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# MIPI CSI and DSI Solutions

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September 25th, 2024

# Agenda

1. Introduction
2. Solutions for CSI/DSI Protocol Analysis and Debug
3. Solutions for CSI/DSI Receiver Characterization
4. MIPI Product Comparison



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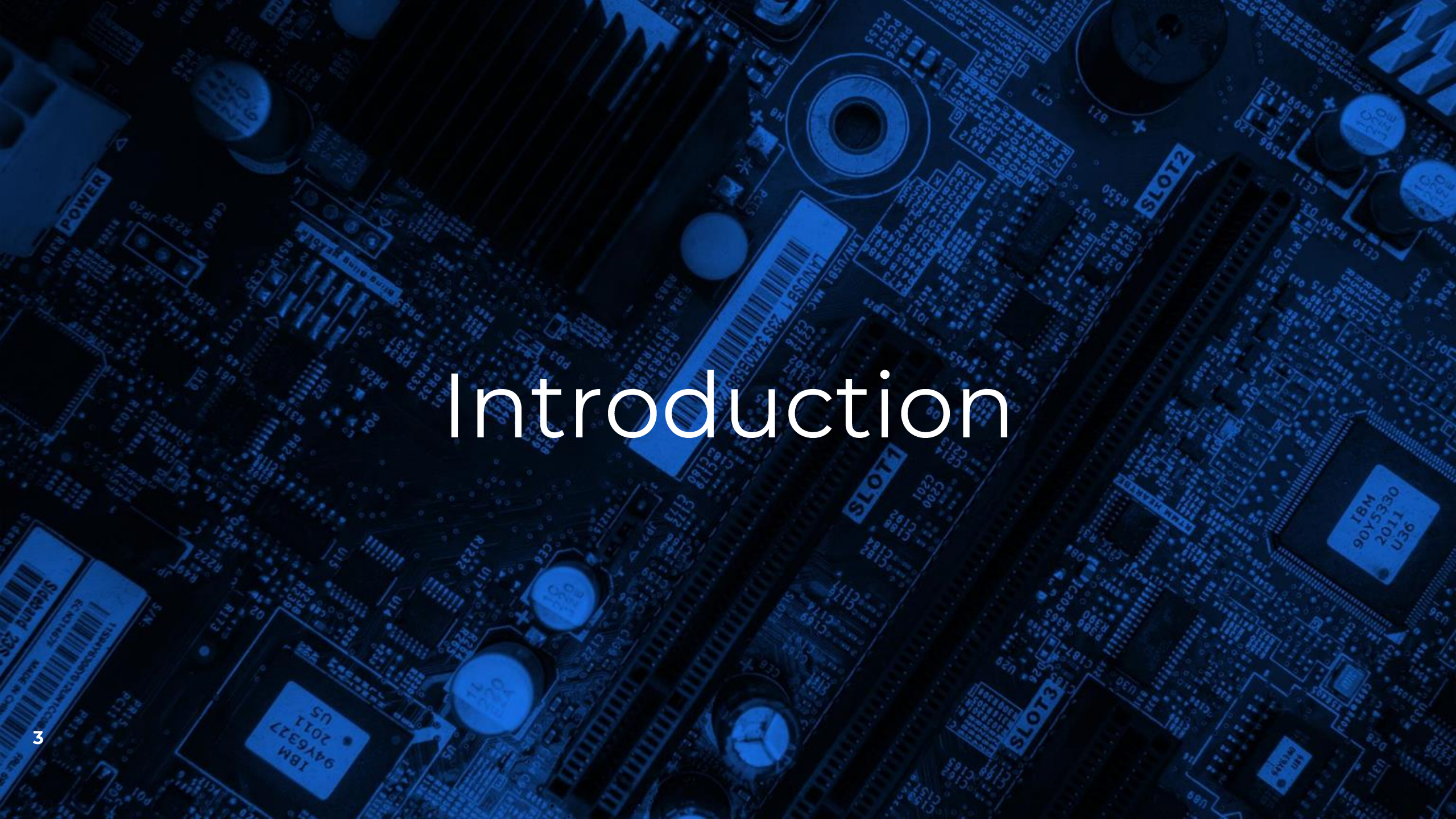
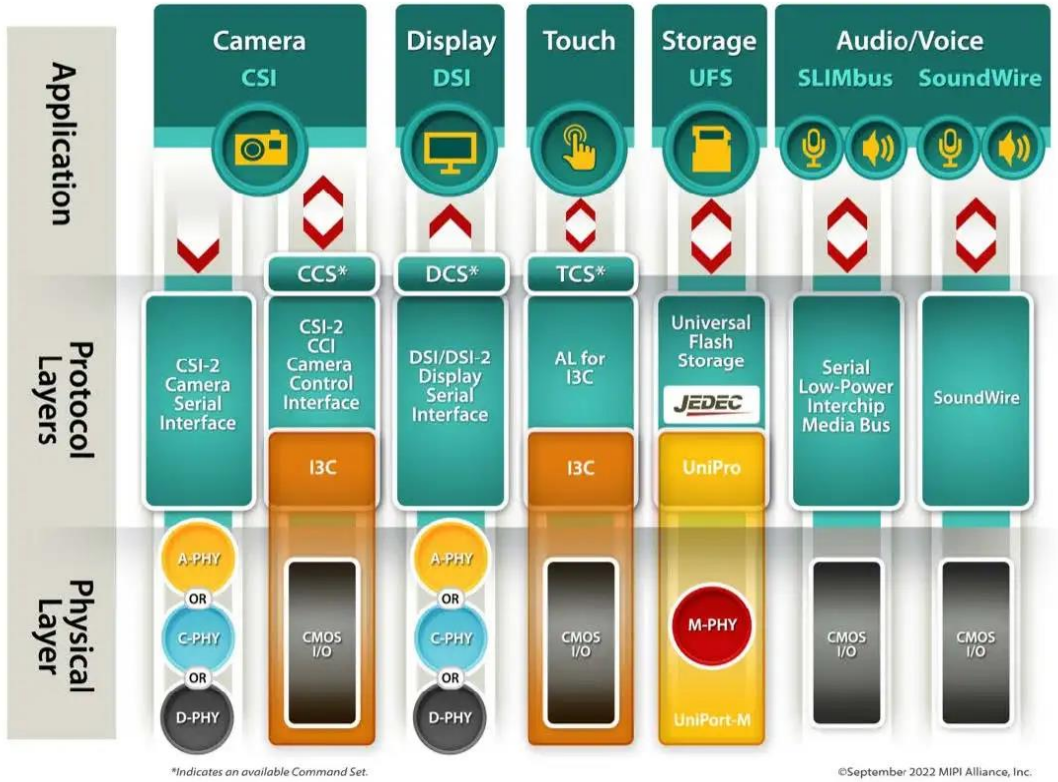



# Introduction

# MIPI DSI and CSI

- DSI (Display Serial Interface): packet-based communication protocol between an application processor (source) and a display panel (sink)
- CSI (Camera Serial Interface): protocol defines communication between a camera and host processor
- Both specifications can utilize either D-PHY or C-PHY as the physical layers to transmit data
- Protocols widely adopted by phone and display manufacturers



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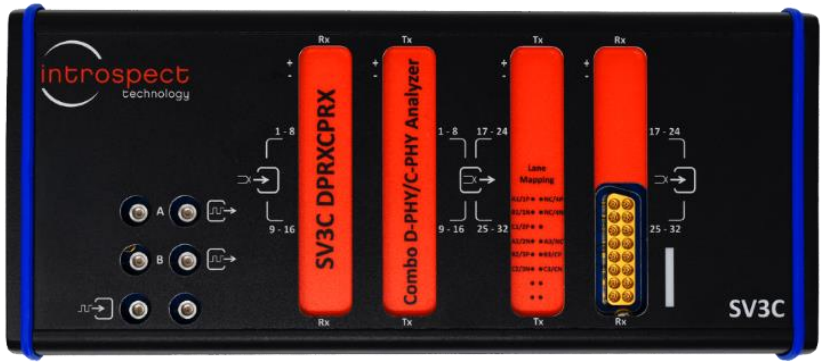
# Solutions for CSI-2 & DSI-2 (Over D-PHY/C-PHY)

SV4E

SV3C




SV5C

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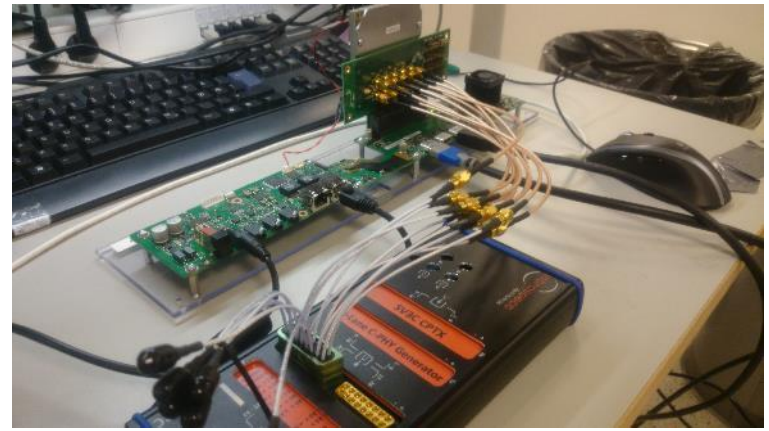
# Covering the Entire Spectrum of Test Requirements

## ELECTRICAL CHARACTERIZATION

## DESIGN VALIDATION

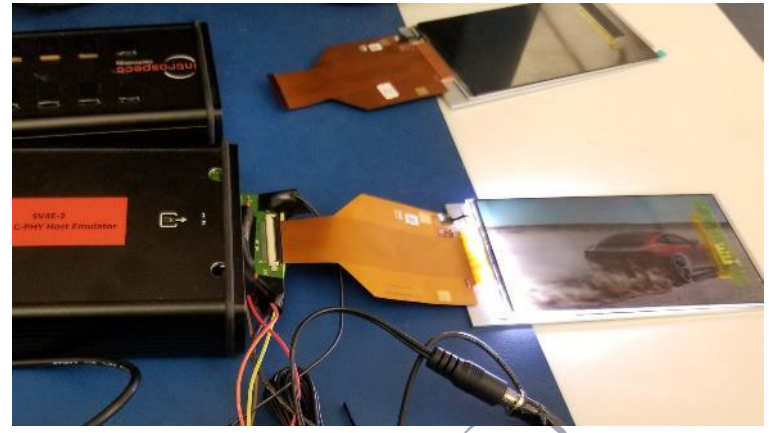
## APPLICATIONS ENGINEERING



## PRODUCTION TESTING

## FAILURE ANALYSIS

## SYSTEM-LEVEL TEST





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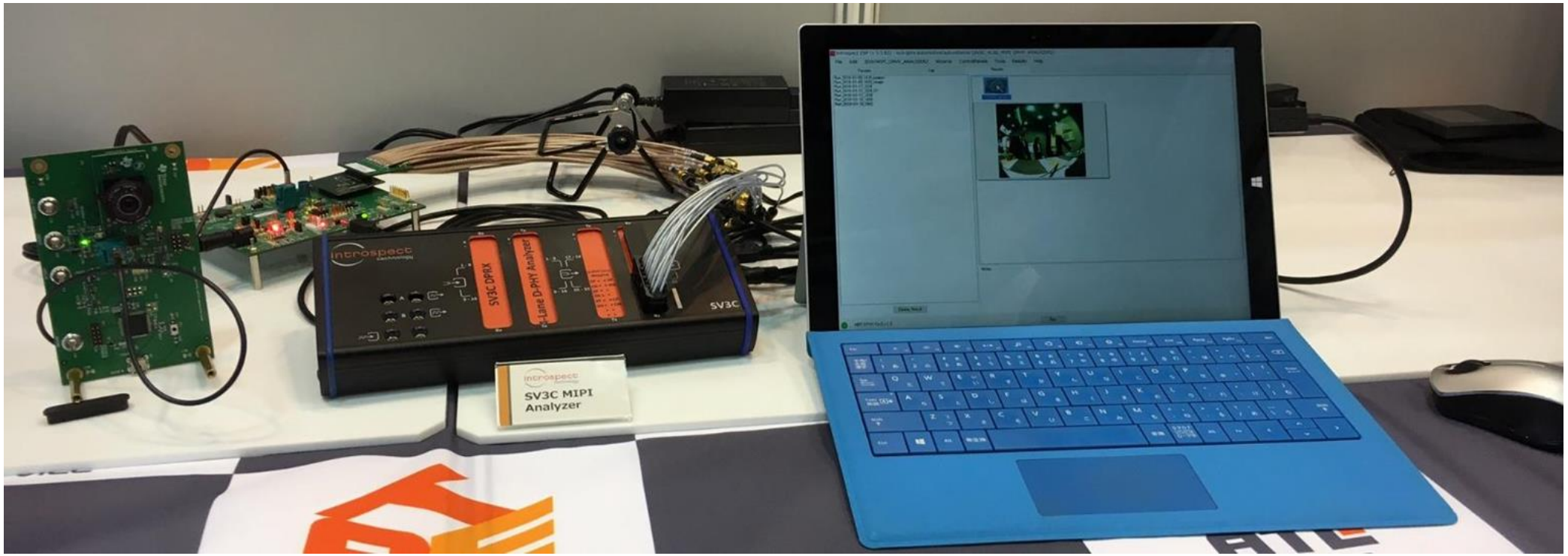
# Working with Introspect Solutions

**DEVICE UNDER TEST**

**MIPI SV3C ANALYZER**

**INTROSPECT ESP SOFTWARE**



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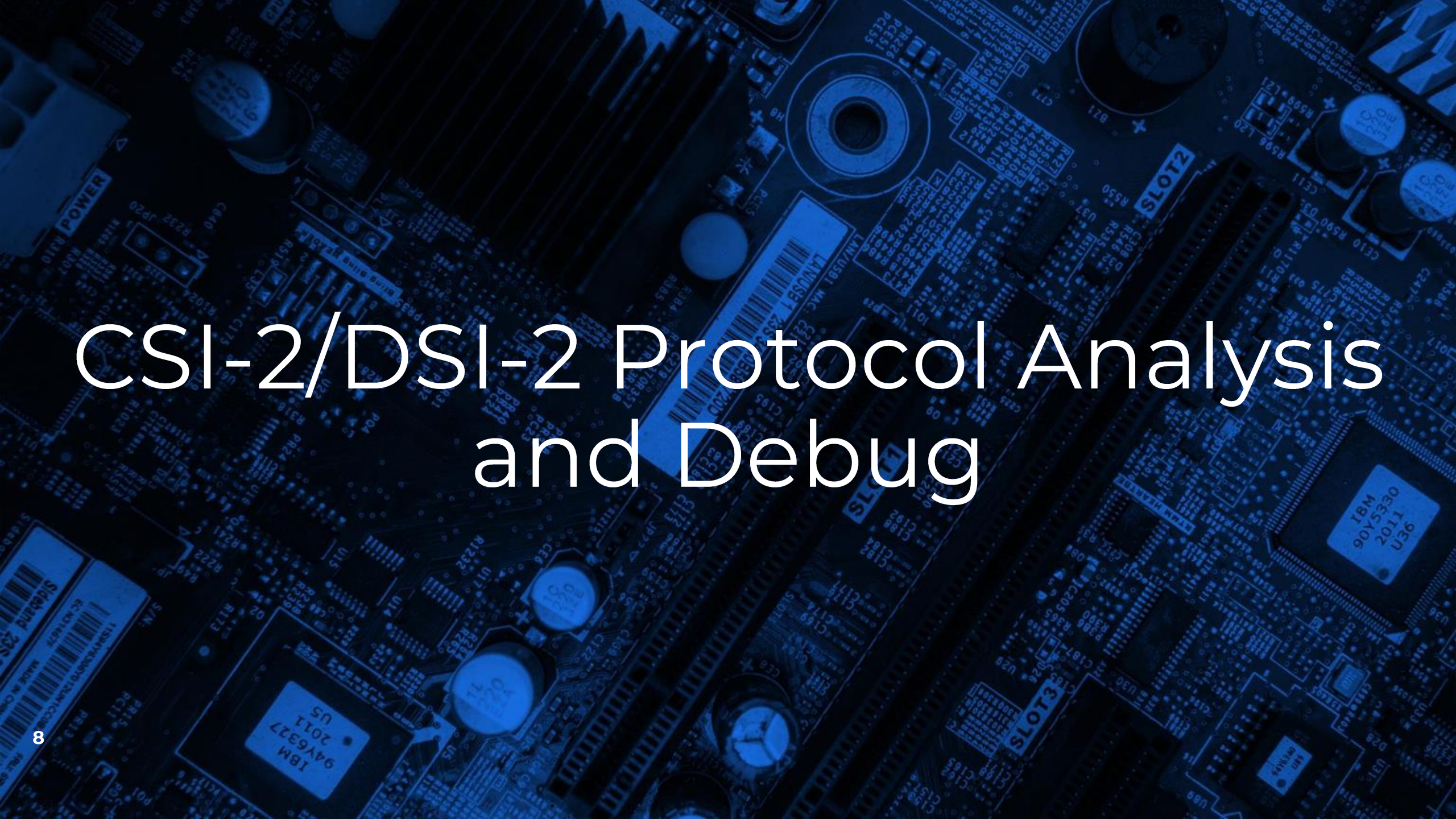
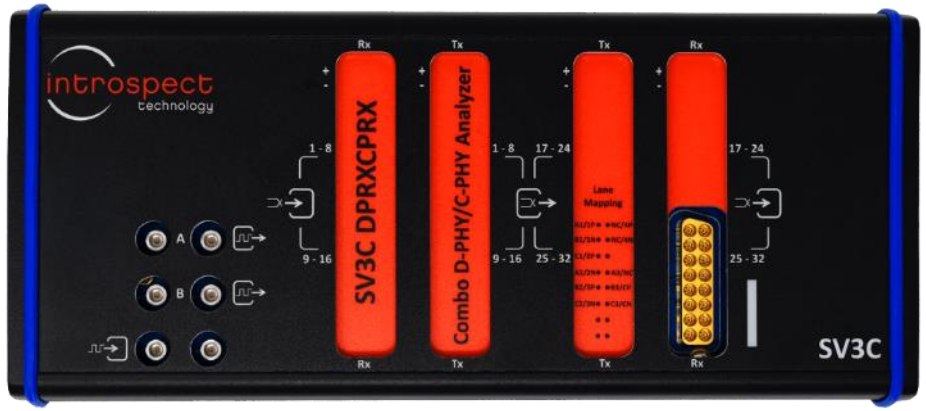


# CSI-2/DSI-2 Protocol Analysis and Debug

C SERIES

# SV3C DPRX-CPRX

Combo MIPI D-PHY/C-PHY Analyzer




## OVERVIEW

Protocol analyzer and debug solution

Completely capable of analyzing physical layer digital interface, protocol layer digital interface, and image sensor array quality

Includes I2C bus and tearing effect triggers

## BENEFITS

- Self-contained solution for DSI-2/CSI-2 link validation
- Automatic image extraction for any pixel type and any resolution
- Automatic compression detection for DSI (including reacting to PPS tables on the fly)

## FEATURES

- Continuous data rate range from 80 Mbps to 3.5 Gsps with ppm resolution
- Tracks SSC waveform for D-PHY 2.1 image sensors
- Up to 8 Gbyte of frame data storage
- High-speed USB3 link to control PC for rapid image extraction

C SERIES

# SV5C DPRX-CPRX

Combo MIPI D-PHY/C-PHY Analyzer

## OVERVIEW

**Number of Signal/Data Analyzers:** 4

**Maximum Per-Lane Data Rate:** 6.5 Gsps in C-PHY mode, 8.7 Gbps in D-PHY mode

**Popular Solutions:** D-PHY up to v3.0, C-PHY up to v2.1

## BENEFITS

- High-level CSI-2 and DSI-2 protocol capture and analysis
- Analog waveform capture on received LP and HS data
- PHY-level burst-mode and continuous-mode analysis with advanced triggering options

## FEATURES

- Continuous data rate range from 80 Mbps to 6.5 Gsps with ppm resolution
- Tracks SSC waveform for D-PHY 2.1 image sensors
- Up to 8 Gbyte of frame data storage
- High-speed USB3 link to control PC for rapid image extraction



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E SERIES

# SV4E DPRX-CPRX

MIPI Receive Device Emulator

## OVERVIEW

Test module for receiving DSI-2/CSI-2 data

Automatically detects video parameters

## BENEFITS

- Full MIPI coverage with native physical layer and protocol layer for DSI-2/CSI-2
- Self-contained system enables true system-like testing
- Complete software environment enables full automation

## FEATURES

- Up to 2.5 Gbps / 2.5 Gsps per lane
- Truly compact design with dimensions of 140 mm x 189 mm
- Flexible programming environment that supports automation



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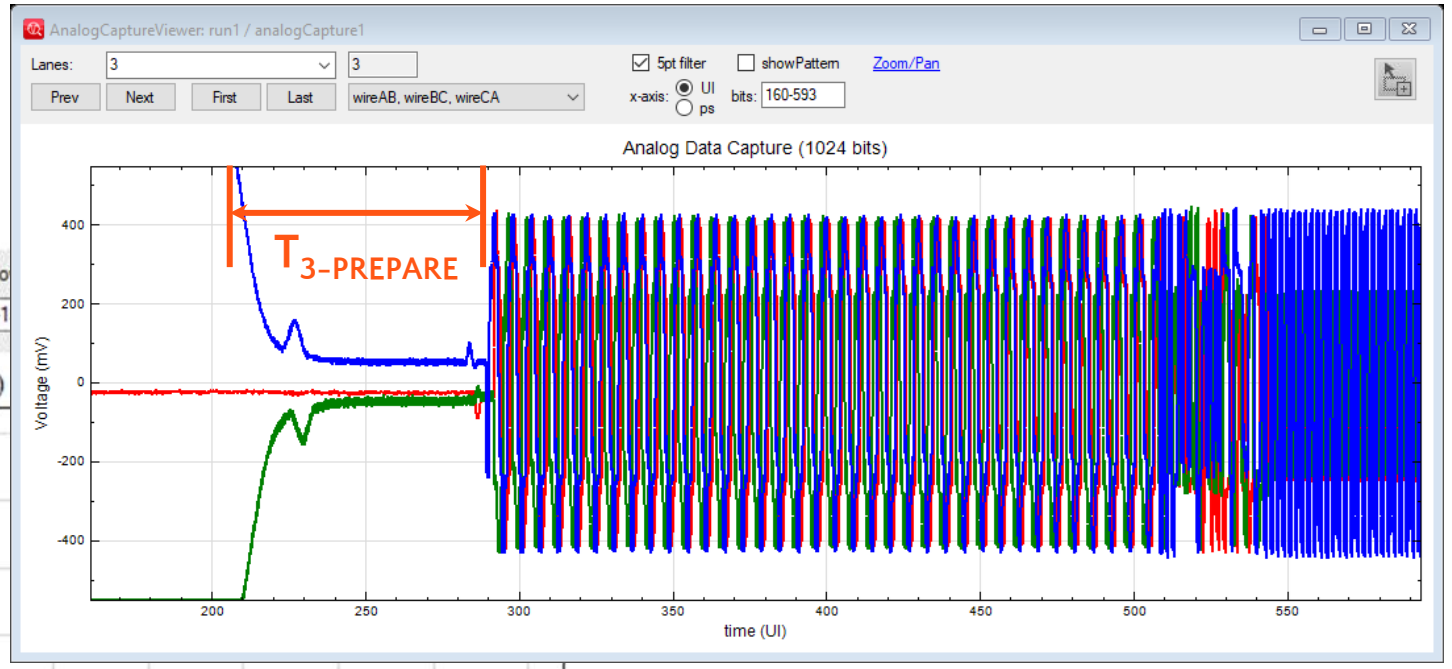
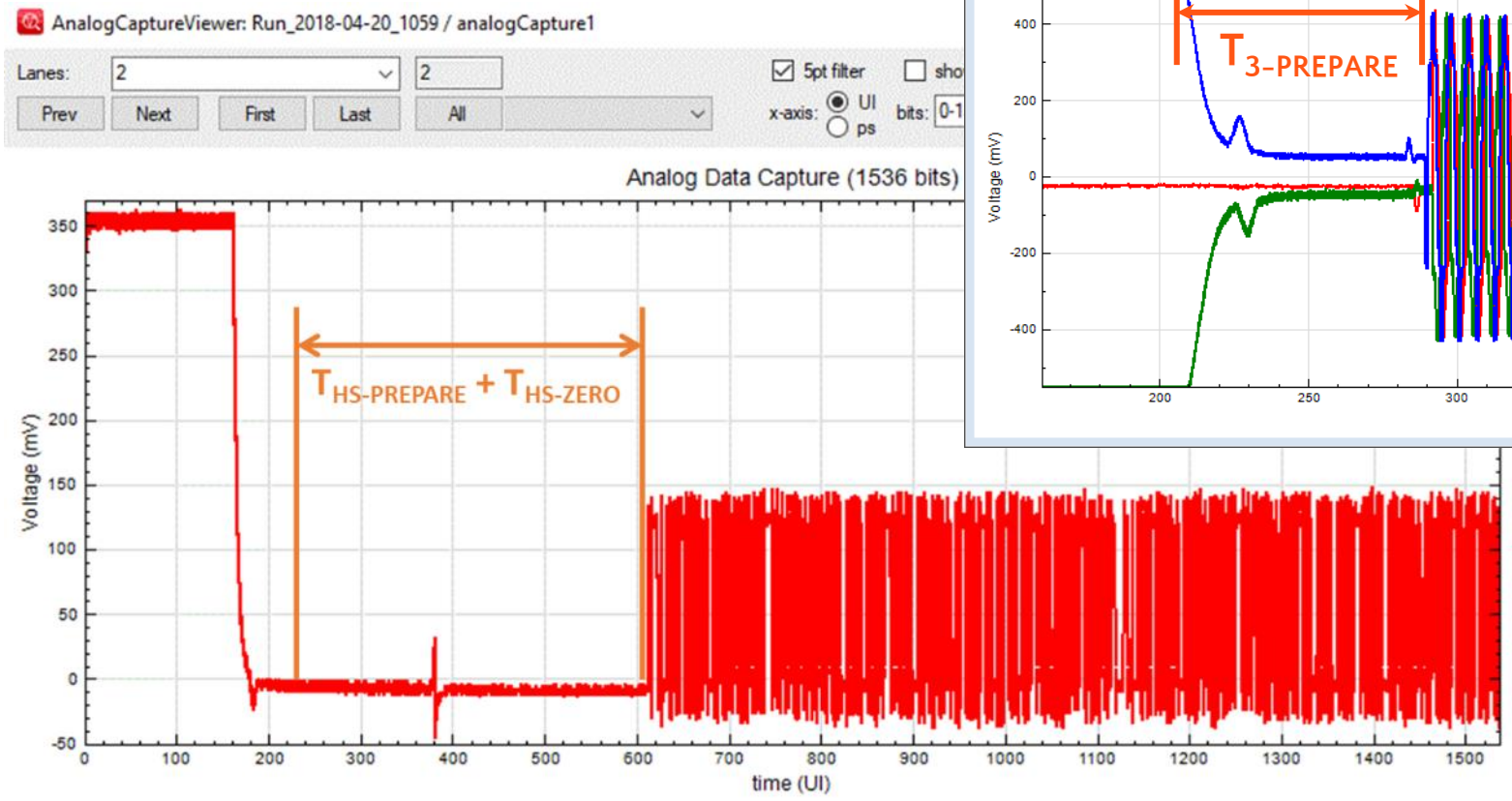
# Physical Layer Analysis




*C-PHY*




*D-PHY*



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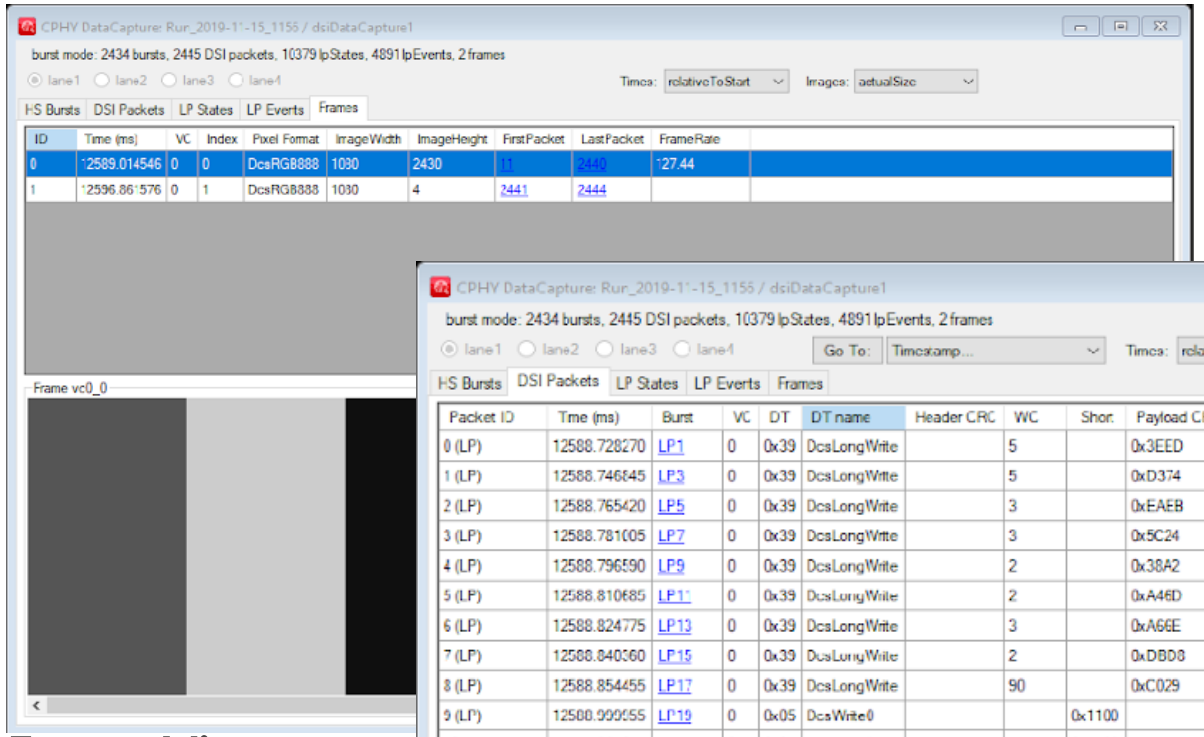
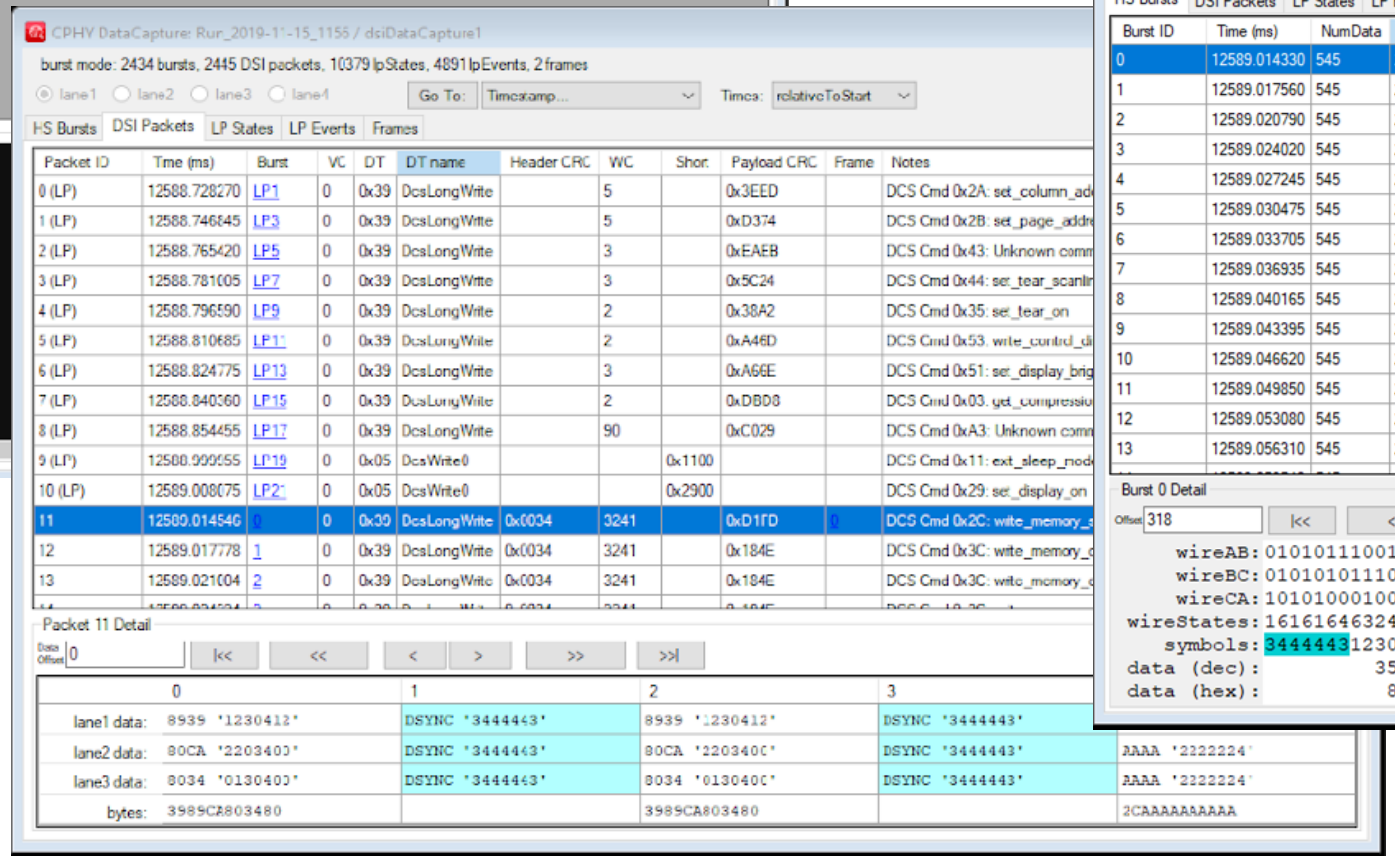
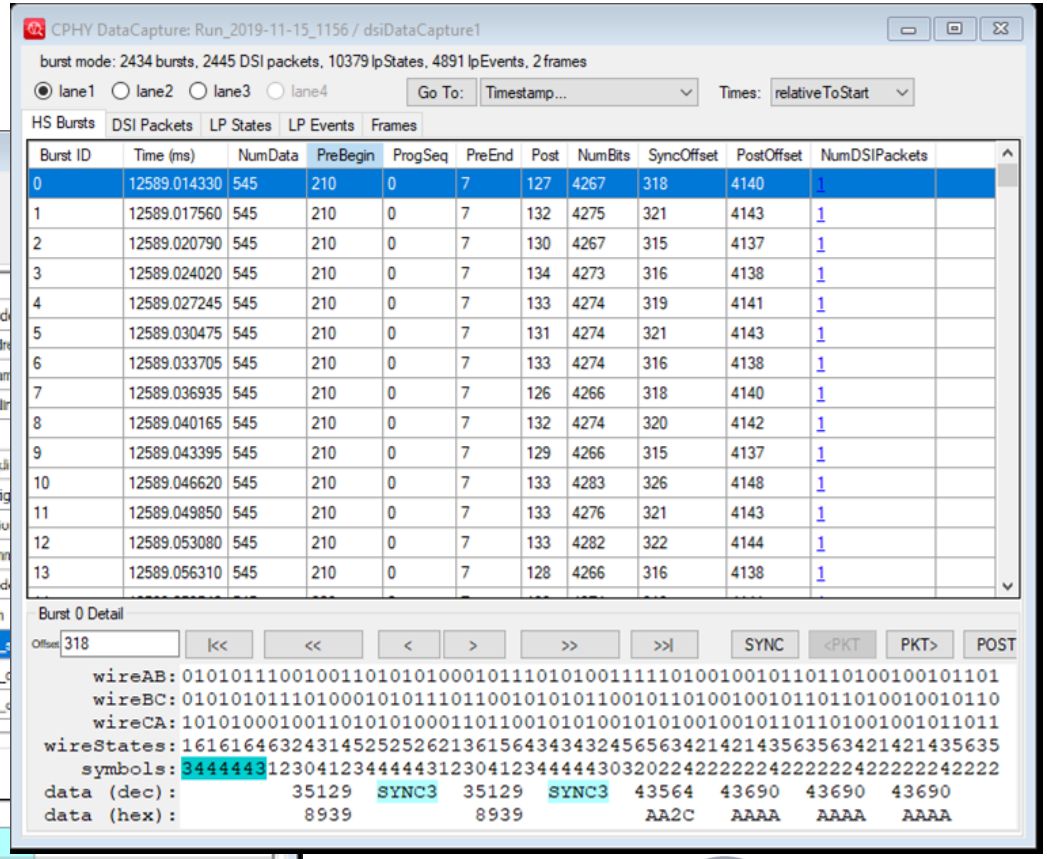
# Hierarchical Protocol Analysis




Frame View




Packet View




Burst View



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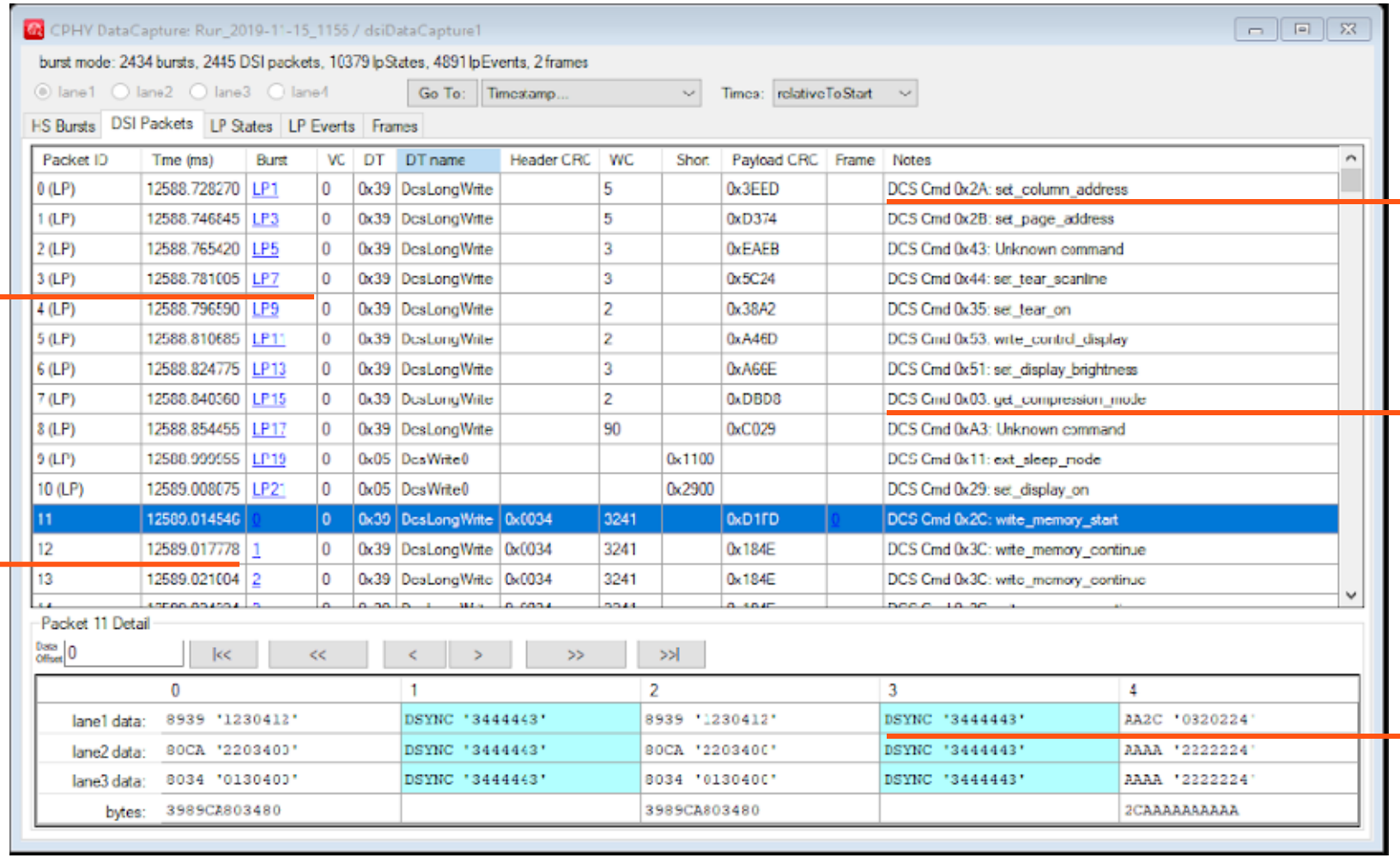
# More on the Protocol Analysis View

Hyperlinks to PHY-layer tabs

High resolution timestamps




Decodes DCS commands

Supports both DSC and V-DCM Compression

Supports all SYNC types and all advanced preamble sequences



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# Live Phone Debug

DPHY DataCapture: Run_2019-05-08_1437 / dsiDataCapture1

burst mode: 961 bursts, 1062 DSI packets (7 errors), 15109 lpStates, 1939 lpEvents, 2 frames

lane1 lane2 lane3 lane4 Go To: Next Error Times: relativeToStart

HS Bursts | DSI Packets | LP States | LP Events | Frames

| Packet ID | Time (ms) | Burst | VC | DT | DT name | Header ECC | WC | Payload CRC | Short | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 88 (LP) | 4337.588635 | LP 12 | 0 | 0x15 | DcsWrite1 | 0x19 | | | 0x0000 | DCS Cmd 0x00: nop |
| 89 (LP) | 4337.588635 | LP 12 | 0 | 0x39 | DcsLongWrite | 0x33 | 17 | 0xA372 | | DCS Cmd 0xE2: Unknown command |
| 90 (LP) | 4337.588635 | LP 12 | 0 | 0x15 | DcsWrite1 | 0x25 | | | 0x1100 | DCS Cmd 0x11: exit_sleep_mode |
| 91 (LP) | 4457.581645 | LP 14 | 0 | 0x15 | DcsWrite1 | 0x02 | | | 0x3A55 | DCS Cmd 0x3A: set_pixel_format |
| 92 (LP) | 4457.587790 | LP 16 | 0 | 0x15 | DcsWrite1 | 0x31 | | | 0x3660 | DCS Cmd 0x36: set_address_mode |
| 93 (LP) | 4457.587790 | LP 16 | 0 | 0x39 | DcsLongWrite | 0x36 | 5 | 0xDEAF | | DCS Cmd 0x2A: set_column_address |
| 94 (LP) | 4457.587790 | LP 16 | 0 | 0x39 | DcsLongWrite | 0x36 | 5 | 0x2057 | | DCS Cmd 0x2B: set_page_address |
| 95 (LP) | 4457.587790 | LP 16 | 0 | 0x15 | DcsWrite1 | 0x07 | | | 0x517F | DCS Cmd 0x51: set_display_brightness |
| 96 (LP) | 4457.587790 | LP 16 | 0 | 0x15 | DcsWrite1 | 0x30 | | | 0x532C | DCS Cmd 0x53: write_control_display |
| 97 (LP) | 4457.587790 | LP 16 | 0 | 0x15 | DcsWrite1 | 0x1E | | | 0x5502 | DCS Cmd 0x55: write_power_save |
| 98 (LP) | 4457.587790 | LP 16 | 0 | 0x15 | DcsWrite1 | 0x3C | | | 0x5EFF | DCS Cmd 0x5E: set_CABC_min_brightness |
| 99 | 4457.631531 | 0 | 0 | 0x15 | DcsWrite1 | 0x0F | | | 0x2900 | DCS Cmd 0x29: set_display_on |
| 100 | 4457.631563 | 0 | 0 | 0x15 | DcsWrite1 | 0x19 | | | 0x0000 | DCS Cmd 0x00: nop |
| 101 | 4457.631595 | 0 | 0 | 0x15 | DcsWrite1 | 0x36 | | | 0x2C00 | DCS Cmd 0x2C: write_memory_start |
| 102 | 4460.039312 | 1 | 0 | 0x39 | DcsLongWrite | 0x36 | 5 | 0xAE02 | | DCS Cmd 0x2A: set_column_address |
| 103 | 4460.040067 | 2 | 0 | 0x39 | DcsLongWrite | 0x36 | 5 | 0x2057 | | DCS Cmd 0x2B: set_page_address |
| 104 | 4460.059573 | 3 | 0 | 0x39 | DcsLongWrite | 0x2E | 401 | 0x705C | | DCS Cmd 0x2C: write_memory_start |
| 105 | 4460.069777 | 4 | 0 | 0x39 | DcsLongWrite | 0x2E | 401 | 0x7516 | | DCS Cmd 0x3C: write_memory_continue |
| 106 | 4460.079971 | 5 | 0 | 0x39 | DcsLongWrite | 0x2E | 401 | 0x2616 | | DCS Cmd 0x3C: write_memory_continue |

Packet 0 Detail

Data Offset 0 |<< << < > >> >>|

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|



Setups like this are used for sample testing on phone assembly lines

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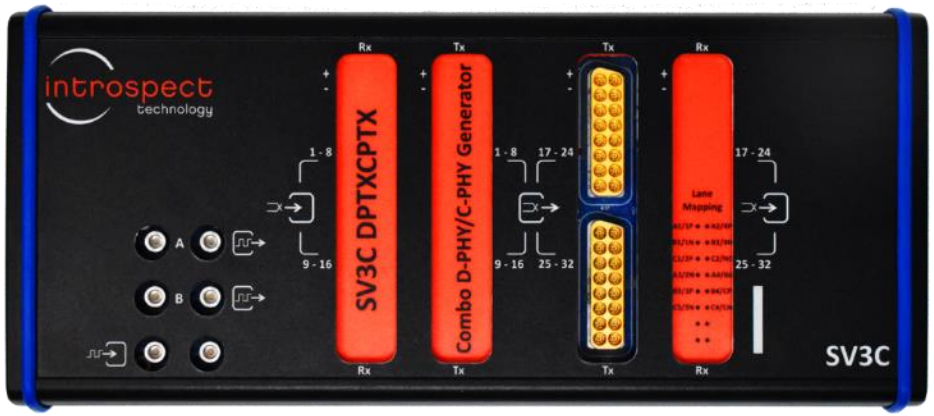
# CSI-2/DSI-2 Receiver Characterization

C SERIES

# SV3C DPTX-CPTX

## Combo MIPI D-PHY/C-PHY Generator




## OVERVIEW

Waveform and protocol generator for DSI-2/CSI-2 receiver testing

Completely capable of characterizing physical layer digital interface, protocol layer digital interface, and video handling capability

Includes I2C and tearing effect triggers

## BENEFITS

- Self-contained solution for DSI-2/CSI-2 link validation and characterization
- Built-in jitter injection and complete waveform synthesis technology
- Deep pattern memory for live video generation and virtual channel interleaving

## FEATURES

- Continuous data rate range from 80 Mbps to 4.5 Gsps / 6.5 Gbps
- Up to 8 Gbyte of frame data storage
- High-speed USB3 link to control PC for rapid image extraction



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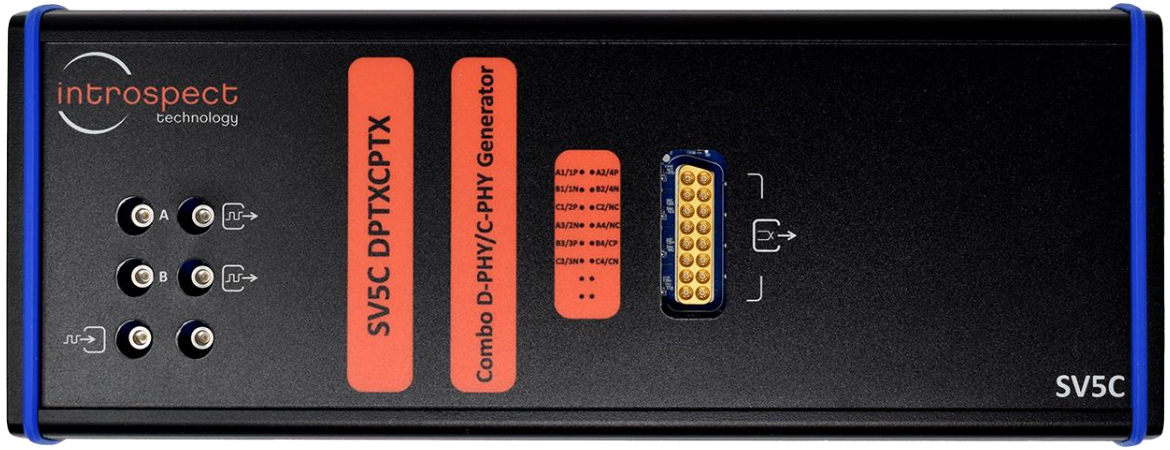
C SERIES

# SV5C DPTX-CPTX

Combo MIPI D-PHY/C-PHY Generator




## OVERVIEW

**Popular Solutions:** MIPI D-PHY up to v3.5, MIPI C-PHY up to v2.0

**Number of Pattern Generators:** 16

**Maximum Per-Lane Data Rate:** 8 Gsps in C-PHY mode, 12.5 Gbps in D-PHY mode

## BENEFITS

- Any-rate operation
- Per-lane HS voltage level and common-mode control
- Per-lane LP voltage level control
- Per-lane skew injection with < 1 ps resolution
- Per-lane multi-source jitter injection

## FEATURES

- Characterization and validation of MIPI D-PHY and C-PHY receiver ports
- Analog parameter controls that enable deep insights into receiver voltage sensitivity, receiver skew and jitter tolerance for receiver stress-testing



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E SERIES

# SV4E DPTX-CPTX

Combo MIPI D-PHY/C-PHY Transmitter

## OVERVIEW

Test module for transmitting DSI-2/CSI-2 data

Supports live streaming of video and still images

Includes full I2C/I3C master and integrated power supplies

## BENEFITS

- Full MIPI coverage with native physical layer and protocol layer for DSI-2/CSI-2
- Self-contained system enables true system-like testing of panels, image sensors etc.
- Complete software environment enables full automation

## FEATURES

- Up to 2.5 Gbps / 2.5 Gsps per lane
- Truly compact design with dimensions of 140 mm x 189 mm
- Built-in power supplies for controlling module power-on sequence
- Flexible programming environment



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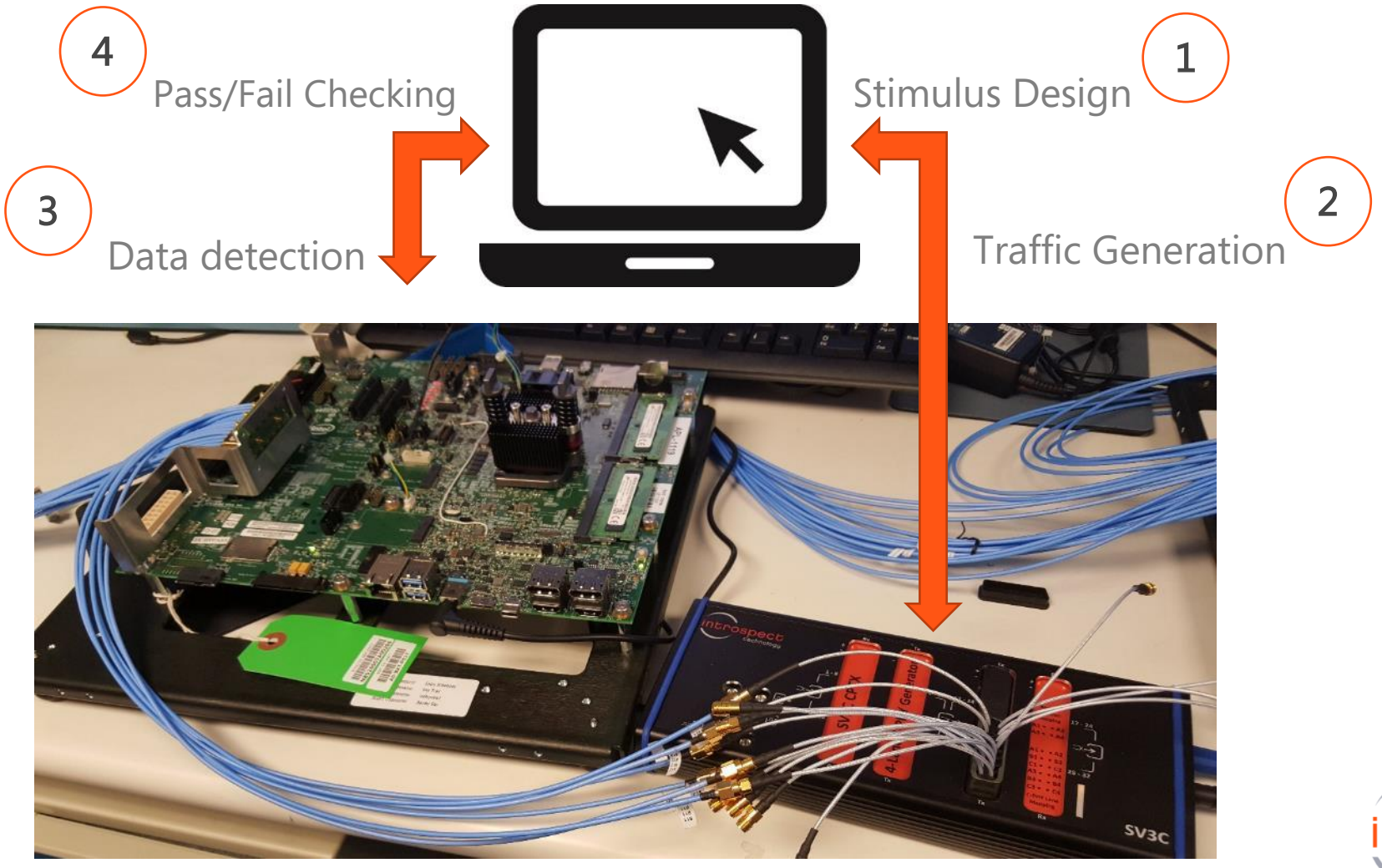
# CSI-2 Receiver Stress Testing



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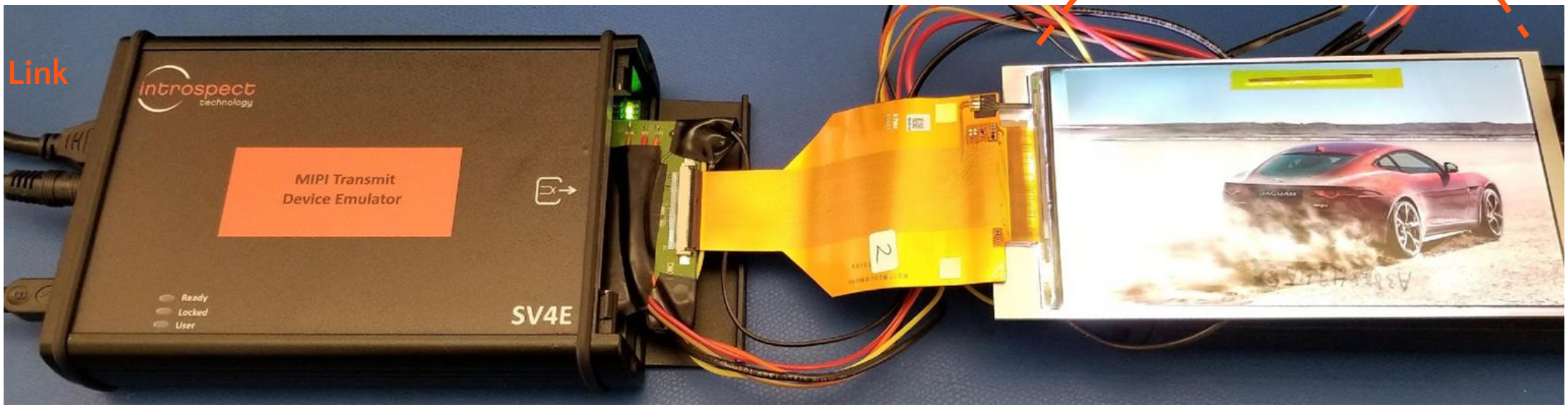
# Typical Application

Optical Inspection

USB 3 Link




Integrated device
power supplies



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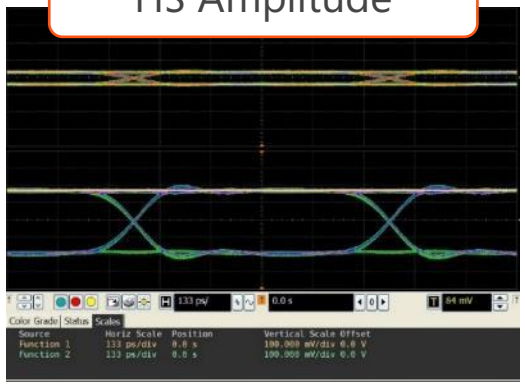
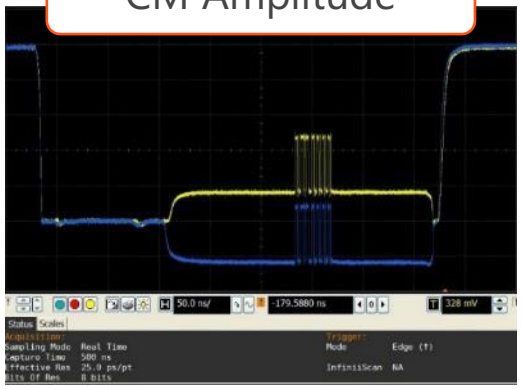
# Full Characterization Capability

- Enables MIPI Alliance conformance testing
- Individually programmable parameters on every wire

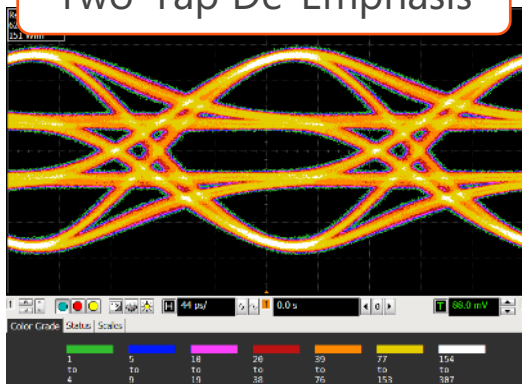
HS Amplitude



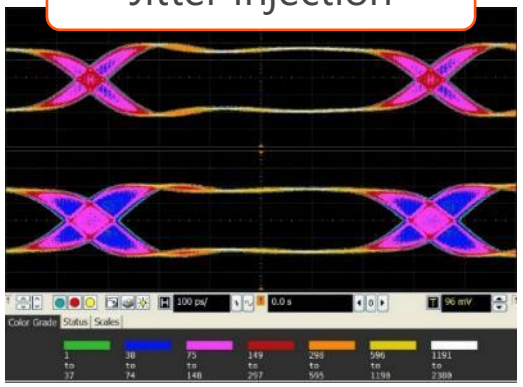
CM Amplitude



Two-Tap De-Emphasis



Jitter Injection



*SV3C Generator waveforms showing analog controls*



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# MIPI Product Comparison Chart

### D-PHY Analyzer Specifications Comparison Table

| | SV5C | SV3C | SV4E |
|---|---|---|---|
| | *Analyzer* | *Analyzer* | *Analyzer* |
| **System Parameters** | | | |
| Number of Lanes | 4 | 4 | 4 |
| Maximum per Lane Data Rate | 8 Gbps | 3.25 Gbps | 2.5 Gbps |
| On-Board Memory | 8 GB | 4 GB | 1 GB |
| Control Link to PC | USB 3.0 | USB 3.0 | USB 3.0 |
| Compatibility with Remote Sampling Heads | • | • | • |
| Automated Conformance Test Suites | • | • | |
| **Protocol Parameters** | | | |
| Arbitrary Image and Video Sequence Extraction | • | • | • |
| Virtual Channel Extraction | • | • | • |

### D-PHY Generator Specifications Comparison Table

| | SV5C | SV3C | SV4E |
|---|---|---|---|
| | *Pattern Generator* | *Pattern Generator* | *Device Emulator* |
| **System Parameters** | | | |
| Number of Lanes | 4 | 4 | 4 |
| Maximum per Lane Data Rate | 8.5 Gbps | 4.5 Gbps | 2.5 Gbps |
| On-Board Memory | 8 GB | 4 GB | 1 GB |
| Control Link to PC | USB 3.0 | USB 3.0 | USB 3.0 |
| Automated Conformance Test Suites | • | • | |
| **Protocol Parameters** | | | |
| Arbitrary Video Frame Generation (Moving Pictures) | • | • | • |
| Color Bar and Fixed Frame Generation | • | • | • |
| Virtual Channel Control | • | • | • |
| LP and HS Packet Commands | • | • | • |

- Main technical difference is in the speed and on-board memory available
- Full chart available upon request



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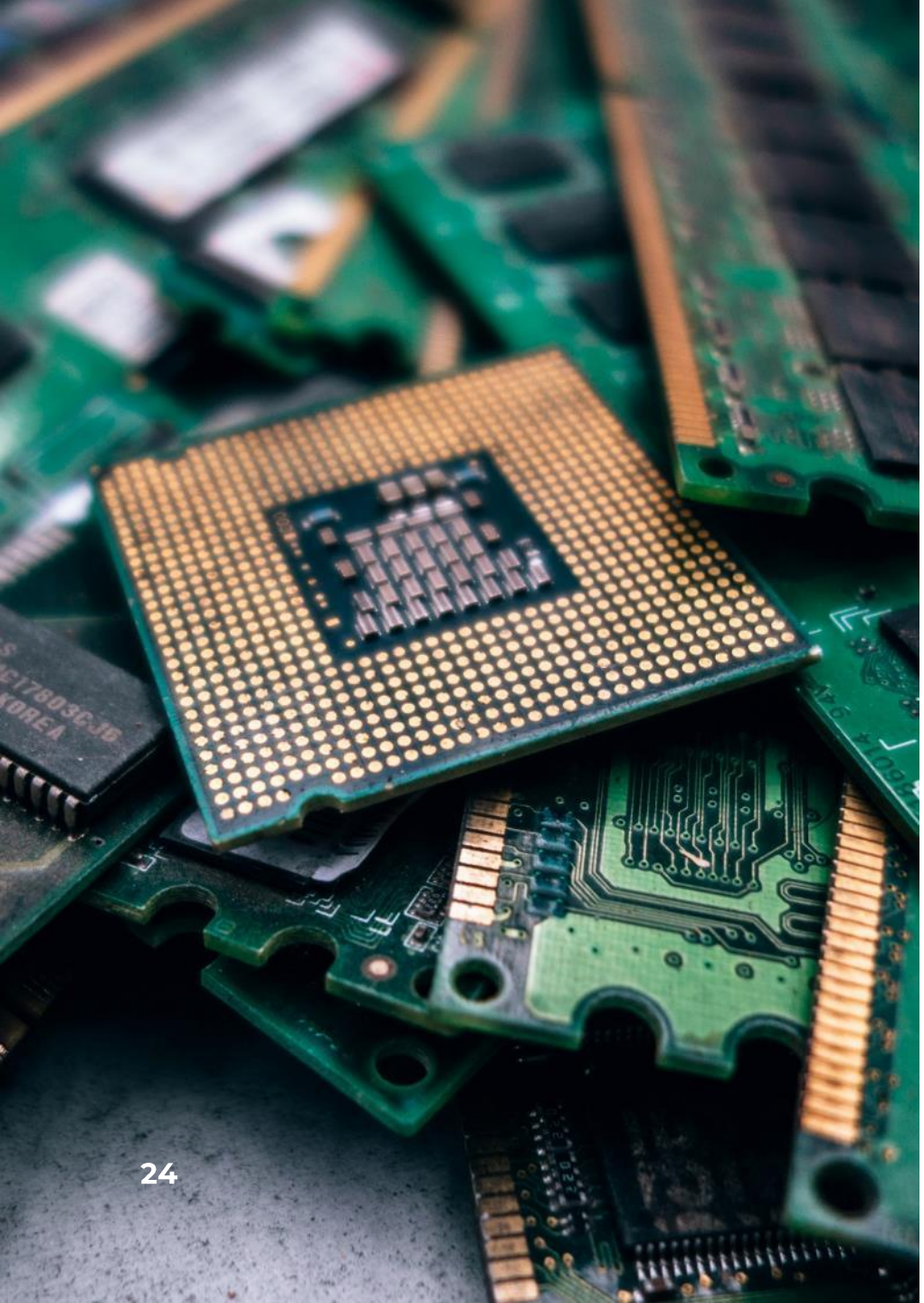

# Summary

## WIDE SOLUTION PORTFOLIO

- Introspect Technology has the widest portfolio of products for DSI-2/CSI-2 characterization, debug, and mass production testing
- The Introspect Technology C and E Series products are acclaimed for link characterization applications
- Flexible purchase options means customer can buy the solution best suited for their needs



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