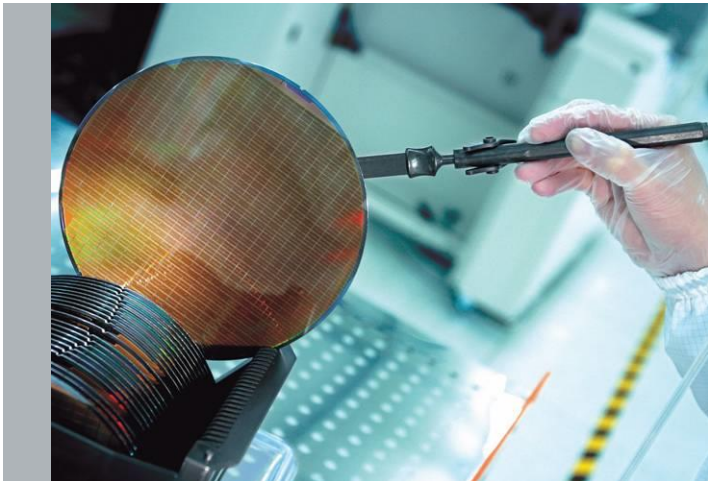


# 泰克公司HDMI设计和验证研讨会

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# HDMI 1.4b/2.0 Compliance Test Solution And Update

泰克华南区应用工程师 Ryan Yu



**Tektronix**<sup>®</sup>

# HDMI 1.4b/2.0 Compliance Test Solution

- Agenda
  - HDMI Overview and Updates
  - HDMI source/sink testing
    - **Source Tests**
      - Tektronix Recommended Test Equipment for source
      - Positioning
    - **Sink Tests & Cable Tests**
      - Tektronix Recommended Test Equipment for Sink & Cable
      - Positioning
  - What's new at HDMI 1.4b and how to test
  - HDMI 2.0 status and test method

# Overview of HDMI

- Problems with the legacy display technologies
  - Unnecessary D to A and A to D components
  - Device resolution increases, display brightness reduced
  - No content protection
- What is HDMI?
  - High Definition Multimedia Interface
  - Connection standard for consumer electronics
  - Uncompressed digital video and audio content interface
  - Digital Content protection
  - Multi channel audio
  - Single cable
  - Cost effective



**HDMI**<sup>™</sup>  
HIGH-DEFINITION MULTIMEDIA INTERFACE

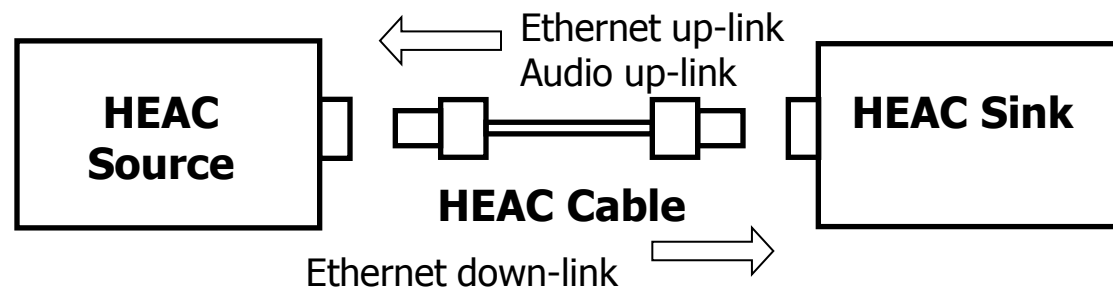
# HDMI Technology and solution status

- Over 1000+ adopters till date Source: HDMI LLC
- HDMI Expands Footprint
  - HDMI has made inroads into PC industry
    - New computer platforms have HDMI interfaces
  - Hand held devices with miniature HDMI devices
    - New connectors Type C and Type D introduced
  - HDMI Forays into Automotive – Type E
  - Year 2011 – 3D Year
  - Still camera
  - Advertising billboards



- HDMI NOW Truly Single Digital Interconnect for uncompressed Audio/Video

- HEAC ( A R C )



# Changes in HDMI standards body

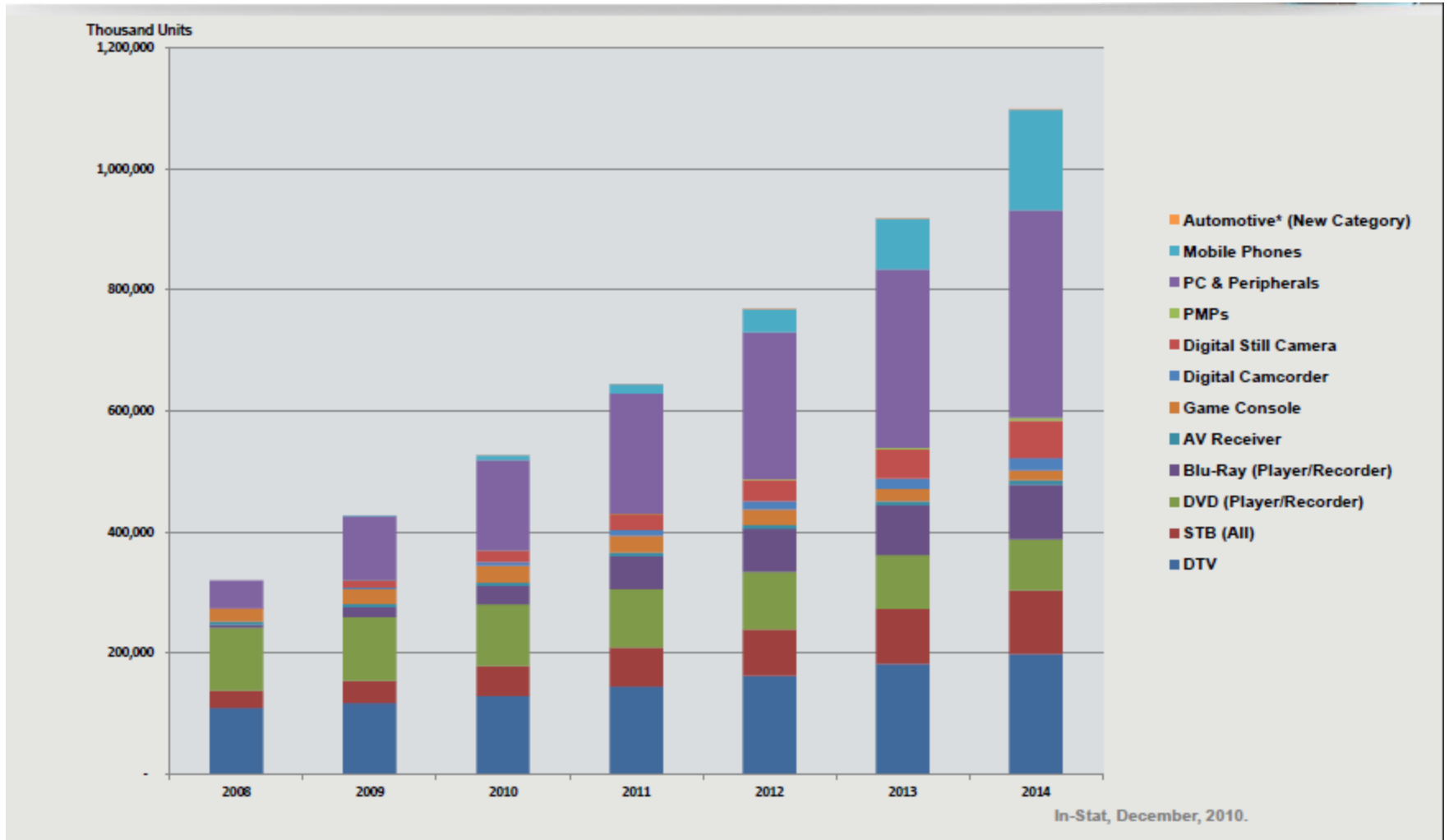
- Due to the HDMI Specification's overwhelming success, the HDMI Founders created an organization where interested companies can participate in the future development of the HDMI Specification
- On October 25, 2011, the HDMI Founders announced the launch of the HDMI Forum

Source: HDMI Forum

# Tektronix and HDMI Forum

- 80+ companies in the HDMI forum as of date. source HDMI Forum
- Tektronix is member of this HDMI Forum. Actively participating in weekly/monthly calls and face-face meetings
- **Tektronix's U.N.Vasudev is co-chair for HDMI forum test sub-group**
- HDMI Forum working on next version of HDMI specifications.
  - Target
    - 2013 Q3 Specification
    - CTS 2013 Q4

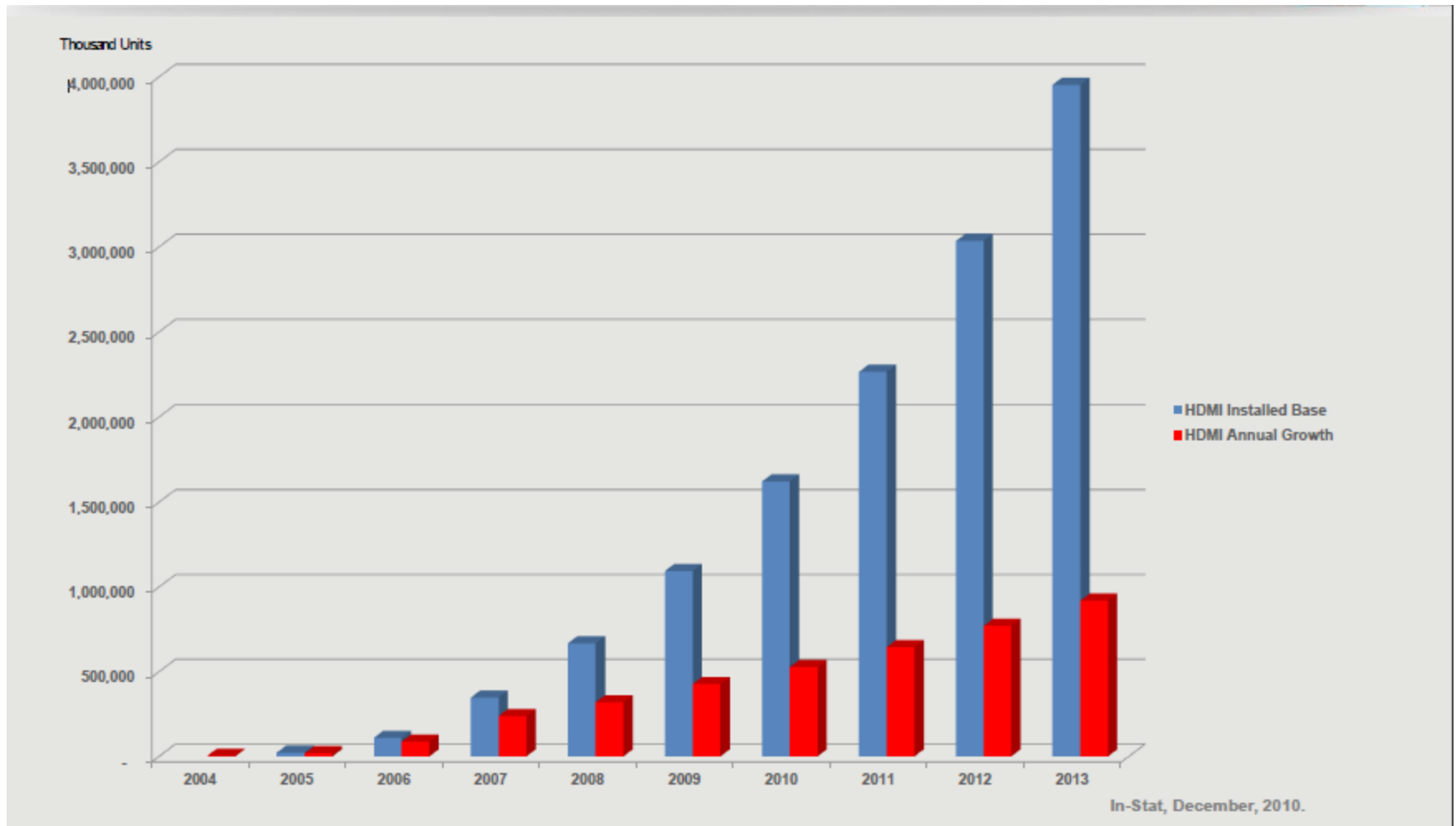
# HDMI Market overview



Source: HDMI Forum



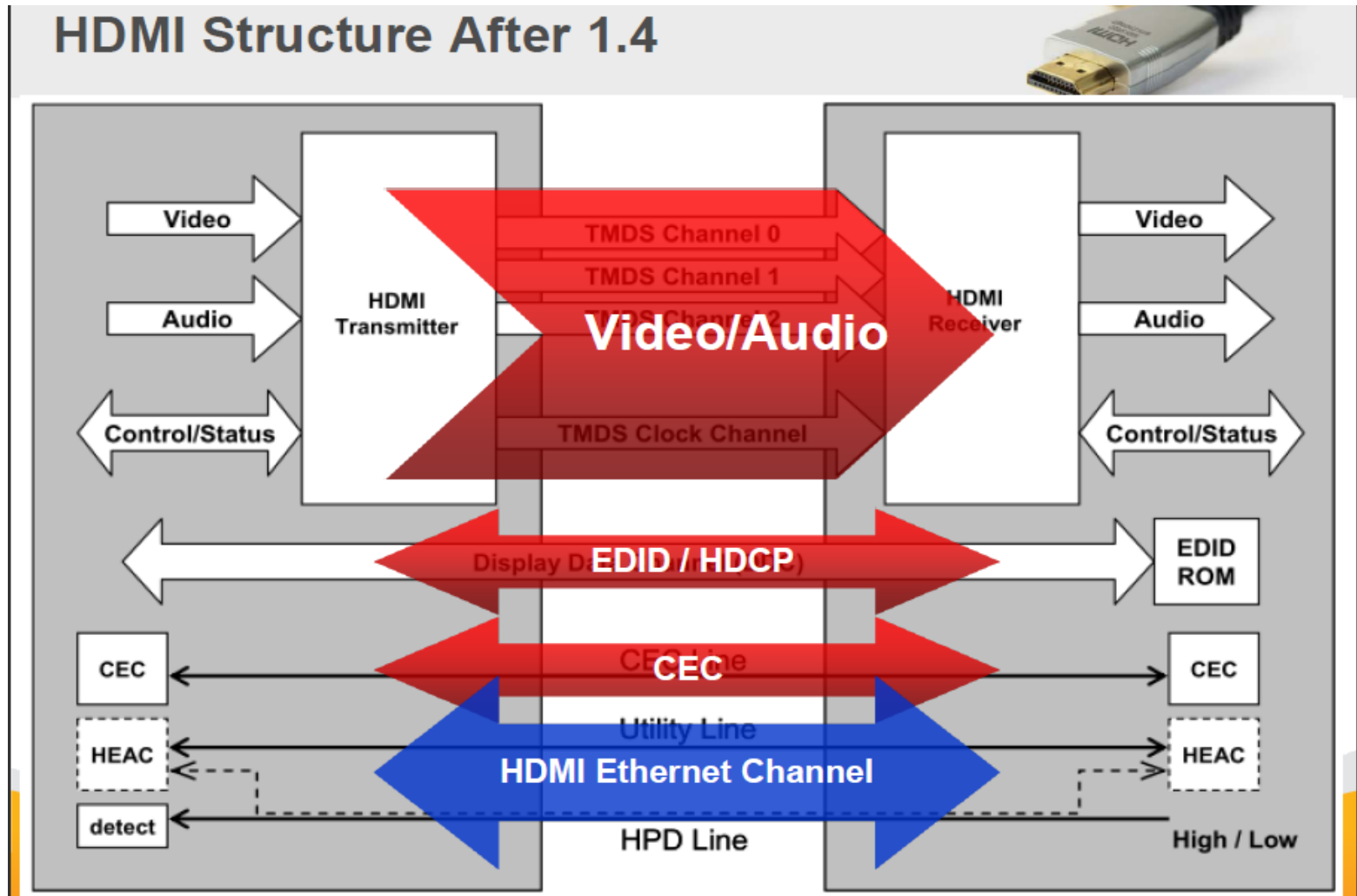
# HDMI Devices take rate



2.2B HDMI devices sold by 2011

Source: HDMI Forum

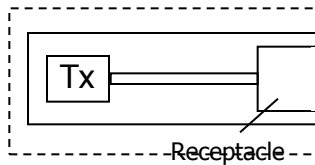
# HDMI Basics



# HDMI – System Overview

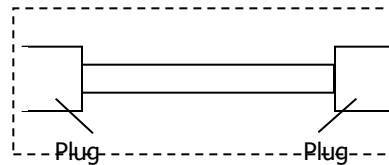


## Source Devices



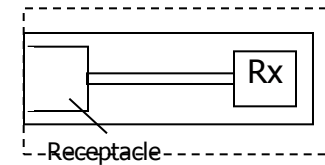
- Set-top Boxes, DVDs, Repeaters, Gaming devices

## Cable Assemblies



- Cables

## Sink Devices



- TVs, Monitors, Repeaters, etc.

# HDMI Overview – Source Devices

- Source Devices: Set-top Box, DVD, Repeaters, Gaming Devices
  - Offer multiple ports: USB, DVI, HDMI, FireWire, Ethernet, SATA
- Representative Suppliers of Source Devices
  - Scientific Atlanta, Motorola, Sharp, Sony, Philips, TiVo, Meriden, Pace, Hughes, Anam, Humax, Onkyo, Pioneer, Kaleidescape, Samsung
- Source Testing
  - Many tests to be performed
  - Key frustrations today
    - Time consuming
    - HDMI test correlation

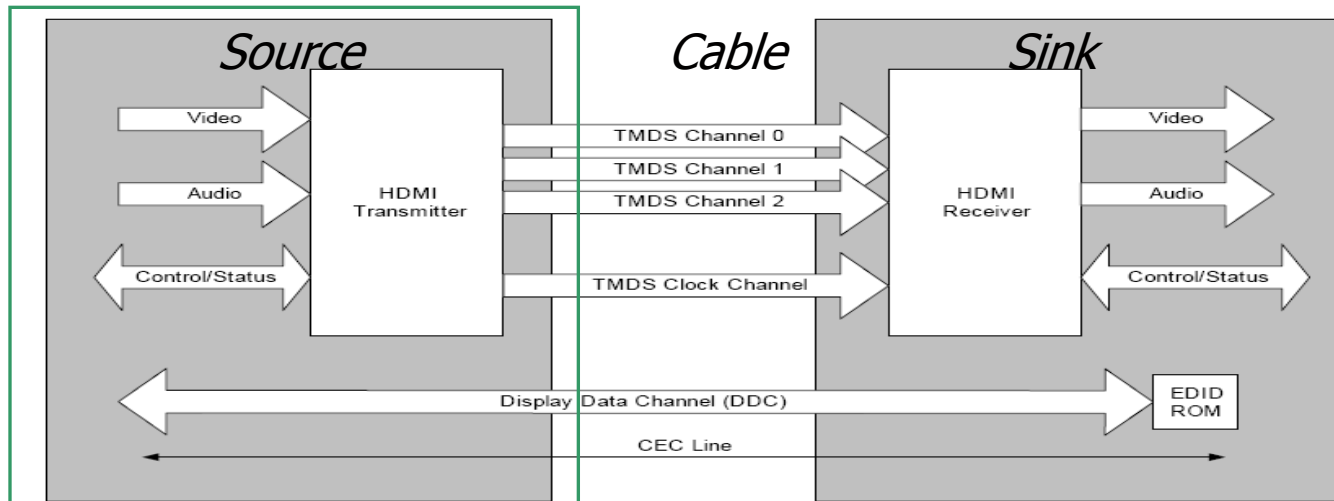


# HDMI Overview – Sink Devices

- Sink Devices: TVs, Monitors, Repeaters, etc.
  - Offer multiple ports:
    - USB, DVI, HDMI, FireWire
- Representative Suppliers of Sink Devices
  - Panasonic, Samsung, Thomson, Sony, Philips, Sharp, Quanta, Tatung, Anam, Humax
- Sink Testing
  - Few tests, but very time consuming
  - Requires a host of Signal Sources
    - DTG, AWG, Sampling scopes-TDR
  - Key frustrations today
    - Time consuming
    - Test complexity



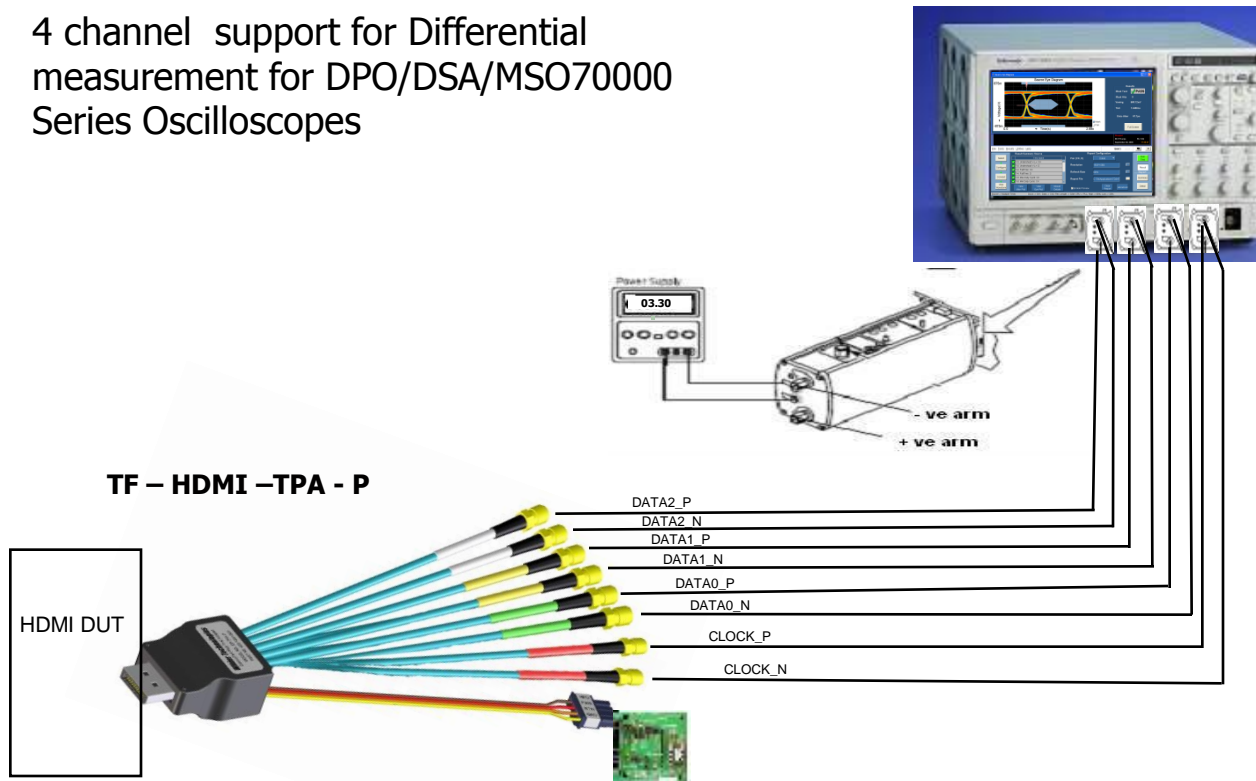
# HDMI Source Testing



- Rise/Fall Time
  - Inter-pair Skew
  - Clock Duty Cycle
  - Clock Jitter
  - Eye Diagram
  - Voltage VL
  - Intra-pair Skew
- } Differential
- } Single-ended

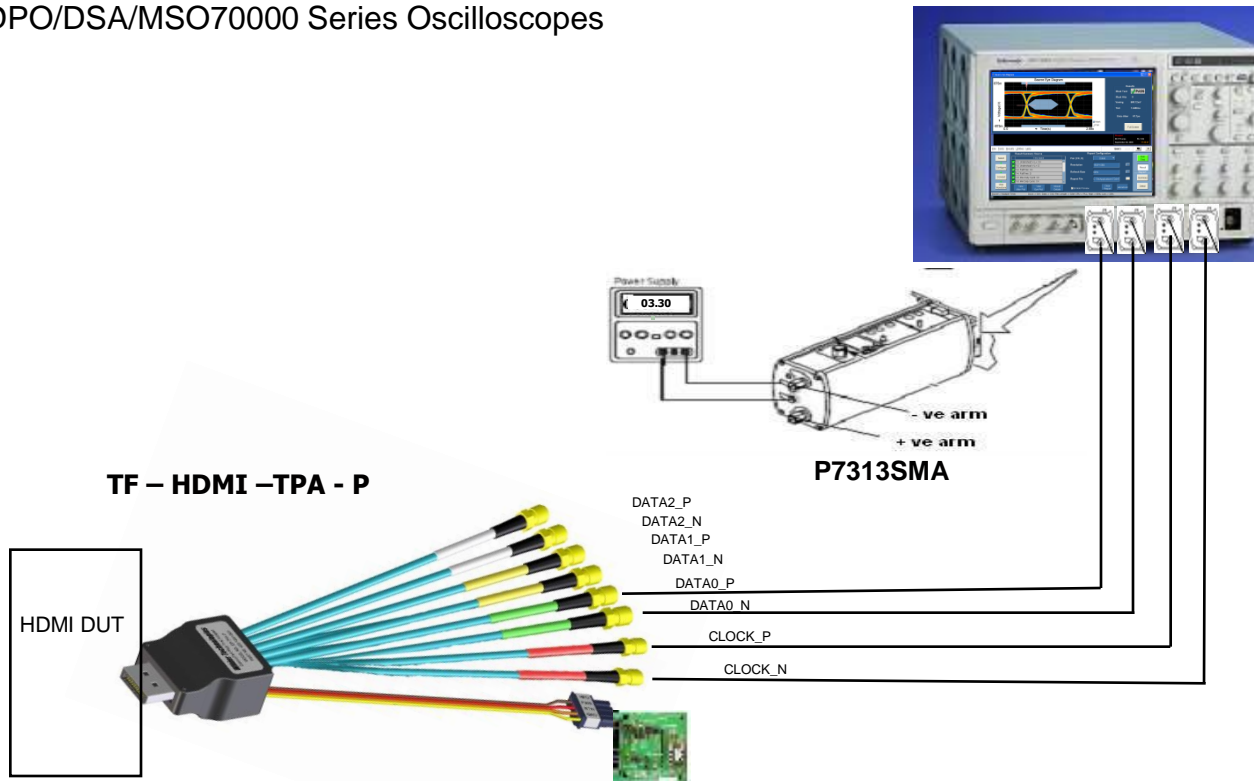
# Typical Source Test Configuration Differential Measurement

4 channel support for Differential measurement for DPO/DSA/MSO70000 Series Oscilloscopes



# Typical Source Test Configuration Single-ended Measurement

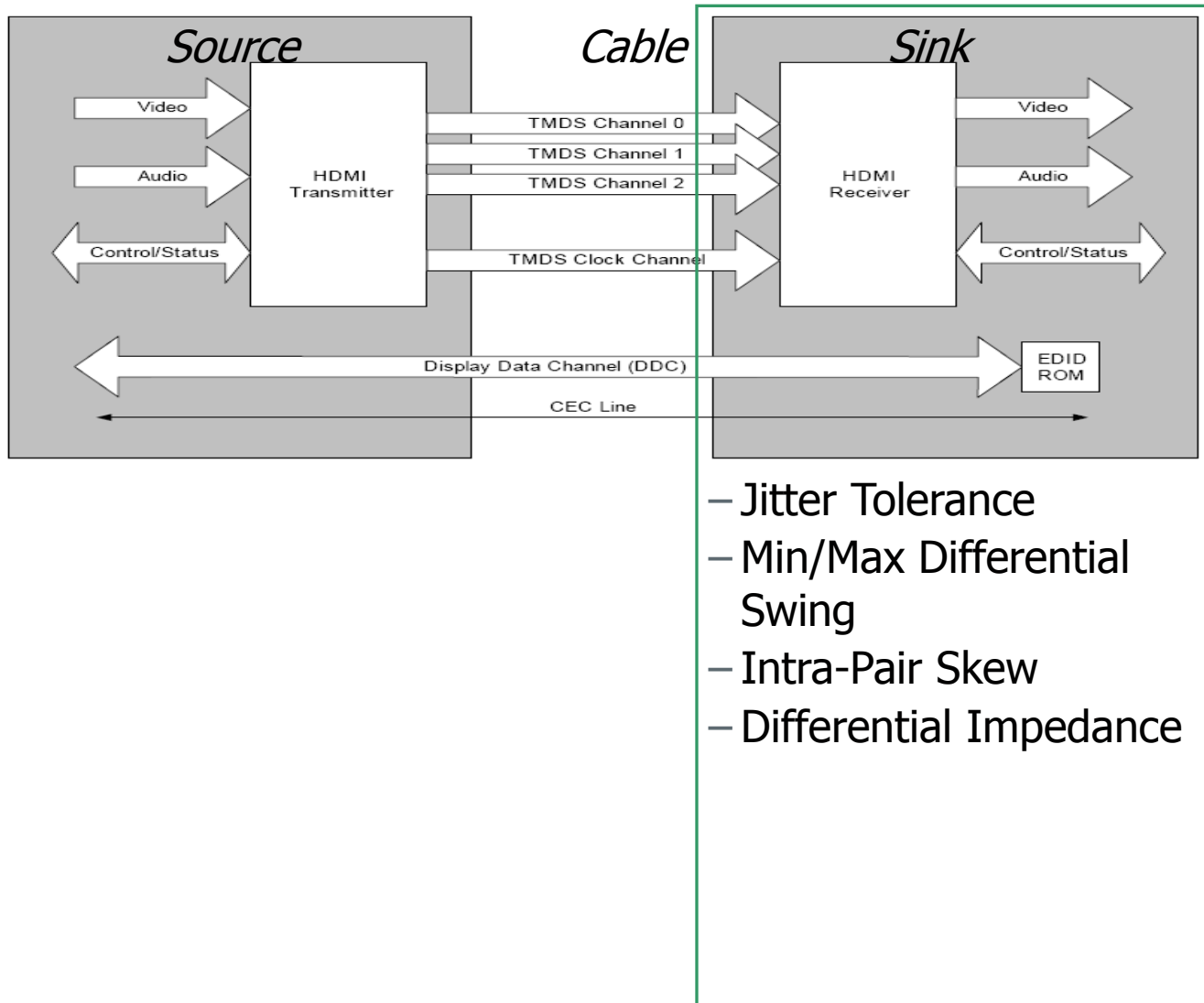
2 channel support for SE measurement on  
DPO/DSA/MSO70000 Series Oscilloscopes



Terminate unused fixture connectors with 50 ohms after pulling them to 3.3V using Bias-Tees

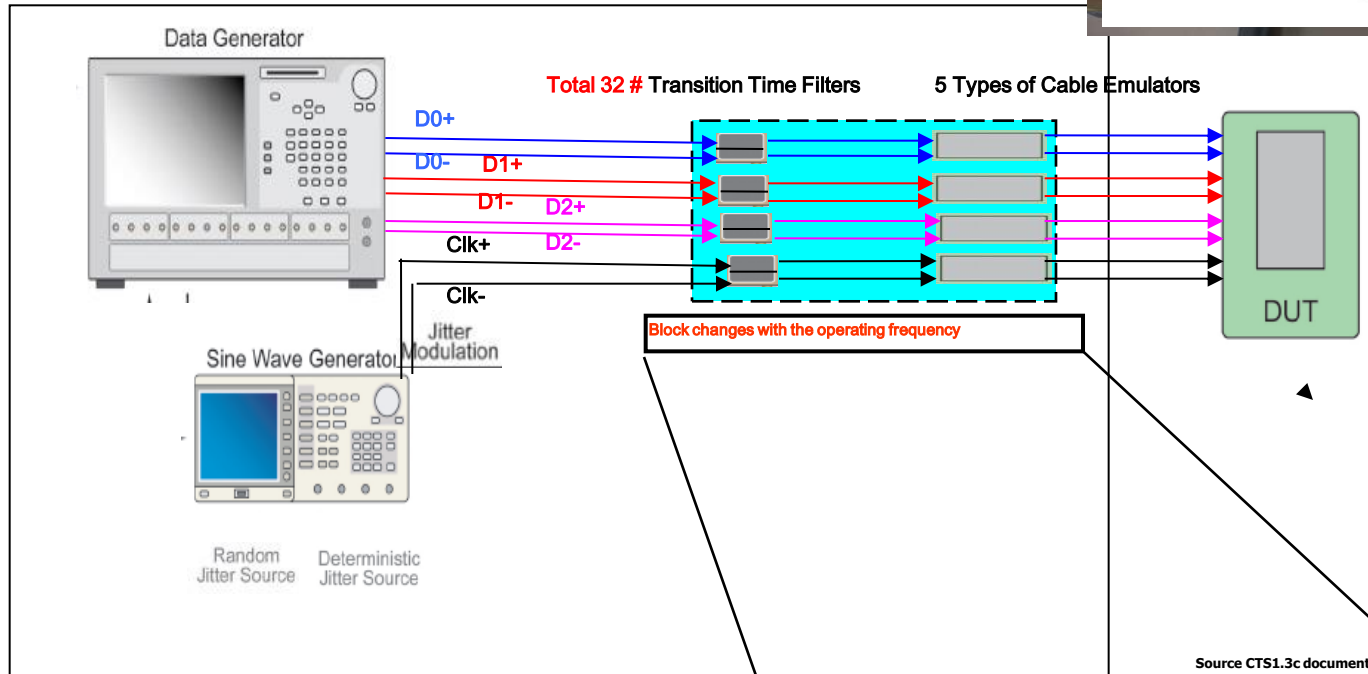


# HDMI Sink Testing



# AWG7000B with Direct Synthesis Significantly Reduces Test Time

## Present Solution-HDMI Sink Jitter Tolerance setup



- Can we reduce the **Complexity** ?
- Can we save the **setup time** ?
- Can we provide cost **effective** solution ?

Typical (MHz)	Low (MHz)	High (MHz)	TTC (MHz) <sup>1</sup>	1 <sup>st</sup> Cable Emulator	2 <sup>nd</sup> Cable Emulator
27	>= 25	<= 27.1	74.25	Tv0e 1 Cat1+Cat2 (Agilent) <sup>2</sup>	Tv0e 2 27MHz (JAE)
74.25	>= 27.1	<= 74.25	74.25	Type 1 Cat1 (Agilent)	Type 2 75MHz (JAE)
148.5	>74.25	<= 165	148.5	Type 1 Cat2 (Agilent)	Type 3 (Agilent)
222.75	>165	<= 222.75	222.75	Type 1 Cat2 (Agilent)	Type 3 (Agilent)
340	>222.75	<= 340	340	Tv0e 1 Cat2 (Agilent)	Type 3 (Agilent)

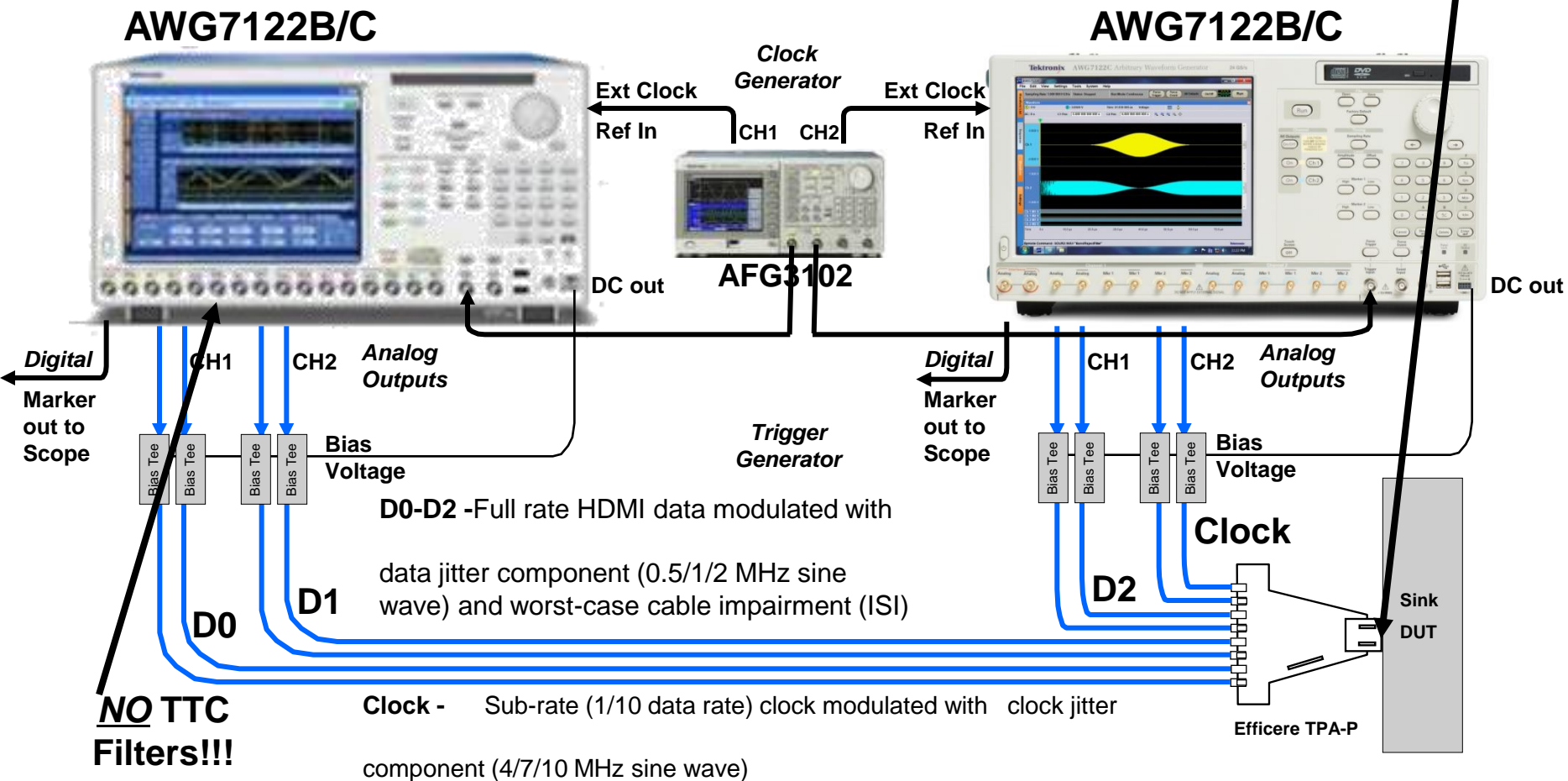
Additional hardware cable emulators will be introduced for automotive HDMI support.

# AWG7000B with Direct Synthesis Significantly Reduces Test Time

## HDMI Jitter Tolerance Test with Direct Synthesis

27 MHz to 340 MHz

**NO Cable Emulator!!!**



# AWG7000B with Direct Synthesis Significantly Reduces Test Time

## Benefits of Direct Synthesis

### ■ Simplicity

- TEKTRONIX ONLY SOLUTION PROVIDER TO SUPPORT ALL CABLE EMULATORS REQUIRED for HDMI Sink Jitter Tolerance test
- Elimination Cable Emulators and TTC (Transition Time Converts)
  - Cable emulators (7 cable types)
  - ~40 transition time filters
- Greatly reduces the opportunity for operator error

### ■ Performance

- Generates a wide range of rise-times without different filters
- Supports both the Combined and the Separate clock/data jitter insertion methods
- Synthesizes any/all Cable Emulator with any requirements
- Enables customers to perform their own margin testing

### ■ Flexibility

- The test repeatability across multiple labs/locations
- Pre-compensates waveforms to produce signals at the DUT launch point
- Emulates any impairment the CTS requires in the future

# What's Changed? – HDMI 1.4a/b

- Specification Released on March 4th 2010 Under Adopter Agreement of HDMI Standards Body
- Salient Features
  - Automotive HDMI ( Type E) - added new cable emulators
  - Mobile HDMI ( Type D)
  - HEAC ( HDMI Ethernet Audio Back Channel)
  - 4k x 2K resolution support
  - 3-D HDMI patterns- **updated**
  - Additional Deep Color patterns
- CTS1.4a Announced on March 4<sup>th</sup> 2010
- CTS1.4b Announced on Oct 11<sup>th</sup> 2011( editorial changes)

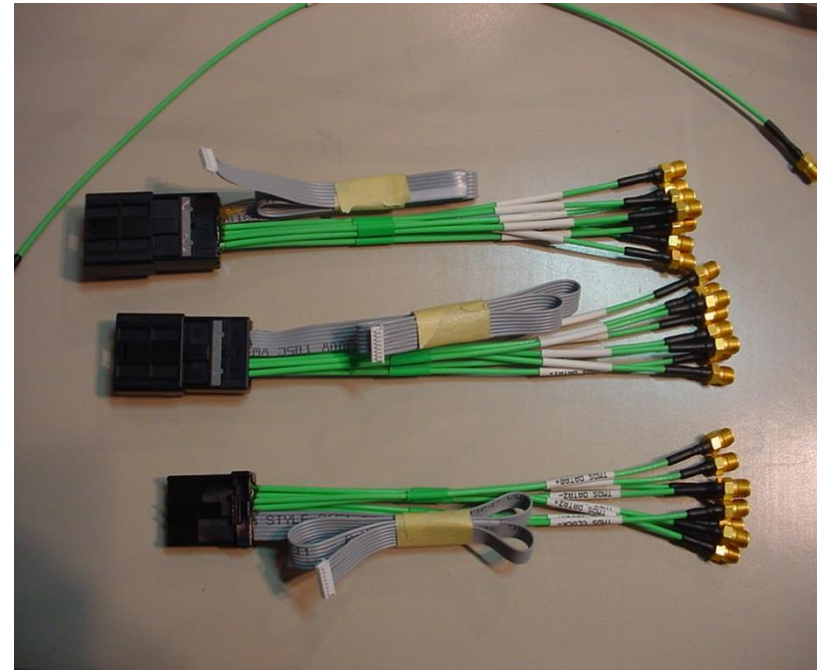
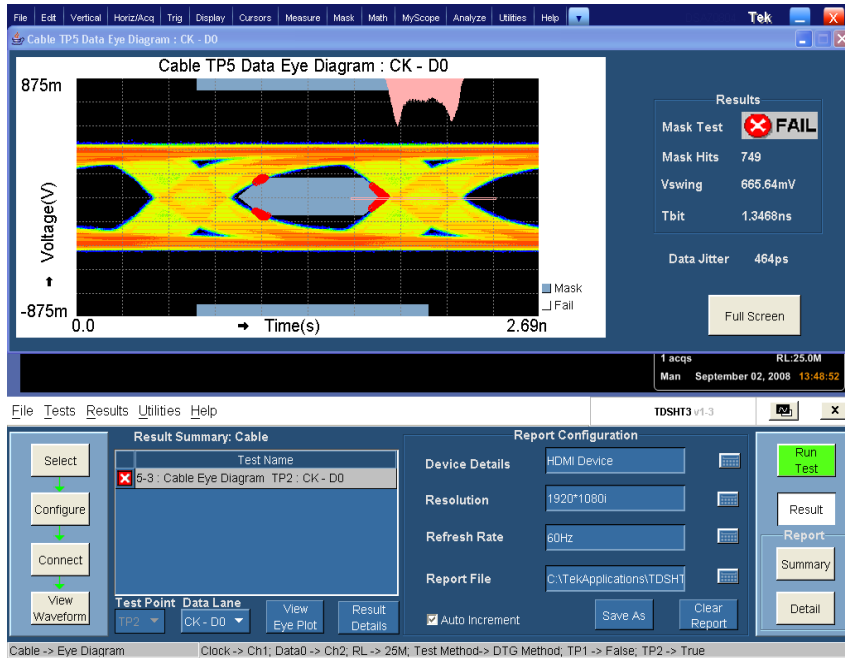
# Automotive HDMI Adaptation



# Tektronix HDMI 1.4a Test Solutions

## Automotive HDMI Solution from Tektronix

- Available in HT3 Software with Direct Synthesis capability approved by HDMI standards



- Type E Fixture from Tektronix approved by HDMI standards

# Tektronix HDMI 1.4a Test Solutions

## HDMI Mobile Solution – Type D

- Mobile companies will support HDMI new connectors
- Type D Fixture will be required and is approved by HDMI standards

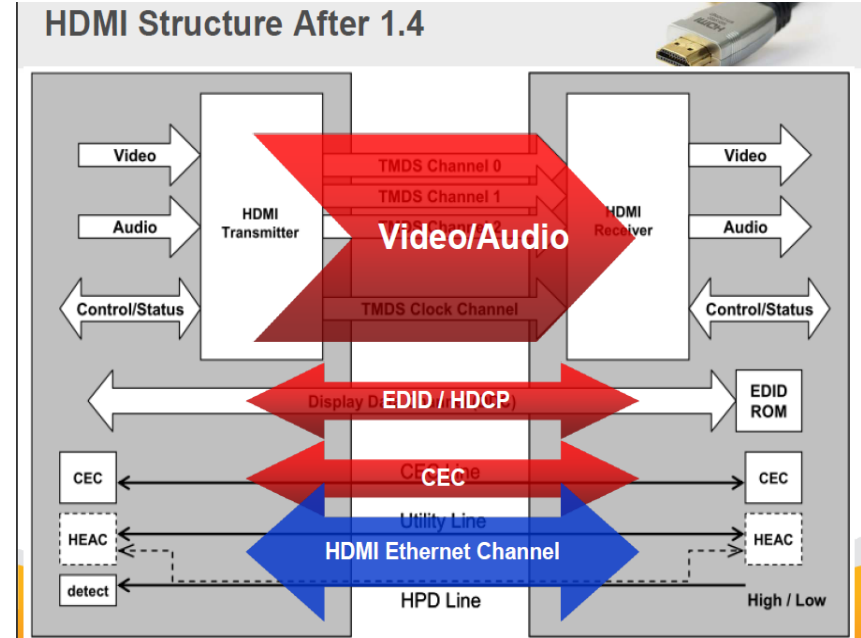




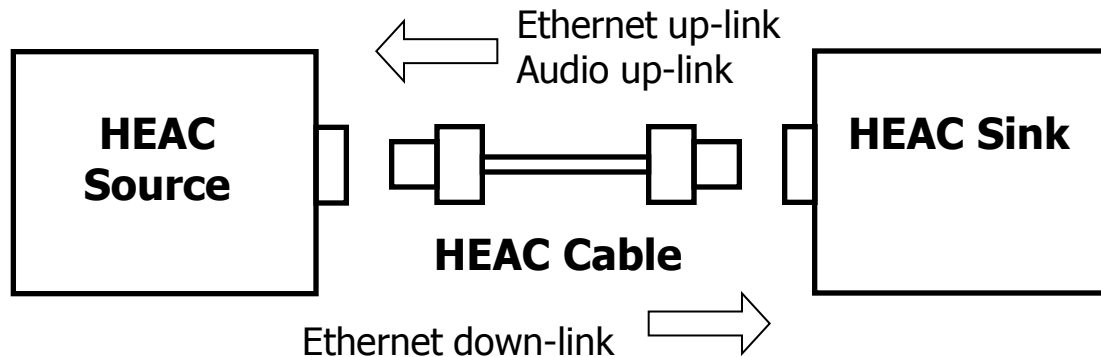
# Tektronix HDMI 1.4a Test Solutions

## What is HEAC?

- High Speed Network Capability
  - Provides bi-directional point-to-point communication
  - Enables building high performance home network
  - 1000 times faster than existing links using CEC
  - Utilizes widely accepted 100Base-TX Ethernet technology
- Digital Audio Stream Transfer
  - Provides SPDIF format digital audio channel
  - Enables versatile handling of digital sound by AV control center
  - Quality audio at 32k/44.1k/48k sampling rates
  - Backward transfer only (Sink to Source)
- Compatibility with Current HDMI
  - Enables inter-connection to existing HDMI devices (upward compatibility)
  - Automatic detection of HEAC enhancement
  - Utilize Hot Plug Detect & Reserve pins

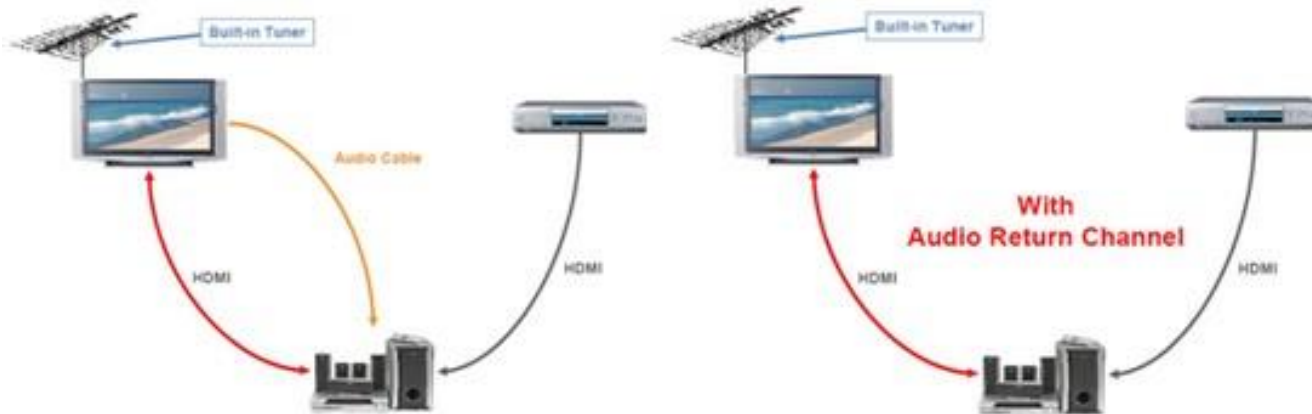
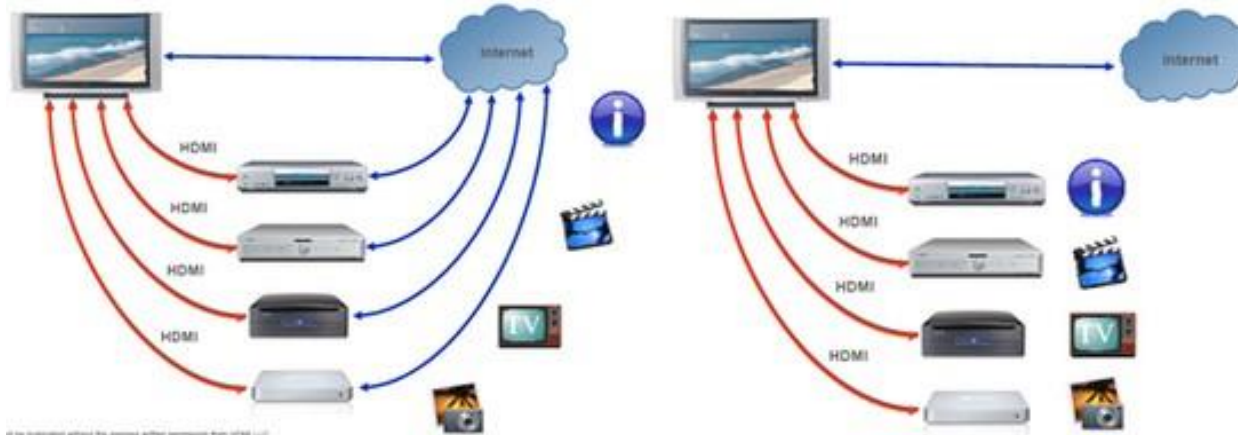


Source: HDMI LLC



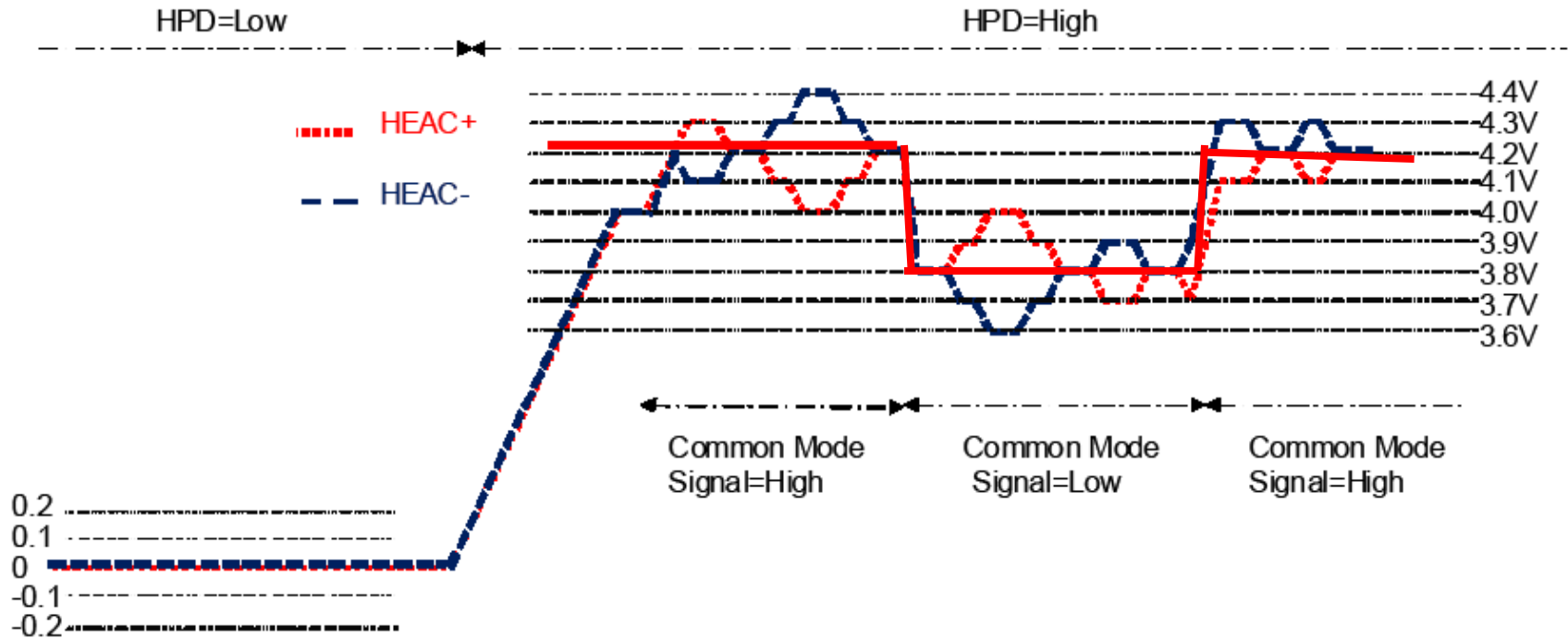
# HDMI ETHERNET AUDIO RETURN CHANNEL (HEAC)

## End Use application



Source: HDMI LLC

# HEAC-HDMI Ethernet and Audio Return Channel



HEAC Figure 2-10 Simultaneous Transmission Waveform

# Tektronix HDMI 1.4a Test Solutions

## HEAC Physical Layer Test (1/2)

- Ethernet Transmitter Test
  - Similar to normal 100Base-TX test except for lower amplitude
- Ethernet Receiver Test
  - Generate test packets with stress using AWG( 5K/7KB)
  - Capture and analyze response packets using oscilloscope
  - Confirm compliant packet error rate
- Audio Transmitter Test
  - SPDIF audio stream in common mode 400mVp-p amplitude
  - 32k/44.1k/48k samples/s rate (up to 6.144Mbps)
  - Measure typical pulse parameters using oscilloscope
- Audio Receiver Test
  - Generate test stream with stress using AWG
  - Listening test to regenerated audible sound

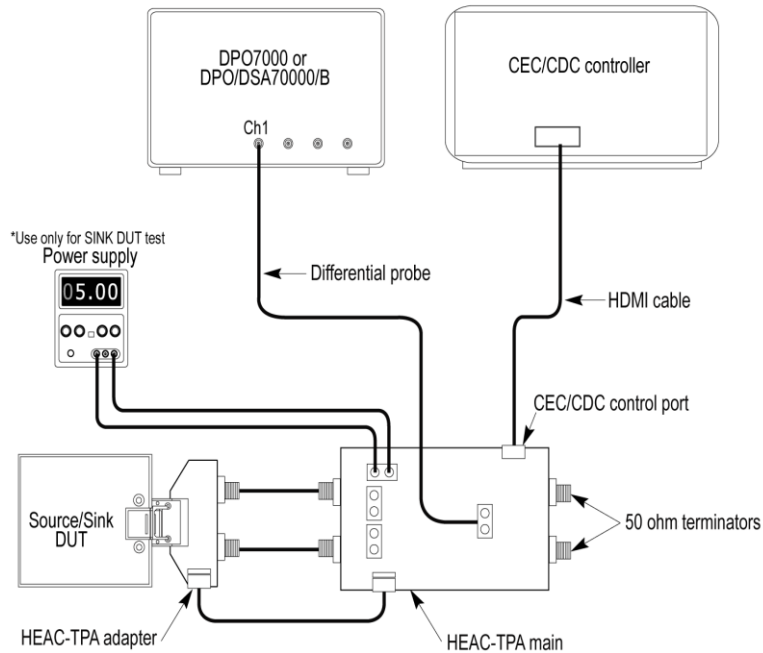
# Tektronix HDMI 1.4a Test Solutions

## HEAC Physical Layer Test (2/2)

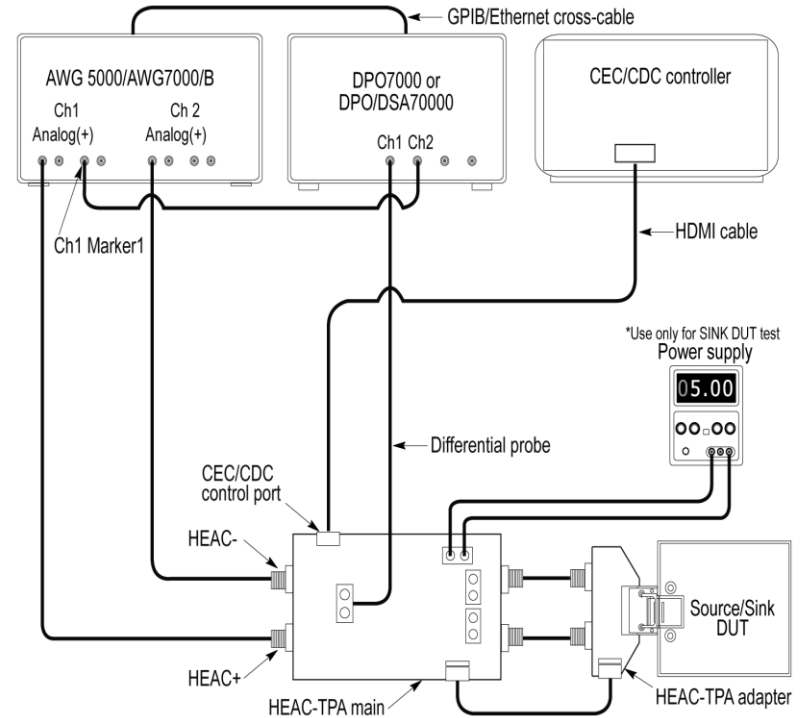
- Device Impedance Test
  - Measure impedance of HEAC lanes using TDR
- Cable Test
  - Measure impedance of HEAC lanes using TDR/TDT
  - Measure S-Parameters of HEAC lanes using TDT+S/W

# Tektronix HDMI 1.4a Test Solutions

## HEAC Solution Configuration



Tx Test Setup



Rx Test Setup

# Tektronix HDMI 1.4a Test Solutions

## HEAC Software

TekExpress HEAC Automated Solution (Evaluation Version) (Untitled)\*

File View Tools Help

DUT ID: DUT001 [Run] [Stop]

Select Acquire Analyze Report

**Select Device**

- HEAC-Transmitter
- HEAC-Receiver

**Select Test Suite**

- Differential-Rx
- CommonMode-Rx
- SingleMode-Rx

**Version**

CTS 1.4

**DUT IP Address**

255.255.255.255

Auto Detect MAC Address

**HEAC-Receiver : Differential-Rx CTS 1.4**

Select	Test Name
<input checked="" type="checkbox"/>	Receiver Performance - Nominal Response
<input checked="" type="checkbox"/>	5.16 Receiver Performance - Amplitude
<input checked="" type="checkbox"/>	5.16 Receiver Performance - Clock Frequency
<input checked="" type="checkbox"/>	5.16 Receiver Performance - Common mode
<input checked="" type="checkbox"/>	5.16 Receiver Performance - Signal Source Impedance
<input checked="" type="checkbox"/>	5.16 Receiver Performance - Worst Case Cable

**Test Description**

This optional test verifies the receiver capability to respond to nominal amplitude, clock frequency and

[Configure]

[Show Schematic]

[Select All]

[Deselect All]

TekExpress launched successfully.

**Tektronix**

# Tektronix HDMI 1.4a Test Solutions

## HEAC Test Report



TekExpress Automation Framework

### HEAC Differential TX Signal Characteristics Test Report

DUT ID : DUT001  
Date/Time : 3/2/2010 12:30

Device Type : HEAC-Transmitter  
Execution Time : 13 Min

CTS Version : CTS 1.4  
Compliance Mode : Yes  
Overall Test Result : Pass

Scope Model : DPO72004  
Probe Model : P6248

Scope Serial Number : Q226  
Probe Serial Number : B011054

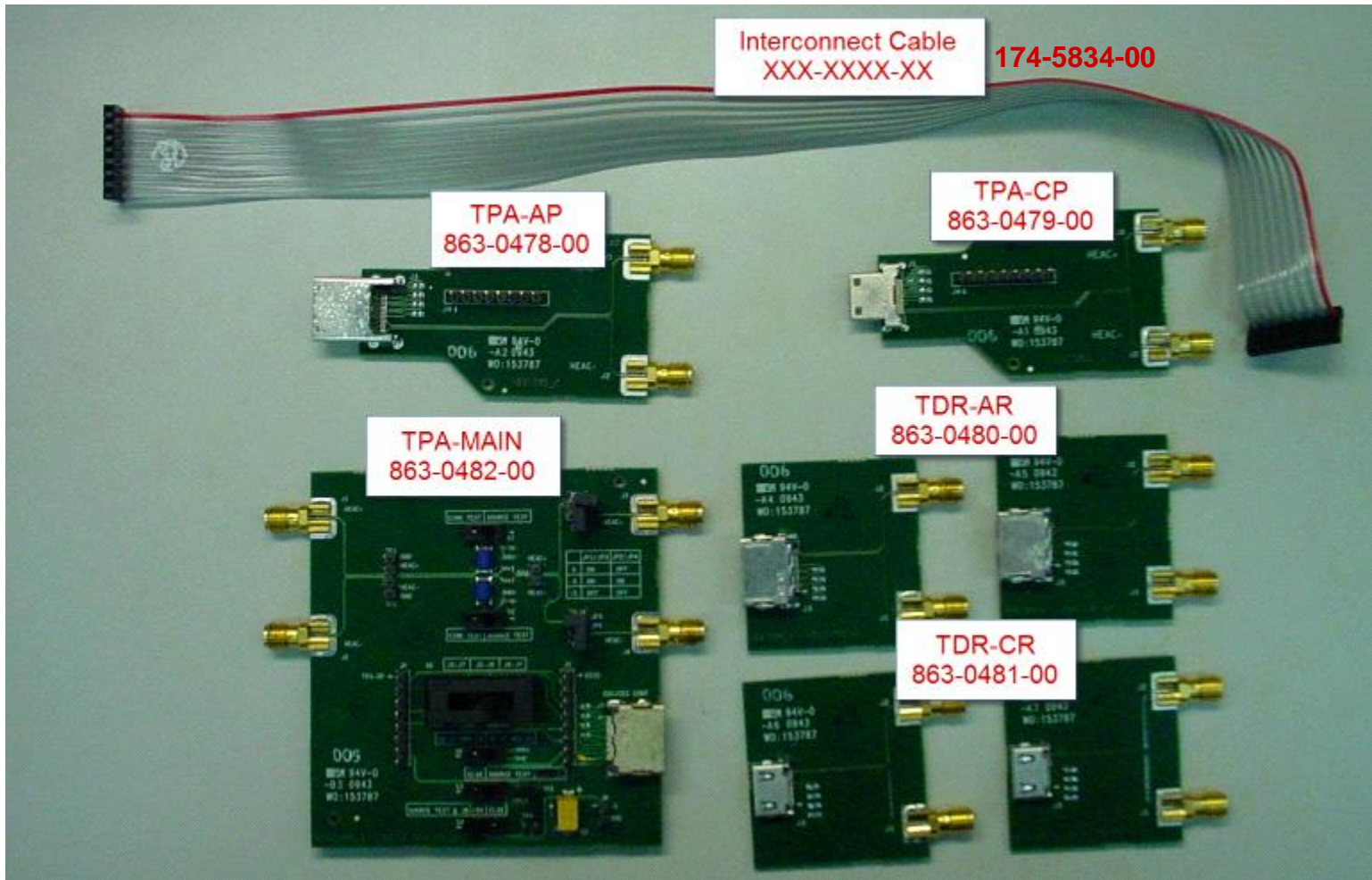
Scope FW Version : 5.1.0 BNSFBUILD 28  
SPC, Factory Calibration : PASS/PASS  
TekExpress Version : HEAC: 1.3.5.56, Framework: 1.3.4.135

Test Name	Measurement Details	Low Limit	Measured value	High Limit	Margin	Units	Test Result	Compliance Mode	Analysis Time	Comments
5.1 Operating DC Voltage	DC Voltage : HEAC + line	>= 3.6	4.1980	<= 4.4	0.202, 0.598	V	Pass	Yes	3 Min	
	DC Voltage : HEAC - line	>= 3.6	4.1539	<= 4.4	0.2461, 0.5539		Pass			
5.2 Jitter MAX	Jitter Max Positive	-	0.9456	< 1.4	0.4544	nS	Pass	Yes	1 Min	
	Jitter Max Negative	-	1.0403	< 1.4	0.3597		Pass			
5.3 Rise-Fall Time	Rise Time Positive Pulses	>= 3	4.9251	<= 5	1.9251, 0.0749	nS	Pass	Yes	3 Min	
	Fall Time Positive Pulses	>= 3	4.7602	<= 5	1.7602, 0.2398		Pass			
	Rise Time Negative Pulses	>= 3	4.9747	<= 5	1.9747, 0.0253		Pass			
	Fall Time Negative Pulses	>= 3	4.7572	<= 5	1.7572, 0.2428		Pass			
5.4 High-Low-Center Level	High Level Voltage	>= 180	199.4449	<= 220	19.4449, 20.5551	mV	Pass	Yes	3 Min	
	Low Level Voltage	>= -220	-194.4681	<= -180	25.5319, 14.4681		Pass			
	Center Level Voltage	>= -20	3.0732	<= 20	23.0732, 16.9268		Pass			
5.5 Cycle Time	Cycle Time Positive Pulses	>= 7.875	8.0581	<= 8.125	0.1831, 0.0669	nS	Pass	Yes	2 Min	
	Cycle Time Negative Pulses	>= 7.875	8.0584	<= 8.125	0.1834, 0.0666		Pass			



# Tektronix HDMI 1.4a Test Solutions

## HEAC Fixtures



# Tektronix HDMI 1.4a Test Solutions

## HEAC Solution

- Real Time Oscilloscope, AWG5KB/7KB, Probes
- Test Fixture Kit( TF-HEAC-TPA-KIT)
  - One MAIN , 2 Plug ( AP/CP), 4#TDR ( 2#AR/2#CR)
- HEAC Software
  - Ethernet Transmitter Test Software
  - Ethernet Receiver Test Software
    - Control AWG & oscilloscope
    - Setup signal (sensitivity, clock frequency, modal rejection, error rate)
    - Extract & check response signal (software HYBRID & packet analysis)
  - Audio Transmitter Test Software
    - HEAC
  - Audio Receiver Test Pattern Suite
    - AWG files (format support, modal rejection, jitter tolerance)

# Tektronix HDMI 1.4a Test Solutions

## HDMI 1.4 Pattern Support

- 4K x 2K Resolution patterns
- 3D HDMI mandatory Patterns (updated)
- New Deep Color Patterns
- 7 New tests will be added to HT3 Sink tests to make the tests automated by HT3. (8-28,8-29, 8-30,8-31, DVI Interoperability, Audio tests)



# Tektronix HDMI Protocol Analysis Solution

- HDMI Protocol Analysis software running on the Tektronix DPO/DSA/MSO70000 Series Oscilloscope
  - Unique value proposition as the same real time scope is used for both Physical layer testing and Protocol testing
  - Gives the seamless transition from Phy layer to Protocol
  - Cost effective solution
- Features
  - Multi View support
    - Bus Analysis
    - Image Viewer
    - Event Viewer
    - Protocol Viewer
    - Linked to the analog waveform
- Tektronix Nomenclature
  - TEK-PGY-HDMI-PA-SW ( HDMI only)
  - TEK-PGY-HDMH-PA-SW ( Combined HDMI and MHL)

# Tektronix HDMI Protocol Analyzer

TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

Mode: HDMI (selected), MHL

Displays:

- Image Viewer
- Protocol Viewer
- Bus Viewer
- Event Viewer
- Data Packet Viewer

List Of Tests:

- Source Protocol Tests
  - 7-16 Legal Codes
  - 7-17 Basic Protocol
  - 7-18 Extended Control Period
  - 7-19 Packet Types
- Source video
- Source audio
  - 7-28 IEC 60958/IEC 61937
  - 7-29 ACR
  - 7-30 Audio Sample Packet Jitter
  - 7-31 Audio InfoFrame
  - 7-32 Audio Sample Packet Layout
- Source interoperability with DVI

Buttons: Select, Configure, View, Capture, Clear All, Select All, Run (Single, Repetitive, No Acq), Analyze, Export, Report

Version: 0.8.0

TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

Signal Source:

- Oscilloscope
- Wfm Files
- P/A/V Binary File

Signal Assignment:

Clock	CH1
Data 0	CH2
Data 1	CH3
Data 2	CH4

Video Format:

Pixel Encoding: RGB

Bits Per Pixel: 24 Bits

Format: 3D-Side by Side

( 2 ) - 720x480 @ 60 Hz

Source\_CN: Not Specified

Non CEA Format |  AVI Supported

Audio Sample Frequency: 32 kHz

Channel Inversion:

- Invert Data 0
- Invert Data 1
- Invert Data 2

Buttons: Select, Configure, View, Capture, Run (Single, Repetitive, No Acq), Analyze, Export, Report

Version: 0.8.0

# Tektronix HDMI Protocol Analyzer

TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

**Select**  
**Configure**  
**View**  
**Capture**

**Total Duration of capture**  
 Duration of capture : 2 Sec  
 Total frames to be tested : 120

**Frame display**  
 Display all captured data  
 Display only complete frame

**Test**  
 Test all captured data  
 Test only complete frame

**Oscilloscope Setup Assistant**  
Pixel Clock Frequency 27 MHz  
**Setup**

Version : 0.8.0

**Run**  
**Single**  
Repetitive  
No Acq  
**Analyze**  
Export  
Report

TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

**Select**  
**Configure**  
**View**  
**Capture**

Frame :1 Frame :2 Frame :3  
Yet to Update Yet to Update Yet to Update

Total number of Frames tested 3  
Number of Tests selected 4  
Number of tests passed 4  
Number of Tests Failed 0

**Stop** **Pause**

View Analyzer

Version : 0.8.0 Decoding - 32% completed (Processed 80,000,000 data samples of total 250,000,000 )

**Run**  
**Stop**  
Repetitive  
No Acq  
**Analyze**  
Export  
Report

# Tektronix HDMI Protocol Analyzer

TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

Measurement

Measurement	Result
Test ID 7-16: Legal Codes	Pass
Test ID 7-17: Basic Protocol	Pass
Test ID 7-18: Extended Control Period	Pass
Test ID 7-19: Packet Types	Pass

Version : 0.8.0

Buttons: Select, Configure, View, Capture, View Analyzer, Run, Single, Repetitive, No Acq, Analyze, Export, Report

PGY HDMI Protocol Analysis Solution - Beta (All features are not completely implemented and tested)

Frame Viewer: Frame 1-9

Bus Viewer

Line	Pixel	Message	Type
6	111	5226	Audio S...
7	111	6084	Audio S...
8	111	6942	Audio S...
9	111	7800	Audio S...
9	642	8299	AVI Inf...

SC3-SC0 = 0x0  
VIC6-VIC0 = 0x0  
HB : 82 02 0D  
SBO : 91 00 00 02 00 18 00 55

Event Viewer

Test Name	Result
Test ID 7-16: Legal Codes	Pass
Test ID 7-17: Basic Protocol	Pass

Pixel Index

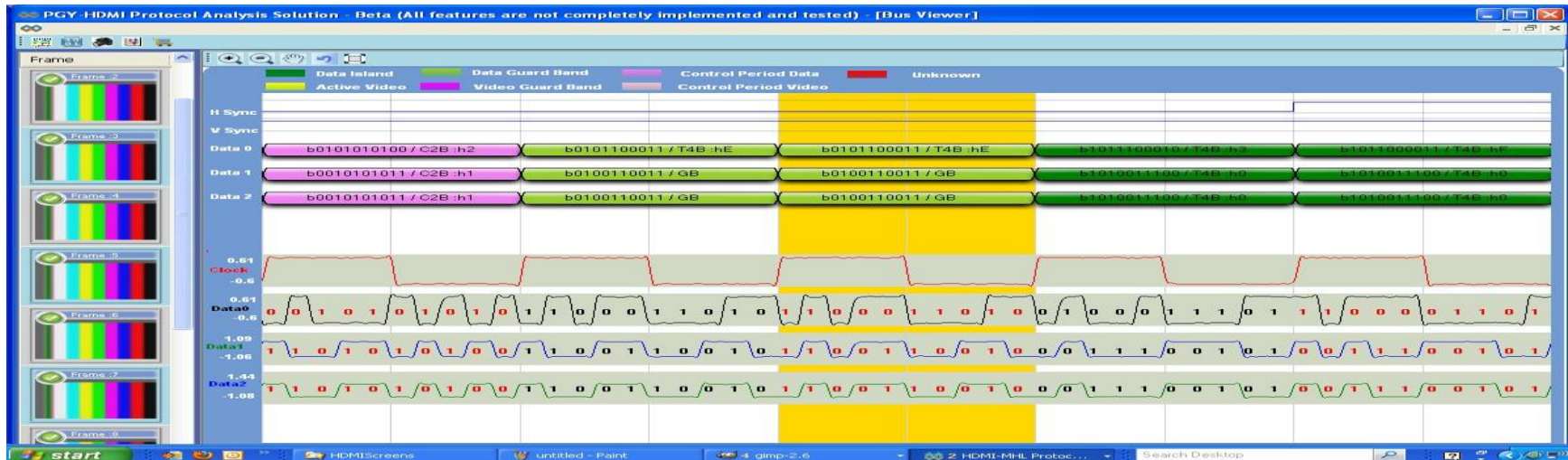
Type	D0 Data	D1 Data	D2 Data
Data Gua...	h163	h133	h133
Data Island	h2E2	h29C	h29C
Data Island	h2C3	h29C	h29C
Data Island	h2C6	h29C	h29C

Cursor Details:  
Cursor: 331.5  
Type: Control Period  
Image: 3763.4

Cursor Data:  
Data 0: 10B :h2AB / C2B :h3  
Data 1: 10B :h354 / C2B :h0  
Data 2: 10B :h354 / C2B :h0

Frame: 0  
Line: 4  
Video Pixels: 0  
Data Island: 32  
Video GB: 0  
Data GB: 0

# Tektronix HDMI Protocol Analyzer



TEK-PGY HDMI/MHL Protocol Analysis solution - Beta

Frame:  .csv (Comma separated values),  .txt (Text, Tab separated values),  .bmp (Bitmap File)

Event:  .csv (Comma Separated Values),  .txt (Text File)

Protocol:  HDMI P/A/V Analyzer format,  Data Island Packets

Export:  Export All Frames,  Frame Range

Start Frame: [dropdown], Start Line: [input]  
End Frame: [dropdown], End Line: [input]

Run: , ,

Analyze, Export, Report

Version :0.8.0



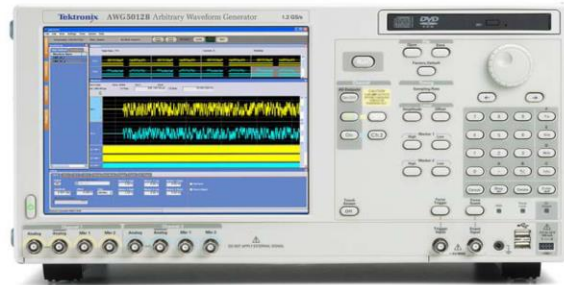
# Tektronix HDMI 1.4a Test Solutions

## Tektronix HDMI 1.4a Solution

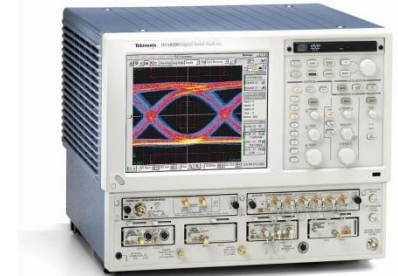
DPO/DSA/MSO70000  
Real Time Oscilloscopes



AWG5K/B or AWG7K/B  
Arbitrary Waveform Generators



DSA8300 Sampling Oscilloscope  
with i-connect software



Common Set of test equipment for HDMI and HEAC

### HDMI Fixtures:

1. Type A( TF-HDMI-TPA-S/-STX)
2. Type C(TF-HDMIC-TPA-S/-STX)
3. Type D( TF-HDMID-TPA-P/-R)
4. Type E(TF-HDMIE-TPA-KIT)
5. HEAC Fixtures(TF-HEAC-TPA-KIT)

### Probes and Accessories

- HDMI Probes
- HEAC Probes
- HDMI Accessory Kit

# Proposed HDMI 2.0 features-Not finalized

- Uses same Cat 2 Cable and HDMI 1.4b connector
- Support 4K 2K 4:4:4 60 Hz – 594Mhz
- Support 4K 2K 4:2:0 – 297Mhz
- Direct Attach device support
- Low level Bit error rate testing
- Scrambling is likely to be introduced for rates >340Mcps.

# Rise time Needs

Table 4-24 Source AC Characteristics at TP1

Item	Value
Rise time / fall time (20%-80%)	<u>if attached Sink supports &lt; 340MHz</u> <u>75psec ≤ Rise time / fall time</u> <u>if attached Sink supports &gt; 340MHz and transmitted TMD5 Character Rate &gt; 340MHz</u> <u>42.5psec ≤ Data Rise time / Data fall time</u> <u>75psec ≤ Clock Rise time / Clock fall time</u>

Table 4-30 TP7 Direct Attach AC Characteristics at 6Gbps

Item	Value
Rise time / fall time (20%-80%)	<u>if attached Sink supports &gt; 340MHz and transmitted TMD5 Character Rate &gt; 340MHz</u> <u>42.5psec ≤ Data Rise time / Data fall time</u> <u>75psec ≤ Clock Rise time / Clock fall time</u>

- HDMI 1.4b, should be capable of measuring 75 psec, but no word about the System Rise time.
- **HDMI 2.0 should be capable of measuring 42.5 psec, but no word about System Rise time.**
- The Error contribution of RT measurement due to System and DUT generally not accounted when we refer to specification

# What is the system bandwidth needed to measure 42.5 (20-80% )psec or less DUT Rise time

- System bandwidth should be around  $(42.5/1.5) = 28$ psec
- Scope bandwidth of 16 Ghz and 16 Ghz DSP enhanced probe has System Rise time of about 23 psec. It can measure the DUT Rise time of 42.5 psec with error of 1%. And can measure DUT Rise time of 37 psec with error of 7%.
- We can indicate Pass or fail confidently only when the System band. width is close to 16 Ghz scope .
- Is it fact for all scope vender ??
  - Spec says it should not be less than 42.5psec.
  - Max Rise time is limited by Eye diagram slope.
  - Both scope and Probe rise time cannot be less or equal to the DUT rise time because it can measure the signal rise time accurately only if DUT RT is slower than system rise time by 1.5 X times.
- How it is handled in HDMI 1.4b today???
  - We recommend 8Ghz scope and 13 Ghz probe, then system rise time is 38 psec which is close 2X faster than 75 psec

# Conclusion

- 16GHz BW scope will give 1% error and hence is recommended for HDMI 2.0 testing.
- HDMI 2.0 RT/FT (20%-80%) data signals is 42.5ps

# HDMI 2.0 Source Testing-Advanced information



# Source Testing 1.4b Vs 2.0

Eye Diagram **and clk jitter** test is **likely to be** changed

Rest of the tests **likely to be** same

1.4b CTS test **likely to be a** pre-requisite for HDMI 2.0 **to ensure interoperability**

Min 8GHz scope to 16GHz scope

Fixtures and Probes

# Likely Source Electrical tests

**Vlow**

**$T_{RISE}$ ,  $T_{FALL}$**

**Inter-Pair Skew**

**Intra-Pair Skew**

**Differential Voltage**

**Clock Duty Cycle**

**Clock Jitter**

**Data Eye Diagram**

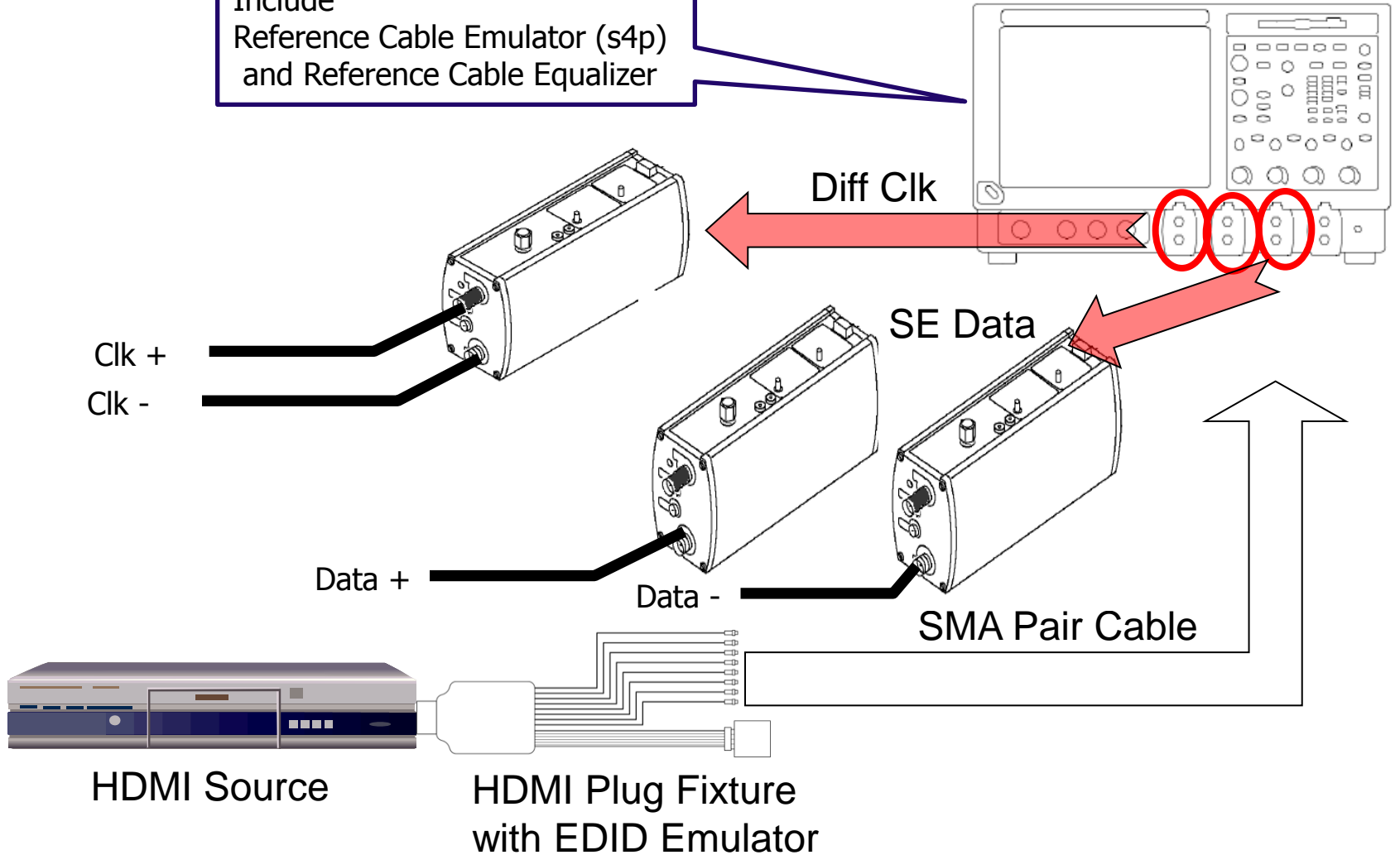
**Differential Impedance**



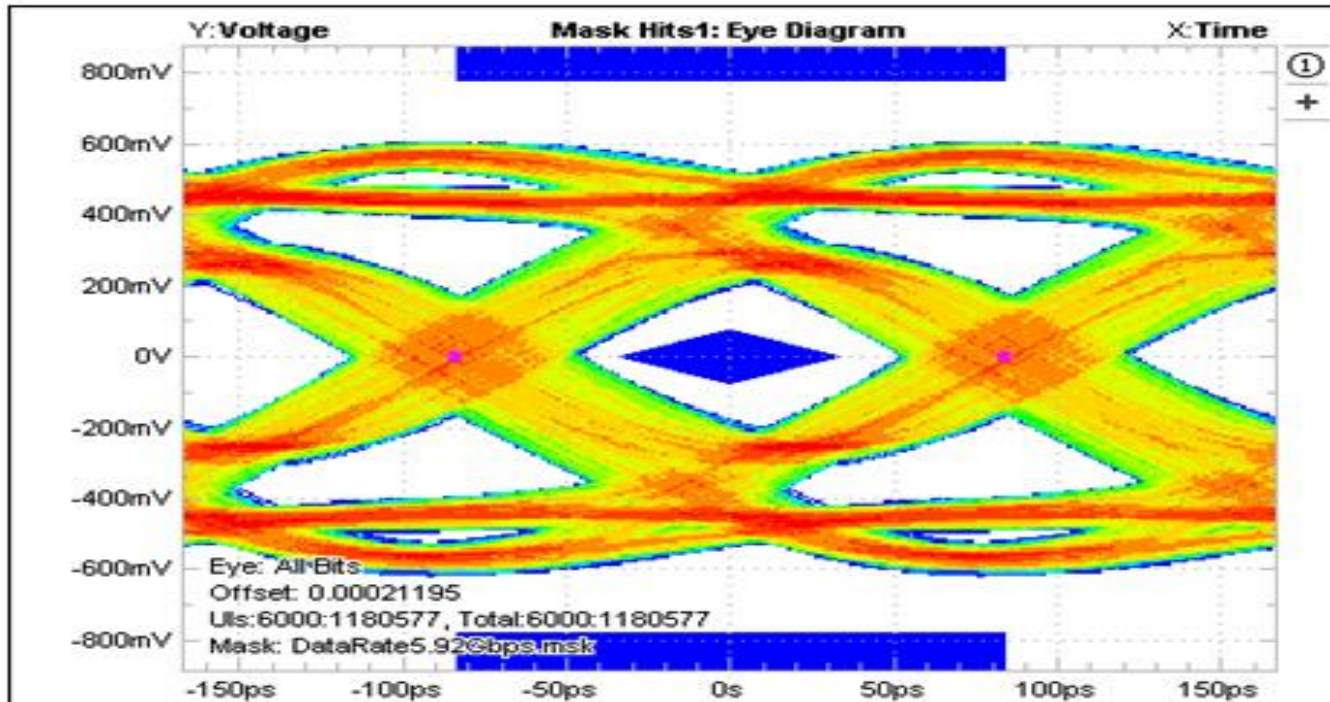
# Source Eye Diagram Test

Tektronix Oscilloscope  
DPO/DSA/MSO70000 Series  
≥ 16GHz

Include  
Reference Cable Emulator (s4p)  
and Reference Cable Equalizer



# TP2 Source Eye for HDMI 2.0 6G signal



Single End Input eye rendered at Tek lab

# HDMI 2.0 Tx Compliance Software

**TekExpress HDM - (Untitled)**

Options ▾ Start [Start] Pause [Pause]

1 DUT DUT ID: DUT001  
 Device: HDM Physical Layer Solution  
 Suite: Source Version: CTS 2.0  
 View: Compliance  
 Acquire live waveforms / Use pre-recorded waveform files  
 Device Profile  
 Termination Source: Internal  
 VTerm (V): 3.3 TBit: 0.0  
 Diff Probe Attenuation (x): 12.5 Recalc TBit [x]  
 SE Probe Attenuation (x): 2.5  
 Number of Lanes to Test: 3 Lanes  
 Selected Test Lanes: ClockD0D1 [Setup]

Status Ready

**TekExpress HDM - (Untitled)**

Options ▾ Start [Start] Pause [Pause]

2 Test Selection HDM Physical Layer Solution : Source : CTS 2.0  
 [Deselect All] [Select All]  
 [x] Differential  
 [x] 1.2 TMDS TRise TFall  
 [x] 1.3 TMDS Inter-Pair Skew  
 [x] 1.5 TMDS ClockDutyCycle  
 [x] 1.6 TMDS Clock Jitter  
 [x] Single Ended  
 [x] 1.1 TMDS V Low  
 [x] 1.4 TMDS Intra-Pair Skew  
 [x] 1.7 TMDS DataEyeDiagram  
 Test Description  
 TMDS Rise Time and Fall Time measurement [Show MOI] [Schematic] [Configure]

Status Ready

**TekExpress HDM - (Untitled)**

Options ▾ Start [Start] Pause [Pause]

Test Status Log View  

Test Name	Acquisition	Acquire Status	Analysis Status
<b>Clock</b>			
1.2 TMDS TRise TFall	Short Record-length for Rise Fall	To be started	
1.5 TMDS ClockDutyCycle	Short Record-length for Clock Duty Cycle	To be started	
1.6 TMDS Clock Jitter	Short Record-length for Clock Jitter	To be started	
1.1 TMDS V Low	Short Record-length for VLow	To be started	
1.4 TMDS Intra-Pair Skew	Short Record-length for Intra-Pair Skew	To be started	
<b>D0</b>			
1.2 TMDS TRise TFall	Short Record-length for Rise Fall	To be started	
1.3 TMDS Inter-Pair Skew	Short Record-length for Inter-Pair Skew	To be started	
1.1 TMDS V Low	Short Record-length for VLow	To be started	
1.4 TMDS Intra-Pair Skew	Short Record-length for Intra-Pair Skew	To be started	
1.7 TMDS DataEyeDiagram	Short Record-length for Data Eye Diagram	To be started	
<b>D1</b>			
1.2 TMDS TRise TFall	Short Record-length for Rise Fall	To be started	
1.3 TMDS Inter-Pair Skew	Short Record-length for Inter-Pair Skew	To be started	
1.1 TMDS V Low	Short Record-length for VLow	To be started	
1.4 TMDS Intra-Pair Skew	Short Record-length for Intra-Pair Skew	To be started	
1.7 TMDS DataEyeDiagram	Short Record-length for Data Eye Diagram	To be started	

Status Ready

**TekExpress HDM - (Test Results)**

Options ▾ Start [Start] Pause [Pause] Clear [X]

Overall Test Result ✖ Fail Preferences ▾

Test Name	Details	TBit	Value	Units	Pass/Fail	Margin
<b>Clock</b>						
1.2 TMDS TRise Time	Clock Rise Time	168.3498 ps	38.7089	ps	✖ Fail	-36.2911
1.2 TMDS TRise TFall	Clock Fall Time	168.3498 ps	38.1015	ps	✖ Fail	-36.8985
1.5 TMDS ClockDutyCycle	Maximum Duty Cycle	168.3498 ps	50.01	%	✔ Pass	-9.99
1.5 TMDS ClockDutyCycle	Minimum Duty Cycle	168.3498 ps	49.99	%	✔ Pass	9.99
1.6 TMDS Clock Jitter	TMDS Clock Jitter	168.3498 ps	40.1239	ps	✔ Pass	-1.9635
1.6 TMDS Clock Jitter	TMDS VSwing	168.3498 ps	64.7812	mV	✔ Pass	-335.22 & 1135.22
1.1 TMDS V Low	TMDS VLow for	168.3498 ps	3.2822	V	✖ Fail	0.9822 & -0.1822
1.1 TMDS V Low	TMDS VLow for	168.3498 ps	3.1738	V	✖ Fail	0.8738 & -0.0738
1.4 TMDS Intra-Pair Skew	TMDS Intra-Pair Skew for Clock	168.3498 ps	9.7096	ps	✔ Pass	-15.5429
<b>D0</b>						
1.2 TMDS TRise Time	D0 Rise Time	168.3498 ps	60.6379	ps	✔ Pass	18.1379
1.2 TMDS TRise TFall	D0 Fall Time	168.3498 ps	58.5778	ps	✔ Pass	16.0778
1.1 TMDS V Low	TMDS VLow for	168.3498 ps	3.1720	V	✖ Fail	0.8720 & -0.2720

Status Ready

# HDMI 2.0 Sink Testing- Advanced Information



# Likely Sink Electrical tests

**Min/Max Differential Swing Tolerance**

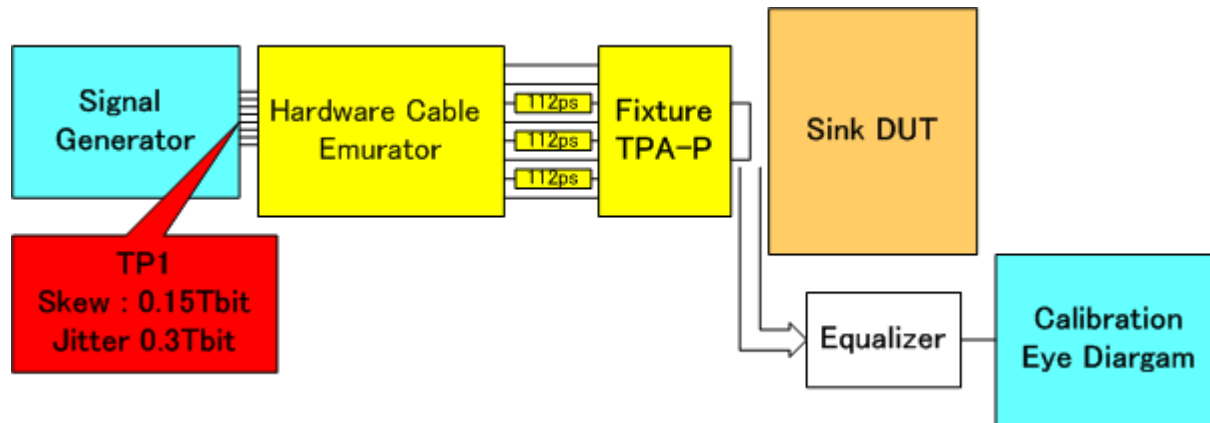
**Intra-Pair Skew**

**Jitter Tolerance**

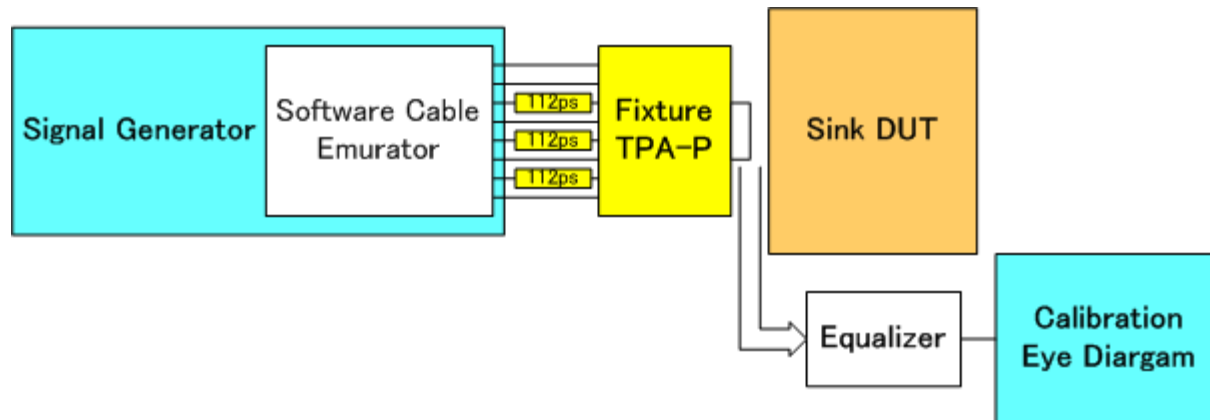
**Differential Impedance**

# Requirement for Signal generation

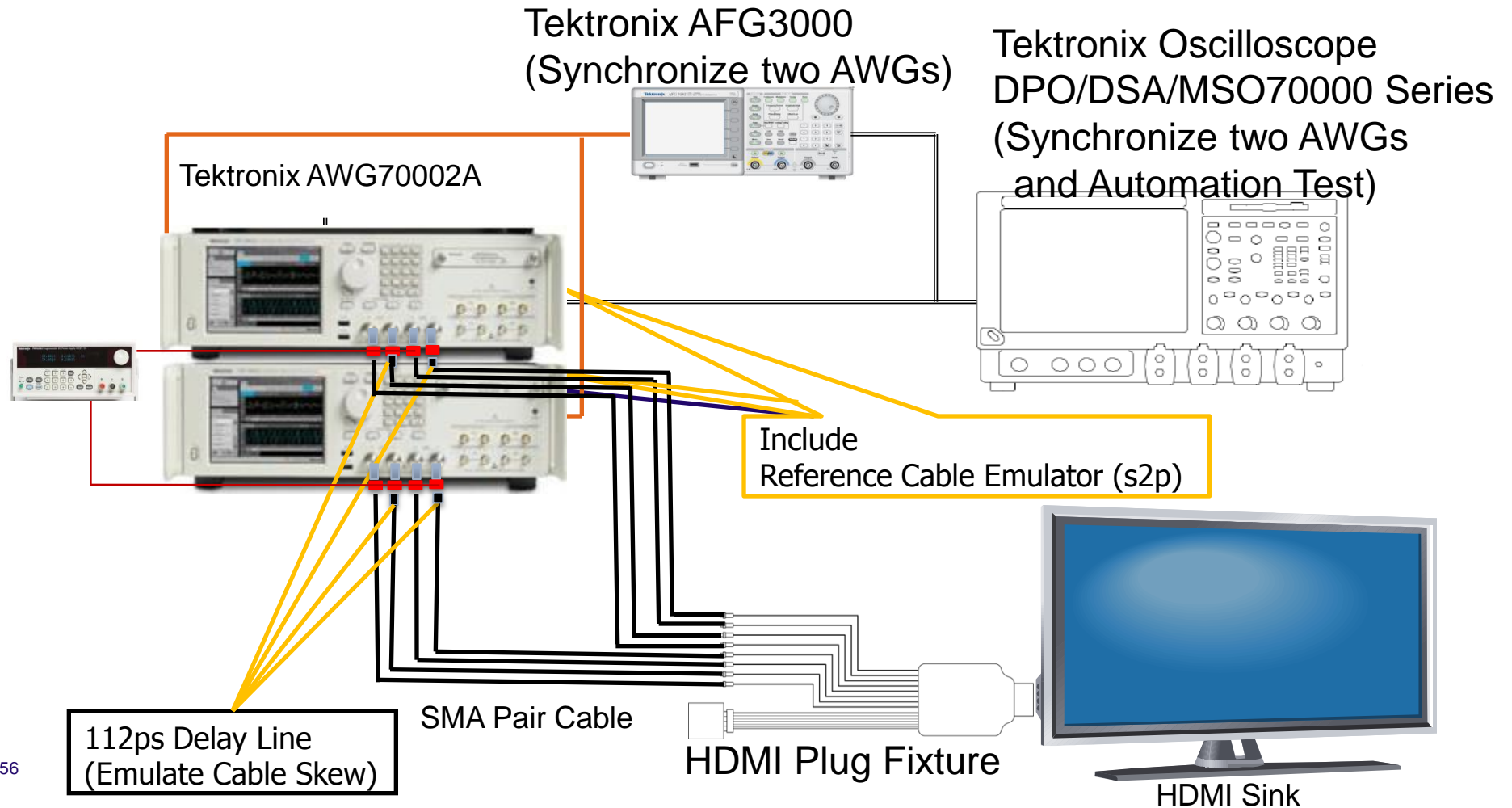
## Cable Emulation and Skew by Hardware



## Tektronix Software Cable Emulation



# Sink Test



# Sink Testing 1.4b Vs 2.0

Jitter Tolerance test needs +ve and –ve lanes tested with 112ps delay line

Rest of the tests is same

1.4b CTS test is a pre-requisite for HDMI 2.0

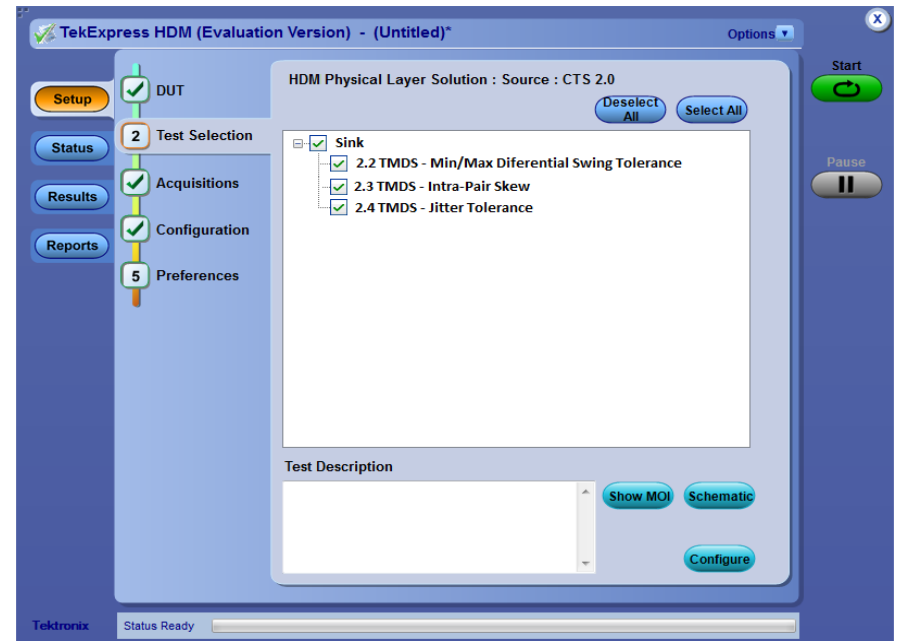
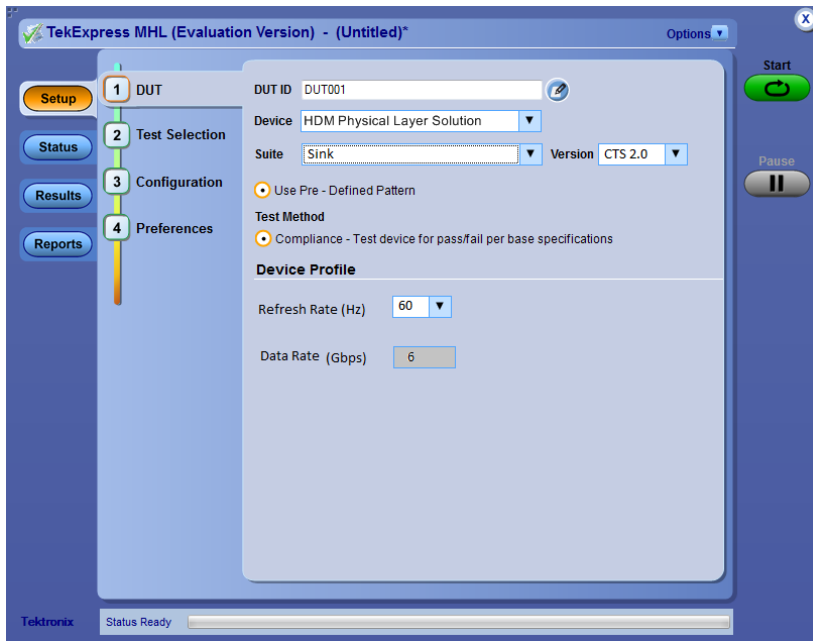
Need AWG70K series for HDMI 2.0 as against AWG7K.

Min 8GHz scope to 16GHz scope

Fixtures and Probes



# HDMI 2.0 Rx Compliance Software



# HDMI 2.0 Equipment List

- DPO/DSA /MSO 70004C/B/D with 2XL-Minimum 16GHz BW
- AWG70002A -Qty2
  - With Option 01, 225 and sequencing
  - Rack Mount Kit
- AFG3xx2/C
- HDMI 2.0 Fixture set
- P7313SMA probes –Quantity 4
- HDMI DS accessory kit(add on to current DS kit)
  - Includes the 45ps TTC filters, Bias Tees
- Programmable Dual Channel Power supply

# Tektronix HDMI 2.0 Solution

- Tektronix HDMI 2.0 Solution will be available aligned to the CTS announcement from the new HDMI Forum.
- Full Source, Sink, Cable and Protocol Solution including probes, Fixtures.
- Support for HDMI 1.4b CTS which is likely to be a pre-requisite for HDMI 2.0 testing.
- Contact local Tektronix sales team for early interaction on our HDMI 2.0 solution.

# High-Speed Serial Data Test Solutions

Design

Verification

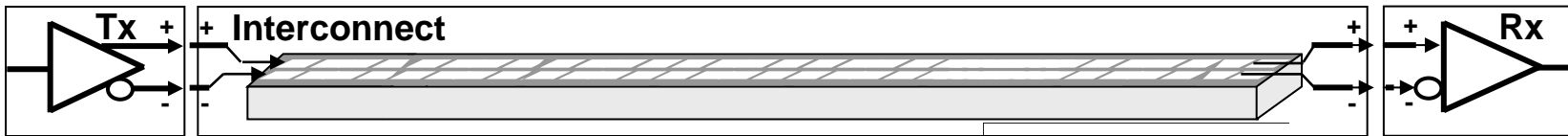
Compliance Test



GbE DisplayPort

HDMI™

MHL ...



Real-time Scopes



Probing Fixtures



Sampling Scopes

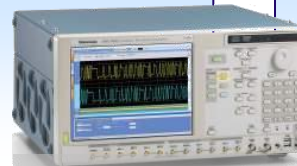
System Integration  
Digital Validation & Debug



Logic Analyzers

Transmitter Testing

Receiver Test  
Margin Testing

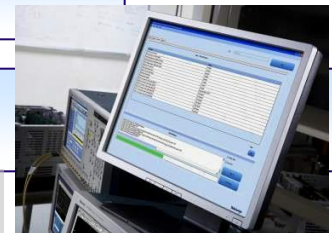


Arbitrary Waveform Generator

Interconnect Test

Compliance Test

Compliance Test Software



**Tektronix®**

