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**
- N5399C HDMI Electrical Compliance Test Software
- DSO90000A Infinium real time scope 13 GHz

**Cable Assembly Test (HDMI 1.4b)**
- E5071C Option TDR ENA Network Analyzer
- N1080B
- BIT-1010-0200-0
- BIT-1010-0201-0

**Sink Test (ParBERT)**
- E4887A ParBERT TMDS Signal Generator
- M8190A AWG
- BIT-1010-0201-0
- BIT-1010-0200-0

**Sink Test (AWG)**
- N5990A Automatic SW for HDMI compliance

**Protocol Test**
- U4998A SW for HDMI compliance
- U4998A (N5998A) HDMI 1.4 protocol analyzer/generator

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

- **Source TMDS Electrical 6G Tests**
  - 1. $V_L$ and $V_{swing}$
  - 2. $T_{RISE}$, $T_{FALL}$
  - ...  
  - 9. Differential Impedance
  - ...

- **Sink TMDS Electrical 6G Tests**
  - 1. Min/Max Differential Swing Tolerance
  - 2. Intra-Pair Skew
  - ...  
  - 4. Differential Impedance
  - ...

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

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

Other Sink TMDS Electrical test items are measured with Signal Generator.
HDMI Source/Sink Impedance Compliance Test
Measurement Parameters

**Time Domain Measurements**
- 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]

Diagram:
- Connect 50Ω pull-ups to each other non-measured TMDS lines to +3.3V
- Connect the TMDS DATA0 of TPA-P to the coaxial cable
- Set EDID and HPD high as a dummy Sink
- Turn on the Source DUT and configure the DUT to output the highest DUT-supported Character Rate signal
**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](http://www.agilent.com/find/ena-tdr_hdmi-txrx)

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**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
- BitifEye Bit-1010-0275-0 HDMI 2.0 Type D Test Plug Adapter Kit

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State files for the ENA Option TDR are available on Agilent Website.
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.
2. Partial reflection from Rx due to impedance mismatches ...

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

1. Signal transmitted from Tx ...

Eye Degradation

Hot TDR Measurements

Why Measure?
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.

Internal bias-tee is available to apply DC Bias.

+3.3V
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 Infinium](image)

- **TDR/TDT Network Analyzer**
  Source Test (HF1-9), and Sink Test (HF2-4)
  ![E5071C ENA Option TDR](image)

- **TMDS Signal Generator**
  Sink Test (HF2-x)
  ![E4887A ParBERT](image), ![M8190A AWG](image)

**Cable Assembly (HDMI 1.4b*)**

- **TDR/TDT Network Analyzer**
  Cable Assembly Test
  ![E5071C ENA Option TDR](image)

* 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
- Time & Frequency
- 100BASE-TX
- 10BASE-T
- 10GBASE-KR
- BroadR-Reach

Transmitter/Receiver (Hot TDR/Hot Return Loss)
- Time & Frequency
- 10GBASE-KR/40GBASE-KR4

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

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

**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

**PNA-X**
- receiver
- 8530A replacement

**Mm-wave solutions**
- Up to 2 THz

**ENA Series**
- E5071C
  - World’s most popular economy VNA
  - 9 kHz to 4.5, 8.5 GHz
  - 300 kHz to 20.0 GHz

- E5072A
  - Best performance ENA
  - 30 kHz to 4.5, 8.5 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

**Agilent 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.

**3 Breakthroughs**

for Signal Integrity Design and Verification

- Simple and Intuitive Operation
- Fast and Accurate Measurements
- ESD Robustness

**Eye Diagram**
What is ENA Option TDR?

[Video]
Agilent ENA Option TDR
Changing the world of Time Domain Reflectometry (TDR) Measurements

• www.youtube.com/watch?v=hwQNlyyJ5hl&list=UUAJAgd97CfnCehC4jZAfkxQ&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
ENAv2.0 Source/Sink

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

<table>
<thead>
<tr>
<th>Time Domain</th>
<th>Frequency Domain</th>
<th>Eye Diagram Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HDMI 1.4b</strong></td>
<td><strong>HDMI 2.0</strong></td>
<td><strong>ENA Option TDR</strong></td>
</tr>
<tr>
<td>Cable Assembly*</td>
<td>Source/Sink</td>
<td>Compliance Testing Solution is one-box solution which provides complete characterization of interconnects: Time Domain, Frequency Domain, and Eye Diagram Analysis</td>
</tr>
<tr>
<td>Intra-Pair Skew</td>
<td>• Differential Impedance (HF1-9, HF2-4)</td>
<td></td>
</tr>
<tr>
<td>Inter-Pair Skew</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Differential Impedance</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Far-end crosstalk</td>
<td>Data Eye Diagram</td>
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<tr>
<td>Attenuation and Phase</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>n/a</td>
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<td></td>
</tr>
</tbody>
</table>

* 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:

IF BW = 70kHz
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:

IF BW = 1kHz