Validating The High-speed Interface In Your Smart Clients (USB、TBT、Displays)

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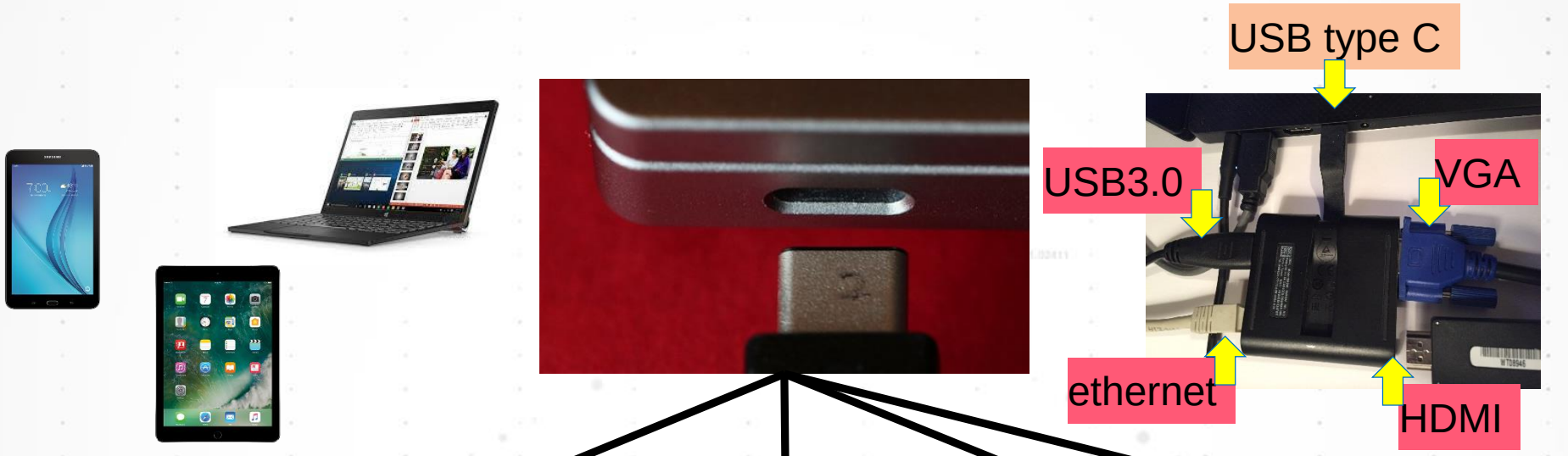
KEYSIGHT TECHNOLOGIES

Agenda

- Type-C Interface
- HDMI Market Overview
- HDMI 2.1 Architecture
- HDMI 2.1 Test Solutions

Type-C Interface

Quick View of USB Type-C Interface



USB-IF **USB3.1**

Intel **TBT3.0**

VESA **DPoC**

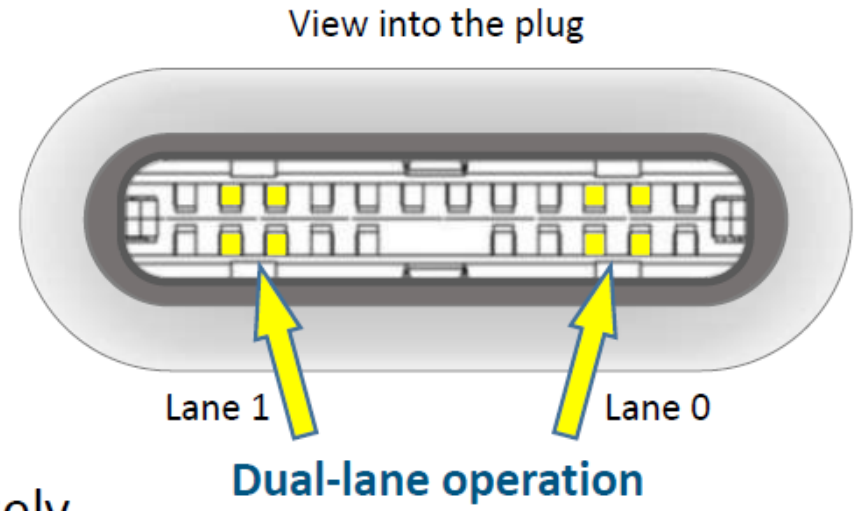
HDMI

Power Delivery Protocol (USB PD2.0/3.0)

One Lane	Two Lanes	Four Lanes
10Gbs per Lane	20Gbs per Lane	8 Gbs per Lane

Introducing USB 3.2 – up to 20Gbps

- Enables SuperSpeed USB to fully utilize USB Type-C cable plug/wires
  - **Doubles performance** with dual-lane operation
  - Same signaling rates (5 Gbps / 10 Gbps) and encoding allows **use of existing cables**
- USB 3.2 supersedes USB 3.1
  - USB 3.2 single-lane operation equates to USB 3.1
  - USB 3.1 Legacy Cable and Connector specifications extracted and published separately



Note: Related branding, certification logos and icons will be announced when available

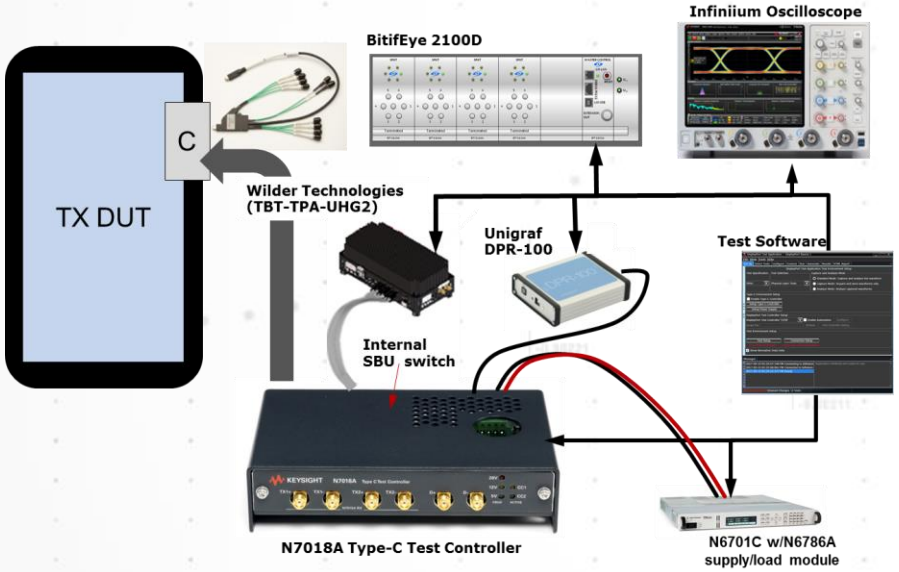
Introducing USB 3.2 – up to 20Gbps

- USB 3.2 updates focus on link layer definition of USB as needed to establish the x2 operation
  - PHY design reuse was a high priority – both 5 Gbps and 10 Gbps rates supported
  - Minimal impact to the other layers – Protocol, Framework, Hub, etc.
    - Significant buffer size impact to Hub implementations
  - x2 operation only applies to USB Type-C cables and connectors
  - Just works with existing software (OS/drivers)
- Beyond doubling bandwidth through lane bonding, the solution targeted maintaining parity with regard to USB 3.1 error performance, channel and power efficiency

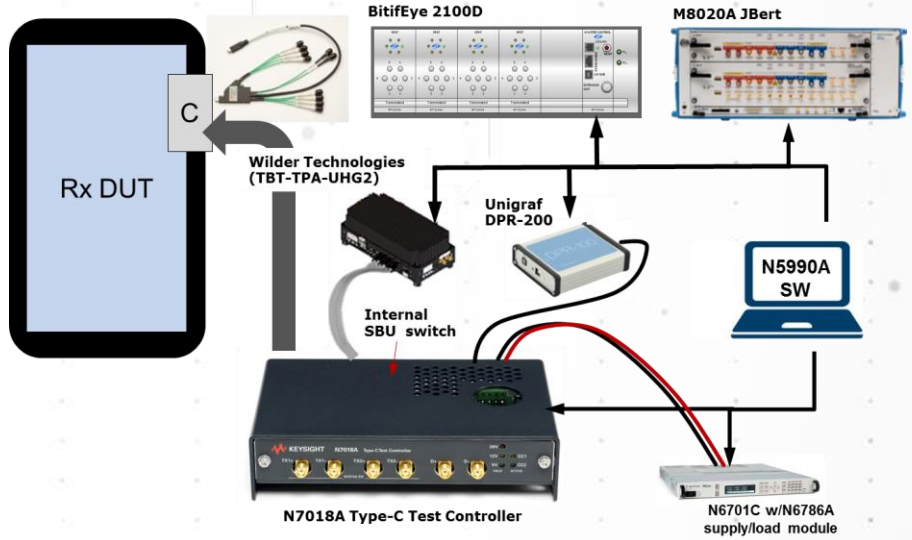
Type-C Solutions

COMPLETE AUTOMATION OF TYPE-C PRODUCTS

Source testing



Sink testing



Coming Soon…

USB4.0

TBT4.0

HDMI Market Overview

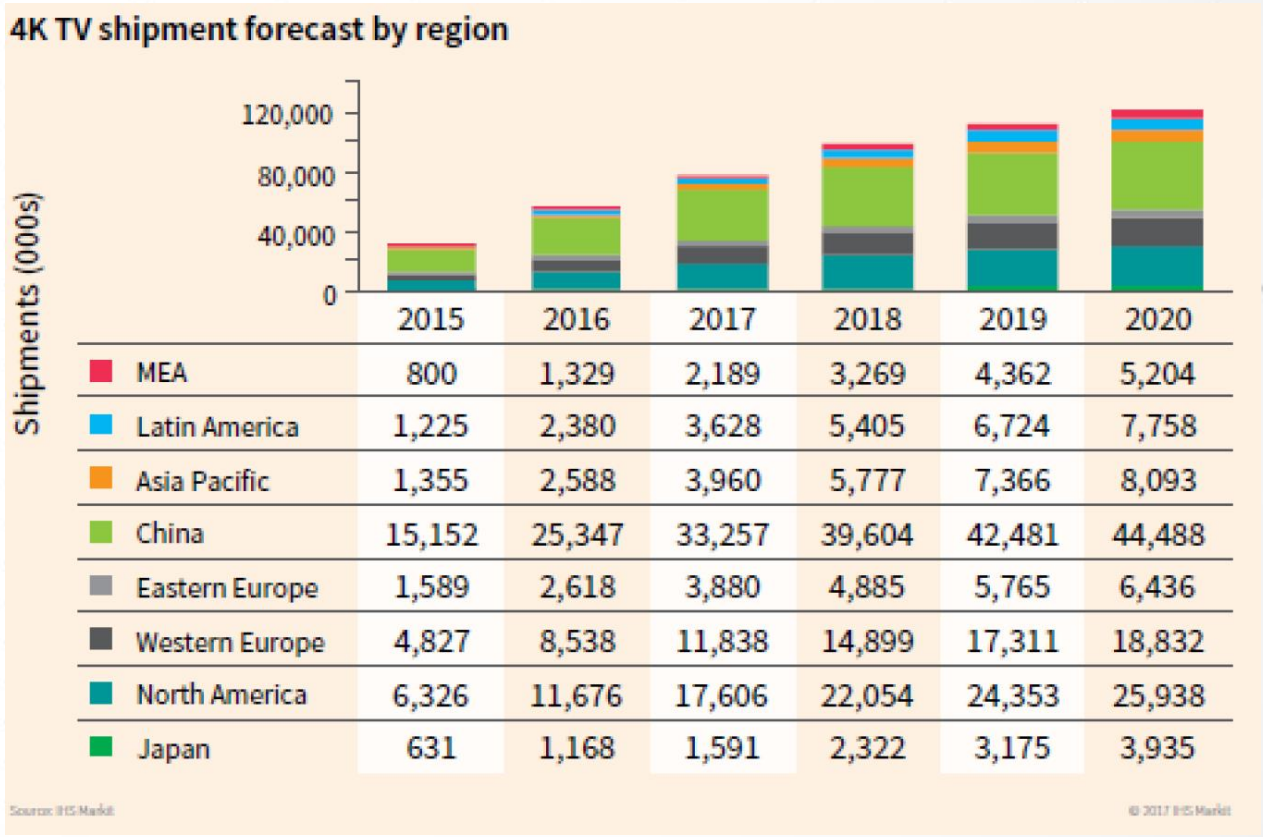
HDMI Technology Market Position

- Almost 900 million HDMI-enabled devices shipped in 2017.
- Installed base of over 7 Billion HDMI products have shipped worldwide.
- 1,800 of the world's largest consumer electronics, PC and mobile device manufacturers include HDMI connectivity in their products.

Source : IHS market

4K TVs Continue Market Growth

- 4K TV shipments continue to increase taking over the mid-price and getting deeper into the lower tier segments.
- In 2018, 4K UHD TVs are expected to reach over 40% of total shipments worldwide and forecast to reach almost 50% in 2020.

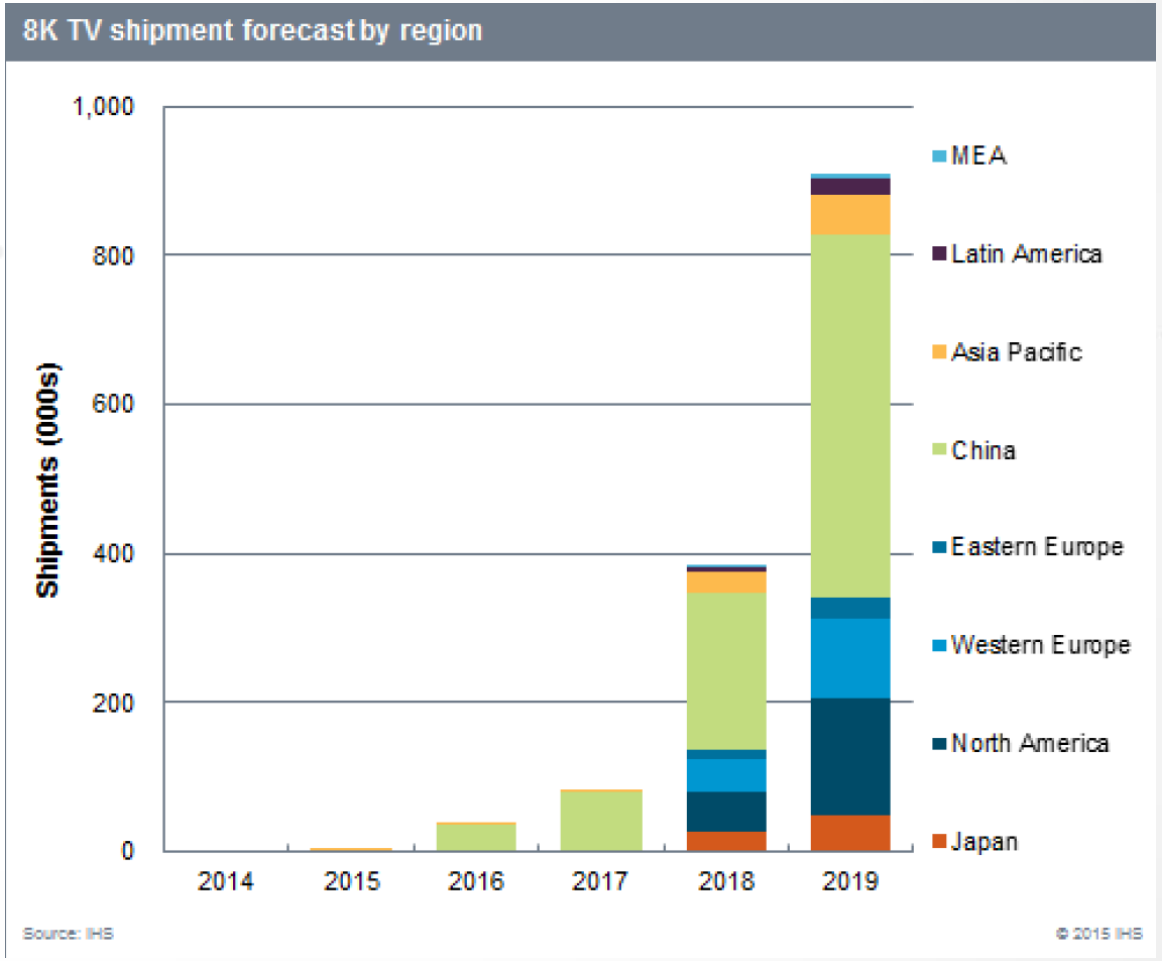


	2015	2016	2017	2018	2019	2020
MEA	800	1,329	2,189	3,269	4,362	5,204
Latin America	1,225	2,380	3,628	5,405	6,724	7,758
Asia Pacific	1,355	2,588	3,960	5,777	7,366	8,093
China	15,152	25,347	33,257	39,604	42,481	44,488
Eastern Europe	1,589	2,618	3,880	4,885	5,765	6,436
Western Europe	4,827	8,538	11,838	14,899	17,311	18,832
North America	6,326	11,676	17,606	22,054	24,353	25,938
Japan	631	1,168	1,591	2,322	3,175	3,935

Source : IHS market

8K TV Shipments Forecast for Strong Growth

- Tokyo Olympics in 2020 and Beijing Winter Olympics in 2022 to be broadcast in 8K.
- Even before there is 8K content, 8K TV shipments are projected to grow rapidly with China leading the way.
- Most major panel makers have added 8K resolution to their immediate product road maps.



Source : IHS market

Beyond Resolution

MORE DRIVERS FOR NEW PRODUCT DEVELOPEMENT

- Virtual Reality and Augmented Reality driving resolution and faster frame rates.
- Drone cameras adopting the higher resolutions and faster frame rates.
- Automotive entertainment systems enabling more connected device integration.
- Smoother, faster, no-lag, no-latency and blackout-free overall experiences with **Variable Refresh Rate** for gaming, **Quick Media Switching**, **Quick Frame Transport**, and **Auto Low Latency Mode** for Movies, TV and personal content.
- Dynamic HDR is the next leap in video quality.
- Easier-to-connect and better audio quality with **eARC**.

HDMI 2.1 Architecture

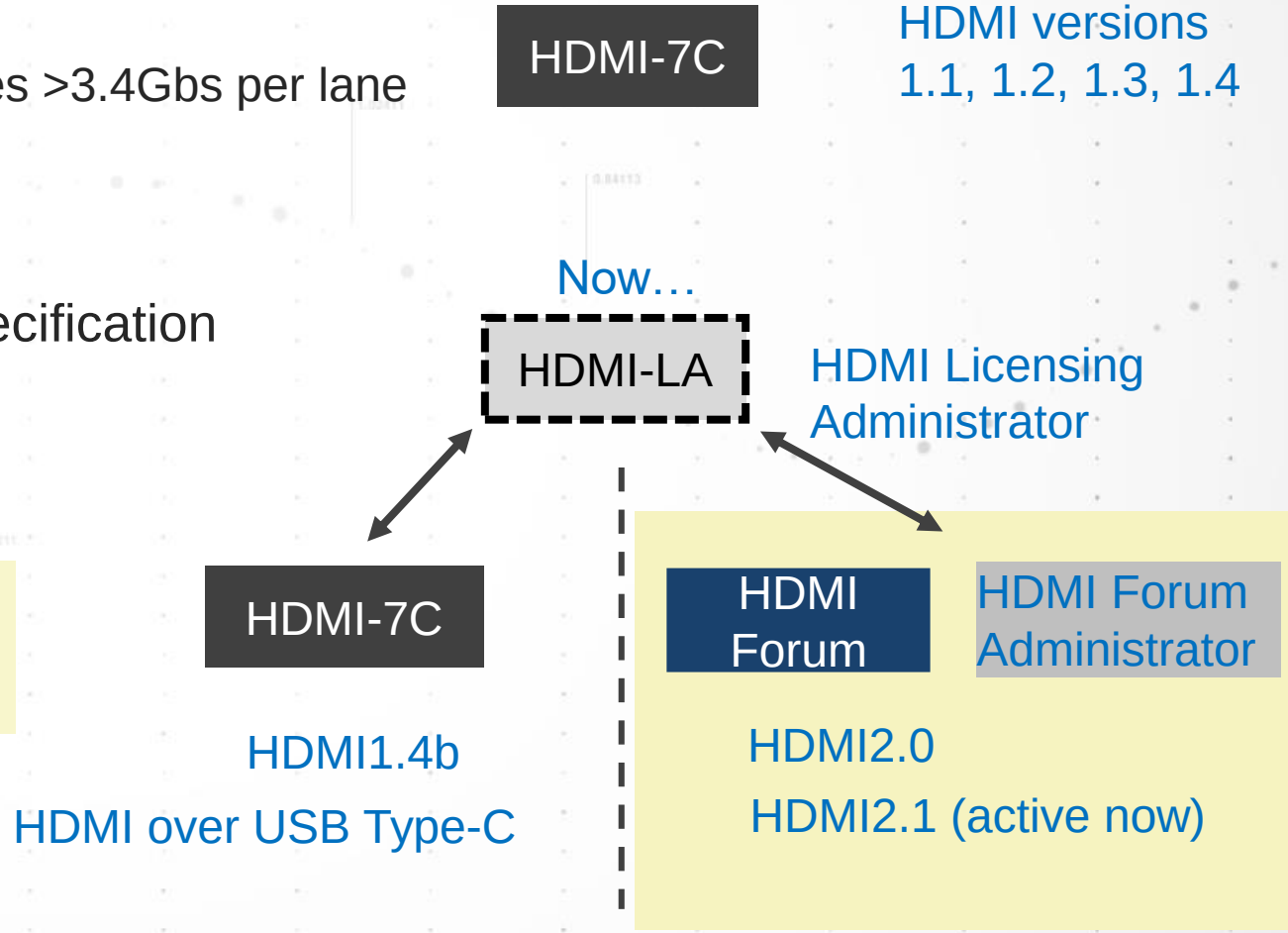
HDMI Organizational Structure

- **HDMI LLC** is responsible **up to HDMI 1.4b**
  - Ruled by “7C” (7 founding companies)
  - No open industry participation in the definition of the Spec
  - CTS (Compliance Test Spec) includes vendor-specific test procedures

- **HDMI Forum** is responsible for **HDMI 2.0 and later**
  - Open industry consortium with 80+ members,1000+ Adopters
  - Keysight is a member of the Technical Working Group and Test Subgroup
  - Keysight was recently elected into Board of Directors
  - Generic CTS describes vendor independent test procedures
  - MOI (method of implementation) is created by each T&M vendor
  - MOIs of all T&M vendors are linked in the CTS document available to Adopters

HDMI Organizational Structure

- HDMI owned by the 7C
  (Thompson, Hitachi, Silicon Image, Panasonic, Philips, Toshiba, Sony)
- In 2011 the HDMI Forum was created
  - Charter: responsible for future of HDMI for rates >3.4Gbs per lane
  - HDMI 7C owns HDMI1.4, HDMI LA is formed.
- 2013 HDMI Forum Rolls out HDMI2.0
- 2017 HDMI Forum Introduces HDMI2.1 Specification



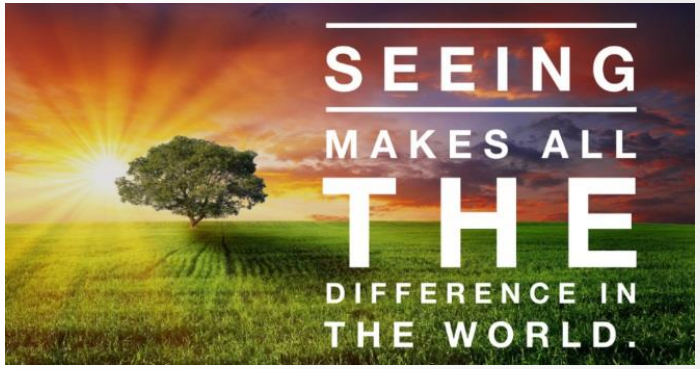
HDMI2.1 products inherit HDMI 1.4b functionality. HDMI over USB Type-C is NOT part of HDMI 2.x functionality

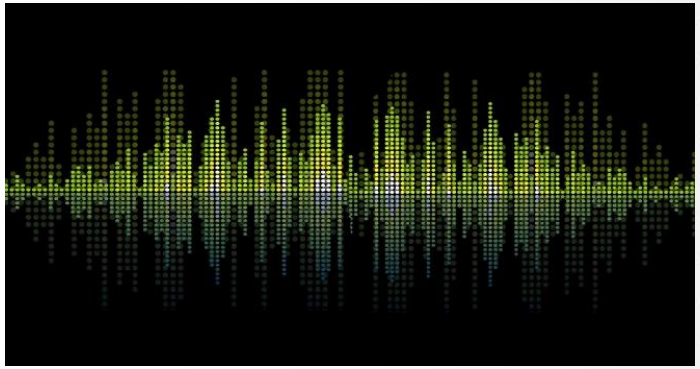
HDMI Feature Support Table

	HDMI version						
	1	1.1	1.2–1.2a	1.3–1.3a	1.4–1.4b	2.0–2.0b	2.1
Full HD Blu-ray Disc and HD DVD video	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consumer Electronic Control (CEC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DVD-Audio	No	Yes	Yes	Yes	Yes	Yes	Yes
Super Audio CD (DSD)	No	No	Yes	Yes	Yes	Yes	Yes
Auto lip-sync	No	No	No	Yes	Yes	Yes	Yes
Dolby TrueHD / DTS-HD Master Audio bitstream capable	No	No	No	Yes	Yes	Yes	Yes
Updated list of CEC commands	No	No	No	Yes	Yes	Yes	Yes
3D video	No	No	No	No	Yes	Yes	Yes
Ethernet channel (100 Mbit/s)	No	No	No	No	Yes	Yes	Yes
Audio return channel (ARC)	No	No	No	No	Yes	Yes	Yes
4 audio streams	No	No	No	No	No	Yes	Yes
2 video streams (Dual View)	No	No	No	No	No	Yes	Yes
Hybrid Log-Gamma (HLG) HDR OETF	No	No	No	No	No	Yes	Yes
Static HDR (HDR static metadata)	No	No	No	No	No	Yes	Yes
Dynamic HDR (HDR dynamic metadata)	No	No	No	No	No	No	Yes
Enhanced Audio Return Channel (eARC)	No	No	No	No	No	No	Yes
Variable Refresh Rate (VRR)	No	No	No	No	No	No	Yes
Quick Media Switching (QMS)	No	No	No	No	No	No	Yes
Quick Frame Transport (QFT)	No	No	No	No	No	No	Yes
Auto Low Latency Mode (ALLM)	No	No	No	No	No	No	Yes
VESA DSC 1.2a	No	No	No	No	No	No	Yes
	1	1.1	1.2–1.2a	1.3–1.3a	1.4–1.4b	2.0–2.0b	2.1
	HDMI version						

HDMI 2.1

TECHNOLOGY





- Two major phy layer changes from HDMI 2.1:

➢ FRL (fixed rate link): New high speed encoding scheme: can operate with 3 or 4 lanes from 3Gbs per lane to 12Gbs per lane for a maximum composite bit rate of 48Gbs. It is encoded as 16b/18b which increases video data throughput 12% over 8b/10b method.

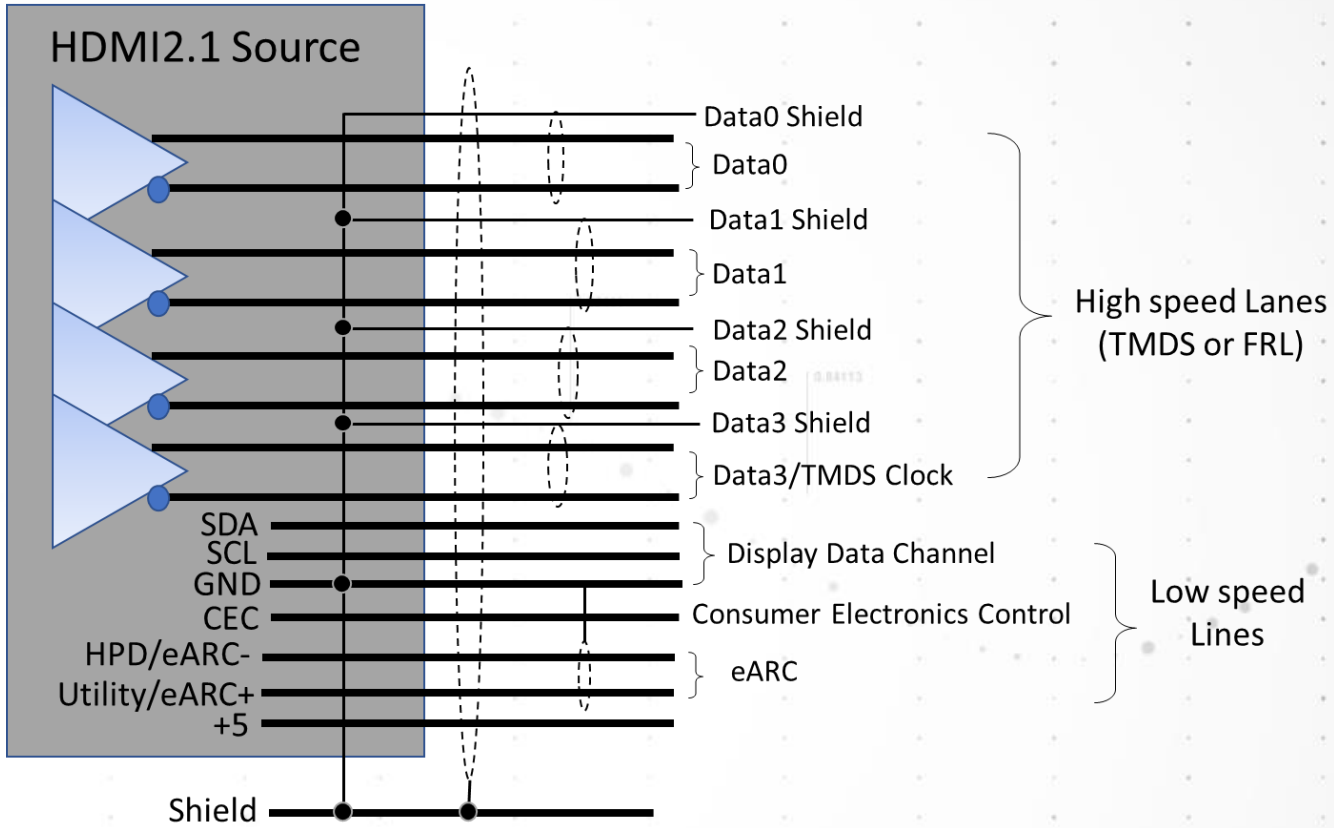
➢ eARC (enhanced Audio Return Channel): improves to differential audio information over single ended, use of spec IEC61937, with common mode discovery management for both TX and RX.

Disruptions:

1. 20 GHz bandwidth required for TX measurement
2. FRL testing of sinks no longer requires image data
3. Cable performance demanded ends ‘wild west’ of cable performance

HDMI 2.1 Interface

HDMI Interface
-High speed lanes to be measured
-Low speed lanes for control and status



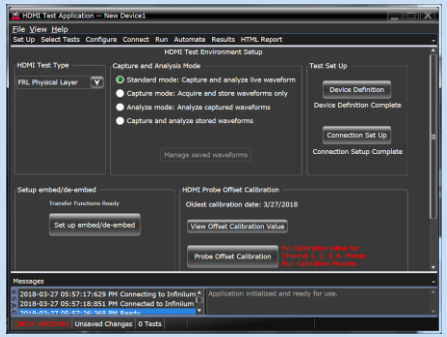
HDMI 2.0 no longer exists. It is referred to as ‘HDMI2.1 TMDS’.
HDMI 2.1 Fixed Rate Link (FRL) now operates 3, 6, 8, 10, 12Gbs and supports 3 & 4 lane operation at 3 and 6Gbs and 4 lane operation for 8, 10, 12Gbs.
FRL encoding is 16b/18b.
~3x composite data rate over HDMI2.0… 14.26Gbs vs 42.66Gbs

HDMI 2.1 Test Solutions

Keysight HDMI 2.1 Compliance Solutions

Source Phy Layer

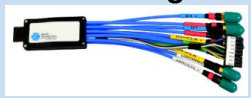
V, Z and UXR Series Oscilloscopes



N5399E Compliance Software

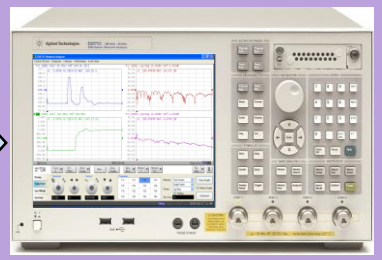
EDID/SCDC Controller

HDMI Plug TPA



Category 3 Cable and Connector Test

Setup Files



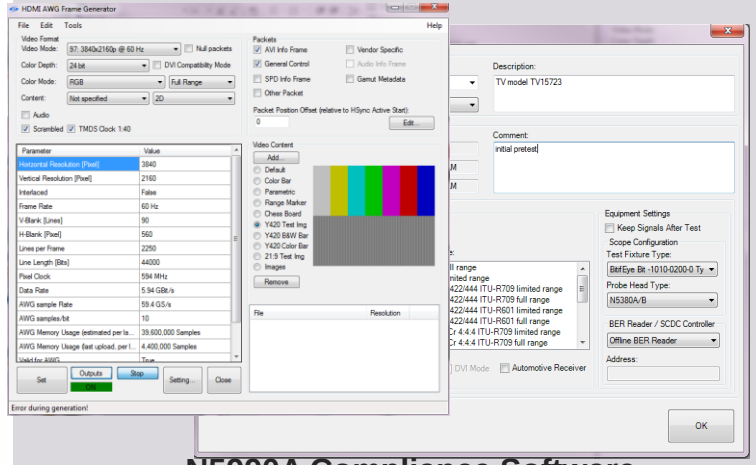
E5071C 4 port Vector Network Analyzer

M937x PXI Vector Network Analyzer

HDMI Receptacle TPAs

Sink Phy Layer

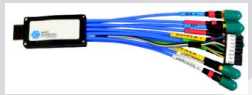
M8195A AWG



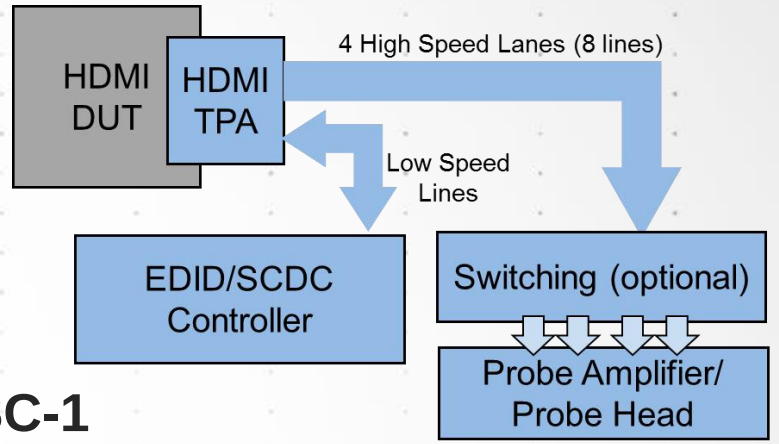
N5990A Compliance Software

EDID/SCDC Controller

HDMI Plug TPA

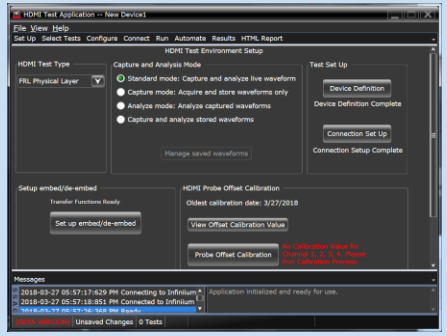


HDMI 2.1 Transmitter Compliance



Source Phy Layer

V, Z and UXR Series Oscilloscopes

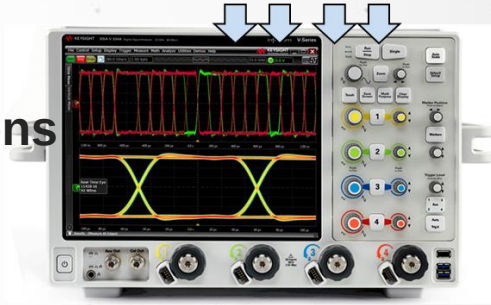


N5399E Compliance Software

EDID/SCDC Controller

HDMI Plug TPA

- TPA: Wilder, Bitifeye, or Luxshare
- EDID/SCDC Controller: Allion AJSC-1
- Probes:
  - N7010A: low cost/low noise, SE only, reconnections
  - N7003A: single-connection FRL testing
- Switching for full automation optional
  - Bitifeye 2100D Platform
  - Precision Probe used to compensate loss and skew
  - Two configurations supported
- Post Processing on both scope and Infiniium Offline (on PC) to increase productivity of oscilloscope.
- MOIs under review (*8/07/2018*)



Four Channel scope

HDMI 2.1 FRL Source Testing

HFR1-1 to HFR1-9

HFR means:

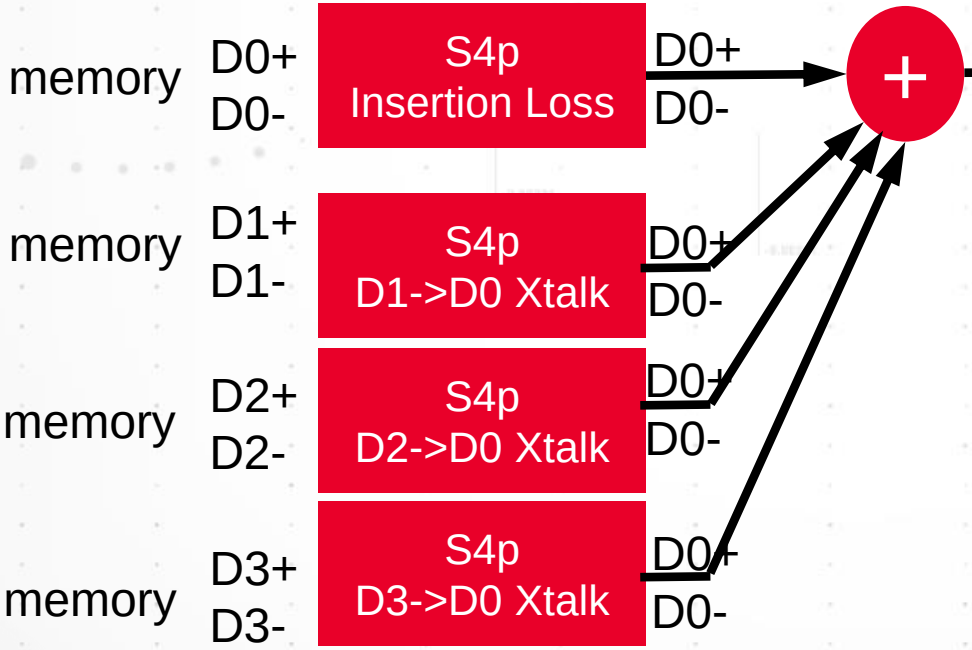
HDMI Fixed Rate

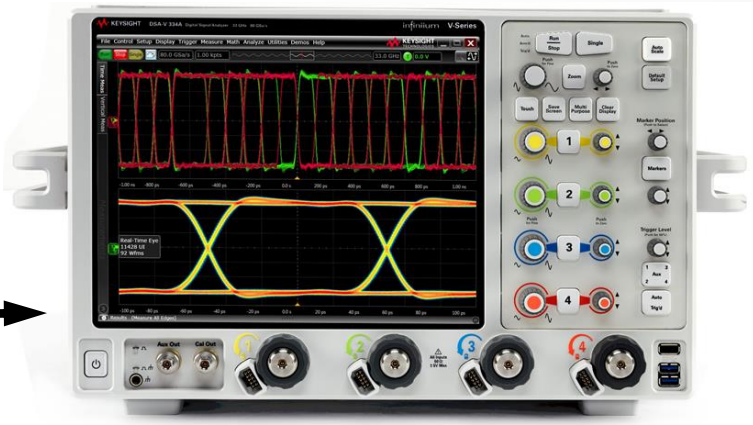
Test ID	Test ID Description	Comments
HFR1-1	DC Common Mode	Average DC value single ended
HFR1-2	Vse_Max, Vse_Min	High and Low voltages averaged over a number of bits.
HFR1-3	Rise/Fall time measurement	Edge rate not to be lower than 22.5ps
HFR1-4	Inter-pair skew measurement D3/D0 (meas)	1. Lane skew from D3 to D0
HFR1-4	Inter-pair skew measurement D1/D2 (meas)	2. Lane skew from D1 to D2
HFR1-4	Inter-pair skew measurement D0/D1 (meas)	3. Lane skew from D0 to D1
HFR1-4	Inter-pair skew measurement D0/D2 (calc)	Calculated from #2 and #3 above
HFR1-4	Inter-pair skew measurement D3/D2 (calc)	Calculated from #1, #2 and #3 above
HFR1-4	Inter-pair skew measurement D3/D1 (calc)	Calculated from #1 and #3 above
HFR1-5	Data FRL Rates	Frequency accuracy of highest and lowest available data rate
HFR1-6	RJ Measurement	RJ measurement using a clock pattern used in eye diagram
HFR1-7	Category 3 Worst Cable Model (WCM3) Eye measurement	TP2Eq measurement using cable model and RJ from HFR1-6 extrapolated from 1E-6 to 1E-10
HFR1-7	Category 3 Short Cable Model (SCM3) Eye measurement	TP2Eq measurement using cable model and RJ from HFR1-6 extrapolated from 1E-6 to 1E-10
HFR1-8	AC Common Mode Noise (Similar to VH/VL)	Peak to peak ac common mode per lane
HFR1-8	DC Differential Swing Voltage (VH/VL to measure Vswing)	Swing from VL to VH
HFR1-9	FFE attributes (pre-emphasis levels)	FFE parameters as defined in Section 6

HDMI 2.1 Source Eye Diagram Test

Testing for Eye diagram and jitter includes crosstalk of other data lanes as manifest in the cable model we use for HDMI 2.1: WCM3 (worst case) and SCM3 (short)

Process:
Acquire and store D0, D1, D2, D3 waveforms.
Render D0 TP2 eye:
D0&cable s4pD0->D0 + D1& xtalk s4p D1->D0 +
D2& xtalk s4pD2->D0 +D3& xtalk s4pD3->D0



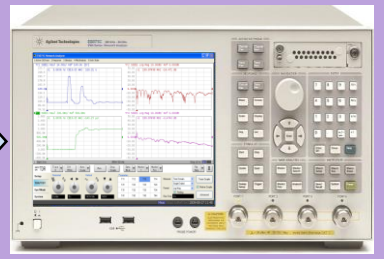


With exception of Inter-pair skew, FRL is tested one lane at a time.

HDMI 2.1 Category 3 Cable and Connector Compliance

Category 3 Cable and Connector Test

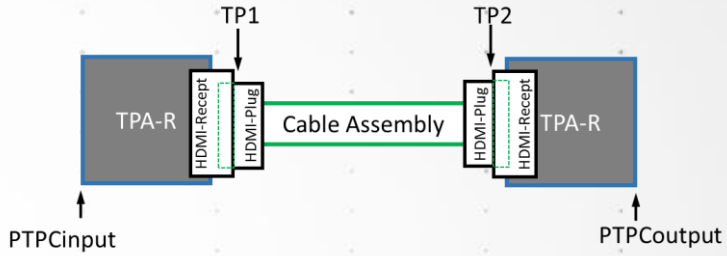
Setup Files



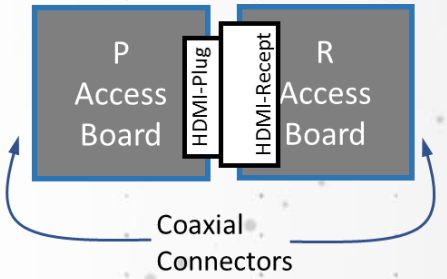
E5071C 4 port Vector Network Analyzer

M937x PXI Vector Network Analyzer

HDMI Receptacle TPAs



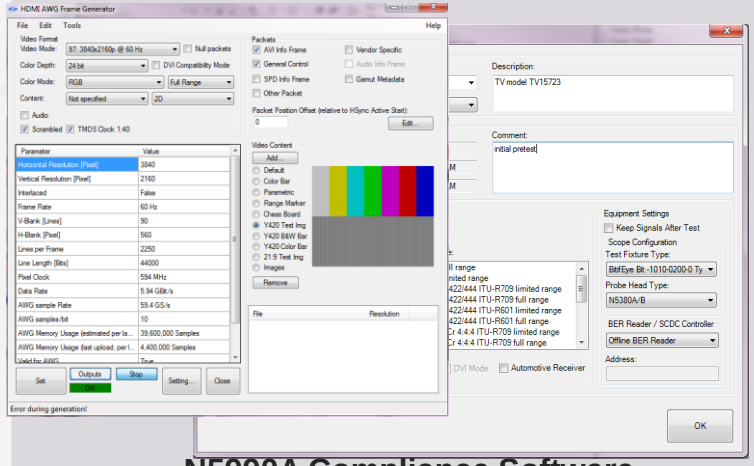
- TPAs: Luxshare, Bitifeye, Wilder
- Vector Network Analyzers
  - Industry Standard E5071C (4 port connection)
    - Cable test time: 90 minutes
  - M937X PXI Modular (16 port connection)
    - Cable test time: 15 minutes
  - E-cal Module N4433A for quick, accurate calibrations
  - Approved MOIs and VNA setup files



HDMI 2.1 Sink Compliance

Sink Phy Layer

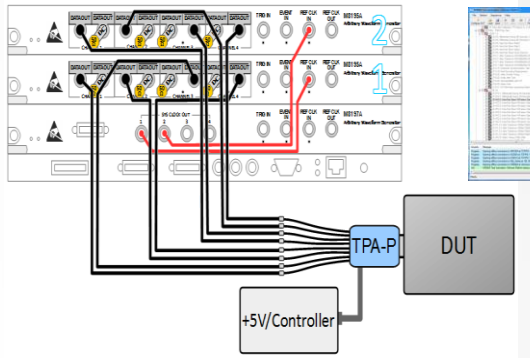
M8195A AWG



N5990A Compliance Software

EDID/SCDC Controller

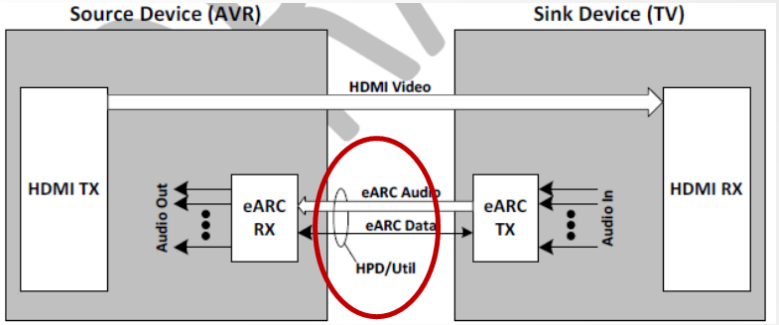
HDMI Plug TPA



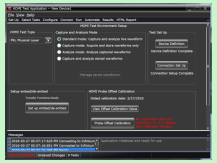
DUT Connection

- TPA: Wilder, Bitifeye, or Luxshare
- EDID/SCDC Controller: Allion AJSC-1
- Full HDMI2.1 TMDS and FRL Support
- Character Error Detection for FRL, Video Inspection for TMDS
- M8195A with precision intra-pair skew settability.
- N5990A software (upgrade from HDMI 2.0 available)
- Calibration with V, Z or UXR series Infiniium Oscilloscopes
  - Probes:
    - N7010A: low cost/low noise, SE only function
    - N7003A/N2801A probe amplifiers with N5444A probe head

eARC: enhanced Audio Return Channel



eARC Phy Layer

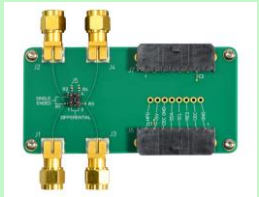


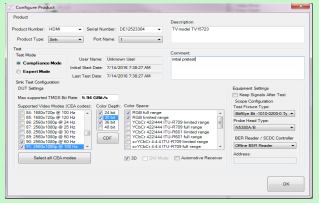
N5399E/F Compliance Software

DSGA from Bitifeye

S, V, Z and UXR Series Oscilloscopes

81160A function generator for differential signal





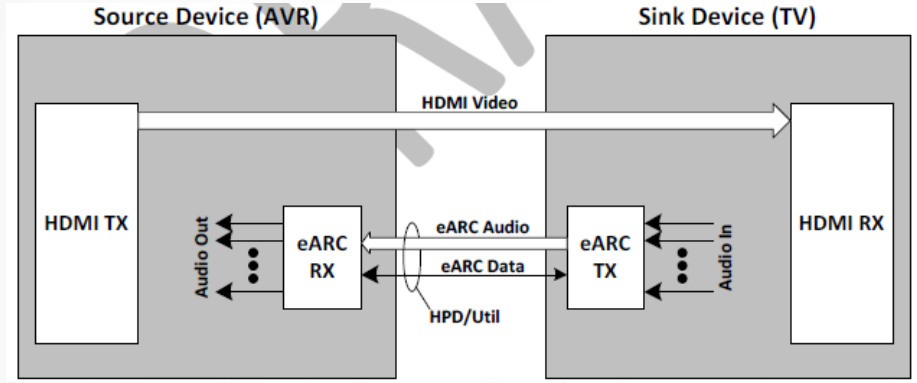
N5990A -351, -352 Compliance Software

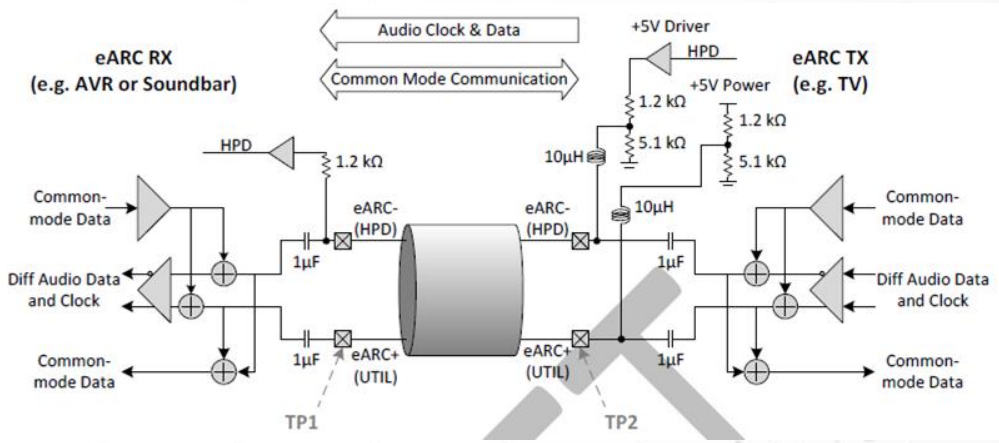
Test Point Access Fixtures

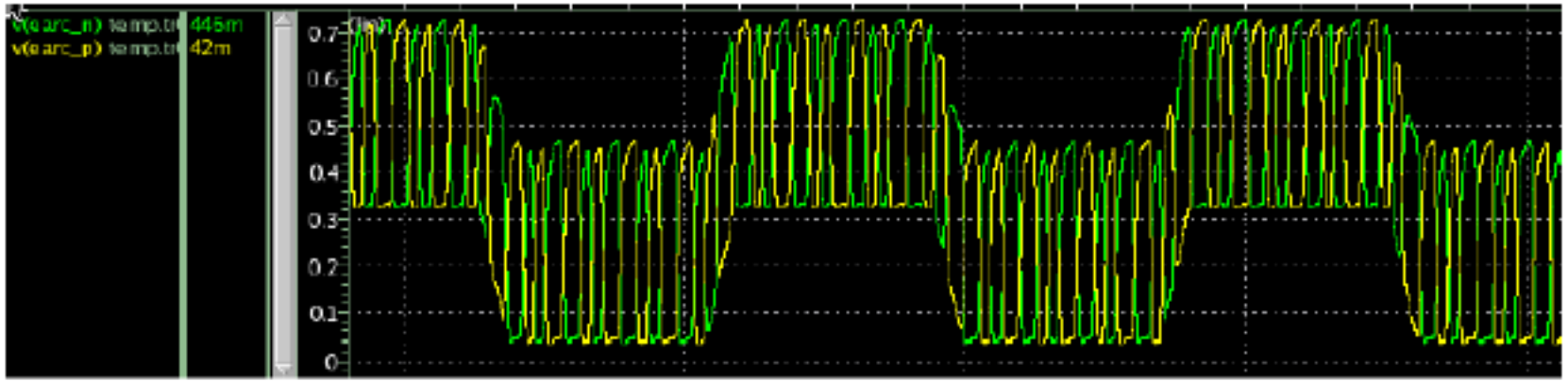
- TPA: Bitifeye
- Link Partner emulation with DSGA
- Probes:
  - E2678B with InfiniiMaxII amplifiers
- Two eARC software configurations:
  - RX and TX
  - RX only
- Scope measurement controlled by N5990A only
  - Requires N5399E-1FP or N5399F-1FP
- MOIs approved

eARC Common Mode Communication

2MBPS BI-PHASE MARK ENCODED COMMON MODE SIGNAL

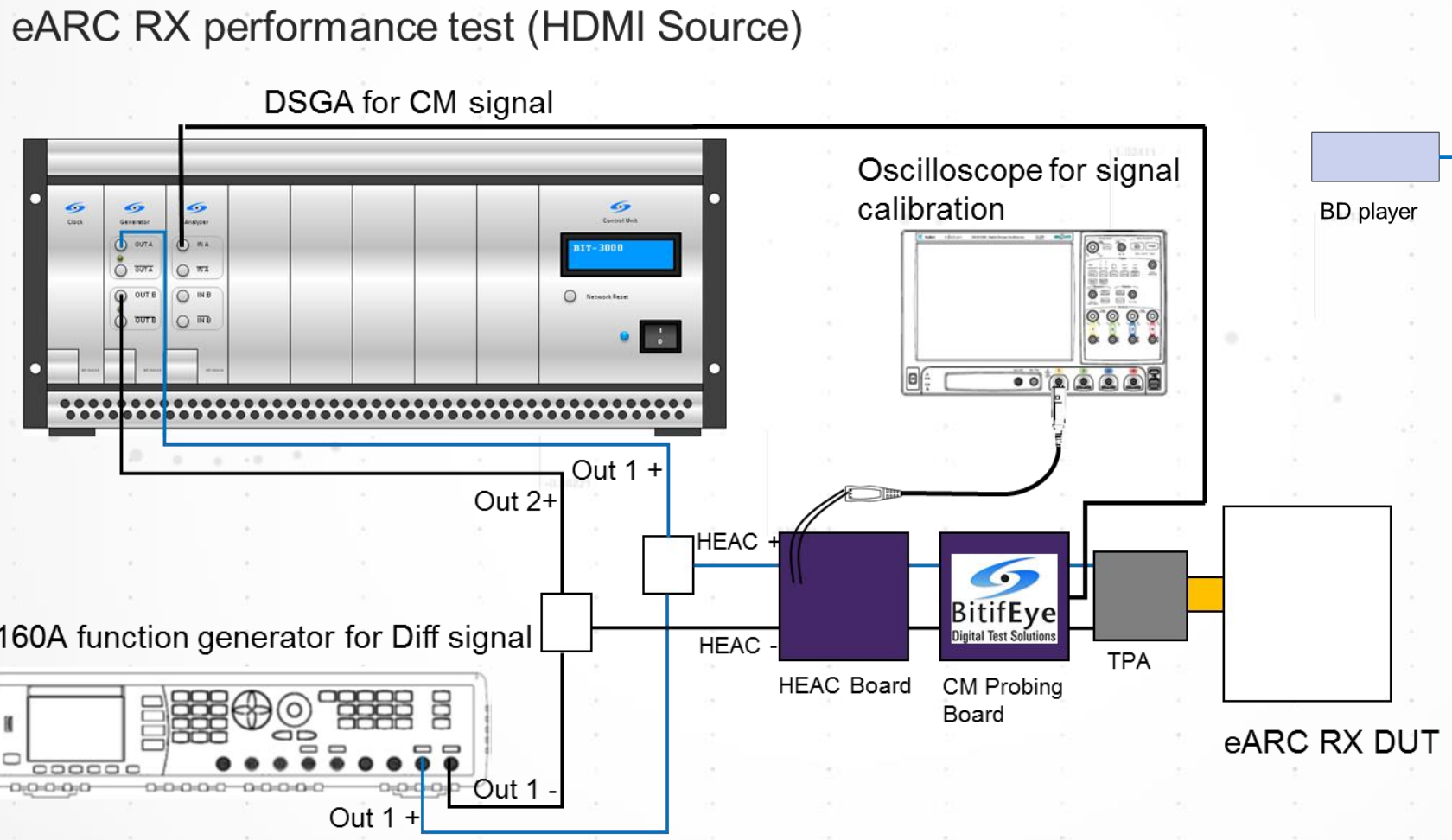


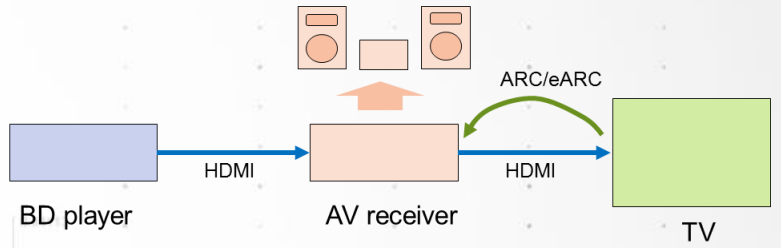




eARC Rx Test

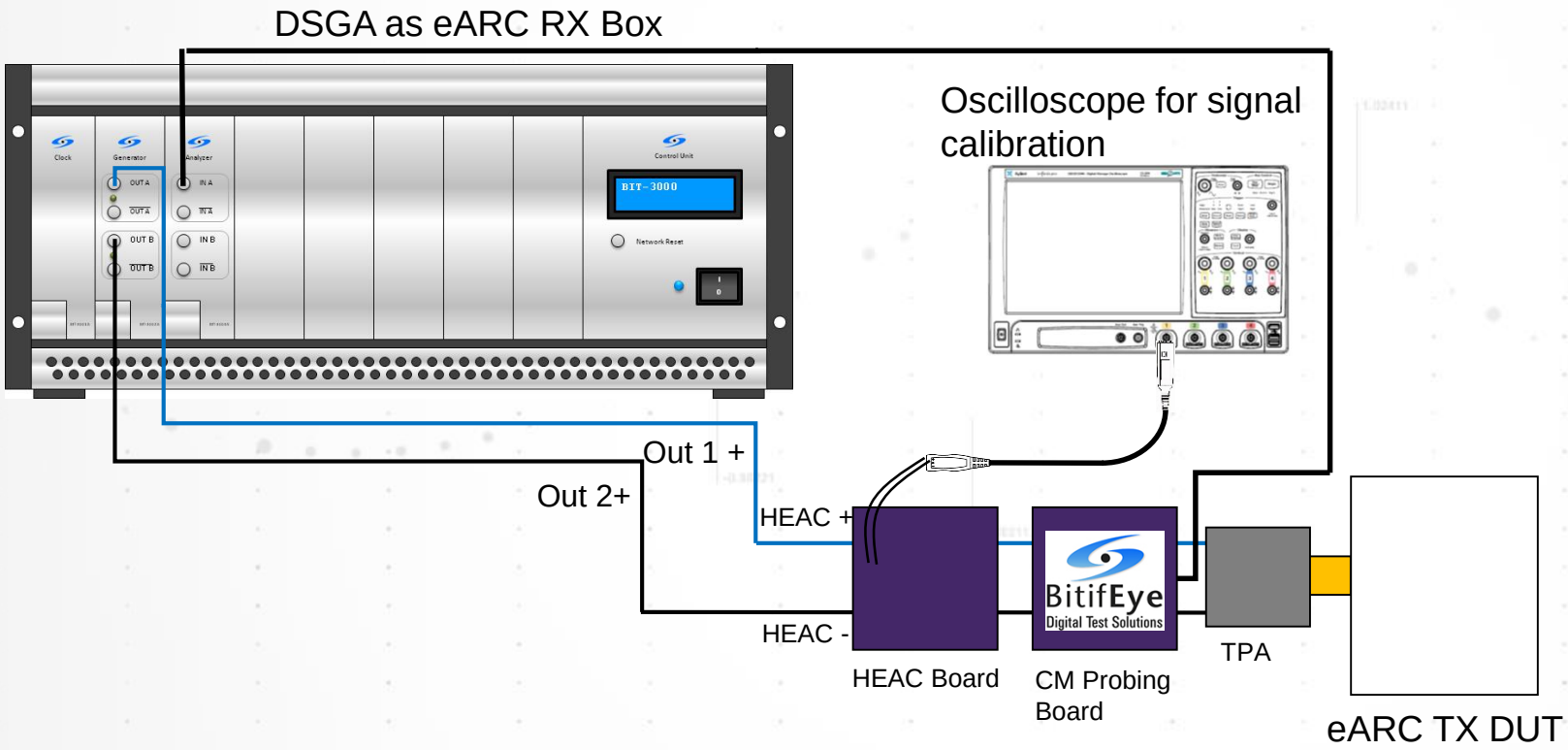
EXAMPLE CONNECTION DIAGRAM

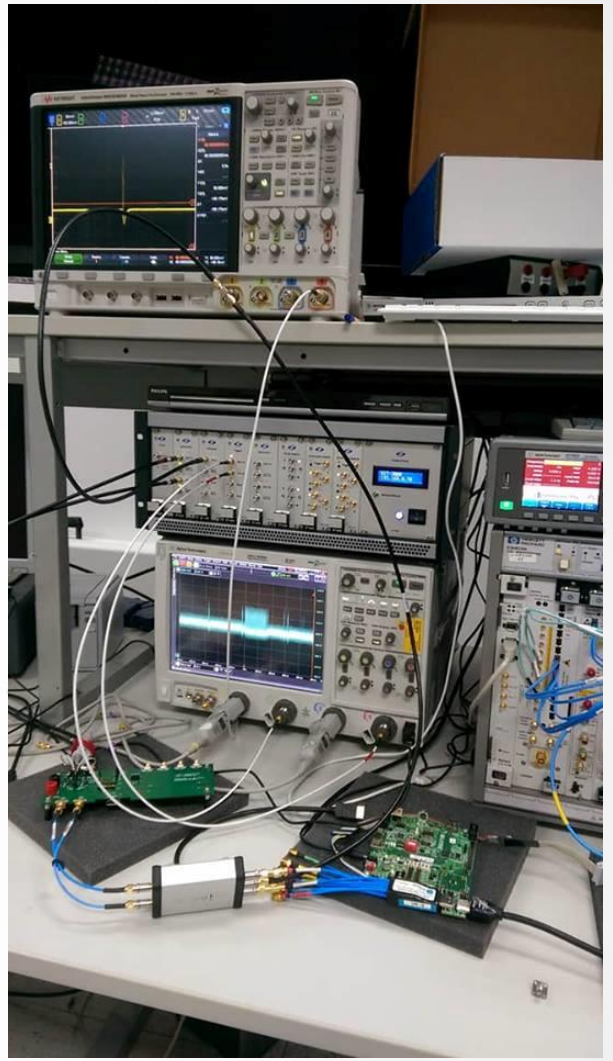




eARC Tx Test

EXAMPLE CONNECTION DIAGRAM





eARC TX performance test (HDMI Sink)

Note: for some test, the Simplay Labs SL-870 is required as eARC RX

Questions

Q AND A SECTION