QUICK START GUIDE

SV5C-DPRX

MIPI D-PHY Analyzer

C SERIES

Table of Contents

Introduction

OVERVIEW

The SV5C-DPRX MIPI D-PHY Analyzer is an ultra-portable, high-performance instrument that provides the most comprehensive capabilities on the market for exercising and validating MIPI D-PHY transmitter ports. Receiving traffic over a continuous range of data rates, the D-PHY Analyzer includes complete hardware LP and HS receivers, dynamic termination, and offers sophisticated capture and compare modes.

The SV5C-DPRX MIPI D-PHY Analyzer operates using the award-winning Introspect ESP Software environment, allowing for automated transmitter tests such as bit error rate, protocol timing, and MIPI conformance testing. The software also includes a full suite of tools for DSI and CSI-2 video frame extraction for packet analysis and system level test.

QUICK START DOCUMENTATION

This Quick Start Guide will provide the information required for a user to get up and running with the SV5C-DPRX system. Basic hardware and software installation instructions are included, followed by a step-by-step procedure to start receiving and analyzing MIPI D-PHY signals using the Introspect ESP Software.

Quick Start Hardware Description

REQUIREMENTS

The full list of hardware required for this Quick Start Guide is provided below:

- 1 x SV5C-DPRX MIPI D-PHY Analyzer
- 1 x 12V 15A AC / DC power supply
- 1 x Personal Computer connected to the SV5C-DPRX via a USB2.0 mini B and a USB3.0 micro B cable
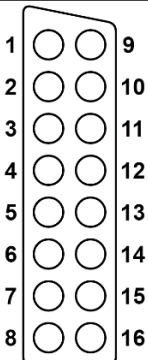- 1 x MXP to SMA Cable Assembly (included with analyzer)

HARDWARE DESCRIPTION

Figure 1 shows a diagram of the physical ports of the SV5C-DPRX.

Figure 1: Illustration of the SV5C-DPRX MIPI D-PHY Analyzer system
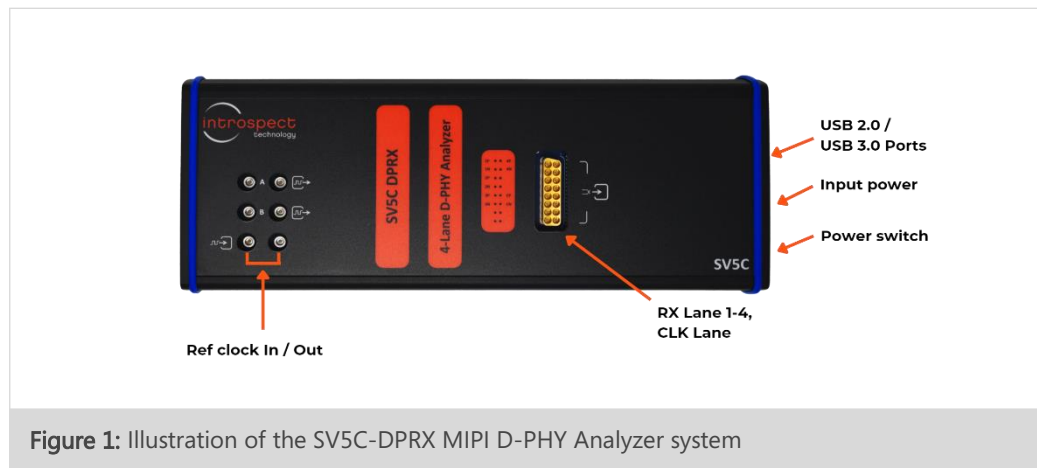
The SV5C-DPRX module uses a single MXP connector to receive signals on its clock and data lanes. A detailed pinout of the connector is provided in Table 1 below.

TABLE 1: MXP CONNECTOR PINOUT

CONNECTOR	PIN	LANE
1 ◯◯ 9 2 ◯◯ 10 3 ◯◯ 11 4 ◯◯ 12 5 ◯◯ 13 6 ◯◯ 14 7 ◯◯ 15 8 ◯◯ 16	1, 2	Rx Lane 1 (P, N)
	3, 4	Rx Lane 2 (P, N)
	5, 6	Rx Lane 3 (P, N)
	9, 10	Rx Lane 4 (P, N)
	13, 14	Clock Lane (P, N)

Introspect ESP Software Installation

SYSTEM REQUIREMENTS

The Introspect ESP Software provides an easy-to-use environment for device characterization and test-plan development. To run the software, the following components are required:

- A PC installed with Windows 10
- The Introspect ESP Software install executable
- USB device drivers (refer to the driver installation instructions later in this document)

NOTE

A fully functional command line version of the Introspect ESP Software is also available for MacOS and Linux. However, this Quick Start Guide will focus on the Windows version of the software.

INTROSPECT ESP SOFTWARE INSTALLATION

1. INSTALLATION PREPARATION

   a) Quit any Introspect ESP Software sessions before starting the installation.
   b) If this is your first installation of the Introspect ESP Software, open the "README_Install.txt" file located in the installation files and install any pre-requisite components by consulting the "Windows Software Requirements" section.

2. SOFTWARE INSTALLATION

   a) From the directory containing the installation files, double-click the "IntrospectESP_Installer.exe" executable and follow the on-screen instructions.

b) When prompted, specify the location where you want to install the Introspect ESP Software. The default location is C:\Introspect. The software will be installed into a sub-folder specifying the version number.

> **NOTE**
>
> It is recommended to install the software under C:\Introspect to keep all versions in one place.

c) By the simple press of a button, the Introspect ESP Software will install its own embedded version of Python, along with its required third-party modules. This means that any previous Python installations on the host computer will not be affected by the Introspect ESP Software.

3. INSTALL THE LICENSE FILE

a) Towards the end of the installation, you will be asked to provide either an activation key or a license file for the software.

b) If you have a valid activation key, simply select the "Use Activation Key" option, and enter your activation key. The installer will then automatically generate the required license files.

c) If you were provided with a license file instead, select the "Use Existing License" option, and the installer will help you copy the license file into the new installation folder.

d) If you do not have any of the above, select the "Get a New License" option, and the installer will provide you with information that needs to be sent to Introspect Technology in order to obtain one. Copy and paste that information to request a license via: license_support@introspect.ca.

e) Upon receipt of the valid license files, place them into the following directory:

C:\[Your Introspect Installation Folder]\Licenses

> **NOTE**
>
> The installer creates a folder called "Introspect" under the "My Documents" folder of your account. This folder is where Test Procedures are usually saved.

4. RUNNING THE INTROSPECT ESP SOFTWARE

a) Double-click on the "IntrospectESP" shortcut on your Desktop and you should see the first "welcome" window of the GUI. Please specify the Form Factor as "SV5C_4L8G_MIPI_DPHY_ANALYZER" and Press "Next" to continue.
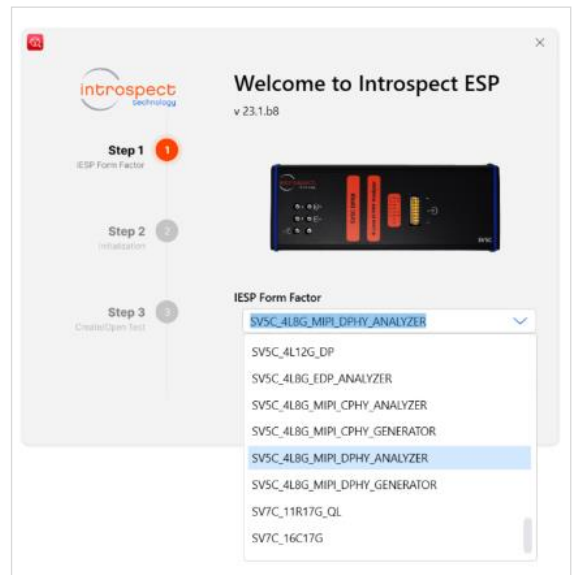

Figure 2: The welcome window of the Introspect ESP Software

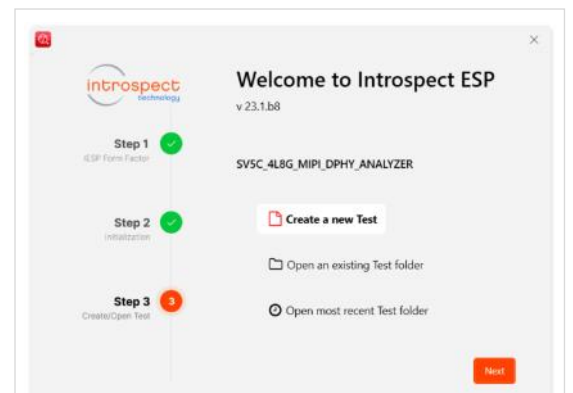b) Select the option "Create a new Test" and click the "Next" button.

Figure 3: Step 2 of the welcome menu: Create a new Test

c) With a valid license in the "Licenses" directory, the following GUI screen should come up, which indicates that the Introspect ESP Software has been successfully installed.
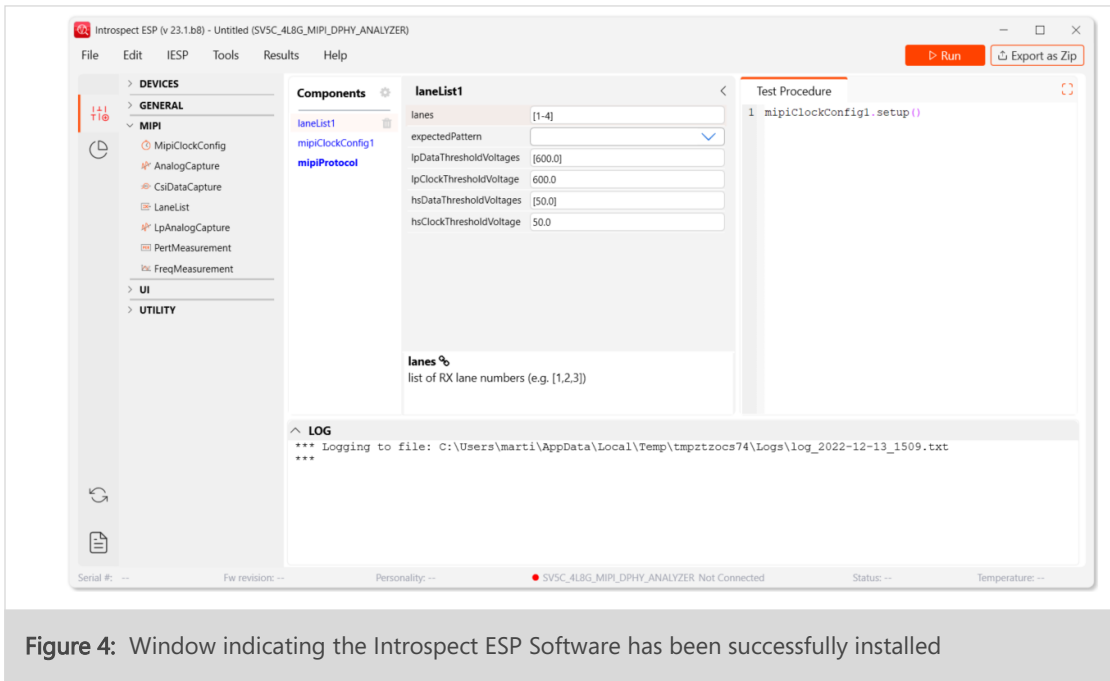

Figure 4: Window indicating the Introspect ESP Software has been successfully installed

5. FURTHER DOCUMENTATION

The Help menu contains the following menu items, giving some information on the software:

- "User Manual" is the user manual for the Introspect ESP Software and is recommended reading for all users. Clicking on this menu item will open the document in your default PDF viewer.
- "Test Procedure Functions", "Component Classes", "Utility Functions" and "Low-level IESP Functions" provide documentation on the Python component classes and lower-level functions specific to the selected form factor. Clicking on one of those menu items will open the corresponding document in your default HTML browser. These documents are intended for intermediate and advanced users.
- "Application Notes" describes advanced features, often in the form of tutorials.

USB Driver Installation

The following procedure will allow for automated FTDI driver installation.

1. HARDWARE SETUP

For this procedure, connect the SV5C-DPRX to the PC using both a USB2.0 mini B and a USB3.0 micro B cable, as shown in Figure 5 below, and power on the module. To allow for driver installation, the PC should be connected to the internet as well.

Figure 5: Connection for the automated FTDI driver installation
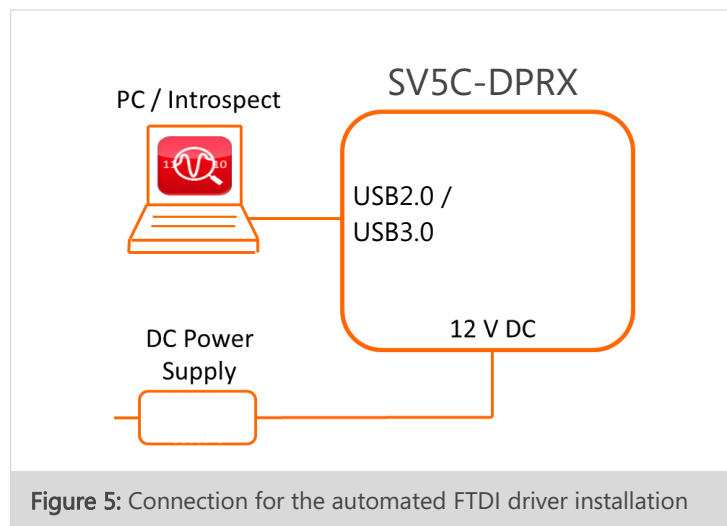
2. WAIT FOR NEW HARDWARE DETECTION

The PC should display the message "New drivers successfully installed" once the installation process is complete. If this does not occur, see the troubleshooting notes at the end of this section.

3. VERIFY DRIVER INSTALLATION

a) If it is not still open, launch the Introspect ESP Software, select the "SV5C_4L8G_MIPI_DPHY_ANALYZER" form factor and create a new test. From the main GUI window, click the "IESP" drop down menu and click "Connect", as shown here. Establishing the connection should take a couple of seconds. If this fails, an error message will pop-up.
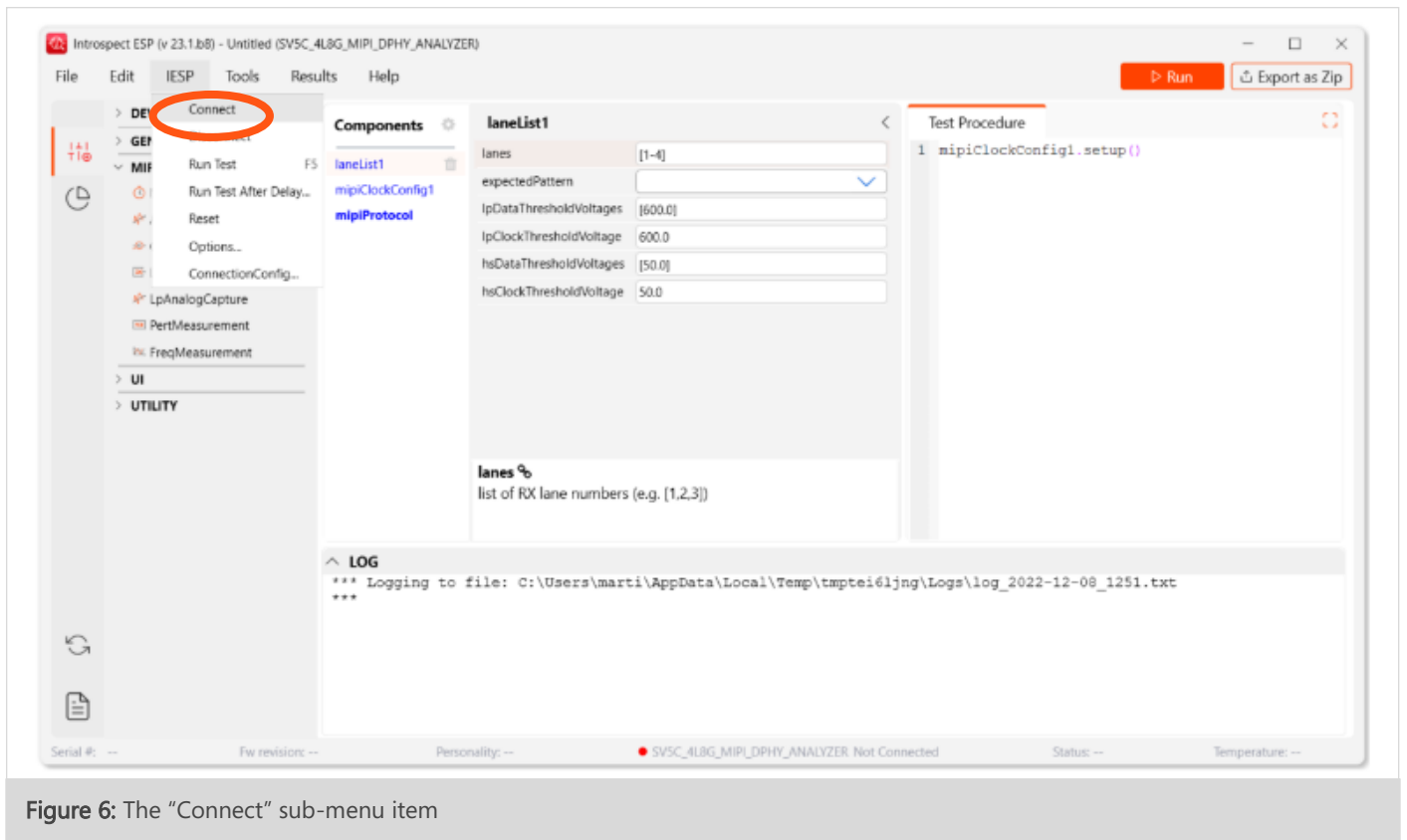

Figure 6: The "Connect" sub-menu item

b) When connected to the unit, the software will display useful information at the bottom of the
    GUI window: Serial number, Firmware Revision and Personality, the Form Factor in use, a
    Status number and the unit's Temperature. The "Connected" message also appears as well as
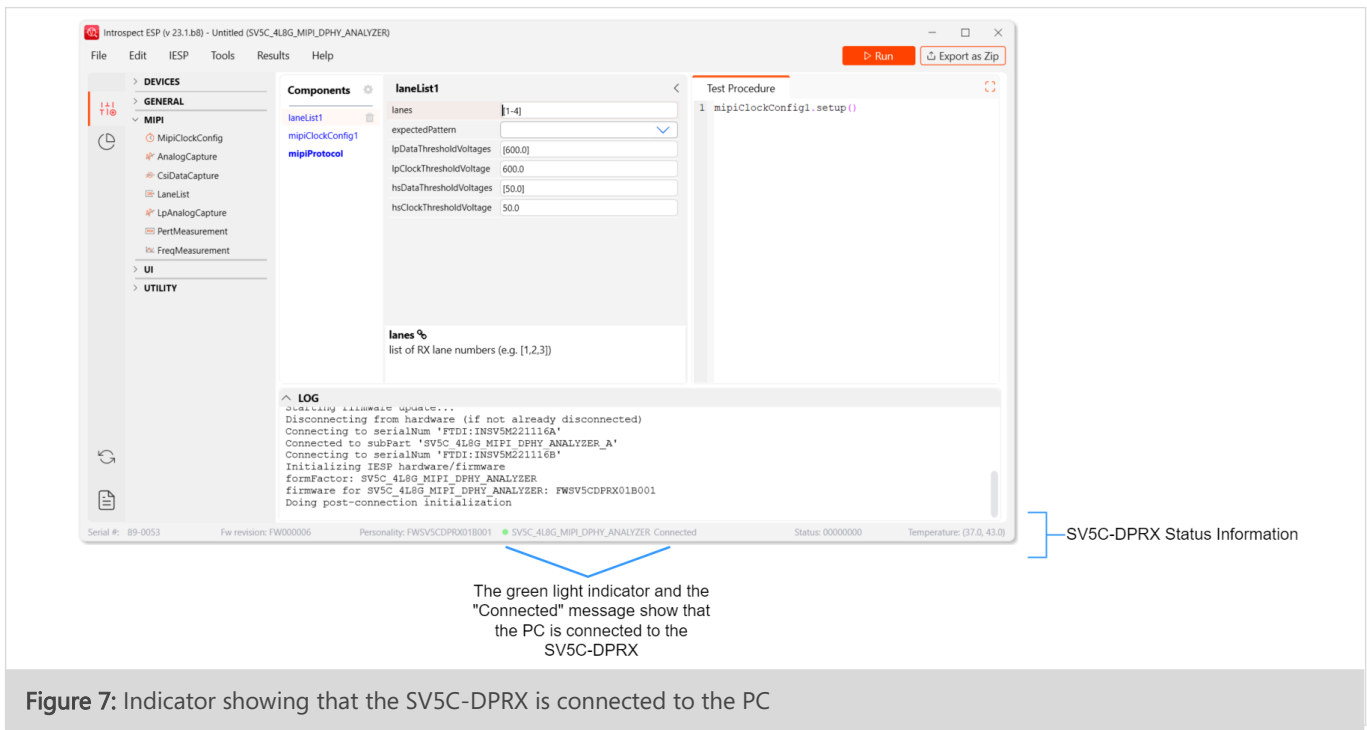   a solid green status indicator.

Figure 7: Indicator showing that the SV5C-DPRX is connected to the PC

4. TROUBLESHOOTING

If the connection cannot be established, or if the drivers cannot be found or automatically installed,
please refer to the "FTDI Driver Manual Installation" Appendix to install the required drivers.

SV5C-DPRX Demonstration

STEP-BY-STEP GUIDE: RECEIVING A D-PHY CSI-2 IMAGE FRAME

The following step-by-step guide will allow the user to set up the SV5C-DPRX module in order to receive a CSI-2 image frame being transmitted over a single D-PHY lane. It will also demonstrate how to capture, visualize, and analyze the received packets using the CsiDataCapture component of the Introspect ESP Software. The following procedure is intended to provide an overview of how to use the Introspect ESP Software GUI and highlight several of its key features.

1. CONNECT THE HARDWARE COMPONENTS

In order to analyze a D-PHY signal, you will need a DUT capable of producing CSI-2 image frames, such as a camera. Connect your DUT's differential clock and data signals to the MXP Rx port of the SV5C-DPRX module according to the pinout shown previously in Table 1.

2. GETTING TO KNOW THE INTROSPECT ESP SOFTWARE GUI

   a) If you have not done so previously during the USB driver installation procedure, launch the Introspect ESP Software, select the "SV5C_4L8G_MIPI_DPHY_ANALYZER" form factor and create a new test procedure. Connect the SV5C-DPRX to your PC using both a USB2.0 mini B cable and a USB3.0 micro B cable and power up the module.

> **NOTE**
>
> The USB3.0 port is used to accelerate data transfers between the SV3C-DPRX and the host PC. A USB3.0 connection is not mandatory for operating the module, but it is highly recommended, especially when capturing large image frames.

b) By default, when started in the "SV5C_4L8G_MIPI_DPHY_ANALYZER" form factor, the GUI contains a single line of code in the "Test Procedure" pane and three components in the "Components" section, as shown below.
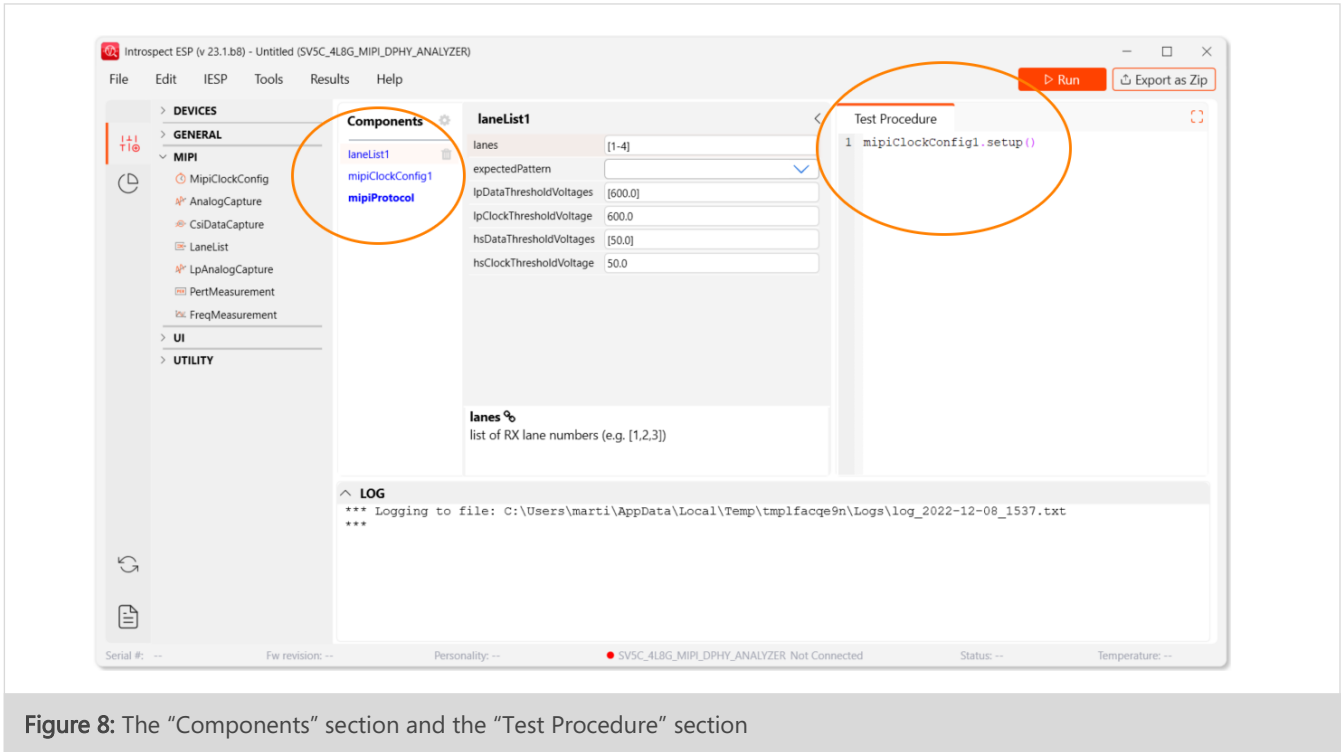

Figure 8: The "Components" section and the "Test Procedure" section

c) The mipiClockConfig1 component is used to specify the rate at which data is being transmitted to the SV5C-DPRX MIPI D-PHY Analyzer. Before continuing, click on the mipiClockConfig1 component in the Components Pane, then make sure the "dataRate" property matches the data rate of the transmitting DUT, or use the "autoDetectClock" functionality by setting this property to "True". The mipiClockConfig1 component can also be used to configure external reference clock signals to synchronize the SV5C-DPRX module to other systems.
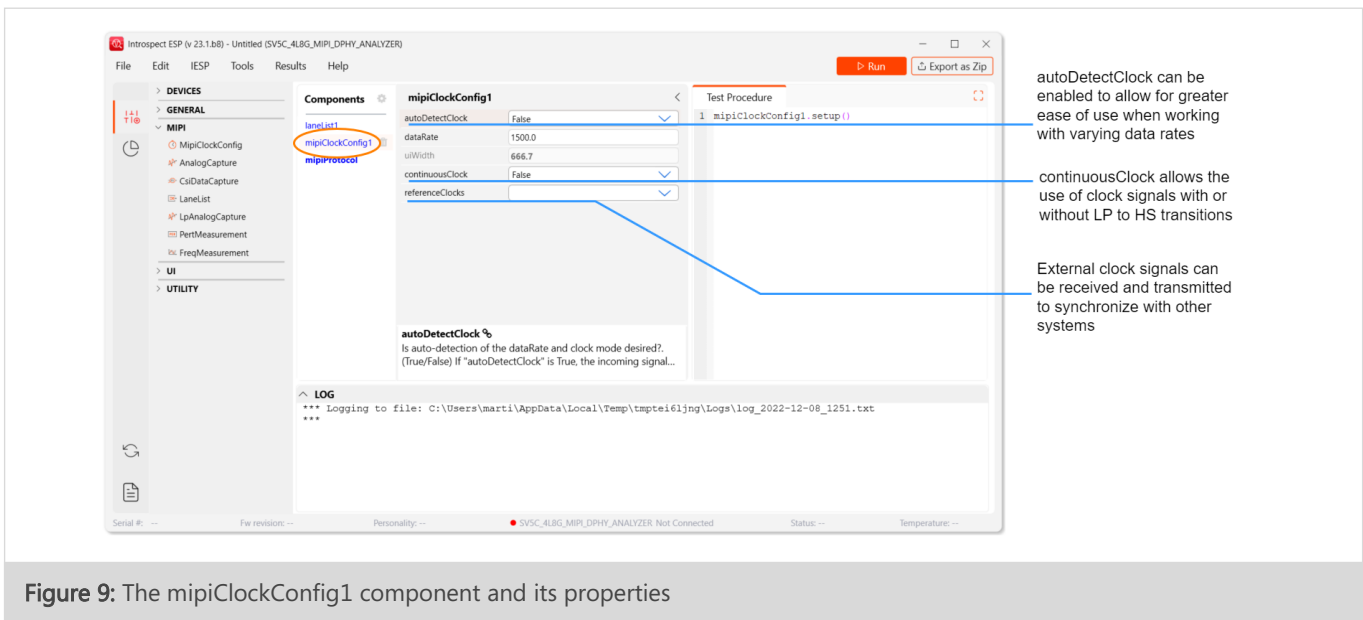

Figure 9: The mipiClockConfig1 component and its properties

NOTE
An external clock reference must be used to capture HS-only data signals.

d) The "laneList1" component configures the data and clock lanes that will be used to capture D-PHY signals with the SV5C-DPRX MIPI D-PHY Analyzer. The SV5C-DPRX supports any combination of data lanes, allowing for greater flexibility when testing multiple types of DUTs.

Figure 10: The laneList1 component and its properties
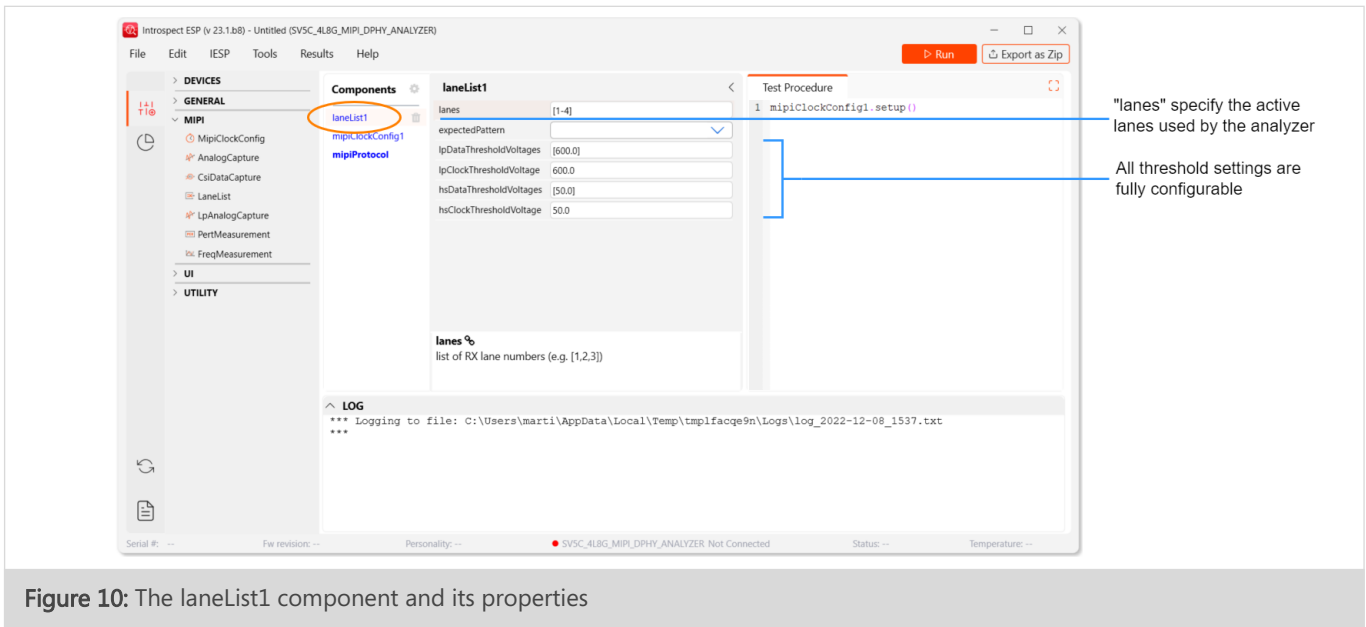
e) In this first example, only a single D-PHY lane will be used to transmit data from the DUT to the SV5C-DPRX MIPI D-PHY Analyzer. To use only lane 1 of the SV5C-DPRX, select the "laneList1" component in the Components Pane, then select the "lanes" parameter in the right view and edit it to: [1]. Make sure that the transmitting DUT is configured likewise.

> **NOTE**
>
> To modify a component property, a user can either manually edit the corresponding field in the "Properties" view, or programmatically via the "Test Procedure" Pane. For example, if a user only wants to use Lane 1, they can add the following line to the "Test Procedure":
>
> ```
> laneList1.lanes = [1]
> ```
>
> This allows on-the-fly change of the attributes during a test run for greater flexibility.

f) The "mipiProtocol" component is used to specify the encoding specifications of the received data packets, as shown below. The SV5C-DPRX module fully supports the DSI, DSI-2, and CSI-2 protocols, as well as the reception of bitstreams at the PHY level without any type of protocol encoding.
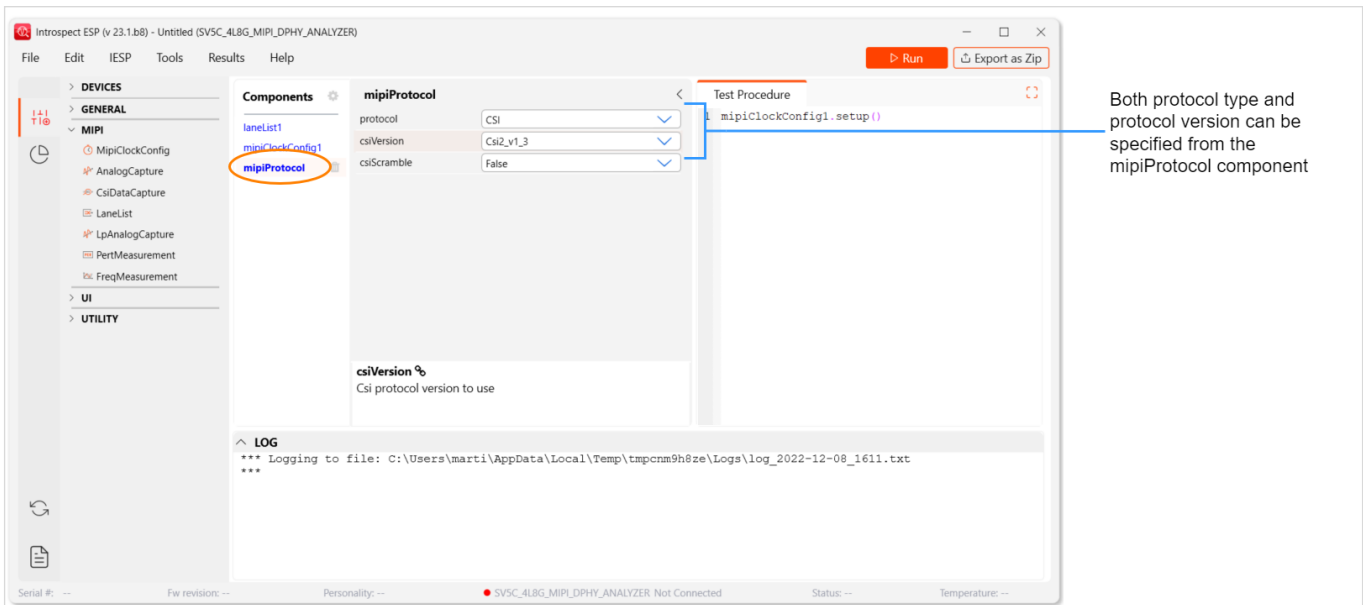

Figure 11: The mipiProtocol component and its properties

g) In this example, the transmitted data packets are encoded using the CSI-2 v1.3 protocol, which are the default settings.

NOTE

If your DUT uses another version of the CSI-2 protocol, make sure to edit the "mipiProtocol" component as described previously to match your device's settings. When DSI or DSI-2 is desired, the "mipiProtocol" must be set to "DSI" and there is no "dsiVersion" property.

3. ADDING TEST COMPONENTS

a) The objective of this step-by-step guide is to capture a CSI-2 encoded image frame over a single D-PHY lane. To capture an image frame, the "CsiDataCapture" component must be added to the test procedure. This component is responsible for capturing, displaying, and analyzing data packets received by the SV5C-DPRX module.

To add the "CsiDataCapture" component, users can double-click it on the list of available components on the left of the GUI window. This will instantiate a "csiDataCapture1" component in the Components list. Another way of doing this is to drag-and-drop the "CsiDataCapture" component from the list of available components into the Components Pane.
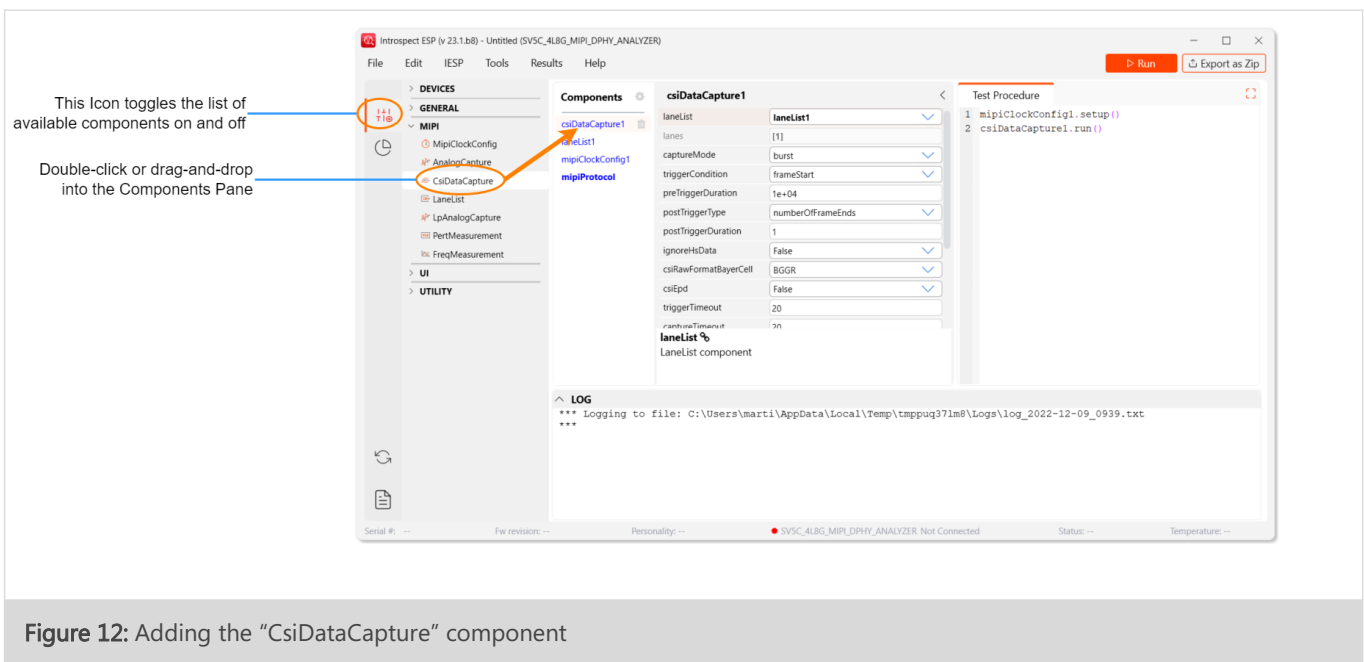

Figure 12: Adding the "CsiDataCapture" component

b) Notice that a new line of code has automatically been added to the end of the "Test Procedure" editor window in order to start the data capture, as shown below.
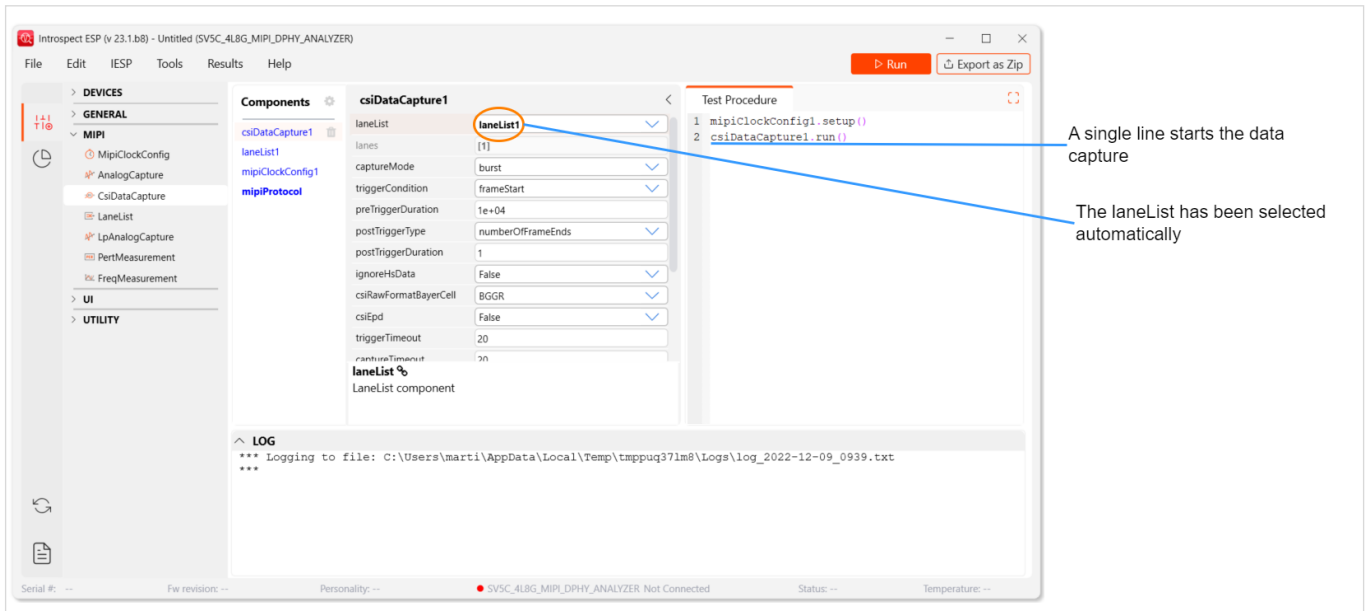

Figure 13: A single line starting the data capture

c) The default configuration of the "CsiDataCapture" component will capture a whole CSI-2 image frame from beginning to end. If you want to capture different types of data, for example a single data packet, you can do so by editing the "triggerCondition", "postTriggerType" and "postTriggerDuration" properties to fit your needs.

4. EXECUTING THE TEST PROCEDURE

a) Now that the procedure has been configured to fit the DUT's settings, the SV5C-DPRX is ready to receive D-PHY CSI-2 image frames. Before starting the procedure, make sure the DUT is transmitting data on lane 1. Once data is being sent to the SV5C-DPRX module, the test procedure can be executed from the GUI. If the PC has not connected to the SV5C-DPRX

already, there is no need to do so manually. The connection will be performed automatically when the Test Procedure is run for the first time.

b) To execute the procedure, click the "Run" button at the top right of the main GUI window as shown here, or use the F5 shortcut key.
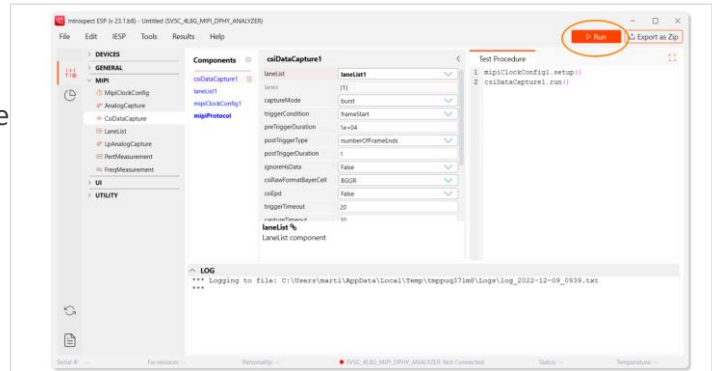

Figure 14: "Run" button placement at the top right of the main GUI

c) After clicking the "Run" button, the GUI will print informative messages in the "Log" Pane at the bottom of the GUI window. Any errors occurring during the test run will also be reported there.
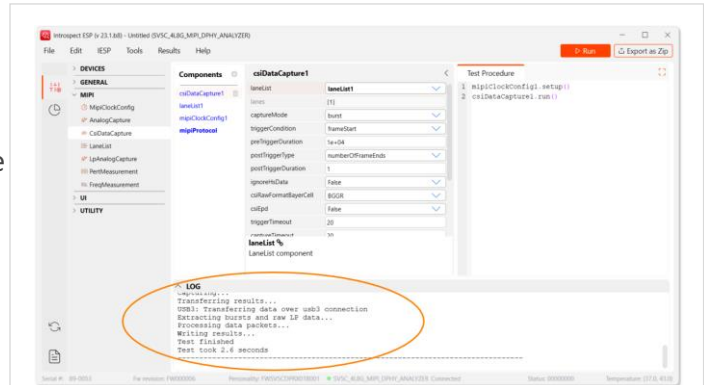

Figure 15: Informative messages in the "Log" Pane at the bottom of the GUI window

NOTE

The Python print function can be added to the Test Procedure to automatically print out messages in the "Log" Pane during the test run. This can be used for debugging as well as keeping track of test procedure execution.

d) After the test procedure has completed, the GUI will print the "Test finished" message in the Log Pane. To see the results, click on the "Show Results" icon on the left side of the GUI window, as shown below. The captured image frame can be previewed by selecting the most recent test run result on the Results list and hovering the mouse above the "csiDataCapture1" results.
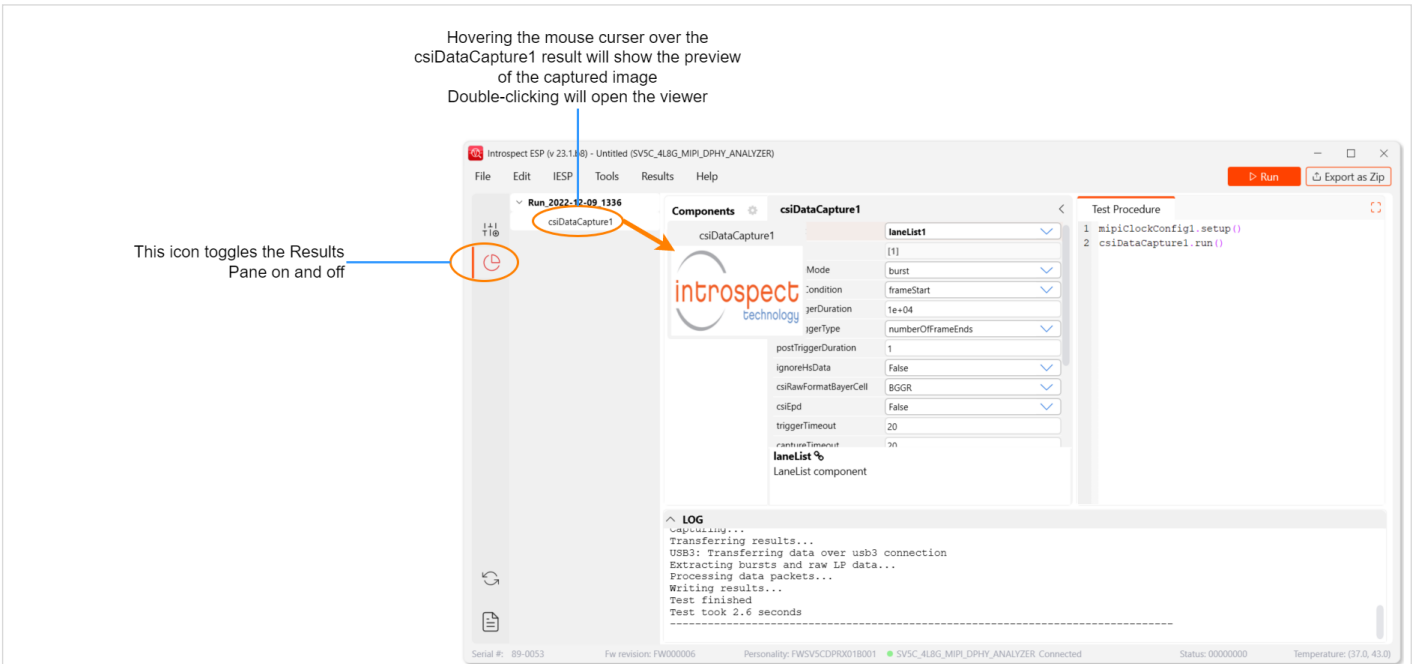

Figure 16: Steps to retrieve the test results

e) As can be seen, the SV5C-DPRX module was able to properly capture the Introspect Technology logo encoded using the CSI-2 protocol and transmitted over a single D-PHY lane.

All packets received during the data capture can be visualized by double clicking the "csiDataCapture1" results on the left side of the GUI window. This will open the CSI data capture viewer in a separate window. The received data can be arranged into "HS Bursts", "CSI Packets" or "Frames" by navigating the "DPHY DataCapture" window. "LP States" and "LP Events" are also accessible to allow easy inspection of LP to HS transitions of the transmitting DUT.
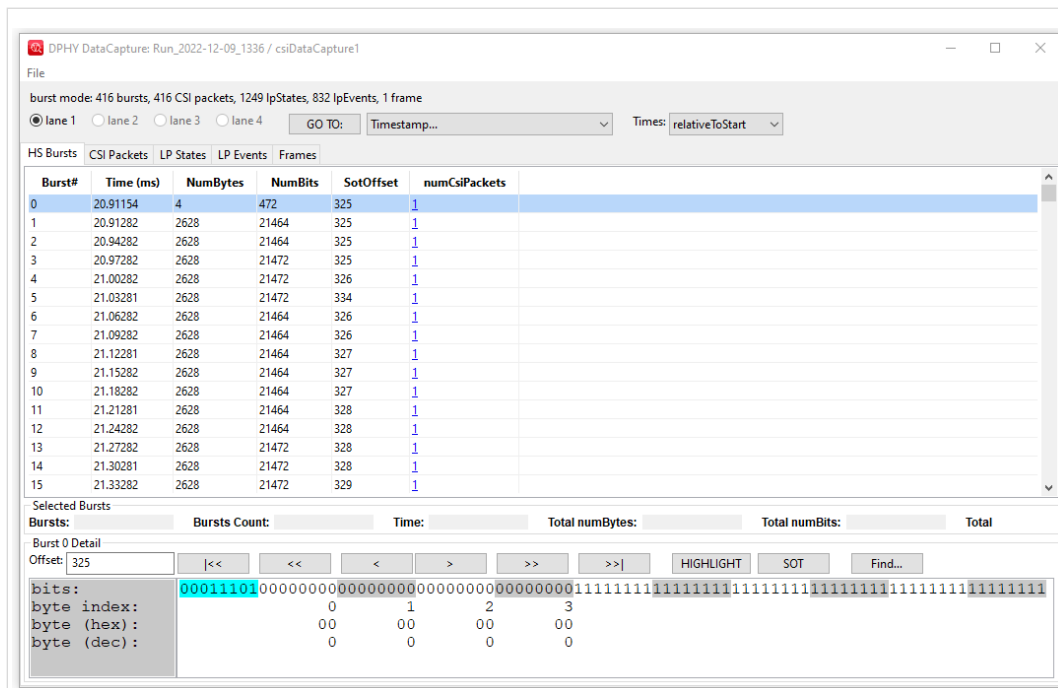

Figure 17: The DataCapture result window

> **NOTE**
>
> The "DPHY DataCapture" result window allows for easy failure analysis by highlighting CSI packets where errors have been detected.

This concludes the SV5C-DPRX Quick Start demonstration. For further information, please consult the Introspect ESP GUI user manual from the "Help > User Manual" pull down menu of the main GUI window.

Appendix

FTDI DRIVER MANUAL INSTALLATION

The Introspect ESP Software communicates with the SPI Controller via an FTDI device (connected via USB). If you don't already have required FTDI drivers installed on your Windows computer, or if the automated driver detection presented earlier in this document was unsuccessful, you will need to download them from the FTDI web site.

To do this, follow the instructions found at:

http://www.ftdichip.com/Documents/InstallGuides.htm

The latest drivers can be found at:

http://www.ftdichip.com/Drivers/D2XX.htm

http://www.ftdichip.com/Drivers/D3XX.htm

You may wish to use the "usbview" utility program linked to on the following FTDI page:

http://www.ftdichip.com/Resources/Utilities.htm

This program will allow you to check that your computer can "see" the FTDI device over USB.

Revision Number	History	Date
1.0	Document Release	December 21, 2022

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