Keysight N5990A-103 SATA Test Automation Software Platform

User Guide

KEYSIGHT TECHNOLOGIES

Notices

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N5990A-103 SATA Test Automation Software Platform

User Guide

1 Introduction

KEYSIGHT TECHNOLOGIES

Overview

The BitifEye “ValiFrame” Test Automation software is globally marketed and supported by Keysight Technologies as N5990A. This document describes the calibrations and test procedures conducted by N5990A ValiFrame for SATA (Serial Advanced Technology Attachment) in detail.

The N5990A software implements the RSG (Receiver Signal Requirements) tests according to the UTD (Unified Test Document) specification and also offers some custom characterization tests to provide more details on DUT behavior beyond the limits. The RSG tests are conducted to verify that the Receiver can handle maximum stress signals according to the specification.

The N5990A SATA Receiver tests support the Keysight Technologies J-BERT M8020A high-performance serial BERT (Bit Error Ratio Tester). An Infiniium oscilloscope is always required.

Document History

First Edition (September, 2014)

The first edition of this user guide describes functionality of software version N5990A ValiFrame_2.23_SATA_2.20 or higher.

Second Edition (October, 2014)

The second edition of this user guide describes functionality of software version N5990A ValiFrame_2.23_SATA_2.20 or higher.

Third Edition (September, 2015)

The third edition of this user guide describes functionality of software version N5990A ValiFrame_2.23_SATA_2.24 or higher.

Fourth Edition (July, 2020)

The fourth edition of this user guide describes functionality of software version N5990A ValiFrame_2.23_SATA_2.50 or higher.

2 ValiFrame SATA Station

After the software has been installed, two icons are added to the desktop as shown in Figure 1 and Figure 5. One is for the Station Configuration and the other for ValiFrame.

ValiFrame SATA Station Configuration

Test Station Selection

The set of test instruments that are used for a specific application are referred to as “Test Station” or just “Station”. The test station is controlled by a suitable PC and the N5990A Test Automation Software Platform.

The ValiFrame SATA Station Configuration must be started prior to launching ValiFrame. It allows you to select the required set of instruments. Double-click the **ValiFrame SATA Station Configuration** icon (see Figure 1) to launch the software. Alternatively, to access the Valiframe Station Configuration on a Windows-based PC, click **Start > BitifEye SATA N5990A > SATA Station Configuration (N5990A)**.

Figure 1 SATA Station Configuration Icon

When the software is started, the Station Selection window appears as shown in Figure 2. Here the SATA Station is selected by default.

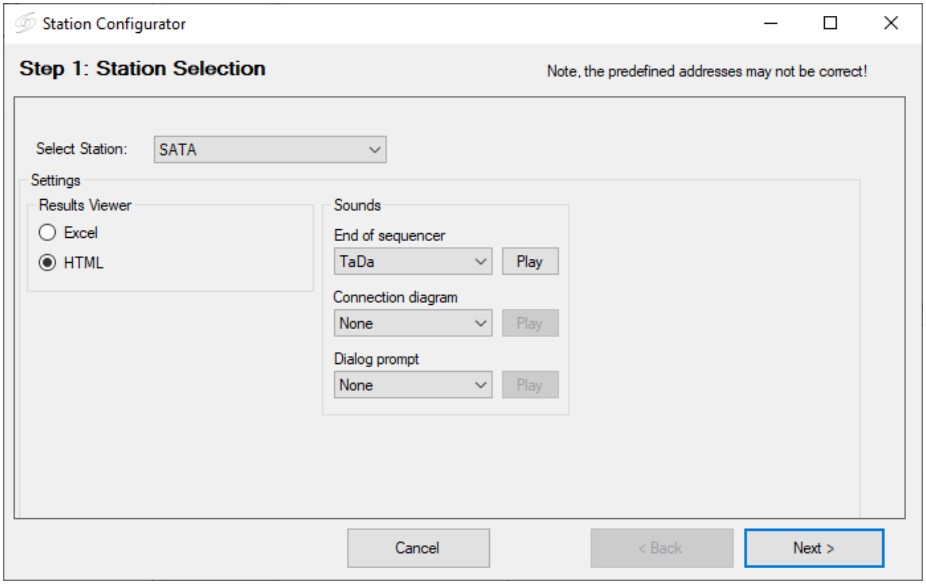


Figure 2 SATA Station Selection Window

You may select either (Microsoft) Excel or HTML as the viewer for test results.

Next, you may optionally assign sounds that would mark the attainment of different states of the program.

1 End of Sequencer plays the selected sound at the end of a sequence.
2 Connection diagram plays the selected sound every time a connection diagram pops up.
3 Dialog Prompt plays the selected sound at each dialog prompt.

Select a sound tone from the following options available in the drop-down options. The option 'None' disables the sound for the respective action.

1 Car brake
2 Feep Feep
3 Ringing
4 TaDa
5 Tud

Test Station Configuration

After selecting the Test Station as “SATA Station”, click **Next** to continue. The **Station Configuration** stage of the Wizard is displayed as shown in Figure 3. It shows the various options for instruments that can be used for SATA testing. It contains options, such as:

- Data Generator
- Error Detector
- BIST Control
- Power Switch

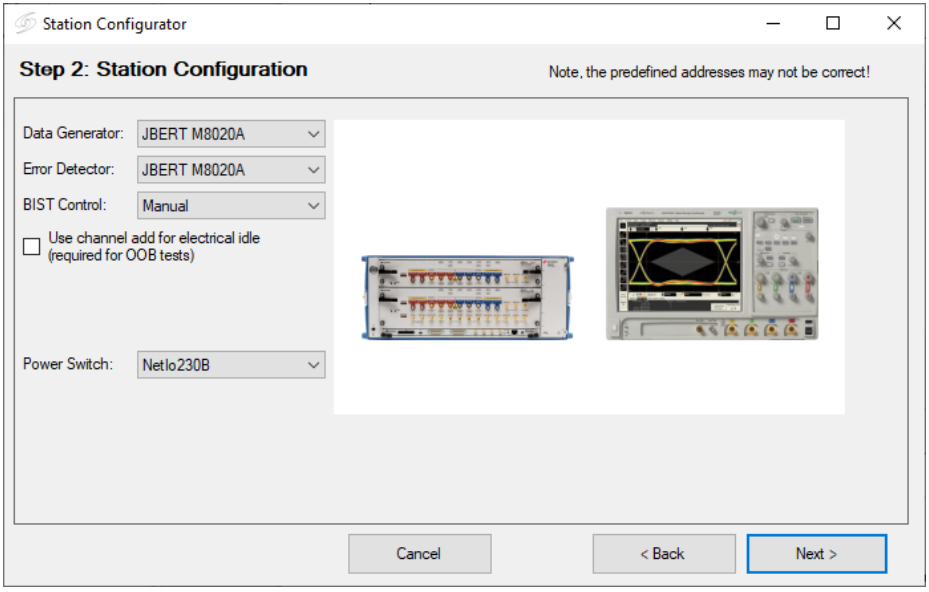


Figure 3 SATA Station Configuration Window

Data Generator:

The data generator has two functions. It can train the DUT (Device Under Test) into a special loopback test mode (BIST-L). It is also used to sends a stressed test signal into the DUT when it is in the loopback mode. It can be selected as:

- Keysight J-BERT M8020A High Performance Serial BERT

Error Detector

The error detector checks if the data looped back from the DUT (Device Under Test) contains errors. It can be selected as:

- JBERT M8020A
- Custom DLL

BIST Control

The BIST control moves the DUT into loopback mode to perform the tests. Typically this is a JBERT with the second channel option. If the second channel option is not available or the DUT needs some special handling to go into loopback, there is the possibility of choosing a customer-specific loopback activation method either manually or with a custom DLL to integrate it into ValiFrame.

This option can be selected as:

- Automated
- Manual
- Custom DLL

Use channel add for electrical Idle

This option is required for OOB test.

Power Switch

This power switch has such options to be selected as:

- Manual
- NetIo230B
- ALL4076
- SynaccessNP

If it is chosen as Manual, the user needs to power cycle the DUT manually and the options for Power Switch Automation (see Figure 9) such as Channel, Off-On Duration, and Settling Time are disabled by default. For the other options, the Power Switch Automation is enabled to select the related parameters and the DUT is power cycled automatically.

Test Instrument Configuration

Once the SATA station is configured, the instrument addresses must be set. An example of the instrument configuration is shown in Figure 4.

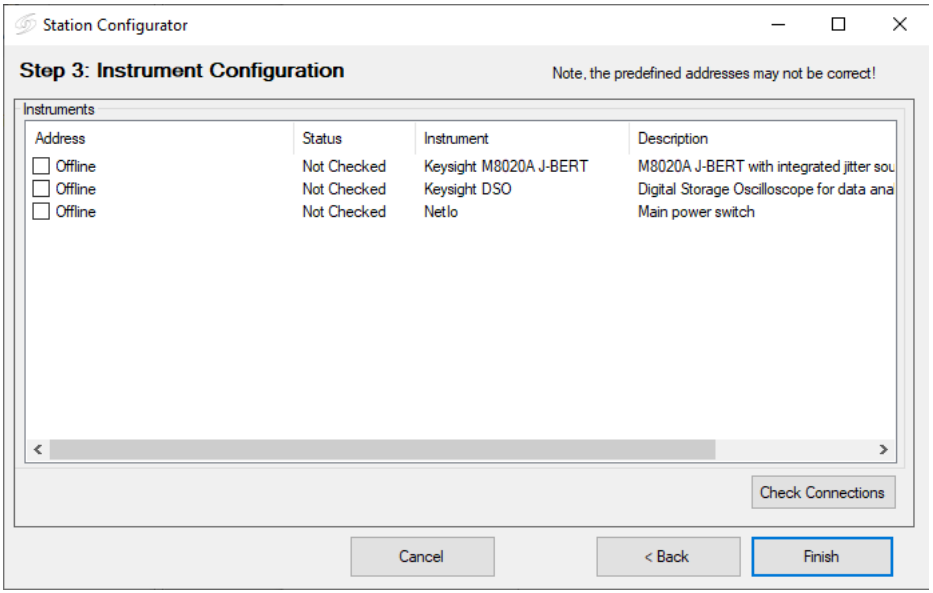


Figure 4 SATA Instruments Configuration Window

After the installation process, 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. The 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 SATA 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, check 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 in the Instrument Address, a window is displayed with a message describing the problem.

NOTE

When starting a specific test station configuration for the first time, all instruments are set to the “Offline” mode. In this mode the test automation software does not connect to any instrument. This mode can be used for demonstrations or checks only.

Starting the SATA Station

Start the Valiframe SATA Test Station by double-clicking **SATA Valiframe (N5990A)** icon on the desktop as shown in Figure 5. Alternatively, click **Start > BitifEye SATA N5990A > SATA ValiFrame (N5990A)**.

Figure 5 ValiFrame SATA Station Icon

The **N5990A Test Automation Software Platform** window shown is displayed as shown in Figure 6:

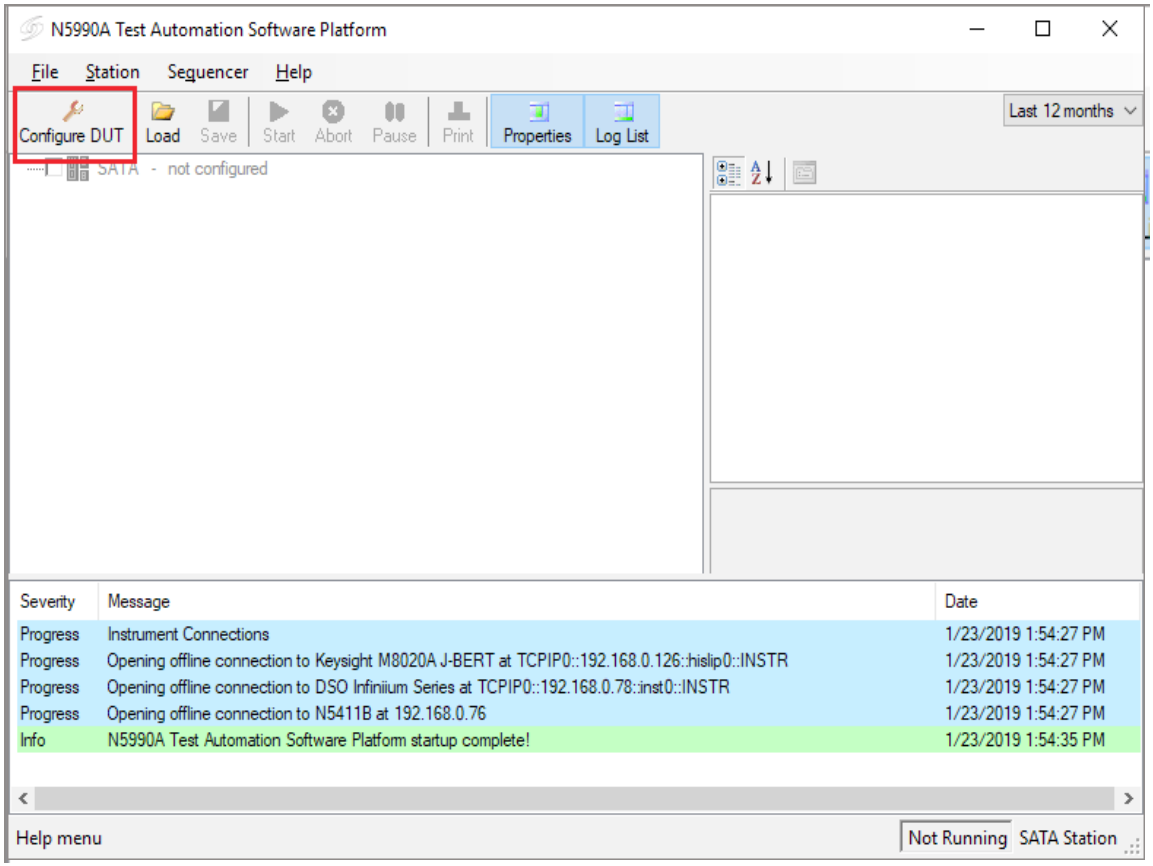


Figure 6 ValiFrame SATA User Interface

The test parameters need to be configured before running any test or calibration procedure. Click the **Configure DUT** button or select the **Configure DUT** option from the **File** menu to pop up the **Configure DUT** window.

Configure DUT

In **Configure DUT** dialog box (Figure 7), the DUT parameters such as DUT Type, spec version, Compliance Mode or Expert Mode and also the parameters related to the receiver test configuration can be selected. Those selected parameters are later used in the calibration and test procedures shown in ValiFrame main window.

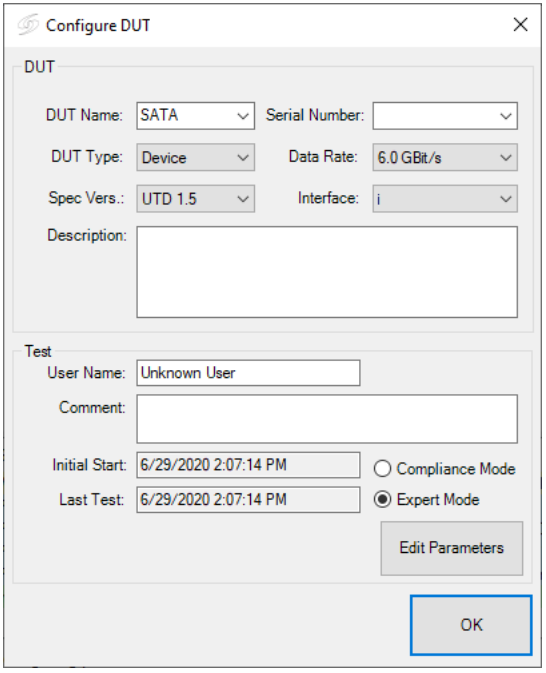


Figure 7 Configure DUT Panel

Configuration Parameters

In Figure 7, various parameters, such as **DUT Type**, **Data Rate** and **Compliance Mode** or **Expert Mode** can be selected. The description for all such parameters are listed in Table 1.

Table 1 DUT Parameter list

Parameter name	Description
DUT Parameters	
DUT Name	Name of the DUT; Used to identify the product
Serial Number	Serial number of the DUT; Used to identify the product
DUT Type	The DUT types are Device or Host. They have different specification limits and default BIST activation settings.
Data Rate	The maximum data rate the DUT supports. This can be selected as:It can be selected as 1.5 GBIt/s, 3.0 Bit/s, or 6.0 GBit/s.
Spec Version	The available versions are: UTD 1.2, 1.3, 1.4, 1.4.2, 1.4.3, and 1.5.
Interface	This can be “i” (internal), “m” (external) or “u”. “i” and “m” use different spec limits but are identical otherwise. “u” has a special calibration procedure for gen3 hosts.
Description	Text field for product description
Test Parameters	
User Name	User name text field.
Comment	Text file for user comments.
Initial Start Date	Time stamp of the start of the current session.
Last Test Date	Time stamp of the last test conducted in the current session.
Compliance Mode	Tests are conducted as mandated by the UTD. The parameters that are shown in the calibration and test procedures cannot be modified by the user
Expert Mode	Calibration and test procedures can be conducted beyond the limits and constrains of the UTD. The parameters that are shown in the calibration and test procedures can be modified by the user.

SATA Parameters

A click on the “Edit Parameters” button (see Figure 7) pops-up the “SATA parameters” window (shown in Figure 8).

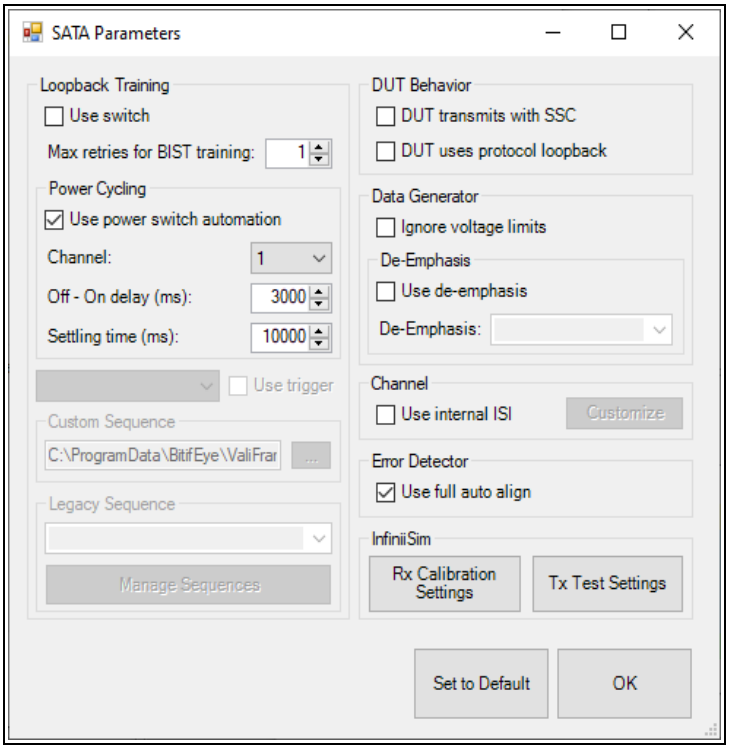


Figure 8 SATA Parameters Configuration

All the SATA parameters are described in Table 2.

Table 2 SATA parameters

Parameter name	Parameter Description
Loopback Training	
Use Switch	When the “Use Switch” option is selected, it adds two switches to the hardware setup to establish connection quickly between the BIST activation tool and the data generator/error detector. This option is only available when BIST initiation mode is set to “Manual” or “Custom DLL”.
Maximum retries for BIST training	This is the maximum number of loop back training retries. If all retries fail the following test will be considered as failed.
Loopback Training > Power Switch Automation	
Use power switch automation	This check box controls if a remote controllable power switch is used for power cycling the DUT. If this is unchecked the remaining options related to it (Channel, Off-On delay and Settling time) are disabled.
Channel	This sets the channel number of the power switch channel which is connected to the DUT.
Off – On delay (ms)	This is the duration between turning the DUT off and then turning it on again.
Settling time (ms)	This is the wait time after the DUT is turned on and before the test continues with loopback training.
Loopback Training	
Loopback Training drop-down selection	This drop-down selection is used to control how loopback training is done. It is disabled when “BIST Control” is set to “Manual” or “Custom DLL”. The default value is “Automatic”. In “Automatic” mode ValiFrame uses internally created sequences for loopback training. In “Custom” mode the user sets a path to a directory containing custom loopback training sequences, typically created with the SATA Link Training Suite. In “Legacy” mode old sequences imported from jbistgui can be used. “Legacy” mode is only available when the data generator is set to “JBERT N4903B”.
Use Trigger	This check box controls if a trigger from the DUT to the JBERT is used during loopback training. Most DUTs work without a trigger, so this is disabled by default. It is only available for hosts.
Loopback Training > Custom Sequence	Select here the path of the directory that contains the custom loopback training sequences. They will be used only if the loopback mode is set to “Custom”.
Loopback Training > Legacy Sequence	

Parameter name	Parameter Description
Manage Settings	Pressing on **Manage Sequences** button displays the window as shown in Figure 9. The sequence for BIST Training is only needed when the defaults for JBERT based loopback activation do not work with a DUT. If it is necessary to use it, first create the JBERT setting that can put the DUT into loopback setup using the separate "jbistgui" software available from The University of New Hampshire InterOperability Laboratory and import it into ValiFrame. Instructions on how to import the setting are given in the Manage BIST Training Sequences Panel.
DUT Behavior	
DUT transmits with SSC	When the "DUT transmits with SSC" check box is checked, the transmitter tests related to SSC are available. If it is unchecked, a "long-term frequency stability" test is available instead. For receiver tests the check box controls error detector settings to correctly expect a signal either with or without SSC from the DUT.
DUT uses protocol loopback	If this option is selected, the JBERT error detector ignores all SATA primitives. Some DUTs add additional primitives other than ALIGN pairs to the data during loopback. This behavior is not compliant with the SATA specification, so this option is disabled by default.
Data Generator	
Ignore voltage limits	Choosing this option makes it possible to set voltage levels higher than the specified limits. This should be used only if it is absolutely needed. If this option is used unnecessarily, it may damage or even destroy the DUT if it is not designed to tolerate high voltage levels.
Data Generator > De-Emphasis	
Use de-emphasis	This check box controls if de-emphasis will be applied to the test signal. Checking it also adds a de-emphasis calibration procedure and parameters to set the desired de-emphasis during tests. This is not required by the SATA specification or UTD. This selection is available for customer convenience. NOTE: When the data generator is a JBERT N4903B enabling de-emphasis also adds a de-emphasis box to the setup. This is not compatible with the channel add method usually used for loopback training. An alternative method that uses a single channel and blocking capacitors is used instead. This alternative method only works for a small number of DUTs.
De-Emphasis:	The calibrated de-emphasis for non-transition bits at TP2 (TP2 is a test end point of a SMA or equivalent lab cable used for RSG calibrations).

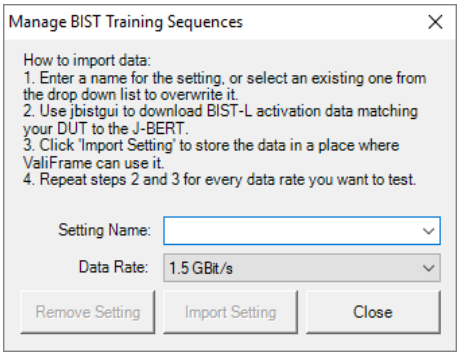
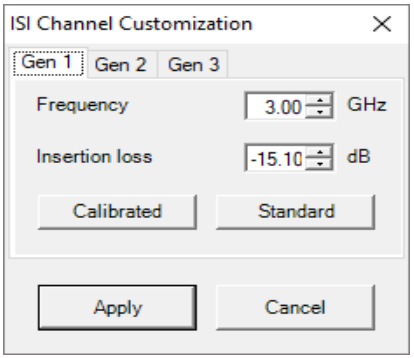


Figure 9 Manage BIST Training Sequence

Parameter name	Parameter Description
Channel	
Use Internal ISI	Check this option to add to the signal the internal ISI generated by the M8020A. To adjust the ISI value click on the Customize button.
Customize	Clicking on the **Customize** button will open the "ISI Channel Customization" dialog (see Figure 10). In this dialog, the ISI channel is defined by setting one insertion loss point. The ISI channel can be configured separately for each data rate. Clicking on the **Calibrated** button, sets the insertion loss point to the value used in the latest calibration available (if there is one). Clicking on the **Standard** button, sets the insertion loss point to the recommended values.  Figure 10 ISI Channel Customization
Error Detector	
Use full auto align:	The "Use full auto align" check box forces using AutoAlign on the error detector every time the sample point is adjusted. Without it TimeCenter is used instead. TimeCenter is a lot faster than AutoAlign. When the DUT transmits a good signal both work equally well. Forcing AutoAlign is useful for testing DUTs that transmit a signal with a deformed eye shape or not properly centered around 0 V.
Error Detector > InfiniiSim	
Rx Calibration Settings	Opens a window where the user can control embedding of a custom channel during receiver calibration by setting paths to .tf4 files.
Tx Test Settings	Opens a window where the user can control embedding of a custom channel during transmitter tests. It is a direct mapping of the options available in the transmitter test app.

3 Using the Software

KEYSIGHT TECHNOLOGIES

Introduction

Once the DUT has been configured, click OK in the Configure DUT panel. All calibration and test procedures are included in the respective groups in a way similar to how they are organized in the UTD.

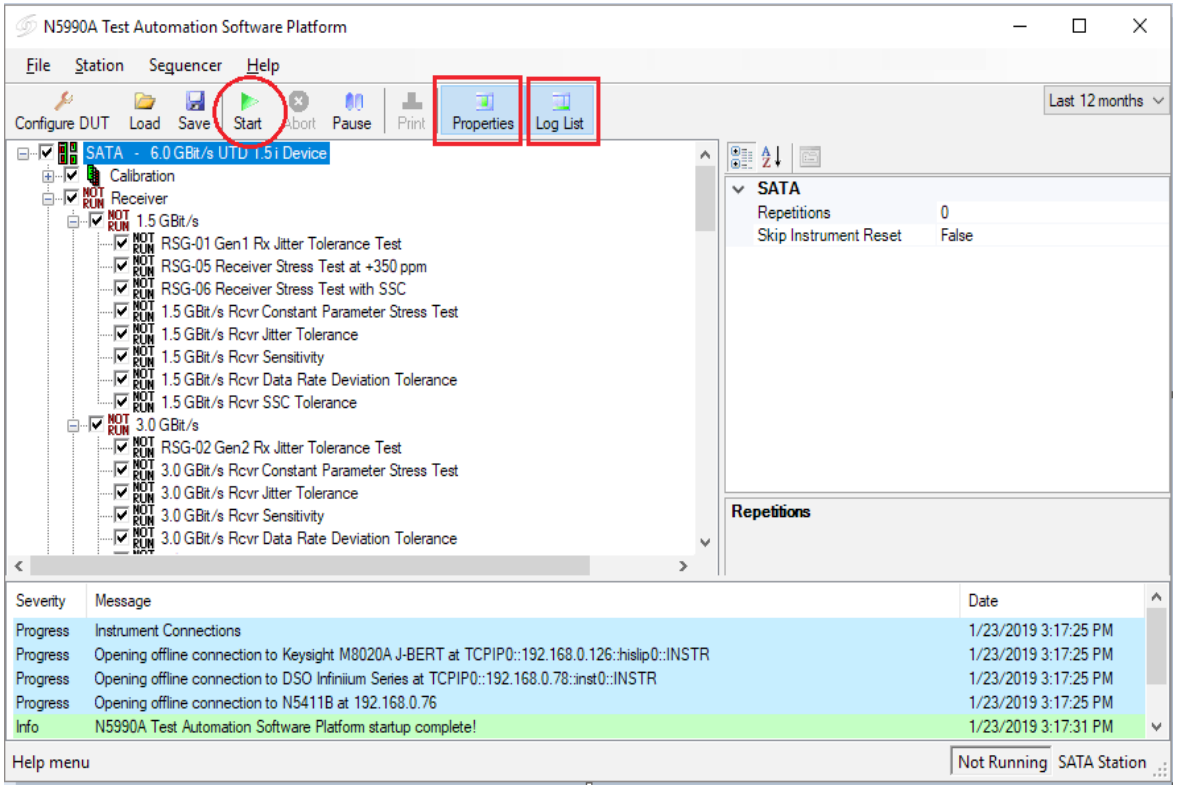


Figure 11 SATA N5990A Valiframe main window

Use the **Properties** and **Log List** buttons of the main menu (highlighted in Figure 11) to display additional information on the right side and at the bottom of the N5990A main window respectively. The parameter grid on the right side of the window shows the parameters which are related to the selected calibration or test procedure subgroups or to individual procedures. These parameters can be set only before the execution of the

procedure subgroup or procedure is started. The log list at the bottom of the window shows calibration and test status messages (regular progress updates as well as warnings and error messages).

Once all the procedures are run, the N5990A configuration can be stored as a single ".vfp" file using **Save** button and recalled using **Load** button without configuring the DUT again.

CAUTION

Before executing the calibration or test procedures, ensure that the SATA Station Configuration is conducted properly with all necessary instruments such as the Infiniium oscilloscope set to "online". All calibrations can be run in offline mode, that is, without any instrument connected. The offline mode is intended for product demonstrations with simulated data. CALIBRATIONS RUN IN OFFLINE MODE DO NOT GENERATE VALID CALIBRATION DATA.

Selecting, Modifying, and Running Tests

Selecting Procedures

The calibration, receiver and transmitter test procedure groups can be selected globally by clicking on the check box at the top of the group. Alternatively, an individual test procedure can be selected by checking the specific selection boxes in front of the tests. Click on the Start button to execute the selected test procedures.

Modifying Parameters

Most calibration and test procedures as well as the groups containing them have parameters that control the details of how the procedures are run. In compliance mode most of these parameters are read-only. In expert mode almost all parameters can be modified. First, select a specific calibration or test procedure or one of the groups containing in the N5990A procedure tree (See Figure 12). The parameters are displayed in a property list on the right side of the screen. If they are not displayed, press the Properties button. Depending on the user selection on the left side of the top of the list, the list is either ordered alphabetically or in categories. The test parameters selected are listed in the MS Excel/HTML test results worksheets.

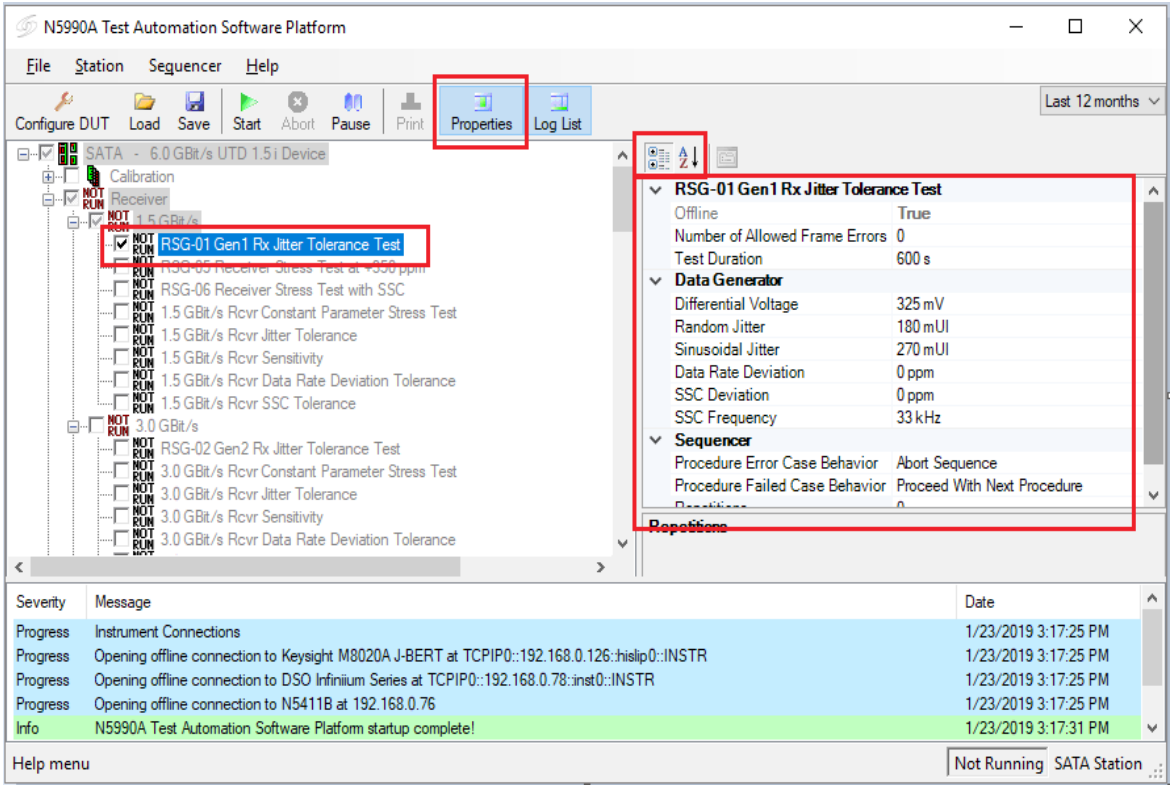


Figure 12 Modifying Parameters

Running Procedures

To run the selected procedure, click the **Start** button (highlighted in Figure 11). The procedures are run in the order, shown in the procedure selection tree. Some procedures may require user intervention such as changing cable connections or entering DUT parameters. The required action is prompted in pop-up dialog boxes prior to the calibration/test runs.

The connection diagram is also displayed by right-clicking the desired test or calibration and selecting **Show Connection**.

Results

Run-Time Data Display

Most procedures generate data output. While the procedure is running, the data is displayed in a temporary MS Excel worksheet or HTML page (depending on the selected viewer in the Station), which opens automatically for each individual procedure.

The MS-Excel worksheet or the HTML page that are opened during the procedure run then are closed once the specific procedure is finished. As long as the N5990A Software is running, each worksheet or page can be reopened with a double-click on the respective procedure. However, the individual worksheets or pages will be lost when the N5990A main window is closed, unless they were saved by the user.

Results Workbook

All calibration and test data worksheets can be saved in a workbook by selecting File > Save Results as Workbook... at any time. It is recommended that this step is carried out at least at the end of each N5990A run. If the calibration and test procedures are conducted several times during the same N5990A run, the result worksheets are combined in the workbook. If a test procedure is conducted without prior execution of calibration procedures in the same test run, only the test results will be saved to the workbook.

NOTE

As a safety feature, all calibration and test results are saved by default to the N5990A “Tmp” directory (refer to “N5990A Getting Started Guide.pdf”). The sub-folder “Results/SATA Station” contains the Excel files of the final results measured at each calibration and test procedure. In addition to the calibration data worksheets, the calibration data files are generated. These files are saved by default to the N5990A calibrations folder. If these calibrations are run again, the data file will be overwritten. In order to save the calibration data files at each configuration, the files must be copied from the directory: “*C:\ProgramData\BitifEye\ValiFrameK0\SATA\Calibrations*” and saved manually in any folder before rerunning the calibrations

SATA Parameters

Sequence Parameters

The sequencer parameters control the flow of the test sequencer only, but not the behavior of individual procedures. They are identical across all versions of ValiFrame. One such parameter, namely Repetitions, is available for all procedures and groups in the procedure tree. The others are only available for specific procedures. Similar to all other parameters, the sequencer parameters are displayed on right side of the ValiFrame user interface and they can be changed manually, as illustrated in Figure 13.

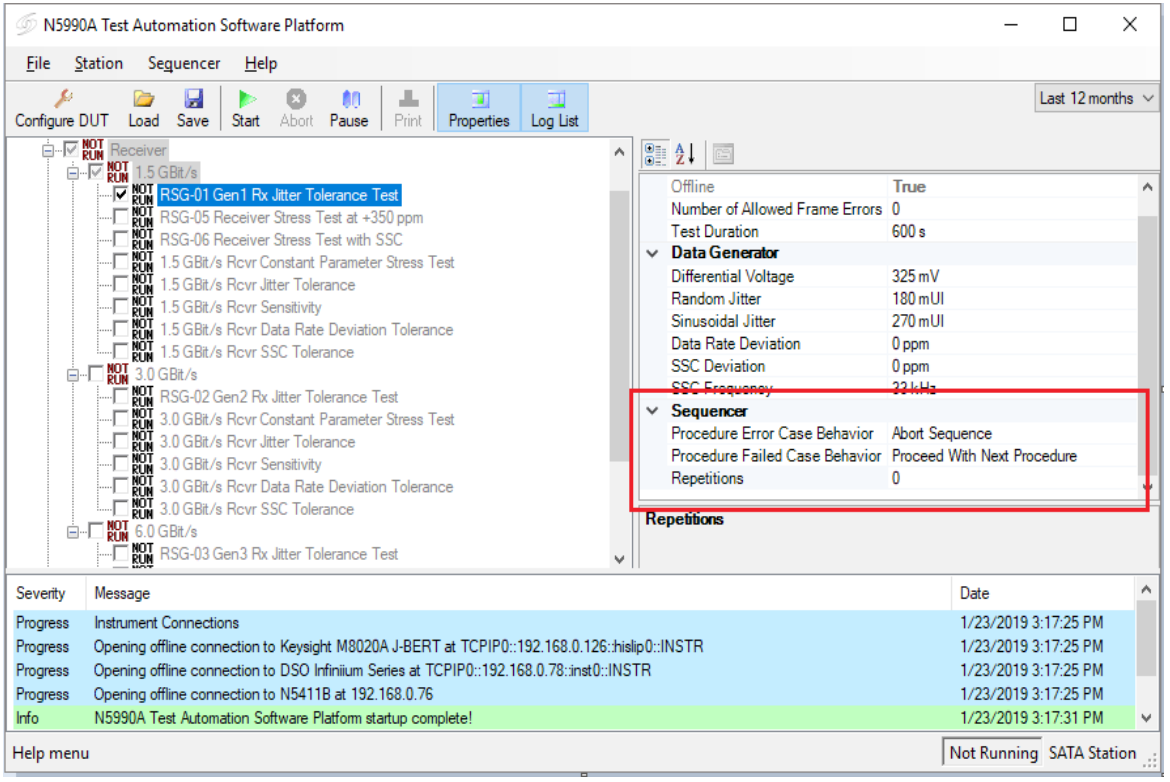


Figure 13 Sequencer Parameters

All sequencer parameters are listed in alphabetical order in Table 3.

Table 3 SATA Sequencer Parameters

Parameter Name	Description
Procedure Error Case Behavior	▪ Proceed With Next Procedure–if an error occurs in the current test or calibration procedure, continue by running the next procedure in the sequence. ▪ Abort Sequence–Abort the further running of the sequence.
Procedure Failed Case Behavior	▪ Proceed With Next Procedure–if the current test or calibration procedure fails, continue by running the next procedure in the sequence. ▪ Abort Sequence–Abort the further running of the sequence.
Repetitions	The number of times the group or procedure will be repeated. If the value is '0', it runs only once.

Common Parameters

The common parameters are used for several related calibration or test procedures. They are displayed on the right side of the ValiFrame user interface. They appear when the selected entry of the procedure tree on the left is a group instead of an individual procedure.

The SATA Receiver Test Software has some group parameters (in addition to “Repetitions”) on the top-level entry of the procedure tree as shown in Table 4. These parameters are common for all ValiFrame procedures.

Table 4 SATA Common Parameters

Parameter name	Description
Skip Instrument Reset	When set to true, ValiFrame will skip the reseting of all the instrument at the beginning of each run.

Procedure Parameters

The Procedure Parameters are all such parameters that are separate from the previously described categories. They are shown on the right side of the ValiFrame user interface. They appear when the selected entry of the procedure tree on the left is an individual procedure. These parameters only change the behavior of the selected procedure. Procedures often have parameters with the same name, but the configured settings always apply on the selected procedure, and the meaning may be slightly different.

4 SATA Calibrations

KEYSIGHT TECHNOLOGIES

Calibration Overview

Before any receiver test procedure can be run, the SATA receiver test system must be calibrated.

The ValiFrame calibration plane is given by the DUT input ports. The receiver test signal characteristics such as the signal generator output voltage level and jitter parameters are typically affected by the signal transmission between the generator output ports and the DUT input ports. Thus, for any signal output parameter that you may select (referred to as the 'set value'), the jitter and the signal received at the DUT input ports (referred to as the 'actual value') deviate from the set value. Additional deviations can be caused by effects such as offset errors, hysteresis, and nonlinear behavior of the signal generator. The ValiFrame calibration procedures compensate the actual value deviations of the relevant signal output parameter from the set values over the required parameter range.

All calibration procedures required for SATA receiver testing are included in the ValiFrame software. The ValiFrame calibration procedures are implemented such that the calibration process is conducted as fast as possible and is automated as much as possible, for example, by minimizing the number of reconfigurations of the hardware connections.

Common Parameters for Calibrations

Table 5 presents a description of the procedure parameters used in the different calibrations.

Table 5 SATA Calibration Parameters

Parameter name	Parameter Description
Calibration	
Embed Custom Channel	Controls if a custom channel is embedded during calibrations.

Parameter name	Parameter Description
CIC Transfer Function File	This shows the path to the transfer function file containing the standard CIC definition for DUT calibrations. Only visible if Embed Custom Channel is false. Read-only.
Custom Channel Transfer Function File	This is the path to a user-created custom transfer function file that will be embedded during calibrations. Only available if Embed Custom Channel is true.
Custom Channel + CIC Transfer Function File	This is the path to a user-created custom transfer function file that will be embedded during gen3 Host calibrations. It should contain a transfer function definition that is equivalent to adding the custom channel definition and the standard CIC definition. Only available if Embed Custom Channel is true.

Calibration Procedures

Random Jitter Calibration Test

The Random Jitter Calibration procedure is available for all data rates.

Purpose and Method

The purpose of this procedure is to calibrate the random jitter.

At first, the pattern generator sends a mid-frequency test pattern (MFTP) to the oscilloscope and then the RJ value is added to the data signal. This minimizes the measurement errors of RJ, compared to the case when the other signal degradations are present, and shall be done before adding additional jitter components and common mode signals. The set RJ value starts from 0 mUI and it is increased in linear steps using the Jitter Step Size value until the value of “Stop Jitter” is reached. At each set value, the corresponding actual RJ amplitude is measured using the RJ/DJ-separation software (EZJIT Plus) on the oscilloscope and the set and measured jitter values are stored separately before the set jitter value is increased for the next step.

Connection Diagram

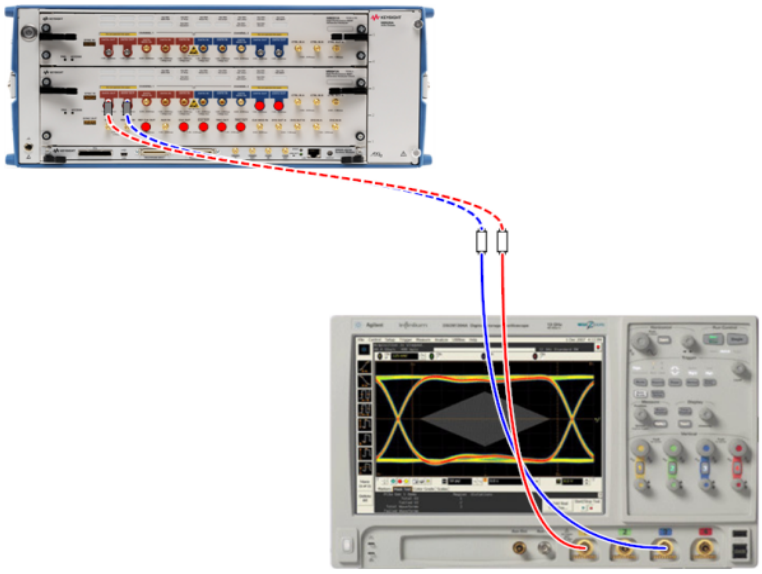


Figure 14 Connection Diagram for Random Jitter Calibration

Parameters in Expert Mode

- Transitions: The number of transitions (0 to 1 or 1 to 0) used for the jitter measurement.
- Stop Jitter: This is the final jitter value for the calibration procedure
- Jitter Step Size: The difference value of set jitter between two jitter measurements.

Result Description

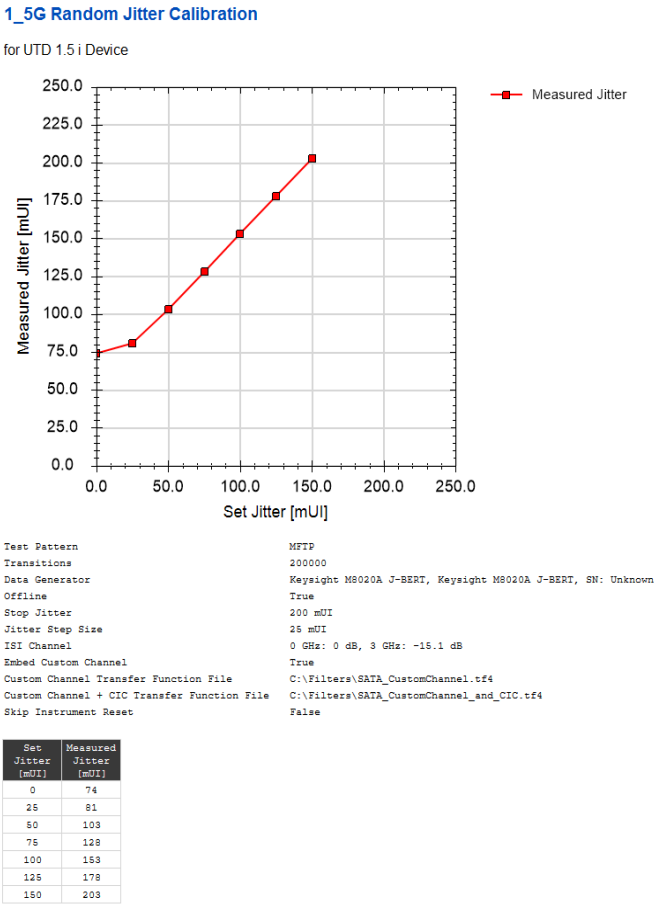


Figure 15 HTML Report for Random Jitter Calibration Test

- Actual Jitter: This is the measured value of jitter amplitude
- Set Jitter: The jitter amplitude set in the instrument.

Sinusoidal Jitter Calibration Test

The Sinusoidal Jitter Calibration procedure is available for all data rates.

Purpose and Method

The purpose of this procedure is to calibrate the sinusoidal jitter.

The pattern generator sends the mid-frequency test pattern (MFTP) to the oscilloscope then the SJ value is added to the data signal. The procedure sets seven SJ frequency points between 0 MHz to the value of Max Jitter Frequency and also sets few SJ values starting from 0 mUI and increases linearly using the value of Jitter Step Size until the Stop Jitter value is reached. At each sinusoidal jitter frequency point, the actual SJ values are measured according to the set SJ values with the RJ/DJ-separation software (EZJIT Plus Software) on the oscilloscope and the set and measured jitter values are stored separately before the value of set jitter is increased for the next step.

Connection Diagram

Same as for Random Jitter Calibration (see Figure 14)

Parameters in Expert Mode

- Transitions: The number of transitions (0 to 1 or 1 to 0) used for the jitter measurement.
- Stop Jitter: This is the final jitter value for the calibration procedure.
- Jitter Step Size: The difference value of set jitter between two jitter measurements.
- Max Jitter Frequency: The highest frequency that is calibrated.
- Random Jitter: The amount of random jitter used for this calibration. This value stays the same for all steps.

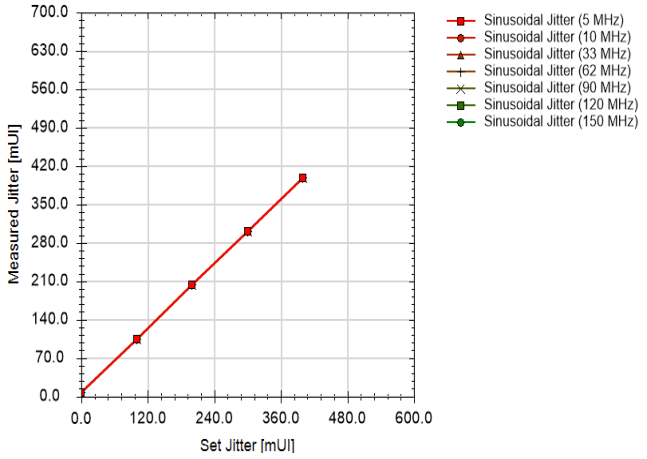
Dependencies

Versions below UTD 1.4 use the Random Jitter Calibration for this procedure. The remaining versions (= UTD 1.4) do not require any calibration.

Result Description

1_5G SJ Calibration

for UTD 1.5 i Device



Test Pattern	MFTP
Random Jitter	0 UI
Transitions	200000
Data Generator	Keysight M8020A J-BERT, Keysight M8020A J-BERT, SN: Unknown
Offline	True
Stop Jitter	600 mUI
Jitter Step Size	100 mUI
Max Jitter Frequency	150 MHz
ISI Channel	0 GHz: 0 dB, 3 GHz: -15.1 dB
Embed Custom Channel	True
Custom Channel Transfer Function File	C:\Filters\SATA_CustomChannel.tf4
Custom Channel + CIC Transfer Function File	C:\Filters\SATA_CustomChannel_and_CIC.tf4
Skip Instrument Reset	False

Set Jitter [mUI]	Sinusoidal Jitter (5 MHz) [mUI]	Sinusoidal Jitter (10 MHz) [mUI]	Sinusoidal Jitter (33 MHz) [mUI]	Sinusoidal Jitter (62 MHz) [mUI]	Sinusoidal Jitter (90 MHz) [mUI]	Sinusoidal Jitter (120 MHz) [mUI]	Sinusoidal Jitter (150 MHz) [mUI]
0	7	7	7	7	7	7	7
100	105	105	105	105	105	105	105
200	203	203	203	203	203	203	203
300	301	301	301	301	301	301	301
400	399	399	399	399	399	399	399

Figure 16 HTML Report for Sinusoidal Jitter Calibration Test

- Set Jitter: The jitter amplitude set in the instrument.
- Sinusoidal Jitter (X MHz): This is the measured value of SJ in mUI (milli unit interval) while applying the “Set Jitter” value.

De-Emphasis Calibration Test

The De-Emphasis Calibration procedure is available for all data rates when the “Use de-emphasis box” is checked in SATA Edit Parameters Panel (see Figure 8).

Purpose and Method

The purpose of this procedure is to calibrate the de-emphasis.

The pattern generator sends a Framed COMP pattern to the oscilloscope and then the de-emphasis value is added to the data signal. The set de-emphasis value starts with a default value of Start De-Emphasis and it is increased linearly with the value of De-Emphasis Step Size. At each step, the actual de-emphasis value is measured using the oscilloscope and the results of set and measured values are stored separately before the value is increased for the next step.

Connection Diagram

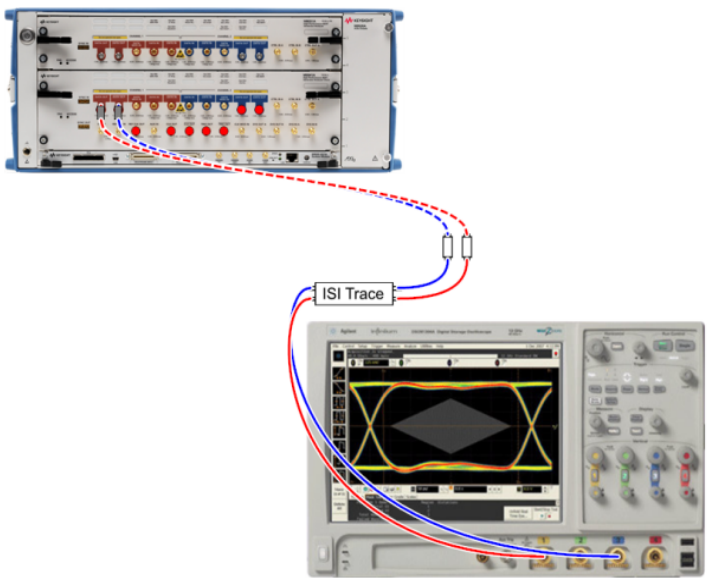


Figure 17 Connection Diagram for De-Emphasis Calibration

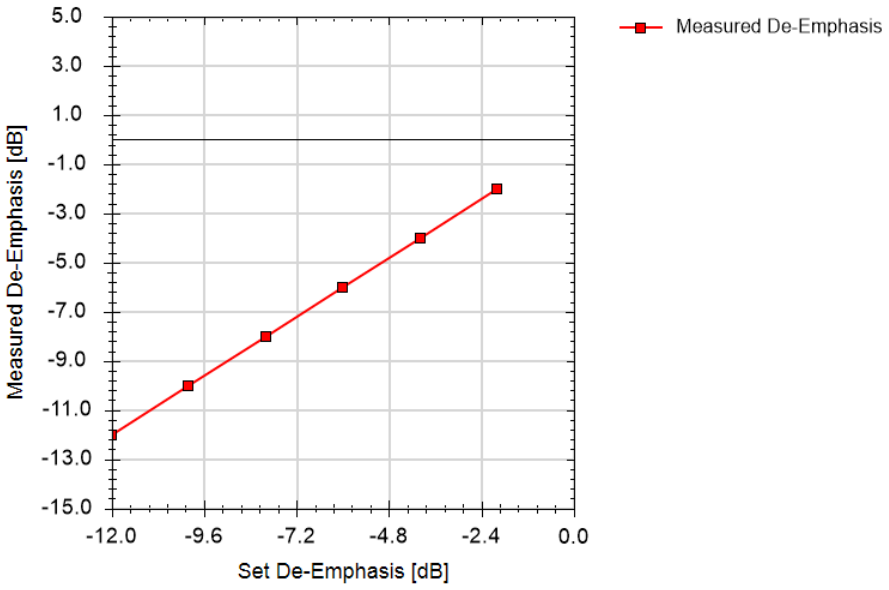
Parameters in Expert Mode

- Start De-Emphasis: This is the initial de-emphasis value set for the calibration.

Result Description

1_5G DeEmphasis Cal

for UTD 1.5 i Device



Test Pattern	FramedCOMP_2Align_NewLBP
Data Generator	Keysight M8020A J-BERT, Keysight M8020A J-BERT, SN: Unknown
Offline	True
Start De-Emphasis	-12 dB
Embed Custom Channel	False
Skip Instrument Reset	False

Set De-Emphasis [dB]	Measured De-Emphasis [dB]
-12.0	-12.000
-10.0	-10.000
-8.0	-8.000
-6.0	-6.000
-4.0	-4.000
-2.0	-2.000

Figure 18 HTML Report for De-Emphasis Calibration Test

- Set De-Emphasis: This is the set de-emphasis value in the instrument.
- Actual De-Emphasis: This is the measured de-emphasis value at the corresponding set value.

Differential Voltage Calibration Test

The Differential Voltage Calibration procedure is available for all data rates.

Purpose and Method

The purpose of this procedure is to calibrate the differential amplitude of the signal.

The method for the Differential Voltage Calibration changes depending on the selected UTD version. The basic principle of this procedure is that the pattern generator sends a pattern to the real-time oscilloscope. Then it sets the default value as the first differential voltage value and increases this linearly with a step size value. At each step, the oscilloscope measures the actual differential voltage values according to the set differential voltage values.

Patterns

For the Framed COMP pattern a lone bit pattern (LBP) is used. This pattern contains the following:

1 Five ‘0’s followed by one ‘1’ (1000001, lone ‘1’)

2 Five ‘1’s followed by one ‘0’ (0111110, lone ‘0’)

The lone bit has the lowest differential amplitude that can occur during the transmission of valid 10-bit SATA symbols. For the calibration procedure, either the full Framed COMP pattern or the LBP can be used.

Signal stress

The calibration can be done with or without inter-symbol interference (ISI), RJ, and SJ.

Measurement methods

- Lone bit amplitude: The oscilloscope is triggered to find the measured values of the lone bit and the amplitude of the bit.
- Extrapolated eye opening: The inner eye height is measured with a histogram and extrapolated to the required bit error rate (BER).
- Fixed length eye opening: The inner eye height is measured over 5 E-6 UI.

Table 6 SATA Common Parameters

Version	Pattern	Signal Stress	Measurement Method
= UTD 1.3	Framed COMP	No	Lone Bit Amplitude
UTD 1.4	Framed COMP	Yes	Extrapolated Eye Opening
UTD 1.4.2	LBP	Yes	Fixed Length Eye Opening
UTD 1.4.3	Framed COMP	Yes	Fixed Length Eye Opening with narrow histogram

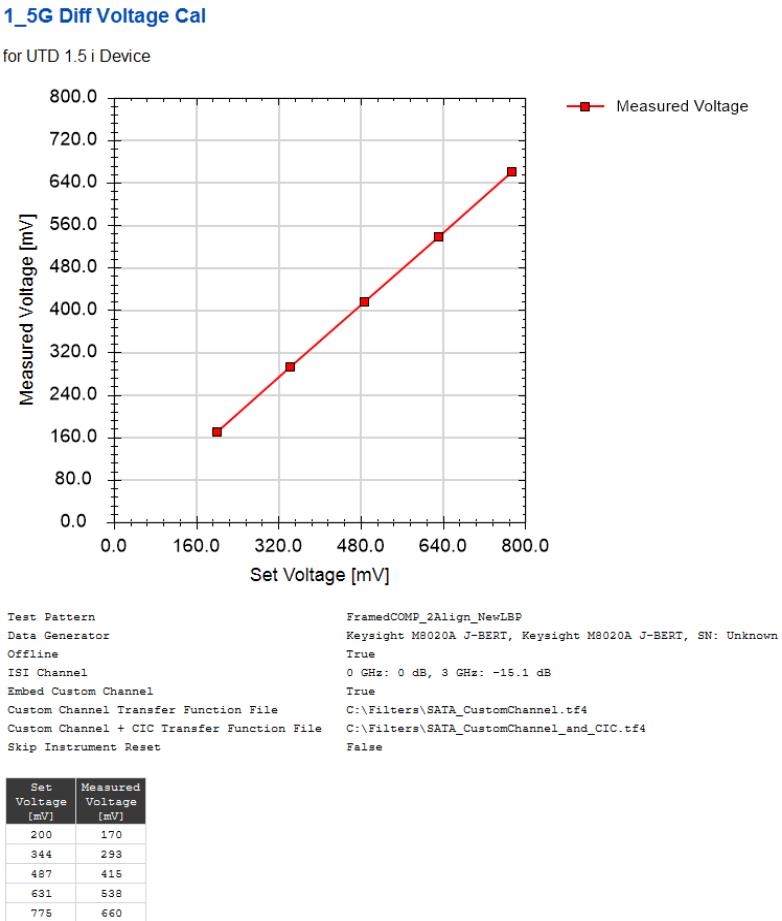
Connection Diagram

Same as in Figure 17.

Parameters in Expert Mode

None

Result Description



Test Pattern	FramedCOMP_2Align_NewLBP
Data Generator	Keysight M8020A J-BERT, Keysight M8020A J-BERT, SN: Unknown
Offline	True
ISI Channel	0 GHz: 0 dB, 3 GHz: -15.1 dB
Embed Custom Channel	True
Custom Channel Transfer Function File	C:\Filters\SATA_CustomChannel.tf4
Custom Channel + CIC Transfer Function File	C:\Filters\SATA_CustomChannel_and_CIC.tf4
Skip Instrument Reset	False

Set Voltage [mV]	Measured Voltage [mV]
200	170
344	293
487	415
631	538
775	660

Figure 19 HTML Report for Differential Voltage Calibration Test

- Set Voltage: The differential voltage (peak–peak) set at the data generator.
- Measure Voltage: This is the measured value of differential voltage at the corresponding set value.

5 Receiver Tests

The basic principle of all SATA receiver tests is as follows:

- Keep the DUT in the Far End Re-timed Loopback Mode (BIST-L)
- Send the Framed COMP pattern with defined stress characteristics
- Use the error detector to verify that the DUT loops back the correct pattern without errors

Most of the Rx tests remain changing the signal stress to collect more data and re-initialize the loopback mode if the DUT terminates from it. If the calibration data is available, the data confirms that the signal stress is at the specified level and test point. If the calibration data is missing, a warning message pops up. When the user explicitly ignores the warning, the tests can be run without the calibration data.

NOTE For Rx tests, the real-time oscilloscope is not needed.

Common Parameters for Receiver Tests

Table 7 Common Parameters for Receiver Tests

Parameter name	Parameter Description
Data Generator	
Number of aligns in Framed COMP pattern	This is the number of ALIGN primitives in each ALIGN block in the test pattern used for receiver tests. This setting has no effect on the part of the training sequence before the looped test pattern.
Error Detector	
Recovery Time	This is the time after the loopback training or changing signal stress the DUT is allowed to settle. Errors during this time are ignored.
Use full Auto Align	This parameter controls how centering the sample point in the error detector is done. If it is “true” a full AutoAlign is used. If it is “false” TimeCenter is used instead. TimeCenter is a lot faster than AutoAlign, but AutoAlign is better at compensating for non-ideal DUT transmitter signals. This parameter is not available if a BusXpert is selected as the error detector.
Data Rate Mode	It has two options, ‘Specific’ and ‘Automatic’. If this is set to “Specific” the BusXpert is set up to expect the specific data rate at which the procedure is running. If it is set to “Automatic” the BusXpert is set up to find the correct data rate automatically. This parameter is only available if a BusXpert is selected as the error detector.
BIST Training	
Force Retraining	When this parameter is “true”, a new loopback training is always done when the SJ frequency changed.
Power Cycle Mode	Controls when a power cycle is performed or requested from the user. ▪ Always: a power cycle is done before every attempt to train the DUT into loopback. ▪ OnlyOnRetry: first try loopback training is done without a power cycle, and only power cycle if that did not work. ▪ Never: no power cycles will be performed or requested. ▪ Loopback Training Max Retries: This is the maximum number of retries to train the DUT into loopback mode. ▪ BIST Activation Sequence: This parameter displays the BIST sequence type selected using the sequence drop-down menu in the Edit Parameters window.
Power Switch Automation	
Use Power Switch Automation	This parameter controls if a remote controllable power switch is used for power cycling the DUT. If it is “false”, all following parameters (Power Switch Channel Number, Off-On delay, Settling Time) are disabled.
Power Switch Channel Number	This sets the channel number of the power switch channel which is connected to the DUT.
Power Cycle Off-On Delay	This is the duration between turning the DUT off and then turning it on again.
Power Cycle Settling Time	This is the wait time after the DUT is turned on and before the test continues with loopback training.

Table 8 Common Parameters for Data Rate specific

Parameter name	Parameter Description
Error Detector	
CDR Bandwidth	This is the loop bandwidth of the error detector clock data recovery (CDR) unit.
CDR Peaking	This is the loop bandwidth of the error detector clock data recovery (CDR) unit. It can be set to “low”, “medium” or “high”.
Transition Density	This is the expected transition density at the error detector used to optimize the internal CDR settings.

SATA Receiver Tests

Rx Jitter Tolerance Test (RSG-01 Gen1, RSG-02 Gen2, and RSG-03 Gen3)

The Rx Jitter Tolerance test is available for all data rates.

Purpose and Method

This Rx Jitter Tolerance Test verifies that the receiver is able to recover the data in presence of jitter and it is an official Rx test that has to be passed in order to obtain SATA certification. This test is available for all data rates such as:

- RSG-01 Gen1 Rx Jitter Tolerance Test runs at 1.5 Gbit/s
- RSG-02 Gen2 Rx Jitter Tolerance Test runs at 3.0 Gbit/s
- RSG-03 Gen3 Rx Jitter Tolerance Test runs at 6.0 Gbit/s

A compliant DUT must pass all the tests including that for the highest data rate required to support. Refer to the beginning of the Receiver Test Procedures (Receiver Tests) for a description of the general operating principle of all SATA receiver tests.

The stress signal is applied to the data signal is RJ and SJ. There is a set of compliance frequencies for the SJ. For each frequency, the DUT has to loop back the pattern for the complete test duration without error. The test duration for a single frequency at different data rates is given as:

- 10 minutes for RSG-01 Gen1 (1.5 Gbit/s)
- 5 minutes for RSG-02 Gen2 (3.0 Gbit/s)
- 2.5 minutes for RSG -03 Gen3 (6.0 Gbit/s)

The compliance jitter frequencies for UTD 1.2 are 5 MHz, 33 MHz, and 62 MHz. For UTD 1.3 and higher versions, 10 MHz is added to the frequencies that are available for UTD 1.2.

Connection Diagram

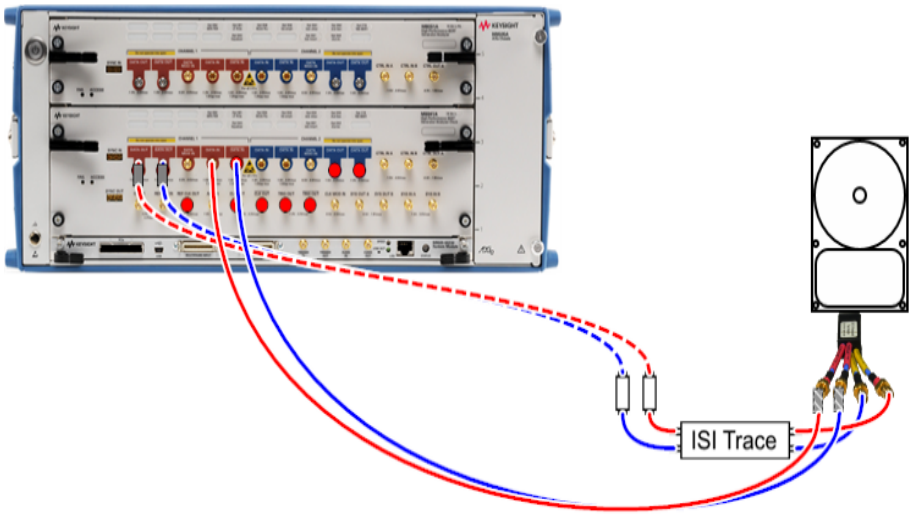


Figure 20 Connection Diagram for Receiver Tests

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Test Duration: The duration of the frame error measurement at each SJ frequency.

Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- Total Jitter (TJ): The amount of calibrated TJ added to the signal. This is only available for UTD versions < 1.4.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal. This is only available for UTD versions = 1.4.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

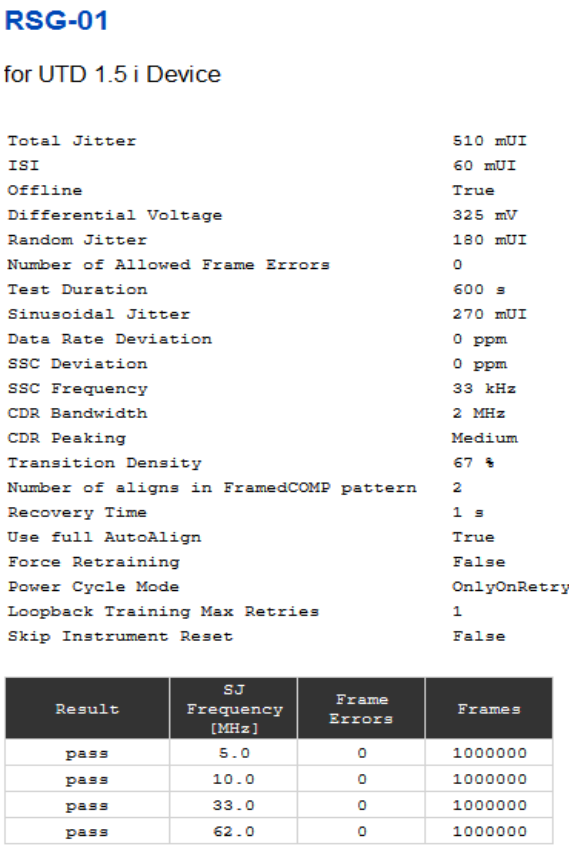
Error Detector

- Show Additional Counters: Additional counters, such as the frame counter, are shown in the result table.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



RSG-01

for UTD 1.5 i Device

Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	0
Test Duration	600 s
Sinusoidal Jitter	270 mUI
Data Rate Deviation	0 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	SJ Frequency [MHz]	Frame Errors	Frames
pass	5.0	0	1000000
pass	10.0	0	1000000
pass	33.0	0	1000000
pass	62.0	0	1000000

Figure 21 Example HTML Viewer for Jitter Tolerance Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- SJ Frequency: This is the frequency value of the SJ that is applied to the test signal.
- Frame Errors: The number of frame errors that occurred during the observation time.
- Min Spec Diff. Swing: The required minimum differential swing voltage level (optionally defined through user-spec instead of CTS)
- Max Swing Test: The maximum applied differential swing voltage level

RSG-05 Receiver Stress Test at +350 ppm (for 1.5 Gbit/s) Test

This test is only available for 1.5 Gbit/s data rate.

Purpose and Method

This is the official receiver data rate deviation tolerance test that has to be passed in order to obtain SATA certification. It was introduced in UTD version 1.4 and so is not available for earlier versions. This test is always performed at the data rate 1.5 Gbit/s even if the DUT supports the higher data rates.

A data rate deviation of +350 ppm is applied to the data signal. The UTD specifies that this test must run for at least 18 successive iterations of the Framed COMP pattern, which is a bit more than 1 ms. The test runs for a whole second.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Test Duration: The duration of the frame error measurement at each SJ frequency.

Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- Total Jitter (TJ): The amount of calibrated TJ added to the signal. This is only available for UTD versions < 1.4.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal. This is only available for UTD versions = 1.4.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

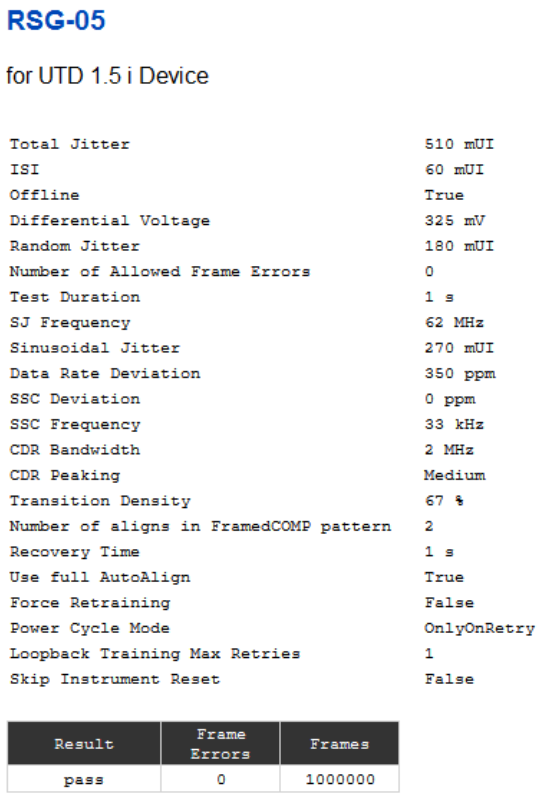
Error Detector

- Show Additional Counters: Additional counters, such as the frame counter, are shown in the result table.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



RSG-05

for UTD 1.5 i Device

Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	0
Test Duration	1 s
SJ Frequency	62 MHz
Sinusoidal Jitter	270 mUI
Data Rate Deviation	350 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Frame Errors	Frames
pass	0	1000000

Figure 22 Example HTML Viewer for Receiver Stress Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Frame Errors: The number of frame errors that occurred during the observation time.

RSG-06 Receiver Stress Test with SSC (for 1.5 Gbit/s) Test

Purpose and Method

This is the official receiver SSC tolerance test defined in the UTD. It is defined as an informative test, so passing it is not required to obtain SATA certification. It was introduced in UTD version 1.4 and so is not available for earlier versions. This test is always performed at the data rate 1.5 Gbit/s, even if the DUT supports higher data rates.

The stress signal that is applied to the data signal for this test is 5000 ppm down-spread SSC at 33 kHz and a Data Rate Deviation of –350 ppm. The UTD specifies that this test must run for at least 18 successive iterations of the Framed COMP pattern, which is a bit more than 1 ms. The test run for a whole second.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Test Duration: The duration of the frame error measurement at each SJ frequency.

Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- Total Jitter (TJ): The amount of calibrated TJ added to the signal. This is only available for UTD versions < 1.4.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal. This is only available for UTD versions = 1.4.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

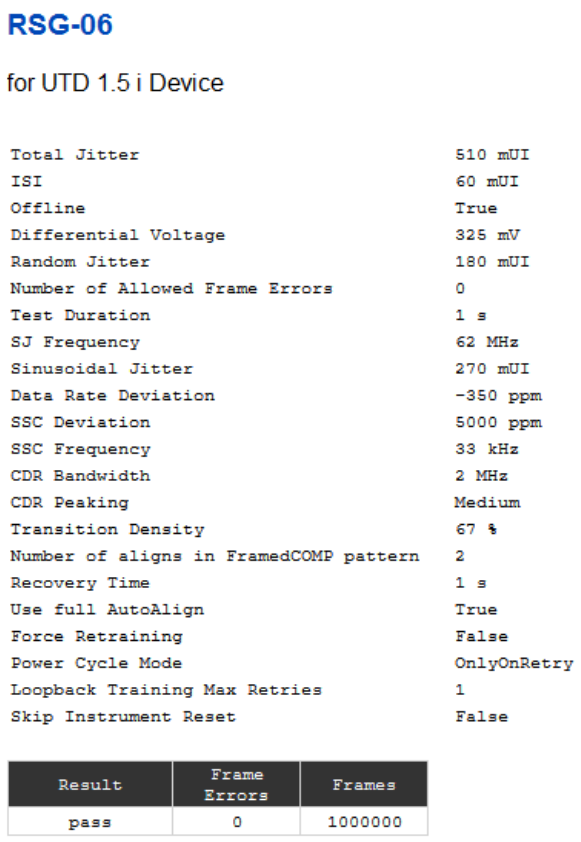
Error Detector

- Show Additional Counters: Additional counters, such as the frame counter, are shown in the result table.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



RSG-06

for UTD 1.5 i Device

Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	0
Test Duration	1 s
SJ Frequency	62 MHz
Sinusoidal Jitter	270 mUI
Data Rate Deviation	-350 ppm
SSC Deviation	5000 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Frame Errors	Frames
pass	0	1000000

Figure 23 Example HTML Viewer for Receiver Stress Test with SSC

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Frame Errors: The number of frame errors that occurred during the observation time.

Rcvr Constant Parameter Stress Test

This test is available for all data rates.

Purpose and Method

The Rcvr Constant Parameter Stress Test examines the DUT with a combination of jitter parameters where the Rcvr Jitter Tolerance Test or one of the compliance tests raises a problem with the specific combination.

This is a debugging test and very similar to the RSG-01 / RSG-02 / RSG-03 Rx Jitter Tolerance Tests. The only difference is that only one FER measurement is performed. The frequency of the SJ component can be selected.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Test Duration: The duration of the frame error measurement at each SJ frequency.

Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- Total Jitter (TJ): The amount of calibrated TJ added to the signal. This is only available for UTD versions < 1.4.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal. This is only available for UTD versions = 1.4.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

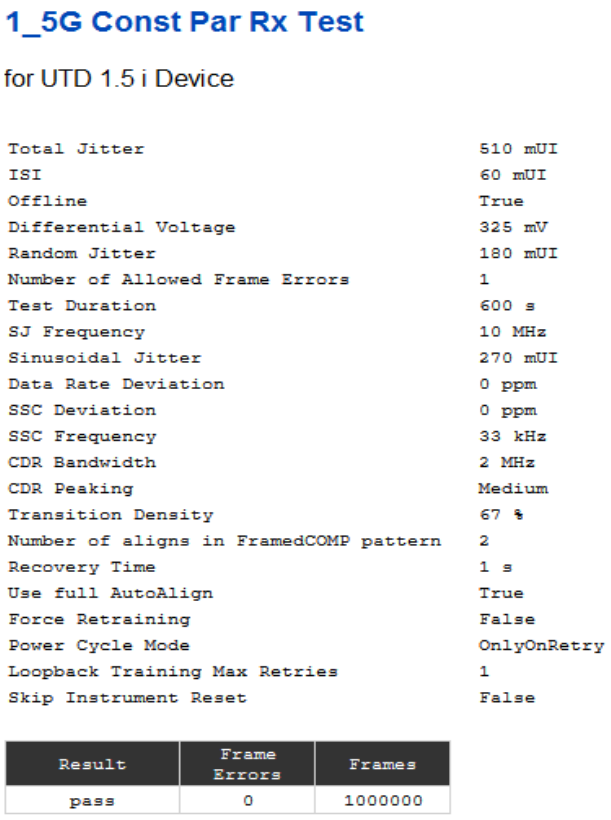
Error Detector

- Show Additional Counters: Additional counters, such as the frame counter, are shown in the result table.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



1_5G Const Par Rx Test

for UTD 1.5 i Device

Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	1
Test Duration	600 s
SJ Frequency	10 MHz
Sinusoidal Jitter	270 mUI
Data Rate Deviation	0 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Frame Errors	Frames
pass	0	1000000

Figure 24 Example HTML Viewer for Constant Parameter Stress Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Frame Errors: The number of frame errors that occurred during the observation time.

Rcvr Jitter Tolerance Test

Purpose and Method

The Rcvr Jitter Tolerance Test determines how much jitter a DUT can tolerate at different SJ frequencies. This test is available for all data rates.

The test procedure depends on the selected value of the Search Algorithm property. The different types of Search Algorithms are explained below. The selected algorithm is sequentially used over a range of jitter frequencies defined with the Min Jitter Frequency, Max Jitter Frequency, Number of Frequency steps and Include Compliance Frequencies properties. At each jitter frequency value the maximum jitter amplitude where the DUT produced no more frame errors than the Number of Allowed Frame Errors is stored as the max passed jitter value. The result is a curve that shows the maximum jitter that the DUT can tolerate over the SJ frequency. It reflects the Rx clock data recovery (CDR) characteristics of the DUT. Typically the CDR can follow low frequency jitter (f < Rx phase-locked loop (PLL) bandwidth) better than high frequency jitter (f > Rx PLL bandwidth).

Search Algorithms

- LinearUp
  This starts with a value of '0' and increases linearly with the value of Jitter Step Size until a test point is failed.
- LinearUp2Layer
  LinearUp2Layer starts with '0' and increases linearly using large steps. When an error is found, it jumps back to the previous test point (which passed the test) and starts increasing linearly with small steps of Jitter Step Size value. The size of the larger steps depends on the relation between Jitter Step Size and the maximum jitter possible with the setup. It is calculated as:

$$\text{Small Step Size} \cdot \sqrt{(\text{Max Jitter}/\text{Small Step Size})}$$

- LinearUpHysteresis

LinearUpHysteresis uses large steps to go linearly up from '0'. If an error occurs, it starts testing from the last test point where the DUT passed the test. If it fails again, it goes down to the previous passed test point and starts again with mid-sized steps until it succeeds. From there it increases with small steps of Jitter Step Size value until an error is found again. The size of the large steps is calculated the same way as for LinearUp2Layer. The size of the medium steps is calculated as:

$$\text{Small Step Size} = \sqrt{(\text{Big Step Size} / \text{Small Step Size})}$$

The stepping down with the mid-sized steps is conducted to ensure that DUTs with hysteresis do not stop the testing process in their failed-state when the final part of the search algorithm starts. For DUTs that do not have any hysteresis the search is performed almost identical to LinearUp2Layer, there is only one test point more.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Number of Frames: The number of frames used for frame error measurement.
- Frequency Mode: It can be selected as:
  - Compliance Frequencies
  - Equally Spaced Frequencies
  - User Defined Frequencies
  - Single Frequency
- Frequency Scale: It is chosen as Linear or Logarithmic scale.
- Min Jitter Frequency: The first and smallest frequency used for the test.
- Max Jitter Frequency: It is the maximum value of the jitter frequency for the procedure.
- Number of Frequency Steps: The number of different jitter frequencies that are tested. The distribution of frequencies between minimum and maximum is equidistant on a logarithmic scale.
- Include Compliance Frequencies: If this value is set to true, the test uses the frequencies defined for the compliance test. The frequencies are defined by minimum and maximum number of steps.
- Start Sinusoidal Jitter: It is the initial value of the SJ for the procedure.
- Jitter Step Size: It is the jitter value to be increased/decreased at each step of the procedure.
- Search Algorithm: Select how the test searches for the fail point for each frequency.

Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

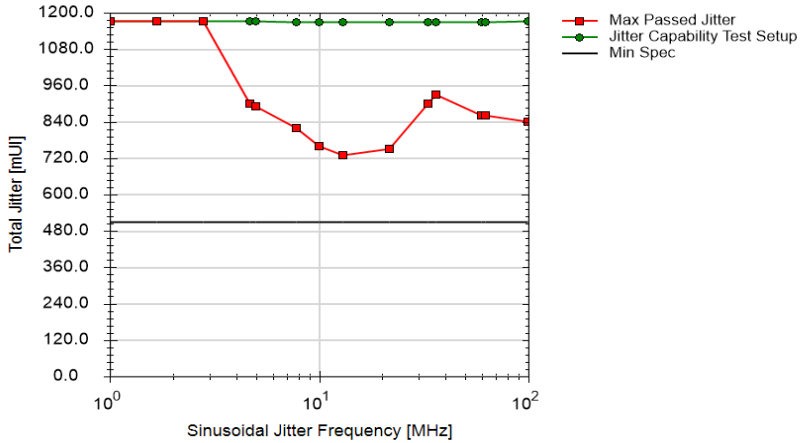
Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description

1_5G Rcvr Jitter Tol

for UTD 1.5 i Device



The device under test shall tolerate up to 510 mUI of total jitter at 5, 10, 33 and 62.5 MHz	
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	1
Number of Frames	5000
Frequency Mode	Equally Spaced Frequencies
Frequency Scale	Logarithmic
Min Jitter Frequency	1 MHz
Max Jitter Frequency	100 MHz
Number of Frequency Steps	10
Include Compliance Frequencies	True
Data Rate Deviation	0 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Sinusoidal Jitter Frequency [MHz]	Max Passed Jitter [mUI]	Jitter Capability Test Setup [mUI]	Min Spec [mUI]	Margin [%]
pass	1.00	1173	1173	510	130.0
pass	1.67	1173	1173	510	130.0
pass	2.78	1172	1172	510	129.8
pass	4.64	900	1171	510	76.5
pass	5.00	890	1171	510	74.5
pass	7.74	820	1170	510	60.8

Figure 25 Example HTML Viewer for Jitter Tolerance Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Sinusoidal Jitter Frequency: This is the value of SJ frequency applied to the test signal.
- Max Passed Jitter: This is the maximum value of SJ that the DUT can tolerate at a specific SJ frequency.
- Jitter Capability Test Setup: This is the maximum value of jitter that the test setup can generate at a specific SJ frequency.
- Min Spec: This is the smallest value of jitter that the DUT must tolerate in order to pass the test.
- Margin: This is the margin between the max passed jitter and min spec.

Rcvr Sensitivity Test

This test is available for all data rates.

Purpose and Method

This Rcvr Sensitivity Test characterizes that the DUT can still work with the minimum differential voltage.

This method starts with the value Start Voltage and steps linearly down with Voltage Step Size value until either an error is found or the Stop Voltage value is reached without an error. The minimum passed value is the final test point that did not return an error.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Number of Frames: The number of frames used for frame error measurement.
- Start Voltage: The value at which the test starts with initial calibrated eye opening at TP2.
- Stop Voltage: The last calibrated eye opening at TP2.
- Voltage Step Size: The amount the calibrated eye opening at TP2 is changed from step to step.

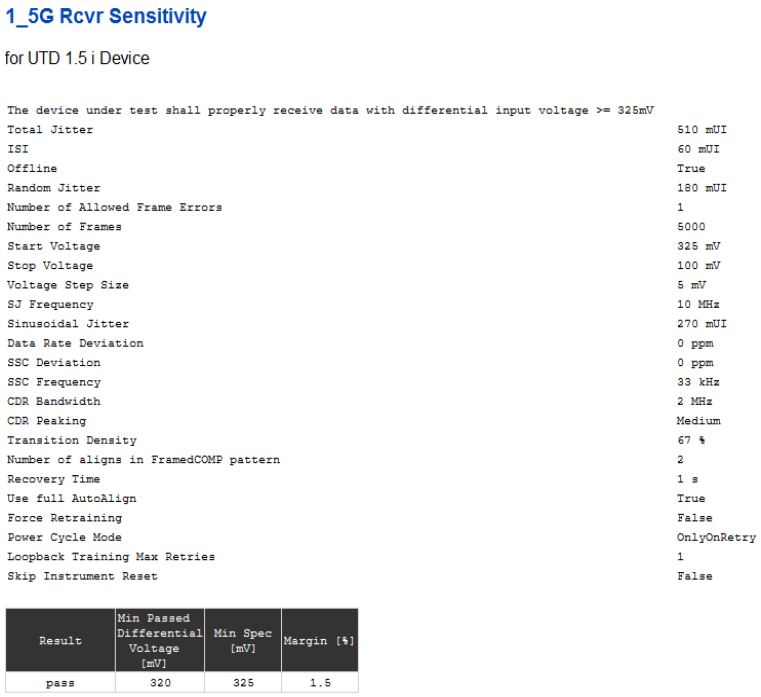
Data Generator

- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- SJ Frequency: The frequency of the calibrated SJ added to the signal.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal.
- Data Rate Deviation: A fixed deviation from the nominal data rate.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



1_5G Rcvr Sensitivity

for UTD 1.5 i Device

The device under test shall properly receive data with differential input voltage >= 325mV	
Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Random Jitter	180 mUI
Number of Allowed Frame Errors	1
Number of Frames	5000
Start Voltage	325 mV
Stop Voltage	100 mV
Voltage Step Size	5 mV
SJ Frequency	10 MHz
Sinusoidal Jitter	270 mUI
Data Rate Deviation	0 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Min Passed Differential Voltage [mV]	Min Spec [mV]	Margin [%]
pass	320	325	1.5

Figure 26 Example HTML Viewer for Sensitivity Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Min Passed Differential Voltage: This is the minimum differential eye opening that the DUT can tolerate.
- Min Spec: This is the minimum differential eye opening for which the DUT must pass the test.
- Margin: This is the margin between min passed differential voltage and min spec.

Rcvr Data Rate Deviation Tolerance Test

This test is available for all data rates.

Purpose and Method

This test assures that the DUT can still work with the maximum data rate deviation (positive and negative).

The test starts with the value of '0' ppm and decreases linearly with Deviation Step Size value until the value of Min Deviation is reached. When an error is found, it jumps back to the previous passed test point and starts stepping down again with the Deviation Step Size value until an error is found. The minimum passed value is the final test point that returns no error. The larger step size value used for this test depends on the relation between Deviation Step Size and Min Deviation. It is calculated as:

$$\text{Deviation Step Size} * \sqrt{|(\text{Min Deviation})/\text{Deviation Step Size}|}$$

For the default values of Deviation Step Size = 10 ppm and Min Deviation = –1000 ppm, the value of an initial step size is 100 ppm. Once the minimum passed value has been found, the test performs the same method for the higher limit with Max Deviation and positive steps instead of Min Deviation and negative steps. This algorithm avoids initializing a DUT repeatedly, which makes the DUT come out of loopback mode. If an error occurs, it requires fewer test points than a simple linear search.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Number of Frames: The number of frames used for frame error measurement.
- Deviation Step Size: The minimum distance between two tested data rate deviations.
- Min Deviation: If no error occurs, this is the lowest data rate deviation that is tested.
- Max Deviation If no error occurs, this is the highest data rate deviation that is tested.

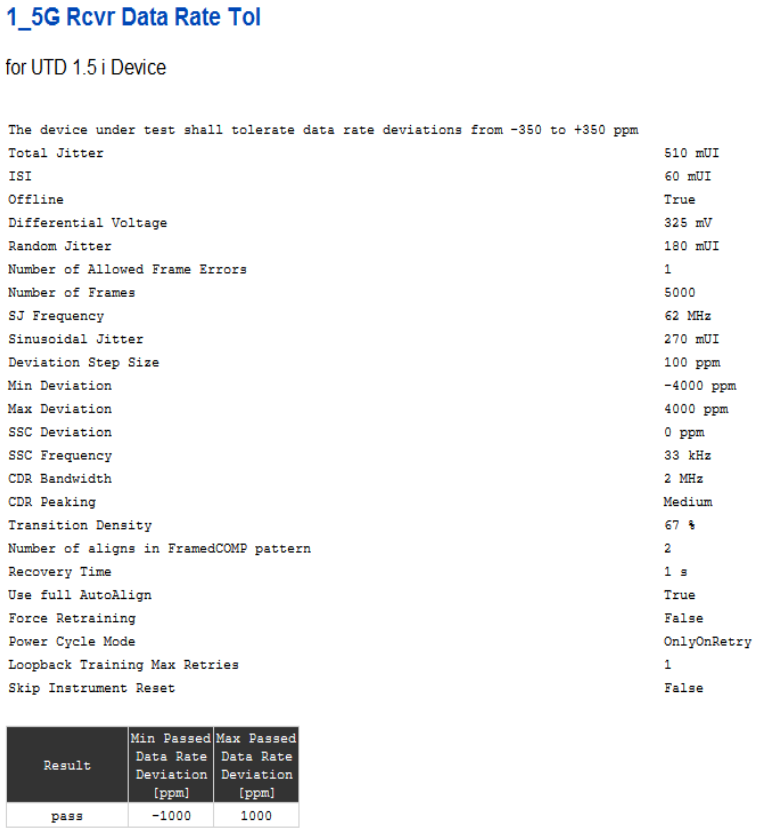
Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- SJ Frequency: The frequency of the calibrated SJ added to the signal.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal.
- SSC Deviation: Maximum amount of deviation from the nominal data rate due to down-spread SSC modulation.
- SSC Frequency: The frequency of the SSC modulation.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



1_5G Rcvr Data Rate Tol

for UTD 1.5 i Device

The device under test shall tolerate data rate deviations from -350 to +350 ppm	
Total Jitter	510 mUI
ISI	60 mUI
Offline	True
Differential Voltage	325 mV
Random Jitter	180 mUI
Number of Allowed Frame Errors	1
Number of Frames	5000
SJ Frequency	62 MHz
Sinusoidal Jitter	270 mUI
Deviation Step Size	100 ppm
Min Deviation	-4000 ppm
Max Deviation	4000 ppm
SSC Deviation	0 ppm
SSC Frequency	33 kHz
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	Min Passed Data Rate Deviation [ppm]	Max Passed Data Rate Deviation [ppm]
pass	-1000	1000

Figure 27 Example HTML Viewer for Data Rate Deviation Tolerance

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- Min Passed Data Rate Deviation: This is the minimum passed data rate deviation that the DUT can tolerate.
- Max Passed Data Rate Deviation: This is the maximum passed data rate deviation that the DUT can tolerate.

Rcvr SSC Tolerance Test

This test is available for all data rates.

Purpose and Method

This test characterizes that the DUT can still work with the maximum down spread SSC.

First, this method uses relatively large steps to step linearly down from '0' ppm using the value of SSC Step Size until the value of Max SSC Deviation is reached. When an error is found, it goes back to the previous passed test point. It steps down from there with the selected SSC Step Size value until an error occurs again. The maximum passed value is the final test point that did not return any error. The step size value for the larger steps at the beginning depends on the relation between the “SSC Step Size” and Max Deviation. It is calculated as:

$$\text{SSC Step Size} * \sqrt{|(\text{Max SSC Deviation})|/\text{SSC Step Size}}$$

For the default values of SSC Step Size = 50 ppm and Max Deviation = 5000 ppm, the value of initial step size is 500 ppm. Once the maximum passed value has been found, the test performs the same method as above for the lower limit with Min SSC Deviation and negative steps instead of Max SSC Deviation and positive steps. This algorithm avoids initializing a DUT repeatedly, which makes the DUT come out of the loopback mode. If an error is encountered, it requires fewer test points than a simple linear search.

Connection Diagram

Refer to Figure 20.

Parameters in Expert Mode

- Number of Allowed Frame Errors: This is the number of frame errors that are allowed. The default value is '0'.
- Number of Frames: The number of frames used for frame error measurement.
- SSC Step Size: The minimum distance between two tested SCC.
- Max SSC Deviation: If no error occurs, this is the highest SSC deviation to be tested.

- Min SSC Frequency This is the minimum value of the SSC frequency to be used for the procedure.
- Max SSC Frequency This is the maximum value of the SSC frequency to be tested.
- Number of SSC Frequency Steps: It is the number of different SSC frequencies to be tested. The distribution of frequencies between minimum and maximum are equidistant.

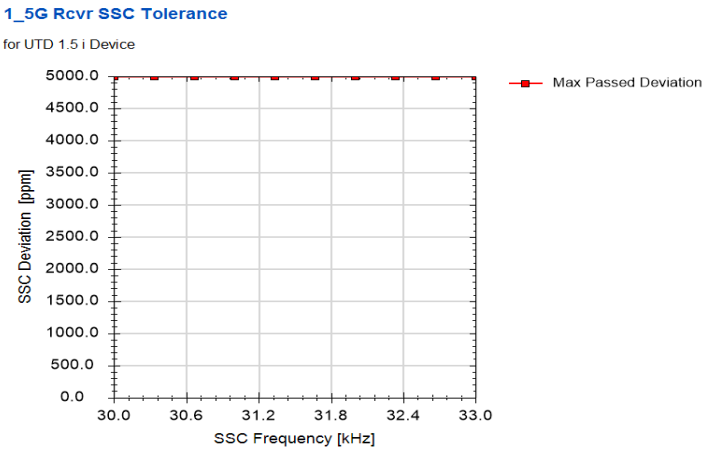
Data Generator

- Differential Voltage: The calibrated inner eye height at TP2.
- Random Jitter (RJ): The amount of calibrated RJ added to the signal.
- SJ Frequency: The frequency of the calibrated SJ added to the signal.
- Sinusoidal Jitter (SJ): The amount of calibrated SJ added to the signal.
- Data Rate Deviation: A fixed deviation from the nominal data rate.

Used Calibrations

- Random Jitter Calibration
- Sinusoidal Jitter Calibration
- Differential Voltage Calibration

Result Description



Number of Allowed Frame Errors	1
Number of Frames	5000
SJ Frequency	62 MHz
Sinusoidal Jitter	270 mUI
Data Rate Deviation	-350 ppm
SSC Step Size	50 ppm
Max SSC Deviation	5000 ppm
Min SSC Frequency	30 kHz
Max SSC Frequency	33 kHz
Number of SSC Frequency Steps	10
CDR Bandwidth	2 MHz
CDR Peaking	Medium
Transition Density	67 %
Number of aligns in FramedCOMP pattern	2
Recovery Time	1 s
Use full AutoAlign	True
Force Retraining	False
Power Cycle Mode	OnlyOnRetry
Loopback Training Max Retries	1
Skip Instrument Reset	False

Result	SSC Frequency [kHz]	Max Passed Deviation [ppm]
pass	30.000	5000
pass	30.333	5000
pass	30.667	5000
pass	31.000	5000
pass	31.333	5000
pass	31.667	5000
pass	32.000	5000
pass	32.333	5000
pass	32.667	5000
pass	33.000	5000

Figure 28 Example HTML Viewer for SSC Tolerance Test

- Result: “Pass”/“Fail”, if the FER test at a specific frequency is passed, the value is “Pass” otherwise “Fail”.
- SSC Frequency: This is the value of the SSC frequency applied to the signal
- Max Passed Deviation: This is the maximum passed SSC deviation that the DUT can tolerate.

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