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The latest HDMI Cable/Connector Test Update

Granite River Labs
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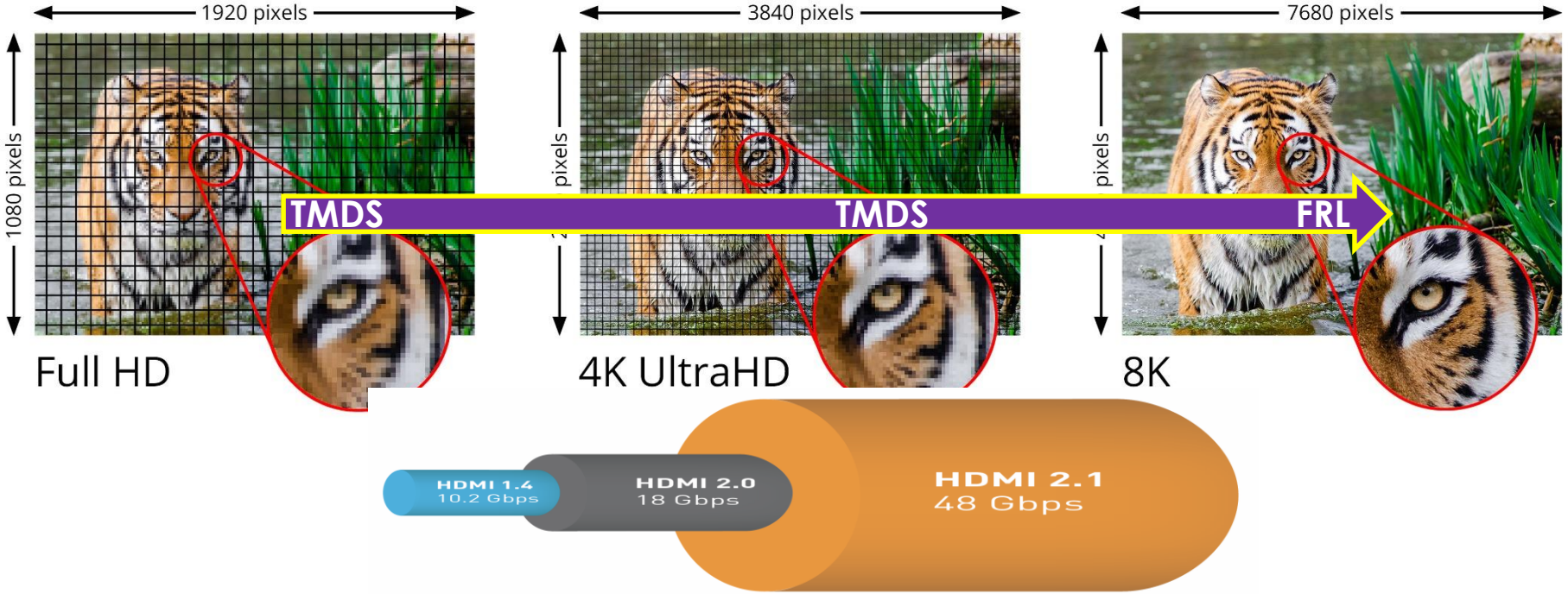
Agenda

- **HDMI 2.1 Introduction**
- **The latest HDMI Cable/Connector Test**
- **HDMI Cable Measurement Case Study**
- **Q&A**

HDMI 2.1 Introduction

Details of Tiger Eye – Why HDMI 2.1



→Demand on CE/IT, Multimedia, Gaming and Virtual Reality application.
→8K streaming displays for the Japan Olympics in 2020.

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图片来源：https://www.hdmi.org/press/press_kit.aspx

HDMI 2.1 Features – Released on November 29, 2017

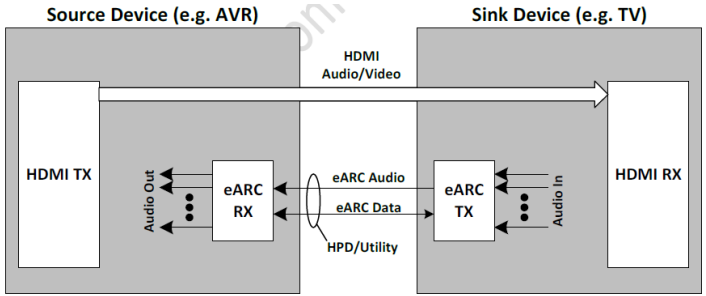
- 8K@60Hz and 4k@120Hz for immersive viewing and smooth fast-action detail.
- Resolution to 10K supports for commercial AV and industrial and specialty usages.
- Dynamic HDR ensures every moment of a video is displayed at its ideal values for depth, detail, brightness, contrast and wider color gamuts, on a scene by scene or even frame by frame basis.
- Ultra High speed HDMI cable supports the 48G BW for uncompressed display.
- eARC supports the most advanced audio formats and highest audio quality.
- Other enhanced features:
  - Enhanced refresh rate
    - Variable Refresh Rate(VRR)
    - Quick Media Switch(QMS)
    - Quick Frame Transport(QFT)
  - Auto Low Latency Mode(ALLM)

HDMI 2.1 Features – Released on November 29, 2017

- Fixed Rate Link(FRL) : New high speed encoding scheme which can operate with 3 or 4 lanes from 3Gbs/per lane to 12 Gbs/ 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.

Rate per Lane	Number of Lanes
3 Gbps	3
6 Gbps	3
6 Gbps	4
8 Gbps	4
10 Gbps	4
12 Gbps	4

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



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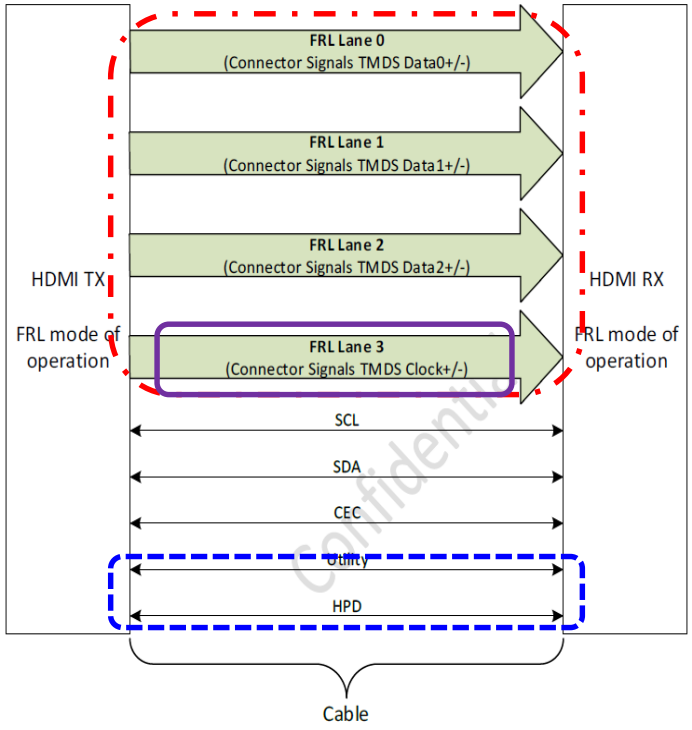
HDMI 2.1 FRL Overview

- Composite bit rate 9Gbs to 48Gbs
- Reference Equalizer used → 12Gbs: CTLE (8 models) + DFE; 3-10Gbs: CTLE (2 models)
- 16b/18b coding
- TMDS clock pair becomes FRL Lane3 and clock in embedded
- Minimum rise time(20%~80%) is 22.5ps (TMDS : 42.5ps)
- Character error detection is mandatory for Sink
- Link Training in FRL is required
- New Category 3 cable and connector
- New eARC



图片来源：https://www.hdmi.org/press/press_kit.aspx

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HDMI 2.1 Cable/Connector Introduction

- Ultra High Speed HDMI Cable
- Category 3 Cable
- Support 8K resolution with HDR
- Support up to 48Gbps Bandwidth over 4 lanes.
- Improved EMI characteristic
- New HDMI 2.1 connector spec. utilizes existing Type-A、C、D HDMI connectors cable and connector
- Backward compatible with legacy HDMI devices

图片来源：https://www.hdmi.org/press/press_kit.aspx

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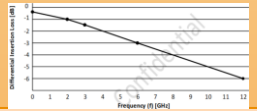
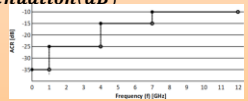
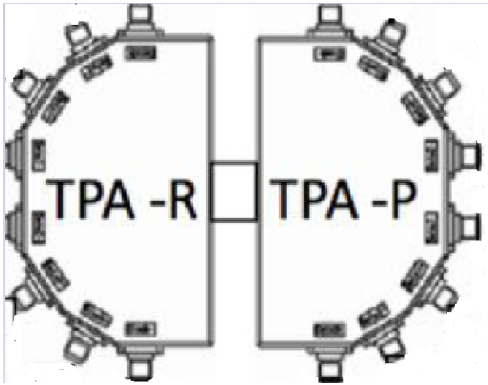
The latest HDMI Connector/Cable Test

The latest HDMI Connector Test

- The initial CTS released on September 27, 2018 and the latest one (Version 2.1a) released on March 11, 2019.
- All MOIs are listed on HDMI LA. Extranet.
- GRL provides HDMI 2.1 connector logo test.

The latest HDMI Connector Test (Cont.)

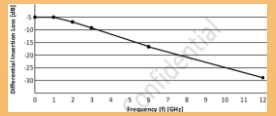
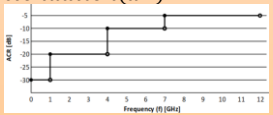
Item	Test Condition	Criterion
Connector Attenuation (DIL)	Receptacle connector mounted on a controlled impedance PCB fixture	Differential insertion loss: from 0.3dB to 6dB at 12GHz DIL > -0.3dB @ 0GHz DIL > -1dB @ 2GHz DIL > -1.5dB @ 3GHz DIL > -3dB @ 6GHz DIL > -6dB @ 12GHz 
Connector DIL to Crosstalk (ACR)	Receptacle connector mounted on a controlled impedance PCB fixture	$ACR(dB) = 10log\sum_{k=1}^{3}(FEXT_k)^2 - Attenuation(dB)$ ACR < -35dB @ 0GHz ≤ f < 1GHz ACR < -25dB @ 1GHz ≤ f < 4GHz ACR < -15dB @ 4GHz ≤ f < 7GHz ACR < -10dB @ 7GHz ≤ f < 12GHz 
Connector Differential Impedance	TDR@Rise Time≤75ps(10% to 90%) Mated connectors mounted on a controlled impedance PCB for micro-probing	Differential impedance: 100Ω ±10%* *A single excursion is permitted out to a max/min of 100Ω ±15% and of duration less than 150ps.



HDMI 2.1 Cable Test

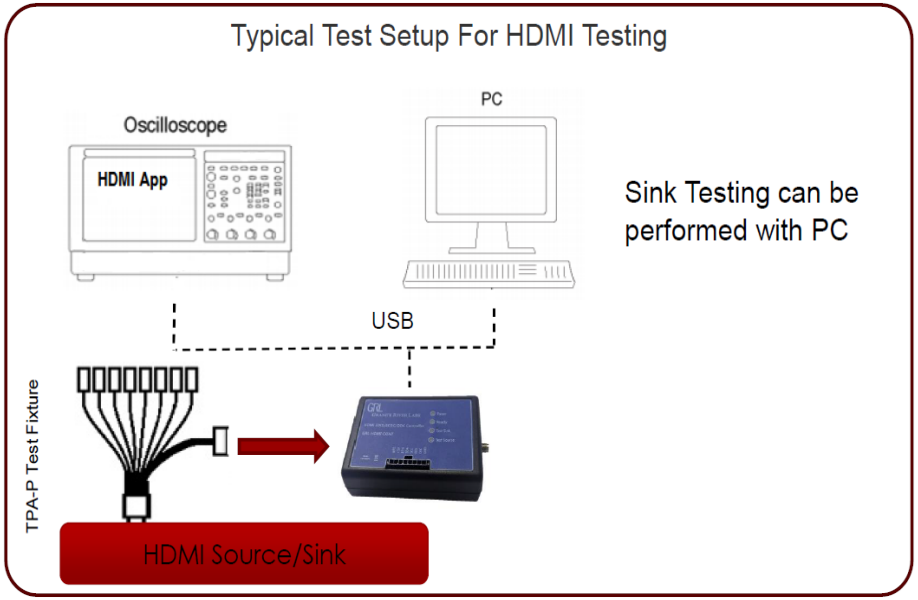
- The CTS and MOIs are under discussing
- GRL provides HDMI 2.1 cable pre-test.

HDMI 2.1 Cable Test

Item	Test Condition	Criterion
Max Intra-Pair Skew	On all data lanes	≤ 30ps
Max Inter-Pair Skew	On all data lanes	≤ 500ps
Attenuation(DIL)	On all data lanes	Differential insertion loss: from 0.3dB to 6dB at 12GHz DIL > -5dB @ 0GHz DIL > -5dB @ 1GHz DIL > -6.5dB @ 2GHz DIL > -9.2dB @ 3GHz DIL > -16.5dB @ 6GHz DIL > -29dB @ 12GHz 
Attenuation to Crosstalk Ratio(ACR)		$ACR(dB) = 10log\sum_{k=1}^{3}(FEXT_k)^2 - Attenuation(dB)$ ACR < -30dB @ 0GHz ≤ f < 1GHz ACR < -20dB @ 1GHz ≤ f < 4GHz ACR < -10dB @ 4GHz ≤ f < 7GHz ACR < -5dB @ 7GHz ≤ f < 12GHz 
Differential Impedance	TDR@Rise Time≤75ps(10% to 90%)	Connection point and transition area(up to 1ns) : 100Ω ±10%* Cable area(1ns to 2.5ns) : 100Ω ±10% *A single excursion is permitted out to a max/min of 100Ω ±15% and of duration less than 150ps.
Max Mode Conversion	Scd21, Scd12, Sdc21, Sdc12	-16dB up to 12GHz

GRL HDMI 2.1 EDID/SCDC Controller

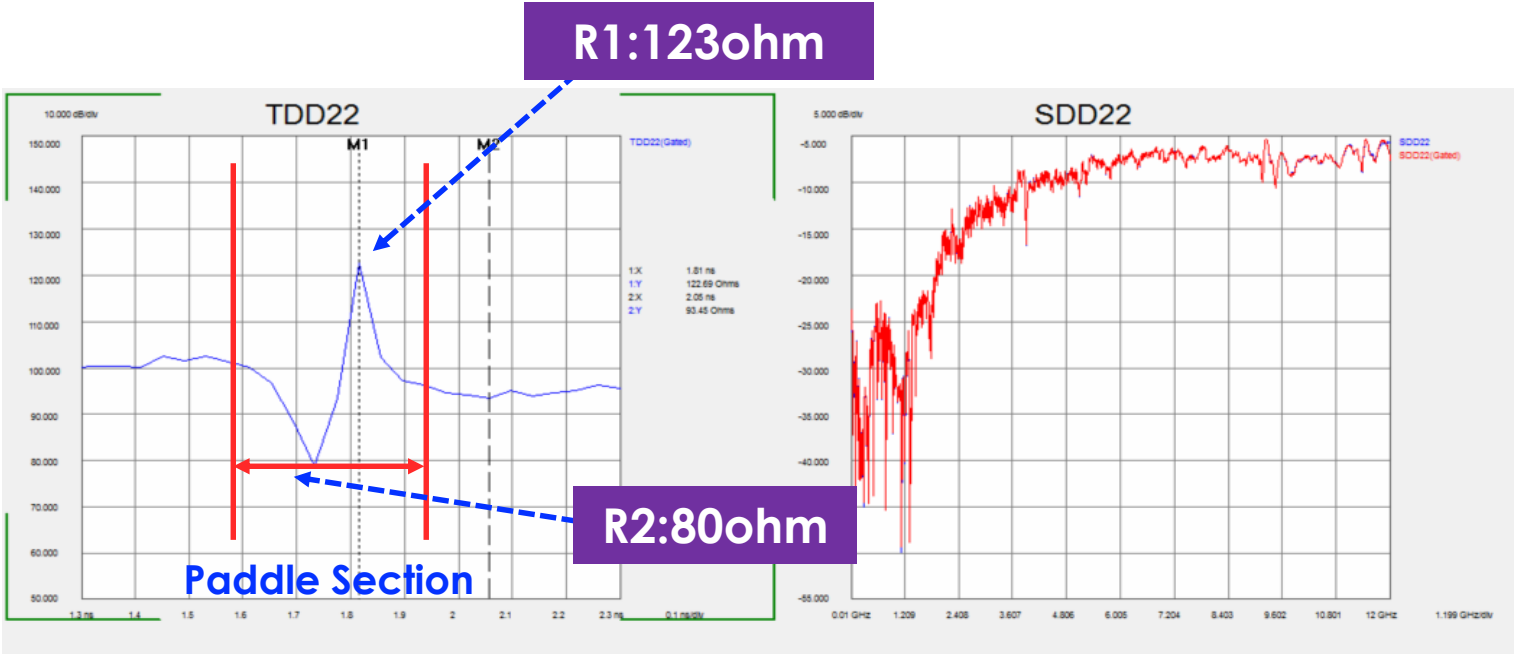
- Work as a Source/sink Emulator and support FRL Link Training
- Source Emulator
  - Read EDID from Sink DUT
  - Read SCDC Register from Sink DUT
  - Write SCDC Register to Sink DUT
- Sink Emulator
  - Emulate Sink EDID
  - Emulate SCDC register
  - Read EDID from files



HDMI Cable Measurement Case Study

Case Study – 1
Impedance Mismatch on Paddle Section

- Impedance Mismatch/Discontinuity – Higher Return Loss



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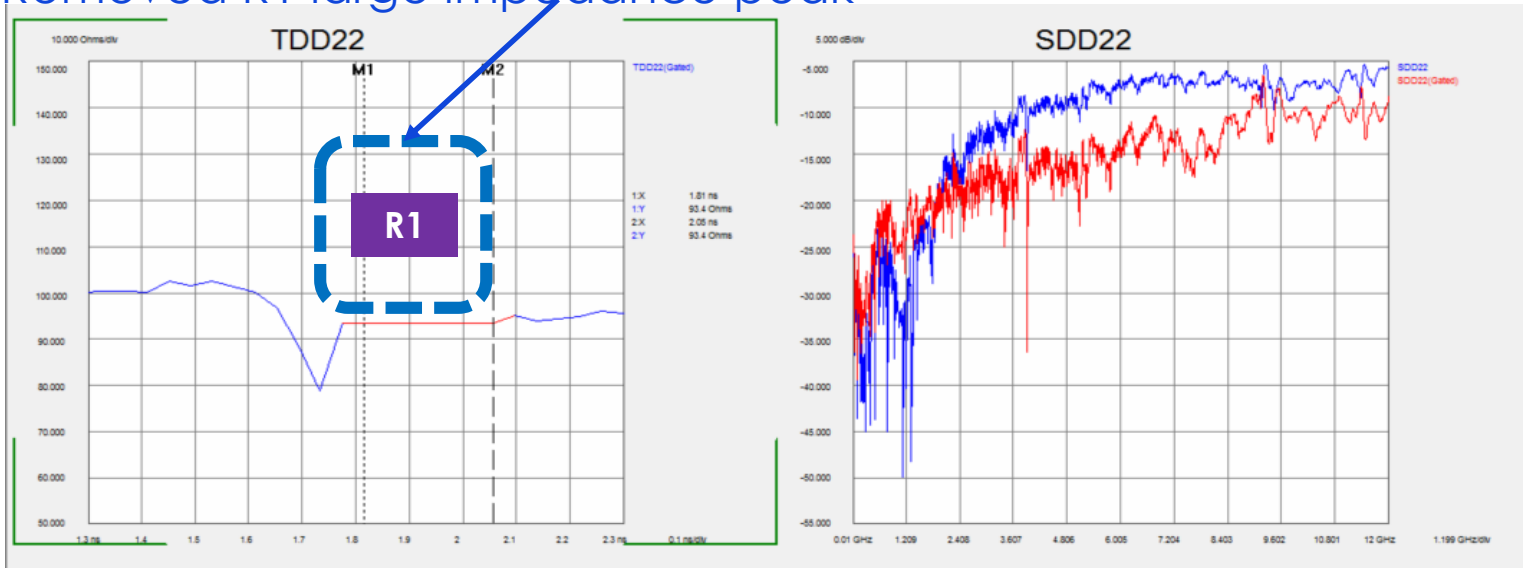
Impedance Mismatch on Paddle Section

- Simulate Insertion Loss without impedance mismatch peak
  - Via “Gating” function on Keysight PLTS to remove R1 impedance mismatch peak to simulate Insertion Loss

Removed R1 large impedance peak



Blue Line : Original Return Loss
Red Line : Improved Return Loss

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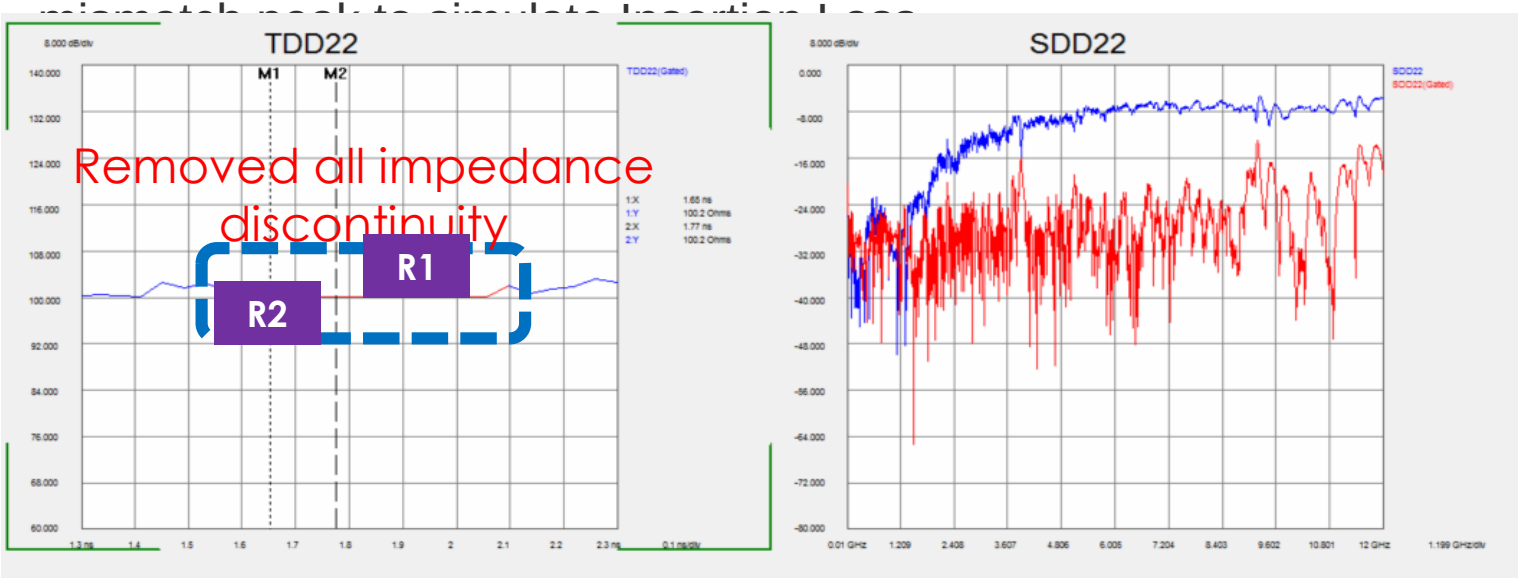
Impedance Mismatch on Paddle Section

- Simulate Insertion Loss without impedance mismatch peak
  - Via “Gating” function on Keysight PLTS to remove R1 and R2 impedance mismatch peak to simulate Insertion Loss



Blue Line : Original Return Loss
Red Line : Improved Return Loss

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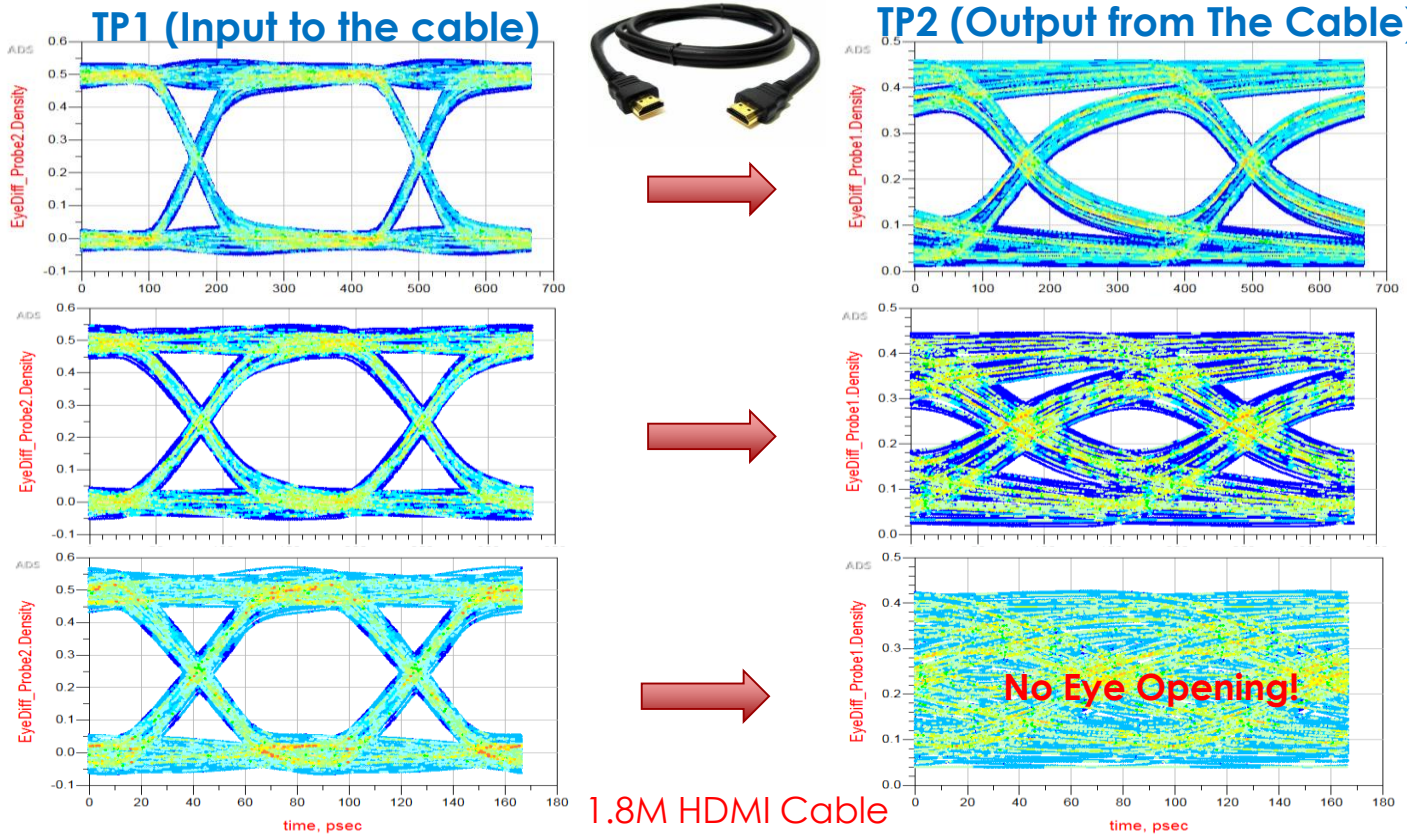
Case Study – 2
What Happens in 12Gbps Signaling



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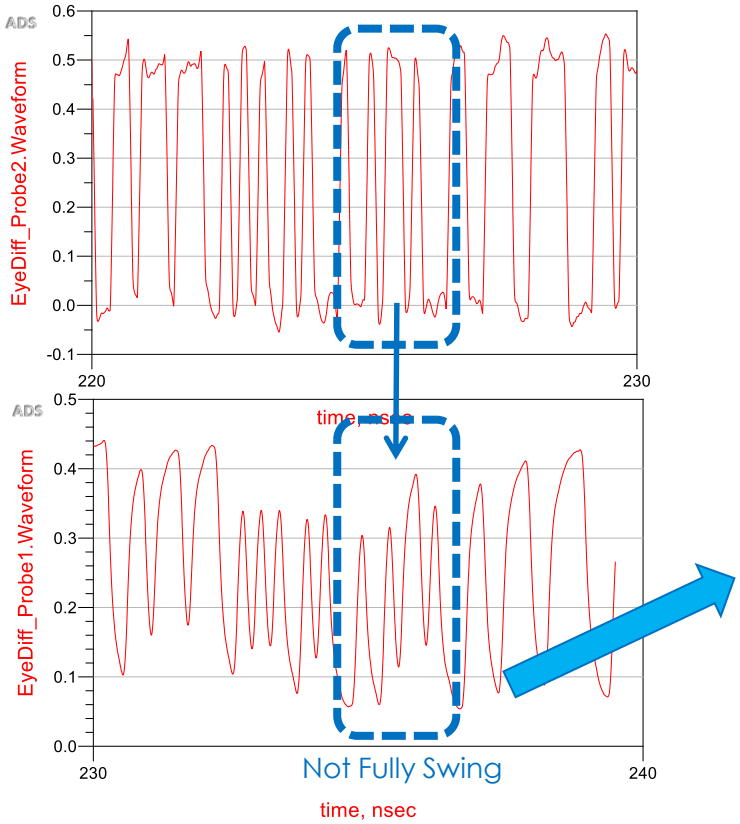
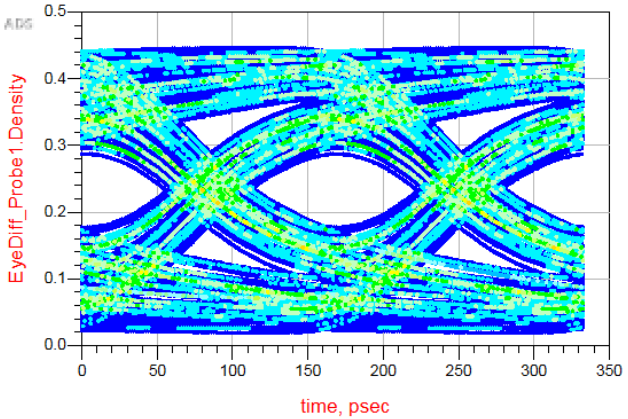
What Happens in 12Gbps Signaling

6Gbps Signal on HDMI 1.4 cable

TP1 Waveform
Cable Input

TP2 Waveform
Cable Output





Causing Eye Closure

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What Happens in 12Gbps Signaling

- Equalizer on Tx/Rx will be used on FRL mode(Up to 12Gbps)

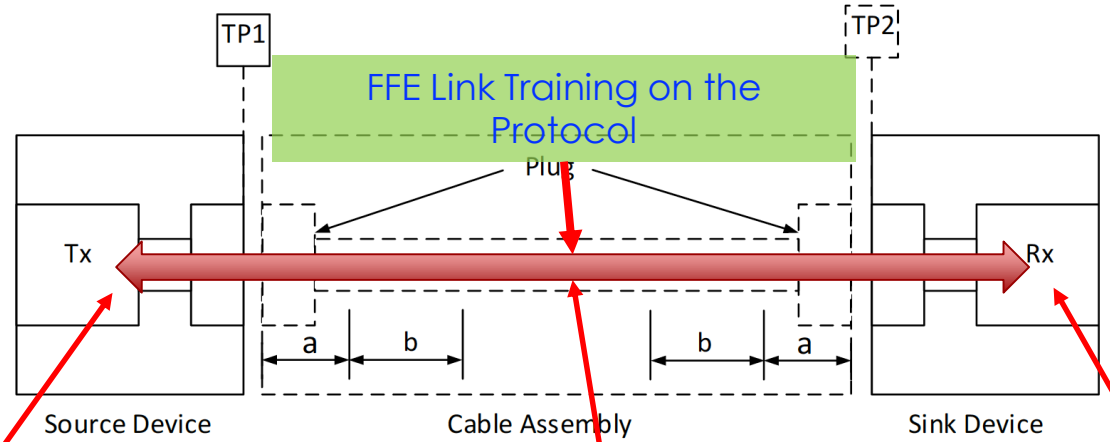

Figure 5-1: Cable Impedance Measurement Points

Feed Forward Equalizer (4 settings)

The cable has to be good enough to support 12Gbps signaling.

CTLE + 1tap DFE

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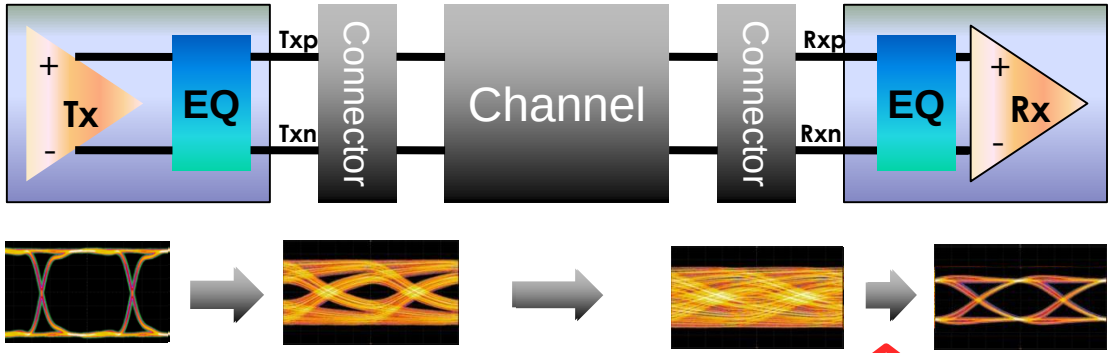
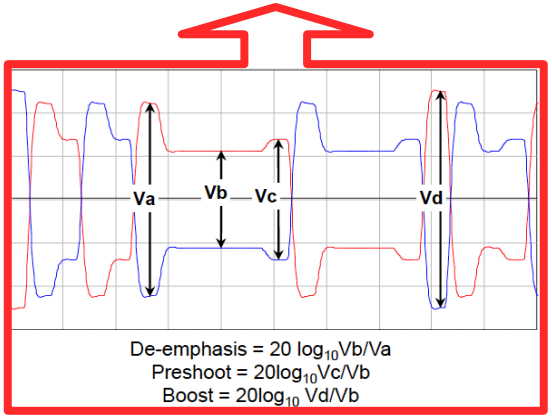
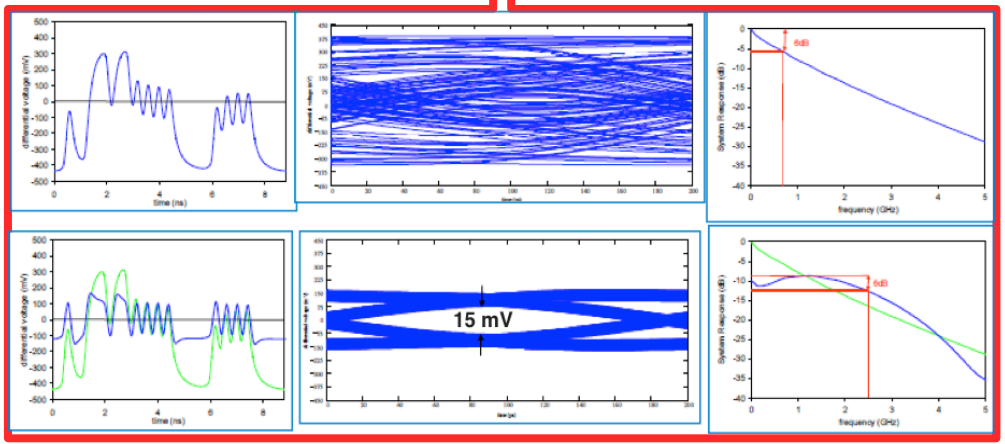
High Speed Test and Challenge







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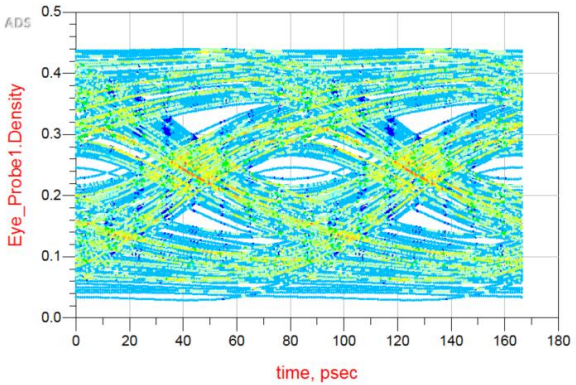
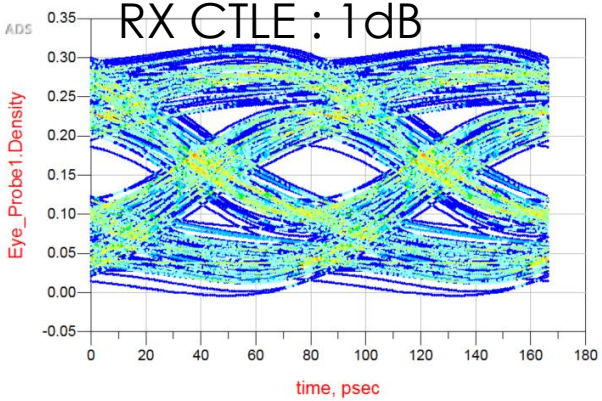
Eye Simlation with Equalizer

- TP2EQ Waveform (After Cable)

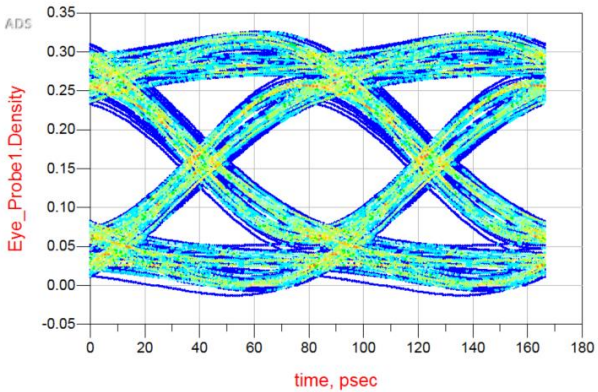
TX FFE : OFF
RX CTLE : OFF



TX FFE :
TXFFE0
RX CTLE : 1dB



TX FFE : TXFFE0
RX CTLE : 4dB



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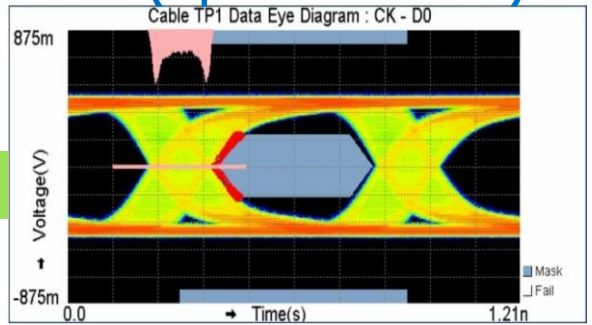
Case Study – 3
Why HDMI Cable pass 3.4Gbps test, but failed at 1.65Gbps ?

- For one 7m HDMI cable

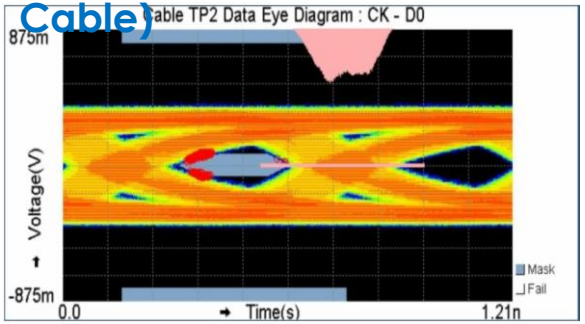
TP1 (Input to the cable)

TP2 (Output from The Cable)

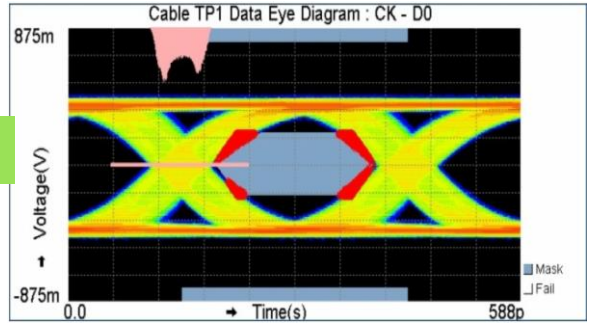
1.65Gbps



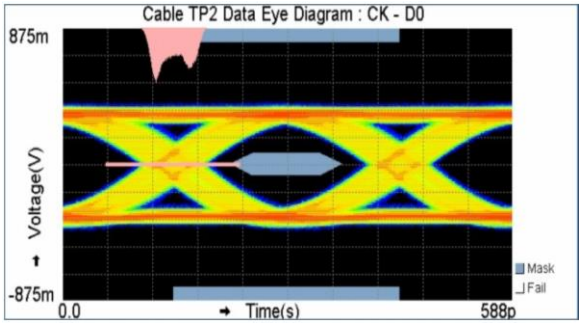
Non-Equalized Eye @165MHz



3.4Gbps



Equalized Eye @340MHz



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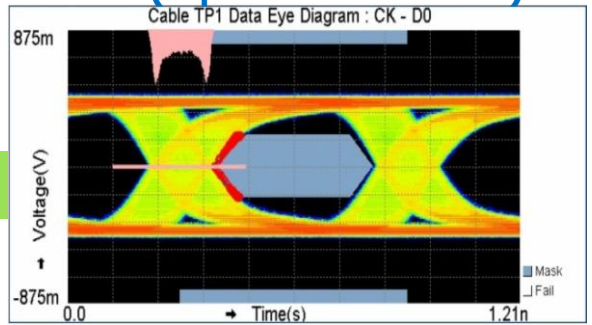
Case Study – 3
Why HDMI Cable test pass 3.4Gbps, but failed at1.65Gbps?

- 以 3m HDMI cable 为例

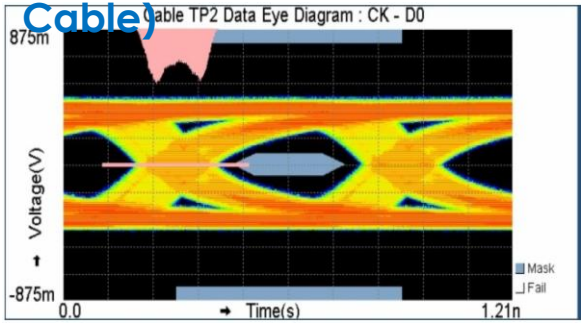
TP1 (Input to the cable)

TP2 (Output from The Cable)

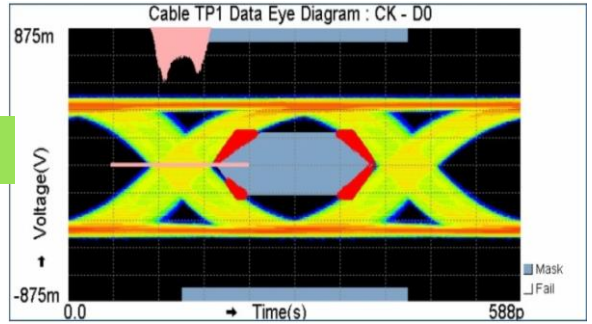
1.65Gbps



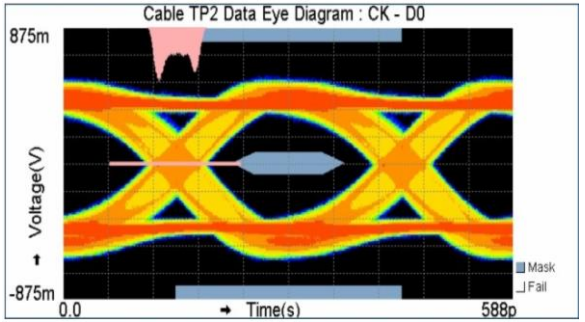
Non-Equalized Eye @165MHz



3.4Gbps



Equalized Eye @340MHz



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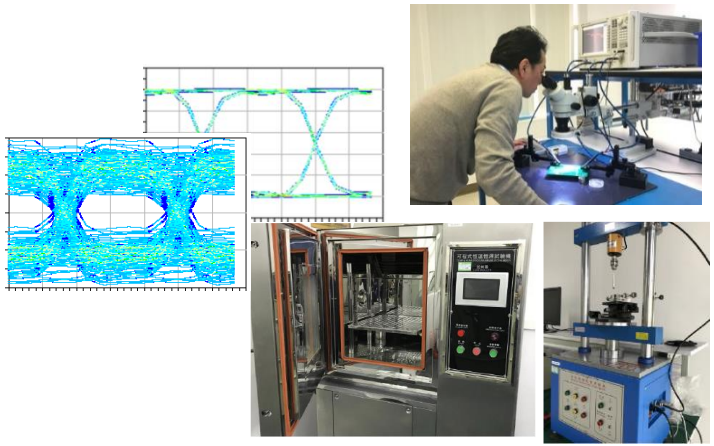
GRL Cable & Connector Services Overview

- Official Compliance Certification – passive & active
  - NOW: USB Type-C, HDMI Premium Cable, MFi Lightning, DisplayPort
  - Expected 2018/2019: Thunderbolt , HDMI 2.1

- Pre-compliance testing on ANY standard, ANY form factor
  - Including raw/bulk cable and connectors
  - Benchmarking

- Cable SI Validation, Design Consulting, Simulation and Modeling
  - VNA & TDR Analysis
  - Design troubleshooting
  - Fixture Design & Validation
  - Fixture/connector de-embedding
  - Test methodology development

- Reliability and FA Test Services and Consulting
  - Environmental
  - Mechanical



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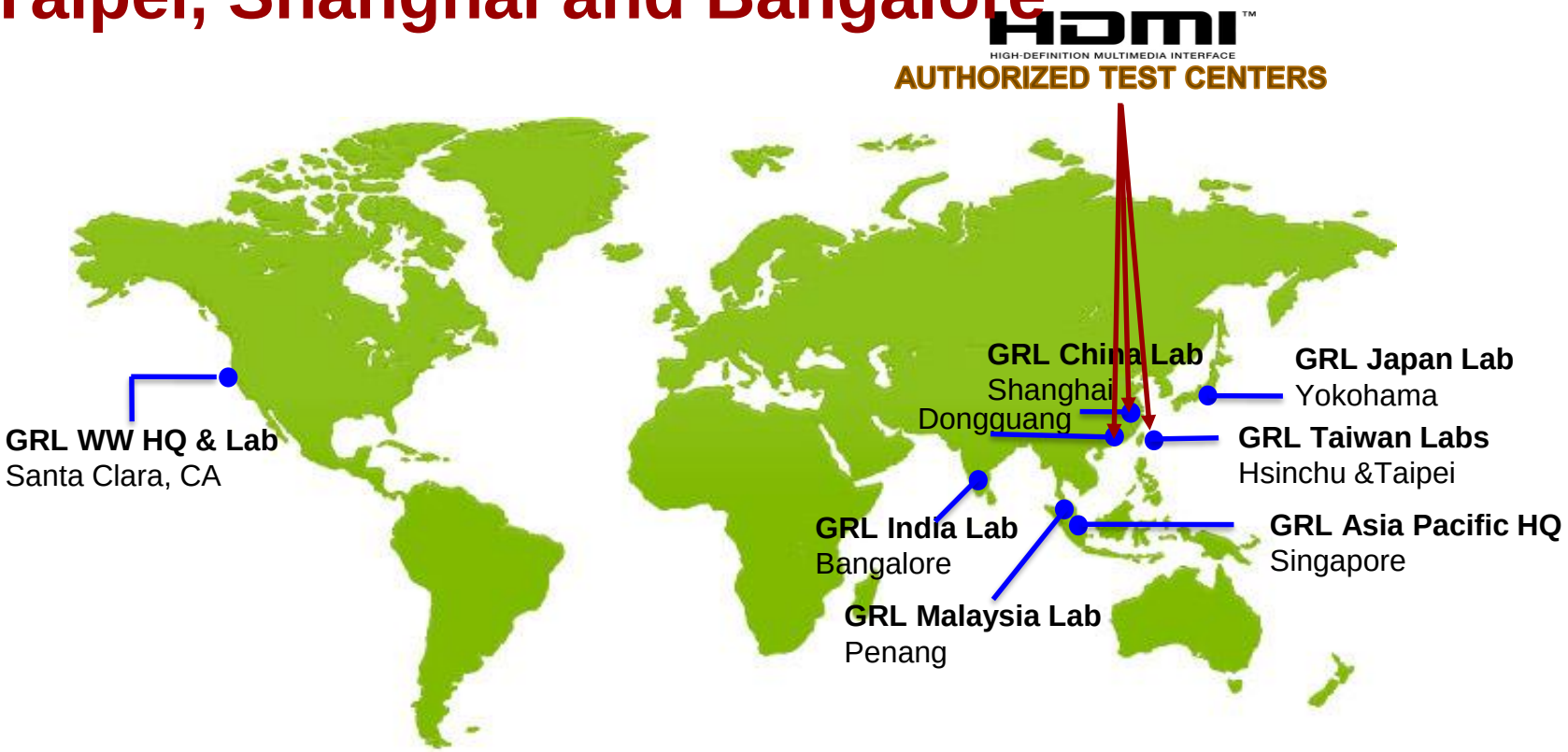
GRL-Philips HDMI ATCs in **Taipei, Shanghai and Bangalore**



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Q&A