MIPI C-PHY Transmitter Conformance Test Suite

User Guide

Table of Contents

List of Figures

Introduction

The Introspect C-PHY Transmitter CTS Application is a Test Procedure that executes within the IntrospectESP software environment and that enables automated testing of C-PHY transmitters using the Introspect SV3C CPRX 4-Lane MIPI C-PHY Analyzer. The Test Procedure provides a fast and easy way to validate and debug C-PHY links as well as execute automated C-PHY electrical checklists based on the MIPI Alliance Conformance Test Suite.

The Introspect C-PHY Transmitter CTS Application enhances your productivity and saves valuable time by allowing you to focus on the device under test (DUT) specific steps of transmitter testing without worrying about test system programming. It provides an easy to use interface for selecting and sequencing tests and gives you visibility into the code structure and execution flows.

The Application also includes report generation features and custom code sections that allow you to achieve true test automation – through a true software handshake. Specifically, the custom code sections are compatible with executing external scripts for controlling a device or for accessing your proprietary .NET DLL for DUT control.

Features

The Introspect C-PHY Transmitter CTS Application offers

- MIPI specification coverage for C-PHY v1.0, v1.1, and beyond
- Configurable lane count and data rate
- Configurable test pattern / packet construction including arbitrary video frames
- User selection of tests based on the CTS test groups
- User-editable custom code for manipulating external components such as power supplies, device handlers, or thermal units
- Report generation
- Enhanced debug modes

Hardware Setup and Global Method of Implementation

Figure 1 shows the hardware setup for transmitter tests in general. All lanes of Introspect SV3C CPRX analyzer are connected directly to the Device under Test (DUT) board. The SV3C CPRX is connected to the control Computer through a USB cable and provided software drivers; and the DUT is connected to the control Computer using its own mechanism (e.g. I2C to USB converter). In the rest of this document, we assume that the DUT is connected to the same control Computer as the SV3C CPRX, but this is generally not a requirement for the Introspect CTS Application.
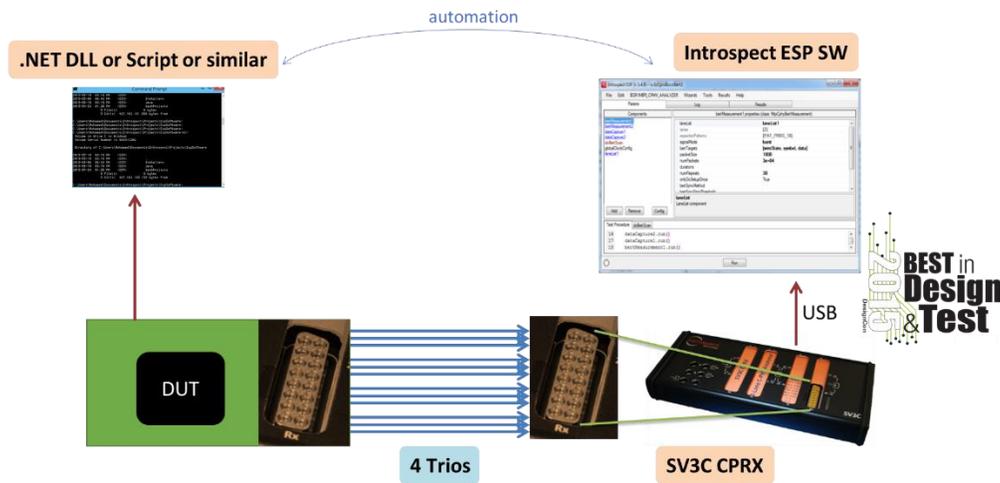
Figure 1   Overall hardware setup for C-PHY Transmitter CTS testing.

Noteworthy!

The SV3C MIPI C-PHY Analyzer contains built-in dynamic termination circuitry as shown in the figure on the right. Thus, unlike conventional oscilloscopes or analyzers, it can be used to directly connect to a MIPI device evaluation board using coaxial cables, without requiring an external Reference Termination Board (RTB) nor external high-impedance probes!

This architecture results in faster setup time, lower overall cost of test, and less potential for connection issues.
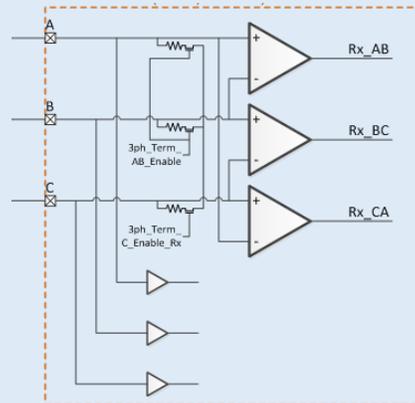
The Introspect ESP Software provides the main control for the SV3C CPRX, and the features of the CTS Application will be described thoroughly in later sections of this document. However, in this section, we describe the general scope of control within the CTS Application. Specifically, transmitter testing typically requires setting up the DUT to generate repeating signals and measuring such signals using the oscilloscope feature of the SV3C CPRX. Referring to Figure 2 which illustrates CTS Test #1.2.2, the DUT is configured to transmit a PRBS9 packet loop as defined in the MIPI C-PHY Specifications. Then, the SV3C CPRX is commanded to perform a triggered oscilloscope capture and to extract the time duration between the last LP transition and the first HS symbol transmission on the line. In general, most CTS tests are performed on PRBS9 packet loops, although this is customizable in the CTS Application.
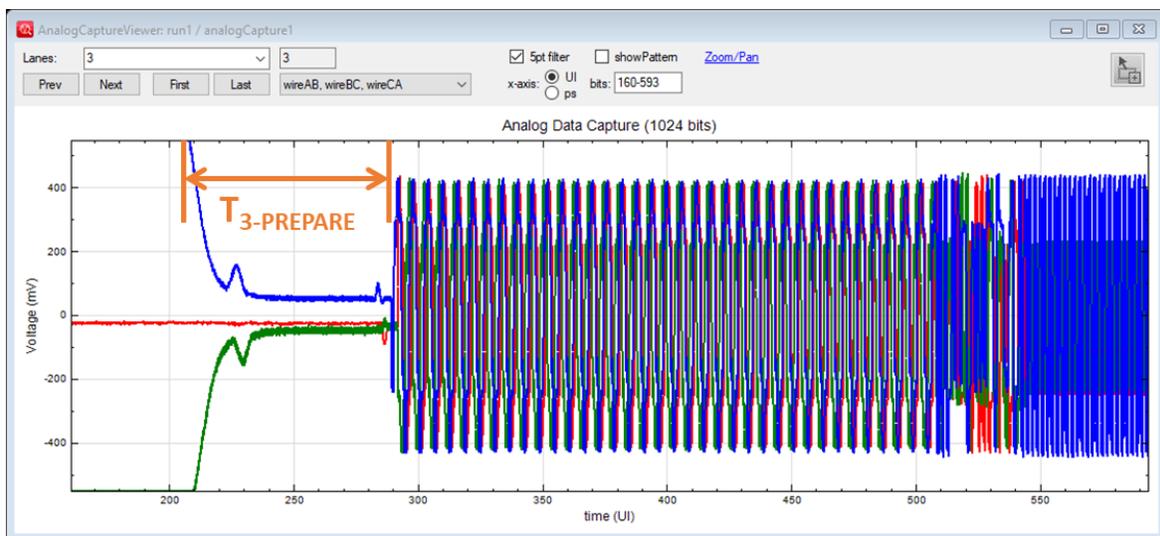
Figure 2   Overall Method of Implementation involves performing waveform captures and extracting measurements. Illustration is shown for CTS Test #1.2.2.

In the capture of Figure 2, differential waveforms on the AB, BC, and CA amplifier signals were displayed because this was appropriate for the particular test. For other tests, it is important to measure the high-speed signals in single-ended manner, and this is illustrated in Figure 3. The Introspect C-PHY CTS Application automatically determines whether or not a test requires single-ended measurement, and it automatically configures the SV3C CPRX to enable such measurement.
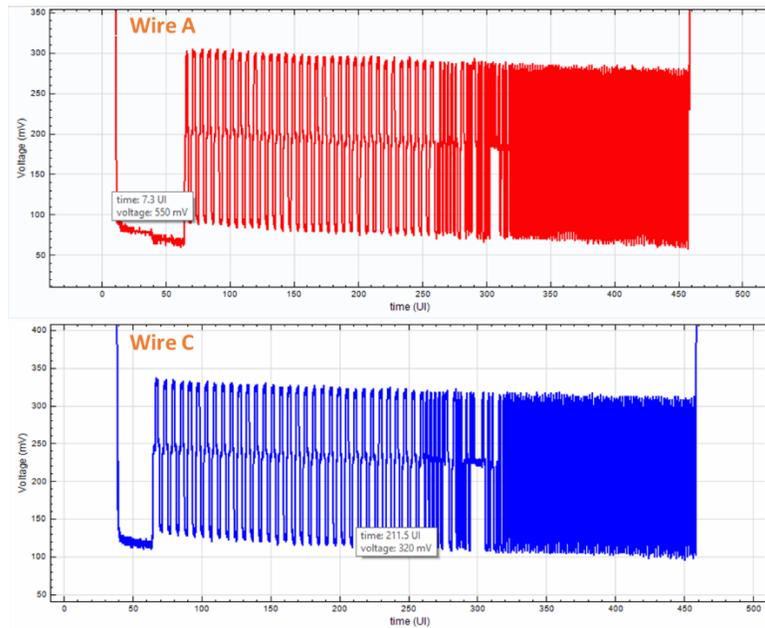
Figure 3   Illustration of single-ended measurements.

For some tests (e.g. Group 1) in the MIPI C-PHY CTS Specifications, the SV3C CPRX is expected to measure large-magnitude LP signals at 1.2V. Since this exceeds the linear range of the high-bandwidth input amplifiers on the Analyzer, these tests require the inclusion of a signal attenuator in the connection between the DUT and the Analyzer. An illustration of such connection is shown in Figure 4, and a list of recommended attenuator components is included in Table 1. During execution, each CTS Test instructs the user to insert the appropriate attenuator into the DUT signal path.

Table 1   Recommended co-axial fixed attenuators for performing voltage measurements in the CTS

Parameter Under Test	Required Attenuation	Recommended Part Number
HS Signal Voltage	6 dB	Mini-Circuits VAT-6+
LP Signal Voltage	15 dB	Mini-Circuits VAT-15+
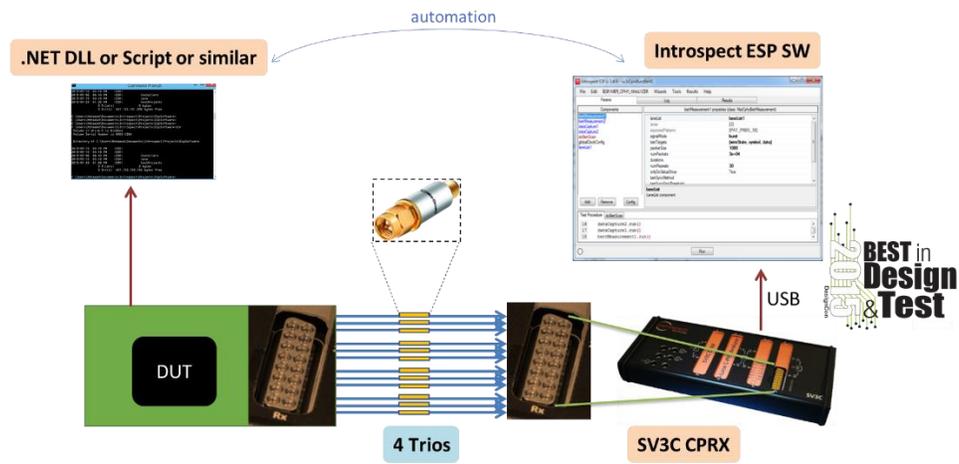
Figure 4   Hardware setup with attenuators in the signal path.

CTS Application User Interface

This section describes the components within the CTS Application. It then proceeds with instructions on how to configure tests, execute them, and customize their responses.

Component Classes Visible to the User

Figure 5 shows the Application window when it is first loaded into the IntrospectESP software. As can be seen, it is populated with a group of components that are highlighted, and these constitute the principal method for configuring tests and automating them. In the following sections, each component will be described briefly.
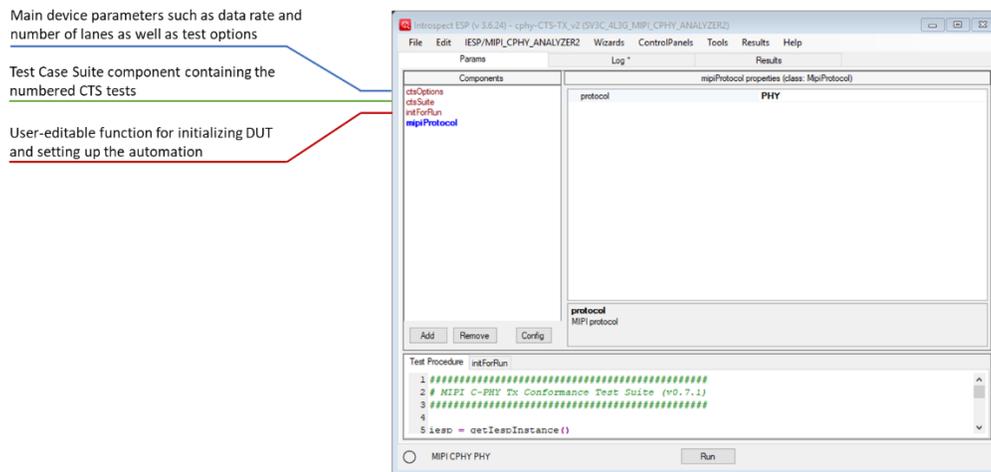
Figure 5   Illustration of the C-PHY Transmitter CTS Test Procedure when opened in IntrospectESP software.

CTS Options Component

This component defines general test options related to automation and report generation. For example, it defines the behavior of the Application in case one of the tests of the CTS fails. Based on the user requirement, the entire test sequence can be aborted, or the test can be skipped and subsequent tests executed. Similarly, this component is used to decide whether automated report generation is required or not. Finally, this component is where DUT parameters such as data rate and number of lanes are specified.

Test Case Suite

The Test Case Suite is a powerful automation development tool within the IntrospectESP software. It allows software developers to create unit test functions and to handle their execution in a robust manner. The Test Case Suite has been used in this Application to create Test Case code for each of the tests in the MIPI C-PHY CTS Specifications.

Double-clicking on the Test Case Suite launches a simple GUI for selecting test, debugging them, or executing the entire test flow.

User-Editable Initialization Function

This is a function tab (visible in the Test Procedure section of the GUI) that allows you to enter custom code for initializing the test in general or for initializing signal transmission from the DUT. In general, the CTS requires the generation of repeating packet loops. But it is possible that some tests can be customized in the following manners:

- Replacing the PRBS9 packet loop with an image pattern loop
- Replacing the PRBS9 packet loop with repeating LPDT transmissions
- Configuring the DUT to generate static LP111 or LP000 values

Selecting the General Options for the Test

Figure 6 shows the ctsOptions data record component, which is used to select the options for the test. Typically, all defaults are valid. The parameter descriptions include items such as:

- runNominalTest: this commands the CTS Application to execute a quick pattern check on the device before any test is performed, thus verifying that the hardware setup is valid
- stopAfterFirstFailure: set this parameter to True if you want the CTS Application to abort after any of the tests fails
- reportGeneration: enables the creation of a CSV report of executed tests. Generated reports are accessible in the Results tab of the GUI

Other options in this data record include features related to particular test configurations. Context help is available for these and other options in the CTS Application.
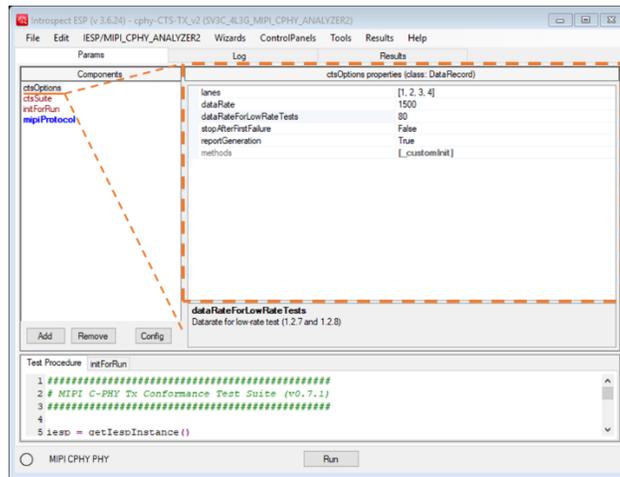
Figure 6   High-level automation options are configured using the ctsOptions data record.

Identifying Which Tests to Execute

Once the general options are established, the next step is to select which CTS tests to execute. This is done from within the Test Case Suite as shown in Figure 7. This Test Case Suite Window was launched by double-clicking on the ctsSuite component from within the IntrospectESP software. The window displays the available tests and allows for a very flexible execution environment for the user. For example, the user can select to enable all test cases, disable all test cases, or individually run each test case in isolation. What is important to note is that each execution is capable of producing the appropriate results data independent of other tests, and this represents tremendous flexibility during the debug and validation phase of testing.
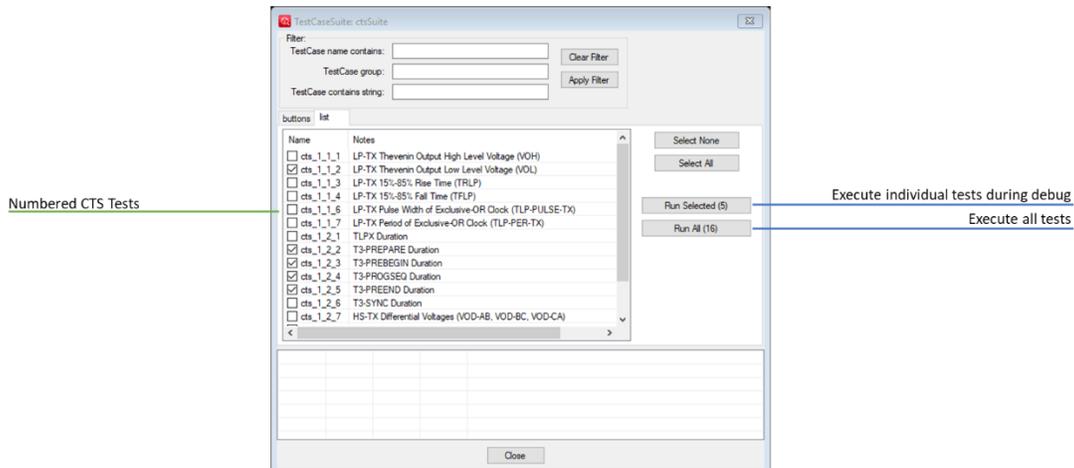
Figure 7   Illustration of the Test Case Suite GUI with a listing of all available tests.

Figure 8 shows an alternative Graphical view of the Test Case Suite Window. This view allows the user to highlight only a specific group of tests and to arbitrarily click on them for execution. When a test is clicked (right hand side of the figure), a context bubble appears indicating execution, and the main window of the IntrospectESP Software displays the activity log as usual.
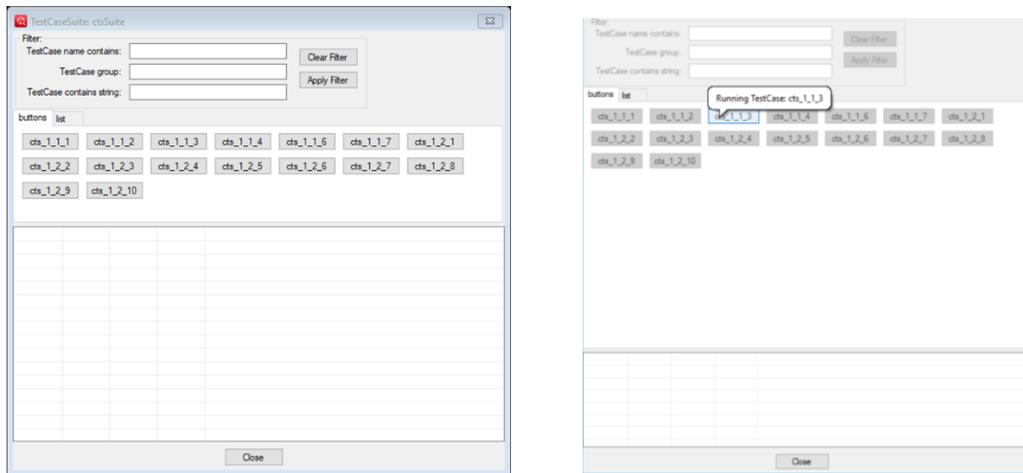
Figure 8   Alternative graphical views of the Test Case Suite Window.

Confirming DUT Connections

As was mentioned earlier, some tests require the insertion of attenuators in the signal path. Determining such connection requirements happens dynamically within the C-PHY CTS Application, and this is illustrated in Figure 9. When a test case is selected, a pop-up window describing the required connections appears, and the test is not executed until the connections have been made.
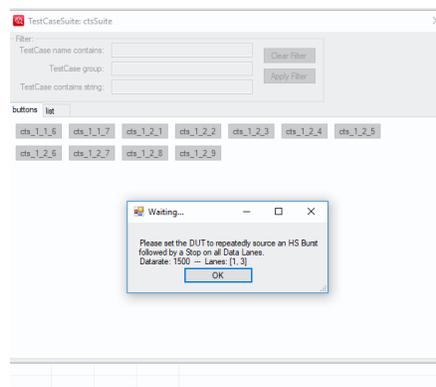
Figure 9   Illustration of the pop-up dialogs with connection instructions.

Entering Custom Code for Initializing the DUT

The C-PHY Transmitter CTS Application includes a function tab with user visible code in it. This function is executed at the beginning of the CTS, and it can be used to send initialization commands to the DUT. An illustration of the function tab with pre-populated code is shown in Figure 10. The illustrated code relates to caching of results or measurement configurations, and it is intended to demonstrate the flexibility of the tool. Indeed, any Python code or system-call code to external software can be included in this function tab.
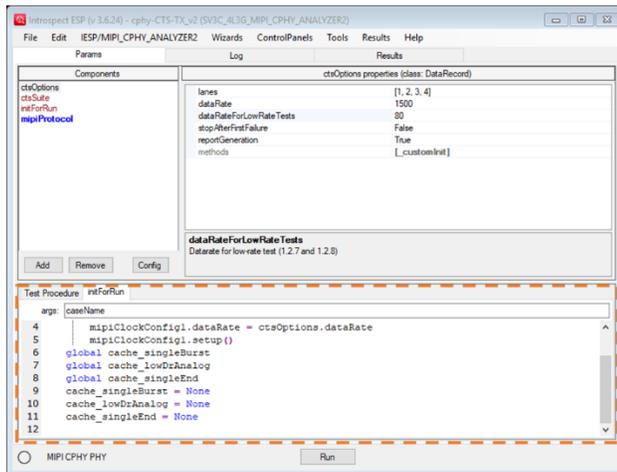
Figure 10   User-editable code area for automatically initializing the test flow or the DUT.

Getting More Help

This document introduced the Introspect C-PHY Transmitter CTS Application at a high level, and it provided a detailed description of its user interface. Various other sources of information are available, and these include

- Online html help files from within the IntrospectESP software
- Context help provided with each of the components and each of the parameters
- Introspect SV3C CPTX CPRX QuickStart (document number EN-G003E-E-15279)
- Introspect SV3C CPRX Data Sheet (document number EN-D002E-E-17339)

Revision Number	History	Date
1.0	Initial document release	June 13, 2018

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