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

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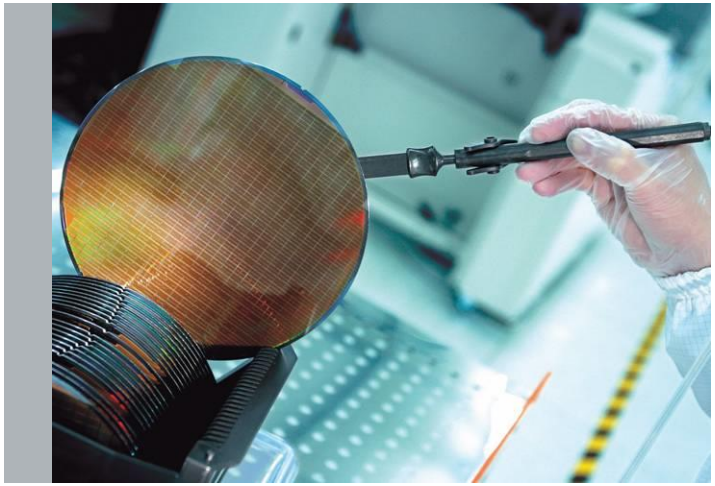

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HDMI 1.4b/2.0 Compliance Test Solution

- 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

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Overview of HDMI

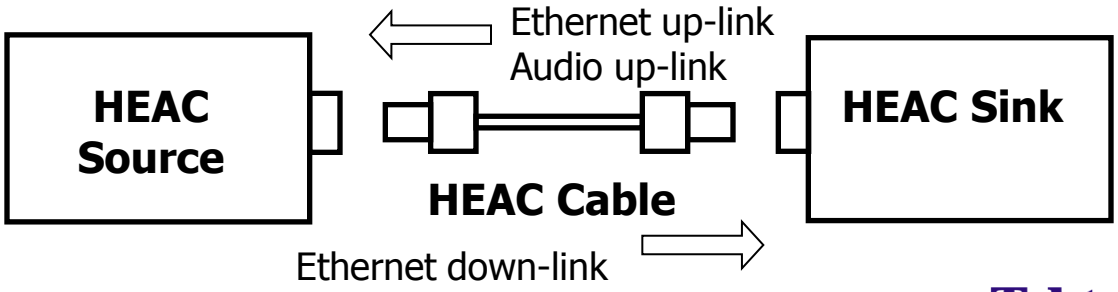
- Problems with the legacy display technologies
  - Unnecessary D to A and A to D components
  - Device resolution increases, display brightness reduced
  - No content protection
- What is HDMI?
  - High Definition Multimedia Interface
  - Connection standard for consumer electronics
  - Uncompressed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

HDMI™
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)



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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

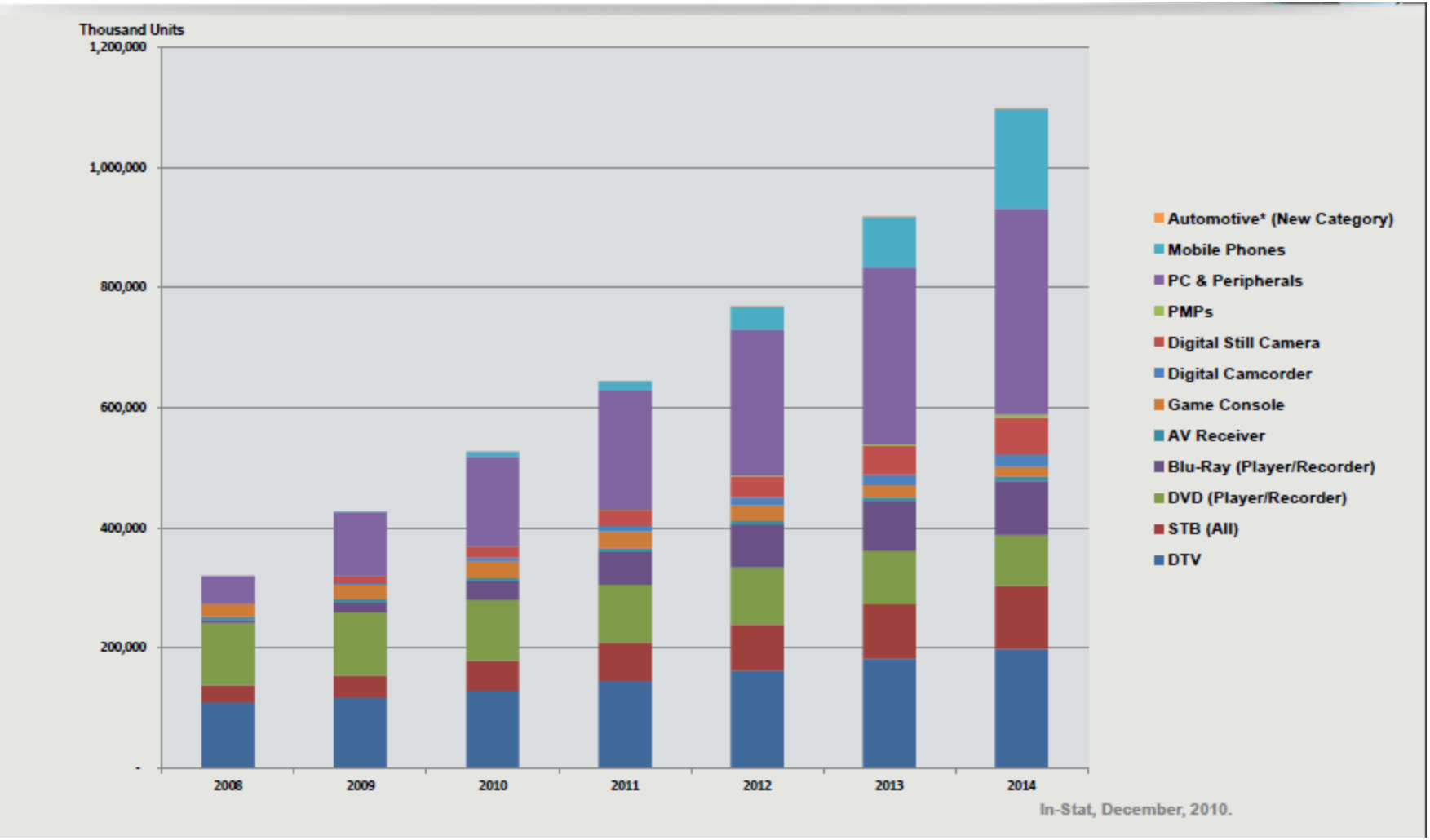
- 80+ companies in the HDMI forum as of date. source HDMI Forum

- 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**

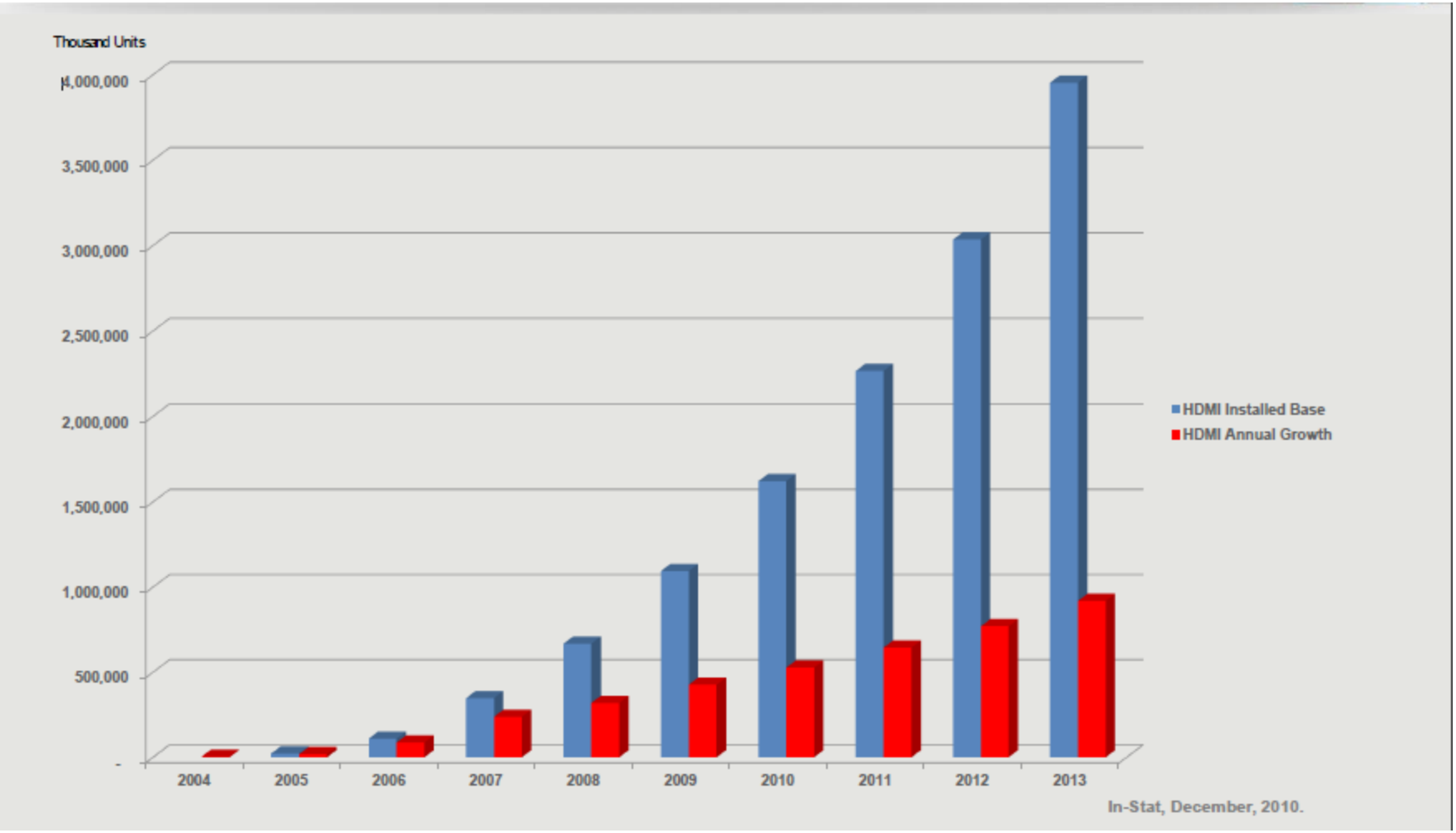
- HDMI Forum working on next version of HDMI specifications.
  - Target
    - 2013 Q3 Specification
    - CTS 2013 Q4

HDMI Market overview



Source: HDMI Forum

HDMI Devices take rate



2.2B HDMI devices sold by 2011

Source: HDMI Forum

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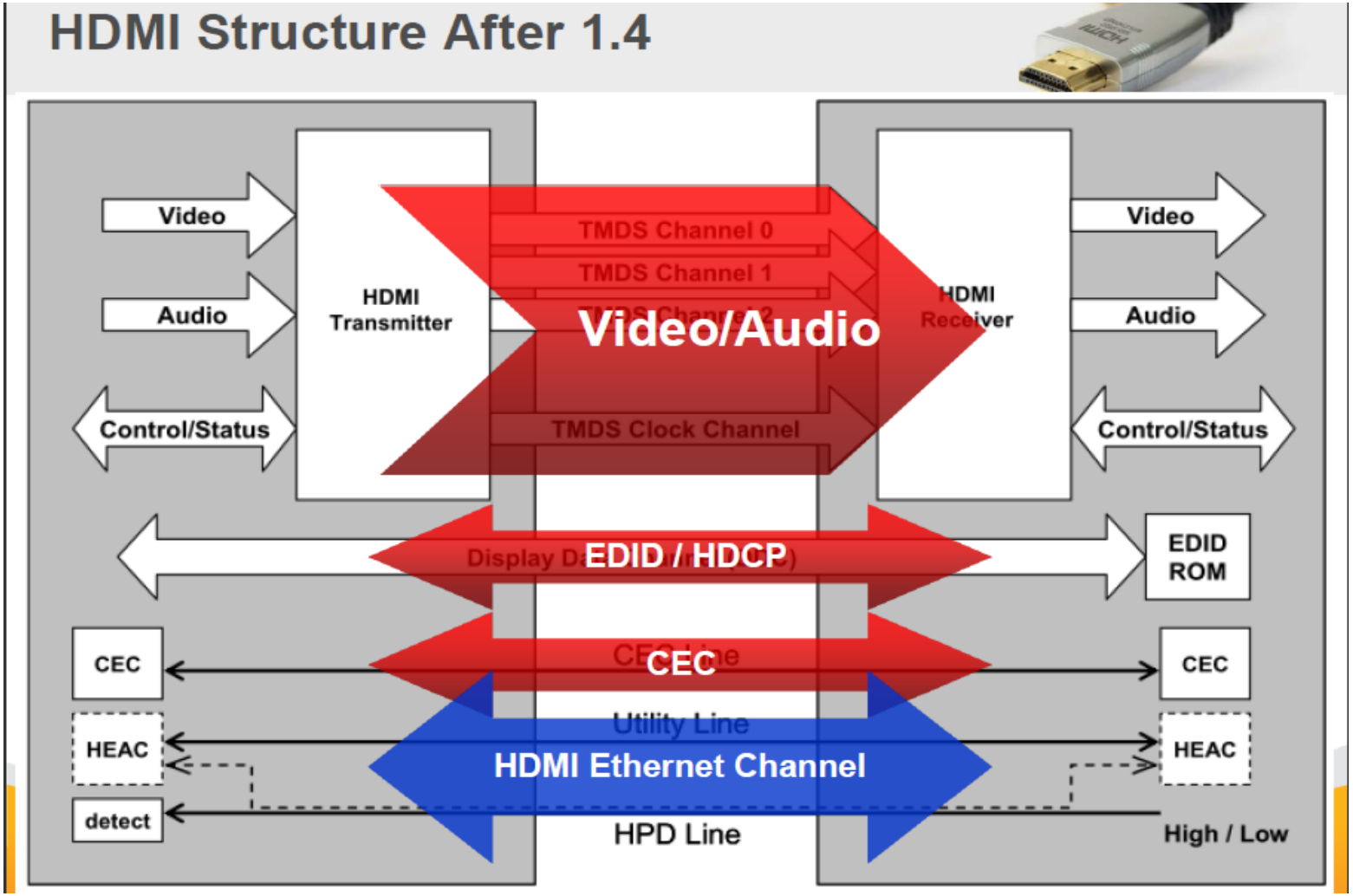
HDMI Basics



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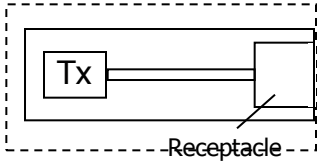
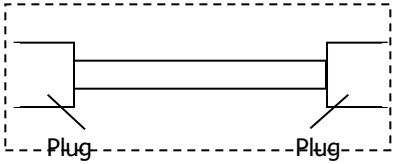
HDMI – System Overview

Source Devices



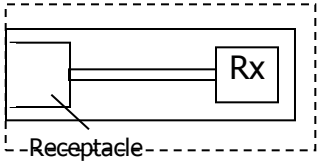
- Set-top Boxes, DVDs, Repeaters, Gaming devices

Cable Assemblies



- Cables

Sink Devices



- TVs, Monitors, Repeaters, etc.

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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, Meridien, 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

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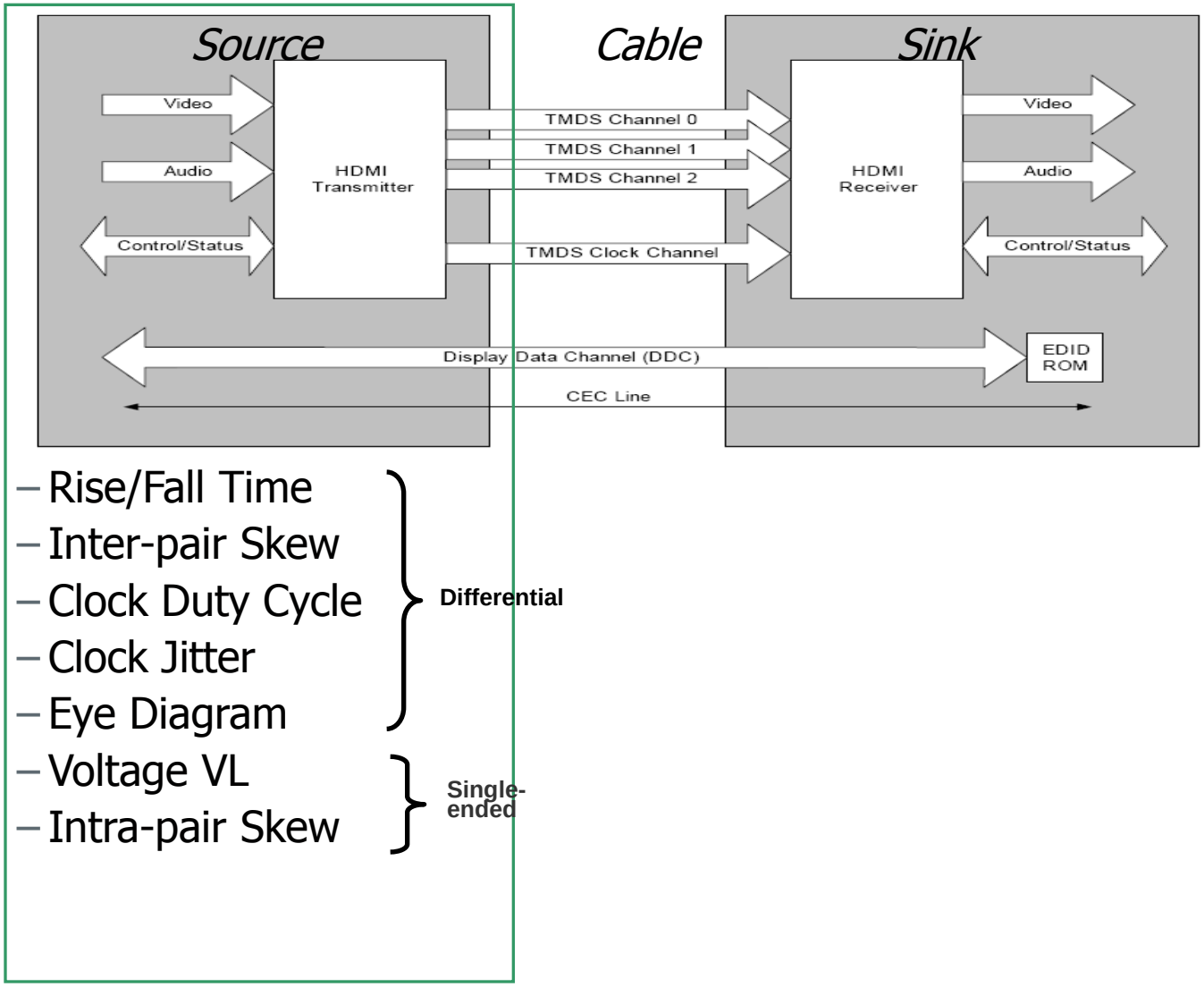
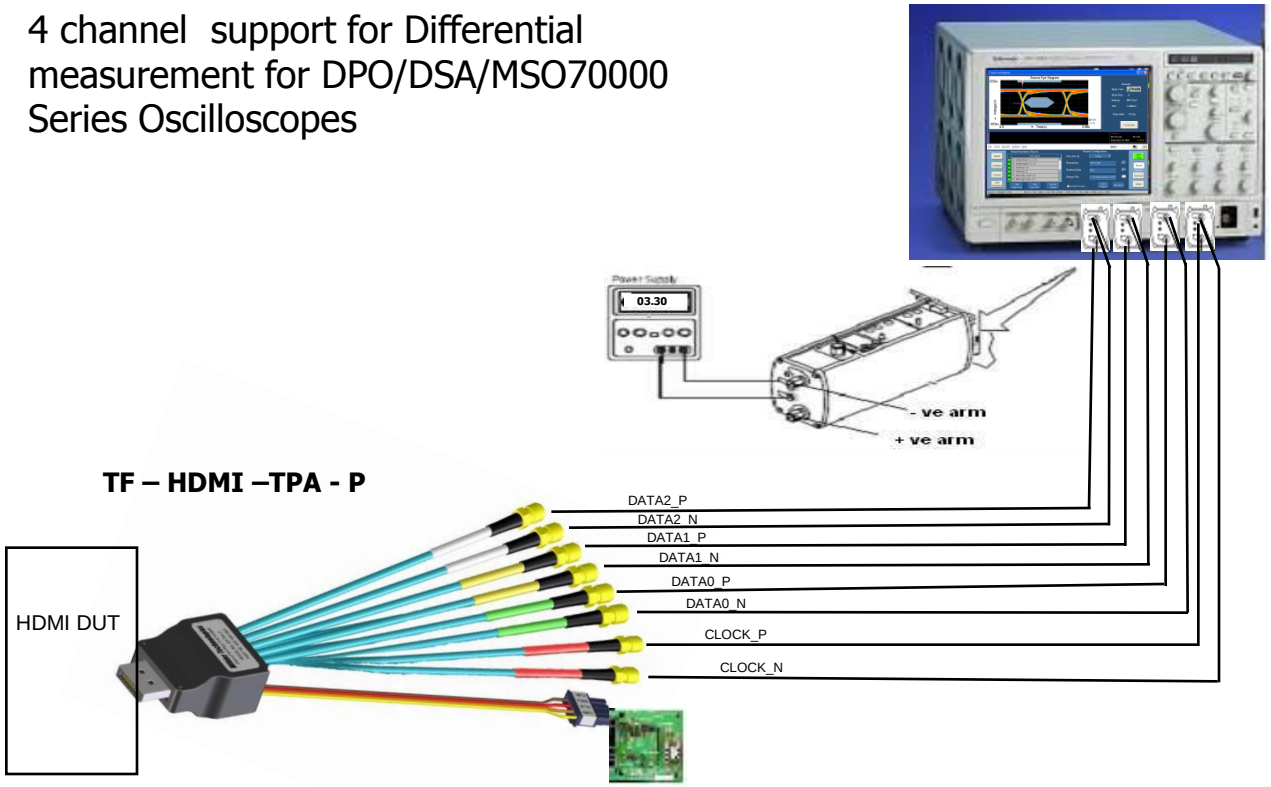
HDMI Source Testing



Typical Source Test Configuration Differential Measurement

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



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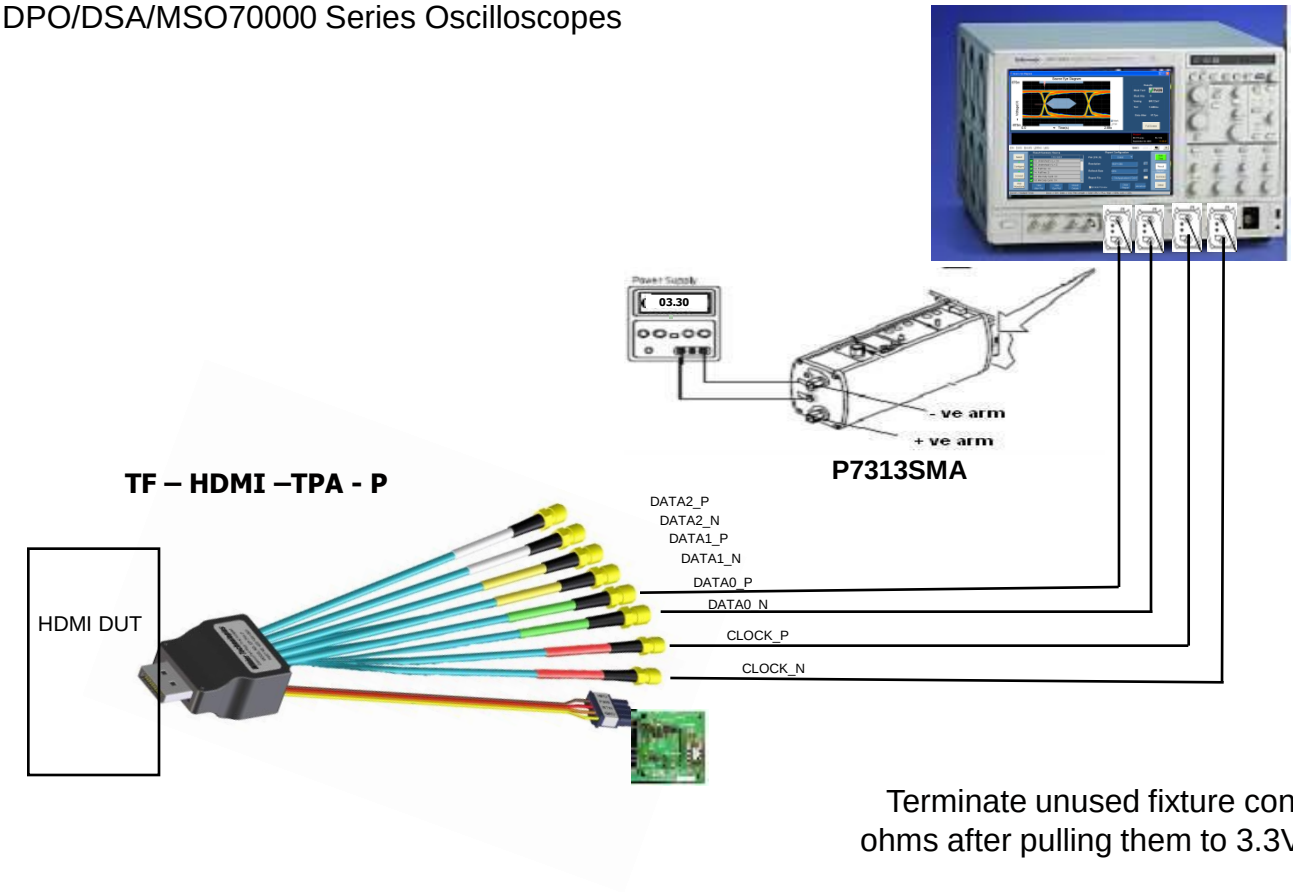
Typical Source Test Configuration
Single-ended Measurement

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

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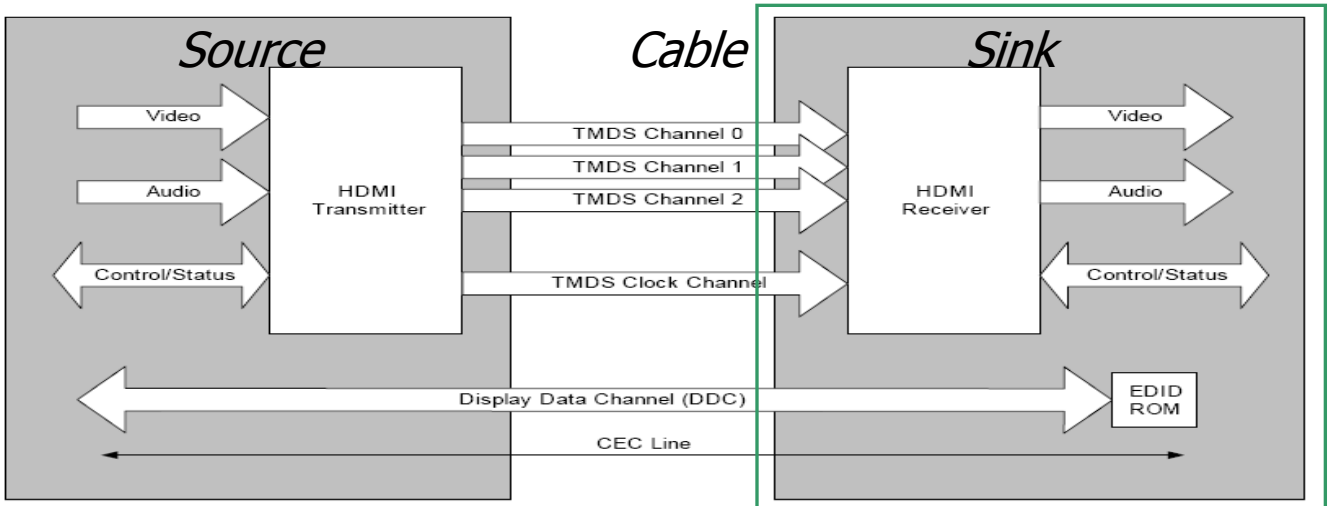
HDMI Sink Testing



- Jitter Tolerance
- Min/Max Differential Swing
- Intra-Pair Skew
- Differential Impedance

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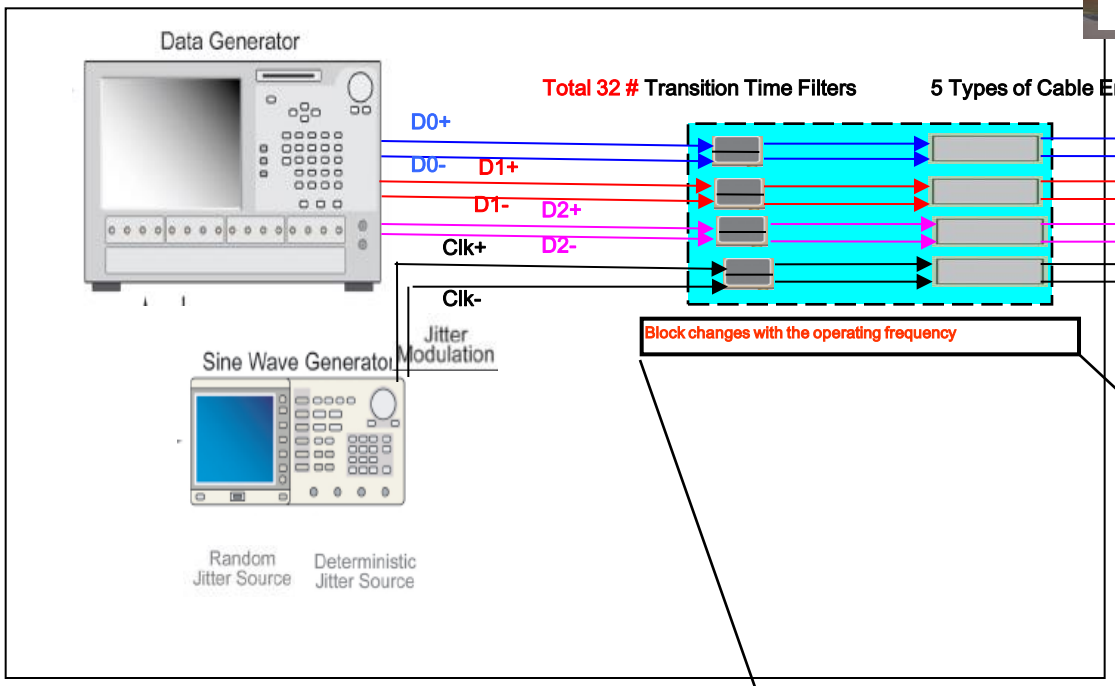
AWG7000B with Direct Synthesis Significantly Reduces Test Time

Present Solution-HDMI Sink Jitter Tolerance setup



Source CTS1.3c document

Typical (MHz)	Low (MHz)	High (MHz)	TTC (MHz)[1]	1st Cable Emulator	2nd Cable Emulator
27	>= 25	<=27.1	74.25	Type 1 Cat1+Cat2 (Agilent)[2]	Type 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	Type 1 Cat2 (Agilent)	Type 3 (Agilent)

Can we reduce the **Complexity** ?

Can we save the **setup time** ?

Can we provide cost **effective** solution ?

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

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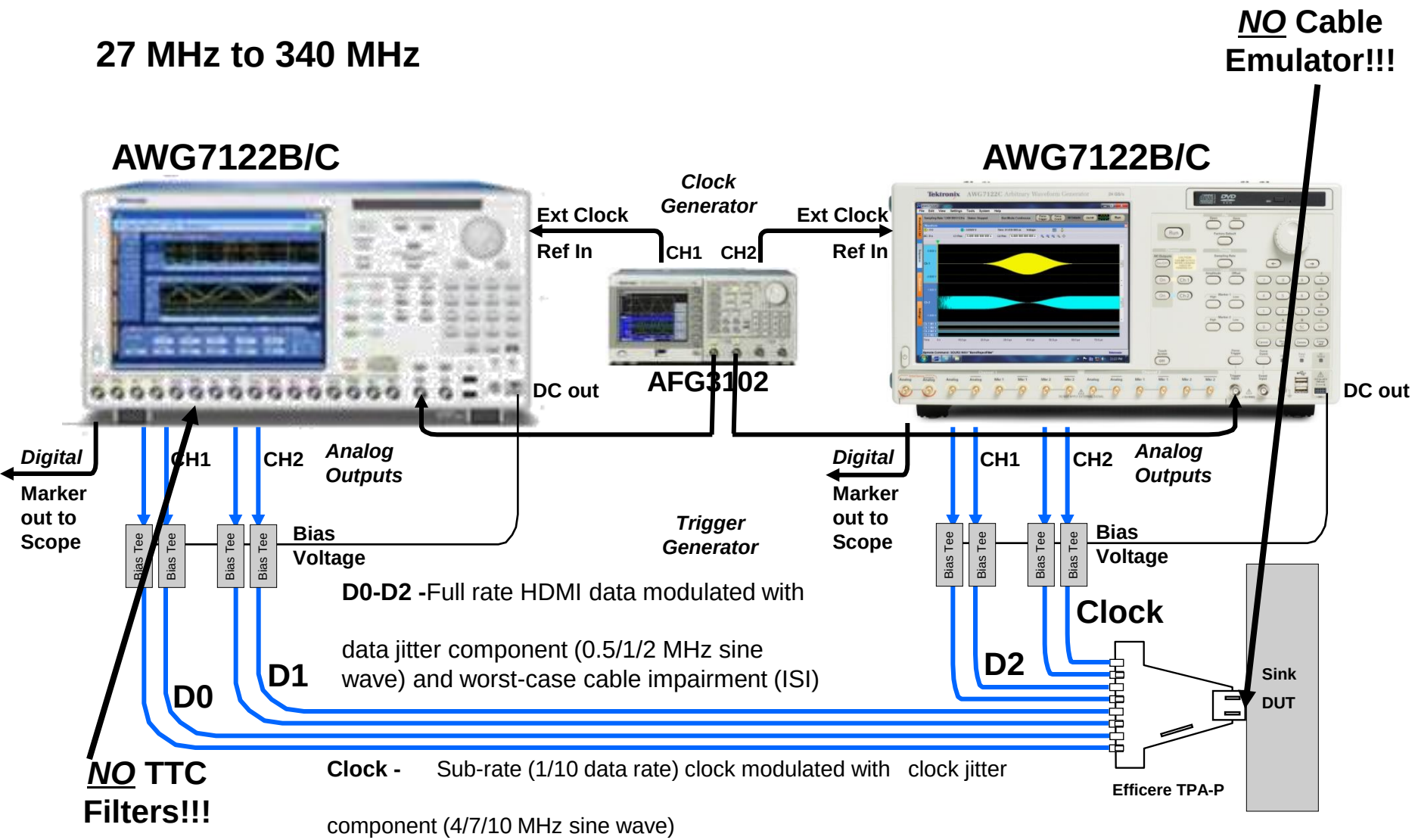
AWG7000B with Direct Synthesis Significantly Reduces Test Time

HDMI Jitter Tolerance Test with Direct Synthesis



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

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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 4th 2010
- CTS1.4b Announced on Oct 11th 2011(editorial changes)

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Automotive HDMI Adaptation

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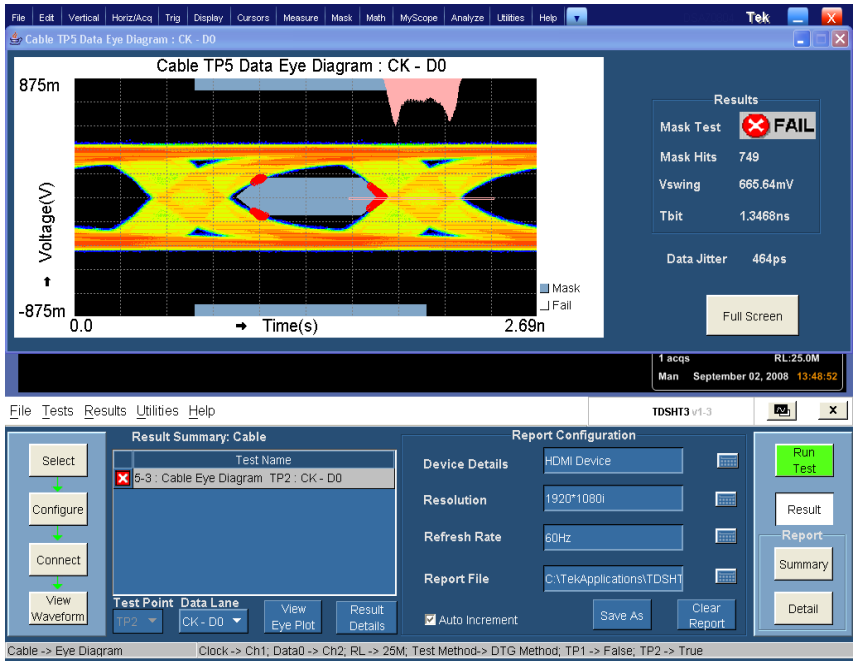
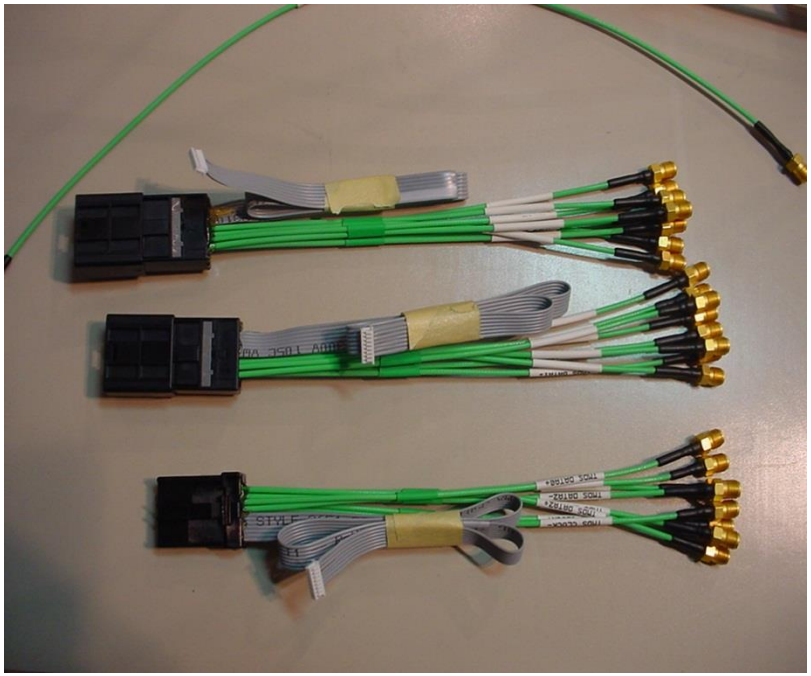
Tektronix HDMI 1.4a Test Solutions
Automotive HDMI Solution from Tektronix

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





- Type E Fixture from Tektronix approved by HDMI standards

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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

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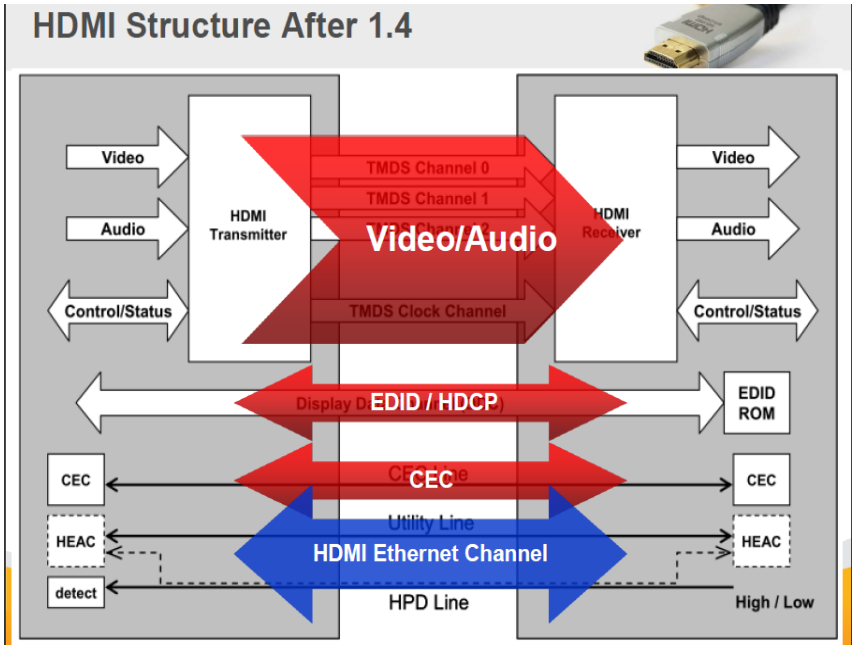
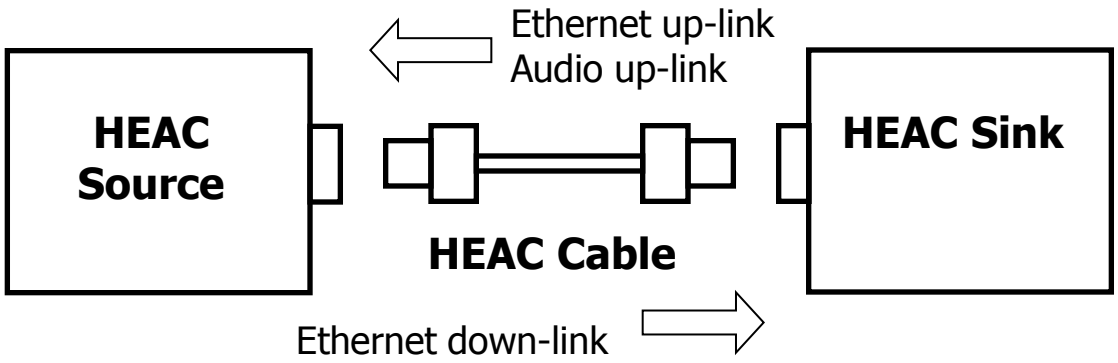
Tektronix HDMI 1.4a Test Solutions
What is HEAC?

- 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



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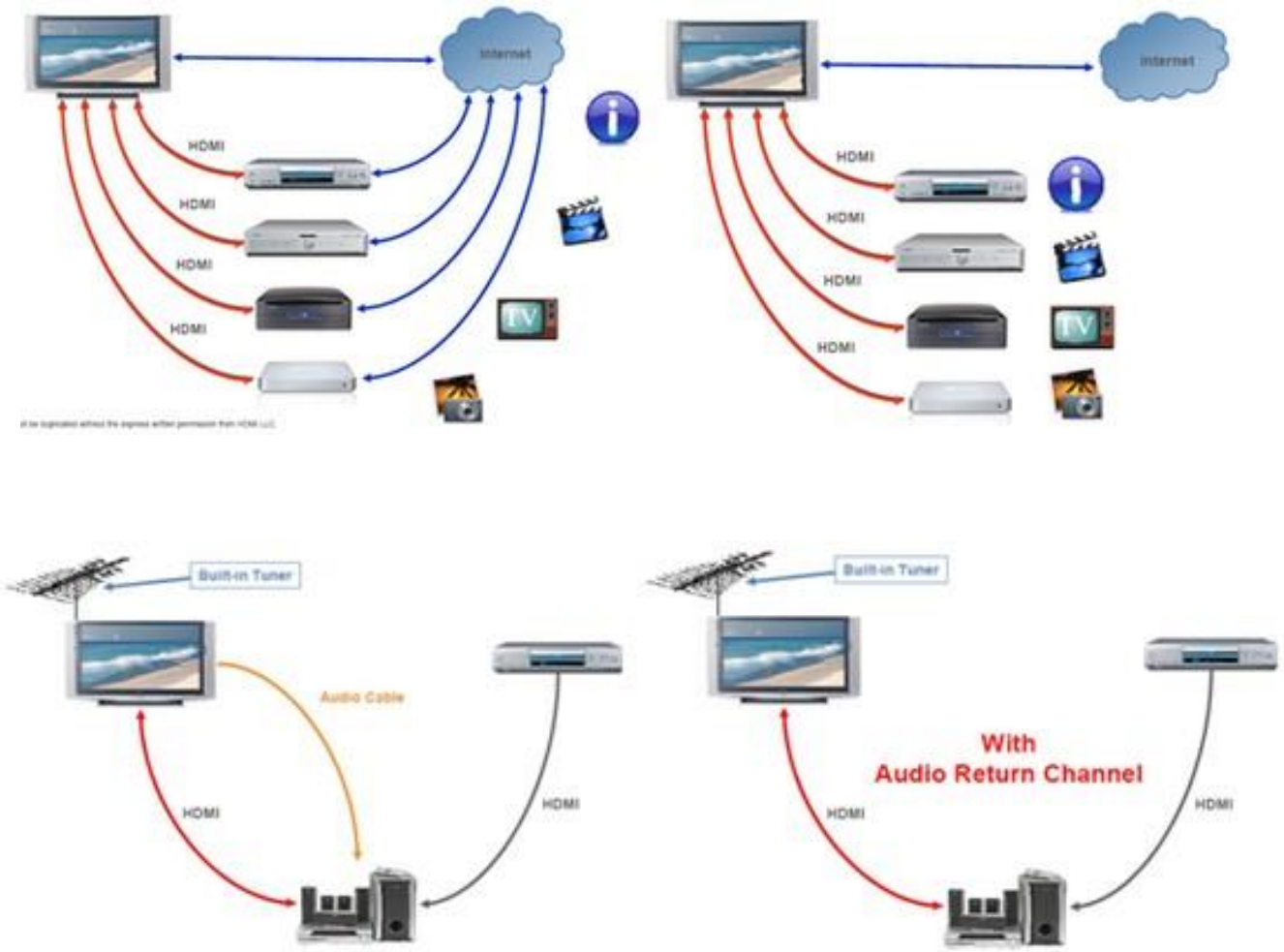
End Use application



Source: HDMI LLC

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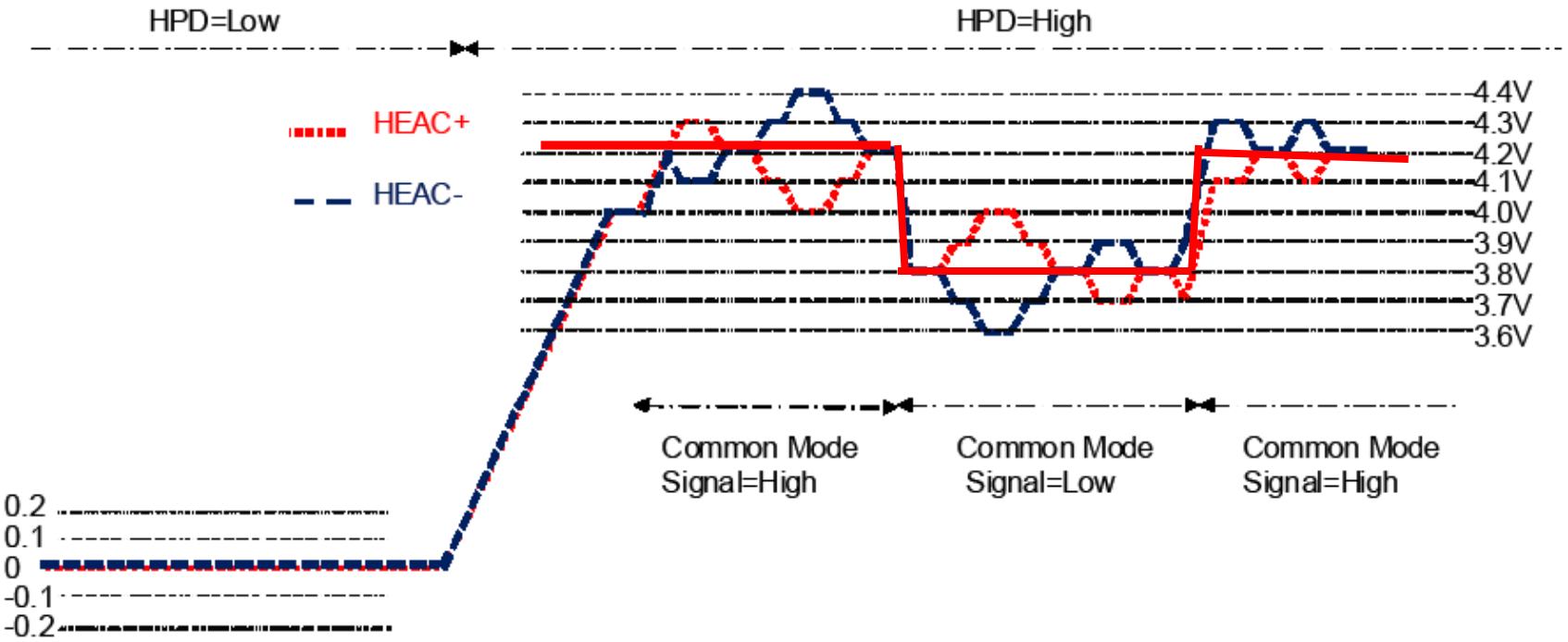
HEAC-HDMI Ethernet and Audio Return Channel



HEAC Figure 2-10 Simultaneous Transmission Waveform

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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

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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

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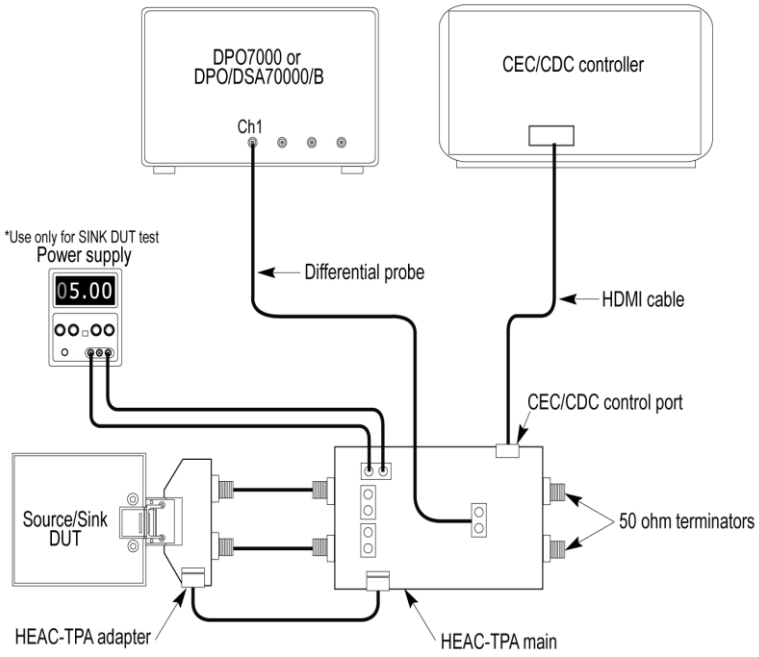
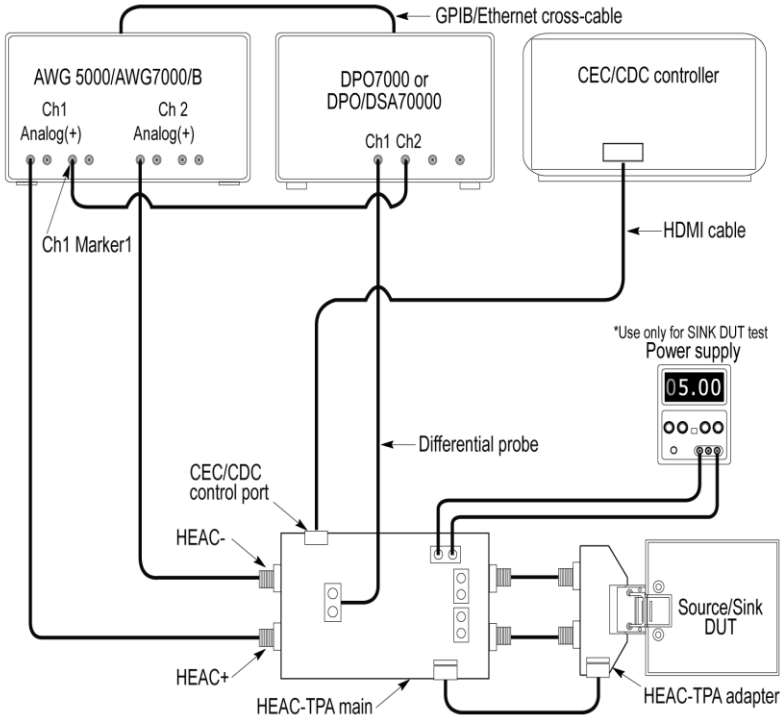
Tektronix HDMI 1.4a Test Solutions
HEAC Solution Configuration



Tx Test Setup



Rx Test Setup

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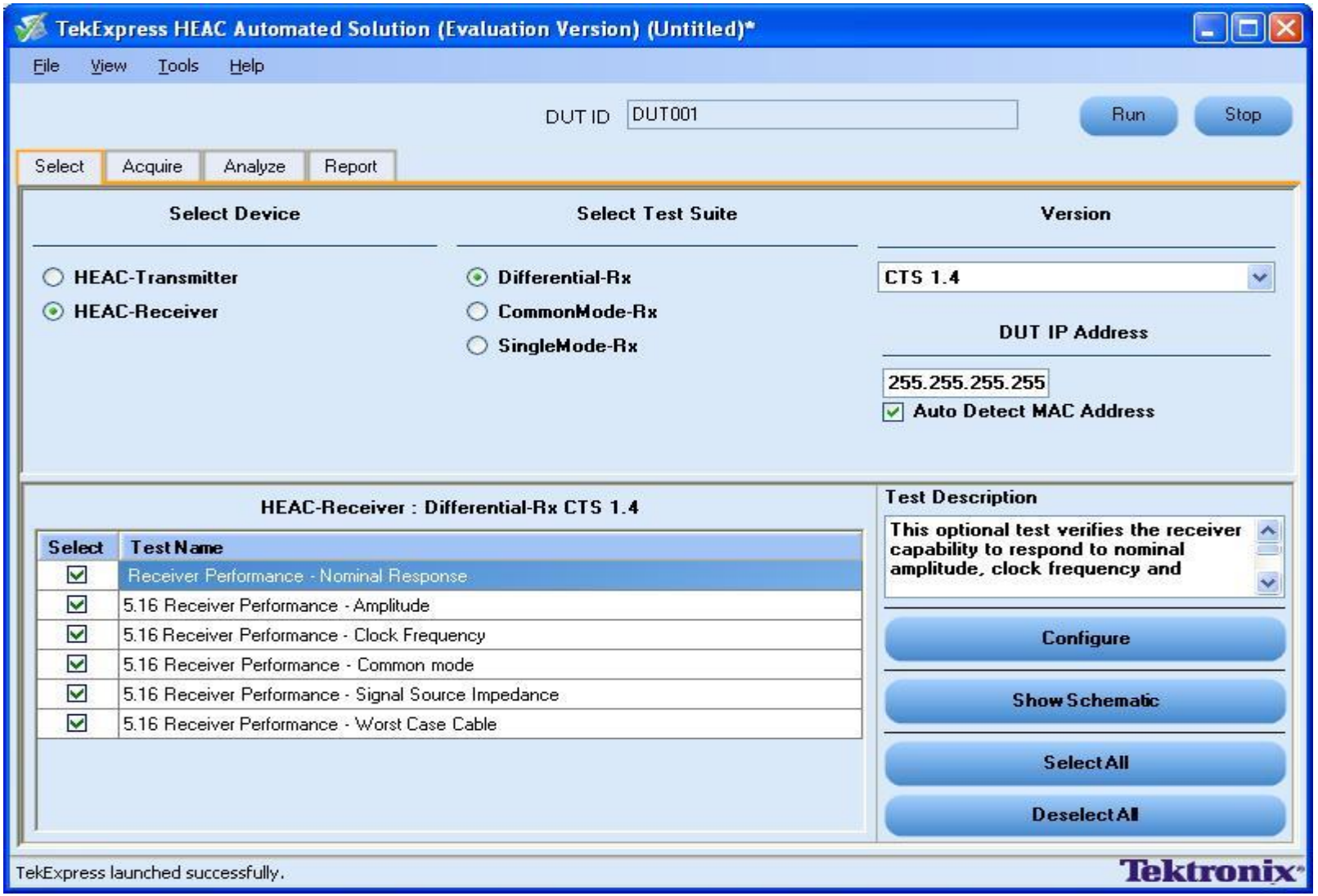
Tektronix HDMI 1.4a Test Solutions
HEAC Software



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Tektronix HDMI 1.4a Test Solutions
HEAC Test Report

Tektronix
Enabling Innovation

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 F/W Version : 5.1.0 BNSFBUILD 28
SPC, FactoryCalibration : 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			

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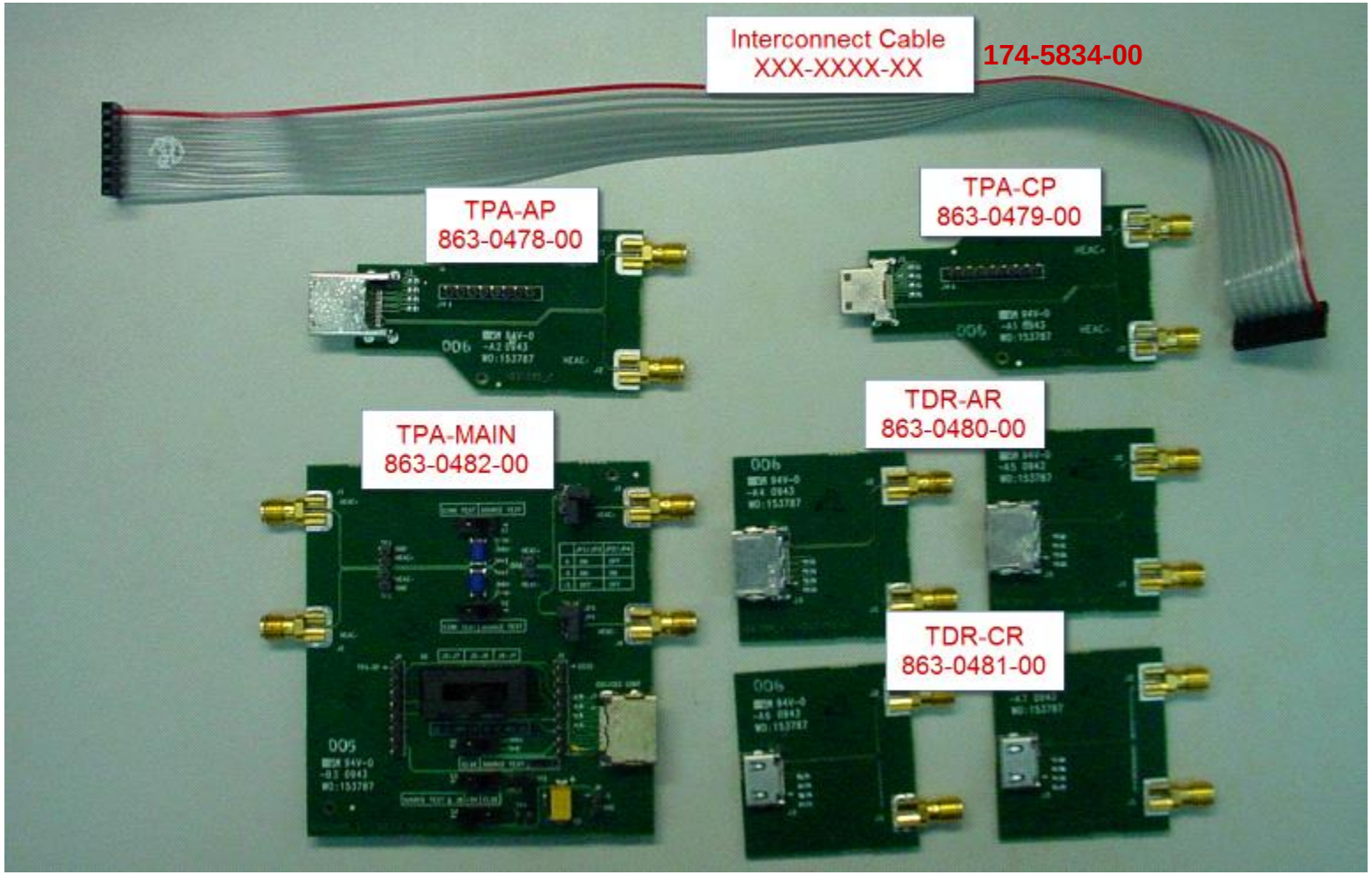
Tektronix HDMI 1.4a Test Solutions
HEAC Fixtures



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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)

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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)

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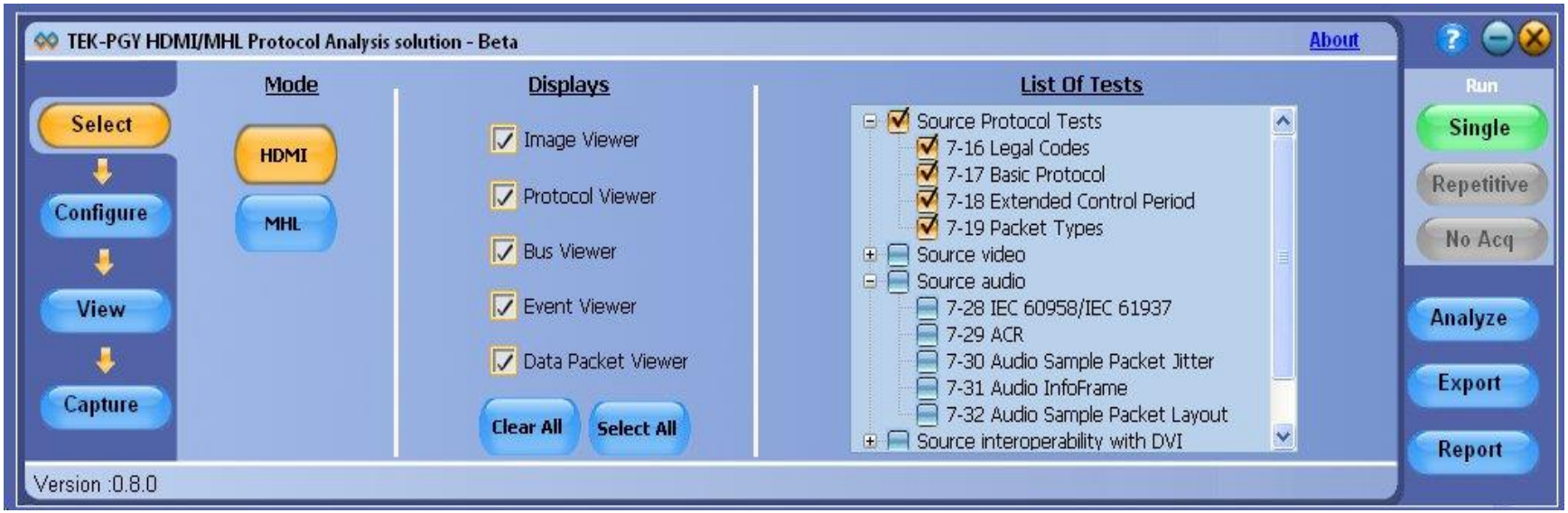
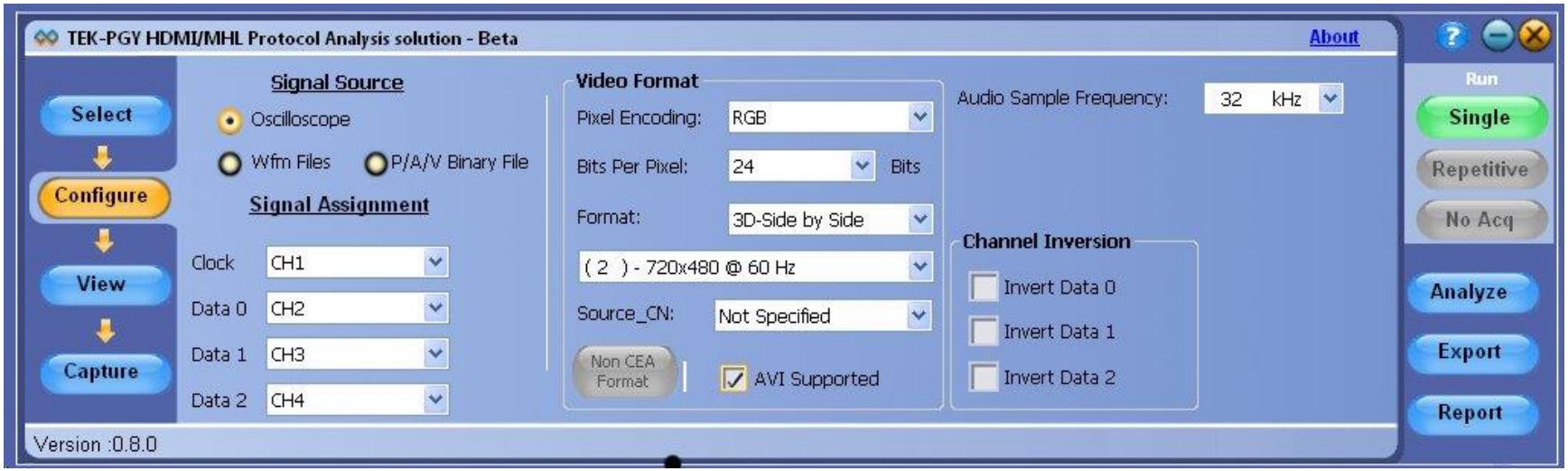
Tektronix HDMI Protocol Analysis Solution

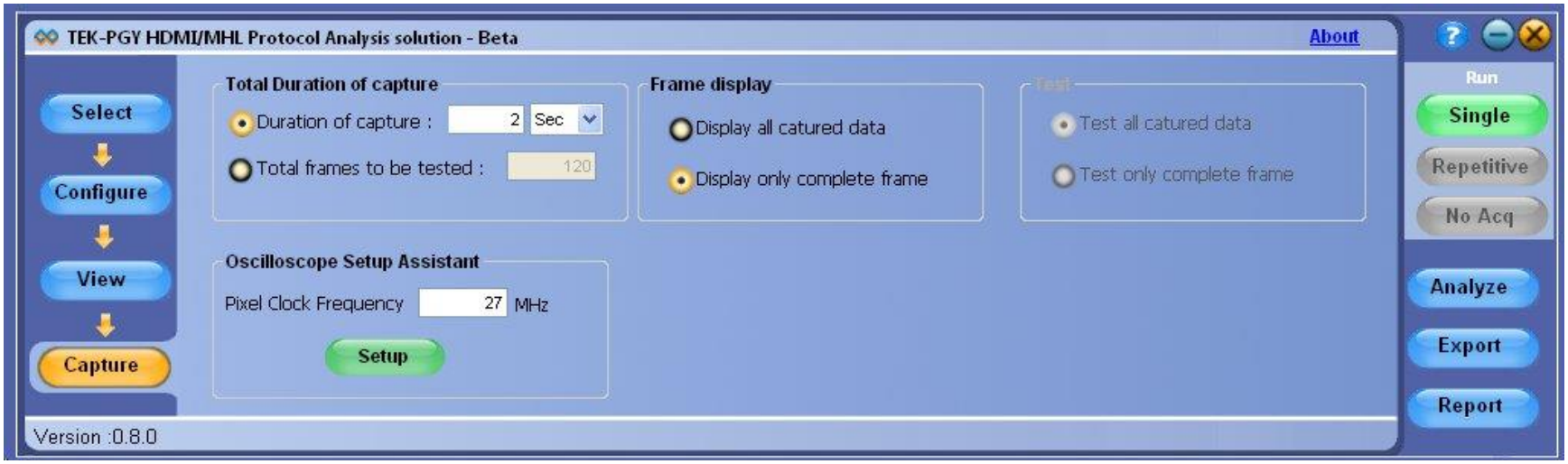
- HDMI Protocol Analysis software running on the Tektronix DPO/DSA/MSO70000 Series Oscilloscope
  - Unique value proposition as the same real time scope is used for both Physical layer testing and Protocol testing
  - Gives the seamless transition from Phy layer to Protocol
  - Cost effective solution
- 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)

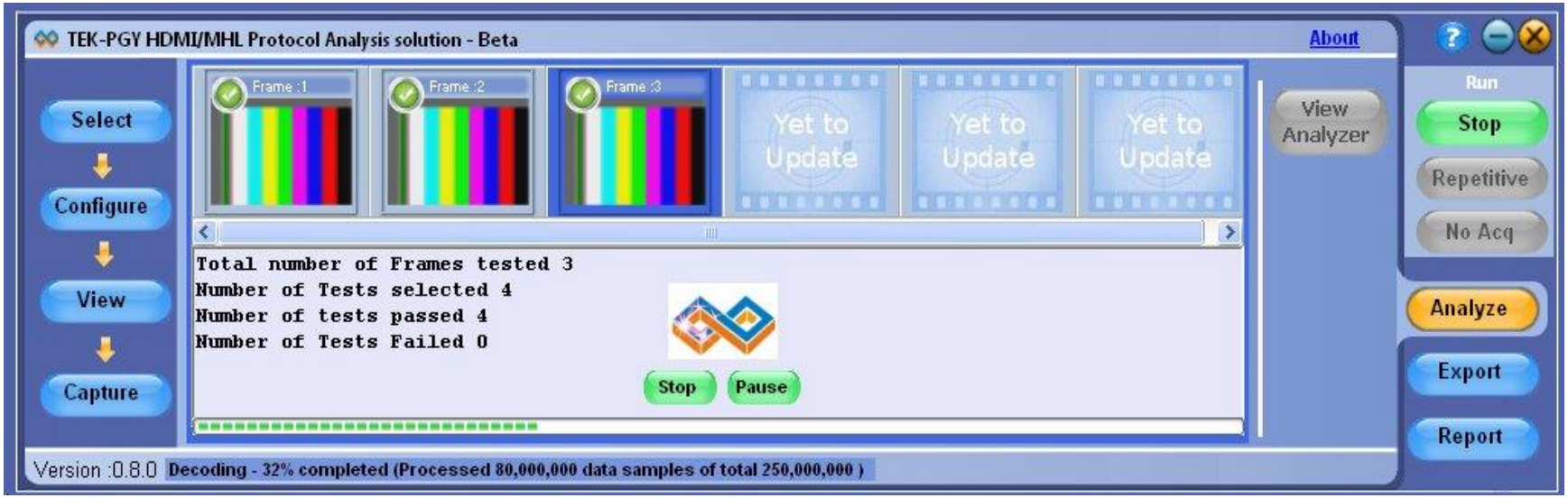
Tektronix HDMI Protocol Analyzer



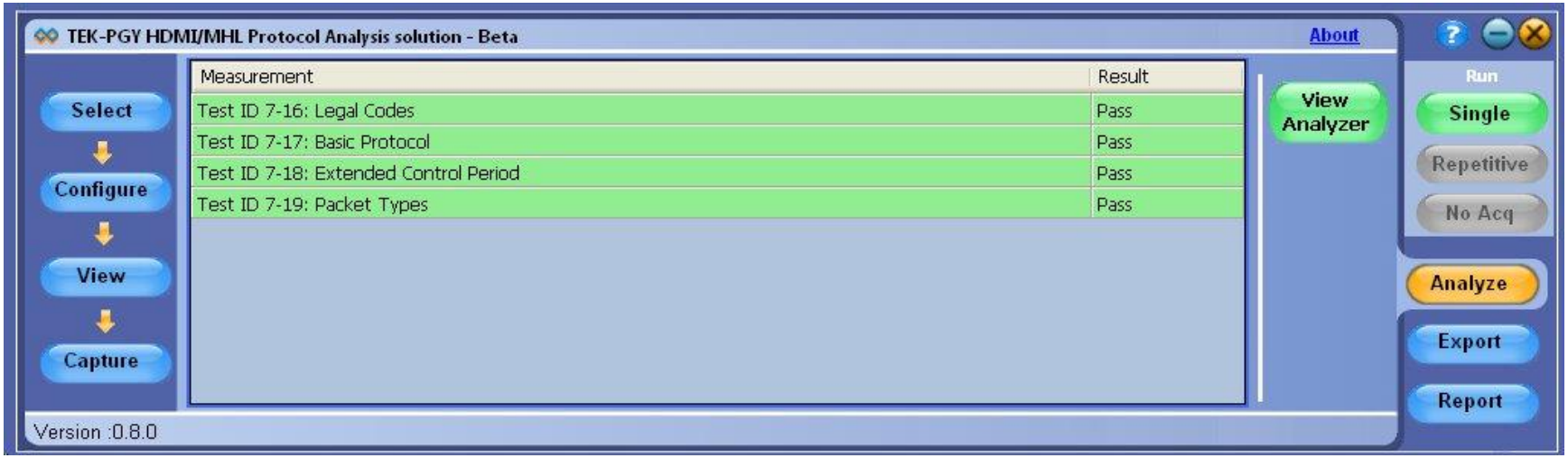


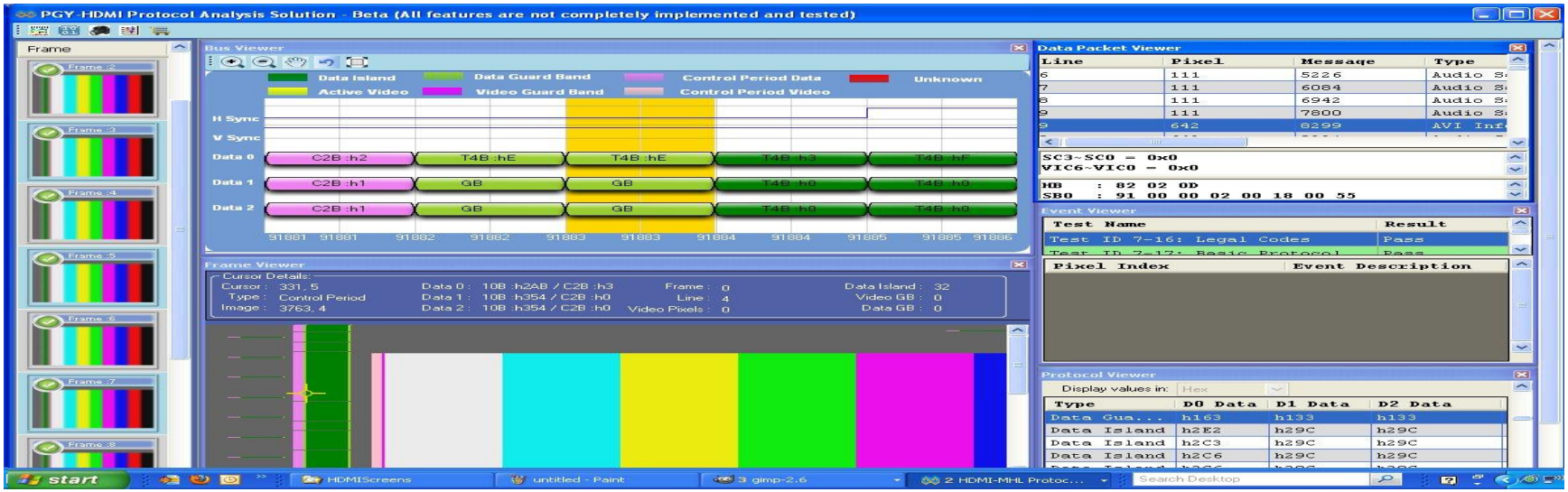
Tektronix HDMI Protocol Analyzer





Tektronix HDMI Protocol Analyzer





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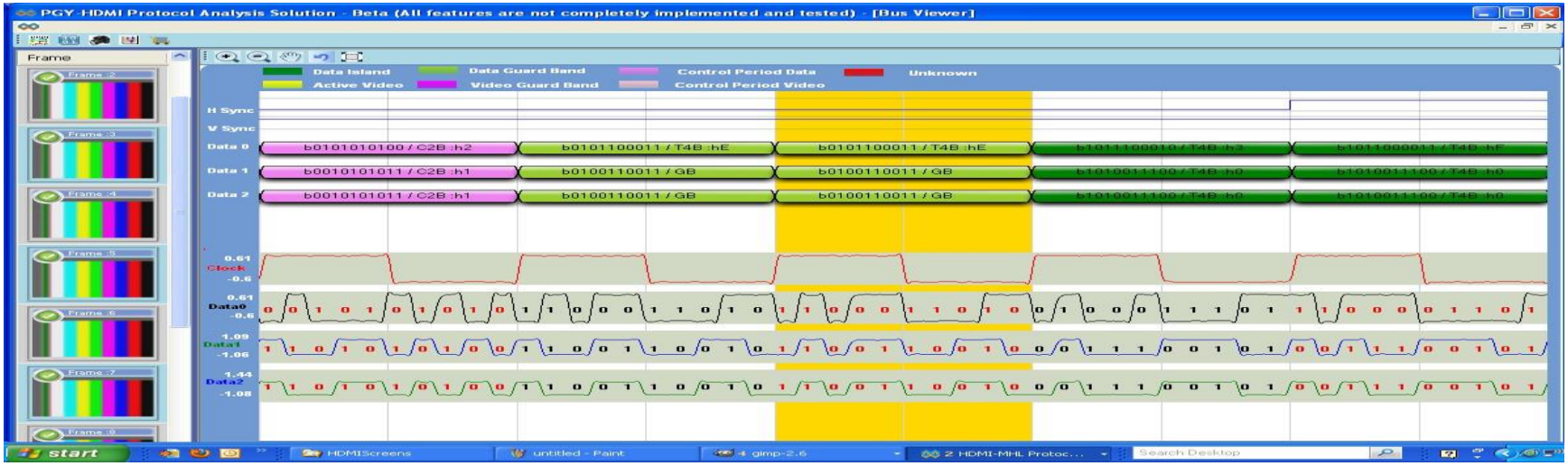
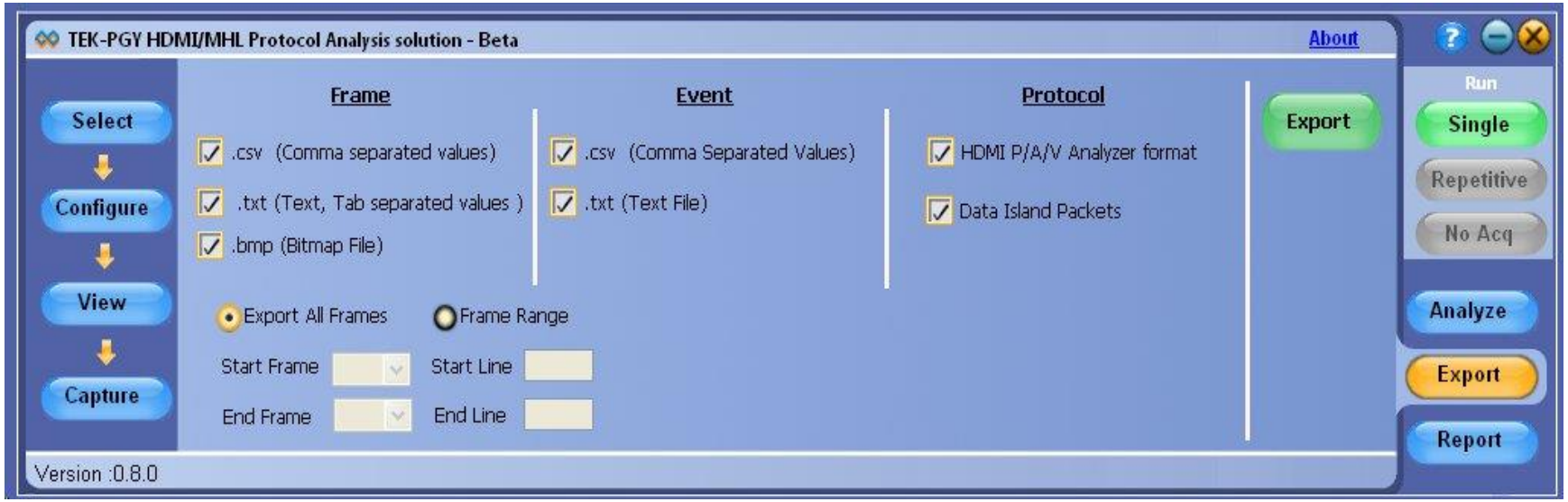
Tektronix HDMI Protocol Analyzer





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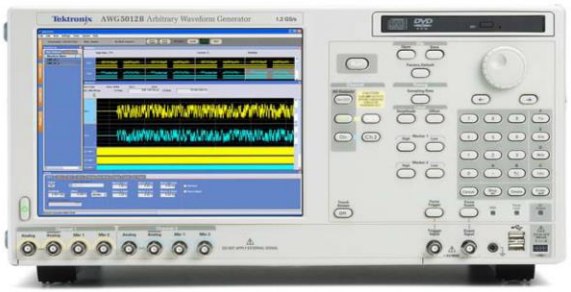
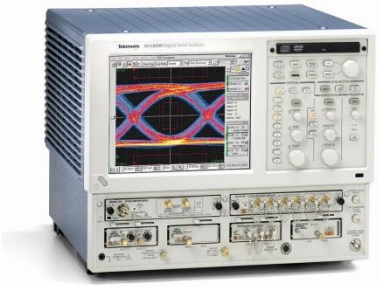
Tektronix HDMI 1.4a Test Solutions
Tektronix HDMI 1.4a Solution

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

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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%)	if attached Sink supports < 340MHz 75psec ≤ Rise time / fall time if attached Sink supports ≥ 340MHz and transmitted TMDS Character Rate ≥ 340MHz 42.5psec ≤ Data Rise time / Data fall time 75psec ≤ Clock Rise time / Clock fall time

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

Item	Value
Rise time / fall time (20%-80%)	if attached Sink supports ≥ 340MHz and transmitted TMDS Character Rate ≥ 340MHz 42.5psec ≤ Data Rise time / Data fall time 75psec ≤ Clock Rise time / Clock fall time

- 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) 28psec
- 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

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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-requsite for HDMI 2.0 **to ensure inter-operability**

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

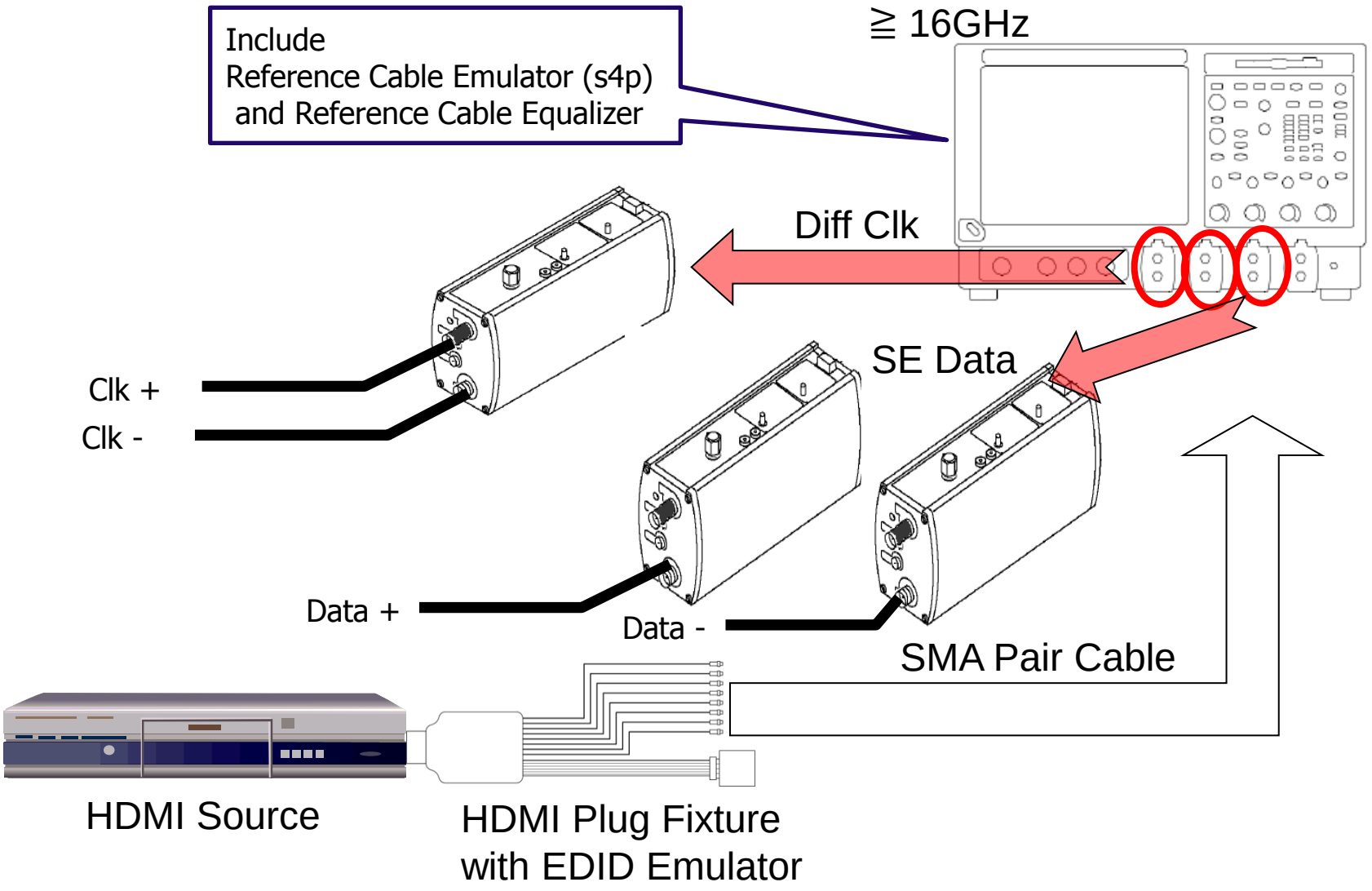
Clock Jitter

Data Eye Diagram

Differential Impedance

Source Eye Diagram Test

Tektronix Oscilloscope
DPO/DSA/MSO70000 Series
≧ 16GHz



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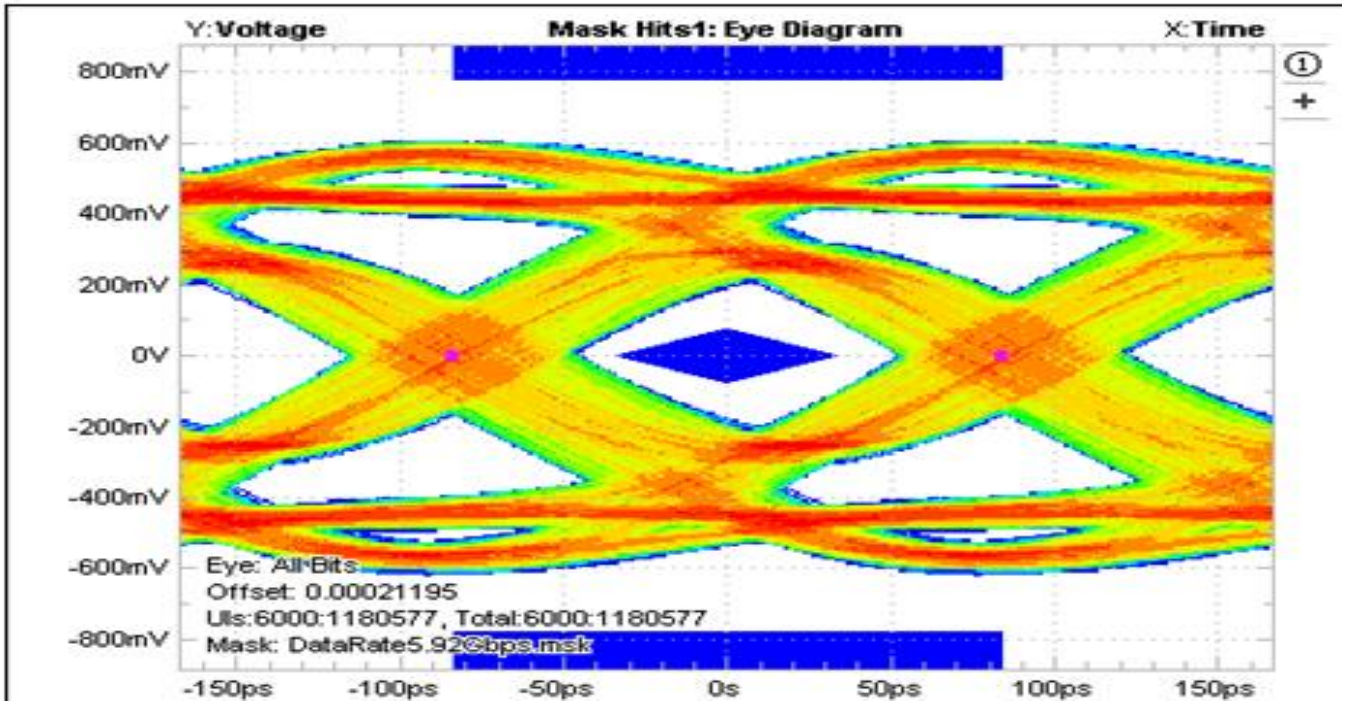
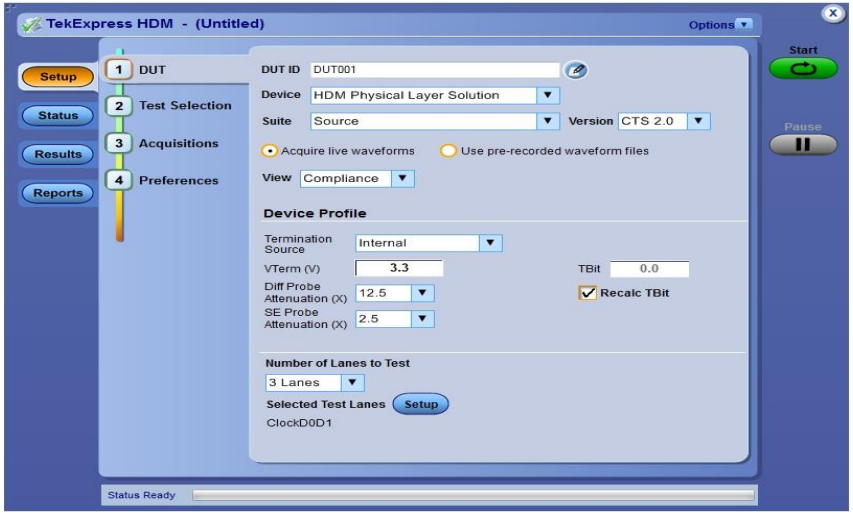
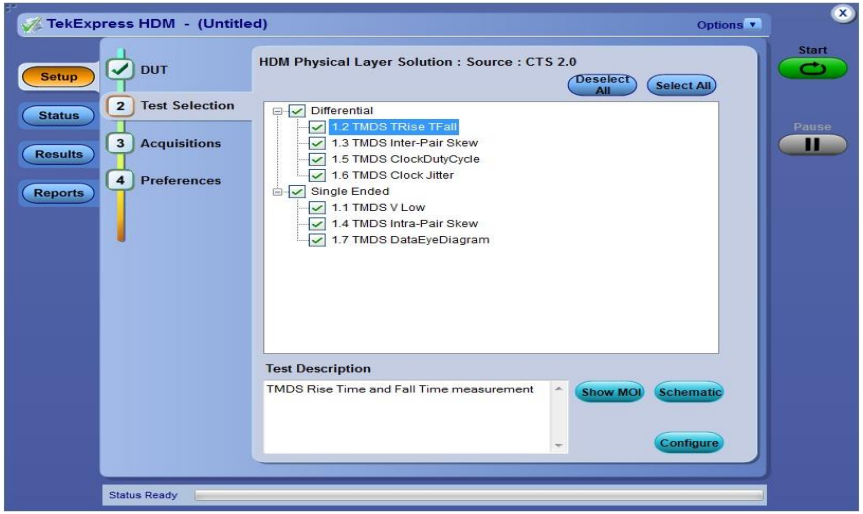
TP2 Source Eye for HDMI 2.0 6G signal

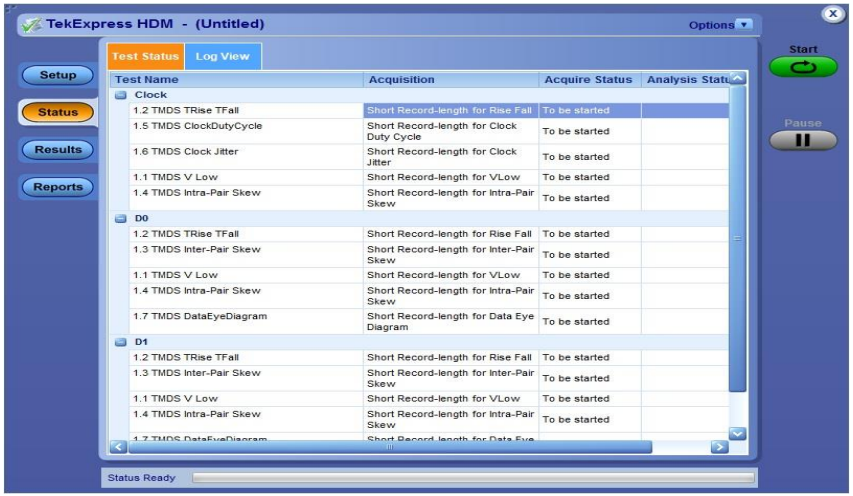


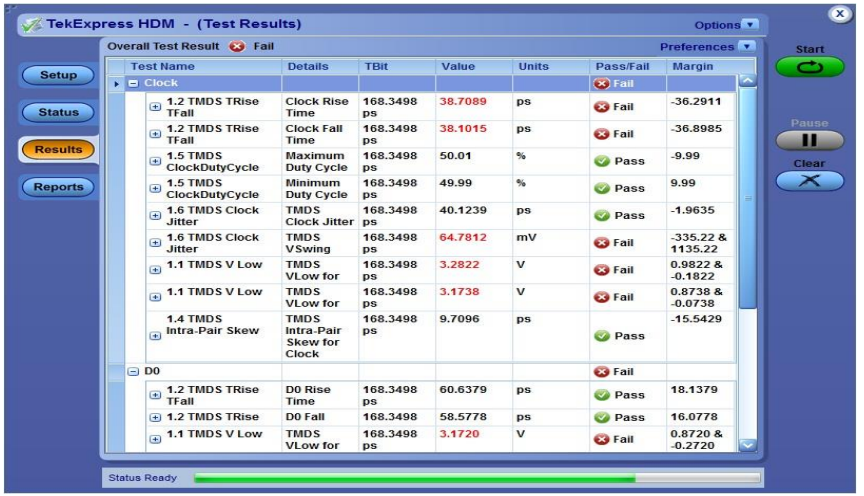
Single End Input eye rendered at Tek lab

HDMI 2.0 Tx Compliance Software









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HDMI 2.0 Sink Testing- Advanced Information

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Likely Sink Electrical tests

Min/Max Differential Swing Tolerance

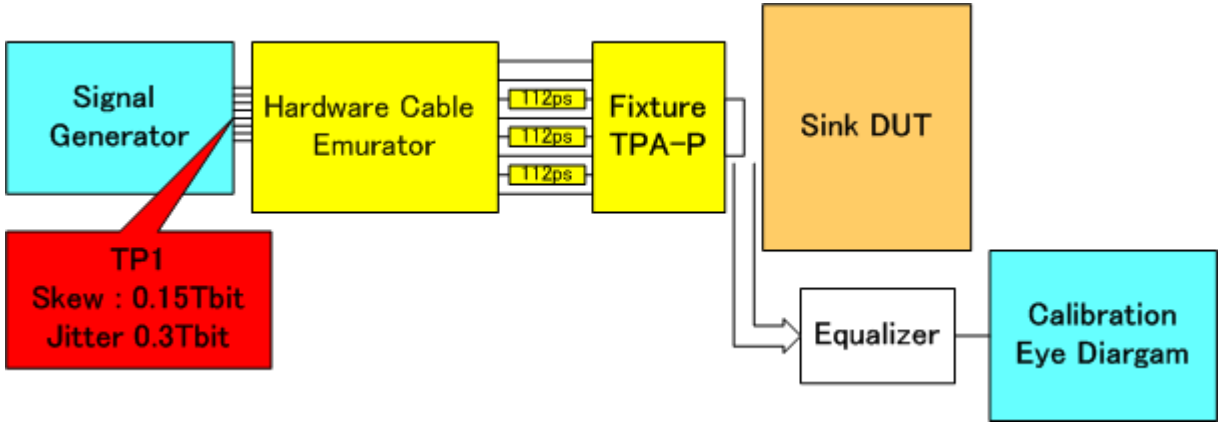
Intra-Pair Skew

Jitter Tolerance

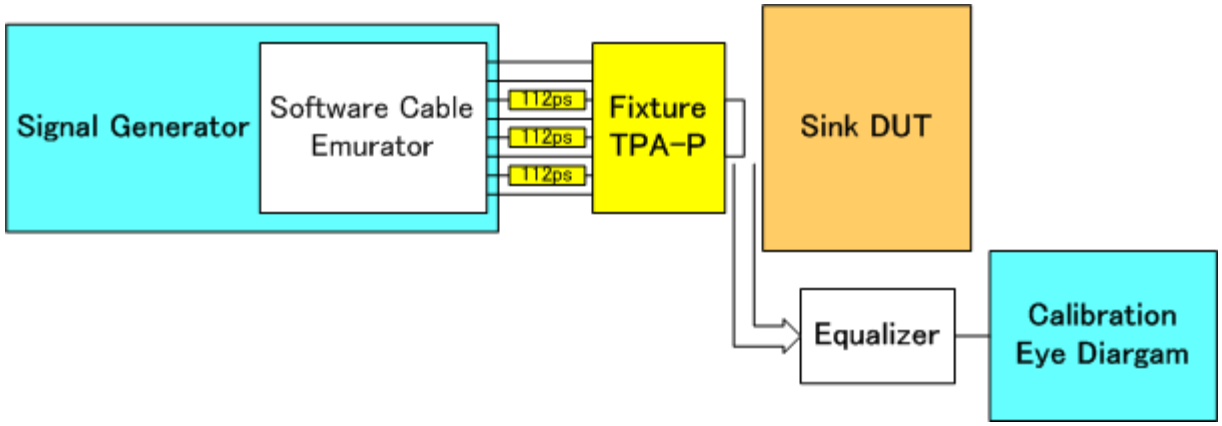
Differential Impedance

Requirement for Signal generation

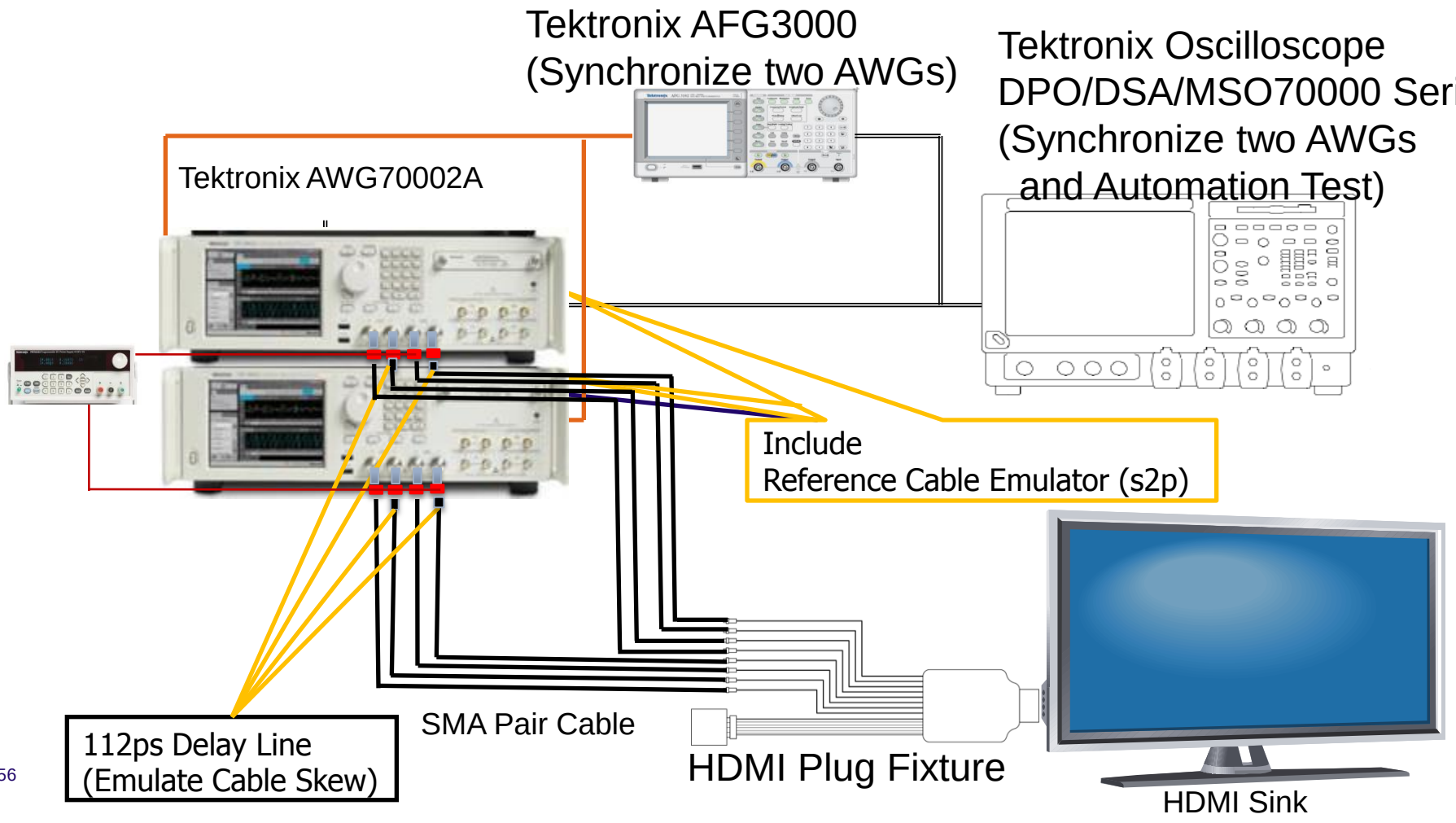
Cable Emulation and Skew by Hardware



Tektronix Software Cable Emulation



Sink Test



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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

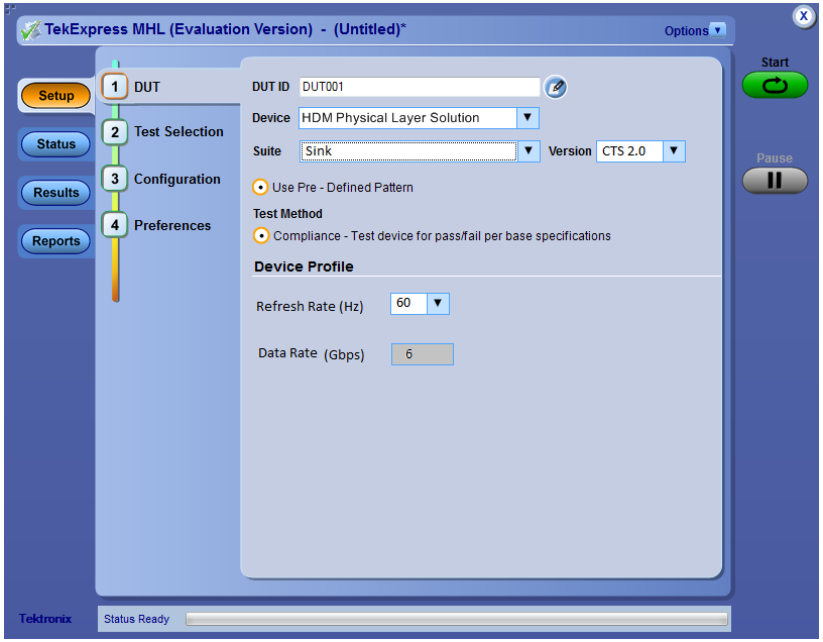
1.4b CTS test is a pre-requsite for HDMI 2.0

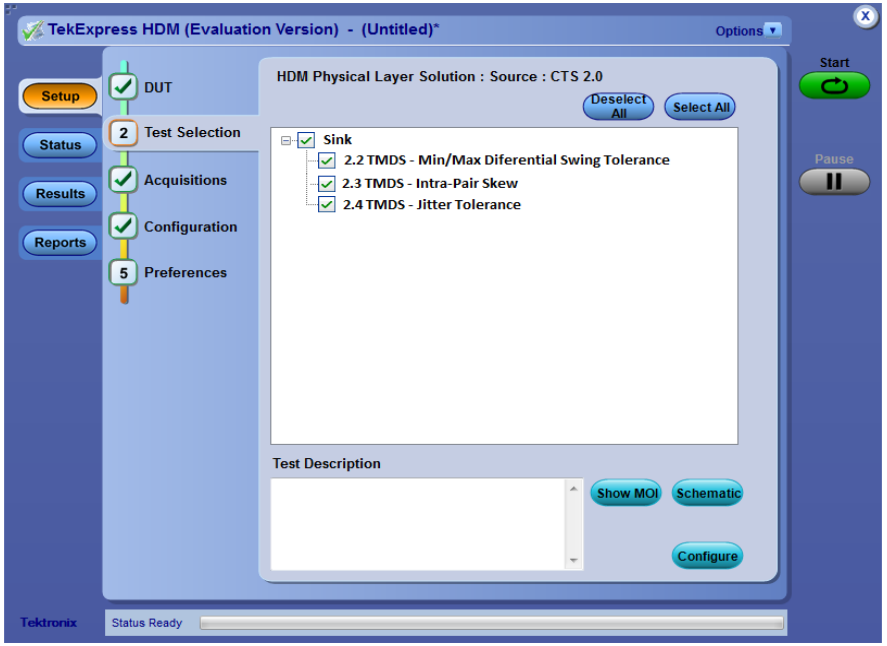
Need AWG70K series for HDMI 2.0 as against AWG7K.

Min 8GHz scope to 16GHz scope

Fixtures and Probes

HDMI 2.0 Rx Compliance Software





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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

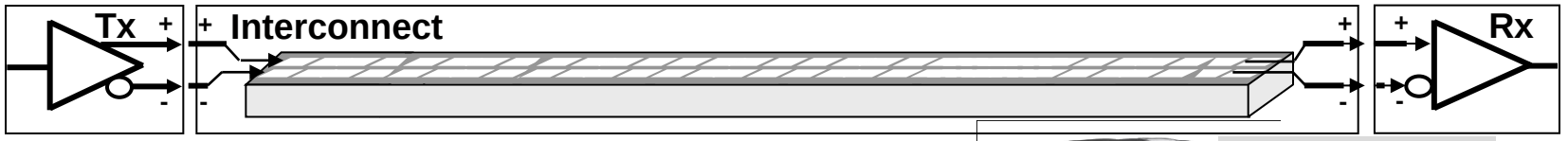
Tektronix HDMI 2.0 Solution

- 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-requiste 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

PCI EXPRESS · SERIAL ATA · SUPERSPEED USB · ddr3 · IEEE GbE · DisplayPort · HDMI · MHL …

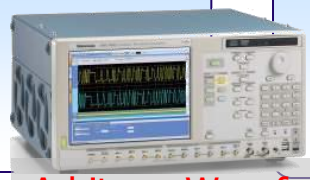


Real-time Scopes

System Integration
Digital Validation & Debug

Logic Analyzers

Transmitter Testing



Receiver Test
Margin Testing

Probing Fixtures

Arbitrary Waveform Generator

Interconnect Test

Sampling Scopes

Compliance Test

Compliance Test Software

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