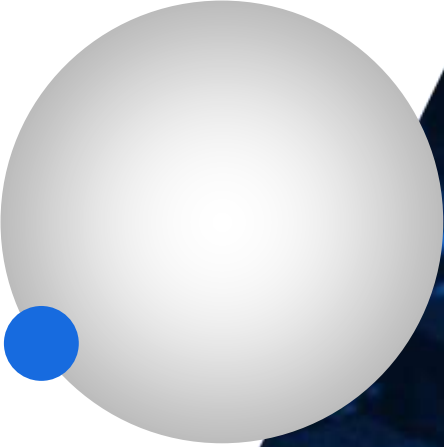




MIPI CSI-2, DSI-2, C-PHY, D-PHY Testing Solutions

With New Trends and
Advanced Topics



High end camera,
imaging, and others



Very High Bandwidth

Sophisticated Signaling

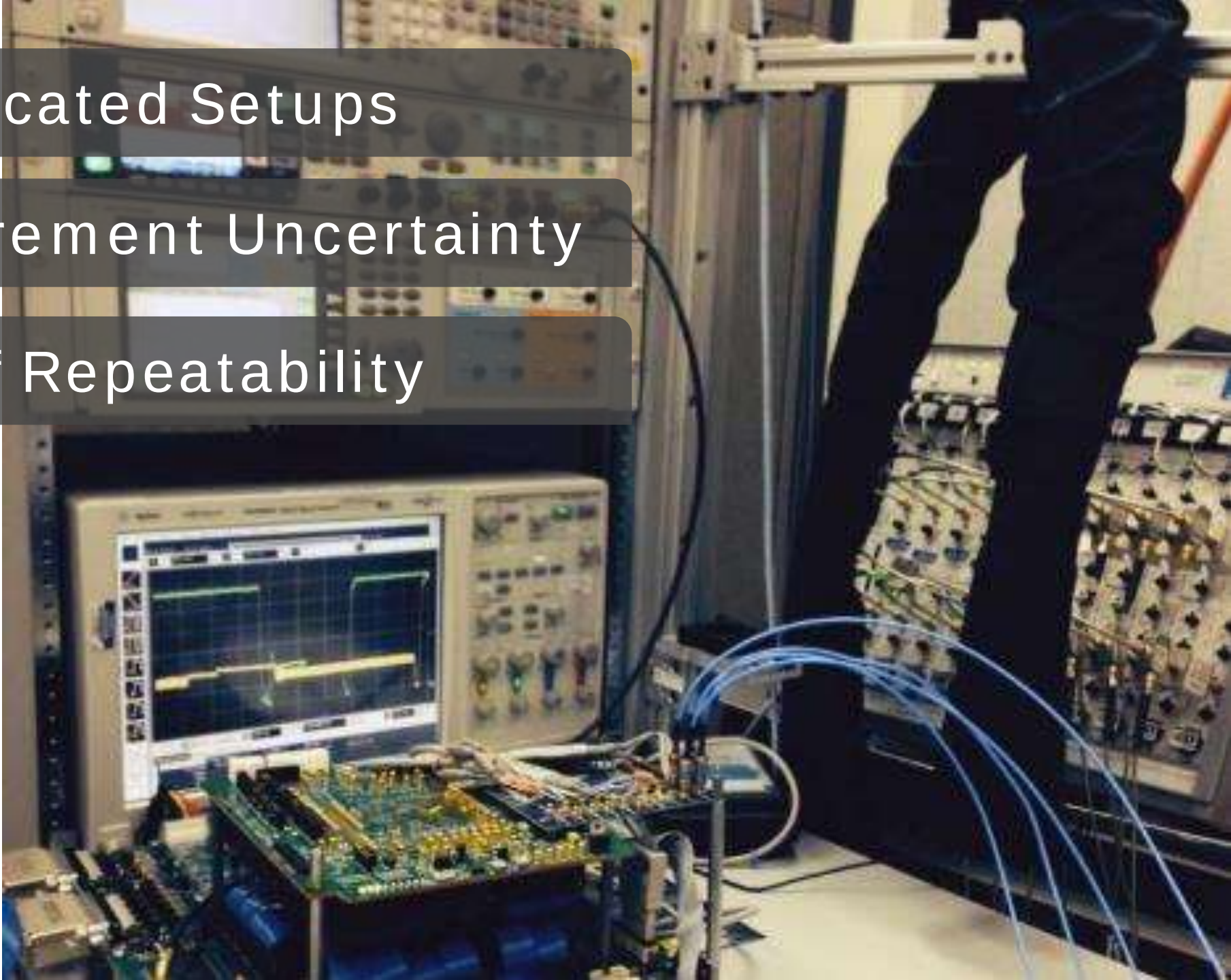
Complex Protocols



Complicated Setups

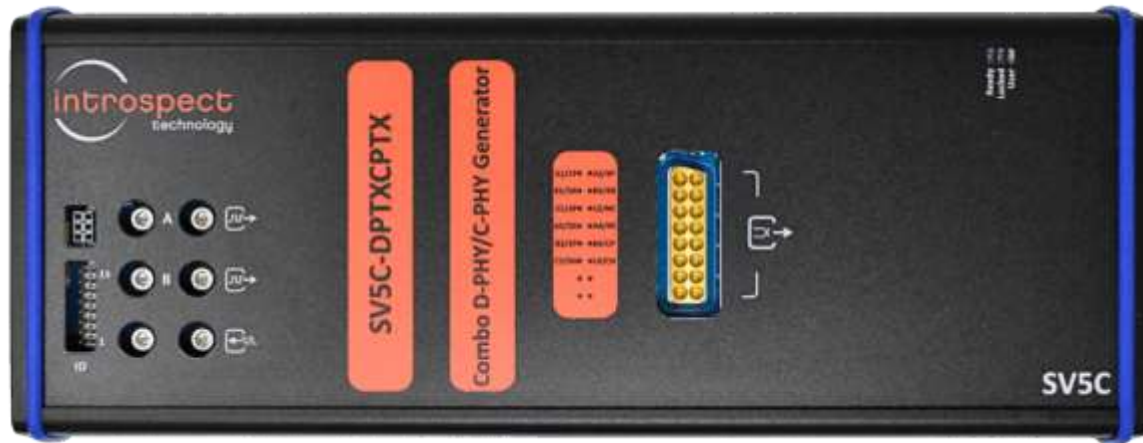
Measurement Uncertainty

Lack of Repeatability

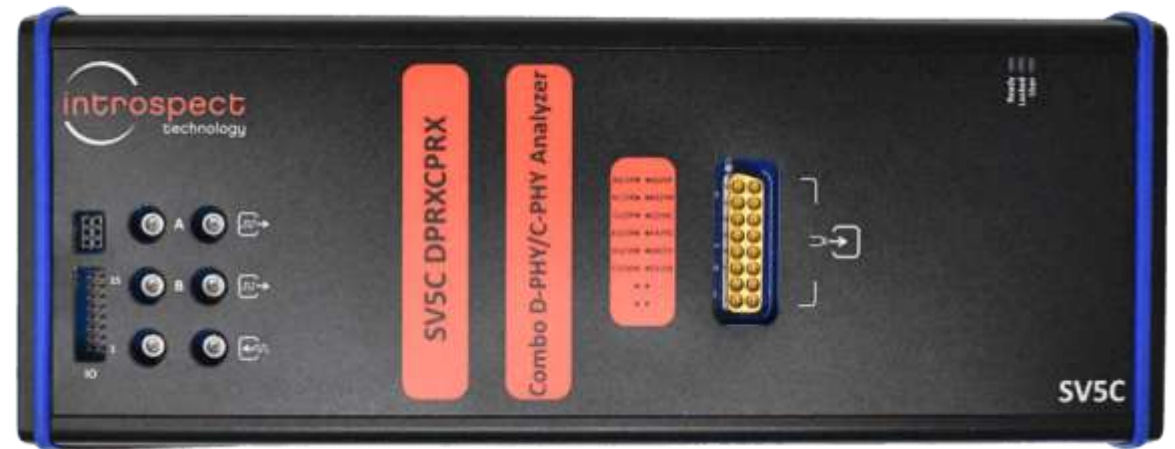


The Cleanest Test and Measurement Solution

FOR C-PHY, D-PHY, CSI-2, DSI-2, TRANSMITTER AND RECEIVER APPLICATIONS



RECEIVER TEST SOLUTION



TRANSMITTER TEST SOLUTION



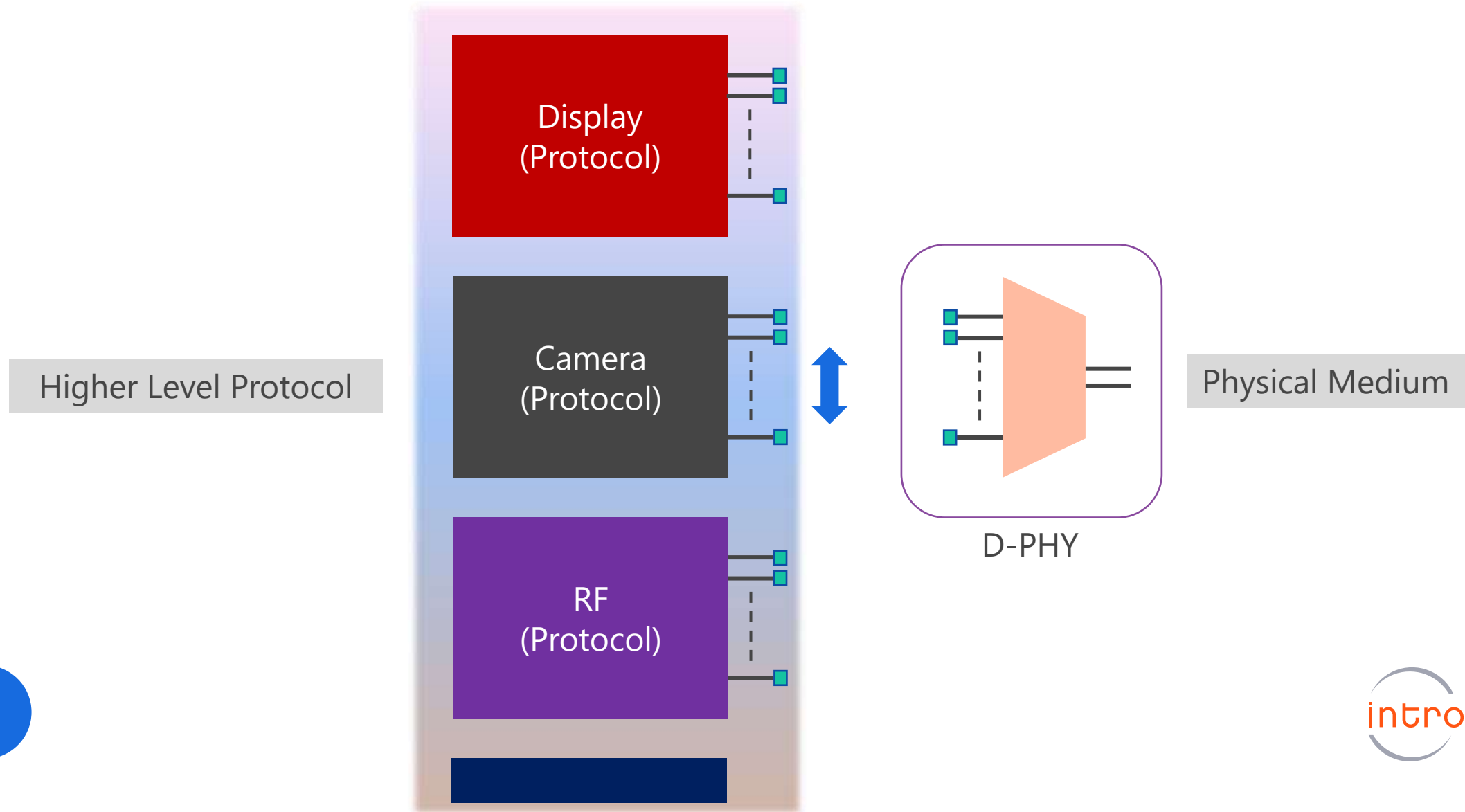
Agenda

1. High-Level Test Challenges
2. Receiver Test Focus
3. Transmitter Test Focus
4. Advanced Topics and New Directions in the MIPI Alliance
5. Conclusion

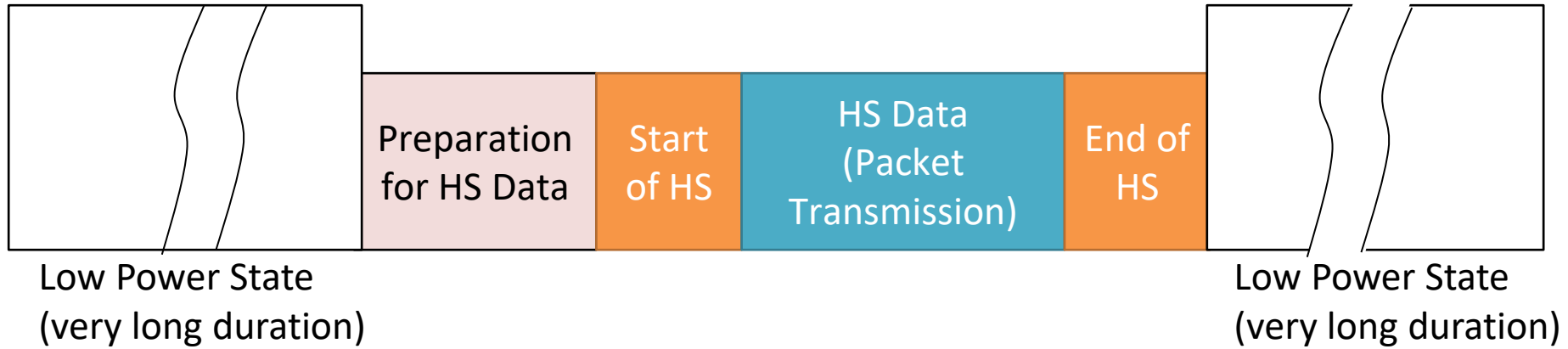


High-Level Test Challenges

Modular PHY & Protocol Specifications

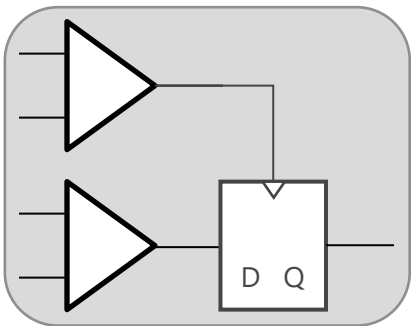
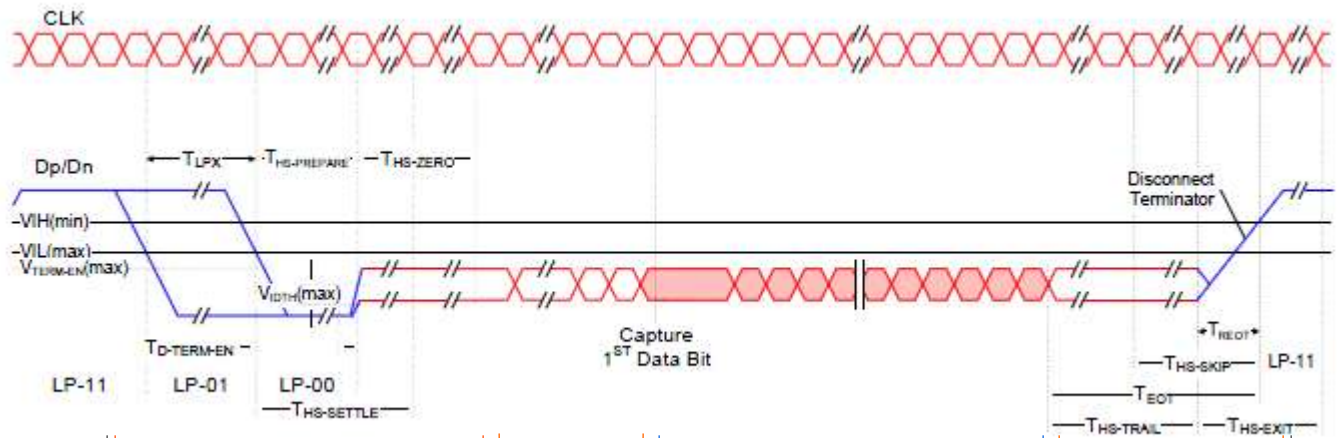
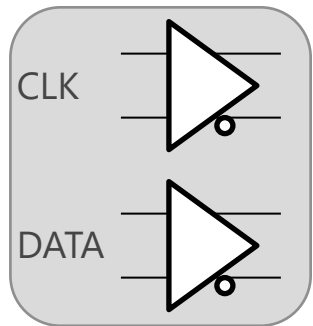


Low-Power, Burst-Mode Operation



- LP state is included to conserve power, with very strict timing rules
- Different PHY layers define the transmission states differently

D-PHY Is Source-Synchronous



LP consists of LVCMOS single-ended signals

HS prep. consists of LP11-LP01-LP00 transition followed by differential zero signal

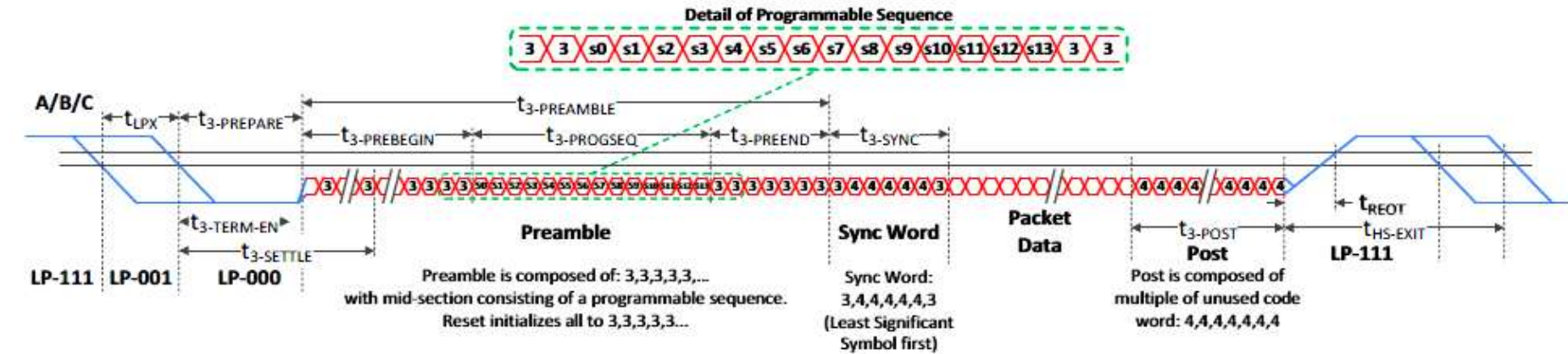
Start of HS data is signified by SOT word

HS data is source synchronous with CLK

End of HS data is signified by constant value followed by LP11

LP is single-ended again

C-PHY Is Three-Phase Encoded



LP consists of LVCMOS single-ended signals

HS prep. consists of LP111-LP011-LP000 transition followed by constant 3,3,3,... sequence

Start of HS data is signified by SYNC word

HS data is "three-phase" specially encoded (no clock)

End of HS data is signified by constant 4,4,4... sequence

LP is single-ended again

See Our Pres at

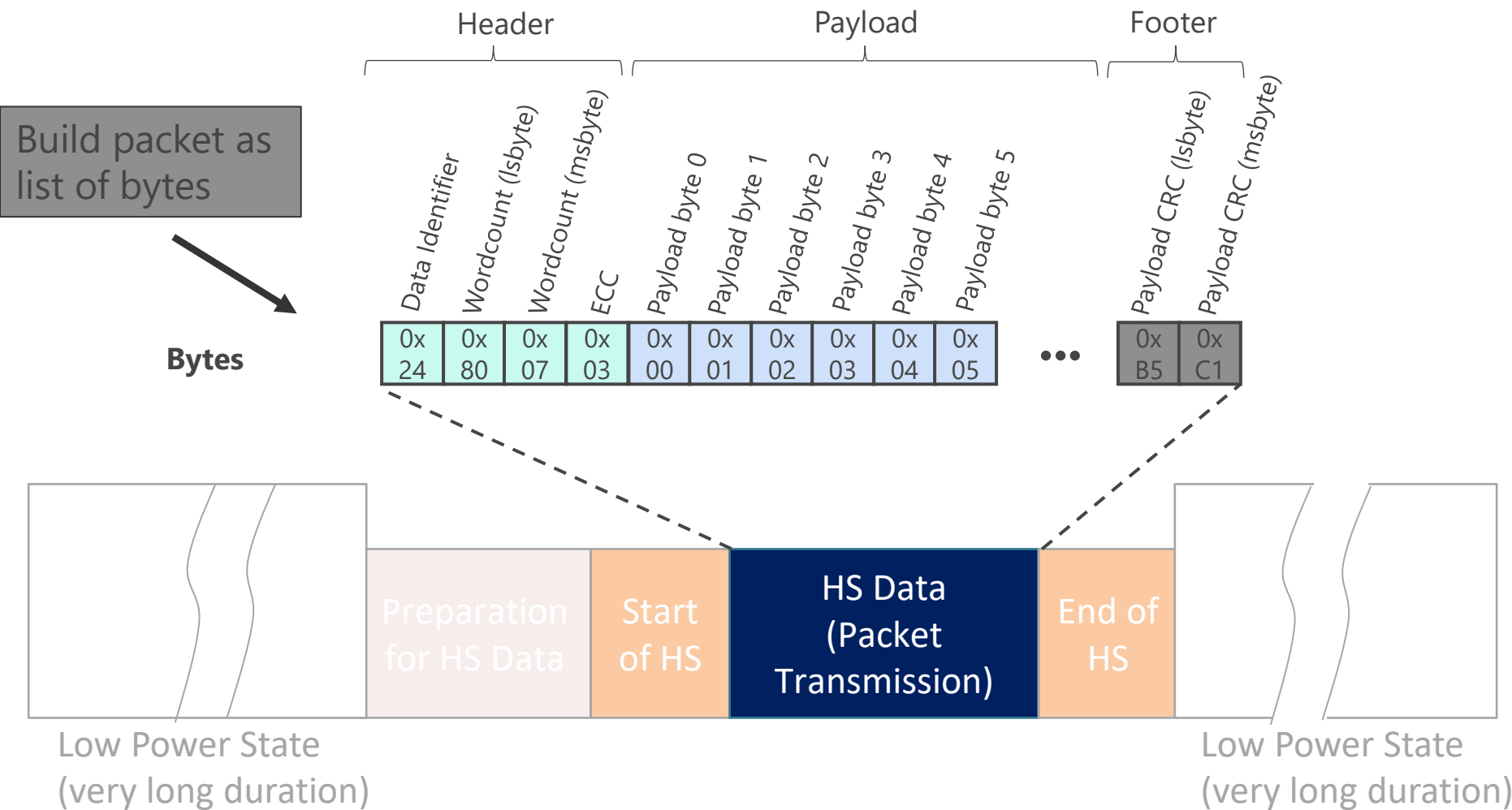
mipl
DEVCON
Mountain View
2016

MIPI.ORG/DEVCON

<https://youtu.be/wCavk7ahGZU?si=QOi2qKAfRO85NeOu>

introspect
technology

HS-Data Is Packet-Based



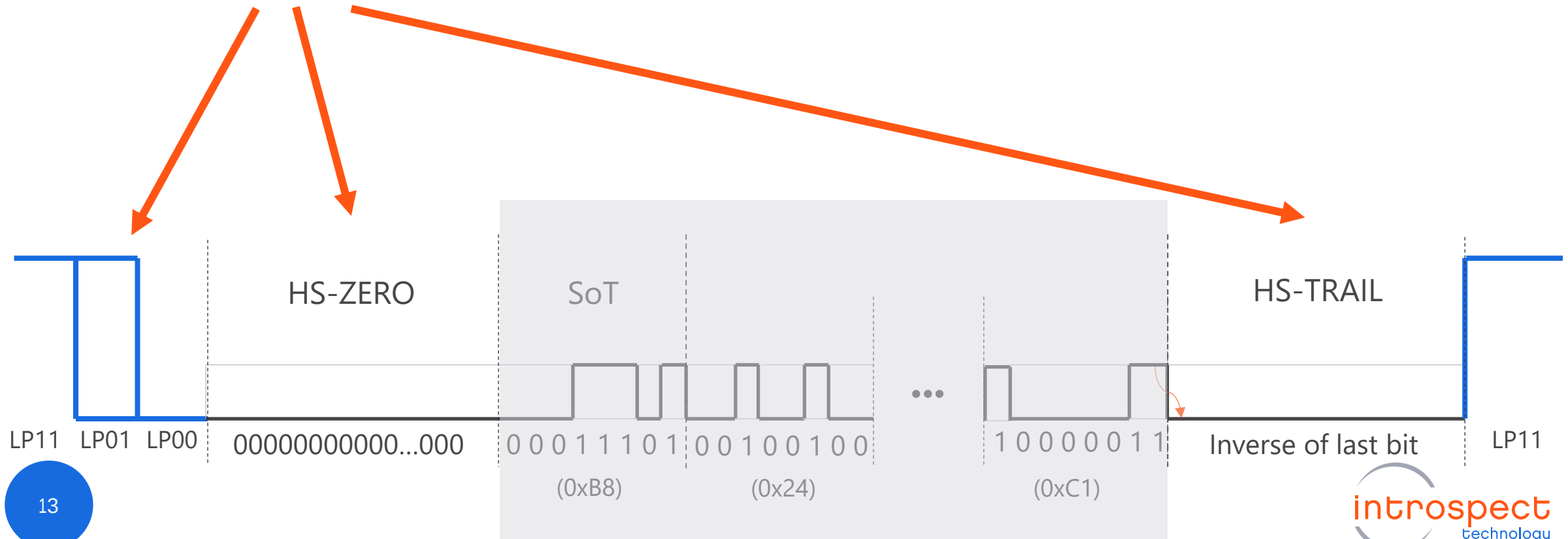
PHY Test Consists of Two Kinds of Tests!

GLOBAL TIMERS TEST

- Stress components related to state transitions from Low Power to High Speed

EYE TEST

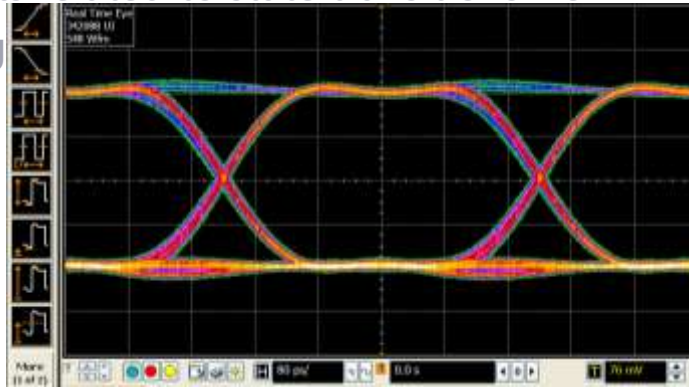
- Stress components related to the High Speed receiver itself



PHY Test Consists of Two Kinds of Tests!

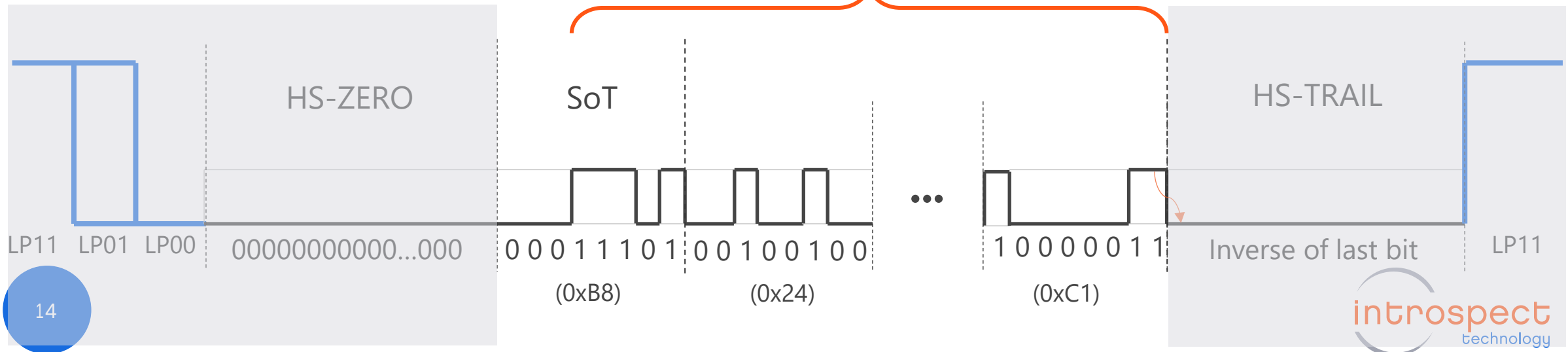
GLOBAL TIMERS TEST

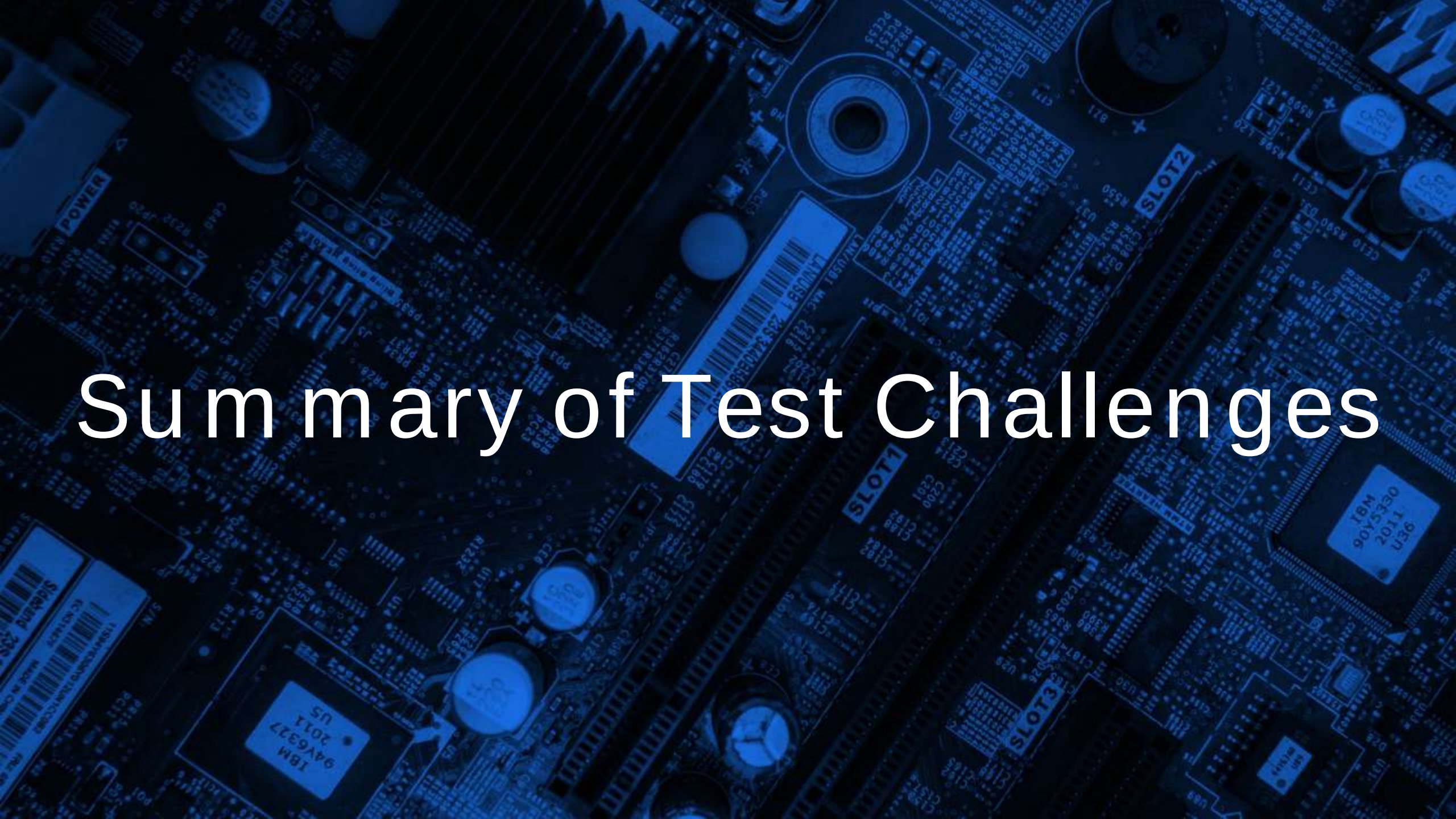
- Stress components related to state transitions from Low Power to High Speed



EYE TEST

- Stress components related to the High Speed receiver itself





Summary of Test Challenges

Need Complete Protocol Capability

DPHY DataCapture: Run_2023-04-05_0937 / csDataCapture1

File

burst mode: 416 bursts, 416 CSI packets, 1249 lpStates, 832 lpEvents, 1 frame

lane 1 lane 2 lane 3 lane 4 GO TO: Timestamp... Times: relativeToStart

HS Bursts CSI Packets LP States LP Events Frames

ID	Time (ms)	VC	Index	DT	DT Name	Image Width	Image Height	First Packet	Last Packet	FrameRate
0	20.91172	0	0	0x24	rgb888	874	414			

Image

Prev Next First Last

Details

Name: image_vc0_0_dt0x24.png

Size: 24.69 KB

Width: 874 pixels

Height: 414 pixels

Color Depth: 24

Location: Open File Location

Pixel Info

X: -

Y: -

Hex: -

RGB: (-, -, -)

RGB Bit Depth: -

Frame View

DPHY DataCapture: Run_2023-04-05_0937 / csDataCapture1

File

burst mode: 416 bursts, 416 CSI packets, 1249 lpStates, 832 lpEvents, 1 frame

lane 1 lane 2 lane 3 lane 4 GO TO: Timestamp... Times: relativeToStart

HS Bursts CSI Packets LP States LP Events Frames

Packet#	Time (ms)	Burst	VC	DT	DT Name	Header ECC	WC	Short	Payload CRC	Notes
177	26.19291	177	0	0x24	rgb888	0x07	2622		0xBF07	
178	26.22291	178	0	0x24	rgb888	0x07	2622		0xBF07	
179	26.25291	179	0	0x24	rgb888	0x07	2622		0x59B0	
180	26.28291	180	0	0x24	rgb888	0x07	2622		0xE00A	
181	26.31291	181	0	0x24	rgb888	0x07	2622		0xFD85	
182	26.34291	182	0	0x24	rgb888	0x07	2622		0xEE5C	
183	26.37291	183	0	0x24	rgb888					
184	26.40291	184	0	0x24	rgb888					
185	26.43291	185	0	0x24	rgb888					
186	26.46291	186	0	0x24	rgb888					

Selected Packets

First Packet: Last Packet: Time:

Packet 184 Detail

Data Offset: 55

	55	56	57	58
lane 1 data	FF	FF	FF	C4
lane 2 data	FF	FF	C4	3A
lane 3 data	FF	FF	3A	8F
lane 4 data	FF	FF	8F	C4
bytes	FFFFFFFF	FFFFFFFF	FF235CF1	235CF123

Packet View

DPHY DataCapture: Run_2023-04-05_0937 / csDataCapture1

File

burst mode: 416 bursts, 416 CSI packets, 1249 lpStates, 832 lpEvents, 1 frame

lane 1 lane 2 lane 3 lane 4 GO TO: Timestamp... Times: relativeToStart

HS Bursts CSI Packets LP States LP Events Frames

Burst#	Time (ms)	NumBytes	NumBits	StartOffset	numCsPackets
180	25.68270	657	5696	326	1
181	25.71270	657	5688	319	1
182	25.74270	657	5688	319	1
183	25.77269	657	5704	328	1
184	25.80269	657	5704	328	1
185	25.83270	657	5704	329	1
186	25.86269	657	5704	329	1
187	25.89269	657	5704	330	1
188	25.92270	657	5696	322	1
189	25.95269	657	5696	323	1
170	25.98269	657	5696	323	1
171	26.01270	657	5696	324	1
172	26.04269	657	5697	325	1

Selected Bursts

Bursts: Bursts Count: Time: Total numBytes: Total numBits: Total numPackets:

Burst 184 Detail

Data Offset: 323

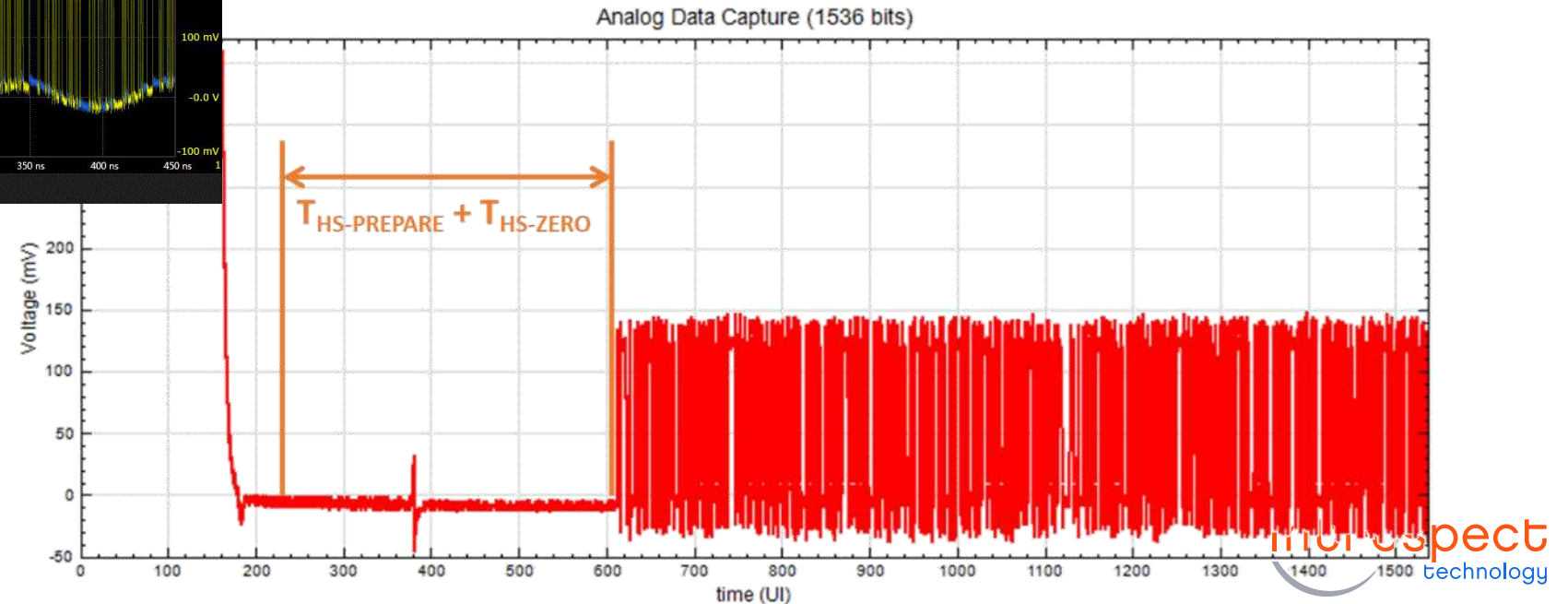
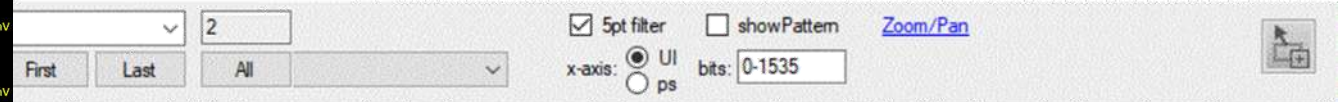
	0	1	2	3	4	5	6	7	8	9	10	11	12
bits:	00011101	00100100	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111
byte index:	24	25	26	27	28	29	30	31	32	33	34	35	36
byte (hex):	04	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
byte (dec):	36	255	255	255	255	255	255	255	255	255	255	255	255

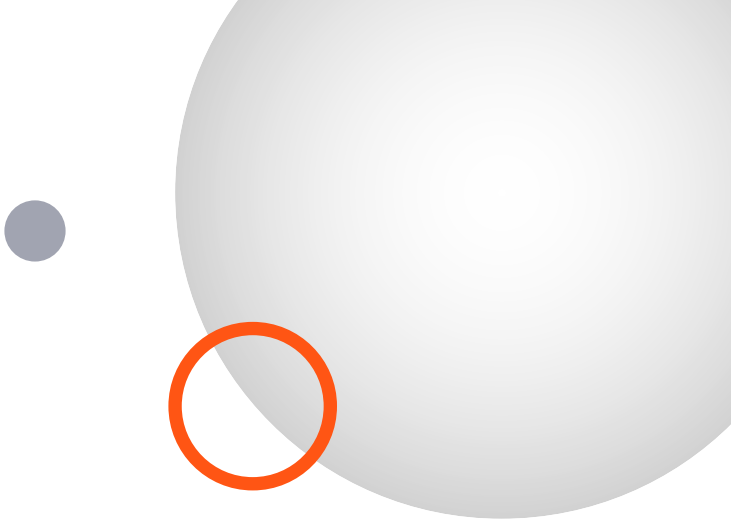
Burst View

Need AWG & Scope Capability

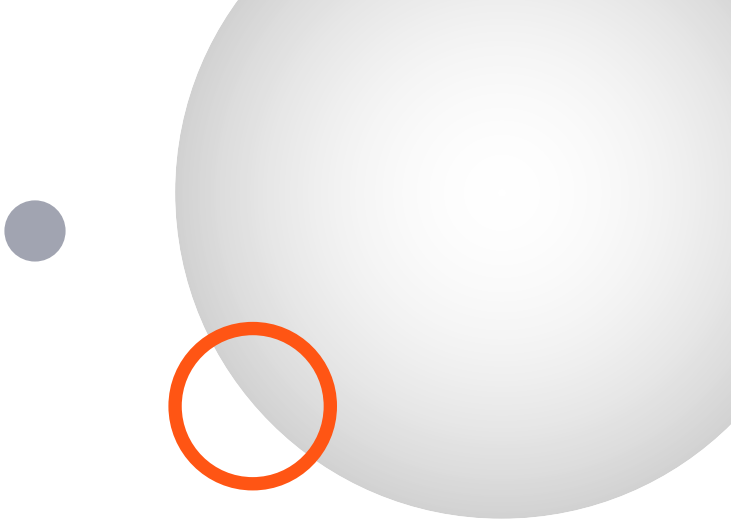


Run_2018-04-20_1059 / analogCapture1





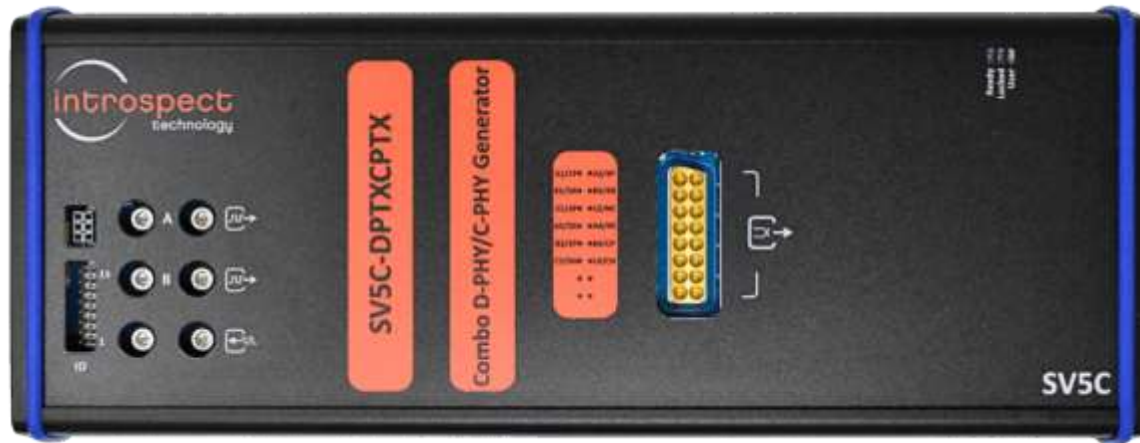
... Across Multiple Lanes
Simultaneously



... In a Single Bench Environment

The Cleanest Test and Measurement Solution

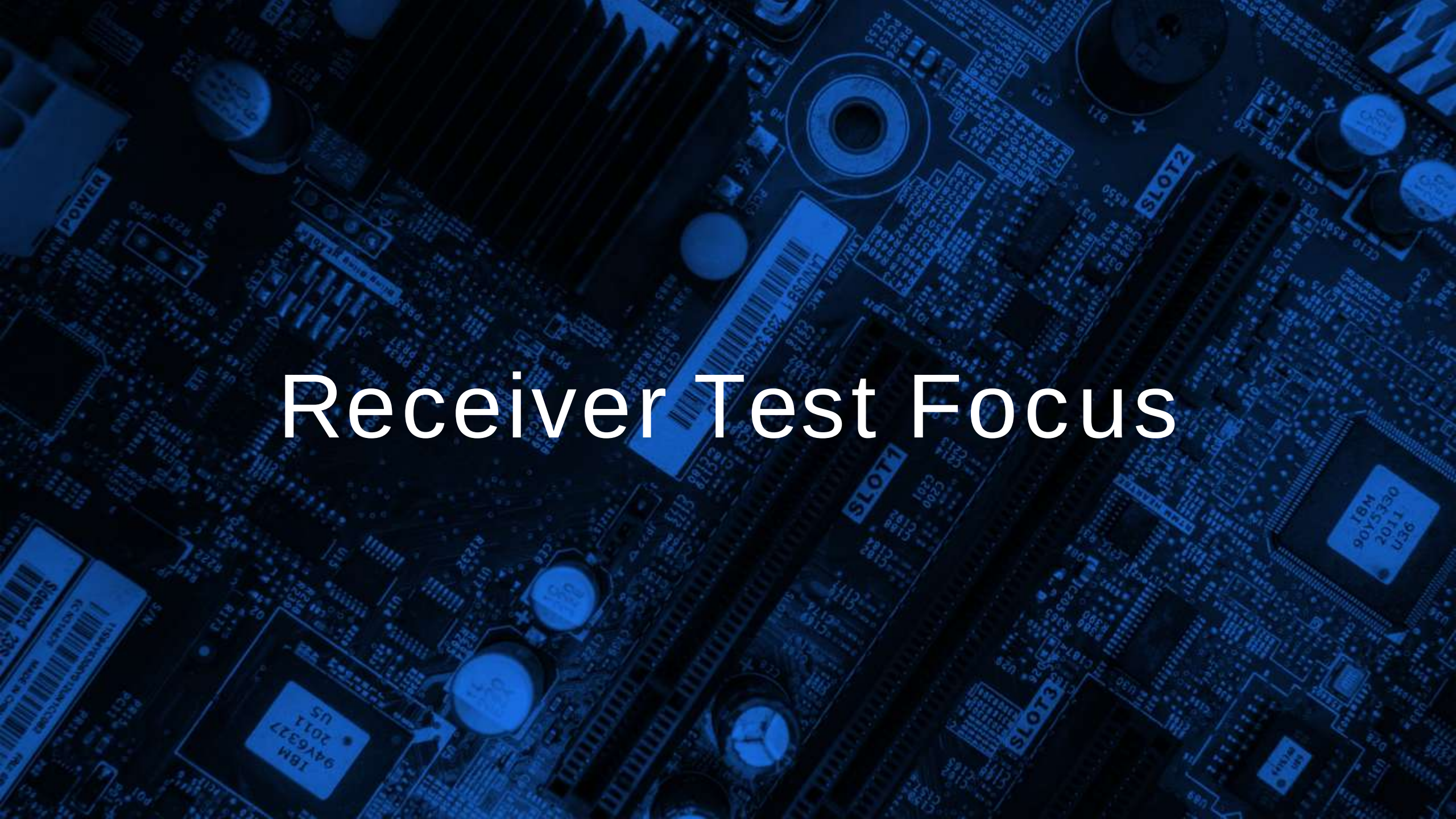
FOR C-PHY, D-PHY, CSI-2, DSI-2, TRANSMITTER AND RECEIVER APPLICATIONS



RECEIVER TEST SOLUTION



TRANSMITTER TEST SOLUTION



Receiver Test Focus

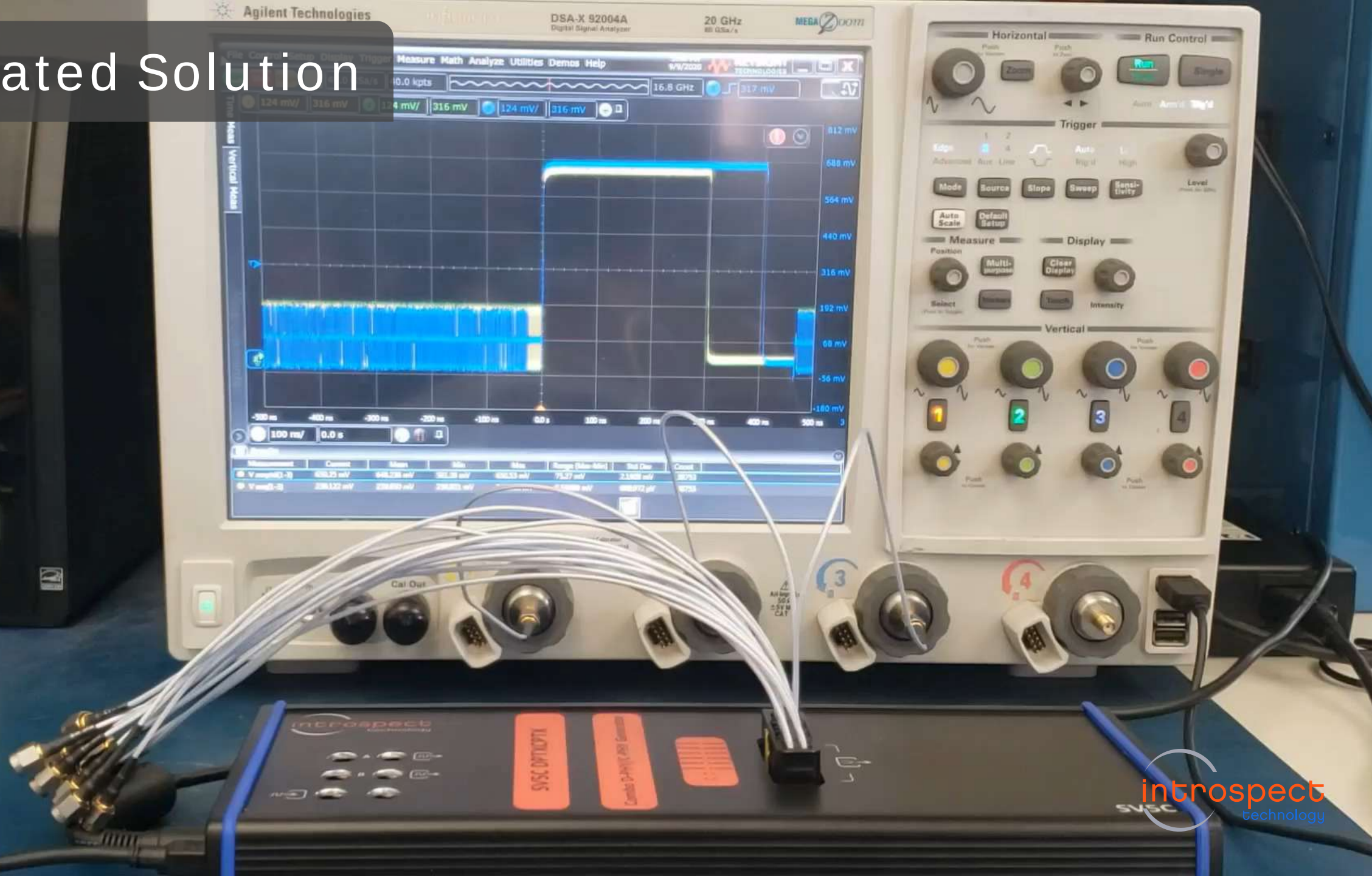
Sophisticated Waveform Generator

CSI-2 / DSI-2 Protocol Generator

Video Streamer



Integrated Solution



On the Fly Programmability



Advanced PHY Timing Control

Introspect ESP (v 20.41.0) - timing (SVSC_4180_MIPI_CPHY_GENERATOR)

File Edit IESP/MIPI_CPHY_GENERATOR Wizards ControlPanels Tools Results Help

Components Log Results

params1 properties (class: CphyParams)

commandPattern1	lp001Duration	100.0
csiImagePattern1	lp000Duration	65.0
customPattern1	tipxDuration	100.0
mipiClockConfig1	tHsExitDuration	300.0
mipiGenerator1	preBeginNumUI	7
mipiProtocol	postNumUI	112
params1	tTaGoDuration	4.0
	tTaSureDuration	1.0
	tTaGetDuration	5
	opticalLink	disabled
	preBeginSymbols	3333333
	progSeqSymbols	333333333333333
	preEndSymbols	3333333
	syncWord	3444443
	postSymbols	4444444
	useAlp	False
	t3AlpPauseMin	50
	t3AlpPauseWake	50
	post2NumUI	112
	calibrationPreambleFormat	format_1
	calPreambleNumUI	21

preBeginNumUI
Duration of the "preBegin" segment (in UIs).

dd Remove Confi

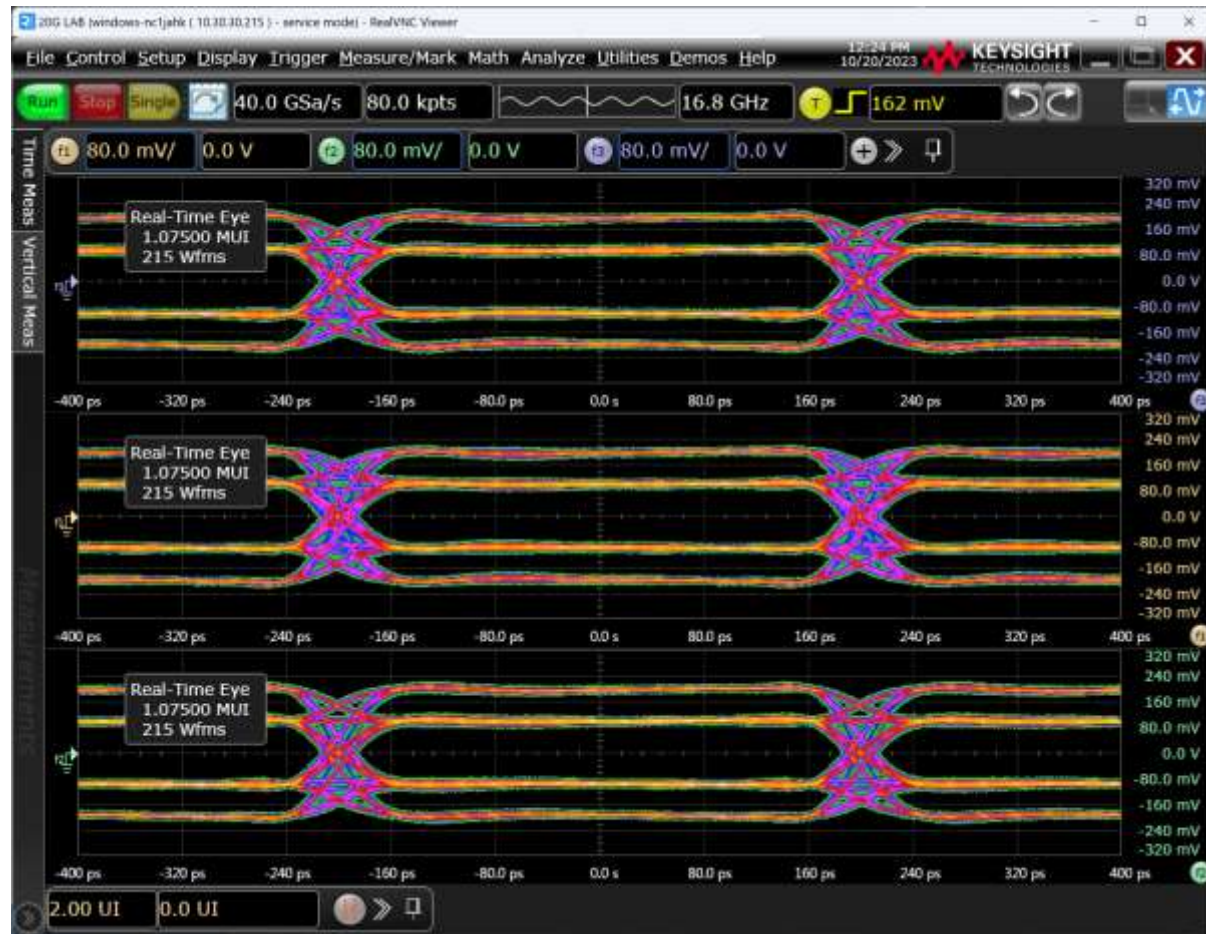
Test Procedure

```
1 mipiGenerator1.update()  
2 for t3pre in range(7,63,7):  
3     params1.preBeginNumUI = t3pre  
4     mipiGenerator1.update()  
5     waitForOkDialog(str(t3pre))
```

MIPI CPHY Csi2_v1_3 Run



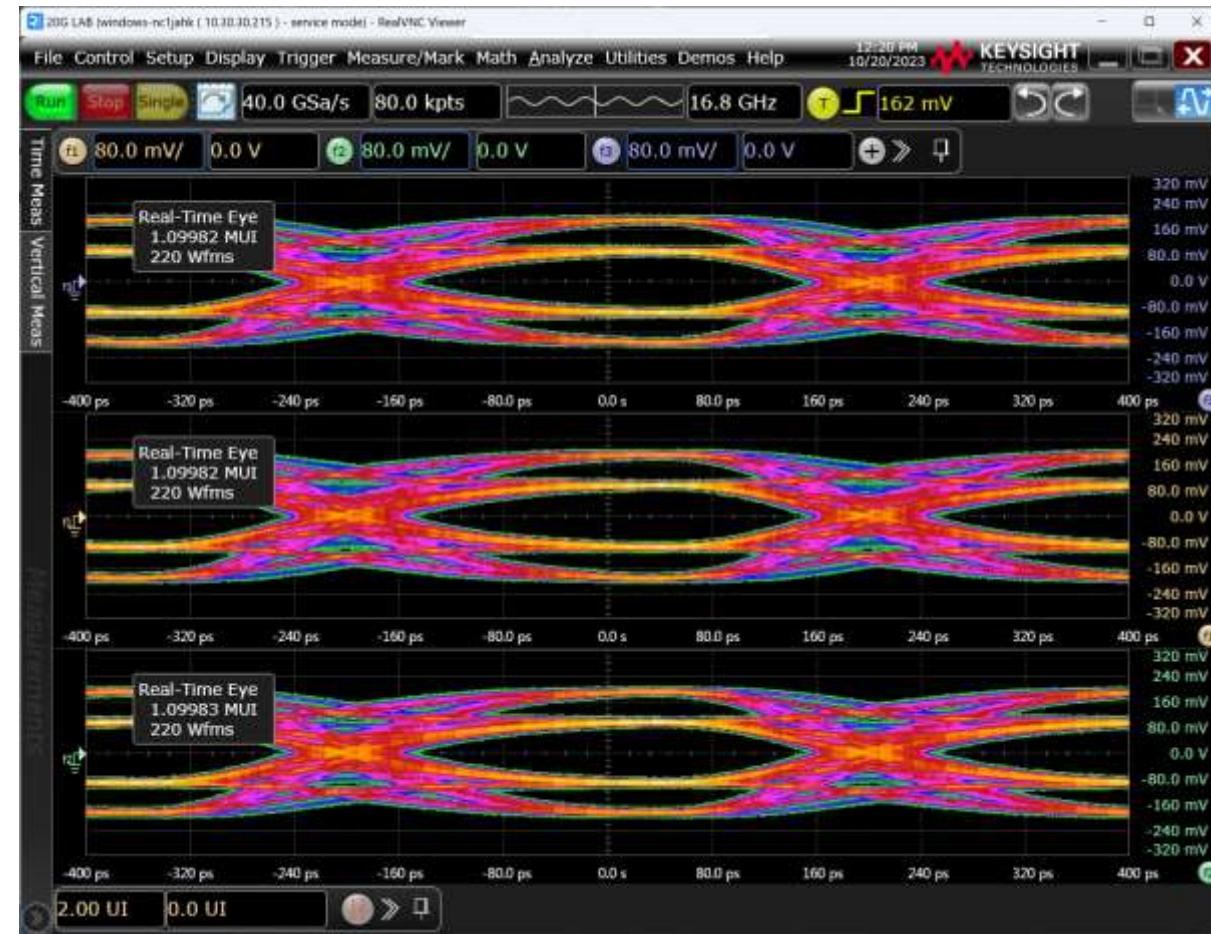
Advanced Waveform Shaping



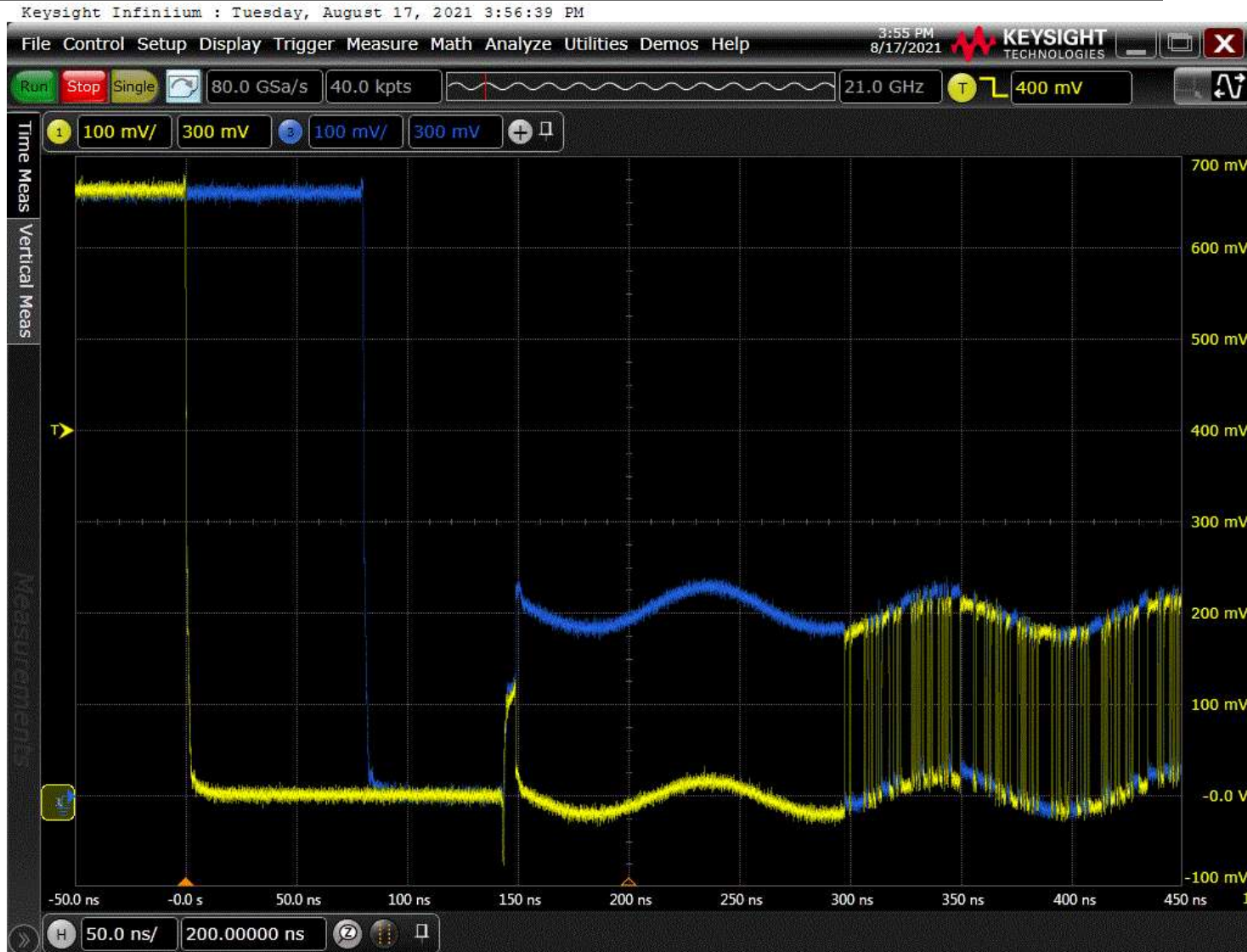
AB1

BC1

CA1

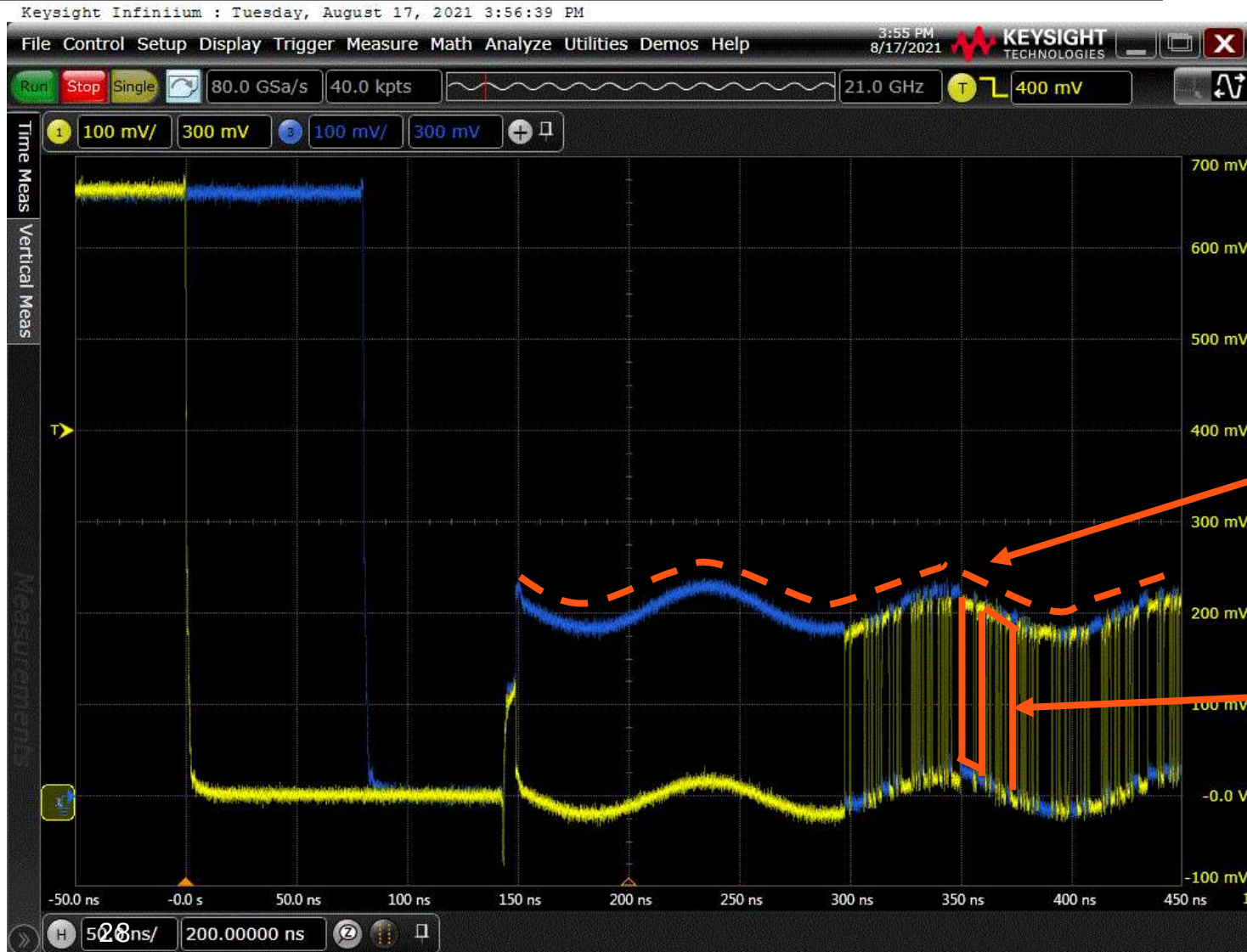


Advanced Waveform Shaping



Built-in AWG capability
without extra cost!

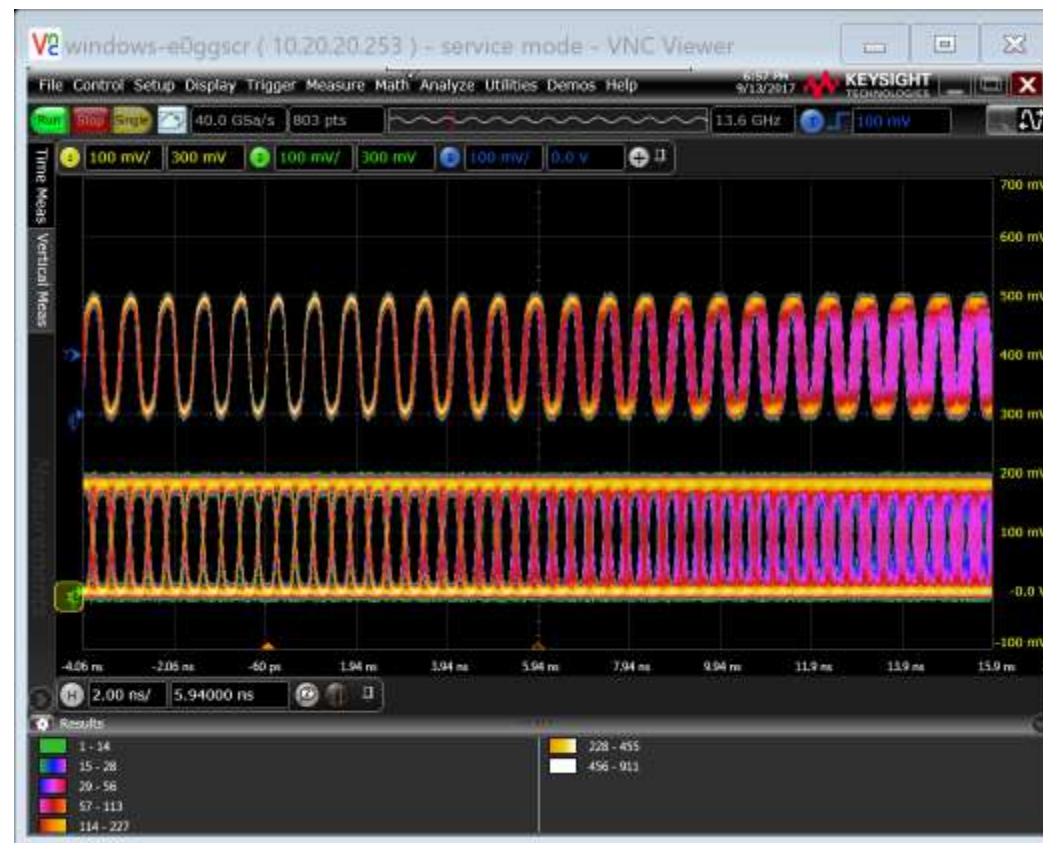
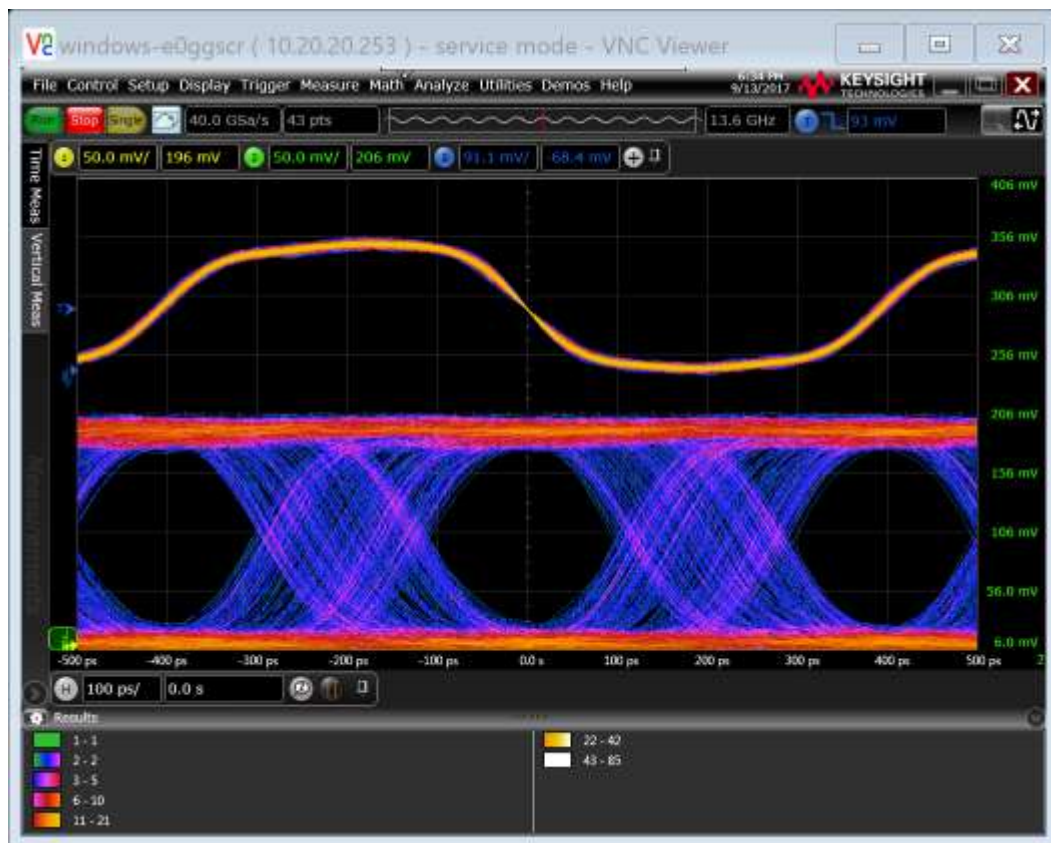
Advanced Waveform Shaping



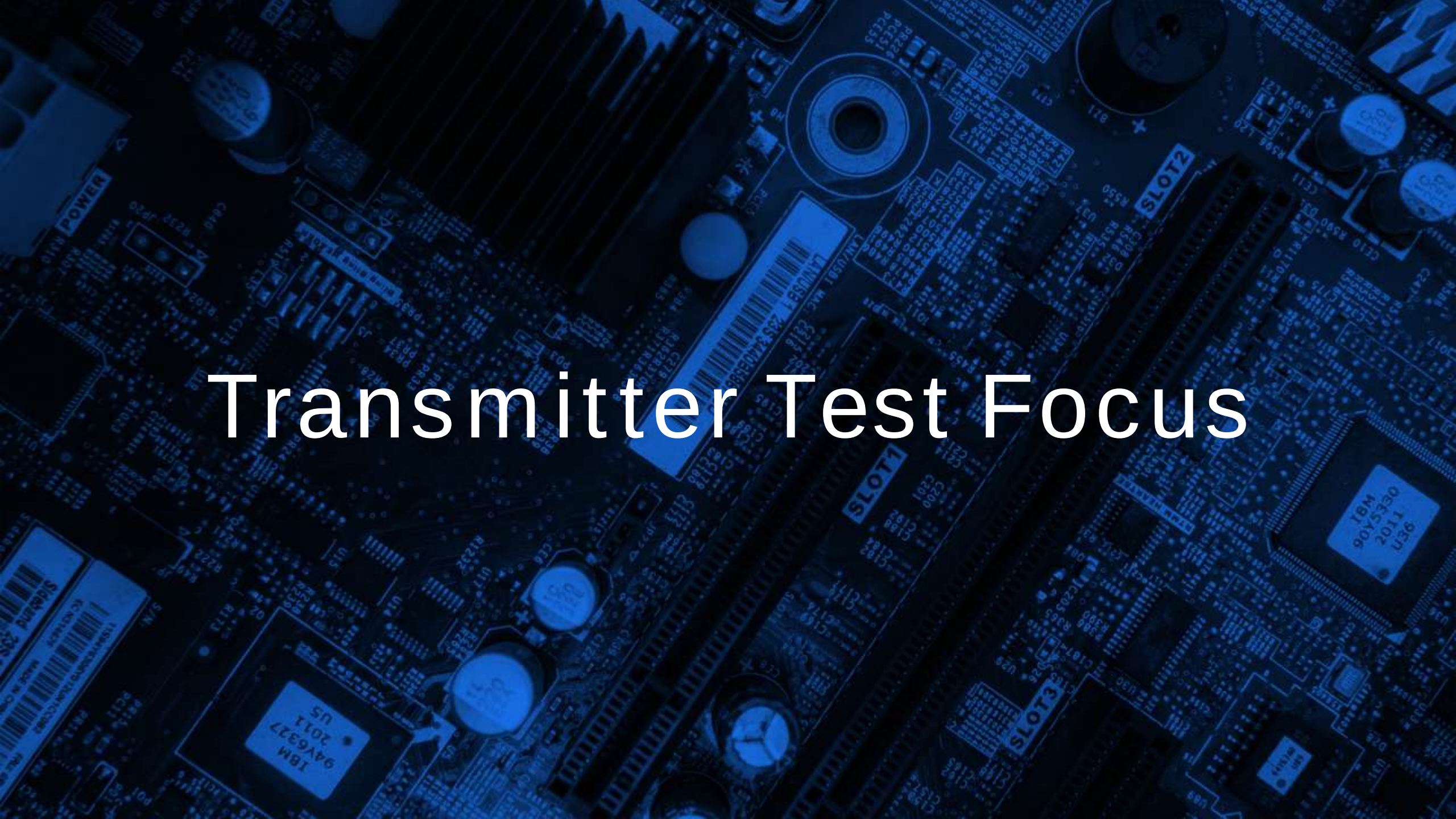
Impairment driven
by an internal AWG
circuit

Payload driven by a
pattern generator

Advanced Waveform Shaping



Jitter injection and frequency modulation are both needed for receiver stressed eye characterization



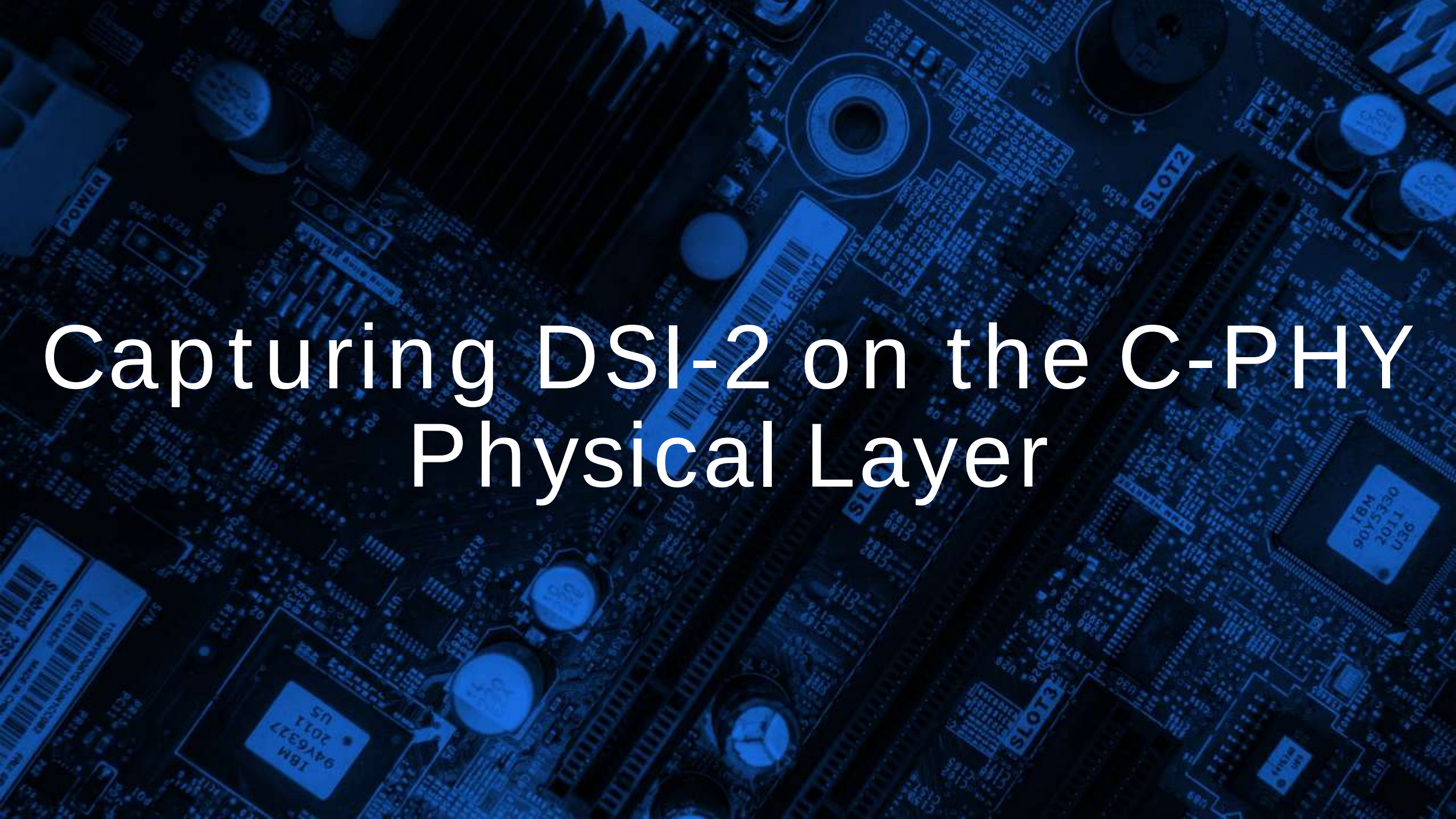
Transmitter Test Focus

Parallel PHY Tester

CSI-2 / DSI-2 Protocol Analyzer

Video Streamer





Capturing DSI-2 on the C-PHY Physical Layer

Phone Processor



Phone Display



Bus



RSH2 Active Probe



Result age < 1 day

Components

DSI Capture 5

dsiDataCapture1

DSI Capture 4

DSI Capture 3

DSI Capture 2

DSI Capture 1

Analog Capture

dsiDataCapture1

freqMeasurement1

laneList1

mipiClockConfig1

mipiDecompressionPara...

mipiDecompressionPara...

mipiDecompressionPara...

mipiProtocol

dsiDataCapture1

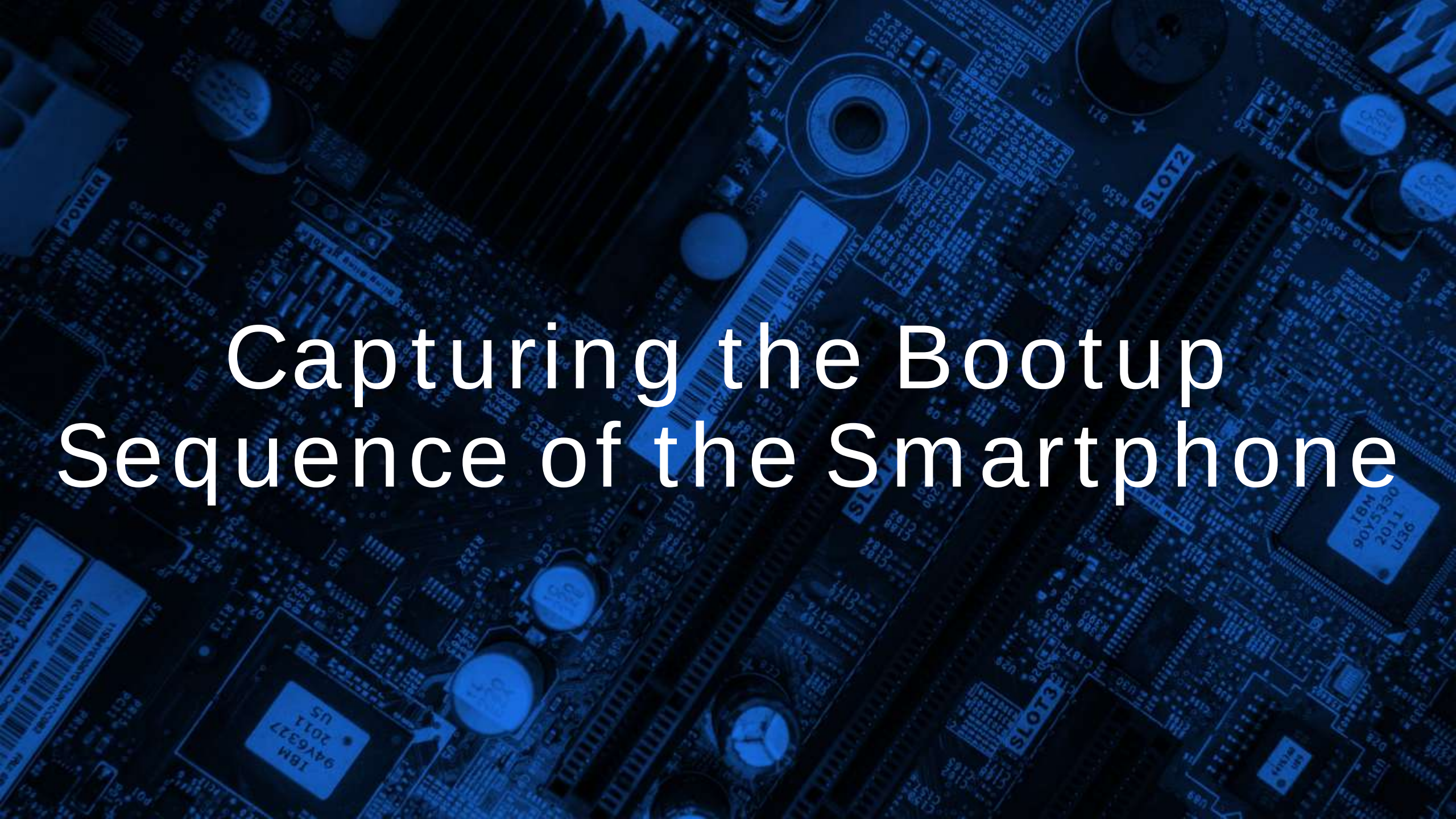
laneList	laneList1
lanes	[1-3]
captureMode	burst
triggerCondition	verticalSyncStart
preTriggerDuration	1e+04
postTriggerType	numberOfVerticalSyncStarts
postTriggerDuration	1
ignoreHsData	False
detectCalibrationPreambles	False
triggerTimeout	20
captureTimeout	20
defaultDcsImageHeight	
defaultDcsImageWidth	
defaultDcsPixelFormat	DSI_DCS_RG8888
wantAnalysis	True
wantCaptureWhenTimeout	False

Procedure

```
1 mipiClockConfig1.setup()  
2 dsiDataCapture1.run()  
3 #freqMeasurement1.run()
```

LOG

```
*** Logging to file: C:\Users\mmhaf\Documents\Introspect\Tests\Scripts\SalesDemos\cphy\OppoResults_26.3.b1_compatible  
\OppoResults_26.3.b1_compatible\Logs\log_2026-03-24_1638.txt  
***
```

Capturing the Bootup Sequence of the Smartphone

Result age < 1 day

DSI Capture 5

dsiDataCapture1

DSI Capture 4

DSI Capture 3

dsiDataCapture1

DSI Capture 2

DSI Capture 1

dsiDataCapture1

Analog Capture

Components

dsiDataCapture1

freqMeasurement1

laneList1

mipiClockConfig1

mipiDecompressionPara...

mipiDecompressionPara...

mipiDecompressionPara...

mipiProtocol

dsiDataCapture1

postTriggerType	numberOfVerticalSyncStarts
postTriggerDuration	1
ignoreHsData	False
detectCalibrationPreambles	False
triggerTimeout	20
captureTimeout	20
defaultDcsImageHeight	
defaultDcsImageWidth	
defaultDcsPixelFormat	DSI_DCS_RGB888
wantAnalysis	True
wantCaptureWhenTimeout	False
unscramblingEnabledAtStart	False
defaultCompressionType	DSC
decompressionParams	mipiDecompressionParams1
imageFileFormat	PNG
pixelDataFileMode	NONE

decompressionParams ⓘ

Parameters to use when capture compressed data that required for the decompression.

Procedure

```
1 mipiClockConfig1.setup()
2 dsiDataCapture1.run()
3 #freqMeasurement1.run()
```

LOG

```
*** Logging to file: C:\Users\mmhaf\Documents\Introspect\Tests\Scripts\SalesDemos\cphy\OppoResults_26.3.b1_compatible
\OppoResults_26.3.b1_compatible\Logs\log_2026-03-24_1638.txt
***
```




Capturing CSI-2 on the D-PHY Physical Layer

Demo Setup – The Cleanest Probing Solution

- Integrates up to 12 active probes into a single, shielded enclosure
- Eliminates a lot of cables/wires
- Reduces connection mistakes
- Does not require any external power supply



Example Remote Sampling Head

Result age < 1 day



Run_2025-09-24_1156

csiDataCapture1

Components

- csiDataCapture1
- laneList1
- mipiClockConfig1
- mipiProtocol
- pertMeasurement1
- rsh1

csiDataCapture1

laneList	laneList1
lanes	[1-4]
captureMode	burst
triggerCondition	frameStart
captureClock	False
preTriggerDuration	1e+04
postTriggerType	numberOfFrameEnds
postTriggerDuration	1
ignoreHsData	False
csiRawFormatBayerCell	BGGR
csiEpd	False
csiDecompressionParams	
wantCseProcessing	False
triggerTimeout	20
captureTimeout	20
wantAnalysis	True
wantCaptureWhenTimeout	False
imageFileFormat	PNG
pixelDataFileMode	NONE
saveResults	True

triggerCondition

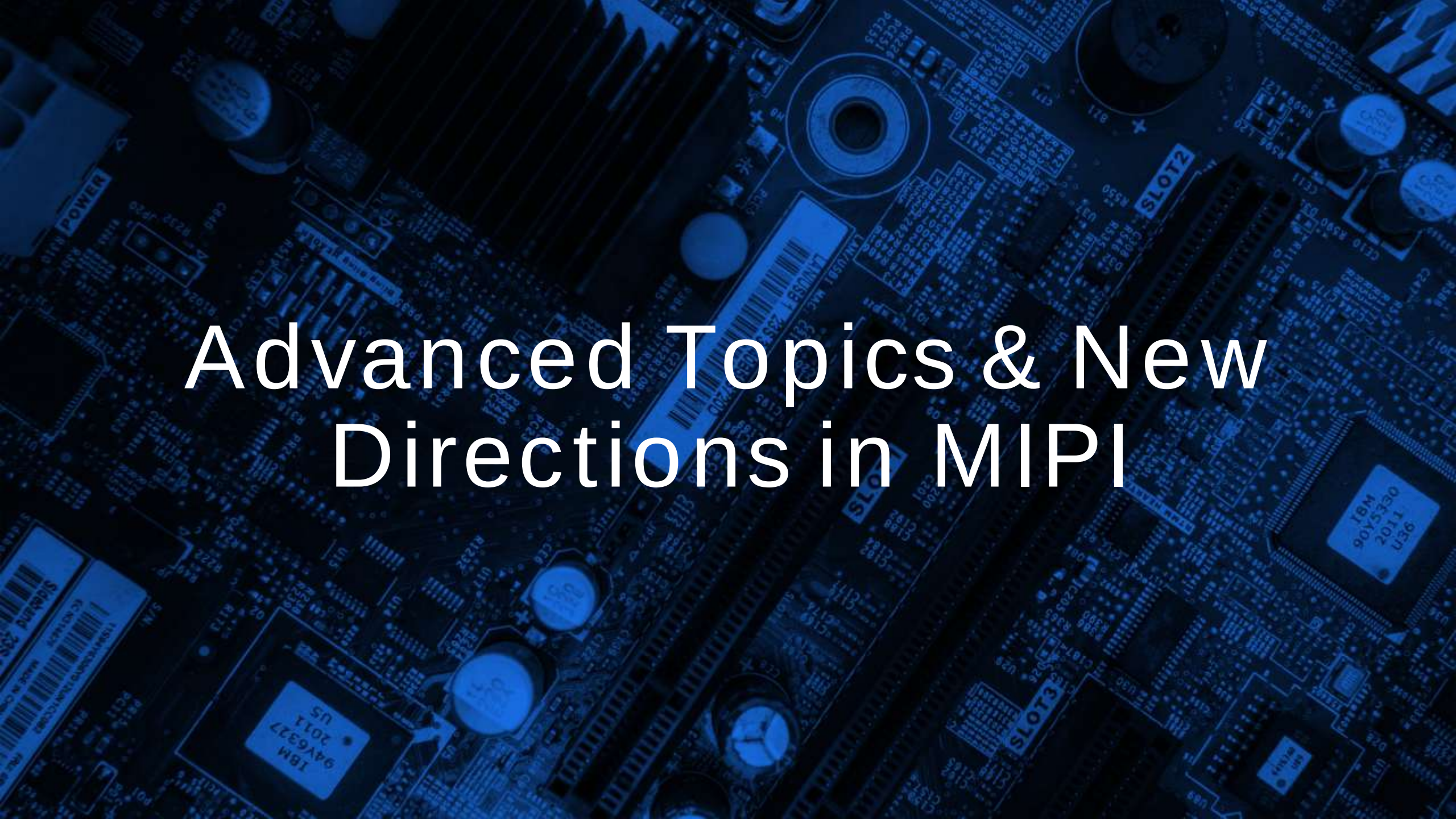
The "triggerCondition" specifies what will trigger the data capture when the "captureMode" is "burst".

Procedure

```
1 mipiClockConfig1.setup()  
2 csiDataCapture1.run()
```

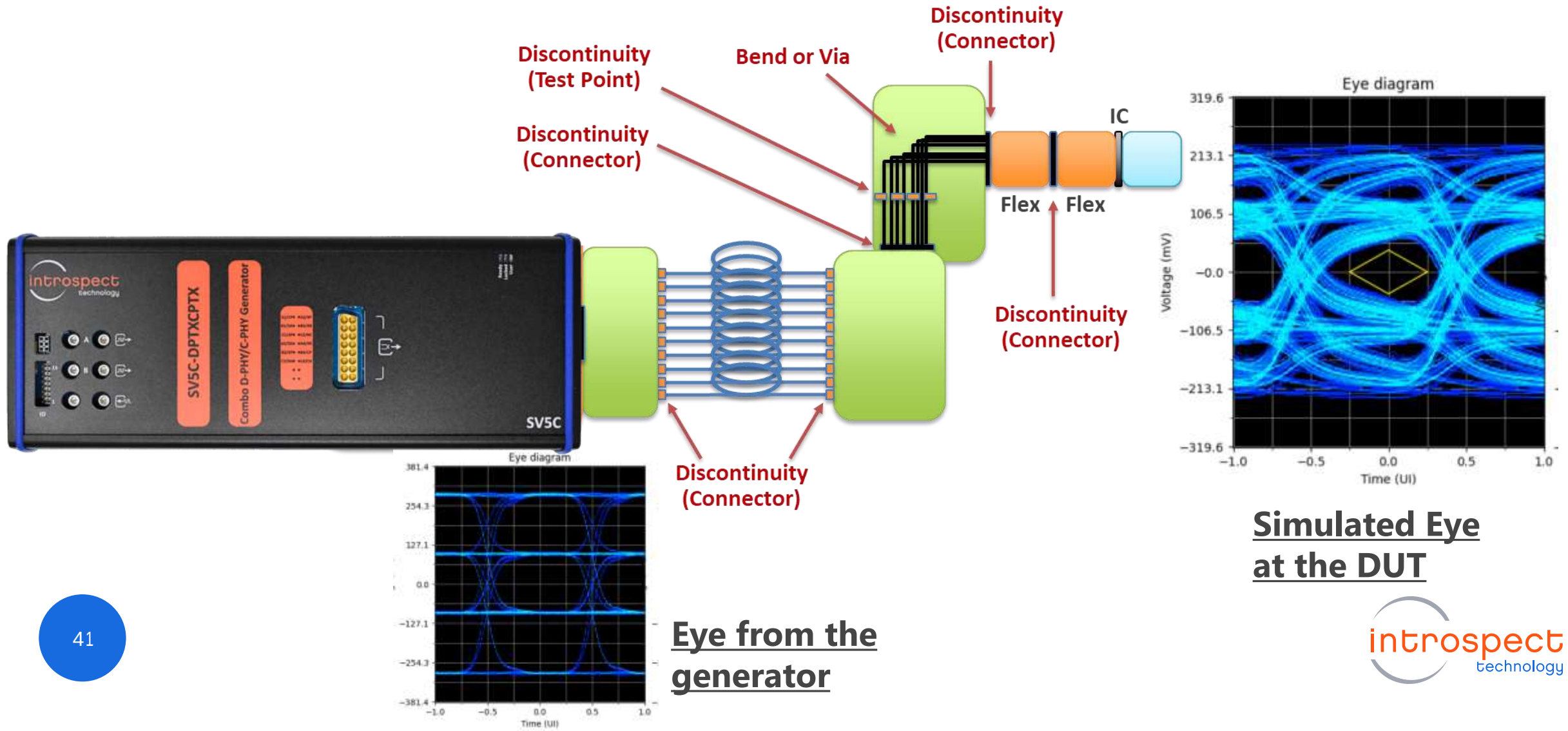
LOG

```
*** Logging to file: C:\Users\mmhaf\Documents\Introspect\Tests\Scripts\SalesDemos\dphy\SV5_phoneCamera_1res\Logs\log_2026-03-24_1755.txt  
***
```

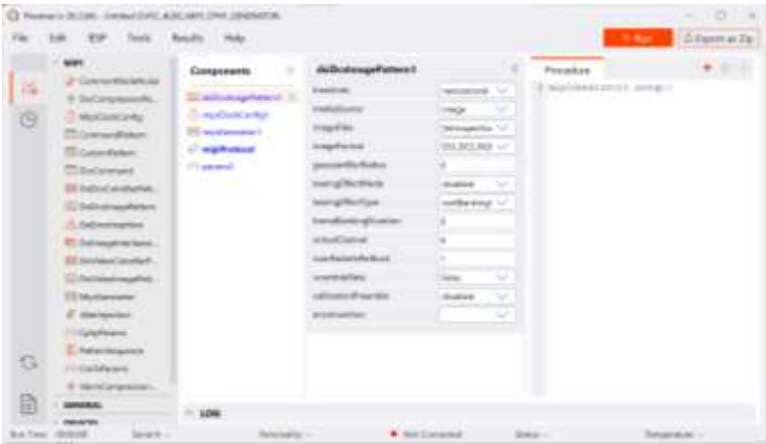



Advanced Topics & New Directions in MIPI

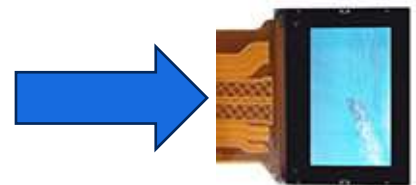
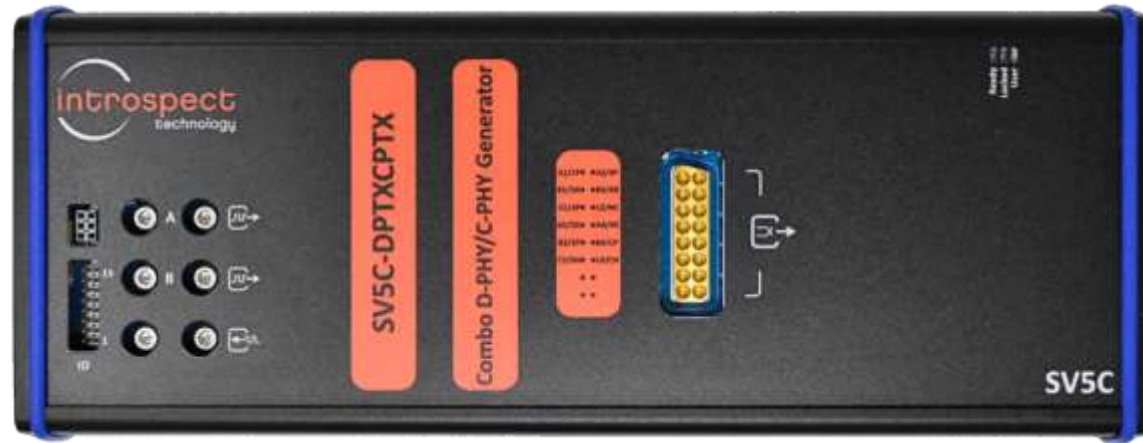
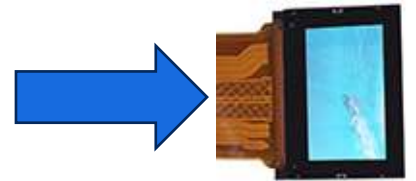
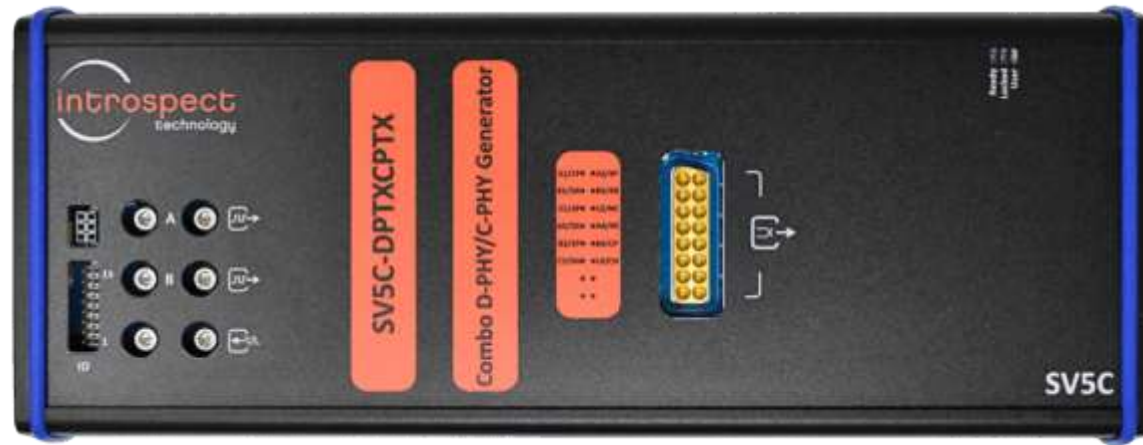
Channel Analysis (Simulation) in Pinetree



Native Support for Dual Links in Pinetree

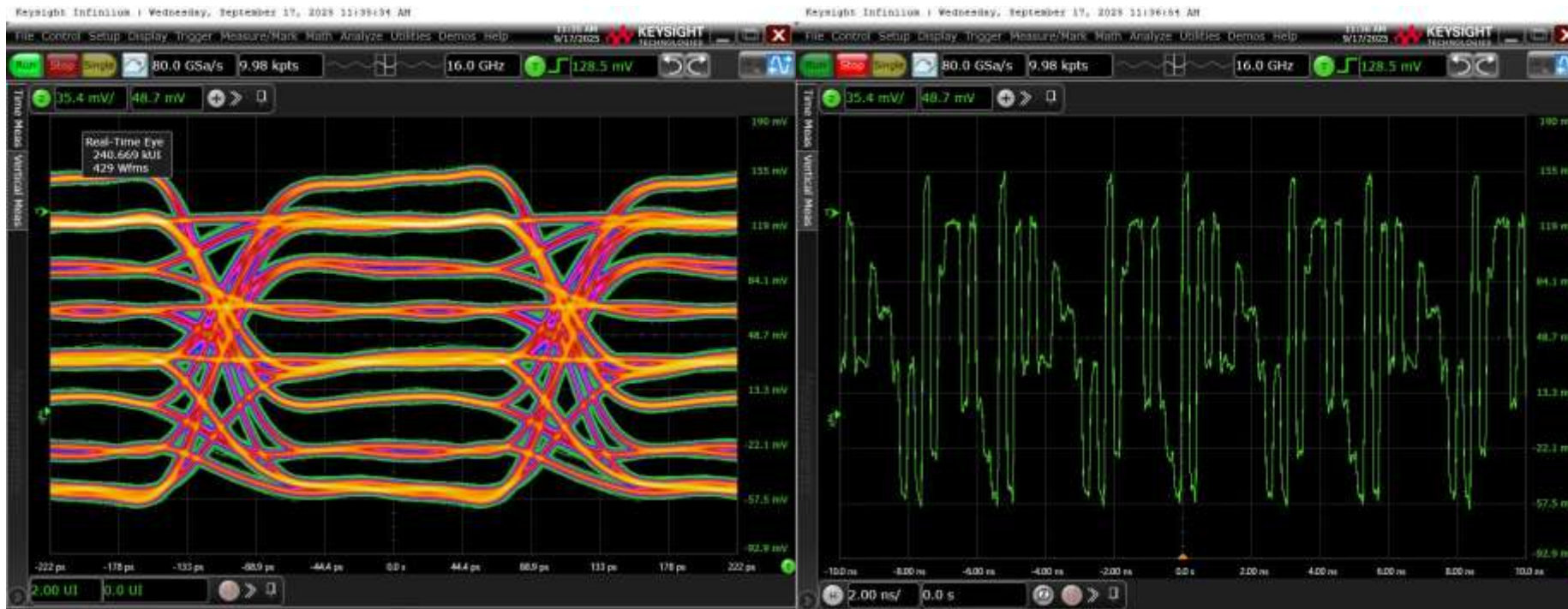


Single Pinetree Instance



Trends from MIPI Alliance

- Multi-drop links (multiple CSI-2 cameras on a single set of wires)
- C-PHY v3.0 with 18 wirestates!





Conclusion

MARKET-LEADING TESTERS FOR MIPI

- MIPI technology is running at high data rates and requires sophisticated signal conditioning
- Traditional test setups are cumbersome and not accurate
- Introspect's revolutionary instruments provide the cleanest bench environment for design validation and characterization
- Dedicated tools exist for receiver testing, transmitter testing, and interoperability testing