Keysight M8085A MIPI® C-PHY Receiver Test Software

Calibration, Conformance and Characterization Procedures

User Guide

Notices

Trademarks

MIPI® C-PHY™ and MIPI® D-PHY™ are registered trademarks of the MIPI Alliance.

Manual Part Number

M8085-91030

Edition

Edition 3.3, July 2019

Keysight Technologies Deutschland GmbH
Herrenberger Strasse 130,
71034 Böblingen, Germany

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

U.S. Government Rights

The Software is “commercial computer software,” as defined by Federal Acquisition Regulation (“FAR”) 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement

(“DFARS”) 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

Safety Notices

CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Contents

5 Test Procedures

1 Introduction

The MIPI C-PHY Receiver Test Software supports the Keysight Technologies M8195A signal generator for single-lane and multi-lane testing.

For the terminology used in this document, such as definitions, abbreviations, and acronyms, refer to the “MIPI Alliance Specification for C-PHY” (for short: MIPI C-PHY specification). The receiver tests described in this document are implemented according to the requirements of the “MIPI Alliance Test Program C-PHY Physical Layer Conformance Test Suite” (MIPI C-PHY).

The following diagram shows the connection for single-lane testing with M8195A:

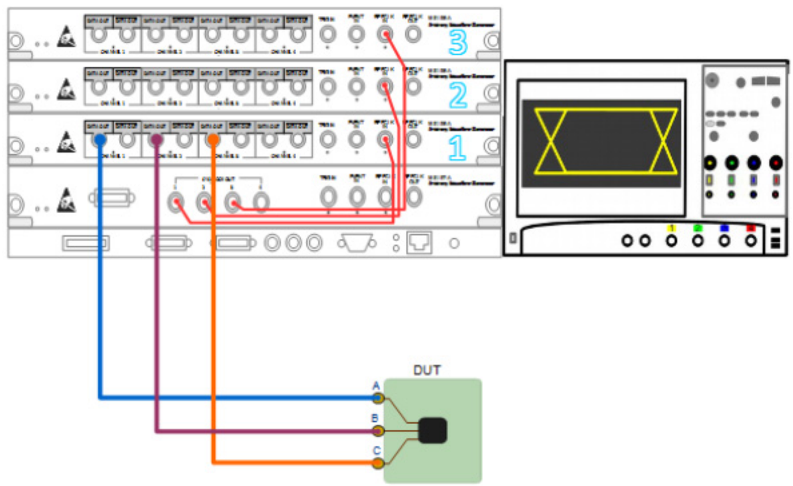


Figure 1 M8195A MIPI C-PHY Receiver Test Setup

The connection diagram displayed above is common to many tests. However, the connection settings vary for different calibration / test procedures based on the configuration you select.

Basic Requirements

Hardware Setup

Single-lane Setup

Using M8195A AWG Module

M8195A uses the following options:

- Option -001, -002, or -004: With these options the number of channels is selected. The M8195A is available in a one channel
- (-001), two channel (-002) or 4 channel (-004) version. A software upgrade from one to two channels is possible by installing option U02. A software upgrade from two to four channels is possible by installing option U04. In order to upgrade from one to four channels, first option -U02 and next -U04 must be installed.
- Option -16G: This option offers 16384 MSa (=16 GSa) waveform memory for the M8195A. Option -16G is software upgradeable.
- Option -SEQ: This option offers extensive sequencing capabilities. Option -SEQ is software upgradeable.
- Option -FSW: This option enables the M8195A to externally select or step through segments or sequences faster than every 500 µs. Option -FSW is export controlled and is software upgradeable.
- Option -1A7, -Z54: Calibration options.

The required hardware setup for single-lane using M8195A module are following:

- One M8195A module
- An Embedded Controller (such as M9537A) or an external controller
- M9502A AXIe chassis
- An Infiniium or SCPI compatible oscilloscope
- LAN or GPIB adapter

For hardware setup follow the given steps:

1. Put M8195A and an Embedded Controller in the 2 slot frame AXIe chassis.
2. M9502A contains only two slots. The Embedded Controller must be installed in the slot 1 of the AXIe chassis otherwise, it will not be able to connect to the internal PCIe interface of the frame.
3. The slot 2 contains the M8195A AWG module.

NOTE

The module itself is already de-skewed. It means that all the signal outs are synchronized with respect to each other, that is, Data Out 1 is synchronous to rest of the data out locations. The only prerequisite is to have 'matched triplet' length for the 3-cable MIPI C-PHY connections. This can be done by doing a de-skew calibration.

Multi-lane Setup

Following hardware setup is required for multi-lane:

- Two or three M8195A AWG modules to enable the multi-lane support
- One M8197A module to synchronize multi M8195A modules
- AXIe chassis
  - 5 slot AXIe chassis for two lane structure, that is, 2 slots for two M8195A modules and 1 slot for one M8197A module
  - 5 slot AXIe chassis for three lane structure, that is, 3 slots for three M8195A modules and 1 slot for one M8197A module

NOTE

M8197A module is used to synchronize M8195A modules (Lane 1, Lane 2 and Lane 3). However, if you are using only single M8195A module (Lane 1), M8197A is not required.

For hardware setup (e.g. three Lane structure i.e. three M8195A modules), follow the given steps:

1 Put three M8195A and one M8197A in the 5 slot frame AXIe chassis

2 The modules should be arranged inside a 5 slot chassis in the following order:

- Slot 1: M8197A (Used for synchronization)
- Slot 2: M8195A (Used for lane 1)
- Slot 3: M8195A (Used for lane 2)
- Slot 4: M8195A (Used for lane 3)

NOTE

You can also use an embedded controller for M8070B and/or the AWG SFP. It should be installed in slot 1 of AXI chassis, thereby shifting the other modules one slot up. The module for multi-lane M8195A is also de-skewed itself.

Software Requirements

To install the MIPI C-PHY CTS plug-in, the M8070B software (version S6.0.100.2 or later) is required. You can download the software from the following link:

http://www.keysight.com/find/M8070B

License Requirements

The MIPI C-PHY CTS plug-in is a licensed feature. To enable it, following are the required licenses:

Table 1 License required for MIPI C-PHY CTS plug-in

P/N	License	Description
M8085CE1A	-1TP	MIPI C-PHY 1.1 Editor for M819xA AWG, Transportable, Perpetual License
	-1NP	MIPI C-PHY 1.1 Editor for M819xA AWG, Network/Floating, Perpetual License
	-1TRL	MIPI C-PHY 1.1 Editor for M819xA AWG, 30 Day Trial License
M8085CC1A	-1TP	MIPI C-PHY 1.1 Calibration, Conformance and Characterization Procedures for M819xA AWG, Transportable, Perpetual License
	-1NP	MIPI C-PHY 1.1 Calibration, Conformance and Characterization Procedures for M819xA AWG, Network/Floating, Perpetual License
	-1TRL	MIPI C-PHY 1.1 Calibration, Conformance and Characterization Procedures for M819xA AWG, 30 Day Trial License
M8085CUEA	-1TP	Upgrade MIPI C-PHY Editor from M8085A-CT1 to MIPI C-PHY 1.1, Transportable, Perpetual License
	-1NP	Upgrade MIPI C-PHY Editor from M8085A-CN1 to MIPI C-PHY 1.1, Network/Floating, Perpetual License

P/N	License	Description
M8085CUCA	-1TP	Upgrade MIPI C-PHY Editor plus Calibration, Conformance and Characterization Procedures from M8085A-CT1 and M8085A-CTA to MIPI C-PHY 1.1, Transportable, Perpetual License.
	-1NP	Upgrade MIPI C-PHY Editor plus Calibration, Conformance and Characterization Procedures from M8085A-CN1 and M8085A-CNA to MIPI C-PHY 1.1, Network/Floating, Perpetual License
N5990A	-010	Test Sequencer

NOTE

The Network license for the M8085A MIPI C-PHY CTS plugin is compatible with both the license types of the Keysight M8070B software, that is, Network license (M8070B-0NP) and Transportable license (M8070B-0TP). For the Network license of the M8085A MIPI MIPI C-PHY CTS plugin to work, there is no need to install Keysight M8070B software's Network license (M8070B-0NP) separately in case only the Transportable license (M8070B-0TP) is installed.

Installing Plug-in

The MIPI C-PHY Editor plug-in must be installed separately by the M8070B system software.

Please make sure that the system should already have M8070B (version S6.0.100.2 or later) software installed on it.

M8195A SFP should be installed from v3.6.0.0 and M8197A SFP should be installed from v3.6.0.0.

The installer for the MIPI C-PHY Editor plug-in is available either on CD or you may download it from the from the following Keysight web-page: www.keysight.com/find/m8085a.

For details on how to install the MIPI C-PHY CTS plug-in, refer to the *Keysight M8085A Plugins for MIPI Receiver Test Solutions Installation Guide*.

Related Documents

The plug-ins are installed separately from the plug-in manager.

For details on how to use the **Plug-in Manager** to install, uninstall and update the **M8085A** plug-in, refer to the *Installing M8085A Plugins for MIPI Receiver Test Solutions* section in *Keysight M8000 Series of BER Test Solutions Plugins for M8070B System Software Getting Started Guide*.

For M8070B plug-ins related documents, click **Start** > **Keysight M8070B** > **Keysight M8070B Documentation**.

Accessing the MIPI C-PHY CTS Plug-in

The MIPI C-PHY Receiver Test Software user interface allows you to set the DUT and test configuration. It can be accessed through the M8070B system software. You must have the valid license to run the application. For licensing details, refer to "License Requirements" on page 13.

Follow the steps to access an installed MIPI C-PHY CTS plug-in through M8070B system software:

1 Click **Start** > **Keysight M8070B**. The user interface for the M8070B system software appears.

2 From the M8070B user interface main menu, click **Application** to view the list of all installed plug-ins.

3 Select the **MIPI C-PHY CTS** plug-in.

4 The **MIPI C-PHY CTS** plug-in interface appears as shown in Figure 2.

NOTE If you are unable to see the MIPI C-PHY CTS option in the **Applications** menu, you must install it separately. Ensure that you have a valid license to install the software.

Currently, the shortcut for Keysight M8085A plug-ins is not auto-generated during installation.

To manually create a shortcut to the Keysight M8070B software on your desktop to access the M8085A plug-ins, perform the following steps:

1 Navigate to *C:\Program Files\Keysight\M8070B\bin* folder on your machine.

2 Right-click *Keysight.M8070B.exe* and click **Create Shortcut**.

3 Click Yes on the 'Shortcut' prompt to place the shortcut on the desktop.

4 On the desktop, right-click *Keysight.M8070B – Shortcut* icon and click **Properties**.

5 In the **Properties** window, modify the 'Target' location to *"C:\Program Files\Keysight\M8070B\bin\Keysight.M8070B.exe" /IgnoreAwg*.

6 Click **Apply** and exit the **Properties** window.

You may launch the *Keysight.M8070B – Shortcut* to access the M8085A plug-ins.

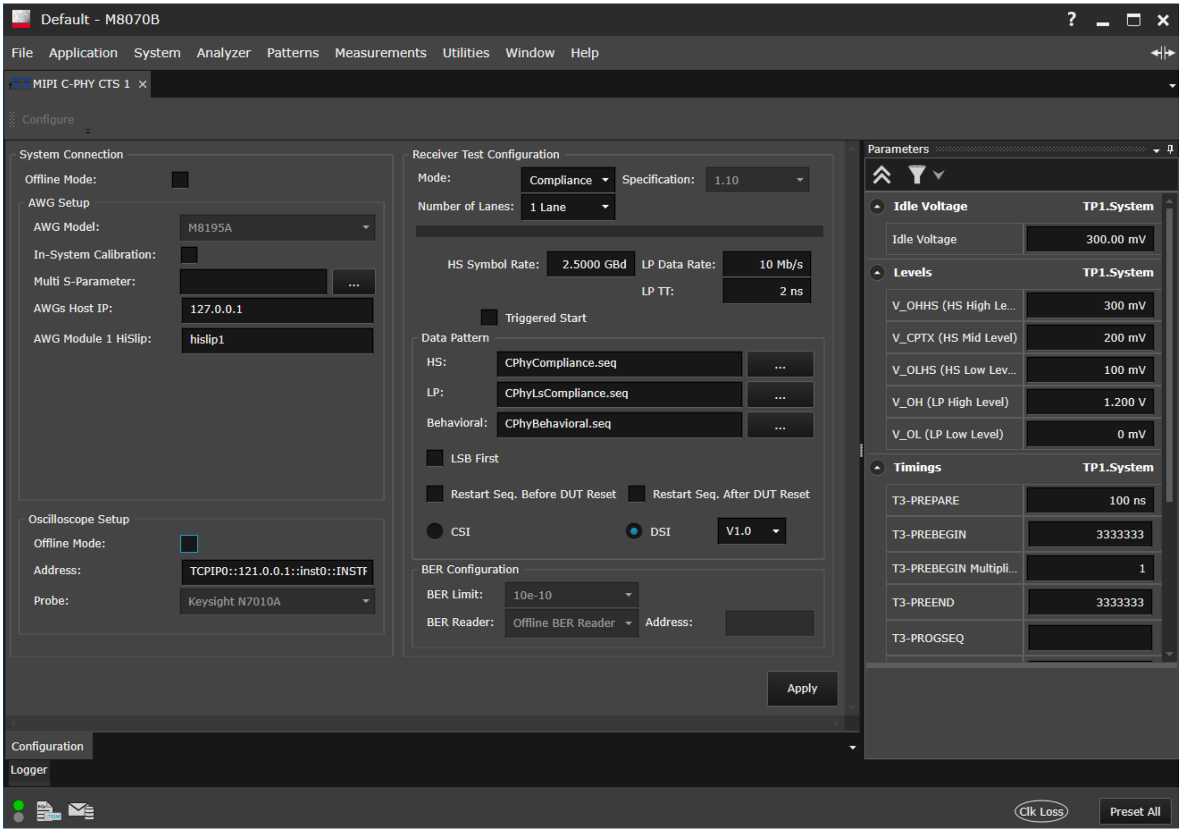


Figure 2 MIPI C-PHY CTS Configuration Window

The MIPI C-PHY Receiver Test Software user interface consists of the following GUI elements:

- Configuration
- Parameters
- Logger

Configuration Panel

The **Configuration** Panel allows you to define the attributes for System Connection and for Receiver Test Configuration.

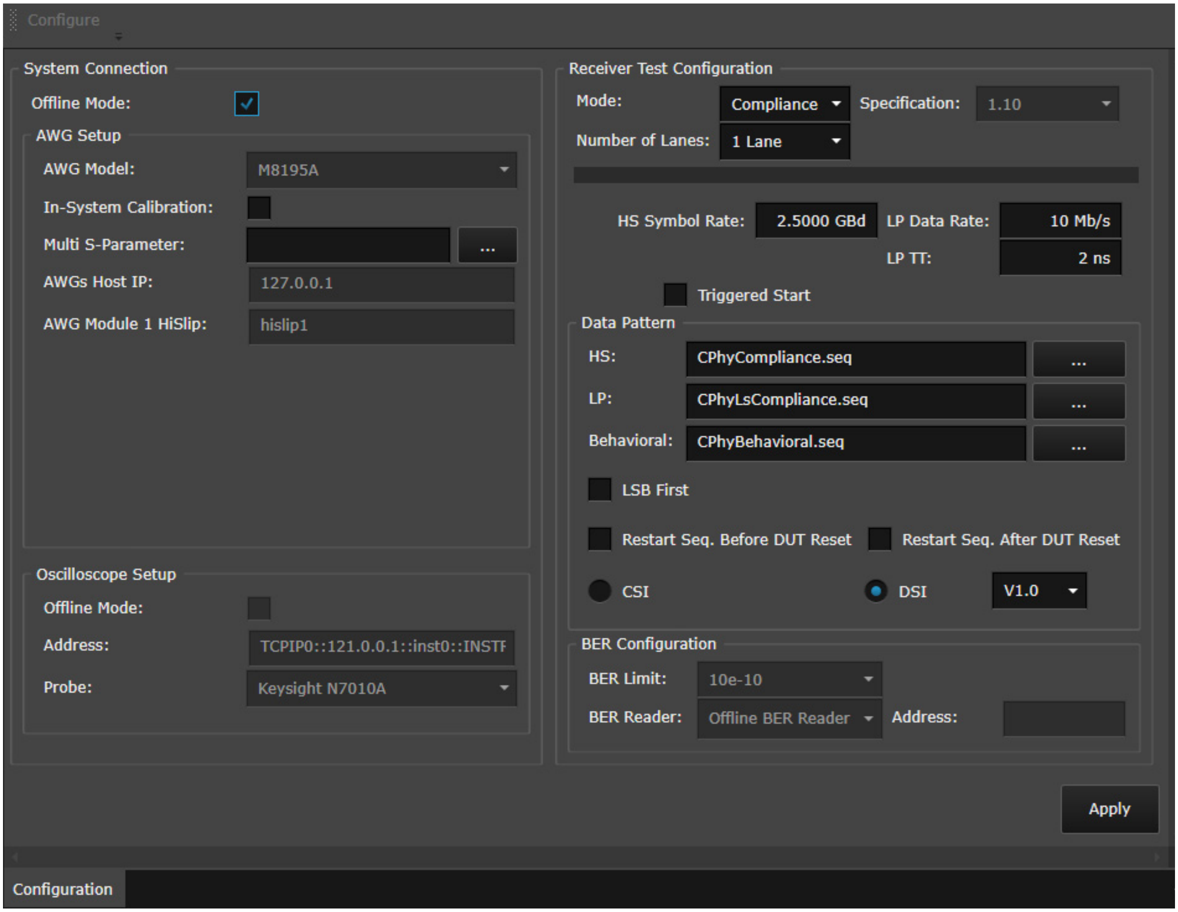


Figure 3 MIPI C-PHY CTS Configuration Panel

System Connection

This area includes the following attributes:

- Offline Mode: Select this check box to use the MIPI C-PHY Receiver Test software in an offline mode, i.e. without a proper physical connection to the DUT. In this mode, the application offers limited functionality and certain features are disabled.
- AWG Setup: This panel provides the following setup options for AWG.
  - AWG Model: The software currently supports the M8195A AWG only.
  - In-System Calibration: If set to ‘On’, this parameter enables the In-System AWG Calibration data for de-embedding. While the process of a normal de-embedding achieves de-embedding of the output amplifier only, using In-System Calibration achieves de-embedding of cables and probes as well (that is, the entire signal path), if applied. For more information regarding how to perform In-System AWG Calibration, see “Performing In-System AWG Calibration with Keysight IQ Tools” on page 34.
  - Multi S-Parameter: Define the s-parameter files to be de-embedded from the calculated waveform.

    To select one or more S-Parameter files, click this field and navigate to *C:\ProgramData\BitifEye\ValiFrame\SParameter\CPhy*. Select the required files and click Open. The selected file locations appear on the field and the de-embedding attributes are loaded.
  - AWG Host IP: The Host IP address is the network address of the controller computer where the M8195A is connected. Enter the Host IP address in the IPv4 format, for example, “127.0.0.1”.
  - Clock Sync Module HiSlip: Provide the HiSlip address of the Clock Sync module.
  - AWG Module 1 HiSlip: It is the HiSlip identifier of the AWG module 1 of the M8195A that will generate the associated MIPI C-PHY lane signal. Enter the HiSlip in the format “hislip<number>”. For example, hislip1.
  - AWG Module 2 HiSlip: It is the HiSlip identifier of the AWG module 2 of the M8195A that will generate the associated MIPI C-PHY lane signal. Enter the HiSlip in the format “hislip<number>”. For example, hislip2.
  - AWG Module 3 HiSlip: It is the HiSlip identifier of the AWG module 3 of the M8195A only that will generate the associated MIPI C-PHY lane signal. Enter the HiSlip in the format “hislip<number>”. For example, hislip3.

NOTE

The MIPI C-PHY CTS plug-in allows connection to more than one module of the M8195A AWG, when you select the option "Number of Lanes" as '2 Lanes' or 3 Lanes'.

Oscilloscope Setup

- Offline Mode: Select this check box to use the oscilloscope in offline mode, that is, without a live signal.
- Address: Specify the VISA address of the connected oscilloscope in the format: "TCPIP0::121.0.0.1::inst0::INSTR".
- Probe: The calibrations are performed with the Keysight N7010A active termination adapter only.

Receiver Test Configuration

It includes the following attributes:

- Mode: There are two modes:
  - Compliance Mode: The Compliance Mode strictly adheres to the tests and its parameter limits are defined in the MIPI C-PHY CTS. By default, the CTS limit values for the parameters used in the Calibration and Test procedures are defined within the application. The application does not allow you to modify values to the test parameters in Compliance Mode.

NOTE

In the Compliance Mode, all tests are performed within the minimum and maximum values of the test parameters as defined in the MIPI C-PHY CTS specification.

  - Expert Mode: The Expert Mode allows you to customize the parameter limits, only if needed, to non-standard values, which can be helpful in debugging. By default, the CTS limit values for the parameters used in the Calibration and Test procedures are defined within the software. However, in Expert Mode, you may edit the parameter fields to indicate different values supported by your DUT.

NOTE

In the Expert Mode, the plug-in allows you to change the parameter values within or beyond the maximum and minimum limits as defined in the MIPI C-PHY CTS specification.

- Specification: This drop-down field displays the versions of the MIPI Alliance Specification for C-PHY, such that MIPI C-PHY Receiver Test software defines the corresponding values for parameters from each specification standard. Currently, the only specification supported is 1.10.
- Number of Lanes: The M8195A module has a multi-lane structure. Therefore, the MIPI C-PHY Receiver Test software displays, by default, 1 Lane for the M8195A module and you may select up to 3 Lanes; that is, either 1 Lane, 2 Lanes or 3 Lanes from the drop-down options.
- HS Symbol Rate: Specify a value for the high speed symbol rate for the signal. You can edit this field, both in Compliance and Expert Modes.
- LP Data Rate: Specify a value for the low power data rate for the signal. You can edit this field, both in Compliance and Expert Modes.

NOTE

Beginning with version 2.7 onwards, the M8085A MIPI C-PHY CTS plug-in supports a minimum **LP Data Rate** value of 1Mbps. However, using such lower data rate values can impact the pattern calculation time and memory usage. Therefore, the default **LP Data Rate** is set to 10 Mbps.

- LP TT: Specify a value for the low power transition time for the MIPI C-PHY signal. You can edit this field, both in Compliance and Expert Modes.
- Triggered Start: Select the check-box to trigger the LP-111 sequence in the signal.

Data Pattern

- HS: Select this radio button to define sequence files, in the **.seq* format, for high speed data signal tests. To select the HS sequence file, click the corresponding ... button.
- LP: Select this radio button to define sequence files, in the **.seq* format, for low power signal tests. To select the LP sequence file, click the corresponding ... button.
- Behavioral: Select this radio button to define sequence files, in the **.seq* format, for behavioral tests. To select the Behavioral sequence file, click the corresponding ... button.
- LSB First: Select this check-box to transmit the Least Significant Bit (instead of the Most Significant Bit) first in the Data Pattern.
- Restart Seq. Before DUT Reset: Select this check box to restart the sequences before the DUT transmission.

- Restart Seq. After DUT Reset: Select this check box to restart the sequences after the DUT transmission.
- CSI: Select this option to verify conformance of the MIPI C-PHY sequences with the Camera Serial Interface (CSI) protocol. For more information on CSI Sequences, refer to "Sequence File Definition for CSI" on page 63.
- DSI: Select this option to verify conformance of the MIPI C-PHY sequences with the Display Serial Interface (DSI) protocol. For the DSI protocol, the MIPI C-PHY CTS user interface displays two drop-down options to choose the DSI version from. By default, V1.0 is selected. The other option is V1.1. The difference in both DSI versions is that the sequence structure of DSI V1.0 contains the SSS block whereas this block is unavailable in the sequence structure of DSI V1.1. For more information on DSI Sequences, refer to "Sequence File Definition for DSI" on page 72.

BER Configuration

For automated receiver testing, it is necessary to determine whether the DUT receives the data properly. This can be achieved by reading pass / fail information from the DUT. The Bit Error Ratio (BER) is measured and read. The MIPI C-PHY Receiver Test Software supports two different BER Reader implementations.

- BER Limit: Select the BER limit for the tests.
- BER Reader: Following are the options available for the BER reader:
  - Offline BER reader: This is the default option and does not require any address. Using the "Offline BER Reader" for each step of the test procedure, the MIPI C-PHY Receiver Tests Software shows pop-up dialogs requesting the user to reset and initialize the DUT and decides whether the DUT is working properly. This method is applicable to the DUT that allow a visual check, e.g. a Digital Serial Interface (DSI) device connected to a display. It is also possible to connect the DUT to the scope and verify if the output data is valid with help of the serial decoder. Using an offline BER reader will result in a semi-automated test as at each test point the user has to enter the pass / fail information.

- iBERreader: This option enables the custom BER reader. The usage of a "Custom BER Reader" enables fully automated testing for all transmission modes (HS and LP). This method requires the implementation of a class supporting the IBerReader interface by the user, providing access to the DUT's pass/fail information. If required, refer to "IBerReader Interface Definition" on page 189 for details on integration method.
    - Address: Provide BER Reader address in this field, after selecting iBERreader.

Once the connections to the instrument are made successfully, click the **Apply** button.

NOTE You must ensure that all the selected instruments for the test station are connected to the test station PC controller by the remote control interfaces such as GPIB (General Purpose Interface Bus), LAN (Local Area Network), USB or VXI (VME eXtensions for Instrumentation).

Parameters Panel

The **Parameters** Panel allows you to change the Idle Voltage, Protocol timings supported by the DUT and the signal levels.

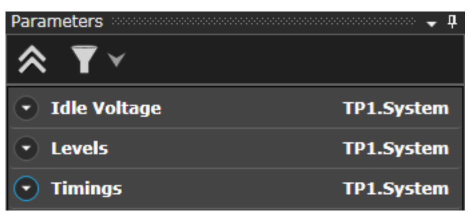


Figure 4 Parameters Panel

Idle Voltage

The parameter for Idle Voltage is shown in Figure 5 and described below.

Figure 5 Idle Voltage Parameter

Idle Voltage: The Idle voltage sets the offset on the AWG output amplifiers. This is the output offset voltage when the AWGs are in the Stop state.

Levels

The parameters provided by Signal Levels are shown in the Figure 6 and described in Table 2 on page 26.

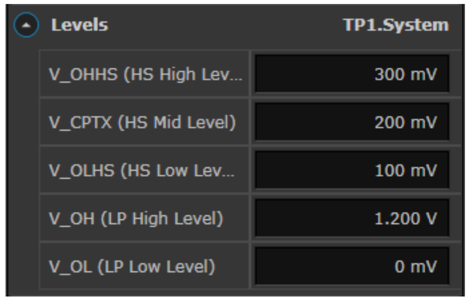


Figure 6 Parameters for Levels

Table 2 Parameters for Levels

Parameter	Description
V_OHHS (HS High Level)	High Speed Mode high voltage level
V_CPTX (HS Mid Level)	High Speed Mode mid voltage level
V_OLHS (HS Low Level)	High Speed Mode low voltage level
V_OH (LP High Level)	Low Power Mode high voltage level
V_OL (LP Low Level)	Low Power Mode low voltage level

Timings

The parameters provided by Timings are shown in the Figure 7 and described in Table 3 on page 27.

Figure 7 Parameters for Timings

Table 3 Parameters for Timings

Parameter	Description
T3-PREPARE	Sets the time that the transmitter drives a LP-000 state immediately before the start of high speed transmission.
T3-PREBEGIN	Sets the T3-PREBEGIN pattern in high-speed MIPI C-PHY pattern format before the beginning of the HS data transmission. The pattern should be a multiple of 7 UI from a minimum of 7UI to a maximum of 448 UI. By default, an HS pattern of 7UI length is defined. To define a pattern of more than 7UI, use the parameter “T3-PREBEGIN Multiplier” to define a multiplier.
T3-PREBEGIN Multiplier	Set the multiplier value between 1 and 64 to set the required HS pattern length from 7UI to 448UI. By default, the multiplier is set to 1, which indicates that a T3-PREBEGIN pattern length of (1 x 7UI) 7UI is defined. You may modify the multiplier value up to 64 to achieve the maximum T3-PREBEGIN pattern length of up to 448UI.
T3-PREEND	Sets the T3-PREEND pattern in high-speed MIPI C-PHY pattern format. By default, this pattern contains a total of 7 symbols of type 3.

Parameter	Description
T3-PROGSEQ	Sets the optional T3-PROGSEQ pattern in high-speed MIPI C-PHY pattern format.
T3-SYNC	Sets the T3-SYNC, which is sent immediately before staring high-speed transmission. By default, the pattern is 3444443.
T3-POST	Sets the T3_POST pattern which is sent immediately after starting high-speed transmission.
T3-POST Multiplier	Set the multiplier value between 1 and 32 to set the required T3-POST pattern length from 7UI to 224UI. By default, the multiplier is set to 1, which indicates that a T3-POST pattern length of (1 x 7UI) 7UI is defined. You may modify the multiplier value up to 32 to achieve the maximum T3-POST pattern length of up to 224UI.
TX-HS-EXIT	Sets the length of LP-111 state following a high-speed burst.
TX-WAKEUP	Time that the transmitter drives a Mark-1 state prior to a Stop state in order to initiate an exit from ULPS.
TX-INIT	Time that the transmitter drives a Stop State (LP-111).
Set Default	Resets all the Timings settings to the default value.

Logger Panel

The Logger Panel displays errors, warnings and information messages along with their respective descriptions, applications from where they are generated and their time stamps.

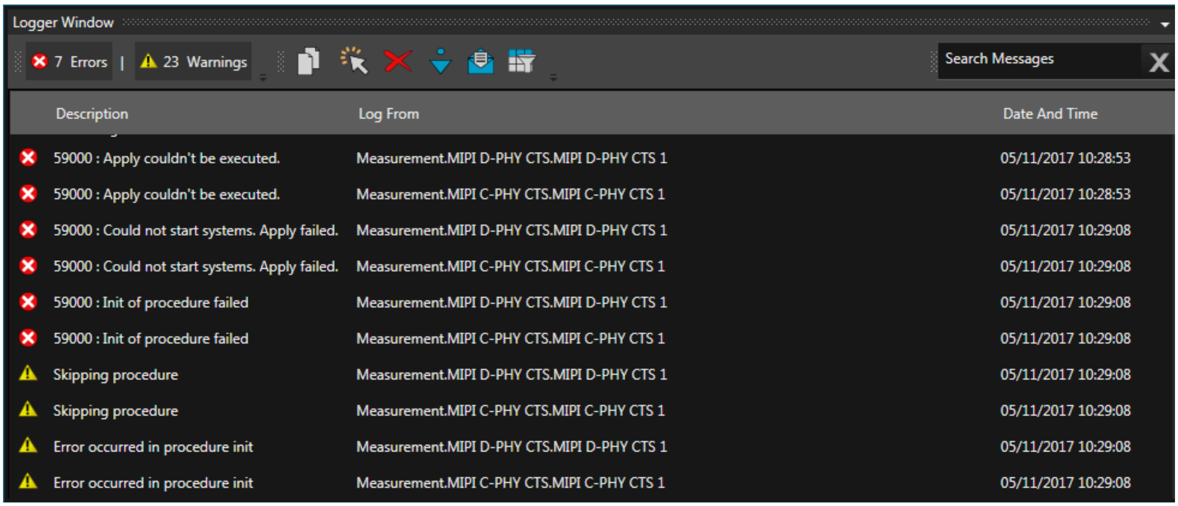


Figure 8 Logger Panel

Running Tests

Once the configuration setup is done, click the **Apply** button on the Configuration Panel, the following test selection window is displayed:

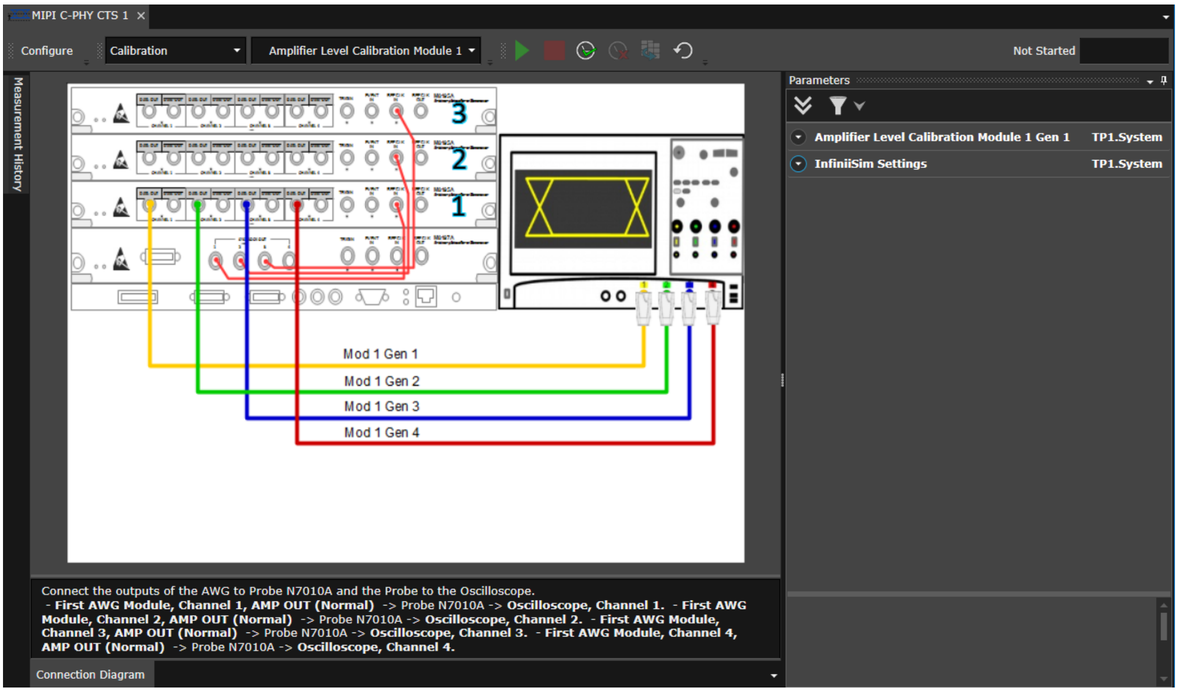


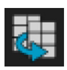
Figure 9 Performing the tests

This window allows you to select and run the MIPI C-PHY CTS tests. For each test, the plug-in displays the connection diagram along with the connection information on how to connect the outputs of AWG, DUT and Oscilloscope. For all calibration and test procedures that are run, the results are displayed automatically in either a data table, either graphically or both. At any point of time, click the Configure button to go back to Configuration Panel to re-configure the DUT and the test mode.

This window has the following options:

1 Toolbar Buttons: The following table shows the available buttons on the toolbar:

Table 4 Toolbar Buttons

	Start /Continue Test	Starts a test.
	Stop Test	Stops the test.
	Enable/Disable Test Run History	Enables or disables the test's run history.
	Clear Test History	Clears the test run history.
	Copy Test History Properties	Copies the test history properties to the currently running test.
	Reset	Resets the test to its default values.

2 Measurement History: Maintains the history of the tests that have been run, along with their time stamp. You may also refer to the previously run measurements and compare the results.

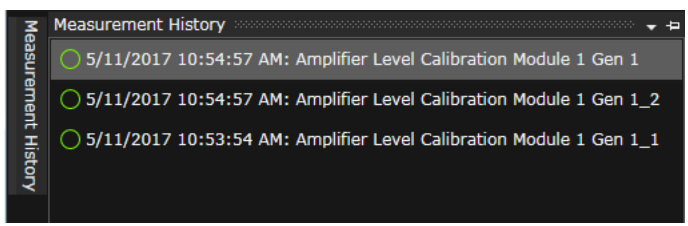


Figure 10 Measurement History

- Click the  button present on the toolbar if you wish to toggle between enabling/disabling measurement run history.
- Click the  button to copy the properties of the run measurements on to the currently running measurement.

3 Status Indicator: Displays the current state of a test. Each test run can have various states, such as Not Started, Running, Stop, Error, Suspended and Finished.

The following figure displays the status indicator while the test is running:

4 Results (Tabular view): Displays results in a tabular format for each procedure, that is, measured values for calibrations and values for tests after they are complete.

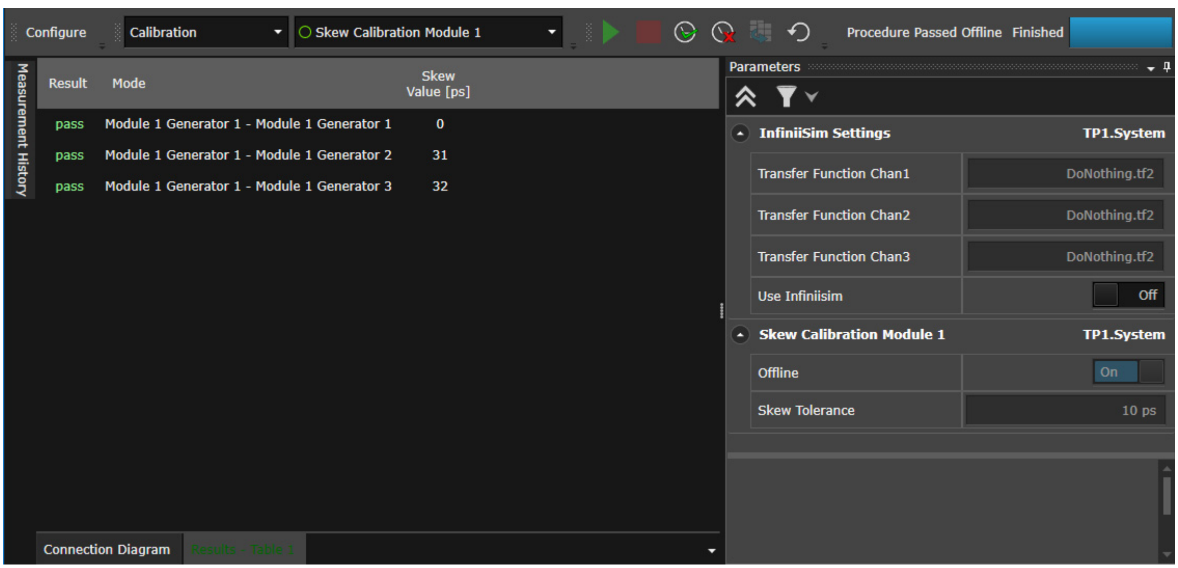


Figure 11 Tabular view for results

5 Results (Graphical view): Displays the graphical results for some procedures, that is, measured values for calibrations and tested values for the tests. For example, the following figure shows the calibration corresponding to the Amplitude Level Calibration Module 1 Gen 3.

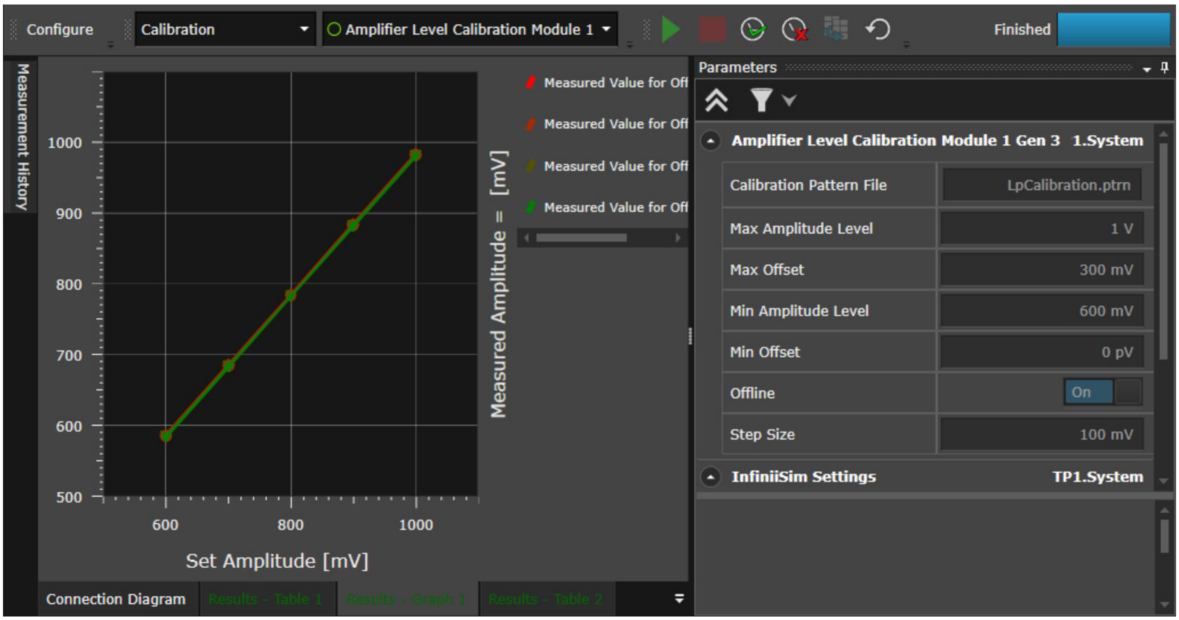


Figure 12 Graphical view for results

Performing In-System AWG Calibration with Keysight IQ Tools

To improve the quality of the MIPI C-PHY signal, you may enable the calibrated values obtained via the In-System Calibration of the connected AWGs. The In-System Calibration can be performed using the Keysight IQ Tools software, which you may download from www.keysight.com.

To perform In-System Calibration:

1 Launch the *Keysight IQ Tools* software.

2 In the **Configuration** area of the main window, click **Configure instrument connection**.

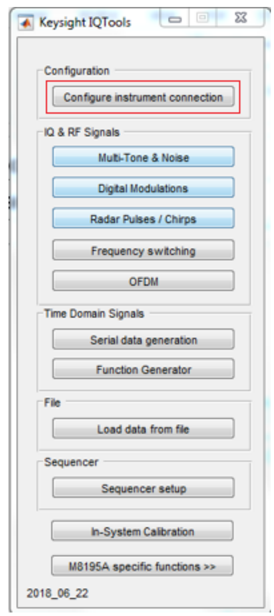


Figure 13 Main window of the IQ Tools software

3 In the **Arbitrary Waveform Generator Configuration** section of the **Instrument Configuration** window,

- For 4-Channel mode:
  - a Select **Instrument model** as *M8195A*
  - b Select **Mode** as *4 ch, deep mem, 16 GSa/s*
  - c Select **Connection** type as *visa*
  - d In the **VISA Address** field, type the address of the M8195A module

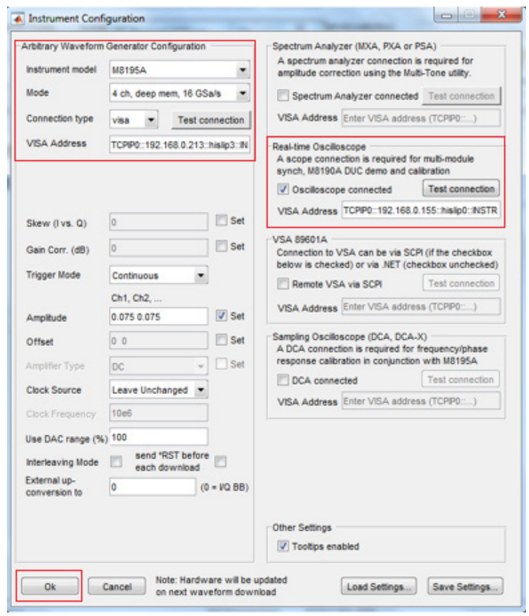


Figure 14 Settings on the Instrument Configuration window for 4-Channel

- For Dual Channel mode:
  - *a* Select **Instrument model** as *M8195A*
  - *b* Select **Mode** as *2 ch, deep mem, 32 GSa/s*
  - *c* Select **Connection** type as *visa*
  - *d* In the **VISA Address** field, type the address of the M8195A module

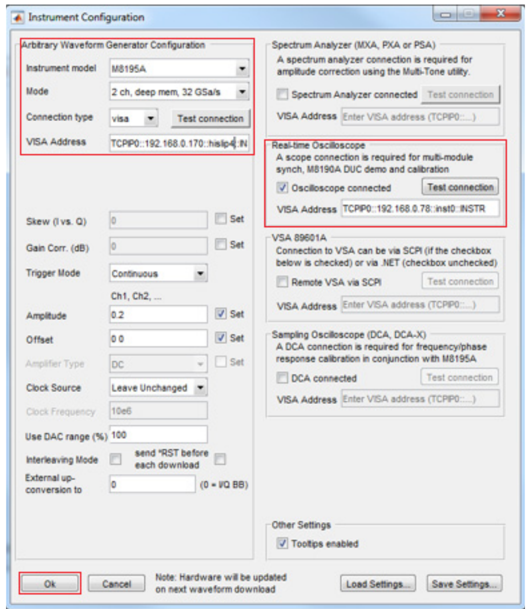


Figure 15 Settings on the Instrument Configuration window for Dual Channel

4 In the **Real-time Oscilloscope** section of the **Instrument Configuration** window,
   - *a* Select the **Oscilloscope connected** check box, if not checked already
   - *b* In the **VISA Address** field, type the address of the Oscilloscope.

5 Click **OK** on the Instrument Configuration window.

6 In the **Time Domain Signals** area of the main window, click **Serial data generation**.

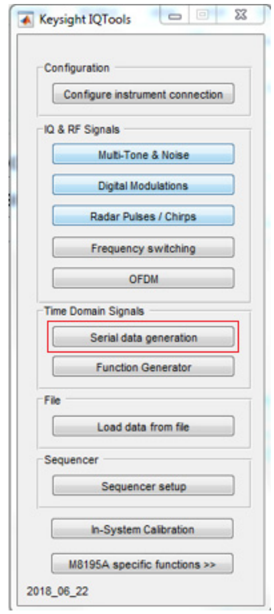


Figure 16 Accessing Serial data generation option

7 In the **Serial Data** window that appears, click **Show Correction**.

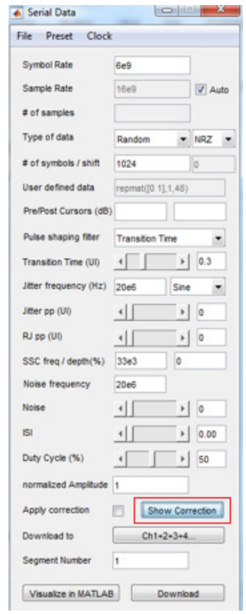


Figure 17 Accessing the Correction Management window

8 From the **Correction Management** window that appears, click **In-System Calibration**.

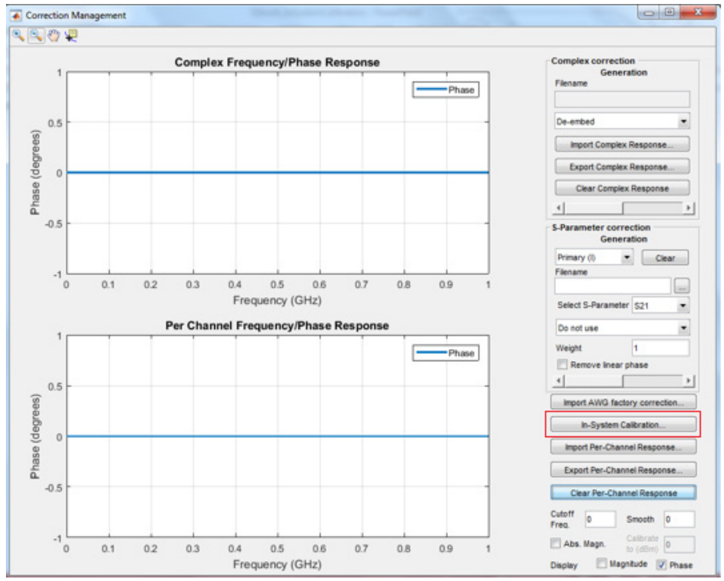


Figure 18 Selecting In-System Calibration option

9 On the **Frequency/Phase response calibration** window that appears,

- For 4-Channel mode

  a Ensure that the physical channels of the AWG and the Oscilloscope are connected as per the configuration shown in the **Channel Mapping** area (AWG Ch1 to Oscilloscope Ch1 and so on).

NOTE On the AWG complement outputs, ensure that terminations are connected.

  b In the **Settings** area,

  - **Sample Rate** value remains as-is
  - If a Low-Pass Filter (LPF) is connected, the **Max. tone frequency** value should not exceed *8e9*

  c Click **Run** to begin calibration measurements.

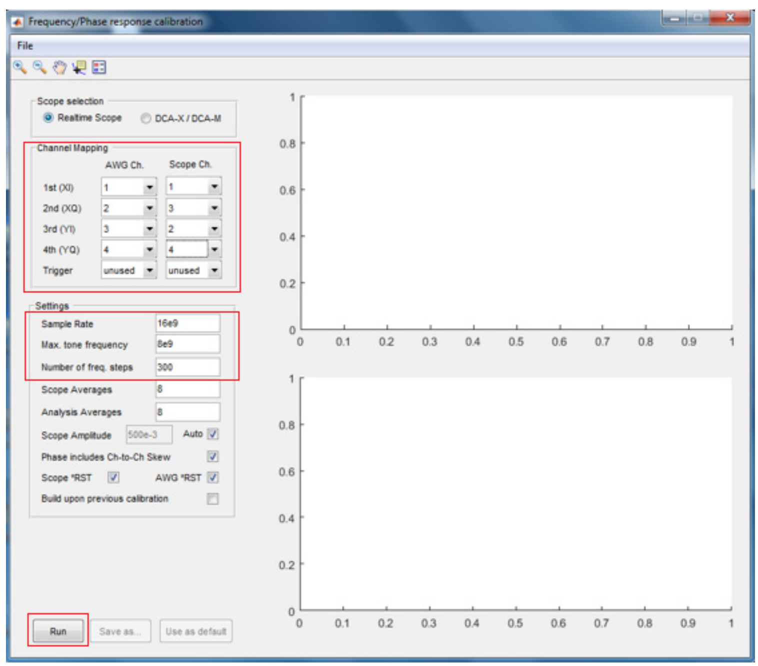


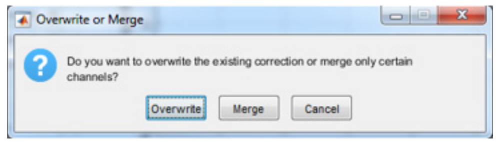
Figure 19 Validating settings to perform In-System Calibration

d If error messages are displayed,

- Validate the AWG-Oscilloscope Channel Mapping
- Reduce the Max. tone frequency value and try again

e If one or more outliers are found in the measurement, repeat the measurement a few more times.

f Once measurements are performed, overwrite the results.



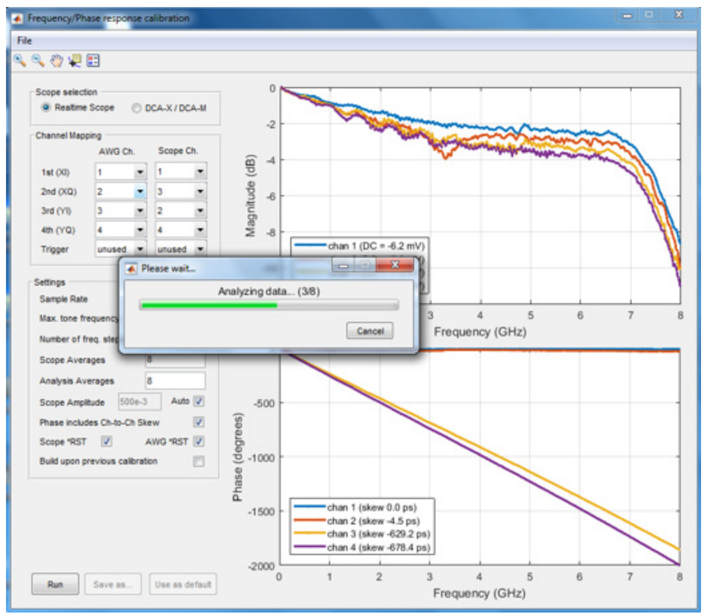


Figure 20 Viewing In-System Calibration results

- For Dual-Channel mode
  a. Ensure that the physical channels of the AWG and the Oscilloscope are connected as per the configuration shown in the **Channel Mapping** area (AWG Ch1 to Oscilloscope Ch1 and so on).

NOTE On the AWG complement outputs, ensure that terminations are connected.

---

  b. In the **Settings** area,
     - **Sample Rate** value remains as-is
     - No Low-Pass Filter (LPF) is connected, therefore, the **Max. tone frequency** value should be *16e9*
  c. Click **Run** to begin calibration measurements.

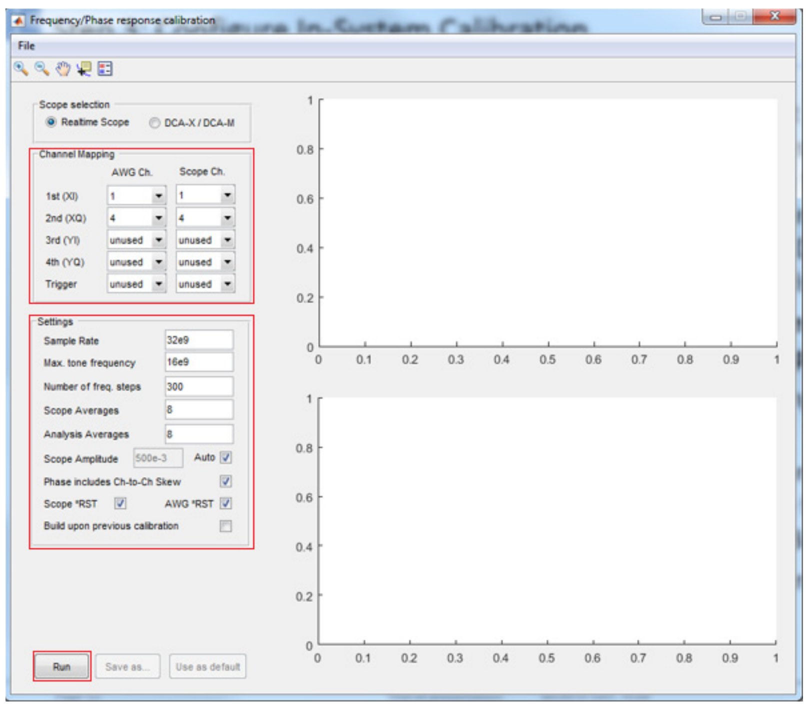


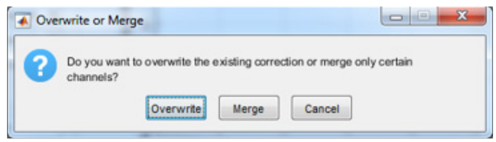
Figure 21 Validating settings to perform In-System Calibration

d If error messages are displayed,

- Validate the AWG-Oscilloscope Channel Mapping
- Reduce the Max. tone frequency value and try again

e If one or more outliers are found in the measurement, repeat the measurement a few more times.

f Once measurements are performed, overwrite the results.



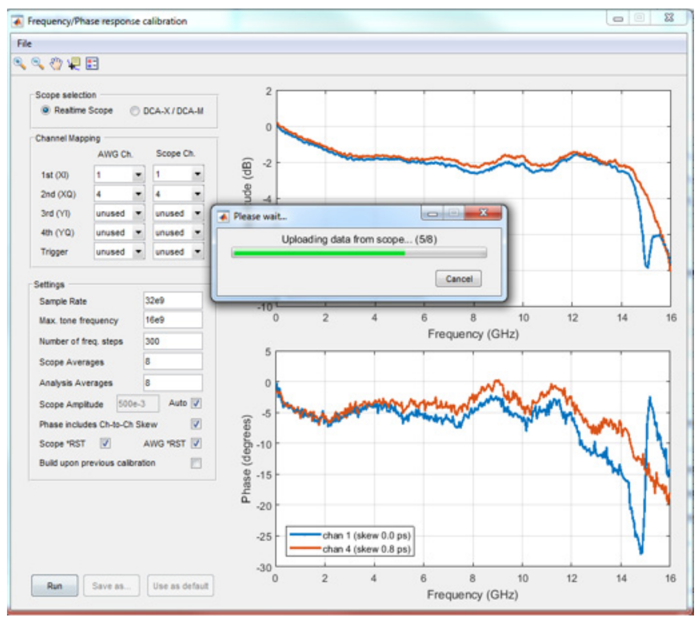


Figure 22 Viewing In-System Calibration results

10 To view the updated results, return to the **Correction Management** window.

- For 4-Channel mode

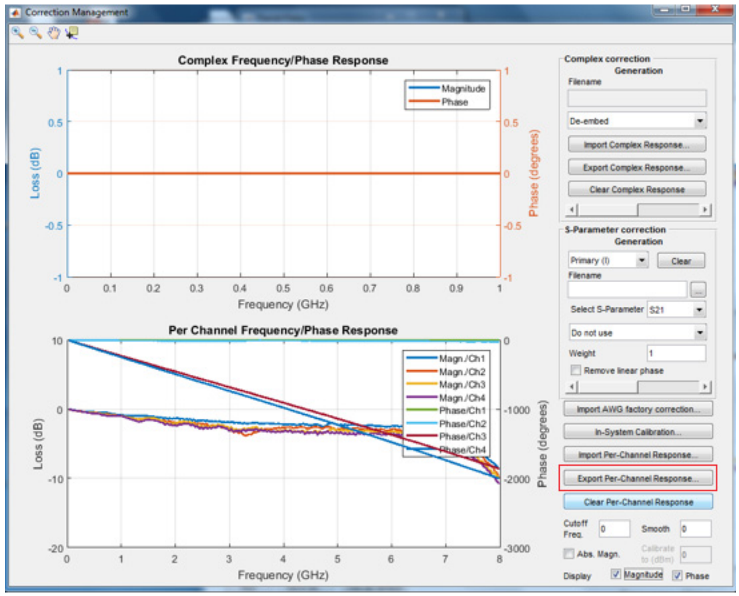


Figure 23 Exporting the Per-Channel Response

- For Dual-Channel mode

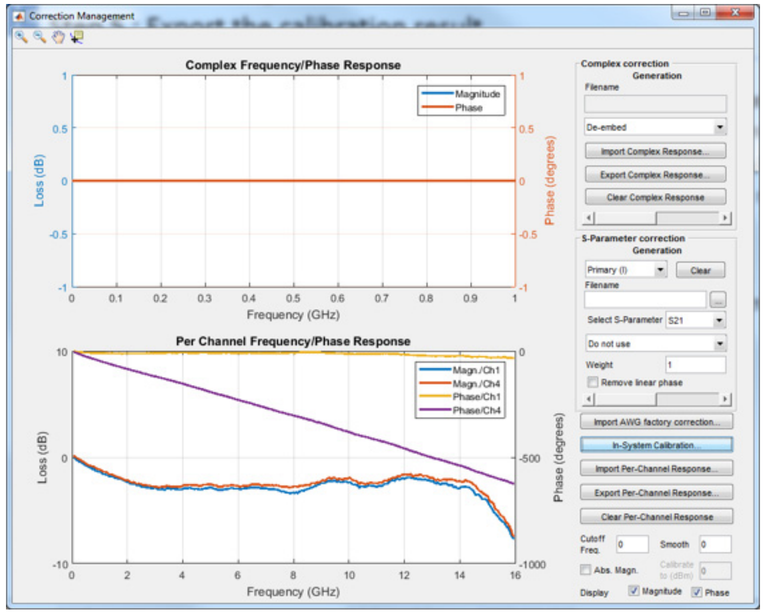


Figure 24 Exporting the Per-Channel Response

11 On the same window, click **Export Per-Channel Response...**.

12 On the **Save Frequency Response As...** window,

- For 4-Channel mode

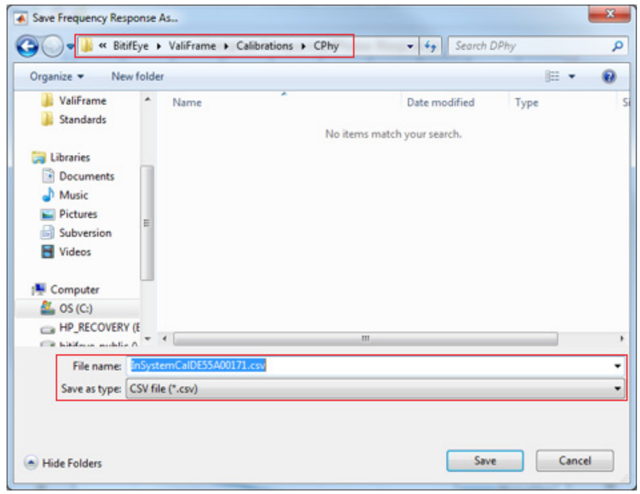


Figure 25 Saving the In-System Calibration values

a In the **Save as type:** drop-down field, select *CSV file (*.csv)*

b Navigate to the location *C:\ProgramData\BitifEye\ValiFrame\Calibrations\Cphy*

c Save the file with the following naming convention:

InSystemCal<*AWG-Serial-Number*>.csv

- For Dual-Channel mode

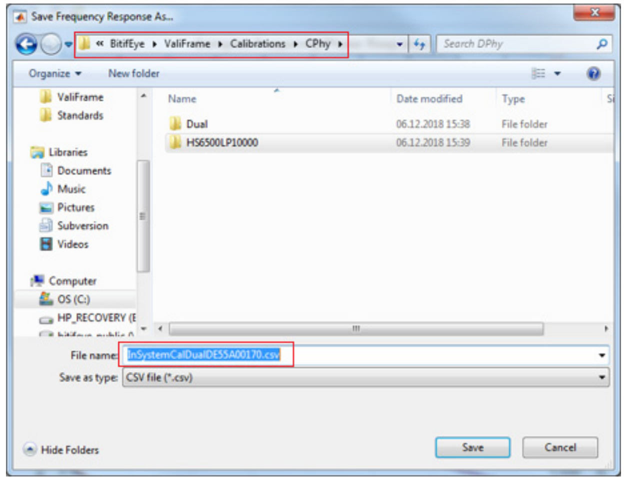


Figure 26 Saving the In-System Calibration values

a In the **Save as type:** drop-down field, select *CSV file (*.csv)*

b Navigate to the location *C:\ProgramData\BitifEye\ValiFrame\Calibrations\Cphy*

c Save the file with the following naming convention:

InSystemCalDual<*AWG-Serial-Number*>.csv *d* To obtain the AWG Serial Number, go to **About Keysight M8195A**.

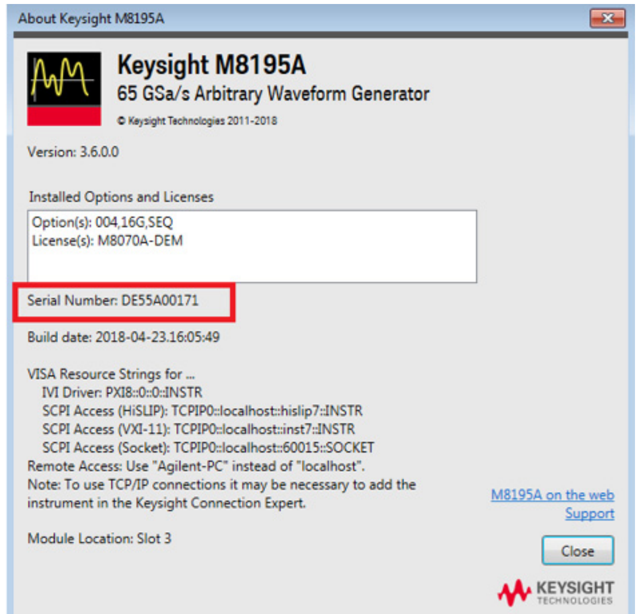


Figure 27 Identifying the AWG Serial Number

13 Repeat the entire process for each AWG that is physically connected.

14 Ensure to save the generated calibration output in the correct folder location with the CSV file format and the correct naming convention, as described earlier.

2 Sequence and Data Files

KEYSIGHT TECHNOLOGIES

Patterns, Data Format and Sequences

Overview

- The Pattern Mode has a *.ptrn file, which contains the definition of LP and/or HS MIPI C-PHY states. The pattern files are loaded with the extension of '*.ptrn' and write in terms of line states.
- The Burst Mode is a block of binary data, which are converted to MIPI C-PHY states, and is repeated infinitely. The burst block may contain either LP Data and HS Data both, pure LP data, or pure HS data, depending on the content of the data given for HS and LP. The files are loaded with the extension of '*.dat'.
- The Pure HS mode contains only HS data and no LP111 transitions are included. For pure HS mode, all the LP data is neglected.
- The Frame mode allows to organize the data in blocks, and a sequence of blocks containing loops. The definition of a sequence is done via a sequence file and it can be loaded with the extension '*.seq'. Each individual block can be repeated ("looped") N-times and the number of repetitions N can be selected for each block separately. In addition to the sequence file, the frame mode may require one or more data files.

NOTE

Currently, the Data Pattern in the MIPI C-PHY CTS plug-in can be defined in the Frame Mode only, that is, using sequence files. However, a sequence file can contain *.ptrn or *.dat/*.txt file names defined within the blocks. The actual *.ptrn or *.dat/*txt files must be included in the same folder location as the sequence (*.seq) files.

D-PHY CTS plug-ins cannot use a sequence that contains MIPI C-PHY specific macros such as three wire LP states (for example, LP000, LP011, etc.) or the P-Macro (for example, P"Patternfile.ptrn"). Otherwise, both MIPI C-PHY and D-PHY CTS plug-ins use the same sequence structure.

*.ptrn File Format (P Macro)

The following table shows the line states available in **High-Speed Mode**:

Table 5 Line States

Pattern File Entry	Line State	Line State {Line A, Line B, Line C}
X	+x	{1, 0, ½ }
x	-x	{0, 1, ½ }
Y	+y	{½ , 1, 0}
y	-y	{½, 0, 1}
Z	+z	{0, ½, 1}
z	-z	{1, ½, 0}

The following table shows the symbols (transitions) available in **High-Speed Mode**:

Table 6 Symbol (Transitions))

Pattern File Entry	Symbol Input Value	Activity
0	000	Rotate CCW, polarity stays same
1	001	Rotate CCW, polarity is inverted
2	010	Rotate CW, polarity stays same
3	011	Rotate CW, polarity is inverted
4	1xx	Same phase, polarity is inverted

The following table shows the line states provided by **Low Power Mode**:

Table 7 Lines states provided by Low Power Mode

Pattern File Entry	Line A	Line B	Line C	Activity
L	0	0	0	One “L” sets all three wires to low state

Pattern File Entry	Line A	Line B	Line C	Activity
C	0	0	1	One pattern file entry defines the state of all 3 wires (1 Symbol). An upper case letter means only the selected wire is high, the 2 other wires are low. A lower case letter means only the selected wire is low, the 2 other wires are high.
B	0	1	0	
a	0	1	1	
A	1	0	0	
b	1	0	1	
c	1	1	0	
H	1	1	1	One “H” sets all three wires to high state

Pattern Coding Examples

The following table shows the example of different types of patten coding used:

Table 8 Pattern Coding Examples

Pattern Coding	Line States	Description
X0123 (XZyzX)	210432113 Resulting Line States: X -> YxzZxyXzX	High speed init pattern and high speed loop pattern. The high speed signal can be coded with transition symbols too.
X0123 (XZyzX)	%0101000011101101% Resulting Transitions: X -> 1432300 Resulting Line States: zZxyZYX	High speed init pattern and coded binary loop pattern. Between the percentage symbols (%) binary coding can be used. The last wire state of the init pattern needs to be equal to the last wire state of the loop pattern (X). If this is not the case coding of the looped pattern will be erroneous.
xXyx	X0241%1011011101001010%x Resulting Line States: X ZXxZ yYzxYZY x	High speed init pattern and high speed loop pattern mixed with binary coding. You can mix the use of wire states, transition symbols and binary coding. This is mainly useful for introducing coding errors.
HLB	xYzxZyyZy	Low power init pattern and high speed loop pattern. There will be a low power to high speed transition at the end of the init pattern.
HLBZ	xYzxZyyZ	Mixed low power/high speed init pattern and high speed loop pattern. The transition from low power to high speed will happen within the init pattern.

Pattern Coding	Line States	Description
acL	y -> 0120412CLAbc	Low power init pattern and high speed and low power loop pattern. There will be a high speed low power transition within the loop pattern and a low power high speed transition at the end of the loop pattern. Limitation: The "LP->HS Start Wire State" cannot be modified.

	Expanded Pattern	Wire States		Expanded Pattern	Wire States
Init Pattern	acL	acL	Loop Pattern 1	0120412	xZXZzYZ
LP->HS Start	H	H	HS->LP Post	4444444	zZzZzZz
LP->HS Request	C	C	HS->LP Exit	C	C
LP->HS Prepare	L	L	Loop Pattern 2	CLAbc	CLAbc
LP->HS Start Wire State	X	X	LP->HS Start	H	H
LP->HS Preamble	3333333	yZxYzXy	LP->HS Request	C	C
LP->HS Pre-End	3333333	ZxYzXyZ	LP->HS Prepare	L	L
LP->HS Sync	3444443	xXxXxXy	LP->HS Start Wire State	X	X
			LP->HS Preamble	3333333	yZxYzXy
			LP->HS Pre-End	3333333	ZxYzXyZ
			LP->HS Sync	3444443	xXxXxXy

*.dat or *.txt File Format (B/LPB Macro)

For data file the hexadecimal (HEX) format is required. Bytes are represented in two digits, ranging from 0 to 9 and A to F. The leading string “0x” is optional. Supported separators between data bytes are

, (comma)

; (semicolon)

space (blank)

tab

line feed

nothing

Some examples:

- 0x01, 0xF3, 0x23
- 0134E734FF
- 32 FF E5 44

In addition to the pure HEX data, special commands are abbreviations of lists of hex bytes:

- 0x<HEX code> N <count>: repeat the byte <HEX code> N times

  Example: 0xABN5 is equal to AB AB AB AB AB
- 0x<HEX code 1>x<HEX code 2>: count up/down from <HEX code 1> to <HEX code 2>

  Example: 0x05x0A is equal to 05 06 07 08 09 0A
- 0x<HEX code 1>c<HEX code 2>: count up/down from <HEX code 1> to <HEX code 2> for each data lane separately. If there is only one data lane, this command is equal to the one before. However, in the case of multiple data lanes, the values are counted with a step size of one for each data lane separately.

  Example for 2 data lanes:

  0x02c05 is equal to D0: 02 03 04 05 and D1: 02 03 04 05.

  For the counter with the “x” and two data lanes, 0x02x05 would lead to D0: 02 04 and D1: 03 05.

NOTE **The special commands require the leading “0x”, otherwise they will not be recognized.**

*.seq File Format

In the sequence file the data rate, data blocks and sequence are defined. Note that all parameters are even integers. The structure of a sequence file is shown in Figure 28.

HSFreq: <frequency in bits/s> Blocks:

<BlockName 1>: <Block Definition 1>, ..., <Block Definition n1>;

...

<BlockName M>: <Block Definition 1>, ...,<Block Definition nM>;

Sequence:

1.<BlockName J>, <Loop Count R>; - First block

...

<N>. <BlockName K>, <Loop Count S>; - Nth block

...

<P>. <BlockName L>, <Loop Count T>; - Pth block

[LoopTo N]

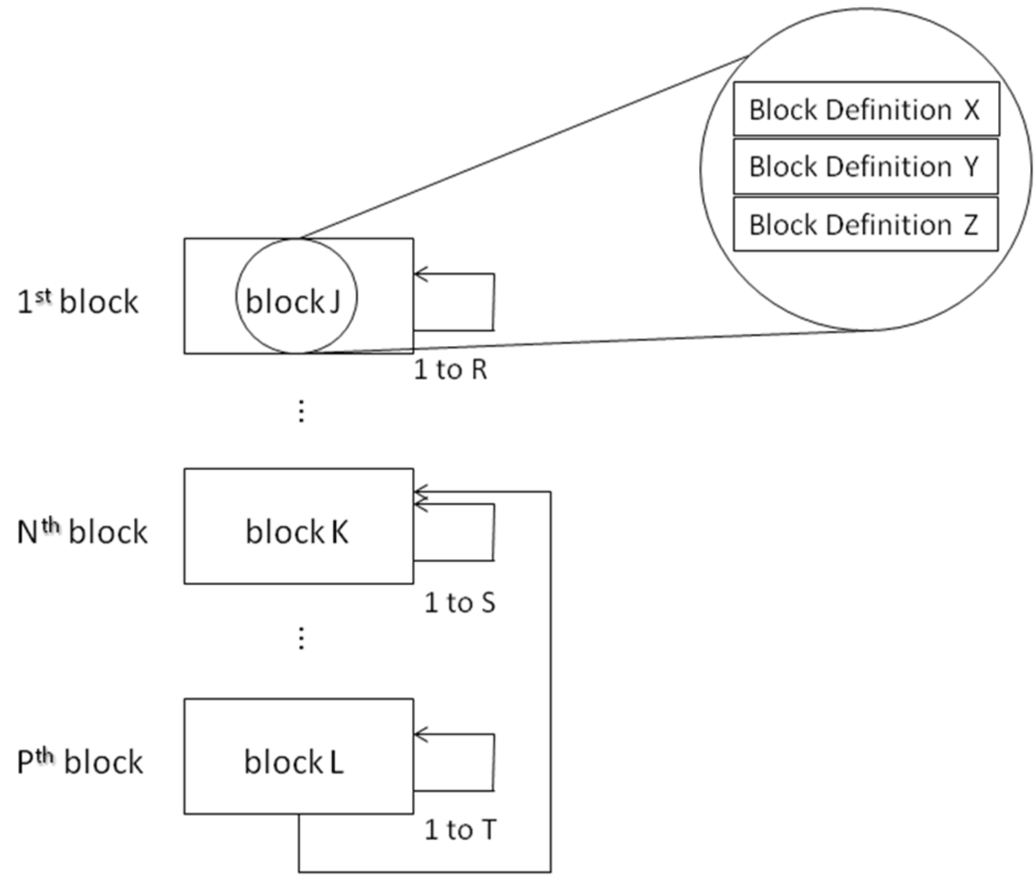


Figure 28 Block Diagram of the structure of sequence file

Each block may comprise multiple sub-blocks (1 to n). Sub-blocks can be used in multiple blocks. In the sequence, blocks can be used as often as needed. Within the sequence, the “LoopTo” expression starts an infinite loop from block <N> to the last block <P>. If no “LoopTo” expression is specified, an infinite loop is created from block 1 to block P (last block). The valid block definitions (macros) may contain the following data:

- LP000, LP001, LP010, LP011, LP100,..,LP111: for a single LP state.

- LPB “<filename>”: for generating LP data specified in the file with the name <filename>. The file should be in the same folder as the sequence file. At the beginning of the data an escape trigger for LP or ULP data mode is sent before the data and a Mark-0/1 sequence is sent after the end of the data. For the data, the data file format given above must be used.
- LP<00, 01, 10, or 11, 000, ..., 111> N <number of bits>: The LP state is sent <number of [HS] bits> times.
- LP<00, 01, 10, or 11 000, ..., 111> E <number of bits>: The LP state is sent until the block size reaches the number of HS bits given in <number of bits>.
- LPHSE <number of bits>: The block is filled with LP111 states and a LP–HS transition until the number of HS bits <number of bits> is reached.
- LPHS: The macro adds a LP–HS transition. It is mainly used for influencing the block ending. For example, if the following block starts with HS data, then the LP-HS transition will done at the end of the actual block. Without this macro the LP-HS transition would be added to the beginning of the following block. You do not need the macro for the following B macros, since they trigger a LP-HS transition automatically if the previous block description contains the LP states.
- B“<filename>”: for generating HS data given in the file <filename>. The file should be in the same folder as the sequence file. If necessary, a LP-to-HS transition is generated before the data. A HS-to-LP transition is added if the following block contains LP states.
- BL <number of blanking bytes>: for generating HS blanking packets with a number of blanking bytes given in <number of blanking bytes>. In this case the header for DSI is different to CSI, and also the checksum. Please refer to CSI and DSI specification for long packets.
- P“<filename>”: for backward compatibility a PTRN file can be used (see pattern definition for PTRN files).
- C<3 hex bytes>: For generating short packets like they are described in the CSI or DSI specification for MIPI C-PHY.

- C<1 hex byte>"<filename>": for generating a long packet. The content in the filename will be taken as payload. The header will have the given hex byte as ID followed by a two byte word counter, followed by a ECC for that header data. At the end of the payload a two byte CRC is added. If necessary, a LP-to-HS transition is generated before the data. A HS-to-LP transition is added if the following block contains LP states.
- PRBS<no.>(<seed1>>|<seed2>| ... | <seedN>): for generating a PRBS of the polynomial <no.> with a seed of <seed1-N> for each lane. The <no.> is just a decimal number (only 9, 11, and 18 are allowed), and the seed is given in a hex number (example 0x789A). The number of input seeds should be the same as active lanes (example for 3 lanes <seed1> goes to D0, <seed2> goes to D1 and <seed3> goes to D2). If #seeds > #lanes the latest seeds will be ignored. If #seeds < #lanes an exception will be thrown. As a special case, if only one seed is provided but more than one lane is active, the pattern is distributed among all lanes.
- ULPEntry: Adds the ULP Entry escape sequence to the block. After the ULPEntry LP000 states plus finally a ULPExit should follow to create a specification conform ULP sequence.
- ULPExit <number of LP100 states>: Creates a ULP exit sequence. It is not allowed to combine this block definitions with other definitions, which means in this case the block must only contain this macro and no other.

NOTE

- If blocks are looped, then the beginning of the block should have the same kind of data mode (LP or HS) as the block following it, otherwise the block loop will result in invalid LP-to-HS transitions.
- Video Frames that contain LP111 blanking periods should be rotated so that the block definition always ends with a LP111E command.
- If only the header contains LP111 states, the header block should end with LPHSE to start the HS transmission at the end of the header block.
- In case of PureHS mode, an initial LP to HS transition is added in the form of a hidden intro block in the waveform generation, before an infinite loop of pure HS data stream is generated.

In any case, an LP111 block is added to each sequence. A LP–HS transition is added if needed to switch the device into HS mode. These blocks need not to be added explicitly to the sequence. They are added automatically for all sequences, i.e. even if a sequence with pure HS blocks is given.

Example of a Sequence File:

HSFreq: 200MBit/s;

Blocks:

LPInit1: LPB"Esc0ms.txt",LP111E13728;

LPPause: LP111N1024;

LPInit2: LPB"Esc100ms.txt",LP111E13728;

LPInit3: LPB"Esc200ms.txt",LP111E13728;

Header: B"FirstHsLine.txt",LP111E6016;

Video: B"VideoLine.txt",LP111E6016;

Sequence:

1. **LPInit1,1;**
2. **LPPause,20000;**
3. **LPInit2,1;**
4. **LPPause,20000;**
5. **LPInit3,1;**
6. **LPPause,20000;**
7. **Header,1;**
8. **Video,319;**

LoopTo 6;

The following sections describe the various elements of a sequence file for the CSI and DSI protocols, such that the sequence file definition generates a waveform that conforms to the MIPI Specification for Camera Serial Interface (CSI) and MIPI Alliance Specification for Display Serial Interface (DSI), respectively.

CSI and DSI Sequences

Generally, a sequence file consists of three elements that form together a sequence:

- HS Data Rate
- Blocks
- Sequence

Following is a real time example of a sequence file definition:

Example of a Sequence File Definition:

HSFreq: 200MBit/s;

Blocks:

LPInit1: LPB"Esc0ms.txt",LP111E13728;

LPPause: LP111N1024;

LPInit2: LPB"Esc100ms.txt",LP111E13728;

LPInit3: LPB"Esc200ms.txt",LP111E13728;

Header: B"FirstHsLine.txt",LP111E6016;

Video: B"VideoLine.txt",LP111E6016;

Sequence:

1 LPInit1,1;
2 LPPause,20000;
3 LPInit2,1;
4 LPPause,20000;
5 LPInit3,1;
6 LPPause,20000;
7 Header,1;
8 Video,319;

LoopTo 6;

Following are real time examples of DSI and CSI sequence file definitions, respectively:

Example of a DSI Sequence File Definition:

HSFreq: 432.432MBit/s;

Blocks:

LPInit: LPB"HSyncEnd.txt",LP111E13728;

HSync: B"HSyncEnd.txt",LP111E12736,B"HSyncStart.txt",LP111E13728;

VSyncStart: B"HSyncEnd.txt",LP111E12736,B"VSyncStart.txt",LP111E13728;

VSyncEnd: B"HSyncEnd.txt",LP111E12736,B"VSyncEnd.txt",LP111E13728;

Video: B"HSyncEnd.txt",LP111E960,B"Video480pHSyncStart.txt",LP111E13728;

Sequence:

1 LPInit,1;

2 HSync,5;

3 VSyncEnd,1;

4 HSync,29;

5 Video,480;

6 HSync,9;

7 VSyncStart,1;

LoopTo 2;

Example of a CSI Sequence File Definition:

HSFreq: 158 MBit/s;

Blocks:

FrameStart: B"FrameStart.txt",LP111E10880;

Blanking: LP111E10880;

Video: C1E"compliance640_480.txt",LP111E10880;

FrameEnd: B"FrameEnd.txt",LP111E2048;

Sequence:

1 FrameStart,1;

2 Blanking,1;

3 Video,480;

4 Blanking,2;

5 FrameEnd,1;

Sequence File Definition for CSI

Overview

CSI is a MIPI Alliance standard for serial interface between a camera module and host processor. CSI adheres to the Low-Level Protocol (LLP), which is a byte orientated, packet based protocol that supports the transport of arbitrary data using Short and Long packet formats. Two packet structures are defined for low-level protocol communication: Long packets and Short packets. The format and length of Short and Long Packets depends on the choice of physical layer (MIPI C-PHY or MIPI D-PHY). For each packet structure, exit from the low power state followed by the Start of Transmission (SoT) sequence indicates the start of the packet. The End of Transmission (EoT) sequence followed by the low power state indicates the end of the packet. However, in CSI implementation, one burst consists of only one packet and LP11 (or LP111 in MIPI C-PHY) state must be inserted before the start of a burst. Since it requires to go to LP state always, an explicit EoT packet is not required.

NOTE

A sequence file used for D-PHY or MIPI C-PHY conformance testing cannot be used for CSI/DSI conformance testing unless the header, payload and checksum data is included in the CSI/DSI block definitions in the sequences else the device rejects the packet.

Long and Short Packet Formats

Long Packet

For D-PHY, a Long Packet shall be identified by Data Types 0x10 to 0x37. A Long Packet for the D-PHY physical layer option shall consist of three elements: a 32-bit Packet Header (PH), an application specific Data Payload with a variable number of 8-bit data words, and a 16-bit Packet Footer (PF). The Packet Header is further composed of three elements: an 8-bit Data Identifier, a 16-bit Word Count field and an 8-bit ECC. The Packet footer has one element, a 16-bit checksum (CRC).

For MIPI C-PHY, the Long Packet structure for the MIPI C-PHY physical layer option shall consist of four elements: a Packet Header (PH), an application specific Data Payload with a variable number of 8-bit data words, a 16-bit Packet Footer (PF), and zero or more Filler bytes (FILLER). The Packet Header is 6N x 16-bits long, where N is the number of MIPI C-PHY physical layer Lanes. The Packet Header consists of two identical 6N-byte halves, where each half consists of N sequential copies of each of the following fields: a 16-bit field containing eight Reserved bits plus the 8-bit Data Identifier (DI); the 16-bit Packet Data Word Count (WC); and a 16-bit Packet Header checksum (PH-CRC) which is computed over the previous four bytes. The value of each Reserved bit shall be zero. The Packet Footer consists of a 16-bit checksum (CRC) computed over the Packet Data using the same CRC polynomial as the Packet Header CRC and the Packet Footer used in the D-PHY physical layer option. Packet Filler bytes are inserted after the Packet Footer, if needed, to ensure that the Packet Footer ends on a 16-bit word boundary and that each MIPI C-PHY physical layer Lane transports the same number of 16-bit words (i.e. byte pairs).

For both physical layer options, the 8-bit Data Identifier field and the 16-bit Word Count (WC) field contain identical data. The CSI receiver reads the next WC 8-bit data words of the Data Payload following the Packet Header. The length of the Data Payload shall always be a multiple of 8-bit data words. For both physical layer options, once the CSI receiver has read the Data Payload, it then reads the 16-bit checksum (CRC) in the Packet Footer and compares it against its own calculated checksum to determine if any Data Payload errors have occurred.

In either case, Packet Data length = Word Count (WC) * Data Word Width (8-bits).

Short Packet

For each option (MIPI C-PHY and MIPI D-PHY), the Short Packet structure matches the Packet Header of the corresponding Low Level Protocol Long Packet structure with the exception that the Packet Header Word Count (WC) field shall be replaced by the Short Packet Data Field. A Short Packet shall be identified by Data Types 0x00 to 0x0F. A Short Packet shall contain only a Packet Header; neither Packet Footer nor Packet Filler bytes shall be present. For Frame Synchronization Data Types, the Short Packet Data Field shall be the frame number. For Line Synchronization Data Types, the Short Packet Data Field shall be the line number.

For the MIPI D-PHY physical layer option, the Error Correction Code (ECC) byte allows single-bit errors to be corrected and 2-bit errors to be detected in the Short Packet.

For the MIPI C-PHY physical layer option, the 16-bit Checksum (CRC) allows one or more bit errors to be detected in the Short Packet but does not support error correction.

Short Packet Data Types shall be transmitted using only the Short Packet format. Refer to Table 6 Synchronization Short Packet Data Type Codes of the MIPI Alliance Specification for Camera Serial Interface (CSI), which indicates that Data Type for Frame Start Code is 0x00 and Data Type for Frame End Code is 0x01.

NOTE **Between Low Level Protocol packets, there must always be an HS-LP or an LP-HS transition.**

Frame and Line Synchronization Packets

Frame Synchronization Packets

Each image frame shall begin with a Frame Start (FS) Packet containing the Frame Start Code. The FS Packet shall be followed by one or more long packets containing image data and zero or more short packets containing synchronization codes. Each image frame shall end with a Frame End (FE) Packet containing the Frame End Code. For FS and FE synchronization packets, the Short Packet Data Field shall contain a 16-bit frame number. This frame number shall be the same for the FS and FE synchronization packets corresponding to a given frame.

Line Synchronization Packets

Line synchronization packets are optional. For Line Start (LS) and Line End (LE) synchronization packets, the Short Packet Data Field shall contain a 16-bit line number. This line number shall be the same for the LS and LE packets corresponding to a given line.

Frame Blanking and Line Blanking

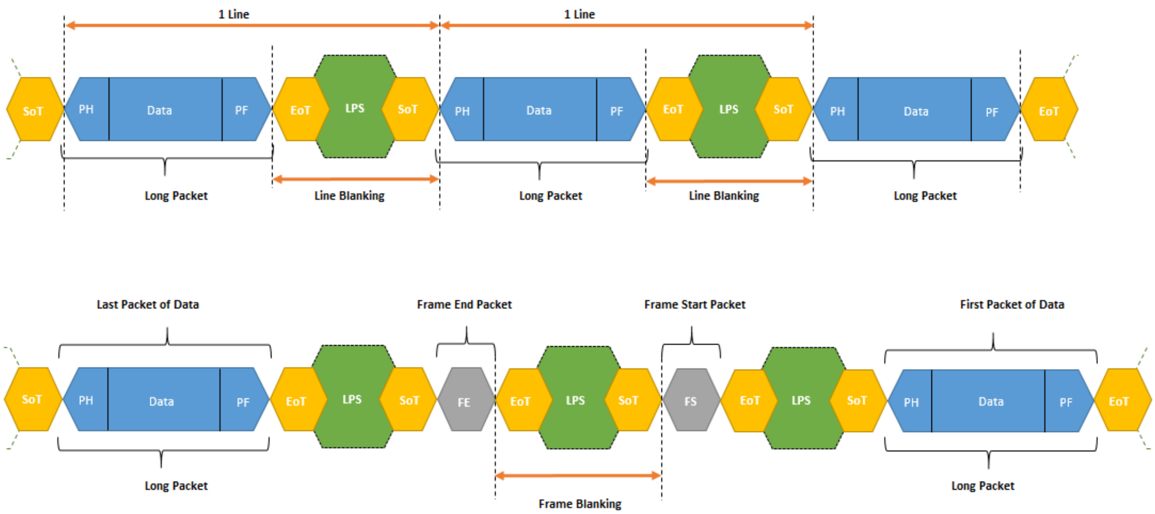


Figure 29 Block Diagram depicting packet structure for CSI sequence

Frame Blanking – The period between the Frame End packet in frame N and the Frame Start packet in frame N+1 is called the Frame Blanking Period.

Line Blanking – The period between the end of the Packet Footer (or the Packet Filler, if present) of one long packet and the Packet Header of the next long packet is called the Line Blanking Period.

Packet Data Payload Size Rules

For YUV, RGB or RAW data types, one long packet shall contain one line of image data. The total size of payload data within a long packet for all data types shall be a multiple of eight bits. The packet payload data format shall agree with the Data Type value in the Packet Header. Refer to *Section 11 Data Formats, Table 3 - Data Type Classes for eight different data type classes* and *Table 8 - Primary and Secondary Data Formats Definitions of the MIPI Alliance Specification for Camera Serial Interface (CSI)*.

To understand the concept of sequences in CSI implementation, consider the block diagram of a video packet shown below.

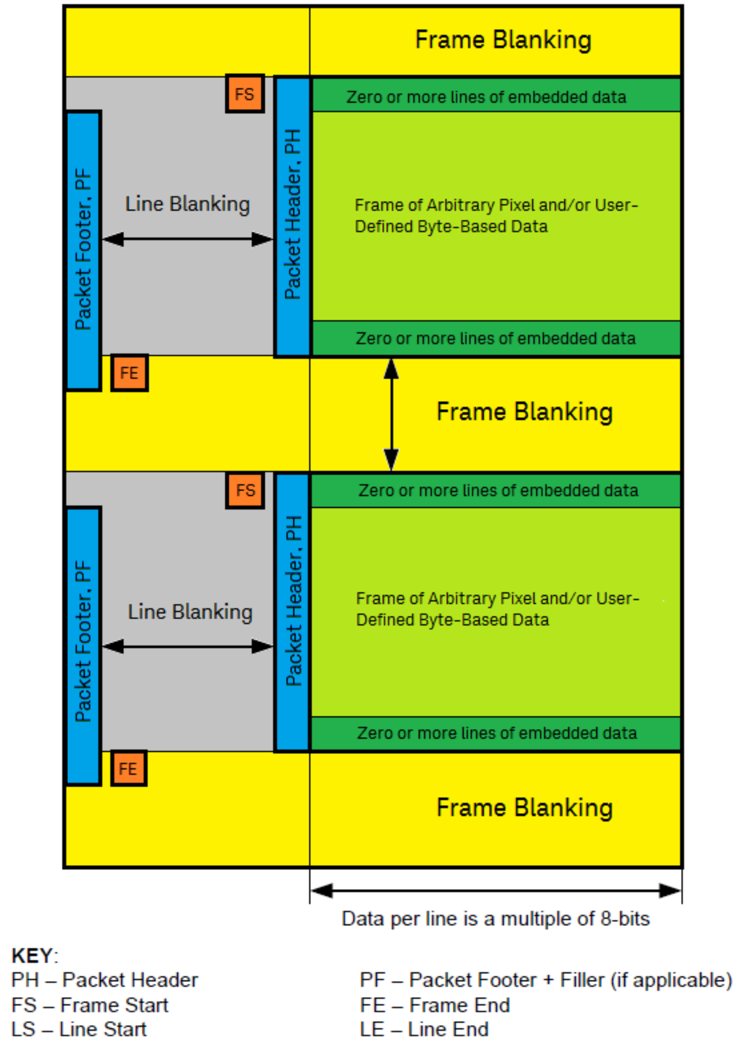


Figure 30 Block Diagram of a CSI Video Frame

For each video line transmission, the short packet or the FrameStart (FS) indicates start of transmission of the video packet. The payload data, which is contained in a long packet, consists of the Packet Header (PH), followed by the actual arbitrary data and ending with the Packet Footer (PF). Another short packet or the FrameEnd (FE) indicates the end of transmission of the video packet. This data burst is in an HS state.

A Line Blanking (LP state) is transmitted between each video line, that is, after the end of a Packet Footer (PF) till the beginning of the next Packet Header (PH).

A Frame Blanking (LP state) is transmitted between each video frame, that is, after the end of a FrameEnd (FE) till the beginning of the next FrameStart (FS) short packet.

Understanding a CSI sequence file

The description of the block diagram corroborates the structure of the CSI sequence file shown below, for CSI implementation. Note that all the text files defined in the sequence must be placed in the same folder directory where the sequence file is located.

HSFreq: 158 MBit/s;

Blocks:

FrameStart: B"FrameStart.txt",LP111E10880;

Blanking: LP111E10880;

Video: C1E"compliance640_480.txt",LP111E10880;

FrameEnd: B"FrameEnd.txt",LP111E2048;

Sequence:

1. FrameStart,1;

2. Blanking,1;

3. Video,480;

4. Blanking,2;

5. FrameEnd,1;

The sequence definition in the given example contains an intrinsic looping. In the sequence, the blanking lines generate the frame blanking, and the video lines contain the line blanking, which is generated by the LP states. The number of lines for the video data and the associated blanking is defined by the device manufacturer. The sequence begins with the FrameStart block running once, followed by a Blanking line. Then, the Video block runs for 480 lines ending with another Blanking line, followed by the FrameEnd block running once. This sequence loops over until manually aborted.

If considered closely, the FrameStart block generates the Frame Start (FS) short packet, with the Frame Start Code 0x00 as its header. This follows an HS-LP transition using LP11 (or LP111 in MIPI C-PHY), where a line blanking is performed with an LPE marker, which fills the LP states until 10880 HS states are attained. The Blanking block generates a frame blanking packet of LP11 (or LP111 in MIPI C-PHY), which fills the LP states until 10880 HS states are attained and is generated to provide for the LP-HS transition before the actual video payload begins transmitting. In the Video block, the C-Macro with a 1-byte data type of 0x1E generates the Packet Header of the long packet, followed by the actual payload video data (in Hex format) in the compliance640_480.txt file.

Since the video data is High-Speed, the end of the video packet follows an HS to LP transition with a line blanking packet of LP11 (or LP111 in MIPI C-PHY), which fills the LP states until 10880 HS states are attained. Two blanking lines are sent to indicate the end of the video payload data and to save energy. The FrameEnd block generates the Frame End (FE) short packet, with the Frame End Code 0x01 as its header. This follows an HS-LP transition with a line blanking packet of LP11 (or LP111 in MIPI C-PHY), which fills the LP states until 2046 HS states are attained.

Some other points to note are:

- Since you cannot send more than one packet per burst, Blanking (LP state) is inserted at the end of each burst to avoid HS data from concatenating.
- The length of the line and frame blanking is device dependent.
- The data type 0x1E corresponds to the pixel color code YUV422 8-bit used in the video. Refer to *Section 11 Data Formats* of the *MIPI Alliance Specification for Camera Serial Interface (CSI)* for more information about the other Data Types for various color codes.
- The line blanking length and bits per pixel of a specific color code helps you in determining the total line length in HS states. The E-marker is used for the LP states instead of N, such that it fills up the blocks until the total defined length of HS States is attained.

NOTE

To retain the same line rate for CSI implementation between D-PHY and MIPI C-PHY, it is recommended that you keep the number of HS states equal in the LP definition.

If all lines in a sequence file definition have an LPE statement in the end, you may calculate the Frame Rate:

1 Multiply the number of lines with the number defined in the LPE statement of the sequence file definition.
2 Repeat step 1 for all lanes in the frame and add the resulting values for each lane.
3 Multiply the sum of all lanes with the HS period length, which derives the Frame Rate.

Calculating HS Data Rate for CSI sequence

To calculate the minimum HS data rate required to run the sequence, you must be aware of at least the frame rate and the device's display resolution, which is provided by the device manufacturer. The HS Frequency is the first line in the definition of a sequence file.

For example, let us consider that the device under test has a Frame Rate of 30 Hz and a display resolution of 640 x 480 pixels, where 640 is the horizontal resolution (or the length of each line) and 480 is the vertical resolution (or the number of video lines).

1 Calculate the line rate using the equation:

   Line Rate = Frame Rate * Vertical Resolution

   However, the number of video lines has certain number of blanking lines preceding and following the video data, which must be considered as well for data rate calculation. The equation for line rate is, therefore, modified to:

   Line Rate = Frame Rate * (Vertical Resolution + no. of blanking lines)

   Let us assume that there are 10 blanking lines in a frame.

   In this case, Line Rate = 30 Hz * (480 + 10) = 14700 Hz

2 Determine the total length of lines in HS states.

   i Determine the number of bits required for transmission of the video data. To do so, check the pixel color coding for the Data Type in the video. In this case, the pixel color code is YUV422, which uses 8-bit per pixel.

      Total no. of bits per line = Bit-size per pixel * Horizontal resolution

      In this case, Total no. of bits = 8 * 640 = 5120 bits per line.

   ii The number of bits for video transmission is not sufficient for determining the total length of lines in HS states, since extra time is required for the LP states in the line blanking. Therefore, you must consider the LP states and accordingly extend the bits per line. Considering these factors, a total length of 10880 lines in HS states can be safely used for calculation of the HS data rate.

3 Calculate the HS Data Rate using the equation:

   Data Rate = Line Rate * Total length of lines in HS state

   In this case, Data Rate = 14700 Hz x 10880 = 159.936 Mbps

Therefore, you can define the HS Data Rate (HSFreq) in the beginning of the sequence file, as shown in the example above.

For information on the CSI implementation in the MIPI D-PHY and MIPI C-PHY physical layer and detailed understanding of the protocol layer, refer to the *MIPI Alliance Specification for Camera Serial Interface (CSI)*.

Sequence File Definition for DSI

Overview

DSI specifies the interface between a host processor and a peripheral such as a display module. It builds on existing MIPI Alliance specifications by adopting pixel formats and command set specified in DPI-2, DBI-489 2 and DCS standards. Some significant differences between DSI and CSI are:

- CSI uses unidirectional high-speed Link, whereas DSI is half-duplex bidirectional Link
- CSI makes use of a secondary channel, based on I2C, for control and status functions
- CSI data direction is from peripheral (Camera Module) to host processor, while DSI's primary data direction is from host processor to peripheral (Display Module)
- CSI sequence file structure is different from that of the DSI sequence file structure. The former consists of only of the FrameStart and FrameEnd packet along with some blanking lines, whereas the latter consists of HSync, VSync and Blanking packages.

At the lowest level, DSI protocol specifies the sequence and value of bits and bytes traversing the interface. It specifies how bytes are organized into defined groups called packets. The protocol defines required headers for each packet, and how header information is generated and interpreted.

On the transmitter side of a DSI Link, parallel data, signal events, and commands are converted in the Protocol layer to packets, following the packet organization. The Protocol layer appends packet-protocol information and headers, and then sends complete bytes through the Lane Management layer to the PHY. Packets are serialized by the PHY and sent across the serial Link. The receiver side of a DSI Link performs the converse of the transmitter side, decomposing the packet into parallel data, signal events and commands.

If there are multiple Lanes, the Lane Management layer distributes bytes to separate PHYs, one PHY per Lane, as described in Section 6 of the MIPI Alliance Specification for Display Serial Interface (DSI). Packet protocol and formats are independent of the number of Lanes used. The DSI protocol permits multiple packets to be concatenated, which substantially boosts effective bandwidth. This is useful for events such as peripheral initialization, where many registers may be loaded with separate write commands at system startup. There are two modes of data transmission, HS and LP transmission modes, at the PHY layer. Before an HS transmission can be started, the transmitter PHY issues a SoT sequence to the receiver. After that, data or command packets can be transmitted in HS mode. Multiple packets may exist within a single HS transmission and the end of transmission is always signaled at the PHY layer using a dedicated EoT sequence. To enhance the overall robustness of the system, DSI defines a dedicated EoT packet (EoTp) at the protocol layer for signaling the end of HS transmission. In HS mode, time gaps between packets shall result in separate HS transmissions for each packet, with a SoT, LPS, and EoT issued by the PHY layer between packets. This constraint does not apply to LP transmissions.

Long and Short Packet Formats

Two packet structures are defined for low-level protocol communication: Long packets and Short packets. For both packet structures, the Data Identifier (DI) is always the first byte of the packet, which includes information specifying the type of the packet.

Long Packet

A Long packet shall consist of three elements: a 32-bit Packet Header (PH), an application-specific Data Payload with a variable number of bytes, and a 16-bit Packet Footer (PF). The Packet Header is further composed of three elements: an 8-bit Data Identifier, a 16-bit Word Count, and 8-bit ECC. The Packet Footer has one element, a 16-bit checksum. Long packets can be from 6 to 65,541 bytes in length.

After the end of the Packet Header, the receiver reads the next Word Count multiplied by the bytes of the Data Payload.

Once the receiver has read the Data Payload it reads the Checksum in the Packet Footer. The host processor shall always calculate and transmit a Checksum in the Packet Footer. Peripherals are not required to calculate a Checksum. Also, note the special case of zero-byte Data Payload: if the payload has length 0, the Checksum calculation results in (0xFFFF). If the Checksum is not calculated, the Packet Footer shall consist of two bytes of all zeros (0x0000). In the generic case, the length of the Data Payload shall be a multiple of bytes. In addition, each data format may impose additional restrictions on the length of the payload data, e.g. multiple of four bytes.

Short Packet

A Short packet shall contain an 8-bit Data ID followed by two command or data bytes and an 8-bit ECC; a Packet Footer shall not be present. Short packets shall be four bytes in length. The Error Correction Code (ECC) byte allows single-bit errors to be corrected and 2-bit errors to be detected in the Short packet. Some short packets may also contain some data in the payload.

Long and Short packets have several common elements. The first byte of any packet is the DI (Data Identifier) byte. The Error Correction Code allows single-bit errors to be corrected and 2-bit errors to be detected in the Packet Header. The host processor shall always calculate and transmit an ECC byte. Peripherals shall support ECC in both forward- and reverse-direction communications.

DSI Sequence Format Description

Sync Event (H Start, H End, V Start, V End), Data Type = XX 0001 (0xX1)

Sync Events are Short packets and, therefore, can time-accurately represent events like the start and end of sync pulses. As “start” and “end” are separate and distinct events, the length of sync pulses, as well as position relative to active pixel data, e.g. front and back porch display timing, may be accurately conveyed to the peripheral. The Sync Events are defined as follows:

- Data Type = 00 0001 (0x01) V Sync Start
- Data Type = 01 0001 (0x11) V Sync End
- Data Type = 10 0001 (0x21) H Sync Start
- Data Type = 11 0001 (0x31) H Sync End

To represent timing information as accurately as possible a V Sync Start event represents the start of the VSA. It also implies an H Sync Start event for the first line of the VSA. Similarly, a V Sync End event implies an H Sync Start event for the last line of the VSA.

Sync events should occur in pairs, Sync Start and Sync End, if accurate pulse-length information must be conveyed. Alternatively, if only a single point (event) in time is required, a single sync event (normally, Sync Start) may be transmitted to the peripheral. Sync events may be concatenated with blanking packets to convey inter-line timing accurately and avoid the overhead of switching between LPS and HS for every event. Display modules that do not need traditional sync/blanking/pixel timing should transmit pixel data in a high-speed burst then put the bus in Low Power Mode, for reduced power consumption.

EoTp, Data Type = 00 1000 (0x08)

This short packet is used for indicating the end of a HS transmission to the data link layer. Therefore, detection of the end of HS transmission may be decoupled from physical layer characteristics. The main objective of the EoTp is to enhance overall robustness of the system during HS transmission mode. Therefore, DSI transmitters should not generate an EoTp when transmitting in LP mode. The Data Link layer of DSI receivers shall detect and interpret arriving EoTps regardless of transmission mode (HS or LP modes) to decouple itself from the physical layer. Unlike other DSI packets, an EoTp has a fixed format as follows:

- Data Type = DI [5:0] = 0b001000
- Virtual Channel = DI [7:6] = 0b00
- Payload Data [15:0] = 0x0F0F
- ECC [7:0] = 0x01

Blanking Packet (Long), Data Type = 01 1001 (0x19)

A Blanking packet is used to convey blanking timing information in a Long packet. Normally, the packet represents a period between active scan lines of a Video Mode display, where traditional display timing is provided from the host processor to the display module. The blanking period may have Sync Event packets interspersed between blanking segments. Like all packets, the Blanking packet contents shall be an integer number of bytes. Blanking packets may contain arbitrary data as payload.

The Blanking packet consists of the DI byte, a two-byte WC, an ECC byte, a payload of length WC bytes, and a two-byte checksum.

Packed Pixel Stream, 16-bit Format, Long Packet, Data Type 00 1110 (0x0E)

This long packet (shown in the sequence example) is used to transmit image data formatted as 16-bit pixels to a Video Mode display module. The packet consists of the DI byte, a two-byte WC, an ECC byte, a payload of length WC bytes and a two-byte checksum.

Packet Header Error Detection/Correction

The host processor in a DSI-based system shall generate an error-correction code (ECC) and append it to the header of every packet sent to the peripheral. The ECC takes the form of a single byte following the header bytes. The ECC byte shall provide single-bit error correction and 2-bit error detection for the entire Packet Header.

Checksum Generation for Long Packet Payloads

Long packets are comprised of a Packet Header protected by an ECC byte and a payload of 0 to 216-1 bytes. To detect errors in transmission of Long packets, a checksum is calculated over the payload portion of the data packet. Note that, for the special case of a zero-length payload, the 2-byte checksum is set to 0xFFFF.

Checksum generation and transmission is mandatory for host processors sending Long packets to peripherals. It is optional for peripherals transmitting Long packets to the host processor. However, the format of Long packets is fixed; peripherals that do not support checksum generation shall transmit two bytes having value 0x0000 in place of the checksum bytes when sending Long packets to the host processor. The host processor shall disable checksum checking for received Long packets from peripherals that do not support checksum generation.

NOTE **An ECC byte can be applied to both Short and Long packets. Checksum bytes shall only be applied to Long packets.**

Transmission Packet Sequences

DSI supports several formats, or packet sequences, for Video Mode data transmission. The peripheral timing requirements dictate which format is appropriate. In the following sections, Burst Mode refers to time-compression of the RGB pixel (active video) portion of the transmission.

Non-Burst Mode with Sync Pulses

This mode enables the peripheral to accurately reconstruct original video timing, including sync pulse widths. Normally, periods shown as HSA (Horizontal Sync Active), HBP (Horizontal Back Porch) and HFP (Horizontal Front Porch) are filled by Blanking Packets, with lengths (including packet overhead) calculated to match the period specified by the peripheral data sheet. Alternatively, if there is sufficient time to transition from HS to LP mode and back again, a timed interval in LP mode may substitute for a Blanking Packet, thus saving power. During HSA, HBP and HFP periods, the bus should stay in the LP-11 state.

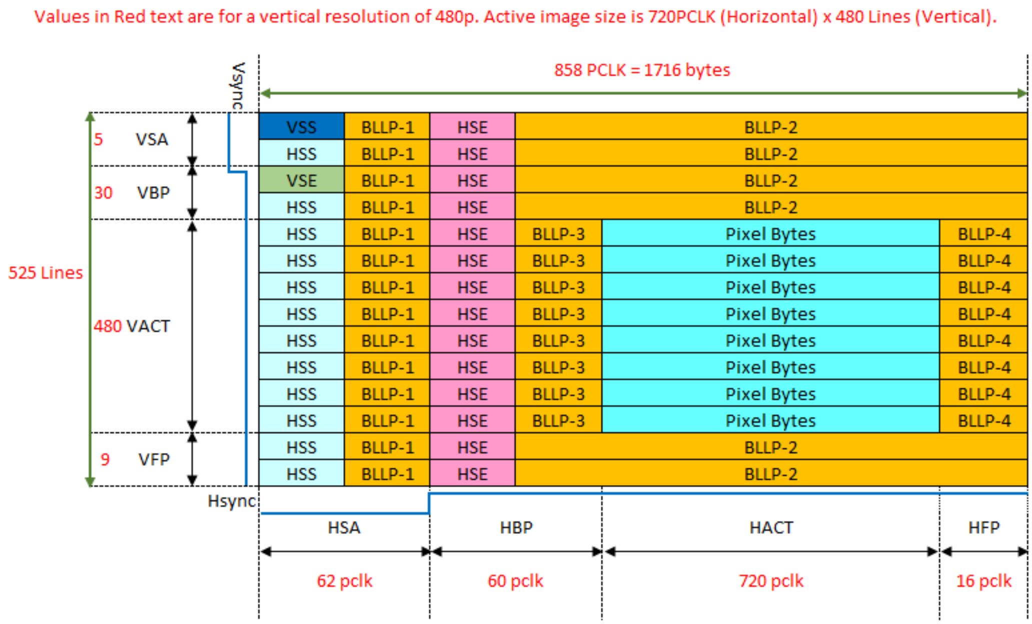


Figure 31 Block Diagram for Video transmission in Non-Burst mode with Sync Pulses

Non-Burst Mode with Sync Events

This mode functions in the same manner as the previous mechanism, but accurate reconstruction of sync pulse widths is not required, so a single Sync Event is substituted. Here, only the start of each synchronization pulse (VSyncSHSyncStart and HSyncStart) is transmitted. The peripheral may regenerate sync pulses as needed from each Sync Event packet received. Pixels are transmitted at the same rate as they would in a corresponding parallel display interface such as DPI-2. As with the previous Non-Burst Mode, if there is sufficient time to transition from HS to LP mode and back again, a timed interval in LP mode may substitute for a Blanking Packet, thus saving power.

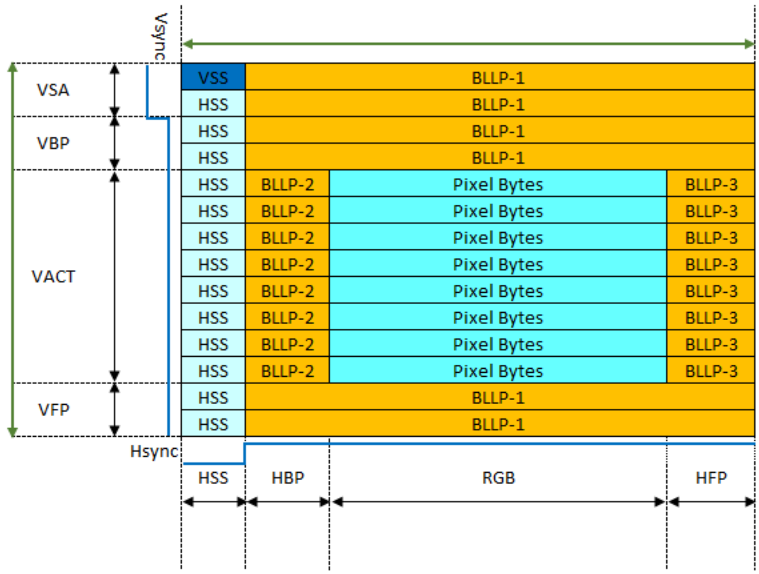


Figure 32 Block Diagram for Video transmission in Non-Burst mode with Sync Events

Burst Mode

RGB pixel packets are time-compressed, leaving more time during a scan line for LP mode (saving power) or for multiplexing other transmissions onto the DSI link. In this mode, blocks of pixel data can be transferred in a shorter time using a time-compressed burst format. This is a good strategy to reduce overall DSI power consumption, as well as enabling larger blocks of time for other data transmissions over the Link in either direction. In the same manner as the Non-Burst Mode scenario, if there is sufficient time to transition from HS to LP mode and back again, a timed interval in LP mode may substitute for a Blanking Packet, thus saving power.

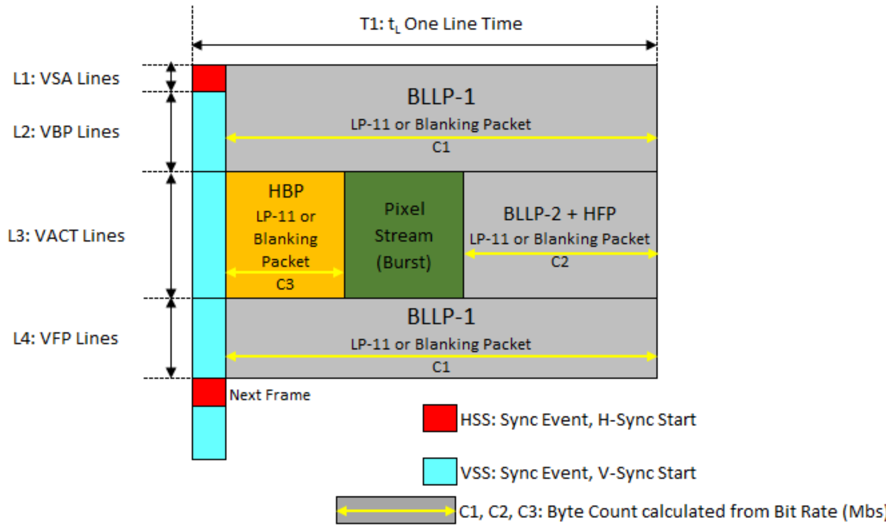


Figure 33 Block Diagram for Video transmission in Burst mode

Note that for accurate reconstruction of timing, packet overhead including Data ID, ECC, and Checksum bytes should be taken into consideration.

To enable PHY synchronization the host processor should periodically end HS transmission and drive the Data Lanes to the LP state. This transition should take place at least once per frame; The host processor should return to LP state once per scan-line during the horizontal blanking time. Regardless of the frequency of BLLP periods, the host processor is responsible for meeting all documented peripheral timing requirements. Note, at lower frequencies BLLP periods will approach, or become, zero, and burst mode will be indistinguishable from non-burst mode.

The sequence of packets within the BLLP or RGB portion of a HS transmission is arbitrary. The host processor may compose any sequence of packets, including iterations, within the limits of the packet format definitions. For all timing cases, the first line of a frame shall start with VSS; all other lines shall start with VSE or HSS. Note that the position of synchronization packets, such as VSS and HSS, in time is of utmost importance since this has a direct impact on the visual performance of the display panel.

Replacing B-Macros with C-Macros in a sequence file

Table 9 shows how a sequence file written originally using the B-Macros can be alternatively written using C-Macros.

Table 9 Sequence file definition using B-Macros and C-Macros

Sequence File Definition using B-Macro	Sequence File Definition using C-Macro
HSFreq: 432.432MBit/s; Blocks: LPInit: LPB"HSyncEnd.txt",LP111E13728; HSync: B"HSyncEnd.txt",LP111E12736,B"HSyncStart.txt",LP111E13728; VSyncStart: B"HSyncEnd.txt",LP111E12736,B"VSyncStart.txt",LP111E13728; VSyncEnd: B"HSyncEnd.txt",LP111E12736,B"VSyncEnd.txt",LP111E13728; Video: B"HSyncEnd.txt",LP111E960,B"Video480pHSyncStart.txt",LP111E137 28; Sequence: 1. LPInit,1; 2. HSync,9; 3. VSyncStart,1; 4. HSync,5; 5. VSyncEnd,1; 6. HSync,29; 7. Video,480; LoopTo 2;	HSFreq: 432.432MBit/s; Blocks: LPInit: LPB"HSyncEnd.txt",LP111E13728; HSync: C310000,C080F0F,LP111E12736,C210000,C080F0F,LP111E13728; VSyncStart: C310000,C080F0F,LP111E12736,C010000,C080F0F,LP111E13728; VSyncEnd: C310000,C080F0F,LP111E12736,C110000,C080F0F,LP111E13728; Video: C310000,C080F0F,LP111E960,C0E"Video480p.txt",BL20,C210000,C080F 0F,LP111E13728; Sequence: 1. LPInit,1; 2. HSync,9; 3. VSyncStart,1; 4. HSync,5; 5. VSyncEnd,1; 6. HSync,29; 7. Video,480; LoopTo 2;

Upon considering each block closely, we notice the following differences, otherwise the rest of the sequence definition remains the same.

- In the HSync block, the B“HSyncEnd.txt” is replaced by C310000,C080F0F and B“HSyncStart.txt” is replaced by C210000,C080F0F.
- In the VSyncStart block, the B“HSyncEnd.txt” is replaced by C310000,C080F0F and B“VSyncStart.txt” is replaced by C010000,C080F0F.
- In the VSyncEnd block, the B“HSyncEnd.txt” is replaced by C310000,C080F0F and B“VSyncEnd.txt” is replaced by C110000,C080F0F.
- In the Video block, the B“HSyncEnd.txt” is replaced by C310000,C080F0F and B“Video480pHSyncStart.txt” is replaced by C0E“Video480p.txt”,BL20,C210000,C080F0F.

To understand how the replacements were done, you must read the description given in the earlier sections about the B“<filename>” macro, C<3 hex bytes> and C<1 hex byte>” <filename>” macros.

Let us consider the contents of each text file closely.

Contents of HSyncEnd.txt

3100 0001

080F 0F01

As mentioned in the previous sections, the Data Type for the HSyncEnd signal is 0x31, which means this short packet has its Data ID as 31 and the following two bytes of Packet DATA as 00 00 followed by the ECC of 01.

Therefore, in a sequence, B“HSyncEnd.txt” can be written using the C<3 hex bytes> macro as C310000.

Contents of HSyncStart.txt

2100 0012

080F 0F01

As mentioned in the previous sections, the Data Type for the HSyncStart signal is 0x21, which means this short packet has its Data ID as 21 and the following two bytes of Packet DATA as 00 00 followed by the ECC of 12.

Therefore, in a sequence, B“HSyncStart.txt” can be written using the C<3 hex bytes> macro as C210000.

Contents of VSyncEnd.txt

1100 0014

080F 0F01

As mentioned in the previous sections, the Data Type for the VSyncEnd signal is 0x11, which means this short packet has its Data ID as 11 and the following two bytes of Packet DATA as 00 00 followed by the ECC of 14.

Therefore, in a sequence, B“VSyncEnd.txt” can be written using the C<3 hex bytes> macro as C110000.

Contents of VSyncStart.txt

0100 0007

080F 0F01

As mentioned in the previous sections, the Data Type for the VSyncStart signal is 0x01, which means this short packet has its Data ID as 01 and the following two bytes of Packet DATA as 00 00 followed by the ECC of 07.

Therefore, in a sequence, B“VSyncStart.txt” can be written using the C<3 hex bytes> macro as C010000.

Notice that within each text file considered so far, a hexadecimal value 080F 0F01 is mentioned. This is the EoT package, which is used at end of each HS transmission in a short packet. The EoT package has a fixed format with Data ID as 08, Payload Data as 0F0F and ECC of 01.

Therefore, at the end of each C<3 hex bytes> macro defined for the four files, you must add the C<3 hex bytes> macro for the EoT package as C080F0F, as shown in the sequence definition.

Contents of Video480pHSyncStart.txt

0EA0 0508

1084 1084

1084 1084

1084 1084

.

.

.

1084 1084

FA44 1914

001F 0000

0000 0000

0000 0000

0000 0000

0000 0000

0000 6F1D

2100 0012

080F 0F01

The elements of the actual video data in the file ‘Video480pHSyncStart.txt’ can be divided as follows:

- The header consists of Data ID: 0E followed by a two-byte word counter A005, followed by the ECC for that header data as 08.
- The actual video payload data starts from a hex value of 1084 and ends at a hex value of 1084. Note that the payload data is too long and has been truncated for documentation purpose.
- At the end of the payload, a two byte CRC is added, which is FA44.
- After the checksum, a Blanking packet is added to covey the blanking timing information in this video packet. This Blanking packet consists of the DI byte of 0x19, a two-byte Word Count of 1400, an ECC byte of 1F, a payload of 20 bytes, and a two-byte checksum of 6F1D. This blanking packet enables the HS-LP transition and corresponds to the HFP (Horizontal Front Porch) before the HSyncStart.
- In the end, a short packet in HS mode is generated, which has the HSyncStart data, which allows the HS-LP transition, before the device goes into a low power state.

Looking back at the Video block, the B“Video480pHSyncStart.txt” is replaced by C0E“Video480p.txt”,BL20,C210000,C080F0F, which indicates that only the actual payload data has been extracted into another text file named Video480p.txt and the rest of the data is appended using the C-Macro to the beginning and to the end of the payload data file. Notice that the Blanking packet with Data ID 0x19, which was part of the initial payload data, has been rewritten using the BL<number of blanking bytes> macros as BL20.

Irrespective of whether you use the B-Macros or the C-Macros, you must ensure that the data is defined in the correct order and you can use the sequence file in either format for waveform generation in the plug-in.

Notice that there has been no change made to the LPInit block of the sequence file, even though the HSyncEnd.txt file is used. This is because even though the HSyncEnd.txt contains hexadecimal data for HS mode, the LPB“filename” macro is used for generating Low Power data specified in the file HSyncEnd.txt, such that the display device is powered on.

To know more about the Data Types required to construct the short or long packets or to define C-Macros in a sequence file, refer to the *MIPI Alliance Specification for Display Serial Interface*.

Understand a DSI sequence file

The DSI sequence file corresponds to the package structure shown in the image below, which is based on the Non-Burst mode with Sync Pulses:

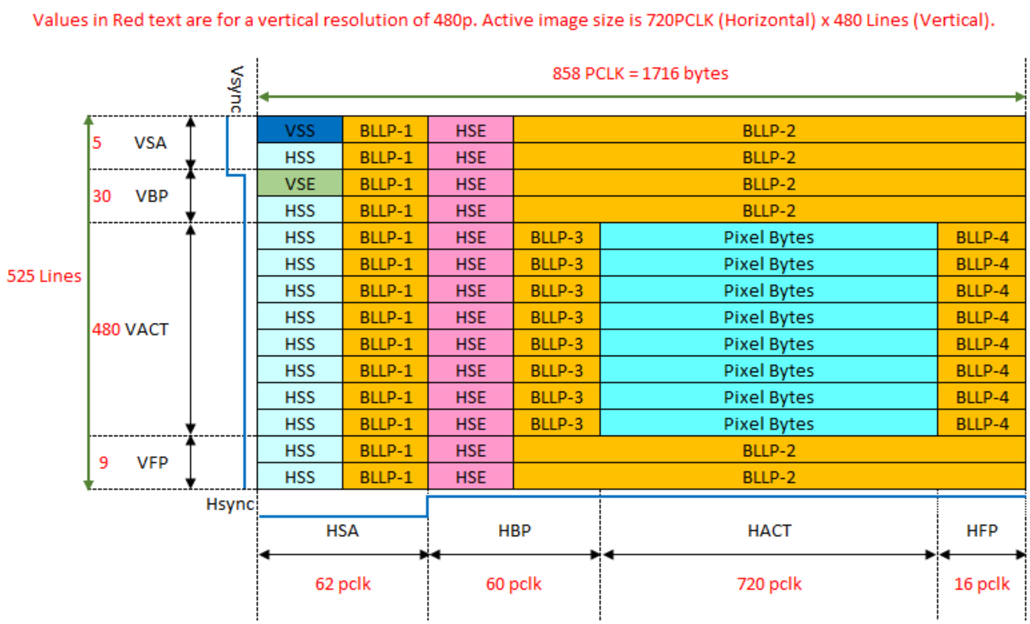


Figure 34 Block Diagram for Video transmission in Non-Burst mode with Sync Pulses

In general, the way the DVI functions is like the CRT mode. In a video frame of the CRT mode, an electron beam performed several horizontal traces and a vertical trace to begin the next frame. In the current technology, the HSS corresponds to the several horizontal traces whereas VSS corresponds to the vertical trace.

The VSyncStart (VSS) and HSyncStart (HSS) pulse are generated to mark the start of the video frame and define the timings of the device. For a video with resolution 720x480p, there are 720 horizontal active pixels, represented by HACT and 480 vertical active lines, represented by VACT. The device manufacturer provides the information about the horizontal blanking pixels and the vertical blanking lines that must be included to meet the timing and power saving requirements of the device, apart from the video transmission. In this case, a total of 138 horizontal blanking pixels are added to the 720 horizontal active pixels. Also, a total of 45 vertical blanking lines are added to the 480 vertical active lines. These HSync and VSync data is required for proper synchronization of the video data and to achieve proper timing in displaying the video data and is represented by HSyncActive (HSA) and VSyncActive (VSA), respectively. As described earlier, HSS, HSE, VSS and VSE are short packets containing High Speed data and blanking header information. They are part of the HSA and VSA.

Sync events are introduced such that only HSS have to be added. In this case, where Sync pulses are used, Blanking Lines can be added, which may be HS or LP, depending on the timing set between HSS and HSE.

The Horizontal Back Porch (HBP), Horizontal Front Porch (HFP), Vertical Back Porch (VBP), Vertical Front Porch (VFP) are indicated by BLLPs. The Blanking or Low-Power Interval (BLLP) is defined as a period during which video packets such as pixel-stream and sync event packets are not actively transmitted to the peripheral. The BLLP provides for the HS-LP and LP-HS transition when the device is powered on, during the switch to video mode and to save the device's power either in the idle state or just before the start of the video data. In this image, the HBP and HFP are indicated by BLLP-3 and BLLP-4, respectively whereas VBP and VFP are indicated by BLLP-1 and BLLP-2, respectively.

Now, let us consider the example given below of a sequence file for DSI implementation, derived from the video package displayed in the image above.

HSFreq: 432.432MBit/s;

Blocks:

LPInit: LPB"HSyncEnd.txt",LP111E13728;

HSync: C310000,C080F0F,LP111E12736,C210000,C080F0F,LP111E13728;

VSyncStart: C310000,C080F0F,LP111E12736,C010000,C080F0F,LP111E13728;

VSyncEnd: C310000,C080F0F,LP111E12736,C110000,C080F0F,LP111E13728;

Video:
C310000,C080F0F,LP11E960,C0E"Video480p.txt",BL20,C210000,C080F0F,LP111 E13728;

Sequence:

1. LPInit,1;

2. HSync,9;

3. VSyncStart,1;

4. HSync,5;

5. VSyncEnd,1;

6. HSync,29;

7. Video,480;

LoopTo 2;

The LPInit block generates the HsyncEnd signal is a low power mode to power on the display device.

To achieve proper synchronization and timing for the video data, the HSync and VSync signals are used. The number of vertical blanking lines and horizontal blanking pixels are provided by the device manufacturer.

The HSync block, which loops over for 9 lines, generates the HSE signal, indicated by C310000,C080F0F before the device switches to low power mode until 12736 HS states are attained. The LP111E12736 corresponds to BLLP-2 on the image. Then, HSS signal is generated, indicated by C210000,C080F0F, after which the device enters into low power mode again until 13728 HS states are attained. The LP111E13728 corresponds to BLLP-1 on the image.

The VSyncStart block, which loops over once, generates the HSE signal followed by LP111E12736 state. Then, VSS signal is generated, indicated by C010000,C080F0F, after which the device enters into low power mode again until 13728 HS states are attained.

The HSync block loops over for 5 lines again before the VSyncEnd block loops over once. The VSyncEnd block generates the HSE signal followed by LP11E12736 state. Then, VSE signal is generated, indicated by C110000,C080F0F, after which the device enters into low power mode again until 13728 HS states are attained.

The HSync block loops over for 29 lines again before the Video block loops over for 480 lines. In the Video block, the HSE signal is generated followed by LP111E960 state. Here, in the duration between the Video line and HSyncEnd, there is a short LP state to allow the device to save power before the video starts. LP111E960, which forms the HBP, allows device to save power before switching to video mode. C0E“Video480p.txt” indicates the header information followed by the active payload data contained in the “Video480p.txt” file. The Video block displays BL20, which forms the HFP, before the HSS is generated again followed by switching into low power mode until 13728 HS states are attained.

Note that BLLP-1 and BLLP-2, that is, LP111E12736 and LP111E13728 are blanking lines. Instead of sending video data, long LP states are generated. The total number of HS states is driven by the E marker, which means each line has a fixed duration, depending on the data rate. It includes the HS states before the LPE marker is defined and the time taken to switch to the HS mode.

You must always ensure that to define a proper sequence, each block must end with the same HS or LP state to avoid any unexpected loops.

Calculating HS Data Rate for the DSI sequence

To calculate the minimum HS data rate required to run the sequence, you must be aware of at least the frame rate, the Blanking Lines (HBlank and VBlank) and the device's display resolution, in other words, the pixels per line and lines per frame, which are provided by the device manufacturer. The HS Frequency is the first line in the definition of a sequence file.

For example, let us consider that the device under test has a Frame Rate of 60 Hz and a display resolution of 640 x 480 pixels, where 640 is the horizontal resolution (or the length of each line) and 480 is the vertical resolution (or the number of video lines). The number of header (blanking lines) is given as 45.

1 Calculate the total no. of lines using the equation:

   Total Lines = Video Lines + Header (Blanking) lines = 480 + 45 = 525 lines

2 Calculate the Line Rate using the equation:

   Line Rate = Frame Rate * Total Lines = 60 Hz x 525 lines = 31.5 kHz

3 Calculate the No. of pixels per line using the equation:

   No. of pixels per line = HBlanking + Horizontal Resolution

   where, the HBlanking data is given by the device manufacturer. Let us assume 160 HBlanking lines.

   Therefore, No. of pixels per line = 160 + 640 = 800 pixels per line.

4 Determine the number of bits required for transmission of the video data. To do so, check the pixel color coding for the Data Type in the video from the device's specification. In this case, the pixel color code is RGB, which uses 24-bits per pixel.

   Calculate the total no. of bits per line using the equation:

   Total no. of bits per line = Bit-size per pixel * No. of pixels per line

   In this case, Total no. of bits per line = 24 * 800 = 19.2 kbits per line

5 Calculate the HS Data Rate using the equation:

   Data Rate = Line Rate * Total no. of bits per line

   In this case, Data Rate = 31.5 kHz * 19.2 kbits per line = 604.8 Mbps

Therefore, for a VGA mode video with a frame rate of 60 Hz, you must set a data rate of 604.8 Mbps, which you can define as HSFreq in the beginning of the sequence file.

For information on the DSI implementation in the MIPI D-PHY and MIPI C-PHY physical layer and detailed understanding of the protocol layer, refer to the *MIPI Alliance Specification for Display Serial Interface*.

3 Results Description and Procedure Parameters

CAUTION

Before running the calibration or test procedures, ensure that the system connections are done properly with the necessary equipment. You may run the calibration and test procedures in Offline mode, that is, without any instrument connected. However, the Offline mode is intended for product demonstrations with simulated data only. Calibration procedures that are run in Offline mode do not generate valid calibration data.

KEYSIGHT TECHNOLOGIES

Result Description

Once the selected procedure is finished, an indicator shows the final status (e.g. Pass / Fail / Incomplete) of a procedure. The description for each indicator is given in the Table 10.

Table 10 Indicator's result description table

Indicator	Description
	Procedure successfully passed the current test run in online mode.
	Procedure successfully passed the current test run in offline mode.
	Procedure could not proceed in the current test run. Most obvious reasons could be that the DUT failed during test initialization or the test was stopped, so no test was performed.
	Procedure failed the current test run in online mode.
	Procedure failed the current test run in offline mode.

MIPI C-PHY Receiver Test Software Procedure Parameters

The MIPI C-PHY CTS plug-in has certain Parameters available for each calibration and test procedure. You can see the respective Parameters on the right side pane of the user interface. Only those parameters appear that are associated with the selected calibration or test procedure. For various procedures, you may find parameters with the same name; however, the implementation is different and a change in the value of a parameter affects only its respective selected procedure.

Table 11 MIPI C-PHY Procedure Parameters

Parameter Name	Parameter Description
Additional Steps	Additional steps to be performed for the test.
Amplitude	Amplitude value to be tested/calibrated.
Amplitude Range	Range of the amplitude values to be tested over the level pairs. It is only available in expert mode. It should be separated by semicolons.
Check Pattern	Value of “True”/”False”. If “True”, the selected BER reader is used to verify that the DUT is in loop-back mode and transmitting the test pattern properly.
Data Rate	Data rate for the selected data speed.
Differential Voltage Start Value	First and the maximum differential voltage to be calibrated.
DSO Channel Complement	DSO channel where the complement output of the generator is connected.
DSO Channel Normal	DSO channel here the normal output of the DUT/generator is connected depending on the procedure.
Eye Width Max. Variation	Allowed variation of the target eye width.
Eye Height Target	Eye height to be calibrated.
Initial Jitter Amplitude Step	Initial step size value of Jitter amplitude.
BER Reader Init string	Configuration parameters of the BER reader for the system initialization mode with the parameters such as data channel, data rate and mode (Terminated / Unterminated).
Jitter Calibration File	Sequence file for the jitter calibration.
Jitter Frequencies	Jitter frequency to be tested/calibrated.
Jitter Amplitude Min Step	Minimum step size value that is used to find the DUT limit for each jitter frequency.
Level Pairs	Pairs of single-ended amplitudes separated by “|”

Parameter Name	Parameter Description
Max. Calibration Voltage Amplitude	Start voltage value to find the target eye height.
Maximum Interference Amplitude	Maximum value of the interference amplitude.
Max Jitter Value	Maximum jitter value to be calibrated.
Max Tested Value	Maximum skew value to be tested.
Min Jitter Value	Minimum jitter value to be calibrated.
Min Spec	Minimum value of the parameter that the DUT shall tolerate according to the specification.
Min Tested Value	Minimum skew value to be tested.
Min User-Defined Interference Amplitude	User-defined value of the common mode interference amplitude for the Common Mode Interference test and it should be passed until this value is reached.
Sequence	Sequence file used during the test of the DUT.
Set Single Ended Amplitude	Single-ended amplitude value set for the data channel.
Show Real Time Eye	Select “True”/”False” to switch between real time eye and single waveform. The measurement time increases by viewing the real time eye.
Skew Tolerance	Limit value. If the skew between the lanes is below this limit value, the calibration process is ended.
Step Size	Value to be increased/decreased at each step or the calibration/test procedure.
Target BER	Default target BER value is 1E-10 and if the measured BER is smaller than the target value, the test is considered as passed.
Tested Accumulated Differential Voltage	Differential voltage value to be tested. It is set according to the calibration in order to match the desired accumulated differential voltage.
Test Sequence	Sequence file used during the test of the DUT.
Infiniium Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

4 Calibrations and Test Procedures

CAUTION Before running the calibration or test procedures, ensure that the system connections are done properly with the necessary equipment. You may run the calibration and test procedures in Offline mode, that is, without any instrument connected. However, the Offline mode is intended for product demonstrations with simulated data only. Calibration procedures that are run in Offline mode do not generate valid calibration data.

Connections and Probing Methods

Connection Diagram for Calibrations

Since the MIPI C-PHY CTS plug-in uses only the M8195A AWG to perform calibrations, all the Calibration procedures have a common connection diagram.

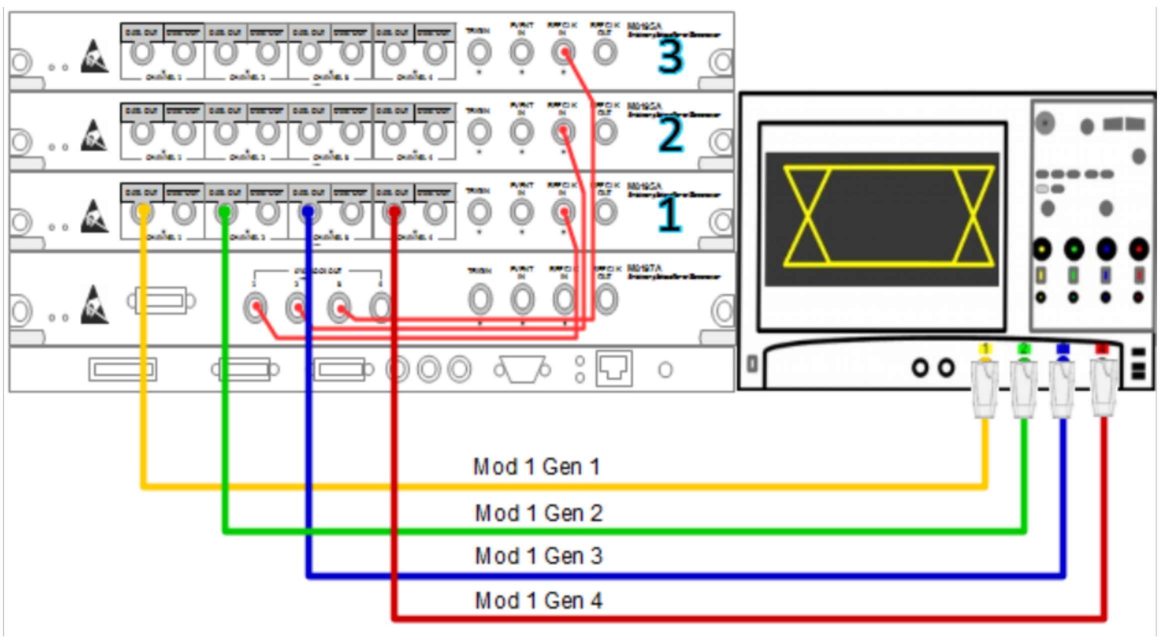


Figure 35 Common connection diagram for Calibrations

NOTE

The calibration procedures described below are performed using the M8195A AWG model. By default, the “Number of Lanes:” is selected as ‘1 Lane’. If you select the “Number of Lanes:” as ‘2 Lanes’ or ‘3 Lanes’, the MIPI C-PHY CTS plug-in also displays the calibrations for Data1 and Data2 lanes, respectively. For a certain calibration corresponding to Data1 or Data2 Lane, use the same test procedures described for Data0 lane.

The TRTF, DCD and Eye Opening Calibrations are not lane-dependent whereas Inter Module Skew Calibration appears for more than 1 lane.

Probing for LP Levels Calibration

For both Large and Small Amplitude LP Calibrations, the connection must be Single-Ended, Into Open. This can be achieved by connecting the outputs of the AWG to an N7010A active termination adapter.

Probing for HS Levels Calibration

For the HS Calibration, the connection must be Differential (one output of AWG is connected to the Normal and other is to the Complement for the calibrated channel), 100 Ohm Terminated. This can be achieved by connecting the outputs of the AWG to an N7010A active termination adapter.

Probing for Jitter Calibrations / Eye Opening Calibration

1 For the Jitter Calibrations, connect the outputs of the AWG lines (Clock N, Data P and Data N) with SMA direct connection to the oscilloscope (Channel 1, 2, 4).

Calibration Procedures

NOTE The calibration procedures described below are performed using the M8195A AWG model. The “Number of Lanes:” is selected as ‘1 Lane’. If you select the “Number of Lanes:” as ‘2 Lanes’ or ‘3 Lanes’, the MIPI C-PHY CTS plug-in also displays the calibrations for Modules 2 and 3 & Data1 and Data2 lanes, respectively. For a certain calibration name corresponding to Modules 2 and 3 & Data1 or Data2 Lane, use the same calibration procedures described for Module 1 or Data0 lane.

Amplifier Level Calibration Module 1 Gen 1

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

It is used to calibrate the amplitude and offset values of all channels within a module. It also adjusts the amplitude and offset settings in order to make the measured values should be equal at all channels. It is run at each module of the AWG (separately for each channel).

Dependencies

No other procedure is required for this calibration.

Procedure

To start the calibration procedure, follow the steps given below:

- Connect the normal data output of all channels within the module to the DSO channels (1 to 4) respectively with SMA cables.
- It sets Target values for the Amplitude (difference between the LP high level and low level values) and Offset using the default values. Then, the AWG generates an LP signal with the default values of LP high level, LP low level and offset
- Once the LP signal is generated, the LP high level, LP low level, and offset are measured using an oscilloscope. Then, it checks whether the measured values are within the limits or not. If not, it continues to set the difference value (between measured and default) within the step till it finds the measured values within the limits

- At each Generator, the above two steps are repeated and at the same time, both target and measured values are stored.

Parameters

Test parameters used in multiple procedures are given in Table 12.

Table 12 Parameters for Amplifier Level Calibration Module 1 Gen 1

Parameter Name	Parameter Description
Amplifier Level Calibration Module 1 Gen 1	
Calibration Pattern File	Pattern file that is used for calibration procedures, which is different from the pattern definition used in the sequence files for configuring the DUT
Max Amplitude Level	Maximum amplitude level set for calibration
Max Offset	Maximum offset limit to be set for the calibration
Min Amplitude Level	Minimum amplitude level set for calibration
Min Offset	Minimum offset limit to be set for the calibration
Offline	If enabled the calibration runs in offline mode
Step Size	Step size to go from the maximum to minimum voltage during the calibration
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under "C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY" or "C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY".
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to 'On', the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

Results

Table 13 Calibration data table "Amplifier Level Calibration Module 1 Gen 1"

Parameter name	Parameter description
Result	▪ Pass: the adjustment passed. ▪ Fail: the adjustment failed.
Set Amplitude [mV]	Maximum Amplitude level set for the calibration. For proper calibration, the plug-in reduces the set amplitude level of the LP signal according to the defined Step Size.
Measured Value for Offset = 300 [mV]	Measured calibrated value when amplitude is offset by 300mV.
Measured Value for Offset = 200 [mV]	Measured calibrated value when amplitude is offset by 200mV.
Measured Value for Offset = 100 [mV]	Measured calibrated value when amplitude is offset by 100mV.
Measured Value for Offset = 0 [mV]	Measured calibrated value when amplitude is offset by 0mV.

Amplifier Level Calibration Module 1 Gen 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 1 Gen 3

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 2 Gen 1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 2 Gen 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 2 Gen 3

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 3 Gen 1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 3 Gen 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Amplifier Level Calibration Module 3 Gen 3

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Amplifier Level Calibration Module 1 Gen 1 on page 96.

Skew Calibration Module 1

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure is used to calibrate the skew of all channels within a module by adjusting the skew of each channel so that the signals are aligned in the reference plane. This calibration should be run at each module.

Dependencies

No other calibration is required for this procedure.

Prior to conducting this calibration, the oscilloscope channels need to be de-skewed to avoid errors caused by the internal skew of the oscilloscope channels. This calibration is needed for all CTS tests.

Procedure

The data output signals of all channels within the module are connected to the DSO channels (1 to 4) respectively with SMA cables. For this procedure, the skew must be calibrated with the values lesser than the Skew Tolerance value. At first, a trigger is generated at the fourth channel and the skew is adjusted for all channels with respect to the fourth channel. The skew is measured and calibrated iteratively until its value is smaller than the given tolerance value.

Parameters

Test parameters used in multiple procedures are given in Table 14.

Table 14 Parameters for Skew Calibration Module 1

Parameter Name	Parameter Description
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

Parameter Name	Parameter Description
Skew Calibration Module 1	
Offline	If enabled, the calibration runs in offline mode
Skew Tolerance	Skew limit value. The calibration is considered finished if the skew between the channels is below this limit.

Results

Table 15 Calibration data table "Skew Calibration"

Parameter name	Parameter description
Result	▪ Pass: the system skew was adjusted below the skew limit value. ▪ Fail: the adjustment failed.
Skew Value [ps]	Skew value of the channel with respect to the fourth channel of the module.

Skew Calibration Module 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Skew Calibration Module 1 on page 100.

Skew Calibration Module 3

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Skew Calibration Module 1 on page 100.

Inter module Skew Calibration

Connection Diagram

Figure 36 Refer to Connection Diagram for Calibrations on page 94.

Purpose

It calibrates the skew among the modules of AWG.

- In case of M8195A 1-Lane mode, it is not available.
- In case of M8915 multi-lanes mode, it uses Line A of each module for Skew Calibration.

Dependencies

This procedure does not depend on any other calibration. This calibration is required for all CTS tests.

However, before conducting the test, the oscilloscope channels need to be de-skewed to avoid errors caused by the internal skew of the oscilloscope channels.

Procedure

The data output signals from two channels of a module and one channel of the second module are connected to the DSO channels (1 to 3) respectively with SMA cables. For this procedure, the skew must be calibrated with the values lesser than the Skew Tolerance value. At first, a trigger pattern is generated at the fourth channel and the skew is adjusted for all other channels with respect to the fourth channel. The skew is measured and calibrated iteratively until its value is smaller than the given tolerance value.

Parameters

Test parameters used in multiple procedures are given in Table 16.

Table 16 Parameters for Inter Module Skew Calibration

Parameter Name	Parameter Description
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	

Parameter Name	Parameter Description
Use InfiniiSim	If set to 'On', the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.
Inter Module Skew Calibration	
Offline	If enabled, the calibration runs in offline mode
Skew Tolerance	Skew limit value. The calibration is considered finished if the skew between the channels is below this limit.

Results

Table 17 Calibration data table "Inter module Skew"

Parameter name	Parameter description
Result	▪ Pass: it was possible to adjust the skew between lanes below the given tolerance. ▪ Fail: it was not possible to adjust the skew.
Skew Value [ps]	Skew value of the channel with respect to the fourth channel of the module.

LP Level Calibration Data0 A

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure calibrates the “LP-RX Logic 1 Input Voltage” (V_IH)” of the first line. Similar procedures are implemented for the remaining lines.

Dependencies

- This calibration is required for the CTS test groups 2.1 and 2.2, as well as for the HS Levels Calibration.
- It does not depend on other calibration procedures.

Procedure

The output signals are connected to the digital storage oscilloscope (for short, DSO or oscilloscope) channel 1 with a high impedance probe. An LP pattern is generated. Starting with the “Max Level” voltage, the LP high level is subsequently decremented by “Step Size” down to the “Min Level” voltage. The signal is measured with the DSO.

Parameters

Test parameters used in multiple procedures are given in Table 18.

Table 18 Parameters for LP Level Calibration Data0 A

Parameter Name	Parameter Description
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.
LP Level Calibration Data0 A	
Calibration Pattern File	Pattern file that is used for calibration procedures, which is different from the pattern definition used in the sequence files for configuring the DUT
Max LP High Level	Maximum LP High Level voltage required to calibrate

Parameter Name	Parameter Description
Max LP Low Level	Maximum LP Low Level voltage required to calibrate
Min LP High Level	Minimum LP High Level voltage required to calibrate
Min LP Low Level	Minimum LP Low Level voltage required to calibrate
Offline	If enabled, the calibration runs in offline mode
Step Size	Step size to go from the maximum to minimum voltage during the calibration

Results

Table 19 Calibration Data Table “LP Level Calibration Data0 A”

Parameter Name	Parameter Description
Result	Pass: the measured level is within the expected range of ±20% of the set level Fail: the measured level deviates more than ±20% from the set level
Set High Level [mV]	Set value of the LP low level
Measured High Level [mV]	Actual value as measured on channel 1 of the DSO using the most frequent value of a histogram measurement

LP Level Calibration Data0 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data0 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data1 A

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data1 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data1 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data2 A

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data2 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

LP Level Calibration Data2 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to LP Level Calibration Data0 A on page 104.

HS Level Calibration Data0 A

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure calibrates the HS level of the signal on the first line. Calibration is performed in the voltage interval between “Min Level” and “Max Level”. The same calibration procedure is used for the remainder HS lines.

Dependencies

- This calibration is required for the CTS test groups 2.3 and 2.4.
- LP Levels calibrations.

Procedure

The output signal is connected to the DSO channel 1 with high-impedance probes. The HS level is swept from the “Max Level” voltage down to the “Min Level” voltage by “Step Size”. The level is measured with a DSO.

Parameters

Test parameters used in multiple procedures are given in Table 20.

Table 20 HS Level Calibration Data0

Parameter Name	Parameter Description
HS Level Calibration Data0 A	
Offline	If enabled, the calibration runs in offline mode
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

Results

Test parameters used in multiple procedures are given in Table 21.

Table 21 Calibration Data Table "HS Level Calibration Data0 A"

Parameter Name	Parameter Description
Result	Pass: the measured level is within the expected range of ±20% of the set level Fail: the measured level deviates more than ±20% from the set level
Set Level [mV]	Set value of the HS level
Measured Level [mV]	Actual value as measured on channel 1 of the DSO using the most frequent value of a histogram measurement

HS Level Calibration Data0 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data0 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data1 A

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data1 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data1 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data2 A

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data2 B

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

HS Level Calibration Data2 C

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to HS Level Calibration Data0 A on page 107.

TRTF Calibration

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure calibrates the Rise and Fall Time (80% to 20%) of the generator and per the CTS. This calibration is Data Rate dependent.

Dependencies

- This calibration is required for the CTS test 2.3.3 and for the Eye Opening Calibration.
- It does not depend on other calibration procedures.

Procedure

Sweep from Min to Max in Step Size, measure effective TRTF time.

Parameters

Test parameters used in multiple procedures are given in Table 22.

Table 22 TRTF Calibration

Parameter Name	Parameter Description
InfiniiSim Settings	
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.
TRTF Calibration 2500 MSps	
Max Calibrated Value	Maximum value that must be attained during calibration above which the test is considered failed.
Min Calibrated Value	Minimum value that must be attained during calibration below which the test is considered failed.
Offline	If enabled, the calibration runs in offline mode

Parameter Name	Parameter Description
Oscilloscope Bandwidth	Optimal Bandwidth of the Oscilloscope set at 10GHz when a Low Pass Filter is not applied on the AWG. If a Low Pass Filter is applied, the maximum bandwidth of the Oscilloscope can be used. Without a Low Pass Filter, there is noise in signal found with an Oscilloscope Bandwidth of 30GHz or higher. The bandwidth can be modified in the Expert Mode only.
Step Size	Step size used to go from the minimum calibrated value to the maximum calibrated value or vice-versa.
Transitions	Number of transitions that the oscilloscope will capture using its Histogram feature

Results

Table 23 Calibration Data Table “TRTF Calibration”

Parameter Name	Parameter Description
Result	Pass: the measured level is within the expected range of ±20% of the set level Fail: the measured level deviates more than ±20% from the set level
Set TRTF [ps]	Set value of TRTF
Measured Eye Closure [mUI]	Actual TRTF value measured with the DSO

DCD Calibration

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure calibrates the DCD of the generator, which is required to reduce the eye opening of the signal to its optimum value. This calibration is data rate dependent.

Dependencies

- This calibration is required for the CTS test 2.3.3 and for the Eye Opening Calibration.

Procedure

Sweep from Min Calibrated Value to Max Calibrated Value according to the Step Size, measure the effective jitter amplitude for the duty cycle.

Parameters

Test parameters used in multiple procedures are given in Table 24.

Table 24 DCD Calibration

Parameter Name	Parameter Description
DCD Calibration	
HS Sequence File	Sequence file that is used for the calibration of the HS data instead of the sequence file specified while configuring the DUT.
Max Calibrated Value	Maximum value that must be attained during calibration above which the test is considered failed.
Min Calibrated Value	Minimum value that must be attained during calibration below which the test is considered failed.
Offline	If enabled, the calibration runs in offline mode.
Oscilloscope Bandwidth	Optimal Bandwidth of the Oscilloscope set at 10GHz when a Low Pass Filter is not applied on the AWG. If a Low Pass Filter is applied, the maximum bandwidth of the Oscilloscope can be used. Without a Low Pass Filter, there is noise in signal found with an Oscilloscope Bandwidth of 30GHz or higher. The bandwidth can be modified in the Expert Mode only.
Step Size	Step size used to go from the minimum calibrated value to the maximum calibrated value.
Transitions	Number of transitions that the oscilloscope will capture using its Histogram feature
InfiniiSim Settings	

Parameter Name	Parameter Description
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

Results

Table 25 Calibration Data Table “DCD Calibration”

Parameter Name	Parameter Description
Result	▪ Pass: the measured level is within the expected range of ±20% of the set level ▪ Fail: the measured level deviates more than ±20% from the set level
Set Jitter [mUI]	Set jitter value for the signal edge times
Measured Jitter [mUI]	Actual jitter value measured with the DSO

Eye Opening Calibration

Connection Diagram

Refer to Connection Diagram for Calibrations on page 94.

Purpose

This procedure calibrates the Eye Opening per the CTS when all other impairments are present. This calibration is Data Rate dependent.

Dependencies

- This calibration is required for the CTS test 2.3.3.
- It depends on the TRTF and DCD calibrations.

Procedure

For Spec version 1.1, the eye opening is measured for different reference channels as defined in the CTS, until one is found that makes the measured Horizontal Eye Opening be within “Eye Width Target” ± “Eye Width Max Variation”.

The M8085A MIPI C-PHY CTS Plug-in automatically performs the ISI Calibration, when performing the Eye Opening Calibration, thereby adjusting the ISI Channel for the Eye Width Target.

Then, a sweep over the amplitude range is performed, starting at “Differential Voltage Start Value” and measuring the Vertical Eye Opening, until the measured value is smaller than “Eye Height Target”.

WARNING **If the calibration fails and shows the message “Levels for Eye Opening according to Specification 40mV were not reached”, the Differential Voltage Start Value shall be increased to reach the Minimum Accumulated Differential Voltage value (default value 40mV). Due to the increased differential voltage, the DUT could be damaged due to the violation of the maximum differential voltage value while running the Test 2.3.3 HS-RX Jitter Tolerance Test.**

Parameters

Test parameters used in multiple procedures are given in Table 26.

Table 26 Eye Opening Calibration

Parameter Name	Parameter Description
Eye Opening Calibration	
Calibration Method	Select one of the following options: ▪ **ExplicitClockRecoveryEye**– (default option) The MIPI C-PHY signal has a 3-wire state used for data transmission. Generally, the 4th wire is left unused. This calibration method uses the 4th wire to transmit an HS explicit clock signal. Instead of recovering clock from the data stream, the trigger is applied on this explicit clock signal for sampling. ▪ **CombinedCPHYEye**–As per the MIPI C-PHY CTS specification, the clock must be recovered from the data signal. In this calibration method, even though the connection diagram shows that the 4th wire is connected to the corresponding channel, it is left unused and clock is recovered from the data stream. The prerequisite for this calibration method to work is that the Oscilloscope Application must have the Clock Data Recovery (CDR) installed and licensed to perform the necessary calibration steps.
Differential Voltage Amplitude	Differential voltage value applied during the Eye-height calibration
Eye Height Target	Required eye-height according to the MIPI C-PHY CTS specification.
Eye Width Max. Variation	Maximum allowed variation of the eye-width according to the MIPI C-PHY CTS specification.
Eye Width Target	Required eye-width according the MIPI C-PHY CTS specification.
HS Sequence File	Sequence file that is used for the calibration of the HS data instead of the sequence file specified while configuring the DUT. ▪ If the Calibration Method is set to **ExplicitClockRecoveryEye**, it uses the *CPhyJitterCalibration.seq* file, which contains Continuous Data sequence. ▪ If the Calibration Method is set to **CombinedCPHYEye**, it uses the *PRBSBurstJitterCalibration.seq* file, which contains Burst Data sequence.
Offline	If enabled, the calibration runs in offline mode.
Oscilloscope Bandwidth	Optimal Bandwidth of the Oscilloscope set at 10GHz when a Low Pass Filter is not applied on the AWG. If a Low Pass Filter is applied, the maximum bandwidth of the Oscilloscope can be used. Without a Low Pass Filter, there is noise in signal found with an Oscilloscope Bandwidth of 30GHz or higher. The bandwidth can be modified in the Expert Mode only.
Rise / Fall Time Eye Closure Target	Required eye-closure according the MIPI C-PHY CTS specification.
S-Parameter File	The S-parameter file, which is used to emulate a channel during the test.
InfiniiSim Settings	

Parameter Name	Parameter Description
Transfer Function Chan 1	Specified Transfer Function file for the scope is applied, which is found either under “C:\Users\Public\Public Documents\Infiniium\Filters\C-PHY” or “C:\Documents and Settings\All Users\Documents\Infiniium\Filters\C-PHY”.
Transfer Function Chan 2	
Transfer Function Chan 3	
Use InfiniiSim	If set to ‘On’, the InfiniiSim transfer function of the Oscilloscope is applied instead of the replica trace.

Results

Table 27 Calibration Data Table “Eye Width”

Parameter Name	Parameter Description
Result	▪ Pass: the measured level is within the expected range of ±20% of the set level ▪ Fail: the measured level deviates more than ±20% from the set level
DCD [mUI]	DCD amplitude that is set to reach the target Eye Opening and obtain the Eye Width
Eye Width [mUI]	Resulting Eye Width for the set DCD amplitude and impairments

Table 28 Calibration Data Table “Eye Height”

Parameter Name	Parameter Description
Result	▪ Pass: the measured level is within the expected range of ±20% of the set level ▪ Fail: the measured level deviates more than ±20% from the set level
Voltage Amplitude [mV]	Voltage amplitude level of the Differential signal
Eye Height [mV]	Vertical Eye Opening measured for the given amplitude and signal impairments
Maximum Vppd [mV]	Maximum measured signal amplitude

5 Test Procedures

The MIPI C-PHY receiver tests comprise of the following test groups:

- HS Tests
- Semi-Automated Tests
- LP Tests
- Behavioral Tests

This grouping streamlines the test process by minimizing the number of physical reconnection of cables and other test accessories.

Connection Diagrams for the Test Procedures

Figure 37 illustrates the connection settings, which are common for all tests listed under HS Tests, LP Tests and Behavioral Tests. The Semi-Automated Tests require slight modifications in the physical connection with the DUT, which has been illustrated in Figure 38.

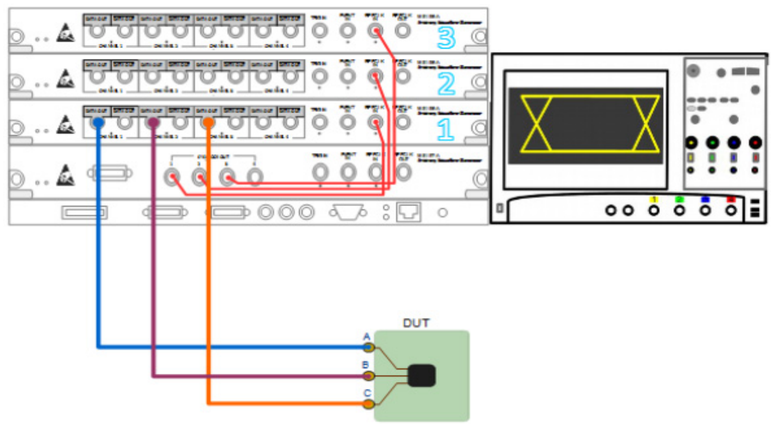


Figure 37 Connection Diagram for M8195A

Each test can be performed in two modes: Compliance and Expert Mode. (Refer to Accessing the MIPI C-PHY CTS Plug-in on page 17). While Compliance has pre-defined optimal values for the test parameters that cannot be modified; the Expert Mode allows you to customize values or limits for the parameters, only if required, so that you may analyze the behavior and limitations of a test. By default, the field for each parameter displays the values/limits from the CTS. If needed, edit the parameter values/limits to those supported by your DUT, which may be less than or beyond the CTS limits.

In Compliance and in Expert Mode, follow the steps given below, which are common to all test procedures under the test groups—Clock, Data, Semi-Automated Tests and LP Tests:

- Make the connections for the selected test procedure as per the connection diagram shown in Figure 37 (and Figure 38 for Semi-Automated tests) for M8195A.
- Click Run to transmit the test sequence to the DUT. Refer to Running Tests on page 30 to know how to run procedures.

- From the Results Table, verify that the DUT received the test sequence without errors.

For the remaining test groups, some of the tests additionally require some manual steps to be performed, which have been described in the respective sections.

NOTE

The test procedures described below are performed using the M8195A AWG model. By default, the “Number of Lanes:” is selected as ‘1 Lane’. If you select the “Number of Lanes:” as ‘2 Lanes’ or ‘3 Lanes’, the MIPI C-PHY CTS plug-in also displays the tests for Data1 and Data2 lanes, respectively. For a certain test name corresponding to Data1 or Data2 Lane, use the same test procedures described for Data0 lane.

HS Tests

Test 2.3.1 Amplitude Tolerance Data 0

CTS Test Number and Name

Test 2.3.1 – HS-RX Amplitude Tolerance (VCPRX(DC), VIHHS, VILHS)

Purpose

To verify that the DUT's HS receiver can successfully receive signaling with common-mode and differential voltage amplitude levels (VCPRX(DC), VIHHS, VILHS) within the conformance limits.

Dependencies

HS Levels calibration.

Procedure

After power-on, it is required that the Master initializes the Slave by driving LP111 for a period longer than T_INIT (100 µs). If the initialization period is shorter or non-existent, all transitions on the line will be ignored by the Slave.

To implement the test:

- Send valid HS or LP data that causes an observable result after T_INIT <100 µs.
- Observe whether the test data is received by the DUT.
- Restart DUT, slowly increase T_INIT (e.g. by 10 µs steps) up to the point where the DUT receives the following data properly.
- The DUT passes the test if minimum T_INIT ≥ 100 µs, otherwise it fails.

Parameters

Table 29 Parameters used in Test 2.3.1 Amplitude Tolerance Data 0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.

LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
V_OD Array	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.

Results

Table 30 Parameters in the result table for "Test 2.3.1 Amplitude Tolerance Data 0"

Parameter name	Parameter description
Result	Pass: the DUT was able to receive the test sequence without errors. Fail: the DUT failed to receive the test sequence.
V_OD [mV]	Tested V_OD for the test
Min Passed V_CPRX [mV]	Minimum passed V_CPRX between all test cases
Min Tested V_CPRX [mV]	Minimum V_CPRX tested so far
Min Spec V_CPRX [mV]	Minimum V_CPRX according to specification
Max Passed V_CPRX [mV]	Maximum passed V_CPRX between all test cases
Max Tested V_CPRX [mV]	Maximum V_CPRX tested so far
Max Spec V_CPRX [mV]	Maximum V_CPRX according to specification

Test 2.3.1 Amplitude Tolerance Data 1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.1 Amplitude Tolerance Data 0 on page 120.

Test 2.3.1 Amplitude Tolerance Data 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.1 Amplitude Tolerance Data 0 on page 120.

Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 0

CTS Test Number and Name

Test 2.3.2 – HS-RX Differential Input High/Low Thresholds (VIDTH, VIDTL)

Purpose

To verify that the DUT's HS receiver can properly detect VOD voltage levels that are at least as small as the minimum required values (VIDTH, VIDTL).

Dependencies

HS Levels calibration.

Procedure

Starting with nominal levels, reduce the differential amplitude until the DUT fails. Record the last working value.

Parameters

Table 31 Parameters used in Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Minimum Tested Vppd	Minimum Peak-to-Peak Differential Voltage as defined in the MIPI C-PHY CTS.
Offline	Offline Mode.
Steps	Step size used to go from the minimum calibrated value to the maximum calibrated value.
V_IHHS	Set value of Single-ended Input High Voltage
V_ILHS	Set value of Single-ended Input Low Voltage
V_MID	Set value of Single-ended Input Middle Voltage

Results

For all test cases, the DUT must successfully receive the HS burst data without error.

Table 32 Parameters in the result table for "Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 0"

Parameter name	Parameter description
Result	▪ Pass: the DUT's V_IDTH and V_IDTL minimum values conform to the specification ▪ Fail: the DUT was not able to receive the test sequence with V_IDTH and V_IDTL values within the specification
V_CM [mV]	Common-mode level used during the test
Min Passed V_IDTH/V_IDTL [mV]	Minimum value of V_IDTH and V_IDTL for which the DUT passed the test
Min Tested V_IDTH/V_IDTL [mV]	Minimum value tested for V_IDTH and V_IDTL
Min Spec [mV]	Minimum value of V_IDTH and V_IDTL according to the specification

Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 0 on page 122.

Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data 0 on page 122.

Test 2.3.3 Jitter Tolerance Data 0

CTS Test Number and Name

Test 2.3.3 – HS-RX Jitter Tolerance

Purpose

To verify that the DUT can tolerate signaling with worst-case timing error.

Dependencies

TRTF, Eye Opening Calibrations

Procedure

The eye is closed according to the CTS and HS data transmission is performed at 175mV and 310mV common mode levels. The DUT will receive the data successfully to pass the test.

WARNING During the Eye Opening Calibration, if the Differential Voltage Start Value is increased to achieve the Minimum Accumulated Differential Voltage (that is, 40mV), the Differential Amplitude set during this test to achieve the required eye opening may exceed the specification limits, which in turn, may damage the DUT.

Parameters

Table 33 Parameters used in Test 2.3.3 Jitter Tolerance Data 0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
DCD	Duty Cycle Distortion value that must be applied on the MIPI C-PHY signal.
Eye Closure Target	Required eye-closure according the MIPI C-PHY CTS specification.
Eye Height Target	Required eye-height according to the MIPI C-PHY CTS specification.
Eye Width Target	Required eye-width according the MIPI C-PHY CTS specification.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.

LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Maximum Tested Common Mode	Maximum Common-mode voltage value set as defined in the MIPI C-PHY CTS.
Minimum Tested Common Mode	Minimum Common-mode voltage value set as defined in the MIPI C-PHY CTS.
Offline	Offline Mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.

Results

Table 34 Parameters in the result table for "Test 2.3.3 Jitter Tolerance Data 0"

Parameter name	Parameter description
Result	Pass: the DUT was able to receive the test sequence without errors Fail: the DUT failed to receive the test sequence
V_CM [mV]	Common-mode level used during the test
Min Passed V_CM [mV]	Minimum value of V_CM for which the DUT passed the test
Min Tested V_CM [mV]	Minimum value tested for V_CM
Max Passed V_CM [mV]	Maximum value of V_CM according to the specification
Max Tested V_CM [mV]	Maximum value tested for V_CM

Test 2.3.3 Jitter Tolerance Data 1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.3 Jitter Tolerance Data 0 on page 124.

Test 2.3.3 Jitter Tolerance Data 2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.3.3 Jitter Tolerance Data 0 on page 124.

Test 2.4.2 T_HS-Prepare - Data0 Procedure

CTS Test Number and Name

Test 2.4.2 – HS-RX T3-PREPARE Tolerance

Purpose

To verify that the DUT's HS-RX can tolerate reception of values that conform for T3-PREPARE.

Dependencies

HS Levels calibration.

Procedure

Test the two cases in the CTS (38ns and 95ns prepare time) while all the other timings are also as stated in the CTS:

- Tlpx: 50ns
- T3-POST Time Interval: 224 UI
- T3-PREBEGIN Time Interval: 448 UI
- T3-PREEND Time Interval: 7 UI
- T3-PROGSEQ: Disabled
- T3-SYNC: 3444443 (7 UI)

Parameters

Table 35 Parameters used in Test 2.4.2 T_HS-Prepare - Data0 Procedure

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
End Value	End value of the Prepare time on the HS signal.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Start Value	Start value of the Prepare time on the HS signal.

Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
T3-POST Time Interval	T3 Post time interval on the HS signal in UI.
T3-PREBEGIN Time Interval	T3 PreBegin time interval on the HS signal in UI.
T3-PREEND Time Interval	T3 PreEnd time interval on the HS signal in UI.
T3-PROGSEQ	ProgSeq pattern on the HS signal.
T3-SYNC	Sync Pattern on the HS signal.

Results

Table 36 Parameters in the result table for "Test 2.4.2 T_HS-Prepare - Data0 Procedure"

Parameter name	Parameter description
Result	Pass: the DUT was able to conform to all compliant values for T3_PREPARE Fail: the DUT was unable to conform to all compliant values for T3_PREPARE
Parameter	Timing Parameter being tested (T3_PREPARE)
Min Passed [ns]	The duration achieved that is compliant with the minimum T3-PREPARE value in the MIPI C-PHY CTS.
Min Failed [ns]	The duration that failed to comply with the minimum T3-PREPARE value in the MIPI C-PHY CTS.
Min Spec [ns]	The minimum T3-PREPARE value specified in the MIPI C-PHY CTS.
Max Passed [ns]	The duration achieved that is compliant with the maximum T3-PREPARE value in the MIPI C-PHY CTS.
Max Failed [ns]	The duration that failed to comply with the maximum T3-PREPARE value in the MIPI C-PHY CTS.
Max Spec [ns]	The maximum T3-PREPARE value specified in the MIPI C-PHY CTS.

Test 2.4.2 T_HS-Prepare - Data1 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.2 T_HS-Prepare - Data0 Procedure on page 126.

Test 2.4.2 T_HS-Prepare - Data2 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.2 T_HS-Prepare - Data0 Procedure on page 126.

Test 2.4.3 T_HS-PreBegin - Data0 Procedure

CTS Test Number and Name

Test 2.4.3 – HS-RX T3-PREBEGIN Tolerance

Purpose

To verify that the DUT’s HS-RX can tolerate reception of values that conform for T3-PREBEGIN.

Dependencies

HS Levels calibration.

Procedure

Slowly, increase T3-PREBEGIN value until the DUT receives the test sequence. The value should be in the range 7 UI to 448 UI. The rest of the timing parameters should also be as per the CTS:

- Tlpx: 50ns
- T3-POST Time Interval: 224 UI
- T3-PREEND Time Interval: 7 UI
- T3-PREPARE: 70 ns
- T3-PROGSEQ: Disabled
- T3-SYNC: 3444443 (7 UI)

Parameters

Table 37 Parameters used in Test 2.4.3 T_HS-PreBegin - Data0 Procedure

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
End Value	End value of the PreBegin interval on the HS signal.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Start Value	Start value of the PreBegin Interval on the HS signal.

Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
T3-POST Time Interval	T3 Post time interval on the HS signal in UI.
T3-PREEND Time Interval	T3 PreEnd time interval on the HS signal in UI.
T3-PREPARE	T3 Prepare time interval on the HS signal in UI.
T3-PROGSEQ	ProgSeq pattern on the HS signal.
T3-SYNC	Sync Pattern on the HS signal.

Results

Table 38 Parameters in the result table for "Test 2.4.3 T_HS-PreBegin - Data0 Procedure"

Parameter name	Parameter description
Result	Pass: the DUT was able to conform to all compliant values for T3_PREBEGIN Fail: the DUT was unable to conform to all compliant values for T3_PREBEGIN
Parameter	Timing Parameter being tested (T3_PREBEGIN)
Min Passed [UI]	The interval obtained that is compliant with the minimum T3-PREBEGIN value in the MIPI C-PHY CTS.
Min Spec [UI]	The interval obtained that failed to comply with the minimum T3-PREBEGIN value in the MIPI C-PHY CTS.
Max Passed [UI]	The minimum T3-PREBEGIN interval specified in the MIPI C-PHY CTS.
Max Tested [UI]	The interval achieved that is compliant with the maximum T3-PREBEGIN value in the MIPI C-PHY CTS.
Max Spec [UI]	The interval that failed to comply with the maximum T3-PREBEGIN value in the MIPI C-PHY CTS.

Test 2.4.3 T_HS-PreBegin - Data1 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.3 T_HS-PreBegin - Data0 Procedure on page 128.

Test 2.4.3 T_HS-PreBegin - Data2 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.3 T_HS-PreBegin - Data0 Procedure on page 128.

Test 2.4.4 T_HS-ProgSeq - Data0 Procedure

CTS Test Number and Name

Test 2.4.4 – HS-RX T3-PROGSEQ Tolerance

Purpose

To verify that the DUT's HS-RX can tolerate reception of values that conform for T3-PROGSEQ.

Dependencies

HS Levels calibration.

Procedure

Only one test case as per the CTS, which is to test the T3-PROGSEQ length of 14 UI. The rest of the timing parameters shall also be as per the CTS:

- Tlpx: 50ns
- T3-POST Time Interval: 224 UI
- T3-PREBEGIN Time Interval: 448 UI
- T3-PREEND Time Interval: 7 UI
- T3-PREPARE: 70 ns
- T3-PROGSEQ: 43434343434343 (14 UI)
- T3-SYNC: 3444443 (7 UI)

Parameters

Table 39 Parameters used in Test 2.4.4 T_HS-ProgSeq - Data0 Procedure

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
T3-POST Time Interval	T3 Post time interval on the HS signal in UI.

T3-PREBEGIN Time Interval	T3 PreEnd time interval on the HS signal in UI.
T3-PREEND Time Interval	T3 PreBegin time interval on the HS signal in UI.
T3-PREPARE	T3 Prepare time interval on the HS signal in UI.
T3-PROGSEQ	ProgSeq pattern on the HS signal.
T3-SYNC	Sync Pattern on the HS signal.

Results

Table 40 Parameters in the result table for "Test 2.4.4 T_HS-ProgSeq - Data0 Procedure"

Parameter name	Parameter description
Result	Pass: the DUT was able to conform to all compliant values for T3_PROGSEQ Fail: the DUT was unable to conform to all compliant values for T3_PROGSEQ
Parameter	Timing Parameter being tested (T3_PROGSEQ)
Min Passed [UI]	The interval obtained that is compliant with the minimum T3-PROGSEQ value in the MIPI C-PHY CTS.
Min Spec [UI]	The minimum T3-PROGSEQ interval specified in the MIPI C-PHY CTS.
Max Passed [UI]	The interval obtained that is compliant with the maximum T3-PROGSEQ value in the MIPI C-PHY CTS.
Max Spec [UI]	The maximum T3-PROGSEQ interval specified in the MIPI C-PHY CTS.

Test 2.4.4 T_HS-ProgSeq - Data1 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.4 T_HS-ProgSeq - Data0 Procedure on page 130.

Test 2.4.4 T_HS-ProgSeq - Data2 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.4 T_HS-ProgSeq - Data0 Procedure on page 130.

Test 2.4.5 T_HS-Post - Data0 Procedure

CTS Test Number and Name

Test 2.4.5 – HS-RX T3-POST Tolerance

Purpose

To verify that the DUT's HS-RX can tolerate reception of values that conform for T3-POST.

Dependencies

HS Levels calibration.

Procedure

Only one test case as per the CTS, which is T3-POST detection threshold, is between 7UI and 224UI. The rest of the timing parameters shall also be as per the CTS:

- Tlpx: 50ns
- T3-PREBEGIN Time Interval: 448 UI
- T3-PREEND Time Interval: 7 UI
- T3-PREPARE: 70 ns
- T3-PROGSEQ: Disabled
- T3-SYNC: 3444443 (7 UI)

Parameters

Table 41 Parameters used in Test 2.4.5 T_HS-Post - Data0 Procedure

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
End Value	End value of the Post interval on the HS signal.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Start Value	Start value of the Post Interval on the HS signal.

Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
T3-PREBEGIN Time Interval	T3 PreEnd time interval on the HS signal in UI.
T3-PREEND Time Interval	T3 PreBegin time interval on the HS signal in UI.
T3-PREPARE	T3 Prepare time interval on the HS signal in UI.
T3-PROGSEQ	ProgSeq pattern on the HS signal.
T3-SYNC	Sync Pattern on the HS signal.

Results

Table 42 Parameters in the result table for "Test 2.4.5 T_HS-POST - Data0 Procedure"

Parameter name	Parameter description
Result	Pass: the DUT was able to conform to all compliant values for T3_POST Fail: the DUT was unable to conform to all compliant values for T3_POST
Parameter	Timing Parameter being tested (T3_POST)
Min Passed [UI]	The interval obtained that is compliant with the minimum T3-POST value in the MIPI C-PHY CTS.
Min Spec [UI]	The minimum T3-POST interval specified in the MIPI C-PHY CTS.
Max Passed [UI]	The interval achieved that is compliant with the maximum T3-POST value in the MIPI C-PHY CTS.
Max Tested [UI]	The maximum tested value for T3-POST in the MIPI C-PHY CTS.
Max Spec [UI]	The maximum T3-POST interval specified in the MIPI C-PHY CTS.

Test 2.4.5 T_HS-Post - Data1 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.5 T_HS-Post - Data0 Procedure on page 132.

Test 2.4.5 T_HS-Post - Data2 Procedure

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.5 T_HS-Post - Data0 Procedure on page 132.

Semi-Automated Tests

NOTE

The test procedures described below are performed using the M8195A AWG model. By default, the “Number of Lanes:” is selected as ‘1 Lane’. If you select the “Number of Lanes:” as ‘2 Lanes’ or ‘3 Lanes’, the MIPI C-PHY CTS plug-in also displays the tests for Data1 and Data2 lanes, respectively. For a certain test name corresponding to Data1 or Data2 Lane, use the same test procedures described for Data0 lane.

Figure 38 illustrates the connection settings for the category Semi-Automated Tests.

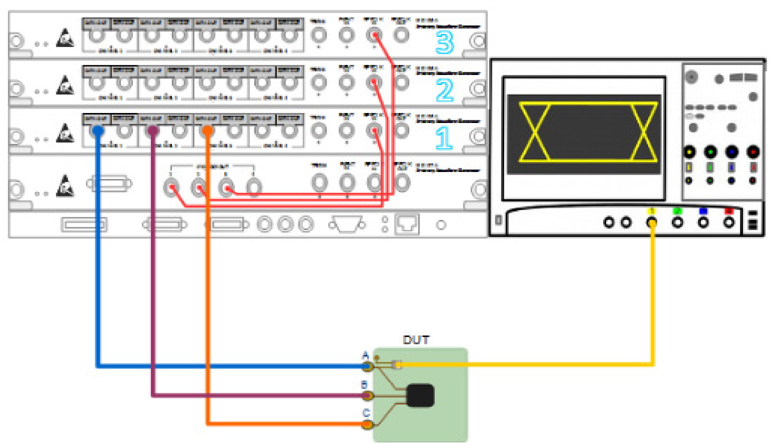


Figure 38 Connection Diagram for M8195A

Test 2.4.1 Data 0 Lane T_HS-TERM-EN

CTS Test Number and Name

Test 2.4.1 – HS-RX T3-TERM-EN Duration

Purpose

To verify that the time required for the DUT's receiver to enable its HS line termination (T3-TERM-EN) is within the conformance limits.

Dependencies

HS Levels Calibration

Procedure

A test pattern is sent to the DUT, with an oscilloscope probe connected to the tested data line. At the LP111 to LP000 transition, a small spike is visible, which marks the enabling of the DUT'S Rx termination. The measured duration of T3-TERM-EN between the LP111–LP000 transition and the visible spike should be less than 38ns. For details, see the CTS.

Parameters

Table 43 Parameters used in Test 2.4.1 Data 0 Lane T_HS-TERM-EN

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Trigger Level	Step size for the modification of the common-mode level.

Results

Table 44 Parameters in the result table for Test 2.4.1 Data 0 Lane T_HS-TERM-EN

Parameter name	Parameter description
Result	▪ Pass: the termination is enabled within the specified time. ▪ Fail: the termination was not enabled on time.
Signal	Signal that is being tested.
Timing [ns]	Time that the DUT took to enable the termination
Max Spec [ns]	Maximum T3-TERM-EN according to the specification

Test 2.4.1 Data 1 Lane T_HS-TERM-EN

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.1 Data 0 Lane T_HS-TERM-EN on page 135.

Test 2.4.1 Data 2 Lane T_HS-TERM-EN

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.4.1 Data 0 Lane T_HS-TERM-EN on page 135.

LP Tests

Test 2.1.1 V_IH Sensitivity Data0

CTS Test Number and Name

Test 2.1.1 – LP-RX Logic 1 Input Voltage (VIH)

Purpose

To verify that the DUT's LP receiver can properly detect Logic 1 voltage levels as low as the minimum required conformance limit (V_IH).

Dependencies

LP level Calibrations

Procedure

A test pattern is sent to the DUT with nominal parameter values and V_OH = 1.2 V and V_OL = 0 V on all clock and data lanes. After it has been verified that the image is received without errors, V_OH is decreased on all clock and data lanes simultaneously until errors can be detected. The lowest value for V_OH with no errors seen is recorded as V_IH. In order for the DUT to pass the test, V_IH should be less than or equal to 740 mV.

Parameters

Table 45 Test 2.1.1 V_IH Sensitivity Data0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Max Tested Value	Maximum Input Voltage (V_IH)
Min Tested Value	Minimum Input Voltage (V_IH)
Offline	Offline Mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.

Results

Table 46 Parameters in the result table for “Test 2.1.1 V_IH Sensitivity Data0”

Parameter name	Parameter description
Result	▪ Pass: the minimum V_IH that the DUT can handle without errors is smaller than or equal to the minimum value in the specification. ▪ Fail: the minimum V_IH that the DUT can handle without errors is larger than the minimum value in the specification.
Min Passed V_IH [mV]	Minimum input high-level voltage, VIH, for which the test data was transmitted without errors
Min Tested V_IH [mV]	Minimum tested V_IH
Min Spec [mV]	Minimum input high-level voltage, VIH, for which the DUT shall receive the data without errors according to the specification

Test 2.1.1 V_IH Sensitivity Data1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.1 V_IH Sensitivity Data0 on page 137.

Test 2.1.1 V_IH Sensitivity Data2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.1 V_IH Sensitivity Data0 on page 137.

Test 2.1.2 V_IL Sensitivity Data0

CTS Test Number and Name

Test 2.1.2 – LP-RX Logic 0 Input Voltage, Non-ULP State (VIL)

Purpose

To verify that the DUT's LP receiver can correctly detect Logic 0 voltage levels as high as the maximum required conformance limit (VIL), when in the non-ULP state.

Dependencies

LP Level Calibrations

Procedure

A test pattern is sent to the DUT with nominal parameter values and V_OH = 1.2 V and V_OL = 0 V on all clock and data lanes. After it has been verified that the image is received without errors, V_OL is increased on all clock and data lanes simultaneously until errors can be detected. The highest value for V_OL with no errors seen is recorded as V_IL. In order for the DUT to pass the test, V_IL should be greater than or equal to 550 mV.

Parameters

Table 47 Test 2.1.2 V_IL Sensitivity Data0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Max Tested Value	Maximum Input Voltage (V_IH)
Min Tested Value	Minimum Input Voltage (V_IH)
Offline	Offline Mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.

Results

Table 48 Parameters in the result table for "Test 2.1.2 V_IL Sensitivity Data0"

Parameter name	Parameter description
Result	▪ Pass: the minimum V_IH that the DUT can handle without errors is smaller than or equal to the minimum value in the specification. ▪ Fail: the minimum V_IH that the DUT can handle without errors is larger than the minimum value in the specification.
Max Passed V_IL [mV]	Maximum input high-level voltage, VIL, for which the test data was transmitted without errors
Max Tested V_IL [mV]	Maximum tested V_IL
Max Spec V_IL [mV]	Maximum input high-level voltage, VIL, for which the DUT shall receive the data without errors according to the specification

Test 2.1.2 V_IL Sensitivity Data1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.2 V_IL Sensitivity Data0 on page 139.

Test 2.1.2 V_IL Sensitivity Data2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.2 V_IL Sensitivity Data0 on page 139.

Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic

CTS Test Number and Name

Test 2.1.3 – LP-RX Input Hysteresis (VHYST)

Purpose

To verify that the Input Hysteresis value (VHYST) of the DUT's LP receiver is within the conformance limits.

Dependencies

LP Level Calibrations

To run this test, it is necessary to know the minimum V_IH and maximum V_IL values that the DUT supports. If Test 2.1.1 V_IH Sensitivity and Test 2.1.2 V_IL Sensitivity are run before this test procedure, the parameters "Tested VIH" and "Tested VIL" are filled automatically with the corresponding values. It is also possible to input these parameters manually before the start of the test.

Procedure

Interference is added to the tested lane LP component. Initially, a sequence is transmitted using nominal V_IL values and a V_IH of "Tested V_IH". In successive steps, the interference is increased until the transmission presents errors. V_HYST-V_IH is recorded as the maximum interference amplitude for which no errors where observed. Then, V_IH is set to nominal values and V_IL is set to "Tested V_IL". Starting without interference, it is increased in successive steps until the transmission presents errors. V_HYST-V_IL is recorded as the maximum interference amplitude for which no errors where observed. Both V_HYST-V_IH and V_HYST-V_IL should be greater than 25mVpk for the DUT to be consider compliant to the specification.

Parameters

Table 49 Parameters used in Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.

Interference Frequency	Interference frequency used during this test step.
Interference Step Size	The step size by which the interference voltage is increased/decreased while running test.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Max Interference Amplitude	Maximum interference amplitude for which the DUT was able to receive the test sequence without errors for the given common-mode and differential voltage levels.
Offline	Offline Mode.
Tested VIH	Minimum V_IH supported by the DUT.
Tested VIL	Maximum V_IL supported by the DUT.
VIH during VIL test	The value obtained by V_IH while running V_IL test.
VIL during VIH test	The value obtained by V_IL while running V_IH test.

Results

Table 50 Parameters in the result table for "Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic"

Parameter name	Parameter description
Result	Pass: the Input Hysteresis value of the DUT's LP receiver line is within the conformance limits. Fail: the Input Hysteresis value of the DUT's LP receiver line is not within the conformance limits.
Max Passed Interference V_IH [mV]	Maximum V_IH single ended interference supported by the DUT
Min Failed Interference V_IH [mV]	Minimum V_IH single ended interference that caused the DUT to fail
Max Passed Interference V_IL [mV]	Maximum V_IL single ended interference supported by the DUT
Min Failed Interference V_IL [mV]	Minimum V_IL single ended interference that caused the DUT to fail
Min Spec [mV]	Minimum single ended interference that the DUT shall be able to handle according to the specification

Test 2.1.3b V_HYST Sensitivity Data0 B Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data0 C Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data1 A Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data1 B Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data1 C Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data2 A Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data2 B Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3b V_HYST Sensitivity Data2 C Dynamic

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic on page 141.

Test 2.1.3 V_HYST Sensitivity Data0 A Static

CTS Test Number and Name

Test 2.1.3 – LP-RX Input Hysteresis (VHYST)

Purpose

To verify that the Input Hysteresis value (VHYST) of the DUT's LP receiver is within the conformance limits.

Dependencies

LP Level Calibrations

Procedure

For the tested line, LP data is transmitted, starting with a V_OH of "Maximum Test Voltage" and decreasing it by "Initial Voltage Step Size" in successive steps until the transmission fails. Once the failure is detected, V_OH is increased again and then decreased by "Voltage Step Size" to find the exact failure point, which is recorded as "Min Passed V_IH". Then the opposite measurement is performed, starting with a V_OH of "Minimum Test Voltage" and increasing it until the transmission happens without errors. That value is recorded as "V_IH Recover". The Input Hysteresis of the DUT's LP receiver is calculated as the difference between "V_IH Recover" and "Min Passed V_IH", and should be equal or greater than 25mV in order for the DUT to be considered compliant to the specification.

Parameters

Table 51 Parameters used in Test 2.1.3 V_HYST Sensitivity Data0 A Static

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
Initial Voltage Step Size	Initial voltage step size used at the beginning of the test, when the test value is close to the minimum value according to specification.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Max Tested Value	Maximum Input Hysteresis (V_HYST).

Min Tested Value	Minimum Input Hysteresis (V_HYST).
Offline	Offline Mode.
Voltage Step Size	The step size by which the voltage is increased/decreased while running test.

Results

Table 52 Parameters in the result table for "Test 2.1.3 V_HYST Sensitivity Data0 A Static"

Parameter name	Parameter description
Result	Pass: the Input Hysteresis value of the DUT's LP receiver line is within the conformance limits. Fail: the Input Hysteresis value of the DUT's LP receiver line is not within the conformance limits.
Min Passed V_IH [mV]	Minimum V_IH supported by the DUT.
Min Spec V_IH [mV]	Minimum V_IH that the DUT must support according to the specification.
V_IH Recover [mV]	V_IH value for which the DUT stops reporting errors after it failed.
V_HYST [mV]	Actual value of the DUT's V_HYST as measured during the test
Min Spec V_HYST [mV]	Minimum V_HYST of the DUT according to the specification.

Test 2.1.3 V_HYST Sensitivity Data0 B Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data0 C Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data1 A Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data1 B Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data1 C Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data2 A Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data2 B Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.3 V_HYST Sensitivity Data2 C Static

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.3 V_HYST Sensitivity Data0 A Static on page 144.

Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0

CTS Test Number and Name

Test 2.1.4 – LP-RX Minimum Pulse Width Response (TMIN-RX)

Purpose

To verify that the DUT's LP receiver can detect LP pulses with the minimum required duration.

Dependencies

LP level Calibrations

Procedure

An LP test pattern is sent on the lane being tested with the LP pulse width T_LPX slowly decreasing until errors in the received sequence can be observed. In order for the DUT to pass the test, the smallest value for T_LPX for which the sequence can be received without errors should be less than or equal to 20ns.

Parameters

Table 53 Parameters used in Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0

Parameter	Description
BER Limit	Limit used for bit-error-ratio test.
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
V_OH	Output high voltage.
V_OL	Output low voltage.

Results

Table 54 Parameters in the result data table "Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0"

Parameter name	Parameter description
Result	▪ Pass: the minimum pulse duration detected by the DUT is smaller than or equal to the specification value. ▪ Fail: the minimum pulse duration detected by the DUT is larger than the specification value.
Min Passed [ns]	Minimum pulse duration detected by the DUT
Min Spec [ns]	Minimum pulse duration according to the specification.

Test 2.1.4 LP-RX Minimum Pulse Width ResponseData1

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0 on page 147.

Test 2.1.4 LP-RX Minimum Pulse Width ResponseData2

CTS Test Number and Name, Purpose, Dependencies, Parameters, Results

Refer to Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0 on page 147.

Behavioral Tests

Test 2.2.1 Init. Period TINIT

CTS Test Number and Name

Test 2.2.1 – LP-RX Initialization period (TINIT)

Purpose

To verify that the Slave DUT's RX Initialization period (TINIT), is greater than the minimum compliant value.

Dependencies

The LP calibrations are required.

If an IBerReader interface is being used, you must ensure that its ResetDut function performs a full restart of the DUT. As the DUT will enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

After power-on, it is required that the Master initializes the Slave by driving LP111 for a period longer than T_INIT (100 µs). If the initialization period is shorter or non-existent, all transitions on the line will be ignored by the Slave.

To implement the test:

- Send valid HS or LP data that causes an observable result after T_INIT <100 µs.
- Observe whether the test data is received by the DUT.
- Restart DUT, slowly increase T_INIT (e.g. by 10 µs steps) up to the point where the DUT receives the following data properly.
- The DUT passes the test if minimum T_INIT ≥ 100 µs, otherwise it fails.

Parameters

Table 55 Parameters used in Test 2.2.1 Init. Period T_INIT

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.

LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
Test Sequence	The name of the sequence file to be used for the test. It does not matter if it contains HS or LP data, as long as it produces an observable result.

Results

The value of T_INIT must be greater than the minimum protocol-specific conformance limit.

Table 56 Parameters in the result table for “Test 2.2.1 Init. Period T_INIT

Parameter name	Parameter description
Result	▪ Pass: the value of T_Init is greater than the minimum limit defined in the specification ▪ Fail: the value of T_Init is smaller than the minimum limit defined in the specification
T_Init [ms]	T_Init Duration obtained.

Test 2.2.2 ULPS Exit TWAKEUP

CTS Test Number and Name

Test 2.2.2 – ULPS Exit: LP-RX TWAKEUP Timer Value

Purpose

To verify that the DUT's LP receiver properly exits ULPS when sent a Mark-1 for minimum time (TWAKEUP) followed by a Stop state.

Dependencies

The LP calibrations are required.

If an IBerReader interface is being used, you must ensure that its ResetDut function performs a full restart of the DUT. As the DUT will enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

When in ULPS, the Slave should wait for an Exit Sequence formed by a Mark-1 State (LP100) with a minimum duration of T_Wakeup = 1 ms followed by a Stop State (LP111).

To implement the test:

- Set DUT to ULPS by using the sequence file named "ULPS Entry Sequence" in the test properties.
- Verify that the DUT is in ULPS by sending a valid HS pattern. If it's not received, it means the DUT is in ULPS. If the test pattern is received, the test reports a failure because it was not possible to put the DUT into ULPS.
- Load "ULPS Entry and Exit Sequence". This sequence shall put the DUT into ULPS as "ULPS Entry Sequence", and shall also contain a block called "ULPSExit", that will be used by the automation to slowly increase the Mark-1 duration.
- In Compliance Mode, send Sequence with T_Wakeup = 1 ms followed by valid HS data and see if the DUT left ULPS mode or not.
- In Expert mode, sweep from Minimum Tested Value to Maximum Tested Value until the DUT leaves ULPS. Record T_Wakeup time.
- If T_Wakeup smaller or equal than 1 ms the DUT has passed the test, otherwise it has failed.

Parameters

Table 57 Parameters used in Test 2.2.2 ULPS Exit TWakeup

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.
Steps	Specifies the number of steps that are tested between the Start Value and the End Value for tests in which a range of values is tested.
ULPS Entry and Exit Sequence	A ULPS entry sequence is sent to the DUT, followed by a Mark-1/Stop plus a valid HS burst on all lanes using nominal voltage levels. ULP Exit Sequence.is active high signal, asserted when ULP state is active and the protocol is ready to leave ULP state.
ULPS Entry Sequence	A ULPS entry sequence is sent to the DUT, followed by a Mark-1/Stop plus a valid HS burst on all lanes using nominal voltage levels.

Results

The DUT must exit the ULPS mode.

Table 58 Parameters in the result table for “Test 2.2.2 ULPS Exit TWakeup”

Parameter name	Parameter description
Result	▪ Pass: the value of T_Wakeup is greater than or equal to the minimum limit defined in the specification. ▪ Fail: the value of T_ Wakeup is smaller than the minimum limit defined in the specification.
T_WakeUp [ms]	Time that a transmitter drives a Mark-1 state prior to a Stop state in order to initiate an exit from ULPS.

Test 2.2.3 Invalid or Aborted Escape Entry

CTS Test Number and Name

Test 2.2.3 – LP-RX Invalid/Aborted Escape Mode Entry

Purpose

To verify that the DUT's LP-RX properly aborts the Escape Mode entry process when it receives an unexpected Stop state prior to completion.

Dependencies

The LP calibrations are required.

If an IBerReader interface is being used, you must ensure that its ResetDut function performs a full restart of the DUT. As the DUT may enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

Being in Stop State (LP111), send aborted Escape mode entry sequence with LP111 at the end, verify that the DUT is still able to receive valid HS data. Two aborted Entry sequences are sent:

- LP-111, LP-100, LP-000, LP-001, LP-111
- LP-111, LP-100, LP-111, LP-111, LP-111

Parameters

Table 59 Parameters used in Test 2.2.3 Clock Invalid or Aborted Escape Entry

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.

Results

In both cases, the integrity of the received data, as well as the overall operation of the DUT must not negatively affected by the presence of the invalid ULPS Entry sequences.

Table 60 Parameters in the result table for "Test 2.2.3 Clock Invalid or Aborted Escape Entry"

Parameter name	Parameter description
Result	▪ Pass: the test data was received by the DUT, which therefore, did not enter ULPS. ▪ Fail: the test data was not received by the DUT.
Test Pattern	The final bit pattern received by the DUT.

Test 2.2.4 Invalid or Aborted Escape Command

CTS Test Number and Name

Test 2.2.4 – LP-RX Invalid/Aborted Escape Mode Command

Purpose

To verify that the DUT’s LP-RX properly ignores invalid or aborted Escape commands.

Dependencies

The LP calibrations are required. If an IBerReader interface is being used, please make sure that its ResetDut function performs a full restart of the DUT. As the DUT may enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

NOTE **This test is considered as informative in CTS, the result graph cannot be drawn from the behavior of the DUT during the test run.**

Send an invalid Escape Mode Entry sequence followed by and aborted Escape command, verify that the DUT still receives the valid HS data that we send afterwards. The command is aborted by adding LP111 states in its final bits. The CTS defines the following test cases:

1. [Valid EM Entry] + LP-001/000/001/000/001/000/100/000/100/000/100/000/100/000/001/111 + [Stop]
2. [Valid EM Entry] + LP-001/000/001/000/001/000/100/000/100/000/100/000/100/111/111/111 + [Stop]
3. [Valid EM Entry] + LP-001/000/001/000/001/000/100/000/100/000/100/111/111/111/111/111 + [Stop]
4. [Valid EM Entry] + LP-001/000/001/000/001/000/100/000/100/111/111/111/111/111/111/111 + [Stop]
5. [Valid EM Entry] + LP-001/000/001/000/001/000/100/111/111/111/111/111/111/111/111/111 + [Stop]

6 [Valid EM Entry] + LP-001/000/001/000/001/111/111/111/111/111/111/111/111/111/111/111 + [Stop]
7 [Valid EM Entry] + LP-001/000/001/111/111/111/111/111/111/111/111/111/111/111/111/111 + [Stop]
8 [Valid EM Entry] + LP-001/111/111/111/111/111/111/111/111/111/111/111/111/111/111/111 + [Stop]

Parameters

Table 61 Parameters used in Test 2.2.4 Invalid or Aborted Escape Command

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
Entry Command Pattern	Escape Entry Code used during the test (default is ULPS Escape Entry Code).
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.

Results

Table 62 Parameters in the result table for "Test 2.2.4 Data Invalid or Aborted Escape Command"

Parameter name	Parameter description
Result	▪ Pass: the test data was received by the DUT, therefore did not enter ULPS. ▪ Fail: the test data was not received by the DUT.
Test Pattern	The final bit pattern received by the DUT.

Test 2.2.5 Post-Trigger-Command

CTS Test Number and Name

Test 2.2.5 – LP-RX Escape Mode, Ignoring of Post-Trigger-Command Extra Bits

Purpose

To verify that the DUT's LP-RX ignores any extra bits received following a Trigger Command.

Dependencies

The LP calibrations are required.

If an IBerReader interface is being used, you must ensure that its ResetDut function performs a full restart of the DUT. As the DUT may enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

An Escape mode sequence containing a Trigger sequence followed by extra post-command bits, which is a combination of an extra byte of data after the Trigger command, and the ULPS Entry command as an extra byte is used. The invalid ULPS command byte should be ignored by the DUT.

To implement the test:

- Click Run to transmit a test sequence to the DUT. Refer to Running Tests on page 30 to know how to run procedures.
- For each of the available Trigger commands (Reset-Trigger, Unknown-3, Unknown-4, Unknown-5), send the appropriate Escape Mode Entry + Trigger Command + Stop State, interleaving a ULPS Entry command between the Trigger Command and the Stop State.
- Send valid data.
- Verify that valid data is received at the DUT.

Parameters

Table 63 Parameters used in Test 2.2.5 Post-Trigger-Command

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
Extra bits	Bits added after the valid Trigger Command and before the Mark-1/Stop Exit sequence (default is ULPS Escape Entry Code).
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.

Results

In all test cases the DUT must ignore all bits occurring after the last bit of the Trigger Command, by observing that the DUT properly received the image data stream without error.

Table 64 Parameters in the result table for “Test 2.2.5 Data Post-Trigger-Command”

Parameter name	Parameter description
Result	▪ Pass: the test data was received by the DUT, which therefore did not enter ULPS. ▪ Fail: the test data was not received by the DUT.
Test Pattern	The final bit pattern received by the DUT.

Test 2.2.6 Data Lane LP-RX Escape Mode Unsupported or Unassigned Commands

CTS Test Number and Name

Test 2.2.6 – LP-RX Escape Mode Unsupported/Unassigned Commands

Purpose

To verify that the DUT's LP-RX properly ignores unsupported and unassigned Escape Mode commands.

An Entry Command Pattern consists of 8 bits, therefore there are 256 possible combinations. Of these, one is assigned to the Low-Power Data Transmission Mode (11100001), one to the Ultra-Low-Power State Mode (00011110) and one to the Reset Trigger (01100010). The remaining 253 combinations are either Undefined modes (2), Unknown triggers (3), or Unassigned (248), and shall be ignored by the DUT. This test verifies that all Unsupported and Unassigned commands are ignored by the DUT.

Dependencies

The LP calibrations are required.

If an IBerReader interface is being used, you must ensure that its ResetDut function performs a full restart of the DUT. As the DUT may enter ULPS during this test, a reset of the bit and error counters is not enough.

Procedure

An Escape mode sequence containing an unassigned Escape Command, which is combination of 248 unassigned command codes, is used. The invalid undefined/unknown/unassigned command codes should be ignored by the DUT.

To implement the test:

- For each of the remaining 253 combinations, send the appropriate Escape Mode Entry + an Undefined/Unknown/Unassigned Command + Stop State.
- Send valid data.
- Verify that valid data is received at the DUT

Parameters

Table 65 Parameters in Test 2.2.6 Data Lane LP-RX Escape Mode Unsupported or Unassigned Commands

Parameter	Description
BER Reader init string	Initialization String for the BER Reader.
HS Symbol Rate	Symbol Rate for the MIPI C-PHY signal in the High-Speed operation mode during the execution of a procedure. Selected during the DUT configuration.
LP Data Rate	Low power data rate for the signal, specified during the DUT configuration.
Offline	Offline Mode.

Results

For all test cases, the DUT must ignore the unsupported/unassigned command, and successfully receives the image data stream.

Table 66 Parameters in the result table for "Test 2.2.6 Data Lane LP-RX Escape Mode Unsupported or Unassigned Commands"

Parameter name	Parameter description
Result	▪ Pass: the test data was received by the DUT, which therefore did not enter ULPS. ▪ Fail: the test data was not received by the DUT.
Test Pattern	The final bit pattern received by the DUT.

6 SCPI Plug-in Interface

Description of already generated generic commands for plug-ins adapted to the new requirements based on the sub-model approach.

The structure of an identifier attached to a SCPI command contains now additional delimiter. A full qualified identifier has following structure:

‘PluginName#SubModel:Location&FunctionalBlock.Parameter’

In many cases it is not necessary to add a full qualified identifier to every SCPI command. For example a plug-in is implemented a singleton or a location/parameter exists on once. Later on a detailed description will explain the usage and simplification of an identifier that comes along with a SCPI command for addressing plug-ins / sub-models / parameters and so on.

The identifier appended to every SCPI command should be optional to avoid SCPI commands like :PLUGin:rootnode:BREak ‘ ’ // empty identifier

Architecture of a plug-in / sub-model concept

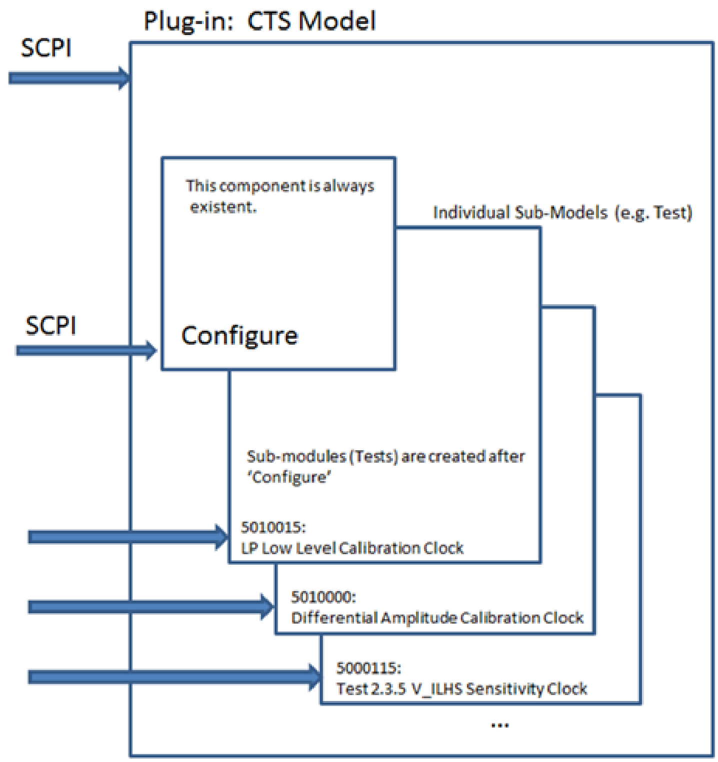


Figure 39 Plug-in / Sub-Model approach

Sorting and Using the SCPI Commands

This chapter describes the order in which the SCPI commands/queries must be sorted and run, which is in accordance with the work-flow on the MIPI C-PHY CTS plug-in user interface.

Following procedure describes how to start a new plug-in instance and how to run tests on the active instance.

1 On the SCPI Editor window, run the catalog query (**:PLUGin:CATalog?**) to check for the existing plug-ins in the M8070B software and to identify the correct plug-in string name.

   -> :PLUGin:CATalog?

   <- "Pattern Capture","Script Editor","DUT Control Interface","Error Ratio","Jitter Tolerance","Jitter Tolerance Template Editor","Output Level","Output Timing","Eye Diagram","MIPI C-PHY CTS","MIPI D-PHY CTS","MIPI C-PHY Editor","MIPI D-PHY Editor"

2 MIPI C-PHY CTS tests can be run only on the MIPI C-PHY CTS plug-in, so from the query result, use the plug-in string name "MIPI C-PHY CTS".

3 Create a new MIPI C-PHY CTS plug-in instance using the :PLUGin:CPHYTests:NEW command. For example, consider the name of the new MIPI C-PHY CTS plug-in instance to be 'MIPI C-PHY CTS 1'.

   :PLUGin:CPHYTests:NEW 'MIPI C-PHY CTS 1'

4 Keysight recommends that prior to configuring the tests, you must manually set up the connection strings to the instrument, either in offline mode or online mode. The MIPI C-PHY CTS plug-in stores the last setting internally. If you have completed the connection setup, skip to step 6 else you must set the configuration parameters remotely. Run the :PLUGin:CPHYTests:PARameter:LIST? query to check for the list of parameters.

   -> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1'

   <-
   ":TP1.Link&Connection.OfflineMode","1",":TP1.Link&Connection.AwgModel","M8195",":TP1.Link&AWG Setup.AwgHostIpAddress","127.0.0.1",":TP1.Link&AWG Setup.AwgClockSyncHiSlip","hislip0",":TP1.Link&AWG Setup.AwgOneHiSlip","hislip1",":TP1.Link&AWG Setup.AwgTwoHiSlip","hislip2",":TP1.Link&AWG Setup.AwgThreeHiSlip","hislip3",":TP1.Link&Oscilloscope Setup.OscilloscopeOfflineMode","1",":TP1.Link&Oscilloscope Setup.OscilloscopeAddress","TCPIP0::121.0.0.1::inst0::INSTR",":TP1.System&Global.Spec Version","v1_00",":TP1.System&Global.Test

Mode","COMpliance",":TP1.System&Global.NumberOfDataLanes","LA
NE1",":TP1.System&Global.Custom BER Reader
Address","",":TP1.System&Global.MIPI BER
Reader","OFFline",":TP1.System&Global.BER
Limit","_1_10",":TP1.System&Global.HS Symbol
Rate","2500000000",":TP1.System&Global.LP Data
Rate","10000000",":TP1.System&Global.LP Transition
Time","2.0000000000000001E-09",":TP1.System&Global.Manual
Deskew","0",":TP1.System&Global.Triggered
Start","0",":TP1.System&Global.HS Sequence Loop
File","CPhyCompliance.seq",":TP1.System&Global.LP Sequence Loop
File","CPhyLsCompliance.seq",":TP1.System&Global.Behavioral
Sequence File","CPhyBehavioral.seq",":TP1.System&Global.Re-Init
Sequence before reset DUT","0",":TP1.System&Global.Re-Init
Sequence after reset DUT","0",":TP1.System&Global.Mipi
Protocol","DSI",":TP1.System&Levels.HS High
Level","0.29999999999999999",":TP1.System&Levels.HS Mid
Level","0.20000000000000001",":TP1.System&Levels.HS Low
Level","0.10000000000000001",":TP1.System&Levels.LP High
Level","1.2",":TP1.System&Levels.LP Low
Level","0",":TP1.System&Timings.T3-PREPARE","9.999999999999999
5E-08",":TP1.System&Timings.T3-PREBEGIN","3333333",":TP1.Syste
m&Timings.T3-PREEND","3333333",":TP1.System&Timings.T3-PROGS
EQ","",":TP1.System&Timings.T3-SYNC","3444443",":TP1.System&Timi
ngs.T3-POST","4444444",":TP1.System&Timings.TX-HS-EXIT","1.9999
999999999999E-07",":TP1.System&Timings.TX-WAKEUP","0.001",":T
P1.System&Timings.TX-INIT","9.9999999999999995E-07",":TP1.Syste
m&Timings.SetDefault","",":TP1.System&Idle Voltage.Idle
Voltage","0.29999999999999999"

If you wish to find the parameters associated with a specific calibration or a specific test, run this command with the identifiers written in the following manner:

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1#Test
2.3.3 Jitter Tolerance Data0'

<- ":TP1.System&Acquisition
Parameters.PropertiesEditable","1",":TP1.System&Test 2.3.3 Jitter
Tolerance Data0.Offline","1",":TP1.System&Test 2.3.3 Jitter Tolerance
Data0.BER Reader init string","Data0_HS",":TP1.System&Test 2.3.3
Jitter Tolerance Data0.Steps","2",":TP1.System&Test 2.3.3 Jitter
Tolerance Data0.BER Limit","1E-10",":TP1.System&Test 2.3.3 Jitter
Tolerance Data0.HS Symbol Rate","2500000000",":TP1.System&Test
2.3.3 Jitter Tolerance Data0.LP Data
Rate","10000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye
Closure Target","0.13500000000000001",":TP1.System&Test 2.3.3

Jitter Tolerance Data0.Six Port S-Parameter File","SParam.s6p",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Height Target","0.040000000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Width Target","0.5",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Minimum Tested Common Mode","0.17499999999999999",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Maximum Tested Common Mode","0.31"

5 To set up / modify the value for one or more parameters, run the :PLUGin:CPHYTests:PARameter[:Value][?] command.

:PLUGin:CPHYTests:PARameter "MIPI C-PHY CTS 1#:TP1.System&Global.HS Symbol Rate","12E+8"

6 Once all parameters are configured, run the :PLUGin:CPHYTests:CONFigure command. Based on your configuration, the list of calibrations and tests are created and the plug-in is ready to run the CTS tests.

7 To check the list of available calibrations and tests, run the :PLUGin:CPHYTests:LIST? query.

-> :PLUGin:CPHYTests:LIST?

<- "Amplifier Level Calibration Module 1 Gen 1","Amplifier Level Calibration Module 1 Gen 2","Amplifier Level Calibration Module 2 Gen 1","Skew Calibration Module 1","Inter Module Skew Calibration","LP Level Calibration High Data0 A","LP Level Calibration Low Data0 A","LP Level Calibration High Data0 B","LP Level Calibration Low Data0 B","LP Level Calibration High Data0 C","LP Level Calibration Low Data0 C","e-Spike Calibration Data0 A","HS Level Calibration Data0 A","HS Level Calibration Data0 B","HS Level Calibration Data0 C","TRTF Calibration 2500 MSps","DCD Calibration 2500 MSps","Eye Opening Calibration 2500 MSps","Test 2.3.1 Amplitude Tolerance Data0","Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data0","Test 2.3.3 Jitter Tolerance Data0","Test 2.4.2 T_HS-Prepare - Data0 Procedure","Test 2.4.3 T_HS-PreBegin - Data0 Procedure","Test 2.4.4 T_HS-ProgSeq - Data0 Procedure","Test 2.4.5 T_HS-Post - Data0 Procedure","Test 2.4.1 Data0 Lane T_HS-TERM-EN","Test 2.1.1 V_IH Sensitivity Data0","Test 2.1.2 V_IL Sensitivity Data0","Test 2.1.3 V_HYST Sensitivity Data0 A Static","Test 2.1.3 V_HYST Sensitivity Data0 B Static","Test 2.1.3 V_HYST Sensitivity Data0 C Static","Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic","Test 2.1.3b V_HYST Sensitivity Data0 B Dynamic","Test 2.1.3b V_HYST Sensitivity Data0 C Dynamic","Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0","Test 2.1.5 LP-RX Input pos. Pulse Rejection e_spike Data0","Test 2.1.5 LP-RX Input neg. Pulse Rejection e_spike Data0","Test 2.2.1 Init. Period TINIT","Test 2.2.2 ULPS Exit

TWAKEUP","Test 2.2.3 Invalid or Aborted Escape Entry","Test 2.2.4 Invalid or Aborted Escape Command","Test 2.2.5 Post-Trigger-Command","Test 2.2.6 Data Lane LP-RX Escape Mode Unsupported or Unassigned Commands"

8 To select a specific calibration / test remotely, run the :PLUGin:CPHYTests:SELect command.

9 To find the list of parameters specific to the selected calibration / test, run the :PLUGin:CPHYTests:PARameter:LIST? query.

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1#Skew Calibration Module 1'

<- ":TP1.System&Acquisition Parameters.PropertiesEditable","1",":TP1.System&Skew Calibration Module 1.Offline","1",":TP1.System&Skew Calibration Module 1.Use Infiniisim","0",":TP1.System&Skew Calibration Module 1.Transfer Function Chan1","DoNothing.tf2",":TP1.System&Skew Calibration Module 1.Transfer Function Chan2","DoNothing.tf2",":TP1.System&Skew Calibration Module 1.Skew Tolerance","9.9999999999999994E-12"

10 To set up / modify the value for one or more parameters specific to the selected test, run the :PLUGin:CPHYTests:PARameter[:Value][?] command.

-> :PLUGin:CPHYTests:PARameter:VALue "MIPI C-PHY CTS 1#Skew Calibration Module 1:TP1.System&Skew Tolerance","15E-12"

NOTE

You can modify the values of parameters specific to calibration / test names only when the **Mode:** option under **Receiver Test Configuration** is set to **Expert Mode.**

11 To run the selected calibration / test on the MIPI C-PHY CTS plug-in instance, run the PLUGin:CPHYTests:STARt command. If you wish to abort the test while it is running, run the PLUGin:CPHYTests:STOP command.

Following procedure describes remote commands that may be run while the CTS tests are running.

1 Setup the connection according to the connection diagram and description displayed on the MIPI C-PHY CTS plug-in user interface. While you may run the :PLUGin:CPHYTests:CONNection:DIAGram? and :PLUGin:CPHYTests:CONNection:CDEScription? queries to obtain the image details of the connection diagram and the connection

description, respectively; the connection setup details can also be viewed on the MIPI C-PHY CTS plug-in user interface.

2 While calibration / test procedures start running, you may optionally run the following queries/commands:
   - :PLUGin:CPHYTests:RUN:PROGress? to check the progress of the calibration / test procedure that is currently running.
   - :PLUGin:CPHYTests:RUN[:STATus]? to indicate whether a calibration / test procedure is in the running state or not.
   - :PLUGin:CPHYTests:RUN:LOG? to view the logs for the calibration / test procedure that has just been run.
   - :PLUGin:CPHYTests:RUN:MESSage? to view the running state (NotStarted, Running, Error and Finished) of the calibration / test procedure.
   - :PLUGin:CPHYTests:RUN:HISTory:CLEar to clear the history information for any calibration / test runs.
   - :PLUGin:CPHYTests:RUN:HISTory[:STATe]? to indicate whether a test run history and result is available (indicated by 1) or no tests were run (indicated by 0).

3 During test runs, several dialogs appear as pop-ups, which describe setting up the device and also display the PASS/FAIL information of the DUT. However, if you require that the CTS test run be fully automated, you must implement an IBerReader. For more details, see IBerReader Interface Definition on page 189.

4 To obtain a list of the calibration / test results that have already been run, use the :PLUGin:CPHYTests:HISTory:CATalog? query.

   -> :PLUGin:CPHYTests:HISTory:CATalog?

   <- "Amplifier Level Calibration Module 1 Gen 1_1","Test 2.1.1 V_IH Sensitivity Data0_1"

5 To view the results for a calibration / test from the historic results displayed in the previous step, run the :PLUGin:CPHYTests:FETCh:RESult[:VALue]? query.

   -> :PLUGin:CPHYTests:FETCh:RESult:VALue? 'MIPI C-PHY CTS 1#Test 2.1.1 V_IH Sensitivity Data0_1'

   <- #41343<?xml version="1.0" encoding="utf-16"?><TestResults version="2.0"><TestResult><Summary><ProcedureName>Test 2.1.1 V_IH Sensitivity Data0</ProcedureName><ProcedureID>5100541</ProcedureID><Result>Passed</Result><DateTime>05/11/2017 15:50:40</DateTime><Duration>00:22:39.4014103</Duration><Description>This procedure test the LP Input High Voltage Sensitivity.</Description></Summary><ResultTables><ResultTable><

Title>V_IH Tolerance_Data0</Title><Subtitle>Verify the V_IH tolerance</Subtitle><Name>V_IH Tolerance_Data0</Name><Parameters><Parameter name="Offline" value="True" /></Parameters><Columns><Column name="Result" unit="" recommendedExponent="0" width="13"><Value>pass</Value></Column><Column name="Min Passed V_IH" unit="V" precision="0" recommendedExponent="-3" width="8"><Value>0.6</Value></Column><Column name="Min Tested V_IH" unit="V" precision="0" recommendedExponent="-3" width="8"><Value>0.6</Value></Column><Column name="Min Spec V_IH" unit="V" precision="0" recommendedExponent="-3" width="8"><Value>0.74</Value></Column></Columns><cellColours><cellColour Name="64033NoColor" Value="16777215" /><cellColour Name="64037NoColor" Value="16777215" /><cellColour Name="64041NoColor" Value="16777215" /><cellColour Name="64042NoColor" Value="16777215" /></cellColours><Images /></ResultTable></ResultTables></TestResult></TestResults>

6 To know if the test has passed or failed after running, run the :PLUGin:CPHYTests:FETCh:RESult:PFResult? query to identify its status. If the status for any test is returned as UNKNown, it is most likely that the test has not been run yet.

-> :PLUGin:CPHYTests:FETCh:RESult:PFResult?

<- "Skew Calibration Module 1",PASS

7 Repeat the previous steps, if you wish to obtain test results for other CTS tests that have already been run.

Following procedure describes remote reconfiguration of CTS Tests using the :PLUGin:CPHYTests:CONFigure command.

- **Method 1:**

1 Run one of the following commands:
  - Run the :PLUGin:CPHYTests:RESet command to reset the settings of the MIPI C-PHY CTS plug-in instance to the default values, OR,
  - Run the :PLUGin:CPHYTests:DELete command to remove the existing MIPI C-PHY CTS plug-in and its configuration. Then, run the :PLUGin:CPHYTests:NEW command to create a new MIPI C-PHY CTS plug-in instance, which contains the default settings.

2 Run the :PLUGin:CPHYTests:PARameter:LIST? query to check for the list of parameters and their default values.

3 To set up / modify the value for one or more parameters, run the :PLUGin:CPHYTests:PARameter[:Value][?] command.

4 Once all required parameters are configured, run the :PLUGin:CPHYTests:CONFigure command. Based on your configuration,

the list of calibrations and tests are created and the plug-in is ready to run the CTS tests.

- **Method 2:**

1 In the existing instance of MIPI C-PHY CTS plug-in, run the :PLUGin:CPHYTests:PARameter:LIST? query to check for the list of parameters and their current values.

For example, if you run :PLUGin:CPHYTests:PARameter:LIST? "MIPI C-PHY CTS 1", a list of parameter name value pairs is returned, such as,

":TP1.Link&Connection.OfflineMode","1",

":TP1.Link&Connection.AwgModel","M8195",

":TP1.Link&AWG Setup.AwgHostIpAddress","127.0.0.1",

":TP1.Link&AWG Setup.AwgClockSyncHiSlip","hislip0",

":TP1.Link&AWG Setup.AwgOneHiSlip","hislip1",

":TP1.Link&AWG Setup.AwgTwoHiSlip","hislip2",

":TP1.Link&AWG Setup.AwgThreeHiSlip","hislip3",

":TP1.Link&Oscilloscope Setup.OscilloscopeOfflineMode","1",

":TP1.Link&OscilloscopeSetup.OscilloscopeAddress","TCPIP0::121.0.0.1::inst0::INSTR",

":TP1.System&Global.Spec Version","v1_00",

":TP1.System&Global.TestMode","COMpliance",

":TP1.System&Global.NumberOfDataLanes","LANE1",

":TP1.System&Global.Custom BER Reader Address","",

":TP1.System&Global.MIPI BER Reader","OFFline",

":TP1.System&Global.BER Limit","_1_10",

":TP1.System&Global.HS Symbol Rate","2500000000",

":TP1.System&Global.LP Data Rate","10000000",

":TP1.System&Global.LP Transition Time","2.0000000000000001E-09",

":TP1.System&Global.Manual Deskew","0",

":TP1.System&Global.Triggered Start","0",

":TP1.System&Global.HS Sequence Loop File","CPhyCompliance.seq",

":TP1.System&Global.LP Sequence Loop File","CPhyLsCompliance.seq",

. . .

2 To set up / modify the value for one or more parameters (for example, the HS Data Rate), run the :PLUGin:CPHYTests:PARameter[:Value][?] command.

For example,

:PLUGin:CPHYTests:PARameter "MIPI C-PHY CTS 1#:TP1.System&Global.HS Symbol Rate","12E+8"

3 Once all required parameters are configured, run the :PLUGin:CPHYTests:CONFigure command. Based on your configuration, the list of calibrations and tests are recreated and the plug-in is ready to run the CTS tests.

Remote Queries to find Parameter ranges (maximum and minimum limits)

The MIPI C-PHY CTS plug-in consists of several parameters, where you may define a value only within a permissible range. The MIPI C-PHY CTS plug-in automatically configures the ranges for such parameters based on certain options you may select on the user interface or remotely.

On the MIPI C-PHY CTS plug-in GUI, you may simply hover the mouse cursor over a specific parameter's value field to find its maximum and minimum permissible values. However, when working remotely, you may have to check the permissible ranges before configuring the value of a parameter.

While running a query for a parameter returns its current value, you can add the **MAX** and **MIN** identifiers in your query (separated by a comma after the plug-in identifier) to find the maximum and minimum value, respectively, for that parameter.

Consider the following examples to understand how to use these identifiers:

1 To check for the list of parameters and their default values, run the :PLUGin:CPHYTests:PARameter:LIST? query. Using this query, you may view the list of either global parameters or only such parameters that are specific to a test/calibration procedure.

2 To check the current value of a specific parameter, run the :PLUGin:CPHYTests:PARameter[:Value][?] query.

For example, consider the global parameter "Idle Voltage":

a Run the query to find its current value.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#:TP1.System&Idle Voltage.Idle Voltage'

<- "0.29999999999999999"

The query returns the current value of Idle Voltage as 300mV.

b To be able to modify this parameter's value within the permissible limits, add the **MAX** and **MIN** identifiers in your query to find the maximum and minimum permissible values, respectively.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#:TP1.System&Idle Voltage.Idle Voltage', MAX

<- "0.34999999999999998"

Using the **MAX** identifier, the query returns the maximum value of Idle Voltage as 350mV.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#:TP1.System&Idle Voltage.Idle Voltage', MIN

<- "0.20000000000000001"

Using the **MIN** identifier, the query returns the minimum value of Idle Voltage as 200mV.

Similarly, you may find the permissible limits for any other global parameter on the Configuration window of the MIPI C-PHY CTS plug-in.

Now, consider another example of the test specific parameter "Maximum Tested Common Mode" in **Test 2.3.3 Jitter Tolerance Data0** test under **HS Tests** category:

a In the Connection Diagram window, run the :PLUGin:CPHYTests:SELect command to select the test whose parameters you wish to view and modify.

:PLUGin:CPHYTests:SELect 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0'

b To check for the selected test parameters and their default values, run the :PLUGin:CPHYTests:PARameter:LIST? query.

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0'

<- ":TP1.System&Acquisition Parameters.PropertiesEditable","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Offline","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Reader init string","Data0_HS",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Steps","2",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Limit","1E-10",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.HS Symbol Rate","2500000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.LP Data Rate","10000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Closure Target","0.13500000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Six Port S-Parameter File","SParam.s6p",":TP1.System&Test 2.3.3 Jitter Tolerance

Data0.Eye Height Target","0.040000000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Width Target","0.40000000000000002",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Minimum Tested Common Mode","0.17499999999999999",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Maximum Tested Common Mode","0.31"

c While the current value of the parameter is displayed along with the name in the previous list, to check the value of the test-specific parameter separately, run the :PLUGin:CPHYTests:PARameter[:Value][?] query.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0:TP1.System&Maximum Tested Common Mode'

<- "0.31"

The query returns the current value of Maximum Tested Common Mode Voltage as 0.31V.

d To be able to modify this parameter's value within the permissible limits, add the **MAX** and **MIN** identifiers in your query to find the maximum and minimum permissible values, respectively.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0:TP1.System&Maximum Tested Common Mode', MAX

<- "2"

Using the **MAX** identifier, the query returns the maximum value of Maximum Tested Common Mode Voltage as 2V.

-> :PLUGin:CPHYTests:PARameter:VALue? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0:TP1.System&Maximum Tested Common Mode', MIN

<- "-2"

Using the **MIN** identifier, the query returns the minimum value of Maximum Tested Common Mode Voltage as -2V.

Similarly, you may find the permissible limits for any other test-related parameters on the Connection Diagram window of the MIPI C-PHY CTS plug-in.

3 To set up / modify the value for one or more parameters, run the :PLUGin:CPHYTests:PARameter[:Value][?] command.

SCPI Commands

:PLUGin:CPHYTests:CATalog?

Query Syntax :PLUGin:CPHYTests:CATalog?

Identifier Not available.

Description This query returns the names of all active or closed MIPI C-PHY CTS plug-in instances in the current session of the M8070B software.

Query Example :PLUGin:CPHYTests:CATalog?

<- "MIPI C-PHY CTS 1"

:PLUGin:CPHYTests:CONFigure

Command Syntax :PLUGin:CPHYTests:CONFigure ['<Identifier>']

Identifier (Optional) MIPI C-PHY CTS plug-in identifier name.

Description This command is equivalent to pressing the Apply button on the MIPI C-PHY CTS plug-in user interface instance. Running this command applies the Configuration settings on the MIPI C-PHY CTS plug-in user interface and displays the Connection Diagram window. If working remotely, first run the :PLUGin:CPHYTests:PARameter:LIST? query to check for the list of available parameters for the configuration and also the :PLUGin:CPHYTests:PARameter[:Value][?] command to modify / change values of parameters individually, if needed.

Command Example :PLUGin:CPHYTests:CONFigure 'MIPI C-PHY CTS 1'

:PLUGin:CPHYTests:CONNection:CDEScription?

Query Syntax :PLUGin:CPHYTests:CONNection:CDEScription? '<Identifier>'

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command returns the description of the physical connection required for the MIPI C-PHY CTS test type selected under a category of tests in the Connection Diagram window of the MIPI C-PHY CTS plug-in user interface. If working remotely, first run the :PLUGin:CPHYTests:SELect command to select the test whose connection description you wish to know.

Query Example Following examples display the connection description from the MIPI C-PHY CTS plug-instance “MIPI C-PHY CTS 1” for “Amplifier Level Calibration Module 1 Gen 1” under the category “Calibration” and for the CTS test “Test 2.3.1 Amplitude Tolerance Data0” under the category “HS Tests”, respectively.

:PLUGin:CPHYTests:CONNection:CDEScription? 'MIPI C-PHY CTS 1'

<- #3365Connect the outputs of the AWG to the Single-Ended probe to the Oscilloscope.\par - {\b First AWG Module, Channel 1, AMP OUT (Normal) \b0} -> {\b Oscilloscope, Channel 1. \b0} - {\b First AWG Module, Channel 2, AMP OUT (Normal) \b0} -> {\b Oscilloscope, Channel 2. \b0} - {\b Second AWG Module, Channel 1, AMP OUT (Normal) \b0} -> {\b Oscilloscope, Channel 3. \b0}

-> :PLUGin:CPHYTests:CONNection:CDEScription? 'MIPI C-PHY CTS 1'

<- #3538Connect the outputs of the AWG to the DUT and to the Oscilloscope.\par - {\b First AWG Module, Channel 1, AMP OUT (Normal) \b0} -> {\b DUT, A. \b0} \par - {\b First AWG Module, Channel 2, AMP OUT (Normal) \b0} -> {\b DUT, B. \b0} \par - {\b Second AWG Module, Channel 1, AMP OUT (Normal) \b0} -> {\b DUT, C. \b0} \par \par {\b First AWG Module, Channel 1, SAMPLE MRK OUT (Normal) \b0} -> {\b Oscilloscope, Channel 3 \b0}. \par - {\b Second AWG Module, Channel 1, SAMPLE MRK OUT (Normal) \b0} -> {\b Oscilloscope, Channel 4 \b0}. \par

:PLUGin:CPHYTests:CONNection:DIAGram?

Query Syntax :PLUGin:CPHYTests:CONNection:DIAGram? '<Identifier>'

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command returns the description of the connection diagram image used for the MIPI C-PHY CTS test type selected under a category of tests in the Connection Diagram window of the MIPI C-PHY CTS plug-in user interface. If working remotely, first run the :PLUGin:CPHYTests:SELect command to select the test whose connection diagram description you wish to know. Since the SCPI Editor is not GUI-based, the resulting output is garbled text.

Query Example :PLUGin:CPHYTests:CONNection:DIAGram? 'MIPI C-PHY CTS 1'

:PLUGin:CPHYTests:CONNection[:WIRing]?

Query Syntax :PLUGin:CPHYTests:CONNection? '<Identifier>'

:PLUGin:CPHYTests:CONNection[:WIRing]? '<Identifier>'

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command returns the number of wiring connections required for the selected calibration / test in the MIPI C-PHY CTS plug-in user interface.

Query Example Following examples use both syntaxes shown for this command:

-> :PLUGin:CPHYTests:CONNection? 'MIPI C-PHY CTS 1'

<- 1

-> :PLUGin:CPHYTests:CONNection:WIRing? 'MIPI C-PHY CTS 1'

<- 1

:PLUGin:CPHYTests:DELete

Command Syntax :PLUGin:CPHYTests:DELete '<Identifier>'

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command deletes the MIPI C-PHY CTS plug-in instance.

Command Example :PLUGin:CPHYTests:DELete 'MIPI C-PHY CTS 1'

:PLUGin:CPHYTests:FETCh:RESult:PFResult?

Query Syntax :PLUGin:CPHYTests:FETCh:RESult:PFResult?

Identifier Not available.

Description This command returns the current Pass/Fail status of the test for the selected MIPI C-PHY CTS Calibration / Test name on the MIPI C-PHY CTS plug-in user interface. The status of the test could be either PASS, FAIL or UNKNOWN. The status Unknown appears if the selected calibration / test has not been run yet. If working remotely, first run the :PLUGin:CPHYTests:SELect command to select the test whose Pass/Fail status you wish to know.

Query Example Following examples display various Calibration / Test names along with their status:

:PLUGin:CPHYTests:FETCh:RESult:PFResult?

<- "Amplifier Level Calibration Module 1 Gen 1",PASS

:PLUGin:CPHYTests:FETCh:RESult:PFResult?

<- "Test 2.1.1 V_IH Sensitivity Data0",UNKNown

:PLUGin:CPHYTests:FETCh:RESult[:VALue]?

Query Syntax :PLUGin:CPHYTests:FETCh:RESult? '<Identifier>'

:PLUGin:CPHYTests:FETCh:RESult:VALue? '<Identifier>'

Identifier The calibration / test name in the MIPI C-PHY CTS plug-in instance. Note that the # symbol is part of the syntax and is inserted as a separator.

Description This query returns all test parameters, the formatting of the table and the results for the selected MIPI C-PHY CTS Calibration / Test name in an XML format.

Query Example Following example displays the data associated with the Test 2.1.1 V_IH Sensitivity Clock test.

-> :PLUGin:CPHYTests:FETCh:RESult:VALue? 'MIPI C-PHY CTS 1#Test 2.1.1 V_IH Sensitivity Data0_1'


```
<-  #41343<?xml version="1.0" encoding="utf-16"?><TestResults
version="2.0"><TestResult><Summary><ProcedureName>Test 2.1.1 V_IH
Sensitivity
Data0</ProcedureName><ProcedureID>5100541</ProcedureID><Result>
Passed</Result><DateTime>05/11/2017
15:50:40</DateTime><Duration>00:22:39.4014103</Duration><Descripti
on>This procedure test the LP Input High Voltage
Sensitivity.</Description></Summary><ResultTables><ResultTable><Title
>V_IH Tolerance_Data0</Title><Subtitle>Verify the V_IH
tolerance</Subtitle><Name>V_IH
Tolerance_Data0</Name><Parameters><Parameter name="Offline"
value="True" /></Parameters><Columns><Column name="Result" unit=""
recommendedExponent="0"
width="13"><Value>pass</Value></Column><Column name="Min Passed
V_IH" unit="V" precision="0" recommendedExponent="-3"
width="8"><Value>0.6</Value></Column><Column name="Min Tested
V_IH" unit="V" precision="0" recommendedExponent="-3"
width="8"><Value>0.6</Value></Column><Column name="Min Spec
V_IH" unit="V" precision="0" recommendedExponent="-3"
width="8"><Value>0.74</Value></Column></Columns><cellColours><cel
lColour Name="64033NoColor" Value="16777215" /><cellColour
Name="64037NoColor" Value="16777215" /><cellColour
Name="64041NoColor" Value="16777215" /><cellColour
Name="64042NoColor" Value="16777215" /></cellColours><Images
/></ResultTable></ResultTables></TestResult></TestResults>
```

:PLUGin:CPHYTests:HISTory:CATalog?

Query Syntax :PLUGin:CPHYTests:HISTory:CATalog?

Identifier Not available.

Description This query returns the names of all calibration / test results that have already been run in the MIPI C-PHY CTS plug-in instance.

Query Example -> :PLUGin:CPHYTests:HISTory:CATalog?

<- "Skew Calibration Module 1_1","Test 2.3.1 Amplitude Tolerance Data0_1"

:PLUGin:CPHYTests:LIST?

Query Syntax :PLUGin:CPHYTests:LIST?

Identifier Not available.

Description This query returns the names of all calibration / test procedures that appear in the Connection Diagram window for a certain Configuration setting in the MIPI C-PHY CTS plug-in instance. Note that this query returns a value only while the Connection Diagram window of the MIPI C-PHY CTS plug-in instance is active.

Query Example -> :PLUGin:CPHYTests:LIST?

<- "Amplifier Level Calibration Module 1 Gen 1","Amplifier Level Calibration Module 1 Gen 2","Amplifier Level Calibration Module 2 Gen 1","Skew Calibration Module 1","Inter Module Skew Calibration","LP Level Calibration High Data0 A","LP Level Calibration Low Data0 A","LP Level Calibration High Data0 B","LP Level Calibration Low Data0 B","LP Level Calibration High Data0 C","LP Level Calibration Low Data0 C","e-Spike Calibration Data0 A","HS Level Calibration Data0 A","HS Level Calibration Data0 B","HS Level Calibration Data0 C","TRTF Calibration 2500 MSps","DCD Calibration 2500 MSps","Eye Opening Calibration 2500 MSps","Test 2.3.1 Amplitude Tolerance Data0","Test 2.3.2 V_IDTH and V_IDTL Sensitivity Data0","Test 2.3.3 Jitter Tolerance Data0","Test 2.4.2 T_HS-Prepare - Data0 Procedure","Test 2.4.3 T_HS-PreBegin - Data0 Procedure","Test 2.4.4 T_HS-ProgSeq - Data0 Procedure","Test 2.4.5 T_HS-Post - Data0 Procedure","Test 2.4.1 Data0 Lane T_HS-TERM-EN","Test 2.1.1 V_IH Sensitivity Data0","Test 2.1.2 V_IL Sensitivity Data0","Test 2.1.3 V_HYST Sensitivity Data0 A Static","Test 2.1.3 V_HYST Sensitivity Data0 B Static","Test 2.1.3 V_HYST Sensitivity Data0 C Static","Test 2.1.3b V_HYST Sensitivity Data0 A Dynamic","Test 2.1.3b V_HYST Sensitivity Data0 B Dynamic","Test 2.1.3b V_HYST Sensitivity Data0 C Dynamic","Test 2.1.4 LP-RX Minimum Pulse Width ResponseData0","Test 2.1.5 LP-RX Input pos. Pulse Rejection e_spike Data0","Test 2.1.5 LP-RX Input neg. Pulse Rejection e_spike Data0","Test

2.2.1 Init. Period TINIT","Test 2.2.2 ULPS Exit TWAKEUP","Test 2.2.3 Invalid or Aborted Escape Entry","Test 2.2.4 Invalid or Aborted Escape Command","Test 2.2.5 Post-Trigger-Command","Test 2.2.6 Data Lane LP-RX Escape Mode Unsupported or Unassigned Commands"

:PLUGin:CPHYTests:NEW

Command Syntax :PLUGin:CPHYTests:NEW '<Identifier>'

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command creates a new MIPI C-PHY CTS plug-in interface. Run this command only when no other MIPI C-PHY CTS instance is active.

Command Example :PLUGin:CPHYTests:NEW 'MIPI C-PHY CTS 1'

:PLUGin:CPHYTests:PARameter:LIST?

Query Syntax :PLUGin:CPHYTests:PARameter:LIST? ['<Identifier>']

Identifier (Optional) The calibration / test name in the MIPI C-PHY CTS plug-in instance or just the MIPI C-PHY CTS plug-in instance name. Note that the # symbol is part of the syntax and is inserted as a separator.

Description This query returns the names and the currently assigned values for each parameter, listed on the Configuration window or those associated with the selected calibration / test procedures in the currently active MIPI C-PHY CTS plug-in instance. If working remotely, you may run the :PLUGin:CPHYTests:NEW command to create a new instance of the MIPI C-PHY CTS plug-in and view the parameter names and their default values. If you have already run the :PLUGin:CPHYTests:CONFigure command to switch to the Connection Diagram window, you may run the :PLUGin:CPHYTests:SELect command to select a calibration / test whose parameters you wish to view.

Query Example Following examples display the parameters associated with the “Test 2.3.1 Amplitude Tolerance Data0” (already selected in the user interface), “Test 2.3.3 Jitter Tolerance Data0” (specified in the query), and all parameters in the ‘MIPI C-PHY CTS 1’ plug-in instance, respectively, when they are selected.

-> :PLUGin:CPHYTests:PARameter:LIST?

<- ":TP1.System&Acquisition Parameters.PropertiesEditable","1",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.Offline","1",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.BER Reader init string","Data0_HS",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.BER Limit","1E-10",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.HS Symbol Rate","2500000000",":TP1.System&Test 2.3.1 Amplitude Tolerance

Data0.LP Data Rate","10000000",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.Min Tested Value","0.095000000000000001",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.Max Tested Value","0.39000000000000001",":TP1.System&Test 2.3.1 Amplitude Tolerance Data0.V_OD Array","0.535;0.245;1|0.43;0.35;1|0.23;-0.04;-1|0.135;0.055;-1"

Test 2.3.3 Jitter Tolerance Data0

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0'

<- ":TP1.System&Acquisition Parameters.PropertiesEditable","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Offline","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Reader init string","Data0_HS",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Steps","2",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Limit","1E-10",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.HS Symbol Rate","2500000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.LP Data Rate","10000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Closure Target","0.13500000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Six Port S-Parameter File","SParam.s6p",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Height Target","0.040000000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Width Target","0.5",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Minimum Tested Common Mode","0.17499999999999999",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Maximum Tested Common Mode","0.31"

For ‘MIPI C-PHY CTS 1’ plug-in instance

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1'

<-
":TP1.Link&Connection.OfflineMode","1",":TP1.Link&Connection.AwgModel","M8195",":TP1.Link&Connection.InSystemCalibrationCTS","1",":TP1.Link&AWG Setup.AwgHostIpAddress","127.0.0.1",":TP1.Link&AWG Setup.AwgClockSyncHiSlip","hislip0",":TP1.Link&AWG Setup.AwgOneHiSlip","hislip1",":TP1.Link&AWG Setup.AwgTwoHiSlip","hislip2",":TP1.Link&AWG Setup.AwgThreeHiSlip","hislip3",":TP1.Link&Oscilloscope Setup.OscilloscopeOfflineMode","0",":TP1.Link&Oscilloscope Setup.OscilloscopeAddress","TCPIP0::121.0.0.1::inst0::INSTR",":TP1.System&Global.Spec Version","v1_20",":TP1.System&Global.Test Mode","COMpliance",":TP1.System&Global.NumberOfDataLanes","LANE1",":TP1.System&Global.Custom BER Reader

Address","",":TP1.System&Global.MIPI BER Reader","OFFline",":TP1.System&Global.BER Limit","_1_10",":TP1.System&Global.HS Symbol Rate","2500000000",":TP1.System&Global.LP Data Rate","10000000",":TP1.System&Global.LP Transition Time","2.0000000000000001E-09",":TP1.System&Global.Manual Deskew","0",":TP1.System&Global.Triggered Start","0",":TP1.System&Global.HS Sequence Loop File","CPhyCompliance.seq",":TP1.System&Global.LP Sequence Loop File","CPhyLsCompliance.seq",":TP1.System&Global.Behavioral Sequence File","CPhyBehavioral.seq",":TP1.System&Global.Re-Init Sequence before reset DUT","0",":TP1.System&Global.Re-Init Sequence after reset DUT","0",":TP1.System&Global.Mipi Protocol","DSI",":TP1.System&Global.Protocol DSI Version","V11",":TP1.System&Global.LsbFirst","0",":TP1.System&Levels.HS High Level","0.29999999999999999",":TP1.System&Levels.HS Mid Level","0.20000000000000001",":TP1.System&Levels.HS Low Level","0.10000000000000001",":TP1.System&Levels.LP High Level","1.2",":TP1.System&Levels.LP Low Level","0",":TP1.System&Timings.T3-PREPARE","9.9999999999999995E-08",":TP1.System&Timings.T3-PREBEGIN","3333333",":TP1.System&Timings.T3-PREEND","3333333",":TP1.System&Timings.T3-PROGSEQ","",":TP1.System&Timings.T3-SYNC","3444443",":TP1.System&Timings.T3-POST","4444444",":TP1.System&Timings.TX-HS-EXIT","1.9999999999999999E-07",":TP1.System&Timings.TX-WAKEUP","0.001",":TP1.System&Timings.TX-INIT","9.9999999999999995E-07",":TP1.System&Timings.SetDefault","",":TP1.System&Idle Voltage.Idle Voltage","0.29999999999999999"

:PLUGin:CPHYTests:PARameter[:Value][?]

Command Syntax :PLUGin:CPHYTests:PARameter '<Identifier>','<new value for the parameter>'

:PLUGin:CPHYTests:PARameter:Value '<Identifier>','<new value for the parameter>'

Query Syntax :PLUGin:CPHYTests:PARameter? '<Identifier>'

:PLUGin:CPHYTests:PARameter:Value? '<Identifier>'

Identifier The parameter name, either from the Configuration window or specific to a specific calibration/test in the MIPI C-PHY CTS plug-in instance along with the new value for the parameter in scientific notation. Note that the # symbol is part of the syntax and is inserted as a separator.

Description This command modifies the value of either the configuration parameters or the specified parameter specific to the selected calibration / test procedures in the MIPI C-PHY CTS plug-in instance. Run the

:PLUGin:CPHYTests:PARameter:LIST? query to check for the list of configuration parameters. You cannot modify the value of the configuration parameters after you run the :PLUGin:CPHYTests:CONFigure command, that is, switch to Connection Diagram window. Once you select a calibration / test procedure remotely using the :PLUGin:CPHYTests:SELect command in the MIPI C-PHY CTS plug-in instance. Run the :PLUGin:CPHYTests:PARameter:LIST? query to check for the list of parameters specific to calibration/test procedures.

Command Example

-> :PLUGin:CPHYTests:PARameter "MIPI C-PHY CTS 1#:TP1.System&Global.HS Symbol Rate","12E+8"

-> :PLUGin:CPHYTests:PARameter:VALue "MIPI C-PHY CTS 1#Test 2.3.1 Amplitude Tolerance Data0:TP1.System&Min Tested Value","0.025"

NOTE

You can modify the values of parameters specific to calibration / test names only when the **Mode:** option under **Receiver Test Configuration** is set to **Expert Mode.**

Notice that the way of denoting the identifier for parameters specific to calibrations / tests are slightly different from that for denoting the identifier for configuration parameters. When you run the :PLUGin:CPHYTests:PARameter:LIST? query for specific calibration / test, it returns a certain value to describe the parameter. For the **:PLUGin:CPHYTests:PARameter:Value** '**<Identifier>**','**<new value for the parameter>**' command to recognize the identifier correctly, you must modify the way the parameter is described.

Consider the following example:

-> :PLUGin:CPHYTests:PARameter:LIST? 'MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0'

<- ":TP1.System&Acquisition Parameters.PropertiesEditable","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Offline","1",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Reader init string","Data0_HS",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Steps","2",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.BER Limit","1E-10",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.HS Symbol Rate","2500000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.LP Data Rate","10000000",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Closure Target","0.13500000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Six Port S-Parameter File","SParam.s6p",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Height

Target","0.040000000000000001",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Width Target","0.5",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Minimum Tested Common Mode","0.17499999999999999",":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Maximum Tested Common Mode","0.31"

When you run the :PLUGin:CPHYTests:PARameter:LIST? query for Test 2.3.3 Jitter Tolerance Data0, it returns the parameters specific to that test along with their current values. If you wish to modify the value of the parameter 'Eye Width Target' (underlined above) remotely, you cannot simply use ":TP1.System&Test 2.3.3 Jitter Tolerance Data0.Eye Width Target" as the identifier for the **:PLUGin:CPHYTests:PARameter:Value** command. You must modify the text such that the identifier displays "current MIPI C-PHY plug-in instance name#Calibration/Test name:Functional Block&Parameter name". So, for this example, the identifier becomes "MIPI C-PHY CTS 1#Test 2.3.3 Jitter Tolerance Data0:TP1.System&Eye Width Target".

:PLUGin:CPHYTests:RESet

Command Syntax **:PLUGin:CPHYTests:RESet '<Identifier>'**

Identifier MIPI C-PHY CTS plug-in identifier name.

Description This command resets the settings of the MIPI C-PHY CTS plug-in instance to the default values.

Command Example :PLUGin:CPHYTests:RESet 'MIPI C-PHY CTS 1'

:PLUGin:CPHYTests:RUN:HISTory:CLEar

Command Syntax **:PLUGin:CPHYTests:RUN:HISTory:CLEar**

Identifier Not available.

Description This command clears the history information for any calibration / test runs from the "Measurement History" area in the MIPI C-PHY CTS plug-in instance.

Command Example :PLUGin:CPHYTests:RUN:HISTory:CLEar

:PLUGin:CPHYTests:RUN:HISTory[:STATe]?

Query Syntax **:PLUGin:CPHYTests:RUN:HISTory?**

:PLUGin:CPHYTests:RUN:HISTory:STATe?

Identifier Not available.

Description This query returns a 1 to indicate test run history and result is available or 0 indicates no tests were run.

Query Example -> :PLUGin:CPHYTests:RUN:HISTory:STATe?

<- 1

:PLUGin:CPHYTests:RUN:LOG?

Query Syntax :PLUGin:CPHYTests:RUN:LOG?

Identifier Not available.

Description This query returns the logs for the calibration / test procedure that has just been run in the MIPI C-PHY CTS plug-in instance.

Query Example Following examples display the query results when the “Skew Calibration Module 1” and “LP Level Calibration Clock” are run.

-> :PLUGin:CPHYTests:RUN:LOG?

<- #3277 05/10/2017 09:13:31,Measurement.MIPI C-PHY CTS.MIPI C-PHY CTS 1.Amplifier Level Calibration Module 1 Gen 1,Info,"Test Passed Offline"

-> :PLUGin:CPHYTests:RUN:LOG?

<- #3264 05/10/2017 09:20:50,Measurement.MIPI C-PHY CTS.MIPI C-PHY CTS 1.Test 2.3.1 Amplitude Tolerance Data0,Warning,"Test Incomplete"

:PLUGin:CPHYTests:RUN:MESSage?

Query Syntax :PLUGin:CPHYTests:RUN:MESSage?

Identifier Not available.

Description This query returns the running state of the calibration / test procedure that you select remotely using the :PLUGin:CPHYTests:SELect command in the MIPI C-PHY CTS plug-in instance. The various running states, which the query returns, are NotStarted, Running, Error and Finished.

Query Example Following examples display the query results for certain tests, respectively, that has finished running and another that has not yet started.

-> :PLUGin:CPHYTests:RUN:MESSage?

<- "Finished"

-> :PLUGin:CPHYTests:RUN:MESSage?

<- "NotStarted"

-> :PLUGin:CPHYTests:RUN:MESSage?

<- "Running"

:PLUGin:CPHYTests:RUN:PROGress?

Query Syntax :PLUGin:CPHYTests:RUN:PROGress?

Identifier Not available.

Description This query returns the progress of the calibration / test procedure that is currently running in the MIPI C-PHY CTS plug-in instance. The progress is indicated by a value between 0 and 1 based on the run progress and is represented in the scientific notation.

Query Example Following examples display the query results for certain tests, respectively, that have finished (1.0), not started (0.0), completed one-fourth (0.25) and half (0.5).

-> :PLUGin:CPHYTests:RUN:PROGress?

<- 1.000000000E+00

-> :PLUGin:CPHYTests:RUN:PROGress?

<- 0.000000000E+00

-> :PLUGin:CPHYTests:RUN:PROGress?

<- 2.500000000E-01

-> :PLUGin:CPHYTests:RUN:PROGress?

<- 5.000000000E-02

:PLUGin:CPHYTests:RUN[:STATus]?

Query Syntax :PLUGin:CPHYTests:RUN?

:PLUGin:CPHYTests:RUN:STATus?

Identifier Not available.

Description This query returns 1 or 0 to indicate whether a calibration / test you select remotely using the :PLUGin:CPHYTests:SELect command is in running state or not.

Query Example -> :PLUGin:CPHYTests:RUN:STATus?

<- 0

:PLUGin:CPHYTests:SELect

Command Syntax :PLUGin:CPHYTests:SELect '<Identifier>'

Identifier The calibration / test name in the MIPI C-PHY CTS plug-in instance. Note that the # symbol is part of the syntax and is inserted as a separator.

Description This command selects the specified Calibration / Test.

Command Example :PLUGin:CPHYTests:SELect 'MIPI C-PHY CTS 1#Test 2.1.2 V_IL Sensitivity Data0'

PLUGin:CPHYTests:STARt

Command Syntax :PLUGin:CPHYTests:STARt

Identifier Not available.

Description This command starts running the calibration / test error ratio measurement that you select remotely using the :PLUGin:CPHYTests:SELect command in the MIPI C-PHY CTS plug-in instance.

Command Example :PLUGin:CPHYTests:STARt

PLUGin:CPHYTests:STOP

Command Syntax :PLUGin:CPHYTests:STOP

Identifier Not available.

Description This command is used to forcefully abort the calibration / test error ratio measurement while it is still running.

Command Example :PLUGin:CPHYTests:STOP

7 IBerReader Interface

The IBerReader interface is a .NET software interface, which allows communication with the proprietary external tools to perform automated tests. It is available for MIPI D-PHY, M-PHY, MIPI C-PHY and SATA Rx test plug-ins. It contains methods that are called during test runs to configure the device under test (DUT) and request the pass/fail information from the DUT. A DLL file is loaded at run time and a class is instantiated, which supports the IBerReader interface. The main function for getting the pass/fail information is the method *GetCounter(out double bitCounter, out double errorCounter)*. This method is defined in IBerReader Interface Definition.

IBerReader Interface Definition

```
using System;

using System.Collections.Generic;

using System.Text;

namespace BerReader

{

public interface IBerReader

{

/// <summary>

/// This method is called to connect to your error
reader.

/// </summary>

/// <param name="address">The address string can be
used by your implementation to configure the
connection to the IBerReader interface</param> void
Connect(string address);

/// <summary>

/// This method is called to close the connection

/// </summary>

void Disconnect();

/// <summary>

/// This method is called prior to individual tests to
select the channels under test and the test mode. It
can be used to load pre-defined settings.

/// </summary>

/// <param name="mode"> Defines the test mode during
the test. The modes are Clock_HS, DataX_HS, DataX_LP,
DataX_ULP with X: 0-<number of data lines -1></param>
void Init(string mode);

/// <summary>
```

```
/// Is called at the beginning of the error
measurement and allows a reset for the DUT to be
implemented.

/// </summary>

void ResetDut();

/// <summary>

/// Starts the counters. This method MUST reset all
counters!

/// </summary>

void Start();

/// <summary>

/// Stop the DUT to read out the counters (see
GetReadCounterWithoutStopSupported()).

/// </summary>

void Stop();

/// <summary>

/// This method returns counters, the 1st counting the
bits/frames/lines or bursts and the 2nd one counting
the errors detected by the MipiBerReader. The
automation software will compute the BER using the
following equation BER=errorCounter/bitCounter. In
the case bitCounter = 0 even when the stimulus is
sending data, this is also interpreted as fail.

/// </summary>

/// <param name="bitCounter"> Contains the number of
bits which are received by the DUT. If it is not
possible to count bits the value can also contain
frames, or bursts. It is just a matter of the value
defined as target BER. If it is not possible to get
the number of bits/frames/bursts then the method can
return a value of -1 and the automation software can
compute the number of bits from the data rate and the
runtime.

</param>

/// <param name="errorCounter"> Total number of errors
since the last start.
```

```
/// </param>

void GetCounter(out double bitCounter, out double
errorCounter);

/// <summary>

/// This method returns a Boolean value indicating
whether the device supports reading the counters while
it is running. If this method returns false, the
device needs to be stopped to read the counters.

In this case the automation software will stop data
transmission before calling the GetCounter()
function, and re-start data transmission again after
reading the counter values.

/// </summary>

/// <returns> false if device needs to be stopped
before reading the counters, true if the counters can
be read on the fly.

</returns>

bool GetReadCounterWithoutStopSupported();

/// <summary>

/// This property returns a number to multiply the
value delivered by the bitCounter in the GetCounter()
function.

/// </summary>

Double NumberOfBitsPerFrame {set; get;};

/// This property returns the number of payload bits
in a frame used for the detection of the BER.

/// If i.e. the errorCounter in the GetCounter()
function is just the checksum error then this
parameter is the number of the payload.

/// </summary>

double NumberOfCountedBitsPerFrame {set; get;};

}

}
```

IBerReader Usage

Each of the methods and properties of this interface are used during test execution. To understand the meaning and duty of the functionality, you must know the point in a test where these functions will be called. A helpful source for understanding the meaning are the comments added for each method in the IBerReader Interface Definition on page 189.

Integration

Copy your compiled version, which is a dll, into the default folder, the path for which is *C:\Program Files\Keysight\M8070B\Plugins\Mipi\bin* folder. Each application (MIPI CPhy, MIPI DPhy, MIPI MPhy, SATA) has a separate program files folder which is named like the application name. The IBerReader Interface Defintion is identified and loaded according to the name of the dll (MIPI C-PHY: CPhyCustomBerReader.dll, MIPI D-Phy: DPhyCustomBerReader.dll, MIPI M-Phy: MPhyCustomBerReader.dll, SATA: SataCustomBerReader.dll) from the sub folder *Plugins\Mipi\bin* of the *C:\Program Files\Keysight\M8070B* folder. If the custom BER reader implementation needs support from other helper DLL files other then the existing PlugIn DLLs, you must place such DLL files also in the same folder location or they must be made available via the PATH variable Windows.

If loaded successfully, a new entry in the BerReader list of the Configure DUT dialog is visible. After selection of the “Custom BER Reader”, the address field becomes editable, and the text of the address field is used as the argument for the Init (string address) method.

Connect/Disconnect

If the operator presses the Start button in the user interface, which is the start of the execution of the test list, the Connect(string address) is called, before the execution of the first test. If this fails with an exception, the test automation aborts the execution. The Init string is needed to check why the connect function did not work. Check the functionality by using the Test GUI with the same text in the address field. At the end of each run, the Disconnect() method is called. A run is the time between the press on the start button and the final completed dialog, which is shown at the end. In case that the repetition parameter is greater than zero, the Disconnect() method is called after the last repetition.

Init

Init(string mode) is called once at the beginning of each test. The default parameters are set for the signaling and it is expected that the DUT can handle these default levels and timings at the RX side.

The content of the argument string “mode” is application dependent and needs to be requested from the application specific documentation. A more direct way to find out the exact string which is given as mode is to apply a break point in the Init method, and verify the setting for each test. In some applications like M-Phy, the argument of the mode string is available via the property grid and can even be modified for each test individually.

ResetDUT and GetCounter

ResetDut() is called just before each test point. It should be used to reset the bit and error counter and re-initialize the DUT to be ready for testing. A RX test procedure requires in the most cases several test points. For example, during a voltage sensitivity test several voltages are set and for each test point, a ResetDUT() is called. After the ResetDUT(), the test automation waits with the GetCounter(out double bitCounter, out double errorCounter) until the expected number of bits are transmitted. The number of bits depend on the target bit error rate and the confidence level that must be attained. As a simple calculation, the number of bits that must be compared is about three times of the target BER. Example target BER: 1e-10, Data Rate 1 GBit/s → 3e10 bits are required → 30 seconds test time is needed for each test point.

For a target BER below 1e-9, it may be suitable to request the bit and error counter before the theoretical integration time is reached to speed up the testing in case that errors are already visible. In this case, the test automation calls the GetCounter() method several times for each test point. It is expected that the bit and the error counters will not be reseted by these calls.

Configuration and Conditions

GetReadCounterWithoutStopSupported() is called before each test point. If the return value is true, then no Stop() or Start() methods are called. For some implementation, it is necessary to stop the execution of the bit comparison (see LogicAnalyserBerReader), before it is possible to read out the counter.

NumberOfBitsPerFrame and NumberOfCountedBitsPerFrame is used to compute the test time and BER. By these properties, it is possible to give a frame counter instead of a bit counter in the GetCounter() function. The

BER is calculated in this case by multiplying the bit counter with the NumberOfCountedBitsPerFrame. In applications where the data stream contains blanking periods, or bits which are not be taken into account for the bit comparison, the NumberOfBitsPerFrame and NumberOfCountedBitsPerFrame will be different, and the test time is extended. The values for these parameters depend on the pattern which is used for testing. For some applications the test pattern is well defined, but the test automation allows to use another one. In this case the IBerReader should provide suitable values for these parameters.

Example Code Description

The SDK for implementing the IBerReader interface comes with several example Visual Studio Projects and a project containing a test user interface, to test the implementation beforehand. The projects are:

- IBerReaderTestGui: project for building the IBerReader Test GUI. Via this GUI the functionality of the own implementation can be tested.
- LogicAnalyserBerReader: implementation using a logic analyzer as configuration tool and error detector.
- MipiCustomBerReader: example code with empty method implementations, which can be used as start for the own implementation.
- OfflineBerReader: example code for an offline BER reader. Instead of a direct access to a tool that configures the DUT, dialogs are shown to let the user do the configuration, and finally ask, if the DUT is working properly.

IBerReader Test GUI

The Test GUI allows to test the own implementation of a CustomBerReader. The GUI allows you to execute all methods of the IBerReader implementation. Since the source code is available, debugging can be done via this user interface.

MipiCustomBerReader

The MIPICustomBerReader project contains an empty CustomBerReader class. All necessary methods and properties are available but just contains a throw new Exception ("Not implemented.") call. This project can be used as a template for implementation.

OfflineBerReader

The OfflineBerReader project contains the implementation of an “offline” version of a IBerReader supporting class. All methods show a dialog to the operator instead of calling the DUT or tools directly. It can be used to see when and how the IBerReader methods are used inside of the test automation.

LogicAnalyserBerReader

The LogicAnalyserBerReader IBerReader implementation enables controlling of the Logic Analyser (LA). In this application, the LA configures the device via the pattern generator modules, and the analyser modules are connected to the parallel interface of the DUT. Via this parallel interface, the same data which are received via the high speed MIPI C-PHY interface are sampled, and via a special trigger setup the pattern is compared. The counter of the trigger are used for gaining the number of received bursts, and the number of errors. The configuration of the DUT is done by loading and executing a LA pattern generator setup file, and the setup for the analyser contains the necessary port assignment for the PPI. To create a suitable setup for the actual DUT is under your control.

Debugging

Debugging using the Test GUI

The easiest way for debugging is using the Test GUI. The source code is available and therefore, it is possible to set break points in each method which is using the IBerReader functionality. If the developer puts the project of the IBerReader implementation in the same Visual Studio solution, it follows the source lines of the IBerReader class in case of stepwise running the debugger (Keys F10, step over, and F11, step into). To get a reasonable signal at the inputs of the DUT the test automation, a frame generator, or any other signal source, which can generate signals, conforming to the specification, can be used. If the test automation is used, either the offline BER reader can be used to stop the execution of the test at each IBerReader call, or the compiled DLL. If the compiled DLL is used, it makes more sense to use the test automation as startup application for debug than the Test GUI. Using the frame generator as controller for the signal sources is the most flexible way, because by the frame generator all parameters can be set in the optimum range to test the error free behavior of the DUT, and setting one parameter at the edge of the DUT capability, the error counter functionality can be tested.

KEYSIGHT TECHNOLOGIES

This information is subject to change without notice.

Edition 3.3, July 2019

M8085-91030

www.keysight.com