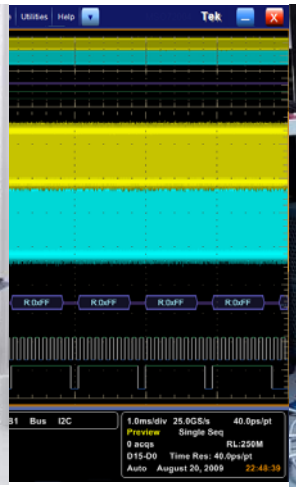
Simplifying HDMI Compliance Testing

Tektronix Support for HDMI 1.3c and 1.4 Test Solutions

HDMI™
HIGH-DEFINITION MULTIMEDIA INTERFACE



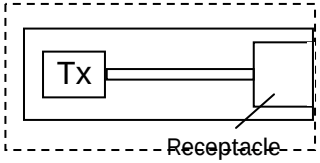
泰克中国区应用工程师 Bright Zeng

Agenda

- HDMI Overview and Updates
- Compliance Test Support from Tektronix
  - Source Tests
  - Sink Tests
  - Cable Tests
- What's new in HDMI v1.4 CTS
- Why Direct Synthesis for Sink Testing?
- Additional resources

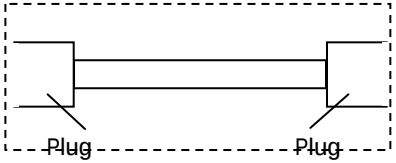
HDMI – System Overview

Source Devices



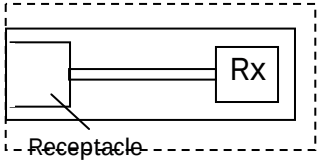
- Set-top Boxes, DVDs, Repeaters, Gaming devices

Cable Assemblies



- Cables

Sink Devices



- TVs, Monitors, Repeaters, etc.

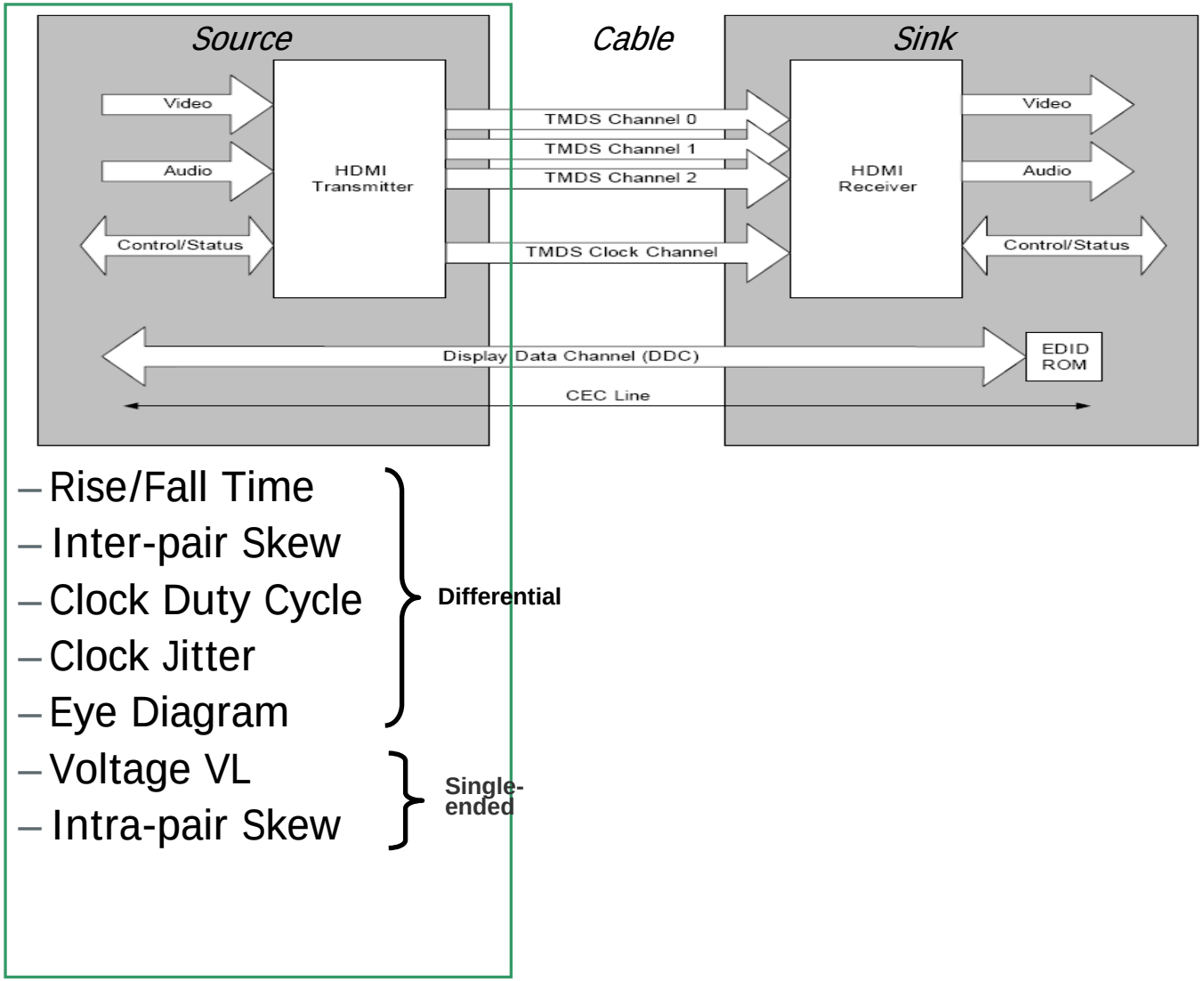
HDMI v1.4 Specifications and Compliance Test Specifications – What's Changed

- Compliance Test Specification (CTS)
  - CTS1.3c announced on July 25th 2008 – Approves Direct Synthesis method for Sink testing
  - CTS1.4 announced on November 3rd, 2009 –Endorses use of Direct Synthesis on Sink Test
- Key improvements in HDMI v1.4
  - HEAC (HDMI Ethernet Audio Back Channel)
  - Automotive HDMI (Type E)
  - Support for micro HDMI connector for mobile devices (Type D)
  - 3D HDMI and 4K x2K patterns support.
  - New Deep color patterns support
- Updated testing requirements in HDMI v1.4 CTS
  - New 2.3dB equalization mandated for cable tests and Sink tests for Automotive HDMI (Type E)
  - Mandatory 3D and 4K x 2K pattern support
  - Included Direct Synthesis Solution in CTS1.3c

HDMI Compliance Test Review

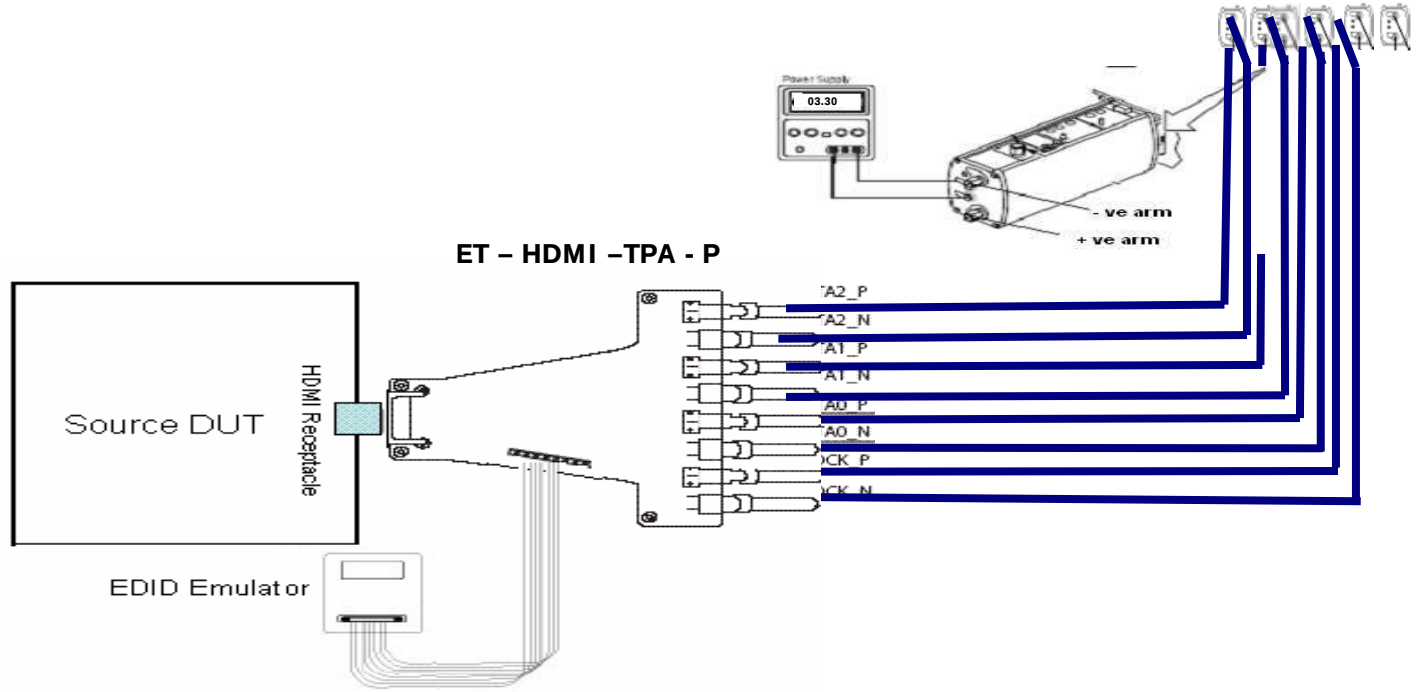
- Source Testing
- Sink Testing
- Cable Testing

HDMI Source Testing



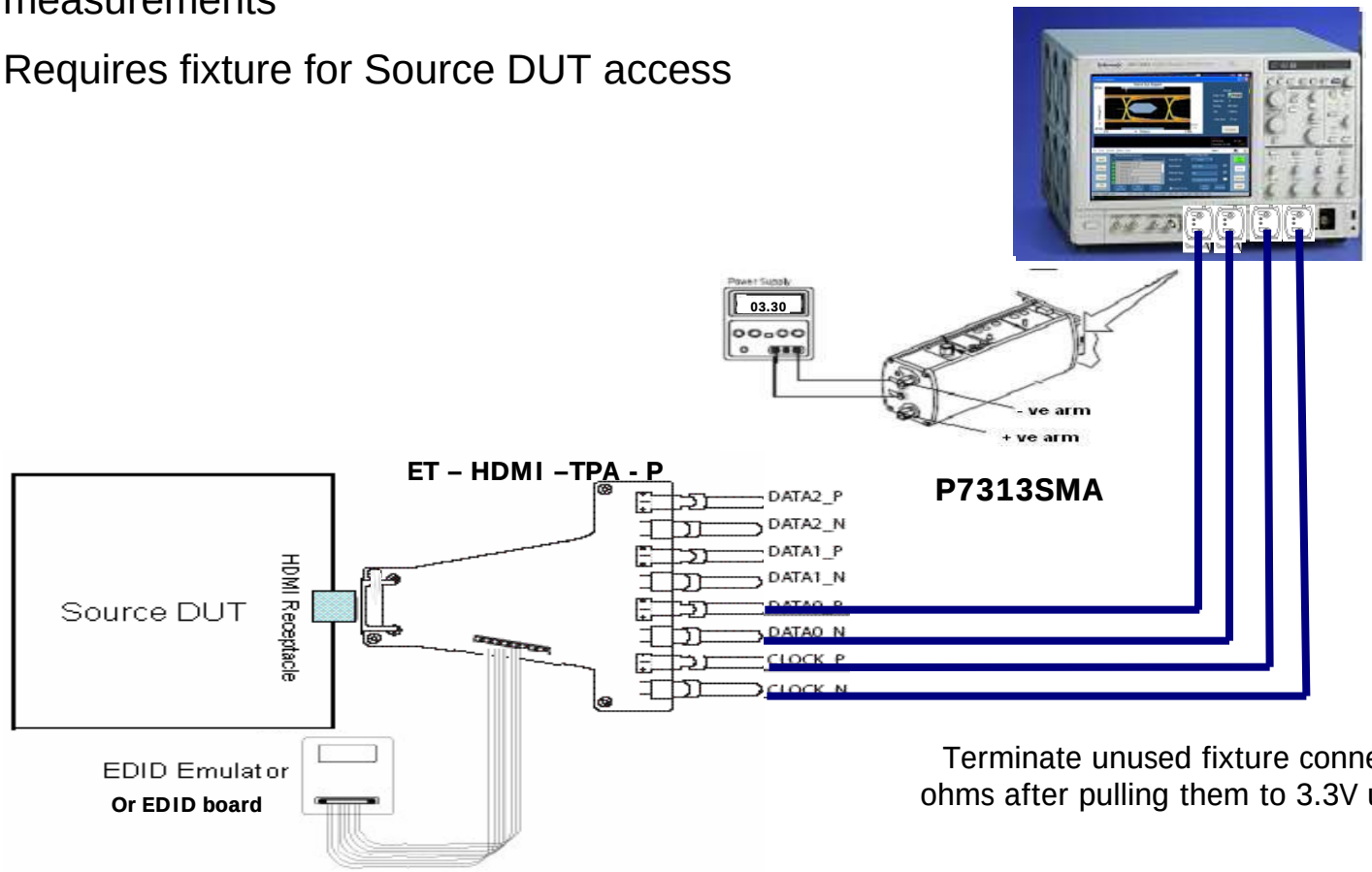
Differential Measurements using Tektronix Oscilloscope

- Tektronix system supports *simultaneous* differential path acquisition
- Requires fixture for Source DUT access



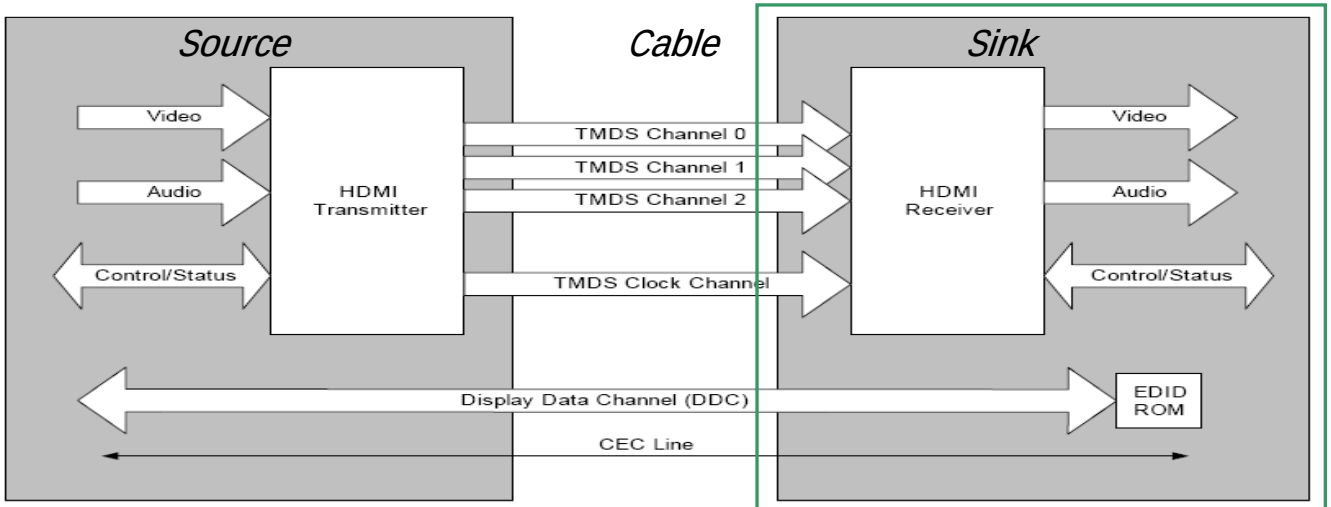
Single-ended Measurements using Tektronix Oscilloscope

- Tektronix DPO/DSA70000B Oscilloscope performs 2 Channel Single-Ended measurements
- Requires fixture for Source DUT access



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

HDMI Sink Testing



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

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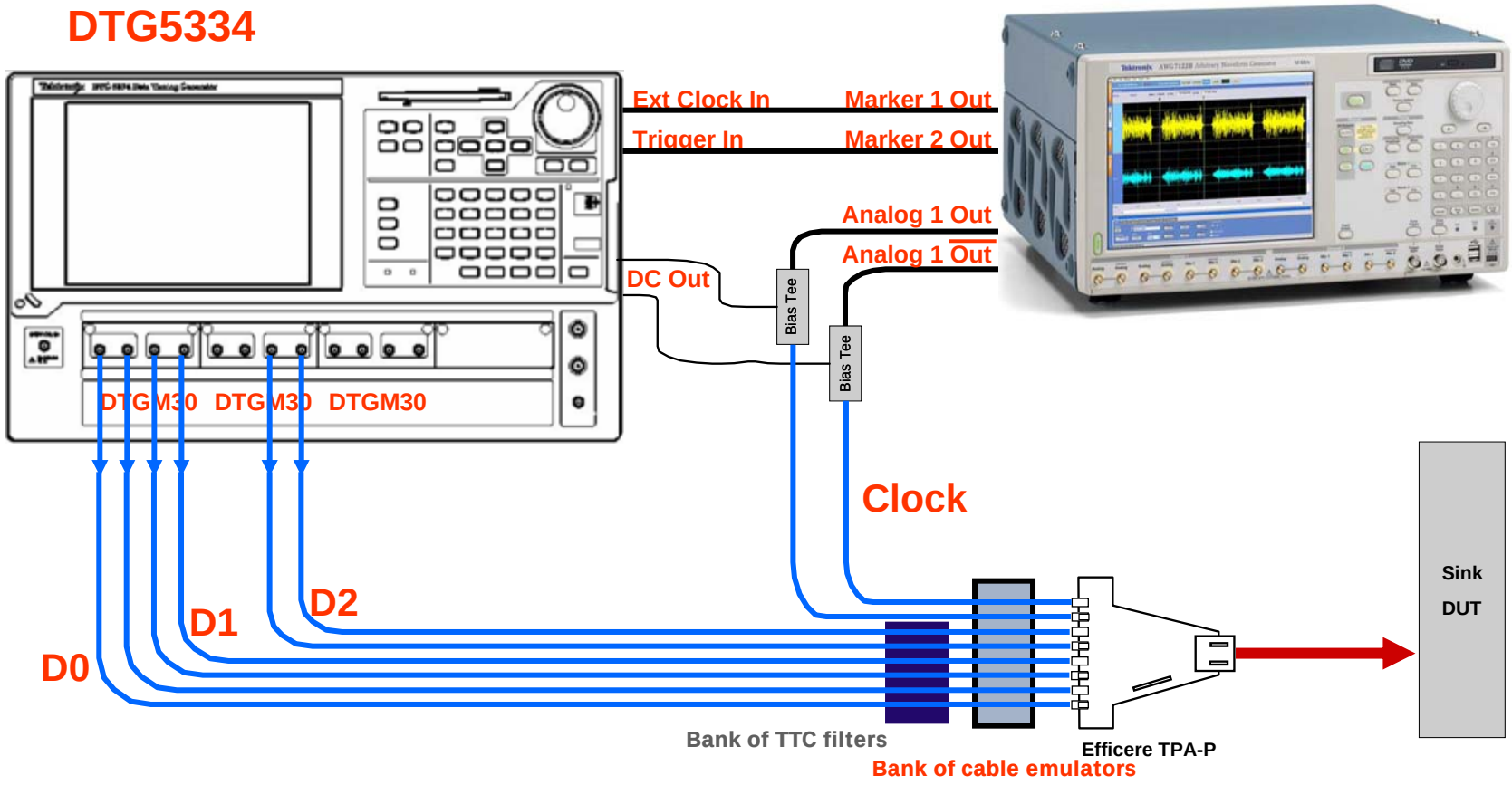
Key Measurements in CTS

- Jitter Tolerance Test
  - Test sequence has been simplified
    - Requires fewer iterations to complete a test (eliminated Djw procedure)
    - CTS1.3c adds TP2 testing
  - Supports two alternative methods of jitter injection
    - Standard Jitter insertion method
      - Combines both clock and data jitter components and modulates them both on the clock signal
      - Minimum test requirement of CTS - HDMI customers
    - Optional Jitter Insertion method
      - Modulates clock signal only with clock jitter component
      - Modulates all data signals with data jitter component
  - Tektronix' HDMI compliance solution supports both methods
    - The standard method is supported at minimal cost using an AFG3102 or AWG710/B for customers who already have them
    - The new AWG7102 with Option 01 supports both methods
- Differential Impedance, Skew & Swing Tests
  - Performed with Tektronix Oscilloscope and Fixtures

Combined clock/data jitter tests

27 MHz to 340 MHz

AWG CH1 - Sub-rate (1/10 data rate) clock modulated with both clock jitter component (10 MHz/7 MHz) and data jitter component (500 KHz/1 MHz)
AWG MK1 - Full rate clock to DTG



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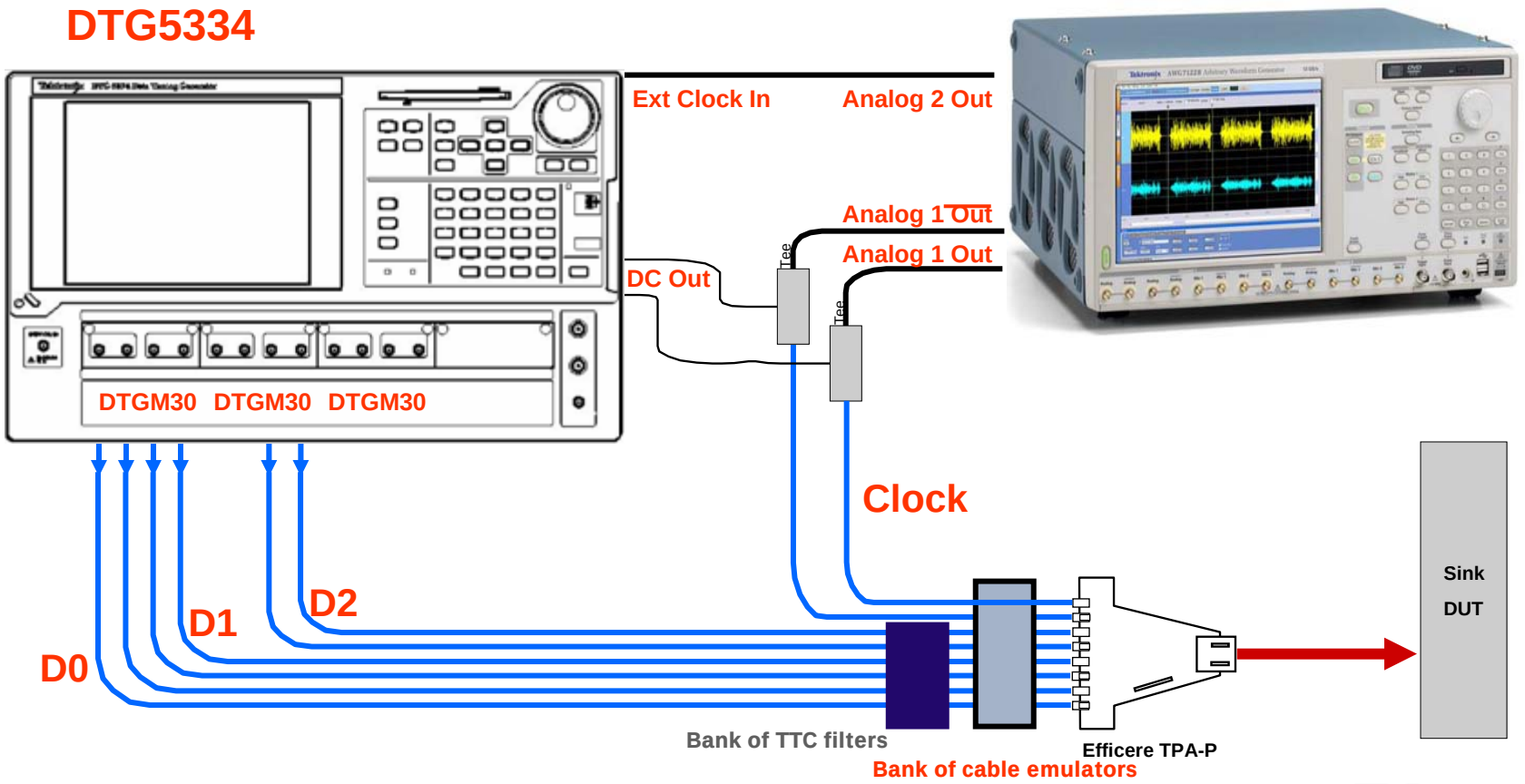
Separate clock/data jitter

27 MHz to 340 MHz

AWG CH1 - Sub-rate (1/10 data rate) clock modulated with clock jitter component (10 MHz/7 MHz)

AWG CH2 - Full rate clock to DTG modulated with data jitter component (500 KHz/1 MHz)



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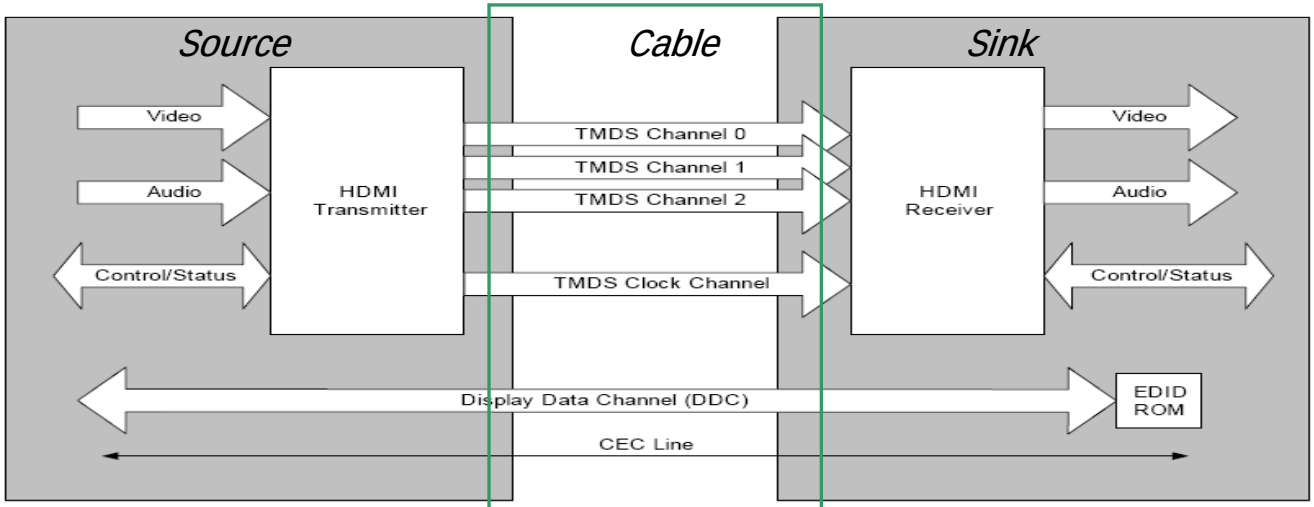
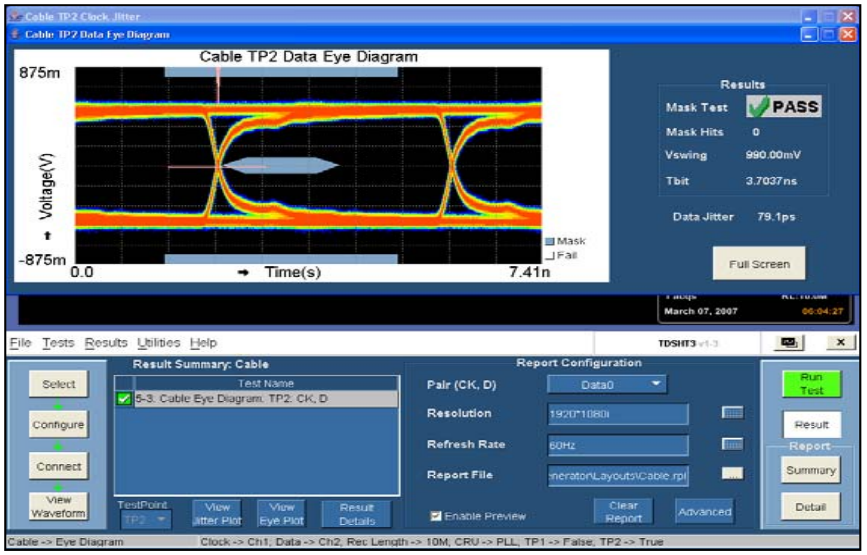
HDMI Cable Testing



- TMDS Data Eye Diagram
- Inter-pair and Intra-pair Skew
- Impedance
- FEXT (Far End Crosstalk)
- Attenuation

Key Measurements in CTS

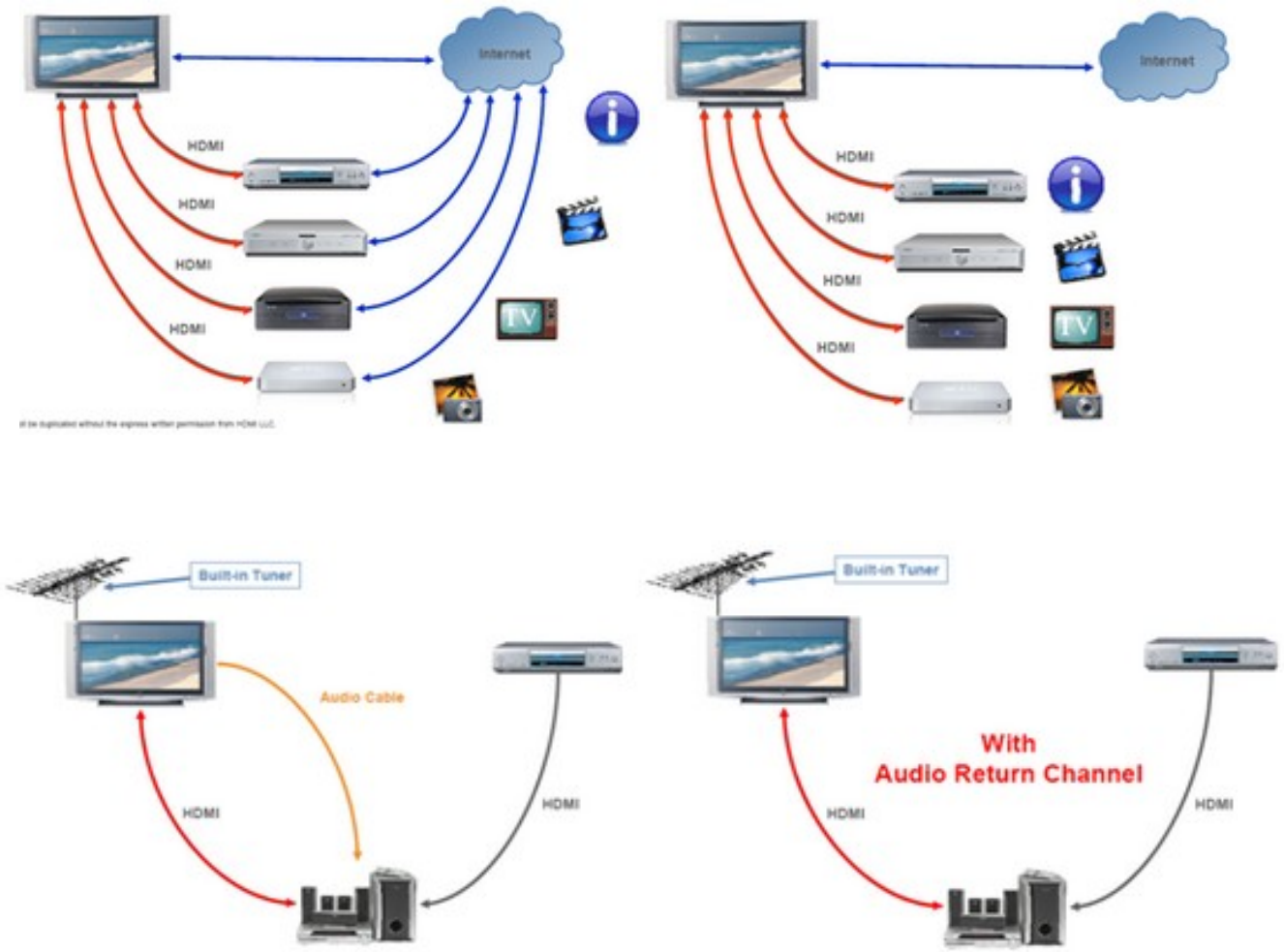
- TMDS Data Eye Diagram
  - 4 channel support for TP2 Eye Diagram test with Tektronix DPO/DSA70000B Oscilloscope
- Jitter insertion for stress testing
  - Tektronix AFG3000 provides jitter insertion for Cable Eye Diagram test
- Inter-pair and Intra-pair Skew Tests
  - Tektronix DSA8200 Sampling (TDR) Oscilloscope
- Impedance Testing
  - Tektronix DSA8200 Sampling (TDR) Oscilloscope
- FEXT (Far End Crosstalk) & Attenuation Tests are performed with a Network Analyzer



What's new for HDMI v1.4?

- HEAC (HDMI Ethernet Audio Back Channel)
- Automotive HDMI (Type E)
- Support for micro HDMI connector for mobile devices (Type D)
- 3D HDMI and 4K x2K patterns support.
- New Deep color patterns support

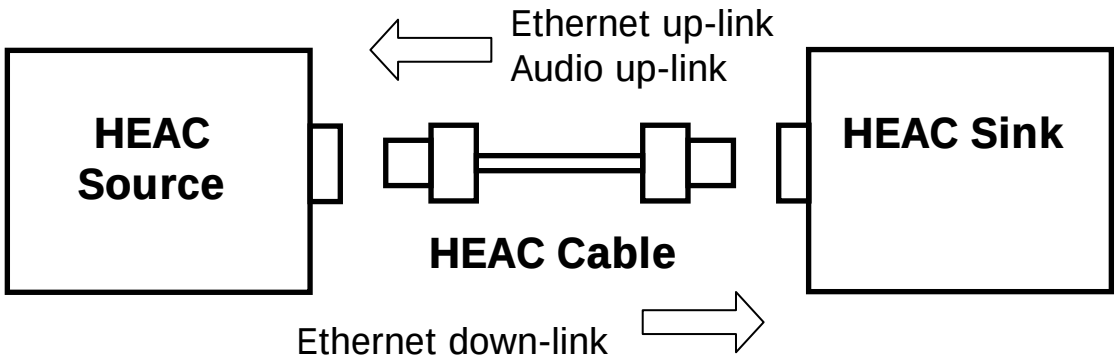
End Use application



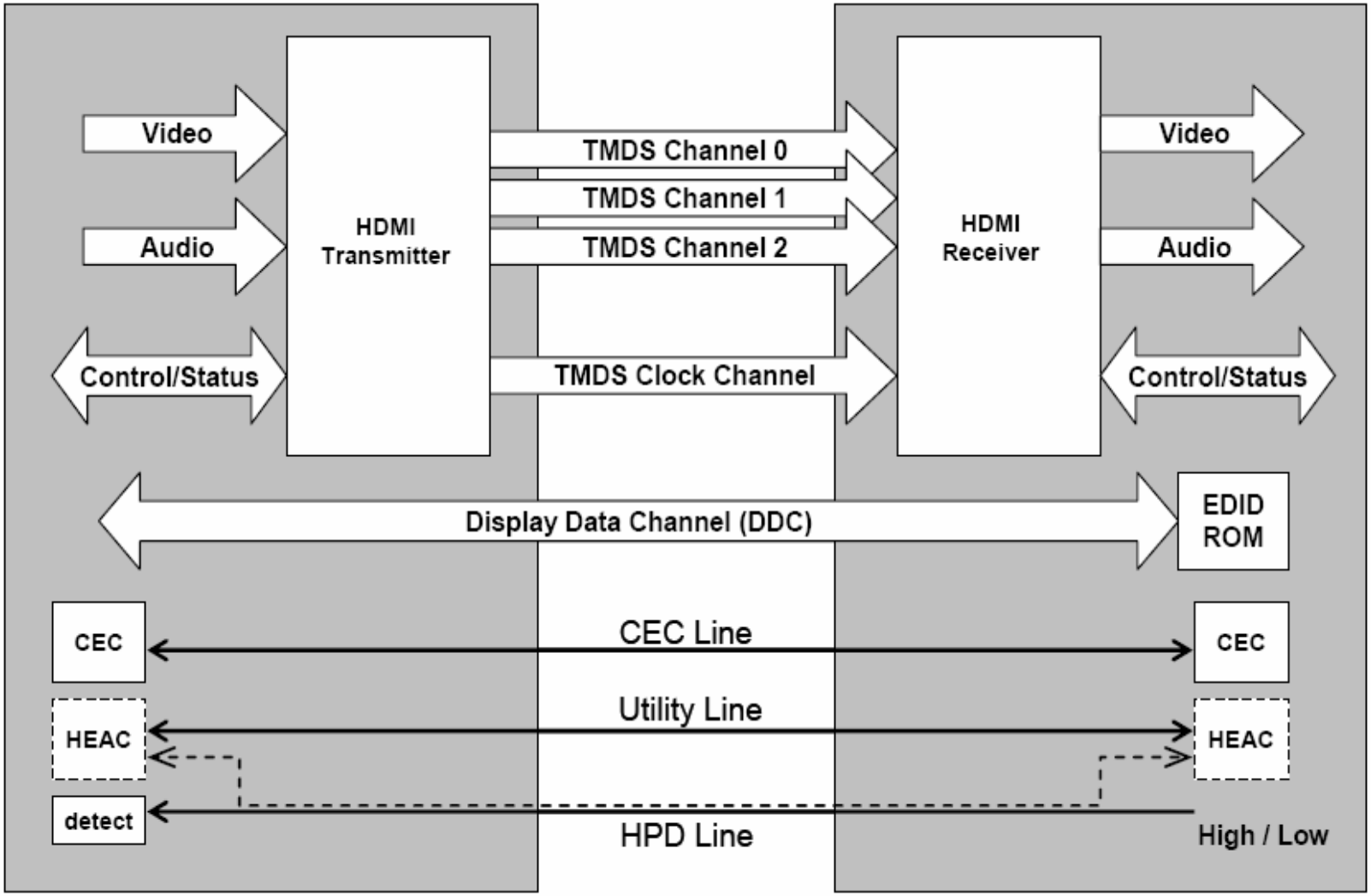
Source: HDMI LLC

HEAC Explained

- 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



HDMI1.4 block diagram



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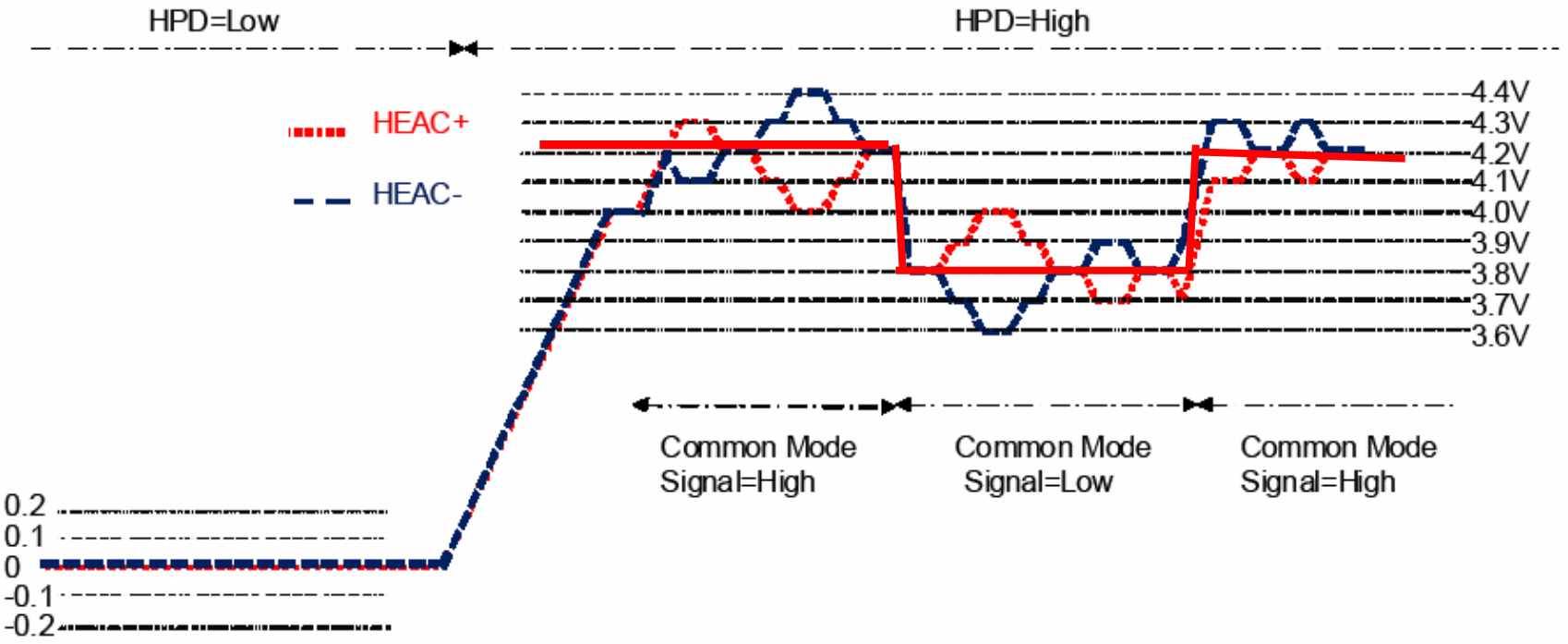
HEAC Specific Signals

- Small Amplitude Ethernet Signal
  - 200mVp-p in contrast to 1Vp-p of normal Ethernet
  - In differential mode, amplitude is 400mVp-p.
  - Except for amplitude, it's an Ethernet.
  - 125Mbps bit rate including overhead
- Bi-Directional Ethernet Transfer
  - Transmitting & receiving streams superposed
  - Embedded HYBRID circuit in TRX chip
  - Software HYBRID needed in measurement instrument
- Common Mode Audio Stream
  - Digital audio stream superposed in common mode
  - 400mVp-p amplitude
  - SPDIF format at 32k/44.1k/48k samples/s rate (up to 6.144Mbps bit rate)
  - Unidirectional transfer (Sink device → Source device)
- High DC Offset
  - Approx. 4V from ground

HEAC-HDMI Ethernet and Audio Return Channel



HEAC Figure 2-10 Simultaneous Transmission Waveform

What's new from Tektronix for HDMI v1.4 CTS Tests

- HDMI Sink, Cable and Type E (Automotive HDMI)
  - Direct Synthesis setup using 2# AWGs, 1# AFG, DPO/DSA70804B with HT3-DS software, P7313SMA probes
  - Type E fixtures – TF-HDMIE-TPA-KIT
  - Type A and Type C fixtures already available
- Type D (Mobile HDMI)
  - Type D Fixtures – TF-HDMID-TPA-KIT
- HEAC (HDMI Ethernet Back Channel Audio)
  - HEAC Setup consisting of DPO/DSA70KB or DPO7K with HEAC Software, P7330, P6247/P6248/P6330, TDP1000/1500/3500 Differential Probes, P7240 P6245, TAP1500/2500/3500 SE probes, AWG5K/B or AWG7K/B
  - HEAC Fixtures – TF-HEAC-TPA-KIT
- HDMI- 3D Patterns, 4Kx2K Patterns and New calorimetric Patterns available

HEAC Physical Layer Test (1/2)

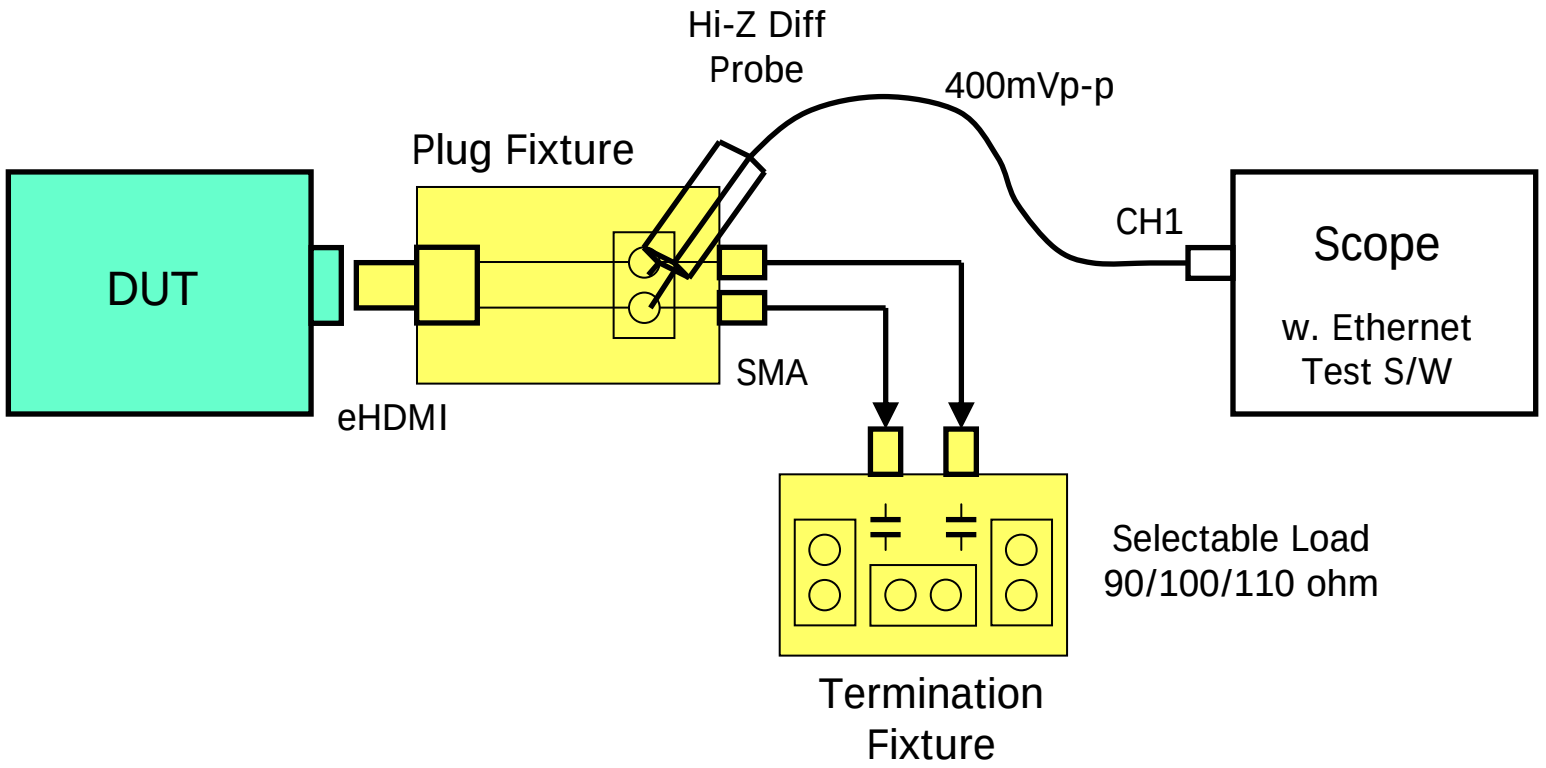
- Ethernet Transmitter Test
  - Similar to normal 100Base-TX test except for lower amplitude
- Ethernet Receiver Test
  - Generate test packets with stress using AWG(5K/7KB)
  - Capture and analyze response packets using oscilloscope
  - Confirm compliant packet error rate
- Audio Transmitter Test
  - 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

HEAC Physical Layer Test (2/2)

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

Ethernet Transmitter Test (1/2)

For Both Source and Sink Device Classes



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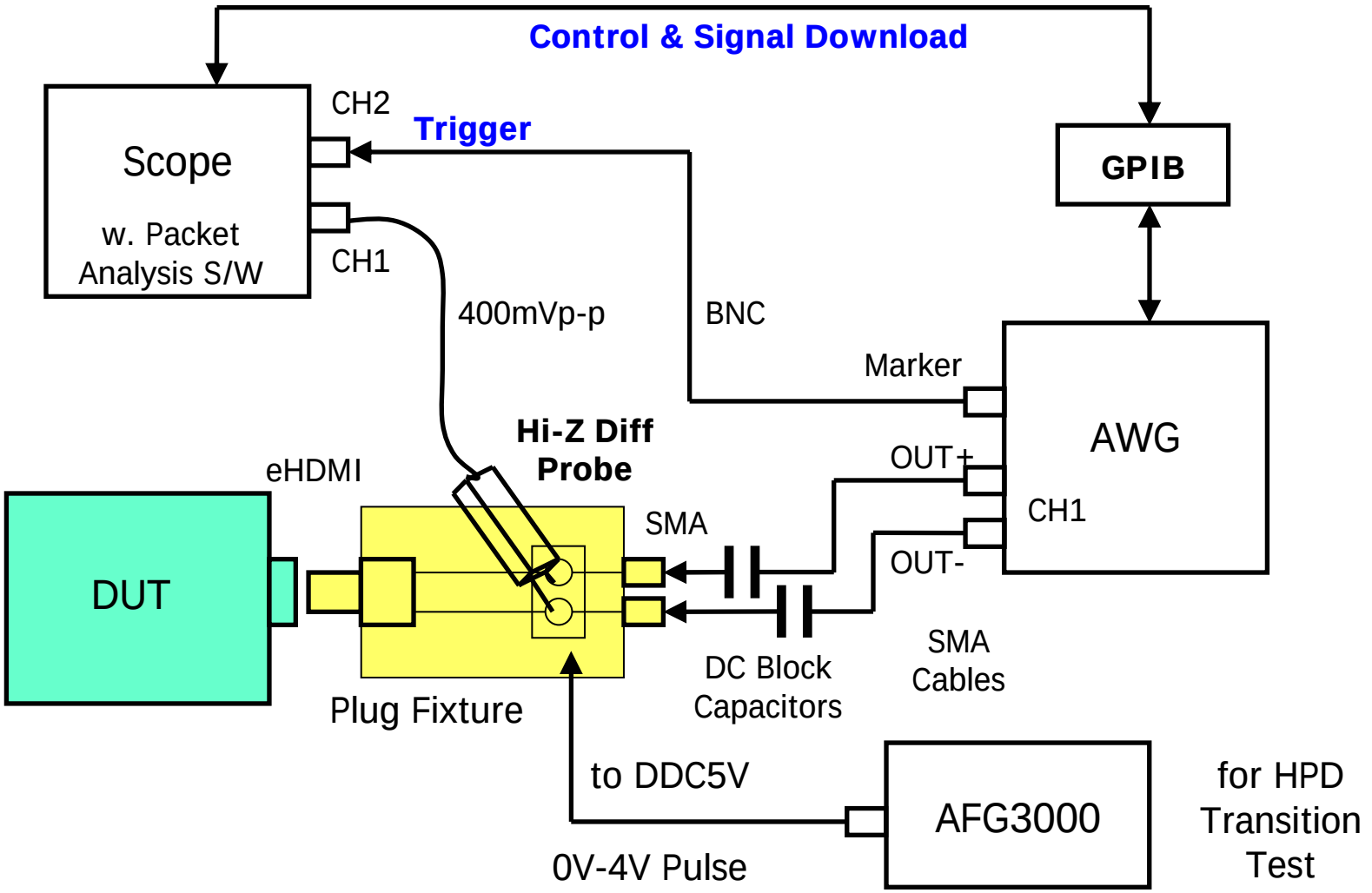
Ethernet Transmitter Test (2/2)

- General Requirement
  - Similar to standard 100Base-TX test
  - Amplitude decreased to 1/5 (400mVp-p in differential mode)
  - Fixed 100M rate --- no Link Partner needed
- Differential Signal Characteristics Tests
  - Operating DC Voltage Test
  - Jitter Max Test
  - Rise Time/Fall Time Test
  - High/Low/Center Level Voltage Test
  - Cycle Time Test
- Common Mode and Single Mode Signal Characteristics Tests
  - Operating DC Voltage Test
  - High/Low Level Voltage Test
  - Rise/Fall Time Test
  - Jitter Max/Clock Frequency Test
  - IEC 60958-1 Stream Verification Test

Ethernet Receiver Test (1/2)

For Both Source and Sink Device Classes



Ethernet Receiver Test (2/2)

- General Requirement

– Generate test signal with decreased amplitude using AWG

– Capture response from DUT using oscilloscope

– Subtract transmitted signal from captured waveform

– Analyze signal to decode and extract packets

- Receiver Performance Tests

– Differential Signal Receiver Performance Test

– Common Mode Signal Receiver Performance Test

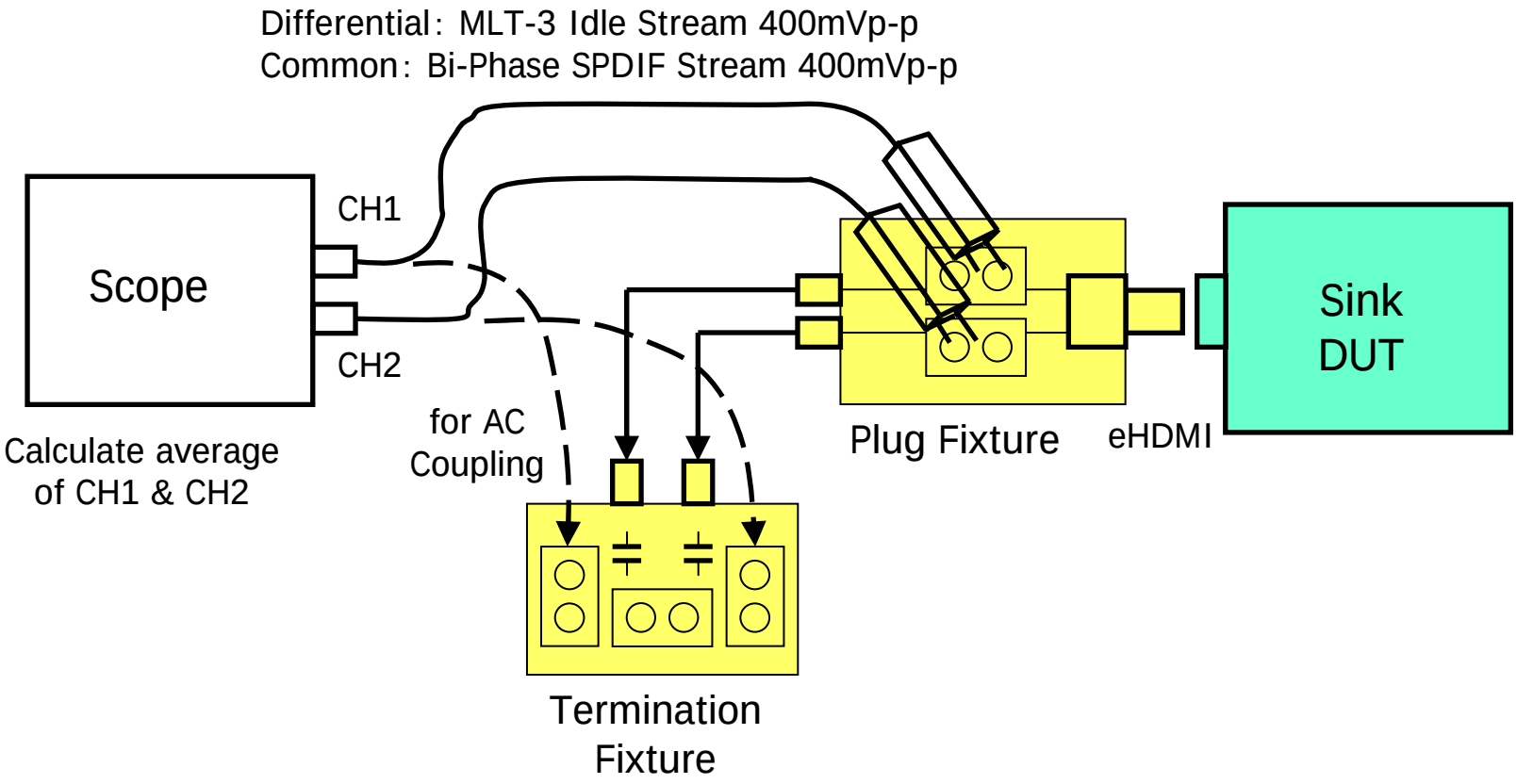
– Single Mode Signal Receiver Performance Test

– Common Mode Operating DC Voltage Test

– Single Mode Operating DC Voltage Test

Audio Transmitter Test (1/2)

Only For Sink Device Class

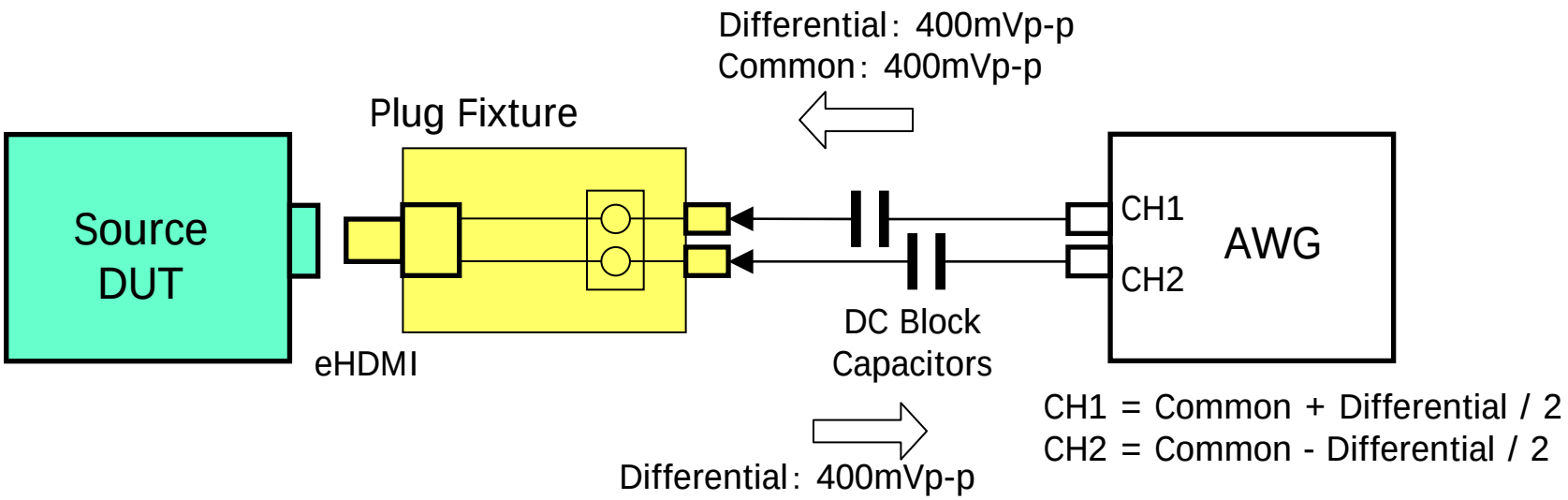


Audio Transmitter Test (2/2)

- General Requirement
  - Capture common mode signal using oscilloscope
  - Sum two channels to remove 100Base-TX differential mode signal
  - Bi-phase coded SPDIF stream
    400mVp-p, 4.096/5.6448/6.144Mbps

Audio Receiver Test (1/2)

Only For Source Device Class



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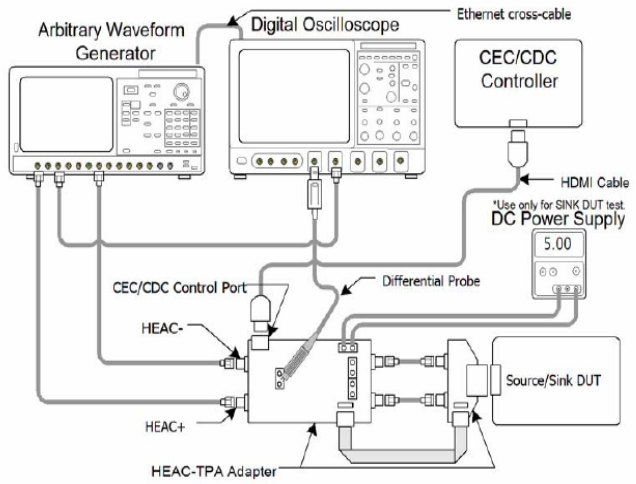
Audio Receiver Test (2/2)

- General Requirement
  - Generate test signal using two channels of AWG
  - Common mode: Bi-phase coded SPDIF stream 400mVp-p, 4.096/5.6448/6.144Mbps
  - Differential mode: 100Base-TX disturbing signal, 200mVp-p
  - Digitally simulate jitter insertion & cable degradation
  - Check regenerated audio signal by listening

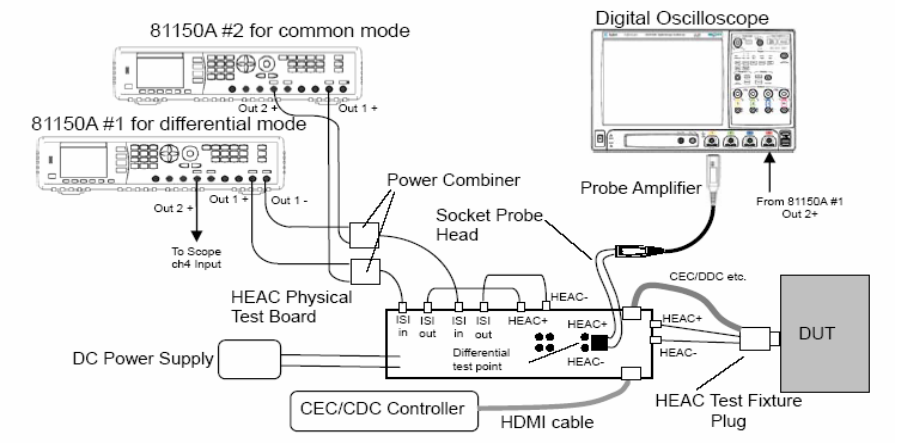
HDMI TMDS and HEAC Using the same equipments

Recommended Test Method – Tektronix DPO70000/B, DPO7000 Series and Tektronix AWG5000/B, AWG7000/B Series

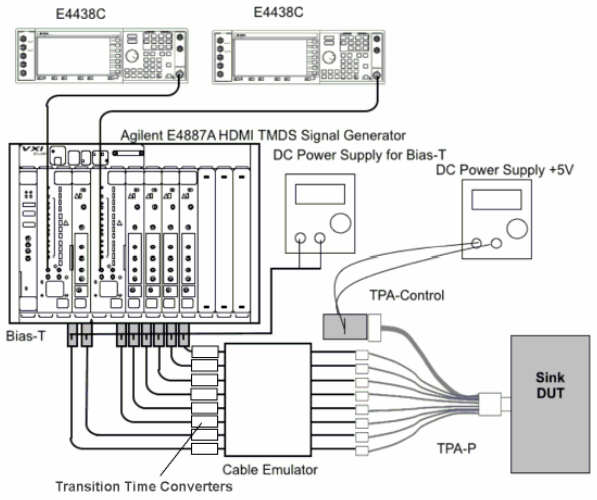


Setup 31. Test ID HEACT 5-16 : Differential Signal Receiver Performance Test-Tektronix

Tektronix-HEAC/TMDS



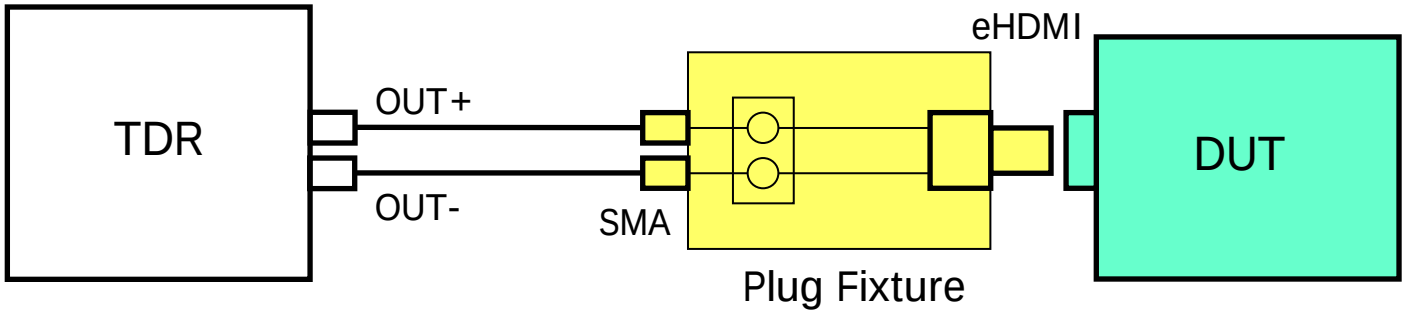
HEAC



TMDS

Device Impedance Test

For Both Source and Sink Device Classes

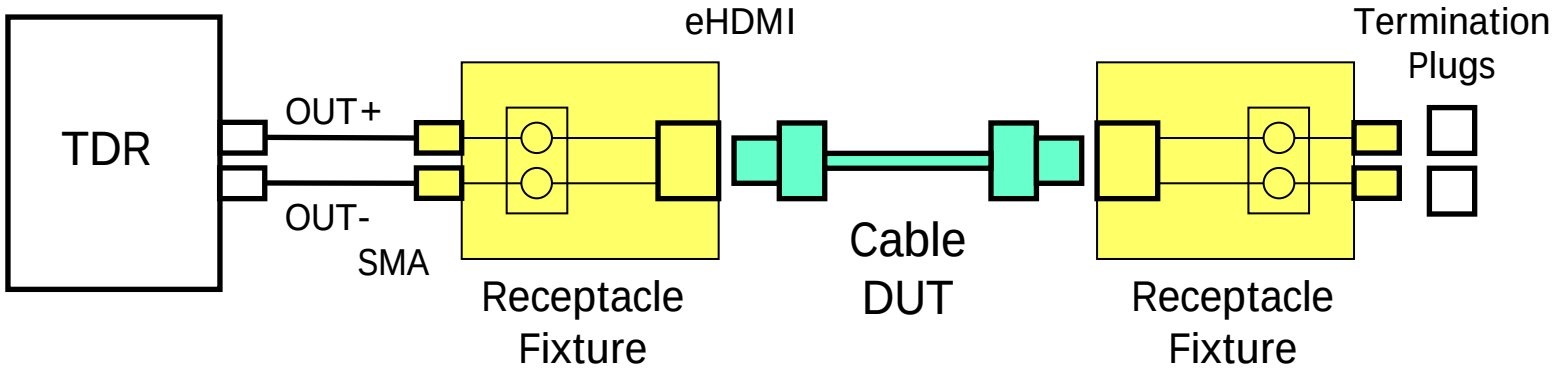


DUT power should be turned off.

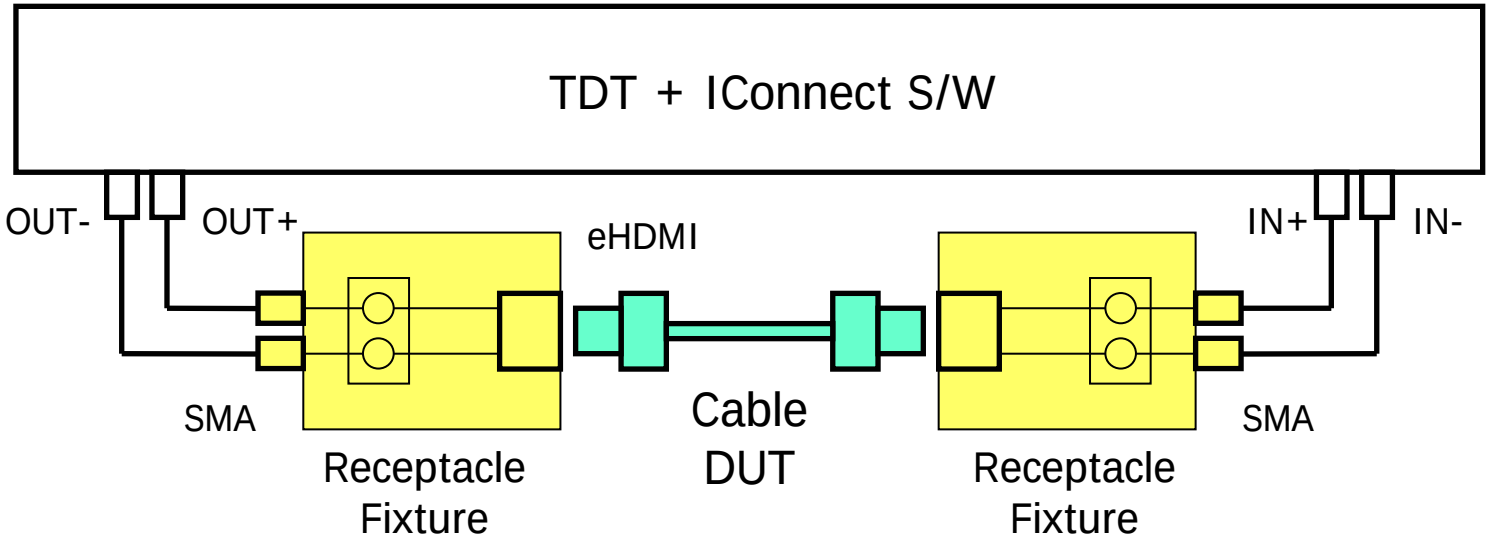
- Impedance
- Return Loss

Cable Test

- Impedance



- S-Parameter & Skew



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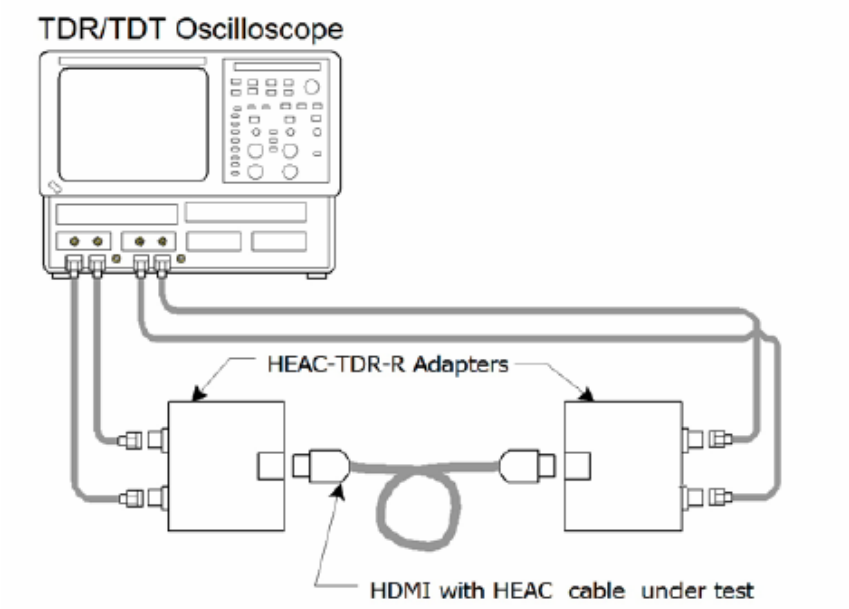
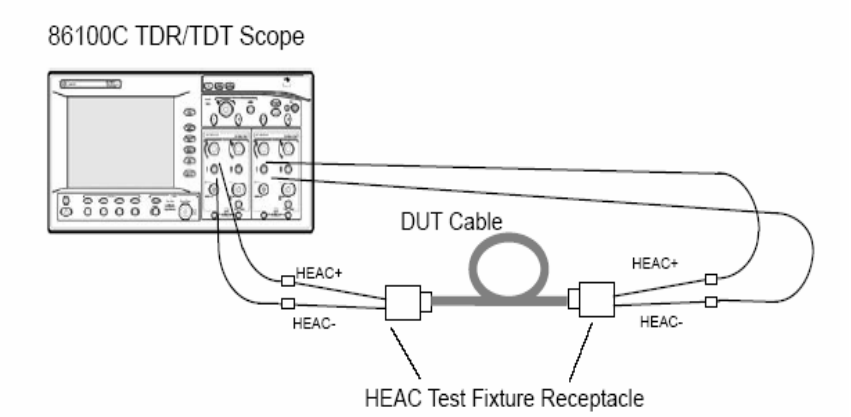
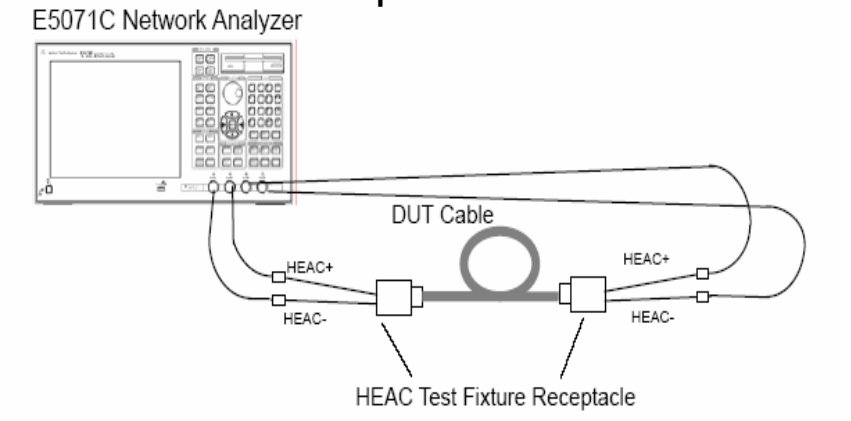
Impedance and attenuation using the same Tek equipments



Tektronix –Impedance/attenuation



Impedance



attenuation

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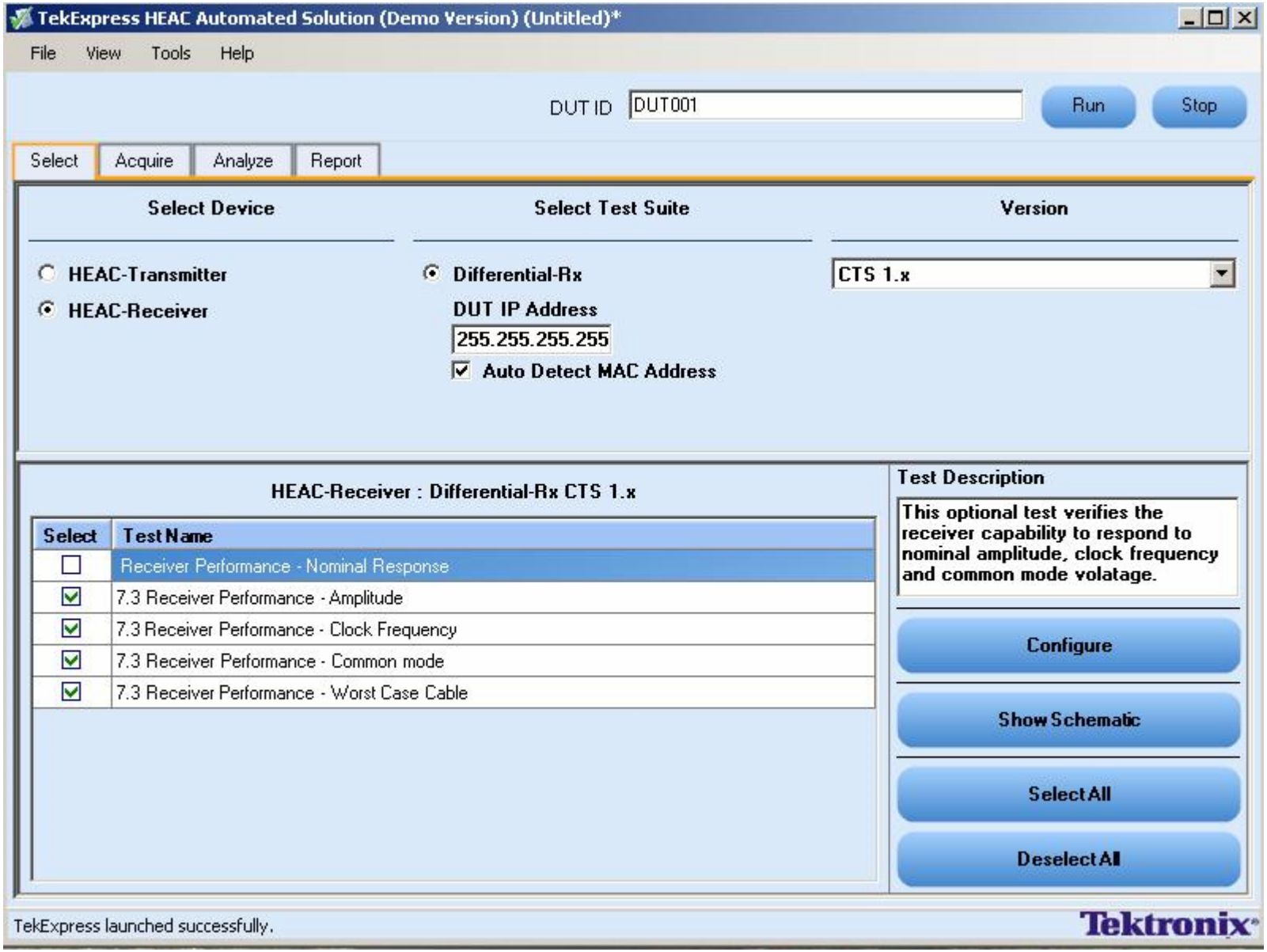
Tools & Utilities

- Test Fixture Set
  - One MAIN , 2 Plug (AP/CP), 2TDR (AR/CR), One Misc board
- Ethernet Transmitter Test Software
  - HEAC 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)

HEAC Software



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Report panel - Transmitter

TekExpress eHDMI Automated Solution (Demo Version) (Untitled)*

File View Tools Help

DUT ID DUT001 Run Stop

Select Acquire Analyze Report

eHDMI-Transmitter : Differential-Tx CTS 1.x

Tektronix
Enabling Innovation

TekExpress Automation Framework

eHDMI Transmitter Differential Signal Characteristics Test Report

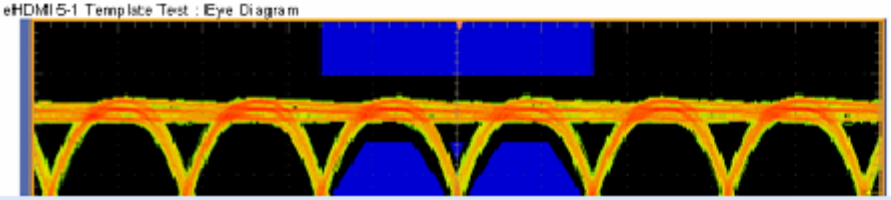
DUT ID : DUT001
Date/Time : 12/12/2008 15:13

Device Type : eHDMI-Transmitter
Execution Time : 16 Min

Version : CTS 1.x
Compliance Mode : Yes
Overall Test Result : Fail

Test Name	Measurement Details	Limit1	Measured value	Limit2	Units	Test Result	Compliance Mode	Execution Time	Comment
eHDMI 5-1 Template Test	Number of Violations	=0	33	-	Hits	Fail	Yes	3 Min	
eHDMI 5-2 Jitter MAX	Positive Pulses Jitter MAX	< 1.4	0.78	-	nSec	Pass	Yes	4 Min	
	Negative Pulses Jitter MAX	< 1.4	0.76	-		Pass			
eHDMI 5-3 Rise-Fall Time	Positive rise-time	>= 3	3.70	<= 5	nSec	Pass	Yes	4 Min	
	Positive fall-time	>= 3	3.61	<= 5		Pass			
	Negative rise-time	>= 3	3.61	<= 5		Pass			
	Negative fall-time	>= 3	3.64	<= 5		Pass			
eHDMI 5-4 High-Low-Center Level	High level voltage	>= 180	194.26	<= 220	mV	Pass	Yes	3 Min	
	Low level voltage	>= -220	-190.45	<= -180		Pass			
	Center level voltage	>= -20	1.09	<= 20		Pass			
eHDMI 5-5 Cycle Time	Positive Window Period	>= 7.875	8.00	<= 8.125	nSec	Pass	Yes	2 Min	
	Negative Window Period	>= 7.875	8.00	<= 8.125		Pass			

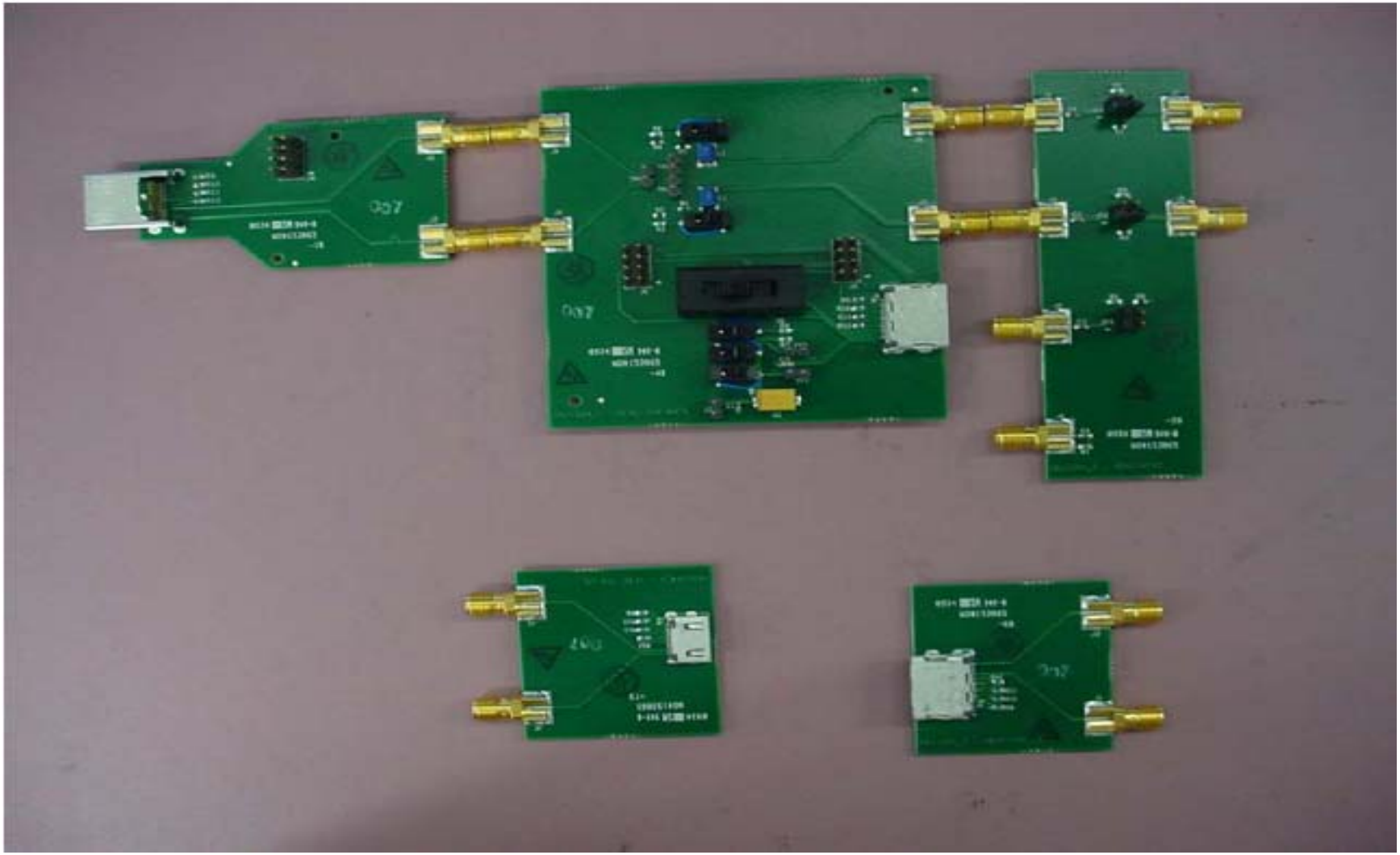
eHDMI 5-1 Template Test : Eye Diagram



TekExpress launched successfully.

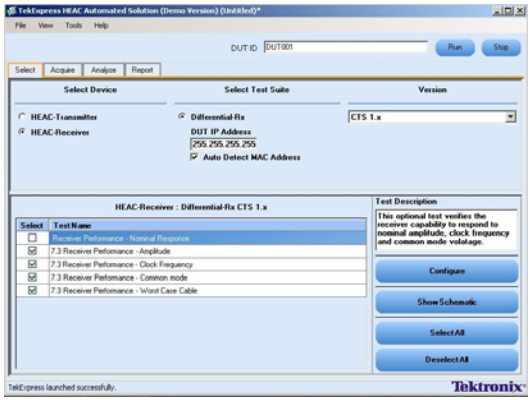
Tektronix

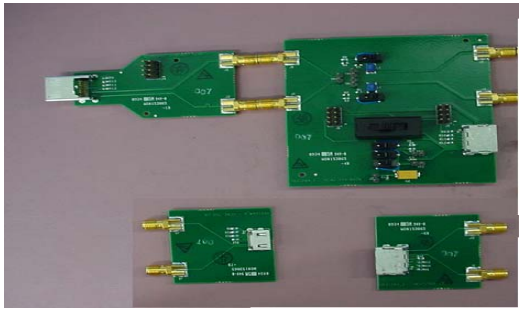
HEAC Fixtures



HEAC Support from Tektronix for CTS v.1.4

- DPO7K to DPO/DSA70K Oscilloscope
  - For new Ethernet/Audio Transmitter Testing
- AWG5000B or AWG7000B Waveform Generator
  - For Direct Synthesis enabled test packet generation
- New Compliance Software (Opt HEAC)
  - For network enabled HDMI tests
- New Fixtures (TF-HEAC-TPA-KIT) consisting of:
  - HEAC Main Fixture – TF-HEAC-TPA-MAIN
  - HEAC Type A Plug fixture – TF-HEAC-TPA-AP
  - HEAC Type C Plug Fixture – TF-HEAC-TPA-CP
  - 2# HEAC Type A Receptacle TDR Fixture – TF-HEAC-TDR-AR
  - 2# HEAC Type C Receptacle TDR Fixture – TF-HEAC-TDR-CR
  - TF-HDMI-TPA-CE- EDID board with EDID EEPROM and EDID Cable
- Mobile Applications (Type D) require different fixture:
  - TF-HDMID-TPA-KIT consisting of:
  - TF-HDMID-TPA-P
  - TF-HDMID-TPA-R
  - TF-HDMI-TPA-CE-- EDID board with EDID EEPROM and EDID Cable





HDMI 1.4 Pattern Support

- 4K x 2K Resolution patterns
- 3D HDMI mandatory Patterns
- New Deep Color Patterns

Test Patterns: Test ID 8-29: 3D Video Format Timing

Verify that Sink DUT supports:

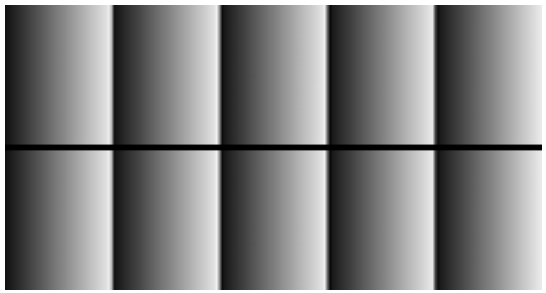
1.1920x1080p@23.98/24Hz.

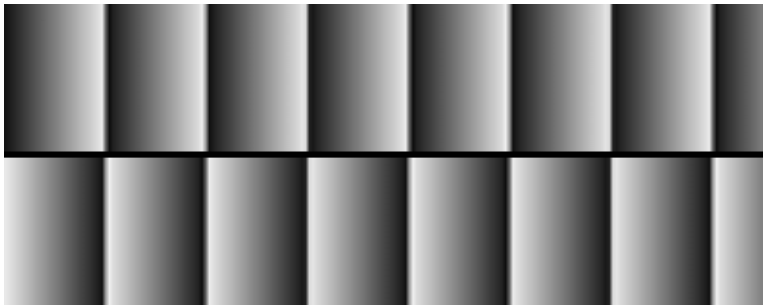
2. 1280x720p@59.94/60Hz If Sink Supports 60HZ

3. 1280x720p@50Hz if Sink Supports 50Hz

Tektronix Support for 8-29

Test ID	DTG	AWG Marker	AWG DS
3D	◯	◯	◯





Test Patterns Test ID 8-30: 4K x 2K Video Format Timing

Verify that Sink DUT supports:

1. If tested HDMI_VIC_X indicates HDMI video formats 0x01 then test 4Kx2K 29.97/30Hz.
2. If tested HDMI_VIC_X indicates HDMI video formats 0x02 then test 4Kx2K 25Hz.
3. If tested HDMI_VIC_X indicates HDMI video formats 0x03 then test 4Kx2K 23.98/24Hz.
4. If tested HDMI_VIC_X indicates HDMI video formats 0x04 then test 4Kx2K24Hz (SMPTE)

Tektronix Support for 8-30

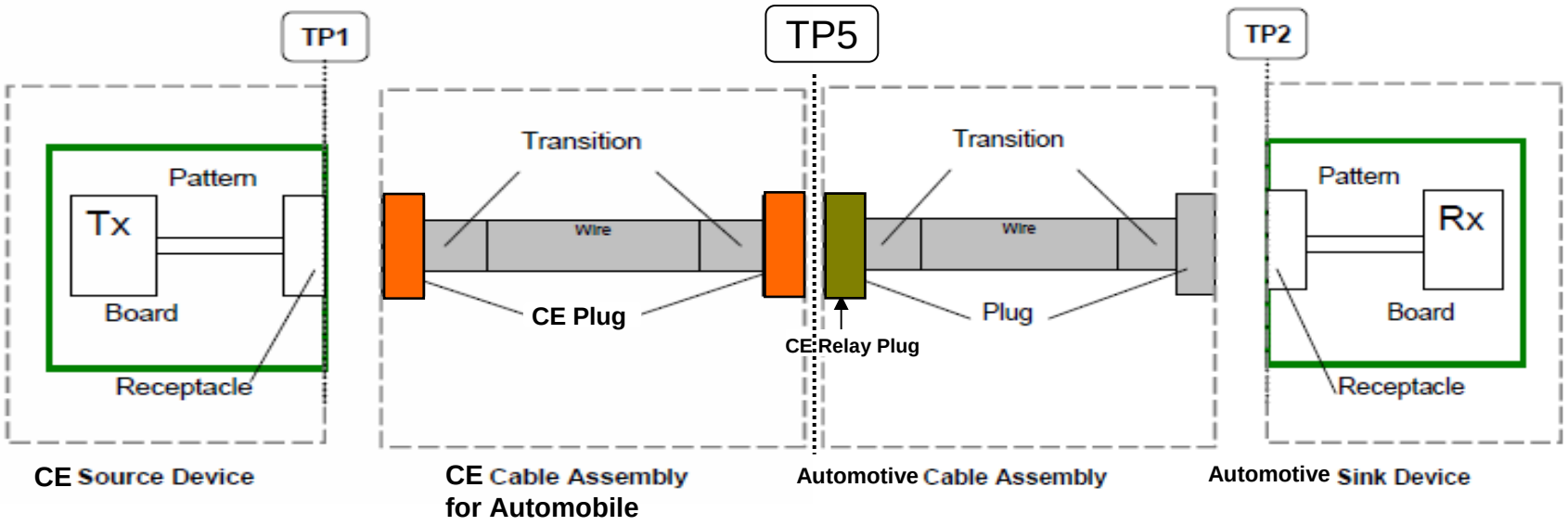
Test ID	DTG	AWG Marker	AWG DS
4K x 2K	◯	◯	◯

Tektronix Support for Test 8-31 in AWG and DTG

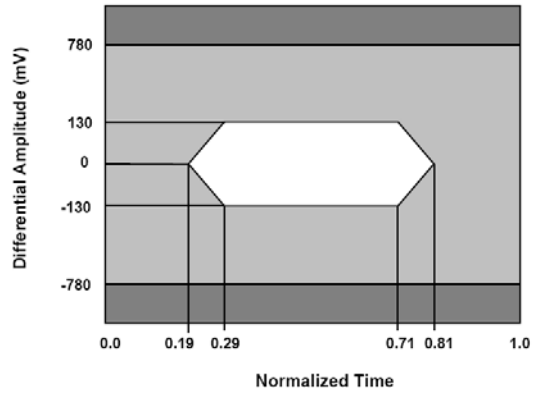
Test ID
576p 50Hz
8-31 sYCC601 Color Space
8-31 AdobeYCC Color Space
8-31 AdobeRGB Color Space
8-31 YCC Full Quantization Range
8-31 Photo Content
8-31 Cinema Content
8-31 Game Content
8-31 Graphics Content

Test ID
480p 60Hz
8-31 sYCC601 Color Space
8-31 AdobeYCC Color Space
8-31 AdobeRGB Color Space
8-31 YCC Full Quantization Range
8-31 Photo Content
8-31 Cinema Content
8-31 Game Content
8-31 Graphics Content

Automotive HDMI (Type E)



Eye Diagram Mask at TP5



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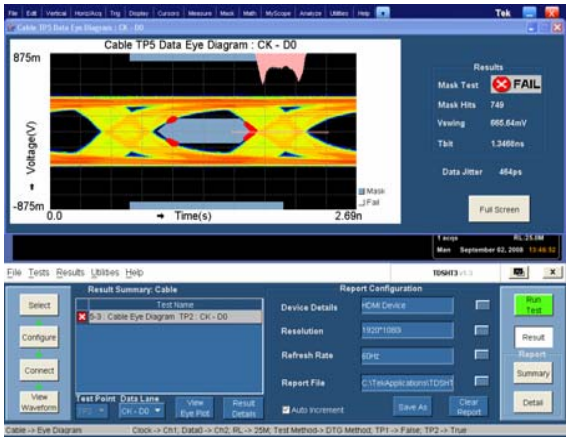
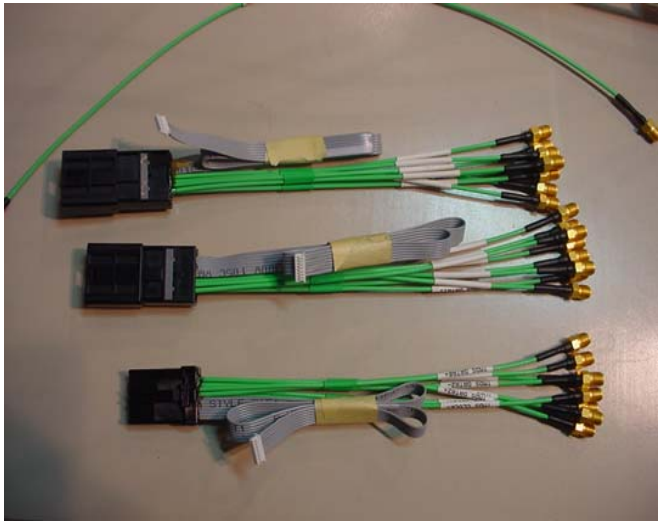
Automotive HDMI (Type E) Test Support from Tektronix

- HT3 DS Compliance Software from Tektronix supports Type E
  - Sink Jitter Tolerance Test for Type E
  - Cable Eye Diagram Test for type E
    - New 2.3dB Equalization Filter incorporated in HT3-DS software
    - Currently focused on 27MHz and 74.25MHz resolutions



- New Type E Fixture
  - Larger dimension connector
  - Capability to handle the ruggedness and Flexibility of a automotive environment



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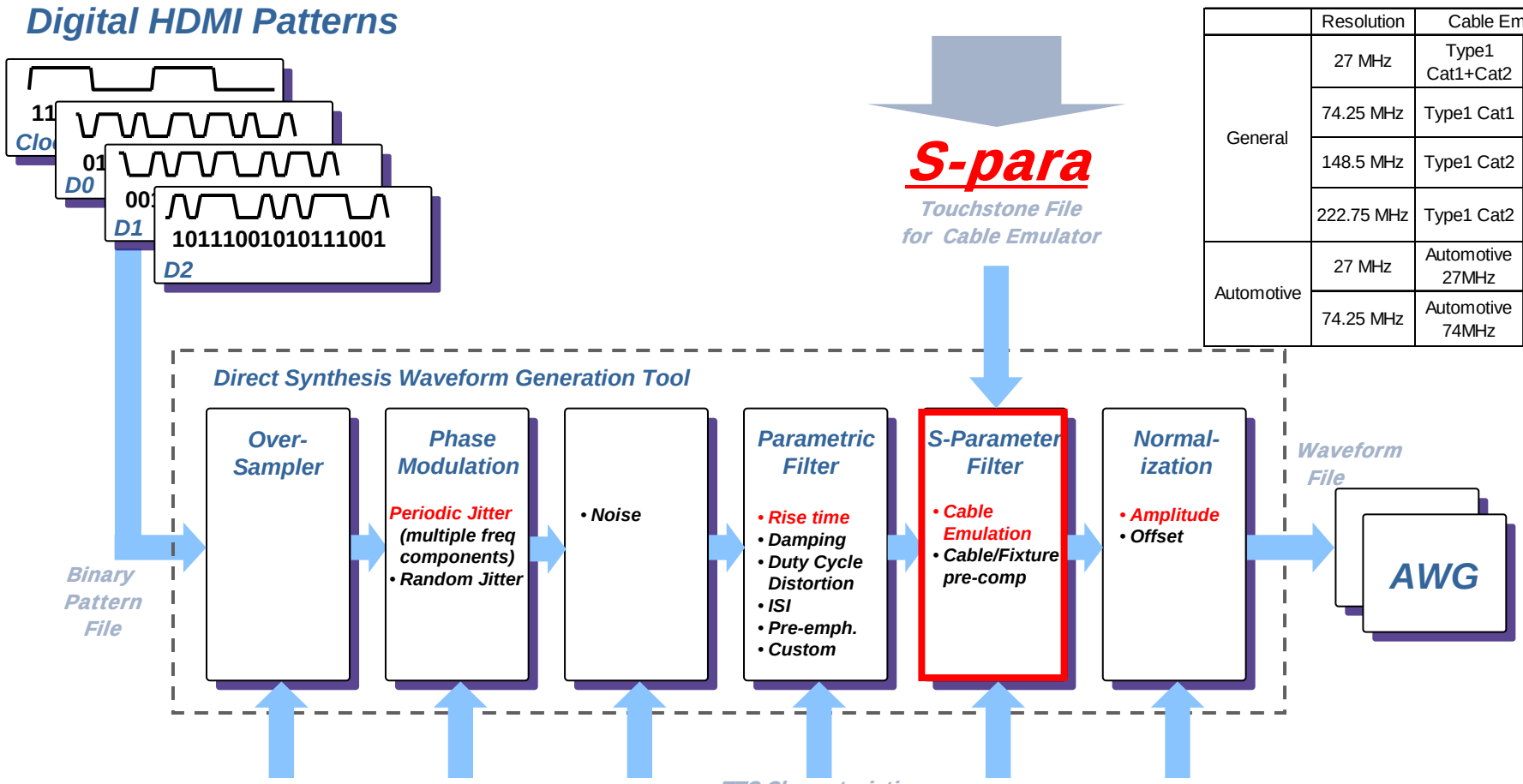
HDMI Mobile Solution – Type D

- Mobile companies will support HDMI new micro connectors (Type D)
  - Tektronix HT3 software can be reused for measurements made using Type D fixtures
- Type D Fixture will be required and is approved by HDMI standards.
  - Tektronix Provides a Type D Fixture Kit:
    - TF-HDMID-TPA-KIT

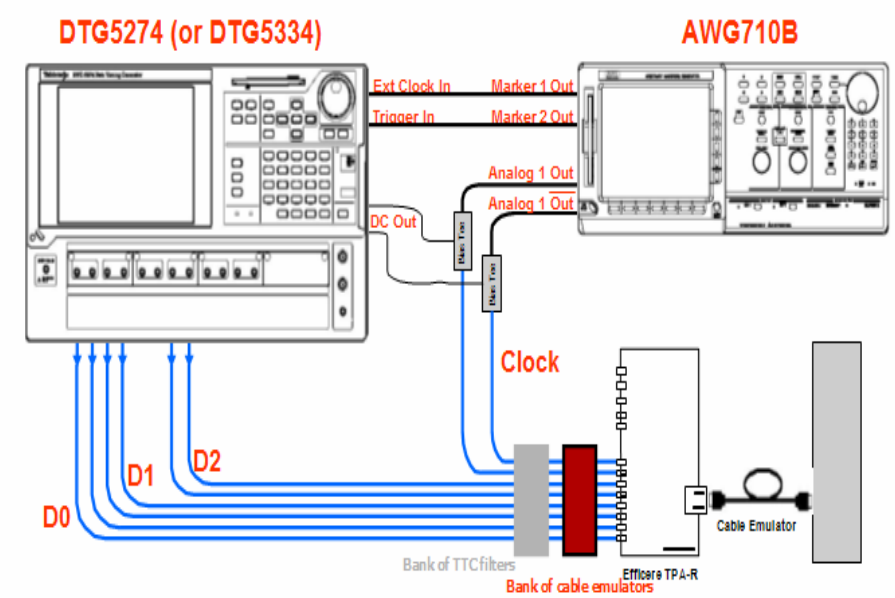
How Tektronix Supports Patt Gen for HDMI CTS v1.4

	Resolution	Cable Emulators	
General	27 MHz	Type1 Cat1+Cat2	Type2 27MHz
	74.25 MHz	Type1 Cat1	Type2 75MHz
	148.5 MHz	Type1 Cat2	Type3
	222.75 MHz	Type1 Cat2	Type3
Automotive	27 MHz	Automotive 27MHz	NA
	74.25 MHz	Automotive 74MHz	NA

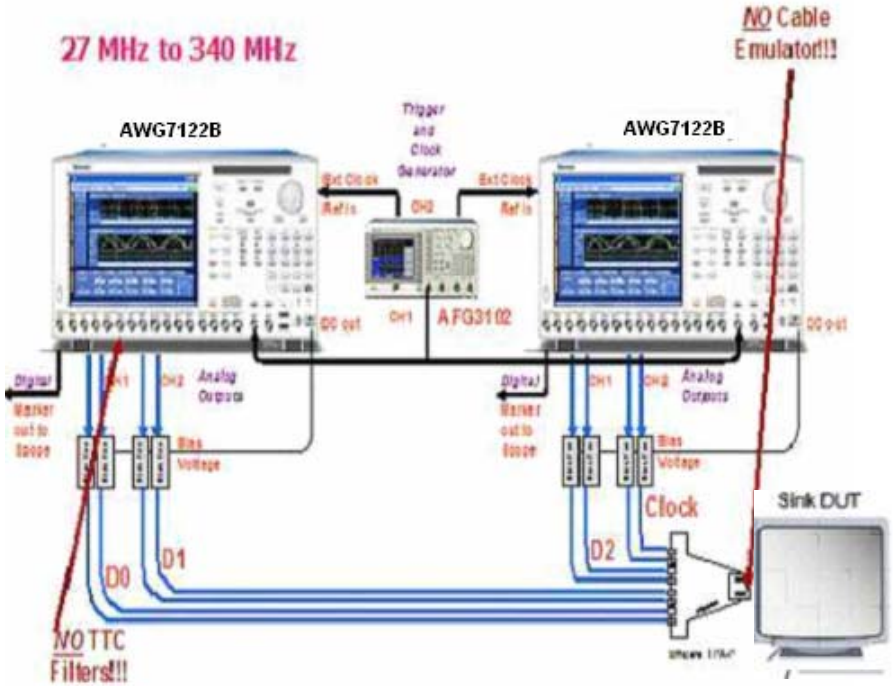


Direct Synthesis removes complexity and cost of setup

DTG Based setup with Hardware CE and TTC filters



Direct Synthesis setup without Hardware CE and TTC filters

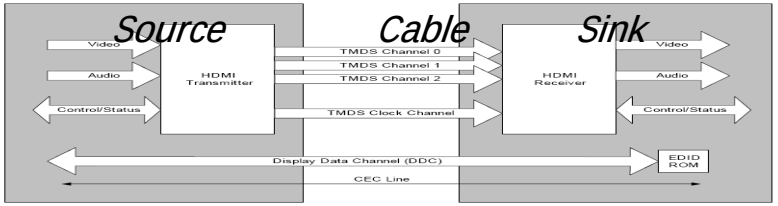


Benefits of Direct Synthesis

- Simplicity
  - Tektronix AWG7000 supports all cable emulation
  - Elimination of Hardware-based Cable Emulators and TTC (Transition Time Convertors)
  - Repeatable, easy to setup in lab
- 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
  - Test repeatability across multiple labs/locations
  - Pre-compensates waveforms to produce signals at the DUT launch point
  - Emulates any impairment the CTS requires now or in future
- Direct Synthesis method has been approved in HDMI CTS 1.4

Tektronix Brings Domain Expertise to HDMI Test

- Unequaled domain expertise
  - Providing leading HDMI test solutions since original HDMI spec introduced
  - Approved direct synthesis method offers greater repeatability as dependency on hardware TTC filters and cable emulators is eliminated.
- Portfolio of test equipment for all critical tests
  - Signal generators, real-time oscilloscopes, compliance test software, sampling oscilloscopes & probing
- Cost effectiveness & Flexibility
  - More affordable upgrade path from previous HDMI test systems
  - Flexible test configuration
- Reduction of test time
  - One-button selection of multiple tests reduces the time needed for compliance testing from days to minutes



HDMI™
HIGH-DEFINITION MULTIMEDIA INTERFACE

Additional Resources

- www.tektronix.com/hdmi
  - Recommended Test Equpment for CTS 1.3c, 1.4
  - HDMI Technology Fact Sheet for key testing highlights
  - HDMI Compliance Fact Sheet for required test support
- www.hdmi.org
  - Test Specifications, Latest update on Spec Release information
  - Plugfest/ATC resources
- www.digital-cp.com
  - High-bandwidth Digital Content Protection
- www.vesa.org
  - Video Electronics Standards Association