

ValiFrame N5990A

MIPI[®] M-PHY[®] Transmitter Test

Method of Implementation

The ValiFrame Test Automation software provides physical testing of MIPI[®] M-PHY[®] devices with test instruments listed in 1. The tests are implemented according to the requirements of the “MIPI Alliance Conformance Test Suite for M-PHY physical layer” version 1.0 and “MIPI Alliance DRAFT Conformance Test Suite for M-PHY physical layer” version 3.0 (still in development/approval).

The transmitter tests are conducted with the integration of the Keysight U7249C MIPI M-PHY Tx Test Software. The N5990A test automation software will control a suitable Infiniium Oscilloscope where the U7249C application is installed.

For loopback test the software supports automatic control of the J-BERT M8020A and the J-BERT N4903B high-performance serial BERTs (Bit Error Ratio Tester). In case UniPro Test Mode is used to configure the DUT, it's recommended to use a BIT-3000 DSGA instead of a J-BERT M8020A BERT, as it can generate long PWM training sequences more easily.

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Required Test Instrumentation

The following table lists all the hardware required. The three last columns show the quantity necessary depending on the test mode (see Modes of Operation).

Module	Module Description	Loopback	UniPro	Custom
For M8020A J-BERT as signal generator				
M8020A with options: M8020A-BU1 or BU2 M8070A-0TP M8041A-0G3 M8041A-0G7	J-BERT M8020A High-performance BERT: Pattern Generator 1 channel, 8Gb/s, jitter sources, AXIe chassis, embedded PC (optional), M8000 SW	1		
M8041A-C08	BERT one channel, data rate up to 8.5 Gb/s. Required for G1, G2 and G3	1		
M8041A-C16	BERT one channel, data rate up to 16 Gb/s.	1		
M8041A-0G4	Multi-tap de-emphasis, module-wide license. * Recommended	1*		
M8041A-0G5	Internal ISI Generation. * Recommended	1*		
For N4903B J-BERT as signal generator				
N4903B with options: N4903B-C13 N4902B-C07 N4903B-J10 N4903B-002	J-BERT N4903B High-Performance Serial BERT 13 Gbit BERT. Required for M-PHY Gear4 7 Gbit BERT. Required for M-PHY Gear1 to Gear3 Needed for 2 lane measurement support	1		
N4915B	De-emphasis Signal Converter – only required for Gear3 and Gear4	1		
For DSGA as signal generator				
BIT-4000-3000-0 (Mainframe) BIT-4000-3001-0 (Clock Module) BIT-4000-3002-0 (Generator Module) BIT-4000-3003-0 (Analyzer Module) BIT-4000-3004-0 (Trigger Module)	DSGA (BIT-3000) set up		1	
BIT-1004-0003-0	Matched cable pair, +/- 2ps. For connecting DSGA to the DUT		1	
Oscilloscope				
DSO90604A or DSAV804A	Digital Signal Analyzer with 13 GHz or higher bandwidth. For testing Gear 1 and 2	1	1	1

DSAV254A or DSAZ254A	Infiniium V-Series Oscilloscope: 20 GHz, 4 Analog Channels any other instrument with higher bandwidth. For testing Gear 3 and Gear 4.	1	1	1
E2688A	High-speed SDA	1	1	1
N5400A	EZJIT Plus	1	1	1
N5465A with option -001	InfniSim basic. For Embedding package mode.	1	1	1
1169B	Infinimax II Series Probe Amplifier. *Recommended for differential connections	2*	2*	2*
N5426A	12GHz InfiniiMax ZIF Tip	1	1	1
N5425B	12 GHz InfiniiMax Differential ZIF Probe Head	1	1	1
E2669B	Differential probe connectivity kit	1	1	1
N5442A	Precision BNC Adapter	1	1	1
Cables				
M8041A-801	Matched cable pair, +/- 5ps for Gear 1 and Gear 2	2	2	2
BIT-1004-0003-0	Matched cable pair, +/- 2ps for Gear 3 and Gear 4	2	2	2
15442A	SMA-SMA cable	1	1	1
Switching (for use with DSGA, optional to avoid reconnections)				
BIT-4000-2100-0	Switch System (BIT-2100) Mainframe		1	
BIT-4000-2101-0	Switch System (BIT-2100) Master Controller		1	
BIT-4000-2122-0	Switch System (BIT-2100) 2x 2:1 Module)		1	
BIT-1004-0003-0	Matched cable pair, +/- 2ps		3	
BIT-1004-0007-0	Single Cable, Connection DUT to the DSGA Analyser Module		1	

Table 1: Instrumentation Requirement List

Required Software

1. Windows XP or 7 operating system
2. Current Keysight IO libraries
3. .Net Framework redistributable 2.0
4. N5990A-265: Interface to U7249C MIPI M-PHY Tx Test Software
5. U7249C MIPI M-PHY Compliance Test Software
6. N5990A-010: Test Automation Software Platform Core Product

7. N5990A-018: Upgrade to MIPI M-PHY Compliance Test Specification Standard and J-BERT M8020A Support
8. N5990A-167: UFS / UniPro CTM Rx Test option. Only required for UniPro Test Mode option.
9. BIT-2001-0002-0: Switch System and DSGA Platform Support
10. For debugging (when using UniPro Test Mode): N5990A-366: MIPI M-PHY Frame Generator for J-BERT M8020A and N4903B
11. For debugging (when using UniPro Test Mode): N5990A-367: MIPI M-PHY/UniPro Error Counter and Test Script Wizard for J-BERT M8020A

Modes of Operation

Before proceeding with the Tx testing it is necessary to configure the DUT to send out a CRPAT pattern through its Tx. Three different ways to do that are supported:

- Loopback Mode
- UniPro Test Mode ⁽¹⁾
- Custom BER Reader Mode

Loopback Mode

The DUT is set to loopback mode manually and then the BERT sends the appropriate CRPAT test pattern to the DUT. The DUT will re-transmit the received test pattern to U7249C and the test will be performed.

UniPro Test Mode

The signal generator directly configures the DUT to transmit the appropriate test pattern by sending PACP packets. This is a fully automated process that requires no user intervention.

For more details about UniPro Test Mode refer to Appendix A: UniPro Test Mode.

Custom BER Reader Mode

The DUT is configured using sideband signals. This mode does not require a signal generator, only an oscilloscope with the U7249 software. A dll implementing the software interface described in the M-PHY CTS for M-PHY Version 3 needs to be copied to ValiFrame's installation directory.

To select the operation mode set the parameter “BER reader” from “Configure DUT” dialog. (See Transmitter Test Configuration).

(1) "MIPI, DIGRF, M-PHY, and UNIPRO are registered service marks of MIPI Alliance. All other MIPI specification names are service marks of MIPI Alliance. [Third party marks are the property of their respective owners.]"

System Setup and Operation

Step 1. Configuring the Station

First step, prior to start with the testing, is to choose the instruments setup and connect to them. Start the ValiFrame M-PHY Station Configuration software by clicking on the icon or accessing from “All Programs/ BitifEye / M-PHY / ValiFrame M-PHY Station Configuration”.



- Database Option: When the N5990A opt. 001 was purchased, the interface to SQL is available and the test configurations and results will be saved on the server.
- Results Viewer: Select here the test results to be represented in Excel or HTML format.
- Sounds: Configure the sound options

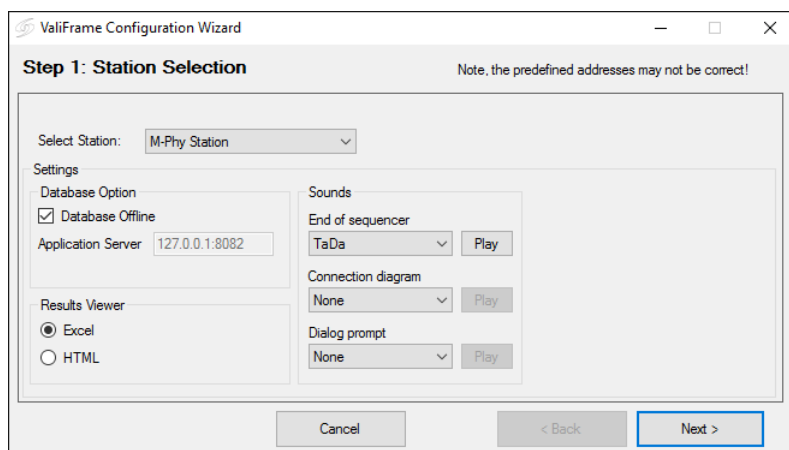


Figure 1: Station Selection dialog

2. After pressing “Next” the Station Configuration window allows to select the instrument setup.

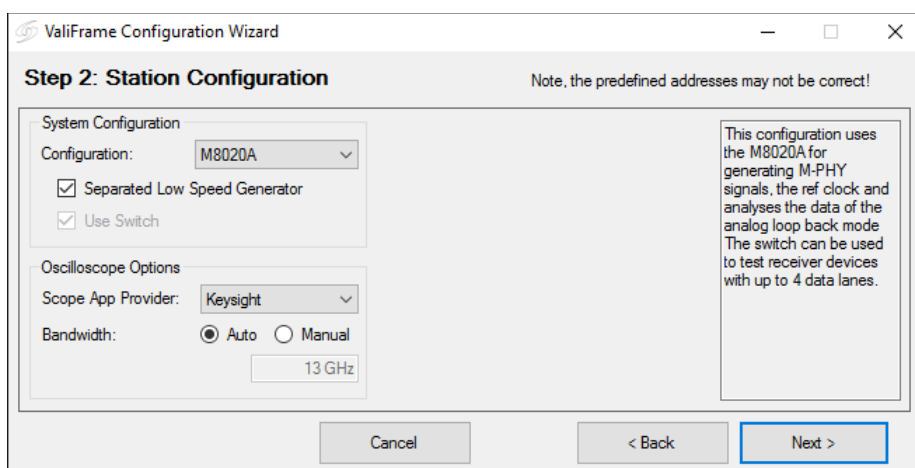


Figure 2: Station Configuration dialog

To bring the DUT into Tx test mode (i.e. sending out a CRPAT pattern) the following hardware configurations can be chosen:

- **J-BERT M8020A**

Select “M8020A” configuration to use this instrument as generator.

This setup supports the three operation modes: Loopback, UniPro Test Mode and Custom BER mode, although for UniPro training sequence generation memory restrictions may apply.

- **J-BERT N4903B**

Select “JBERT” configuration to use the N4903B as generator.

This setup supports the Loopback and Custom BER operation modes. The J-BERT is in general not able to train DUTs to operate in UniPro Test Mode, because of memory and sequencer limitations.

- **DSGA**

Select “DSGA” configuration to use the DSGA as generator.

This system configuration is recommended for the UniPro Test Mode. The DSGA configuration does not support Loopback Mode.

- **J-BERT M8020A + DSGA and J-BERT N4903B + DSGA**

To use this setup, select “M8020A” or “JBERT” configuration and check the “Separate Low Speed Generator” option.

This setup supports the three operation modes: Loopback, UniPro Test Mode and Custom BER mode. For UniPro Test Mode, only the DSGA will be used.

3. Once the desired setup is selected continue to the instrument configuration window. Here all the instruments that need to be connected are listed.

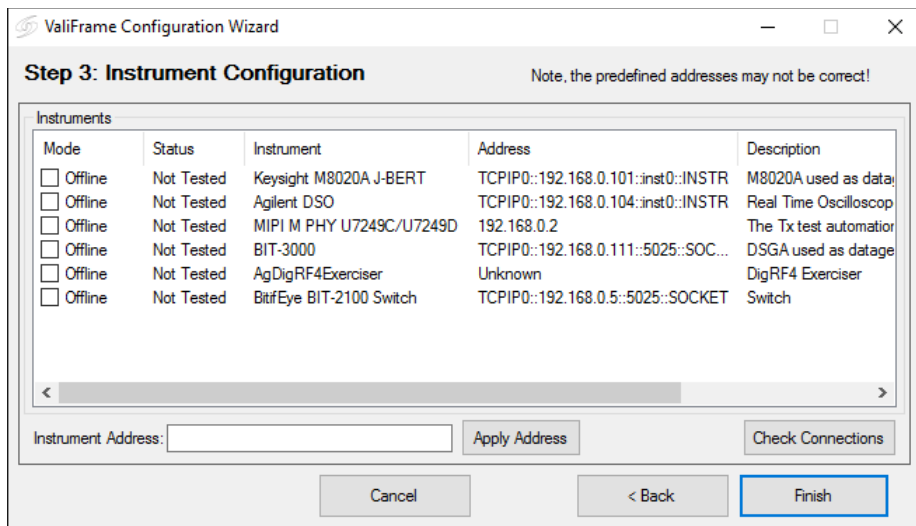


Figure 3: Instrument Configuration dialog

All instruments are configured by default in “Offline” mode. In this simulation mode, hardware does not need to be physically connected to the test controller PC. ValiFrame can not connect to any instrument in this mode. In order to control the instruments that are connected to the PC, the instrument address must be entered. The address depends on the bus type used for the connection, for example, GPIB (General Purpose Interface Bus) or LAN (Local Area Network).

Most of the instruments used in the M-PHY station require a VISA (Virtual Instrument System Architecture) connection. To determine the VISA address, run the “VISA Connection Expert” (right-click on the Keysight IO Control icon in the task bar and select the first entry “Keysight Connection Expert”). Enter the instrument addresses in the “Station Configuration Wizard”, for example, by copying and pasting the address strings from the Connection Expert entries. After the address strings have been entered, click on the “Apply Address” button before checking the “Offline” box to set the instruments needed to be online and then press “Check Connections” button to verify that the connections for the instruments are established successfully. If anything is wrong with the instrument address, a window is displayed with a message describing the problem.

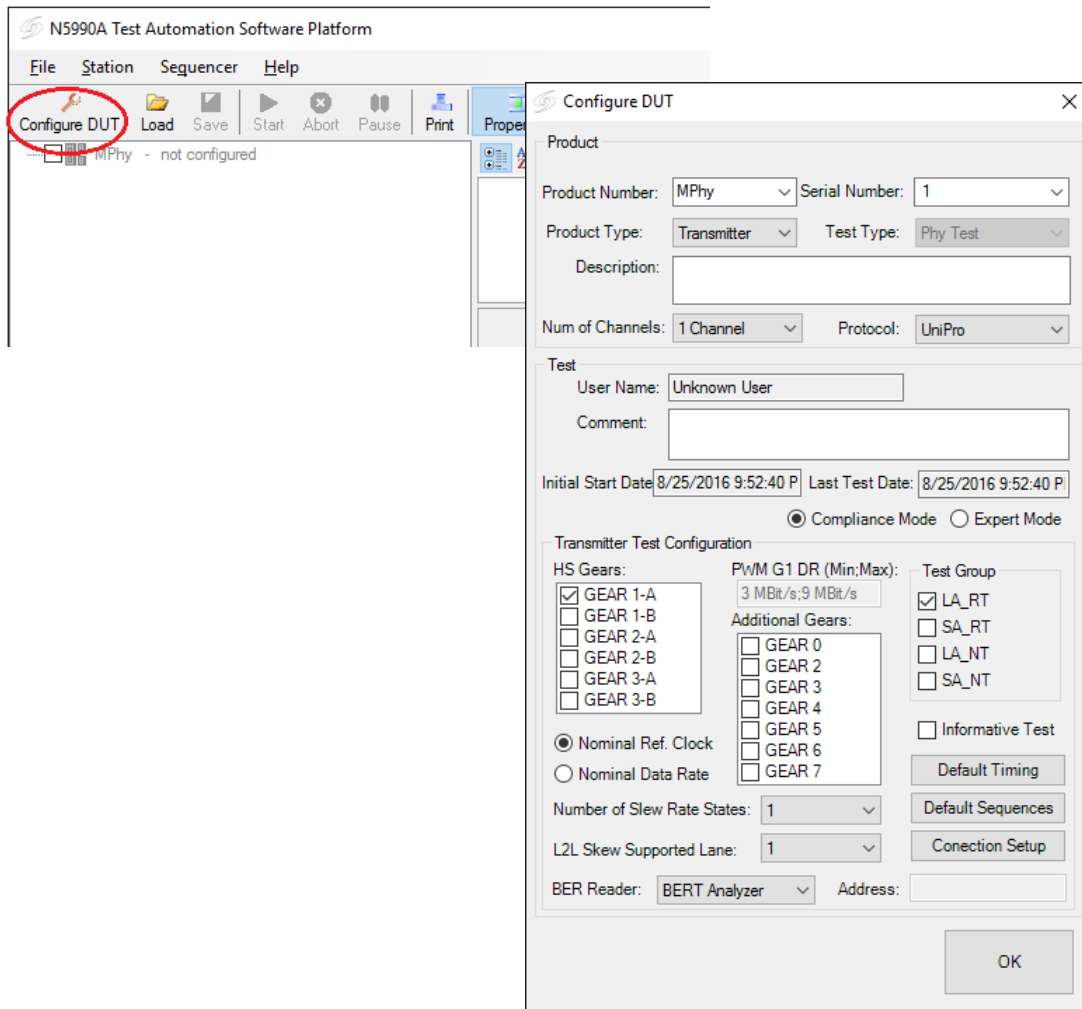
For transmitter testing is necessary to set online the following instruments:

- The selected signal generator: M8020A, JBERT or DSGA (BIT-3000)
- The DSO (Real Time Oscilloscope)
- The MIPI M PHY U7249C (Tx test software)

Step 2. Configuring the DUT

After the Station is configured open the ValiFrame M-PHY software by clicking in the icon or accessing from “Start / All Programs / Bitifeye / M-PHY / ValiFrame M-PHY”.





For product properties select:

1. Transmitter as product type
2. Phy Test as Test Type
3. The desired protocol: DigRF v4, LLI, UniPro, SSIC, PCIe, UFS

NOTE: To operate in UniPro Test Mode only UniPro or UFS protocols can be selected.

4. **Num of Channels:** Select the number of DUT input channels from 1 to 4

The rest of properties to be selected are described below:

Test parameters

- **User Name:** User name text field (user input).

- **Comment:** Text field for user comments.
- **Initial Start Date:** Time stamp of the start of the current test session.
- **Last Test Date:** Time stamp of the last test conducted in the current session.
- **Compliance Mode:** In this mode, the tests are conducted as mandated by the CTS, the test parameters used in the test procedures are shown but cannot be modified by the user.
- **Expert Mode:** Calibrations and tests can be conducted beyond the limits and constraints of the CTS; the test parameters used in the test procedures are shown and can be modified by the user.

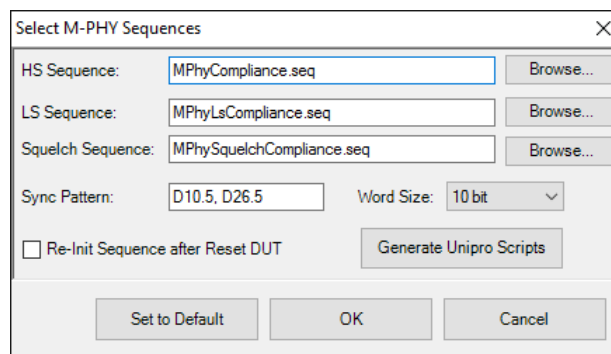
Transmitter Test Configuration

- **HS Gears:** The HS-Gears that are available:
 - GEAR 1-A
 - GEAR 1-B
 - GEAR 2-A
 - GEAR 2-B
 - GEAR 3-A
 - GEAR 3-B

The selection of gears is not limited. If “x” number of gears are selected, the HS terminated and non-terminated tests are available “x” times in respective test sub-groups. For receiver test the GEAR 3-A and 3-B are only available for spec. 3.00.

- **Additional PWM Gears:** PWM Gear 1 is always tested. Additionally PWM Gear 0 and Gear 2 to 7 can also be tested by selecting the checkboxes.
- **Test Group:** Selecting the check box will add the test procedures for the respective group in the test tree, whereas:
 - RT: Tx connection is terminated
 - NT: Tx connection is non-terminated (into-open)
 - LA: Large Amplitude
 - SA: Small Amplitude
- **Nominal Data Rate:** It sets the reference clock frequency to achieve the nominal Gear x-B data rate value as given in the specification. In case of custom data rates, the reference clock is adjusted to achieve the HS data rate that the user provided.

- **Nominal Ref. Clock:** For the selected reference clock frequency, the generated data rate is calculated as a multiple of the reference clock.
- **Number of Skew-Rate States:** If the skew state rate is more than 1, additional Tx tests for the skew characterization will be added.
- **L2L Skew Supported Lane:** Select the lane to be tested in the L2L (lane to lane) Skew PWM Tx test and the L2L HS Tx test
- **Informative Test:** Check to add informative tests to the test tree.
- **Default Timing:** It allows the timing parameters (Prepare Length, Stall, Sleep, Sync Length) to be set.
- **Default Sequences:** It allows the HS, LS, and Squelch sequence files to be selected.



- The D10.5 and D26.5 symbols are used as default for sync pattern.
- The word size can be selected as 8 bit, 10 bit, 16 bit and 20 bit with the drop-down menu.
- If the “Re-Init Sequence” check-box is checked, the pattern generator sequencer will be restarted for every test step. It will bring up the link while the signal impairments are being applied, which can be harder on the DUT. If is not checked, the sequencer will bring up the link only once during the initialization.
- Click on “Generate UniPro Scripts” to generate the scripts required for the UniPro Test Mode (see for more details UniPro Script Generation). **IMPORTANT:** This step is mandatory and only necessary for this test mode and requires a license for option 167.
- **Connection Setup:** It opens a dialog with the selection of Connection and Probing Modes.

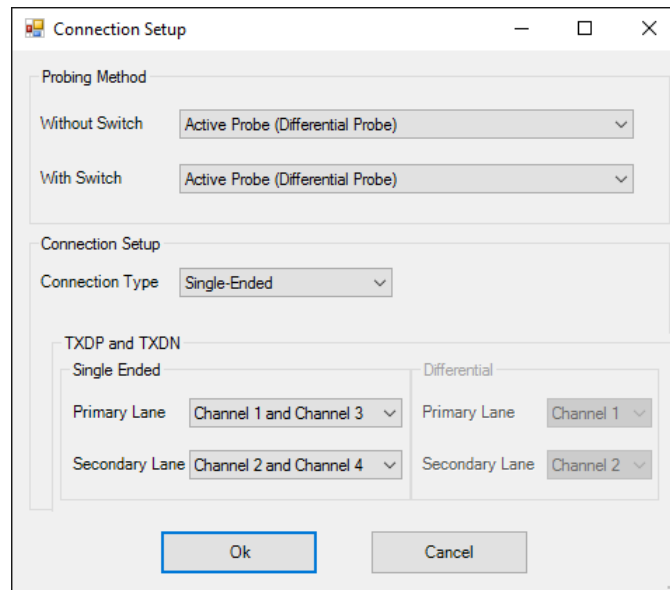


Figure 6: Connection Setup dialog

- **BER Reader:** See Modes of Operation.

Step 3. Selecting Procedures

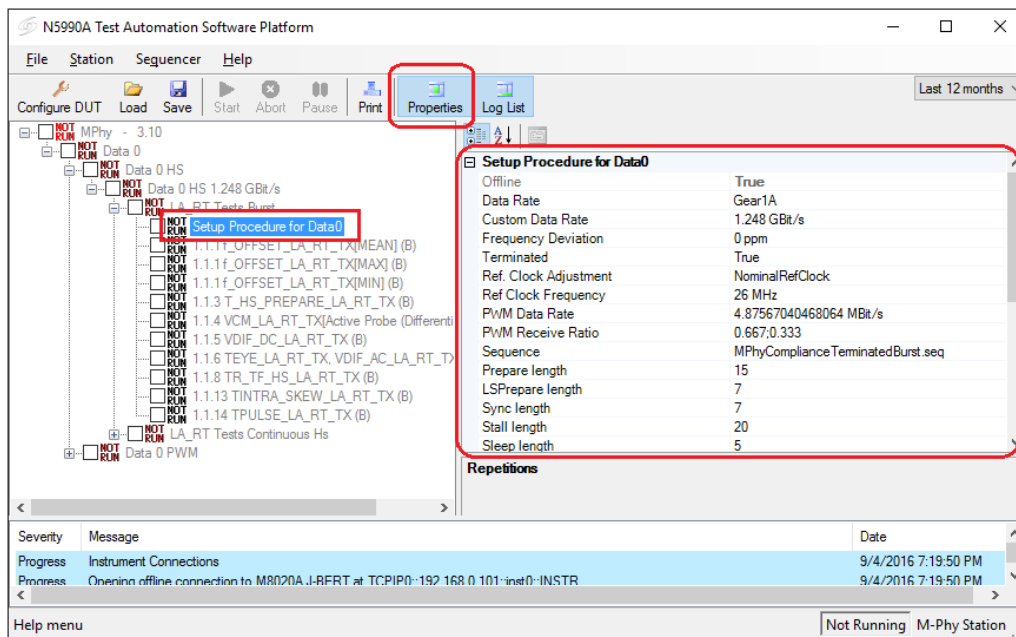
When the Configure DUT dialog is closed, the ValiFrame main window shows the list of transmitter procedures. All test procedures are organized in different sub-groups depending on the previous parameters selection:

- **First Level:** Data channel. Tests are executed for each channel selected.
- **Second Level:** HS / PWM. Tests are executed for high and low speed mode.
- **Third Level:** Gears. Tests are executed for each gear selected.
- **Fourth Level:** LA_RT/LA_NT/SA_RT/SA_NT. Tests are executed for each Amplitude/Termination group selected. In case of HS, tests are performed for Burst and for Continuous transmission mode.
- **Fifth Level:** The set of transmitter tests. Previous to each set of transmitter tests that will be performed a Setup Procedure is run in order to configure the DUT to transmit the test pattern with the corresponding data rate, transmission mode, etc.

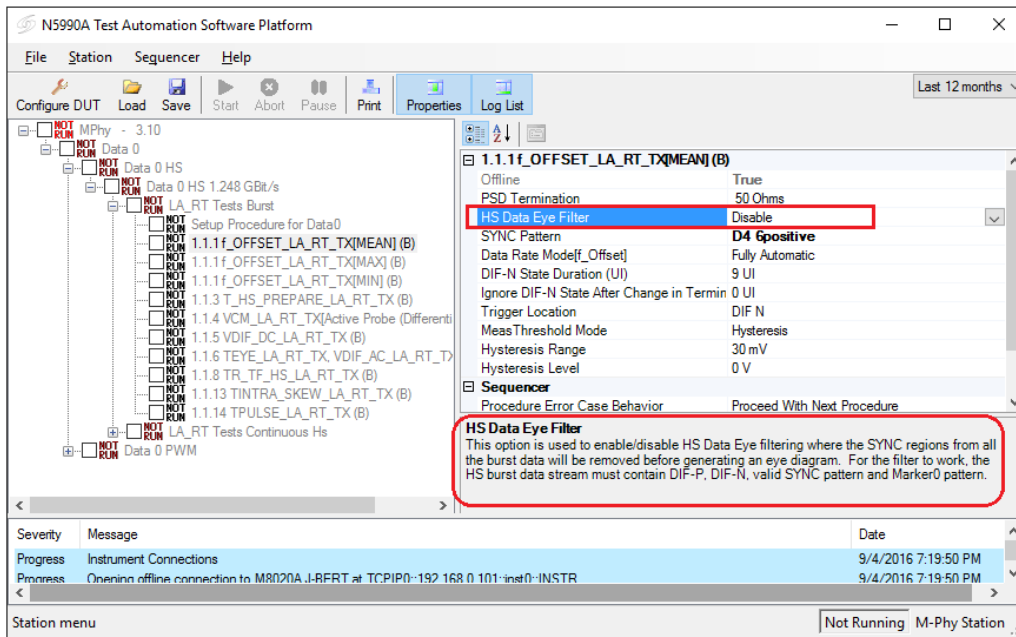
All the procedures can be selected globally by clicking on the check box at the top of the group. Alternatively, you can expand each test group with the '+' marker in front of each group so that the individual procedure can be selected by checking the specific selection boxes in front of the tests. Only the procedures which are selected will be executed.

Step 4. Modifying Procedure Parameters

For most procedures specific parameters can be set. These parameters are shown on the right side of the ValiFrame User Interface when a specific test procedure or group is selected. These values are editable when the "Expert Mode" was chosen in the configuration. If the parameters are not displayed press the "Properties" button of the main menu.



The bottom part of the properties panel shows the description of the selected parameter.



Step 5. Start the Testing

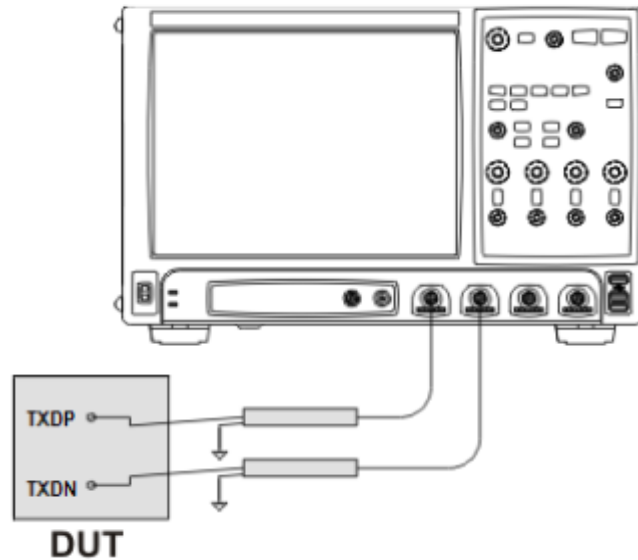
Once the tests are selected the “Start” button is enabled and colored in green. When clicking on the “Start” button the tests are run in the order shown in the test procedure selection tree.

Run the respective Setup Procedure in each test subgroup to set the device to the appropriate test mode. This step is mandatory if UniPro Test Mode is used and optional for Loopback and Custom BER.

Step 6. Connecting the Setup

Below is the generic connection setup for the Tx tests. The diagram is provided by the U7249C MIPI M-PHY Compliance Test Software.

It does not depend on the system configuration chosen. Once the DUT has been configured with the Setup Procedure, its Tx only needs to be connected to the scope.



- Connect the DUT Tx Dp to Channel 1 of the oscilloscope and Tx Dn to Channel 3

Refer to Appendix B: Connection Setups for detailed description of the connection required for the Setup Procedures in order to set the DUT into test mode.

When the setup is correctly connected press “OK” and the procedure will continue.

Step 7: Saving the Project

It is possible to save the current state of the project in “File → Save Project / Configuration...”. This will save the selected DUT configuration, the value of all procedure parameters and the results of all the test executed until that time.

This allows to close ValiFrame and continue with the testing on another moment by loading the project (File → Load Configuration...).

Result Description

Run-Time Data Display

While the program is running the data is displayed in a temporary MS Excel or HTML worksheet, which opens automatically for each individual test

The worksheet is closed once the specific test is finished. As long as the Test Automation Software is running, each worksheet can be reopened by double clicking on the procedure

name. However, the individual worksheets will be lost when ValiFrame is closed, unless individual worksheets or a collection of them were saved by the user.

Interpreting Results

Once the selected procedures are run successfully, the smiley at the front of each individual procedure indicates the result (Pass / Fail / Incomplete) by displaying it's face in specific ways as given below.









Smiley	Description
	It indicates that the procedure passed successfully in a previous run and the results are available.
	It indicates that the procedures passed in offline mode in a previous run and the results are available
	It indicates that the procedure passed successfully in the present run
	It indicates that the procedure was not run completely in the previous run.
	It indicates that the procedure could not be run in the present run. Most likely the DUT failed during initialization, so no test(s) were conducted.
	It indicates that the procedure failed in the previous run.
	It indicates that the procedure is failed in the present run.
	Generally, this kind of smiley displays two results such as the first half indicates that the result of the present run and the second half shows the result of the previous run. In this example, the first half indicates that the procedure is passed successfully in the present run and the second half means that it was not completely run in the previous run.

Table 2: Smiley's Result Description table

The DUT will be considered conformant when all required CTS tests are passed successfully. Please refer to the Appendix C: Test Coverage for more detailed information the performed tests.

Test report Document

After all tests have been run, a test report document can be generated. All individual worksheets are combined in a summary Excel/HTML workbook at the end of the test run. The workbook must be saved explicitly (File > Save Results as Workbook...), otherwise the data will be lost.

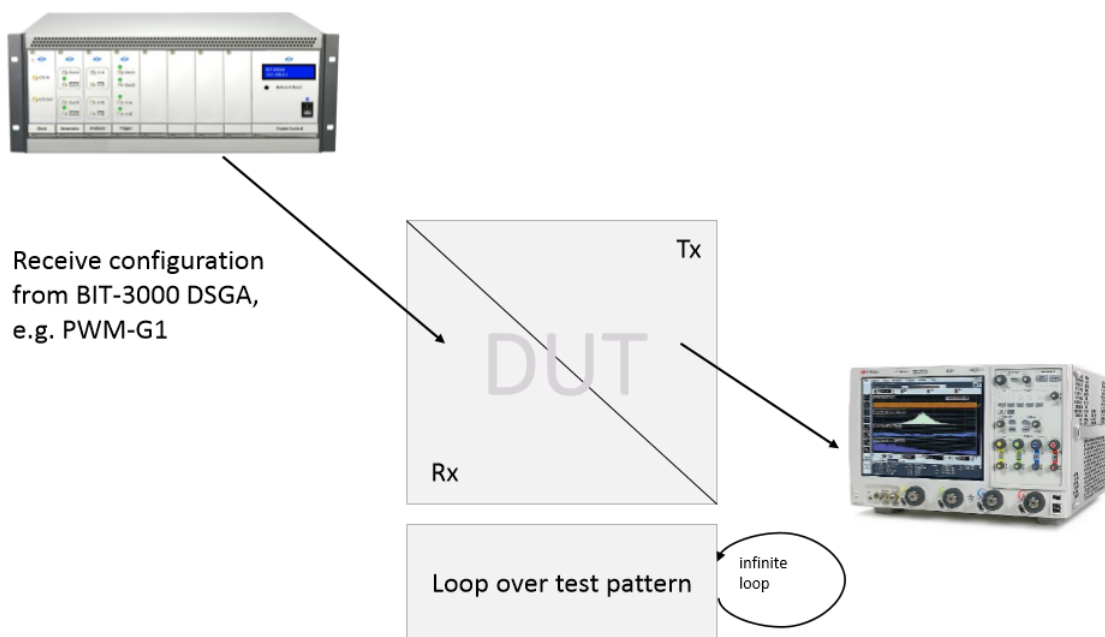
Appendix A: UniPro Test Mode

The main characteristics of this mode are:

- Set the device to Test Mode by means of in-band UniPro PACP packets.
- The DSO performs the signal analysis.
- PACP Packets can be HS or PWM, default is PWM Gear 1.

For Tx tests the UniPro Mode implementation is very simple. The generator (M8020A or DSGA) sends the training sequence to configure the DUT. Then the actual testing is performed by the scope app (U7249C).

Figure 10 shows the setup required in case of DSGA generator.



The training sequence needs to have the following structure:

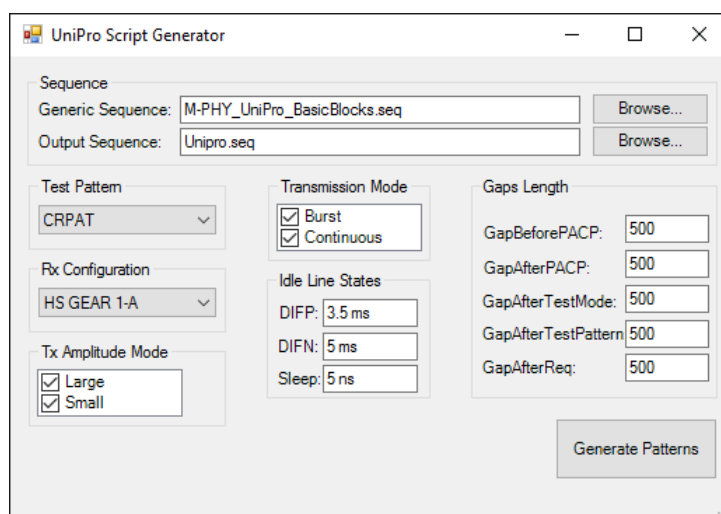
- Send PACP Test Mode Request (TestModeReq() macro)
- Bring TX out of HIBERN8 (SetReq(...) macro, set register 2B)
- Configure Tx transmission Mode, Gear, etc (register 15C2 and 21, 22, 23, 24)
- Configure Pattern (reg. 15C2)

- Wait for test to run

UniPro Script Generation

To operate in UniPro Test Mode it is necessary to replace the default scripts by UniPro scripts. These are generated in the “UniPro Script Generator” dialog in the N5990A enhancement of option 167.

From the “Configure DUT” dialog, click on the button “Default Sequence” and then on “Generate UniPro Scripts” and the “UniPro Script Generator” dialog will open.



Here several properties can be selected:

- **Test Pattern:** Chose between the two test patterns supported by the UniPro Adapter Layer:
 - CJTPAT
 - CRPAT
- **Rx Configuration:** The DUT can be configured to receive the PACP packets in high or low speed.
 - PWM Gear 1: The DUT will expect to receive the signal in low speed PWM. This option must be selected for the DSGA setup.
 - HS Gear 1-A: The DUT will expect to receive the signal in high speed. This option must be selected for the M8020A setup.
- **Tx Amplitude Mode:** The DUT can be configured to transmit with two different amplitude modes

- Large
- Small

Select the desired amplitude mode. If both are selected different scripts will be generated for each mode.

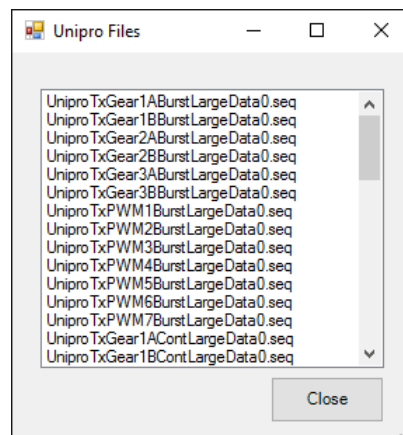
- **Transmission mode:** The two transmission modes can be selected

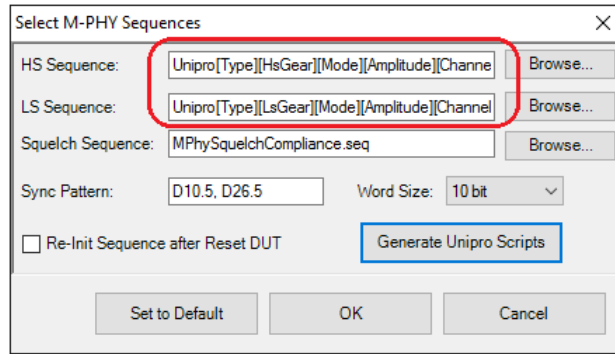
- Burst
- Continuous

Different scripts will be generated for each transmission mode. For conformance testings, both modes should be selected because there are procedures that requires burst mode and there are procedures that requires continuous mode.

- **Idle Line States:** Specify the time of the different Idle signals
- **Gaps Length:** Specify the length of the different GAPS that are used in the training sequence

After pressing the “Generate Patterns” button all the scripts will be created and listed. A script for each HS and LS test mode is generated and the generic name selected in the Configure DUT dialog.





When the dialog is closed, the HS and LS default sequences are replaced in the “Select M-PHY Sequences” window. Now the HS and LS sequence names make use of Wildcards.

This word between in brackets is replaced in run time by the current parameters. Therefore a different script is loaded depending on the test conditions.

Wildcard	Value
[Type]	RX, TX
[LsGear]	PWM1, PWM2, PWM3,..PWM7
[HsGear]	Gear1A, Gear1B,..Gear3B
[Mode]	Cont, Burst
[Channel]	Data0, Data1, Data2, and Data3
[Amplitude]	Large, Small

Table 3: Wildcards Description

Example: When running a transmitter test for:

- HS Gear 1A
- in burst transmission mode
- large amplitude
- channel 1

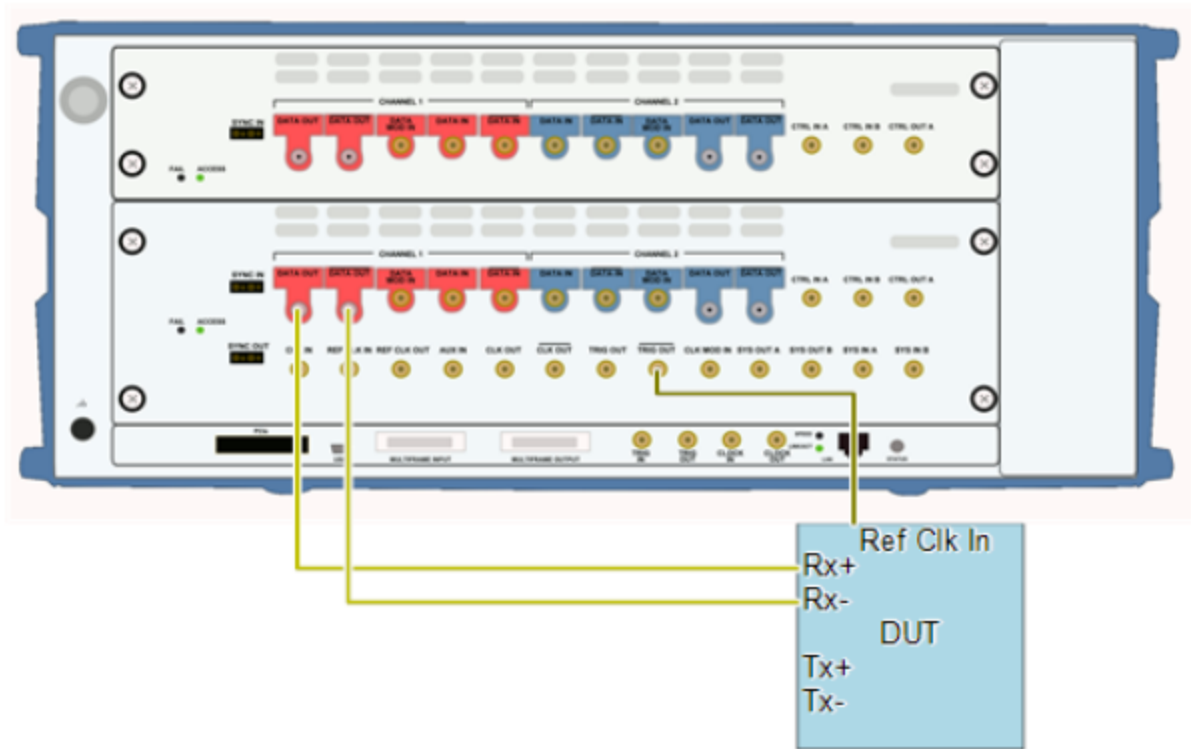
The UniPro[Type][HsGear][Mode][Amplitude][Channel].seq sequence name will be replaced by:

- UniproTxGear1ABurstLargeData0.seq

Appendix B: Connection Setups

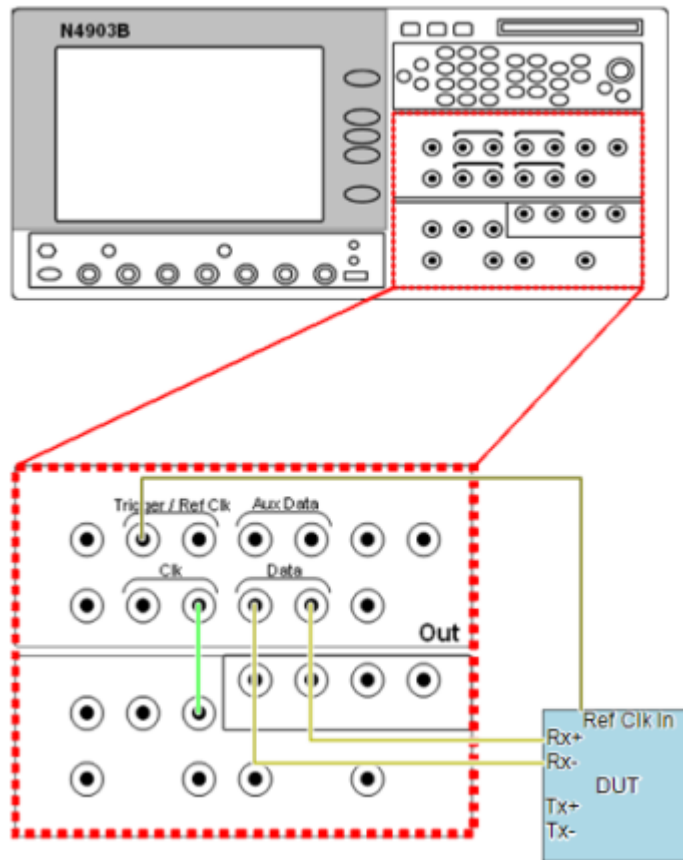
This section describes the connections required in order to configure the DUT into Tx test mode.

Connection for M8020A Setup Procedure



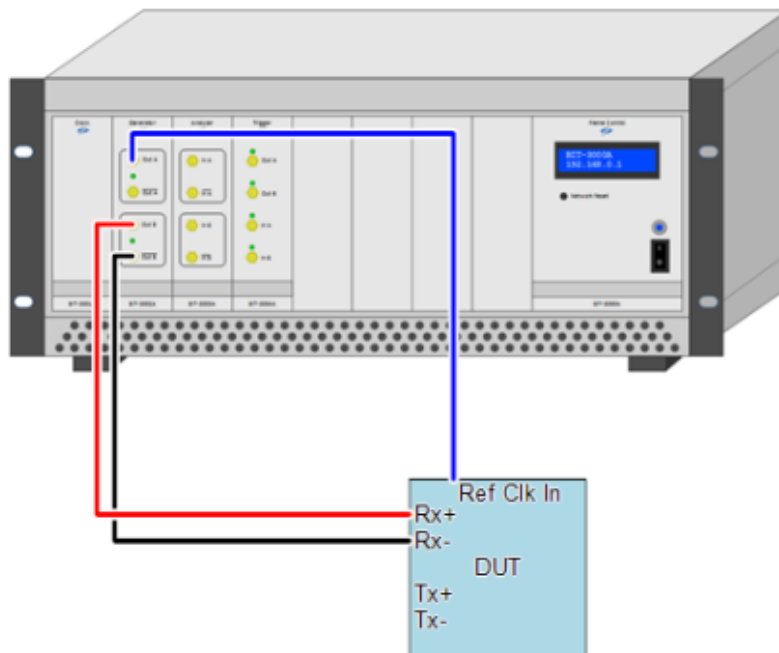
- Connect the M8020A DATA OUT and DATA OUT complement outputs to the DUT Rx inputs.
- Connect the M8020A TRIG OUT output to the reference clock input of the DUT.

Connection for J-BERT N4903B Setup Procedure



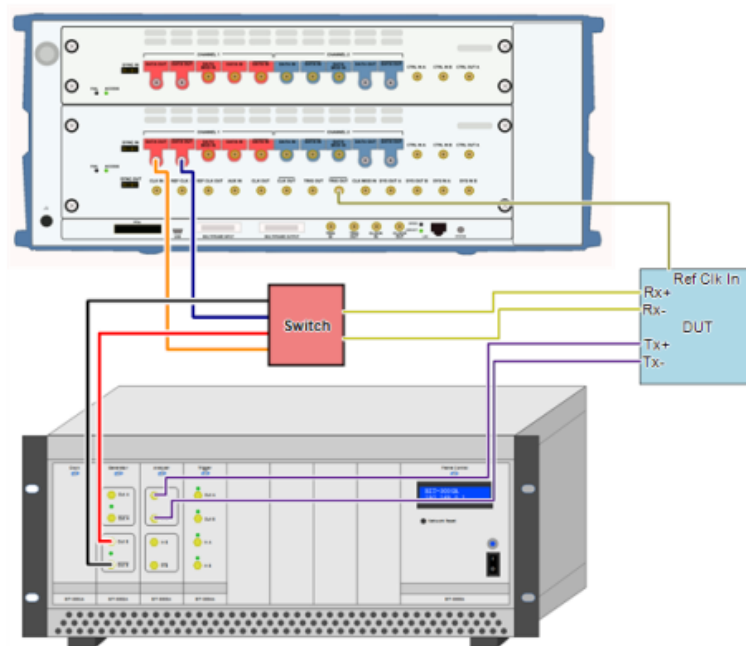
- Connect the J-BERT Data and Data complement outputs to the Rx inputs of the DUT
- Connect the JBERT Trigger/Ref Clk output to the reference clock input of the DUT.

Connection for DSGA Setup Procedure



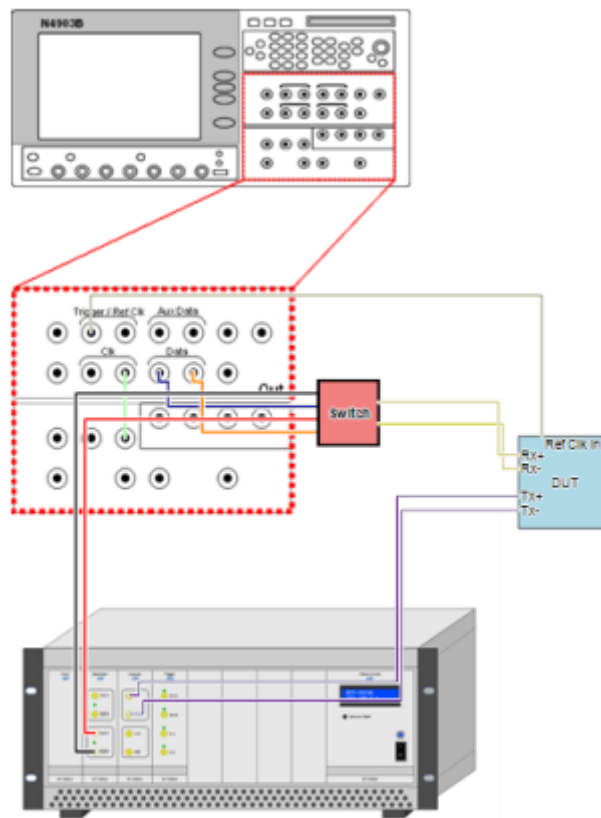
- Connect the DSGA, first module, second generator Dp to the Rx+ input of the DUT.
- Connect the DSGA, first module, second generator Dn to the Rx- input of the DUT.
- Connect the DSGA, first module, first generator Dp output to the reference clock input of the DUT.

○ Connection for J-BERT M8020A + DSGA Setup Procedure



- Connect the Dp switch output to the Rx+ input of the DUT.
- Connect the Dn switch output to the Rx- input of the DUT.
- Connect the M8020A TRIG OUT output to the reference clock input of the DUT.

○ Connection for J-BERT N4903B + DSGA Setup Procedure



- Connect the Dp switch output to the Rx+ input of the DUT.
- Connect the Dn switch output to the Rx- input of the DUT.
- Connect the J-BERT Trigger/Ref Clk output to the reference clock input of the DUT.

Appendix C: Test Coverage

HS Tests

Test 1.1.1 – $f_{\text{OFFSET_TX}}$ (LA_RT/SA_RT)_TX (MEAN/MAX/MIN) (B/C)

This procedure implements the CTS test “Test 1.1.1 – HS-TX Unit Interval and Frequency Offset (UI_{HS} and $f_{\text{OFFSET-TX}}$)”. The purpose is to verify that the Unit Interval (UI_{HS}) and Frequency Offset ($f_{\text{OFFSET-TX}}$) of the DUT’s HS-TX are within the conformance limits,

The test pass when the max/mean/min $f_{\text{OFFSET-TX}}$ value is between -2000ppm and + 2000ppm; otherwise fails.

It must be performed for burst and continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.2 - $PSD_{\text{CM-TX}}$ (LA_RT/SA_RT)_TX (B)

This procedure implements the CTS “Test 1.1.2 – HS-TX Common-Mode AC Power Spectral Magnitude Limit ($PSD_{\text{CM-TX}}$)” and is an informative test. The purpose is to verify that the Common-Mode AC Power Spectral Magnitude of the DUT’s HS-TX is below the conformance limits.

The test pass if the measured $PSD_{\text{CM-TX}}$ value is greater than zero; otherwise fails.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.3 - $T_{\text{HS PREPARE_LA_RT_TX}}$ (B)

This procedure implements the CTS “Test 1.1.3 – HS-TX PREPARE Length ($T_{\text{HS-PREPARE}}$)”. The purpose is to verify that the length of the DUT’s transmitted HS PREPARE period is consistent with the value indicated by its $TX_{\text{HS_PREPARE_LENGTH}}$ configuration attribute.

The test pass if the measured $T_{\text{HS-PREPARE}}$ value is greater than or equal to the expected value defined by the $TX_{\text{HS_PREPARE_LENGTH}}$ configuration attribute setting.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.4 – VCM_(LA_RT/SA_RT)_TX [Active Probe (Differential Probe)] (B)

This procedure implements the CTS “Test 1.1.4 – HS-TX Common-Mode DC Output Voltage Amplitude (V_{CM-TX})”. The purpose is to verify that the Common-Mode DC Output Voltage Amplitude (V_{CM-TX}) of the DUT’s HS-TX is within the conformance limits.

The test pass if the measured $V_{CM-LA-RT-TX}$ is between 160 and 260 mV in large amplitude case, and if the measured $V_{CM-SA-RT-TX}$ is between 80 and 190 mV in small amplitude case.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.5 VDIF_DC_(LA_RT/SA_RT)_TX (B)

It implements the CTS “Test 1.1.5 – HS-TX Differential DC Output Voltage Amplitude ($V_{DIF-DC-TX}$)”. The purpose is to verify that the Differential DC Output Voltage Amplitude ($V_{DIF-DC-TX}$) of the DUT’s HS-TX is within the conformance limits

that for the DIF-P (PREPARE) state. ☒

The test pass if the measured $V_{DIF-DC-LA-RT-TX}$ is between 160 and 240 mV in large amplitude case, and if the measured $V_{DIF-DC-SA-RT-TX}$ is between 100 and 130 mV in small amplitude case.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.6 TEYE_(LA_RT/SA_RT)_TX, VDIF_AC_LA_RT_TX (B/C)

It implements the CTS “Test 1.1.6 – HS-TX G1 and G2 Differential AC Eye (T_{EYE-TX} , $V_{DIF-AC-TX}$)”. The purpose is to verify that the DUT’s HS-TX meets the requirements for Transmitter Eye Opening (T_{EYE-TX}), and Maximum and Minimum Differential AC Output Voltage Amplitude ($V_{DIF-AC-TX}$).

The test pass when the eye diagram does not violate conformance eye mask; otherwise fails.

It must be performed for burst and continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.7 TEYE_(LA_RT/SA_RT)_TX, VDIFF_AC_(LA_RT/SA_RT)_TX (B/C)

It implements the CTS “Test 1.1.7 – HS-TX G3 Differential AC Eye ($T_{EYE-HS-G3-TX}$, $V_{DIF-AC-HS-G3-TX}$)”. The purpose is to verify that the DUT’s HS-TX meets the requirements for Transmitter Eye Opening ($T_{EYE-HS-G3-TX}$), and Maximum and Minimum Differential AC Output Voltage Amplitude ($V_{DIF-AC-HS-G3-TX}$, $V_{DIF-AC-TX}$).

The test pass when the eye diagram does not violate conformance eye mask; otherwise fails.

It must be performed for burst and continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.8 TR_TF_HS_(LA_RT/SA_RT)_TX (B)

This procedure implements the CTS “Test 1.1.8 – HS-TX 20/80% Rise and Fall Times ($T_{R-HS-TX}$ and $T_{F-HS-TX}$)”. The purpose is to verify that the 20%-80% Rise and Fall Times ($T_{R-HS-TX}$ and $T_{F-HS-TX}$) of the DUT’s HS-TX are within the conformance limits.

The test pass when $T_{R-HS-TX}$ and $T_{F-HS-TX}$ are greater than $0.1 * U_{HS}$. otherwise fails.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.9 T_L2L_SKEW_HS_(2/3/4)LANE_LA_RT_TX

This procedure implements the CTS “Test 1.1.9 – HS-TX Lane-to-Lane Skew ($T_{L2L-SKEW-HS-TX}$)”. The purpose is to verify that the Skew between any two DUT HS-TX LANEs ($T_{L2L-SKEW-HS-TX}$) is less than the maximum allowed conformance limits.

The test pass when the measured $T_{L2L-SKEW-HS-TX}$ is less than the HS limits defined in the specifications. otherwise fails.

It must be performed for burst signaling, for Large Amplitude in terminated line, and for each supported gear.

This test will appear in the test tree if the parameter “L2L Skew Supported Lane” is greater than 1.

Test 1.1.10 SR_DIF(LA_RT/SA_RT)_TX [MAX/MIN] (B)

This procedure implements the CTS “Test 1.1.10 – HS-TX Slew Rate Control Range ($SR_{DIF-TX[MAX/MIN]}$)”. The purpose is to verify that the Slew Rate (SR_{DIF-TX}) of the DUT’s HS-TX can be suitably adjusted across the minimum required range of values.

For Large Amplitude case, the test pass when at least one of the reported SR_{DIF-TX} is greater than 1.665 V/ns and one is less than 0,6475 V/ns.

For Small Amplitude case, the test pass when at least one of the reported SR_{DIF-TX} is greater than 0,90/ns and one is less than 0,35 V/ns.

It must be performed for burst signaling, for Large and Small Amplitude in terminated line, for HS G1 and for each lane.

This test will appear in the test tree if the parameter “Number of Slew Rate States” is greater than 1.

Test 1.1.11 SR_DIF(LA_RT/SA_RT)_TX Monotonicity (B)

This procedure implements the CTS “Test 1.1.11 – HS-TX Slew Rate State Monotonicity”. The purpose is to verify that the Slew Rate control states of the DUT’s HS-TX support monotonically decreasing Slew Rate settings.

The test pass when the N reported SR_{DIF-TX} are monotonically decreasing.

It must be performed for burst signaling, for Large and Small Amplitude in terminated line, for HS G1 and for each lane.

This test will appear in the test tree if the parameter “Number of Slew Rate States” is greater than 1.

Test 1.1.12 SR_DIF(LA_RT/SA_RT)_TX Resolution (B)

This procedure implements the CTS “Test 1.1.12 – HS-TX Slew Rate State Resolution (ΔSR_{DIF-TX})”. The purpose is to verify that the Slew Rate State Resolution (ΔSR_{DIF-TX}) of the DUT’s HS-TX Slew Rate Control satisfies the conformance requirements.

The test pass when all the reported ΔSR_{DIF-TX} are greater than 1% and less than 30%.

It must be performed for burst signaling, for Large and Small Amplitude in terminated line, for HS gear 1 and for each lane.

This test will appear in the test tree if the parameter “Number of Slew Rate States” is greater than 1.

Test 1.1.13 TINTRA_SKEW_(LA_RT/SA_RT)_TX (B)

This procedure implements the CTS “Test 1.1.13 – HS-TX Intra-Lane Output Skew ($T_{INTRA-SKEW-TX}$)”. The purpose is to verify that the Intra-Lane Output Skew ($T_{INTRA-SKEW-TX}$) of the DUT’s HS-TX is within the conformance limits.

The test pass when $T_{INTRA-SKEW-TX}$ is between $-0.06*UI_{HS}$ and $0.06*UI_{HS}$; otherwise fails.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.14 TPULSE_(LA_RT/SA_RT)_TX (C)

It implements the CTS “Test 1.1.14 – HS-TX Transmitter Pulse Width ($T_{\text{PULSE-TX}}$)”. The purpose is to verify that the Pulse Width ($T_{\text{PULSE-TX}}$) of the DUT’s HS-TX is within the conformance limits.

The test pass when the measured $T_{\text{PULSE-TX}}$ is greater than $0.9 \cdot UI_{\text{HS}}$; otherwise fails.

It must be performed for burst signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

Test 1.1.15 TJ_(LA_RT/SA_RT)_TX (C)

It implements the CTS “Test 1.1.15 – HS-TX Total Jitter (TJ_{TX})”. The purpose is to verify that the Total Jitter (TJ_{TX}) of the DUT’s HS-TX is within the conformance limits.

The test pass when the measured TJ_{TX} is less than $0.32 \cdot UI_{\text{HS}}$; otherwise fails.

It must be performed for continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

This test will appear in the test tree if the parameter “Informative Test” is checked.

Test 1.1.16 STTJ_(LA_RT/SA_RT)_TX (C)

It implements the CTS “Test 1.1.16 – HS-TX Short-Term Total Jitter ($STTJ_{\text{TX}}$)”. The purpose is to verify that the Short-Term Total Jitter ($STTJ_{\text{TX}}$) of the DUT’s HS-TX is within the conformance limits.

The test pass when the measured $STTJ_{\text{TX}}$ is less than $0.20 \cdot UI_{\text{HS}}$; otherwise fails.

It must be performed for continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

This test will appear in the test tree if the parameter “Informative Test” is checked.

Test 1.1.17 DJ_(LA_RT/SA_RT)_TX (B/C)

It implements the CTS “Test 1.1.17 – HS-TX Deterministic Jitter (DJ_{TX})”. The purpose is to verify that the Deterministic Jitter (DJ_{TX}) of the DUT’s HS-TX is within the conformance limits.

The test pass when the measured DJ_{TX} is less than $0.15 * UI_{HS}$; otherwise fails.

It must be performed for burst and continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

This test will appear in the test tree if the parameter “Informative Test” is checked.

Test 1.1.18 STDJ_(LA_RT/SA_RT)_TX (B/C)

It implements the CTS “Test 1.1.18 – HS-TX Short-Term Deterministic Jitter ($STDJ_{TX}$)”. The purpose is to verify that the Short-Term Deterministic Jitter ($STDJ_{TX}$) of the DUT’s HS-TX is within the conformance limits.

The test pass when the measured $STDJ_{TX}$ is less than $0.10 * UI_{HS}$; otherwise fails.

It must be performed for burst and continuous signaling, for Large Amplitude and Small Amplitude in terminated line, and for each supported gear and lane.

This test will appear in the test tree if the parameter “Informative Test” is checked.

PWM Tests

Test 1.2.1 TPWM-TX_(LA_RT/SA_RT/LA_NT/SA_NT)_TX [MEAN/MAX/MIN]

It implements the CTS “Test 1.2.1 – PWM-TX Transmit Bit Duration (T_{PWM-TX})”. The purpose is to verify that the Transmit Bit Duration (T_{PWM-TX}) of the DUT’s PWM-TX is within the conformance limits.

The test pass when the max/mean/min T_{PWM-TX} values are between the values defined in the specification; otherwise fails.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.2 kPWM-TX_(LA_RT/SA_RT/LA_NT/SA_NT)_TX [MEAN/MAX/MIN]

It implements the CTS “Test 1.2.2 – PWM-TX Transmit Ratio (k_{PWM-TX})”. The purpose is to verify that the PWM Transmit Ratio (k_{PWM-TX}) of the DUT’s PWM-TX is within the conformance limits.

The test pass when the max/mean/min k_{PWM-TX} values are between 1.7027 and 2.5714.  ; otherwise fails.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.3 TPWM_PREPARE_(LA_RT/SA_RT/LA_NT/SA_NT)_TX

It implements the CTS “Test 1.2.3 – PWM-TX PREPARE Length ($T_{\text{PWM-PREPARE}}$)”. The purpose is to verify that the length of the DUT’s transmitted PWM-PREPARE period is consistent with the value indicated by its TX_LS_PREPARE_LENGTH configuration attribute.

The test pass when the measured $T_{\text{PWM-PREPARE}}$ is equal to the expected value corresponding to the configured TX_LS_PREPARE_LENGTH attribute value.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.4 VCM_(LA_RT/SA_RT/LA_NT/SA_NT)_TX [Active Probe (Differential Probe)]

It implements the CTS “Test 1.2.4 – PWM-TX Common Mode DC Output Voltage Amplitude ($V_{\text{CM-TX}}$)”. The purpose is to verify that the Common-Mode Output Voltage Amplitude ($V_{\text{CM-TX}}$) of the DUT’s PWM-TX is within the conformance limits.

For large amplitude case, the test pass if the measured $V_{\text{CM-TX}}$ is between 160 and 260 mV.

For small amplitude case, the test pass if the measured $V_{\text{CM-TX}}$ is between 80 and 190 mV.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.5 VDIF_DC_(LA_RT/SA_RT/LA_NT/SA_NT)_TX

It implements the CTS “Test 1.2.5 – PWM-TX Differential DC Output Voltage Amplitude (VDIF-DC-TX)”. The purpose is to verify that the Differential DC Output Voltage Amplitude ($V_{\text{DIF-DC-TX}}$) of the DUT’s PWM-TX is within the conformance limits.

For large amplitude unterminated line case, the test pass if the measured $V_{\text{DIF-DC-TX}}$ is between 320 and 480 mV.

For small amplitude unterminated line case, the test pass if the measured $V_{\text{DIF-DC-TX}}$ is between 200 and 260 mV.

For large amplitude terminated line case, the test pass if the measured $V_{\text{DIF-DC-TX}}$ is between 160 and 260 mV.

For small amplitude terminated line case, the test pass if the measured $V_{\text{DIF-DC-TX}}$ is between 100 and 130 mV.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.6 TEYE_(LA_RT/SA_RT/LA_NT/SA_NT)_TX

It implements the CTS “Test 1.2.6 – PWM-TX Minimum Differential AC Eye Opening ($T_{\text{EYE-TX}}$)”. The purpose is to verify that the DUT’s PWM-TX meets the requirements for Transmitter Eye Opening ($T_{\text{EYE-TX}}$), at the minimum Differential AC Output Voltage Amplitude levels.

For large amplitude case, the test pass if the measured $T_{\text{EYE-TX}}$ is greater than $(1/15)*T_{\text{PWM-TX}}$ at $V_{\text{DIF-AC-TX}} = 140\text{mV}$.

For small amplitude case, the test pass if the measured $T_{\text{EYE-TX}}$ is greater than $(1/15)*T_{\text{PWM-TX}}$ at $V_{\text{DIF-AC-TX}} = 80\text{mV}$.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.7 DIF_AC_(LA_RT/SA_RT/LA_NT/SA_NT)_TX

It implements the CTS “Test 1.2.7 – PWM-TX Maximum Differential AC Output Voltage Amplitude ($V_{\text{DIF-AC-TX}}$)”. The purpose is to verify that the DUT’s PWM-TX meets the requirements for the Maximum Differential AC Output Voltage Amplitude ($V_{\text{DIF-AC-TX}}$).

For large amplitude unterminated line case, the test pass if the measured $V_{\text{DIF-AC-TX}}$ is between $\pm 500\text{mV}$.

For small amplitude unterminated line case, the test pass if the measured $V_{\text{DIF-AC-TX}}$ is between $\pm 280\text{mV}$.

For large amplitude terminated line case, the test pass if the measured $V_{\text{DIF-AC-TX}}$ is between $\pm 250\text{mV}$.

For small amplitude terminated line case, the test pass if the measured $V_{\text{DIF-AC-TX}}$ is between $\pm 140\text{mV}$.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.8 TR_TF_PWM_(LA_RT/SA_RT/LA_NT/SA_NT)_TX

It implements the CTS “Test 1.2.8 – PWM-TX 20/80% Rise and Fall Times ($T_{R-PWM-TX}$ and $T_{F-PWM-TX}$)”. The purpose is to verify that the Rise and Fall times ($T_{R-PWM-TX}$ and $T_{F-PWM-TX}$) of the DUT’s PWM-TX are less than the maximum conformance limit.

The test pass if the measured $T_{R-PWM-TX}$ and $T_{F-PWM-TX}$ are less than $0.07 * T_{PWM-TX}$.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.9 T_L2L_SKEW_PWM_(2/3/4)LANE_LA_RT_TX

It implements the CTS “Test 1.2.9 – PWM-TX Lane-to-Lane Skew ($T_{L2L-SKEW-PWM-TX}$)”. The purpose is to verify that the Lane-to-Lane Skew ($T_{L2L-SKEW-PWM-TX}$) of the DUT’s PWM-TX is within the conformance limits.

The test pass when the measured $T_{L2L-SKEW-PWM-TX}$ is less than the PWM limits defined in the specifications. otherwise fails.

It must be performed for Large Amplitude terminated line, and for each supported gear and lane.

Test 1.2.10 TOLPWM-TX_(LA_RT/SA_RT/LA_NT/SA_NT)_TX[MIN/MAX]

It implements the CTS “Test 1.2.10 – PWM-TX Transmit Bit Duration Tolerance (TOL_{PWM-TX} , $TOL_{PWM-G1-LR-TX}$)”. The purpose is to verify that the Transmit Bit Duration Tolerance (TOL_{PWM-TX}) of the DUT’s PWM-TX is within the conformance limits.

The test pass if the measured TOL_{PWM-TX} is between 0,90 and 1,10.

For PWM G1 case, the test pass if the measured $TOL_{PWM-G1-LR-TX}$ is between 0,97 and 1,03.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, and for each supported gear and lane.

Test 1.2.11 TPMW-MINOR_(LA_RT/SA_RT/LA_NT/SA_NT)_TX[MIN/MAX]

It implements the CTS “Test 1.2.11 – PWM-TX GO Minor Duration ($T_{PWM-MINOR-GO-TX}$)”. The purpose is to verify that the PWM-GO Minor Duration ($T_{PWM-MINOR-GO-TX}$) of the DUT’s PWM-TX is within the conformance limits.

The test pass if the measured $T_{PWM-MINOR-GO-TX}$ is between 37.04 and 111.11 ns.

It must be performed for Large Amplitude and Small Amplitude, for terminated and unterminated line, for PWM G0 and for each lane.