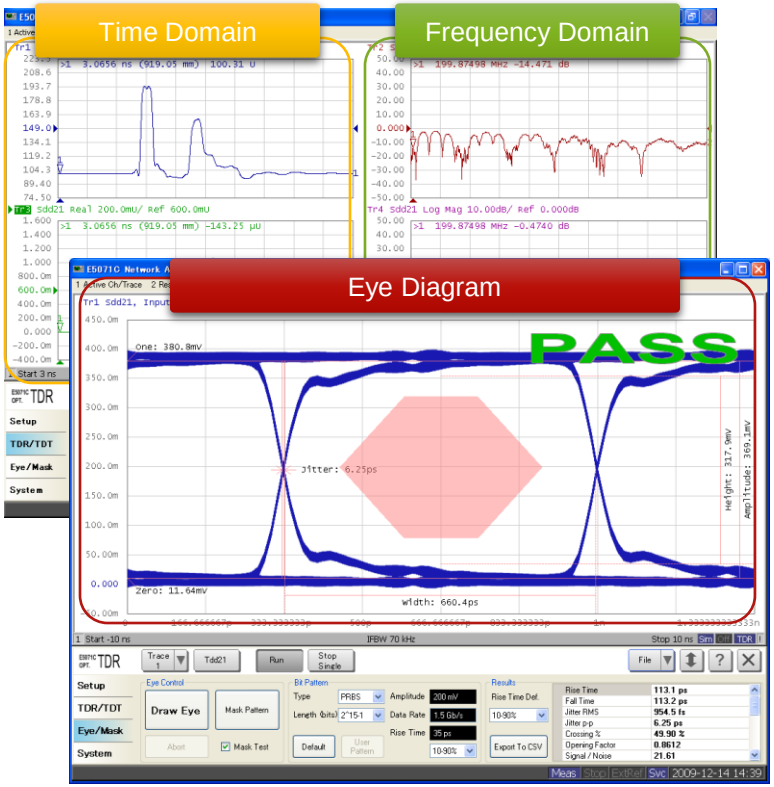
E5061B
NA + ZA in one-box
5 Hz to 3 GHz
Low cost RF VNA
100 k to 1.5/3.0 GHz

FieldFox
Handheld RF Analyzer
5 Hz to 4/6 GHz

ENA Series

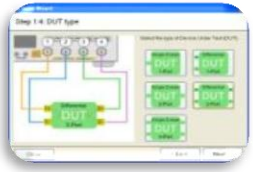
What is ENA Option TDR?

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

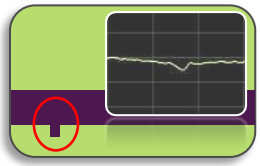


3 Breakthroughs

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

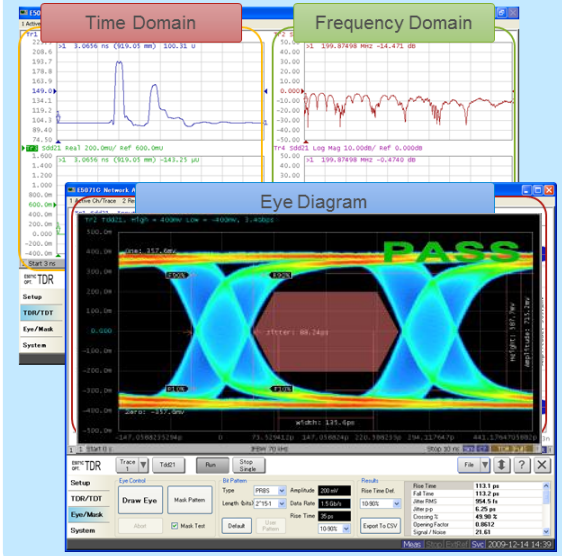
HDMI Compliance Test Solution Overview

Covered by **ENA Option TDR**

• **ENA Option TDR** Compliance Testing Solution is one-box solution which ***provides complete characterization of interconnects***: Time Domain, Frequency Domain, and Eye Diagram Analysis

One-box Solution !!

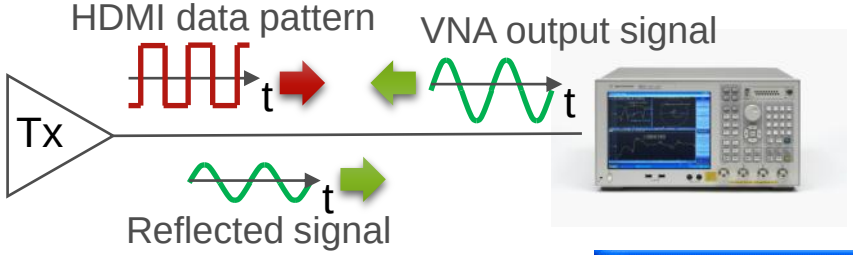
	HDMI 1.4b Cable Assembly*	HDMI 2.0 Source/Sink
Time Domain	•Intra-Pair Skew •Inter-Pair Skew •Differential Impedance	•Differential Impedance (HF1-9, HF2-4)
Frequency Domain	•Far-end crosstalk •Attenuation and Phase	n/a
Eye Diagram Analysis	•Data Eye Diagram	n/a



* No new cable spec/test defined in HDMI 2.0.

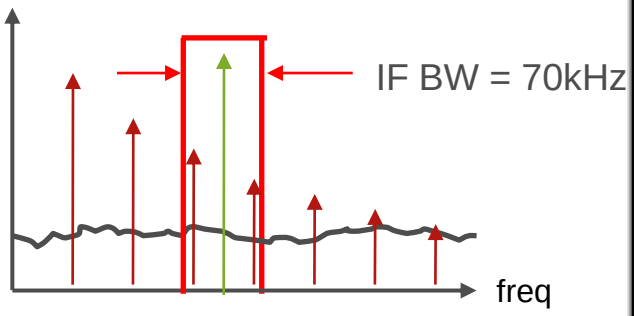
HDMI 2.0 Measurement Example

HDMI Source Impedance Measurement Example

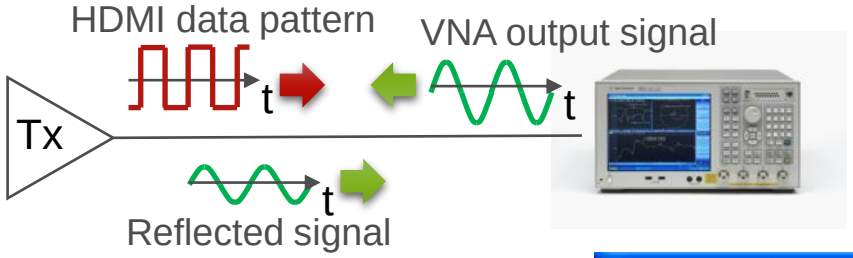


The transmitter spurs contribute significant measurement errors, resulting in highly unstable results. (same as sampling scope)

With wide IF BW:



HDMI Source Impedance Measurement Example



Narrow IFBW setting reduces the effects of the transmitter spurs. In many cases, averaging is not necessary to obtain a stable waveform.

With narrow IF BW: