Agilent U7243A USB 3.0 Electrical Compliance Test Application

Methods of Implementation

Agilent Technologies

Notices

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USB 3.0 Electrical Compliance Test Application — At A Glance

The Agilent U7243A USB 3.0 Electrical Compliance Test Application helps you verify the USB 3.0 device complies to the electrical requirements on the SuperSpeed physical layer as defined in the USB 3.0 specification, with the Agilent Infiniium digital storage oscilloscopes. The USB 3.0 Electrical Compliance Test Application:

- Lets you select individual or multiple tests to run.
- Lets you identify the device being tested and its configuration.
- Shows you how to make oscilloscope connections to the device under test.
- Automatically checks for proper oscilloscope configuration.
- Automatically sets up the oscilloscope for each test.
- Provides detailed information for each test that has been run and lets you specify the thresholds at which marginal or critical warnings appear.
- Creates a printable HTML report of the tests that have been run.

NOTE

The tests performed by the USB 3.0 Electrical Compliance Test Application are intended to provide a quick check of the electrical health of the DUT. This testing is not a replacement for an exhaustive test validation plan.

Compliance testing measurements are described in the *Universal Serial Bus (USB) 3.0 Specification revision 1.0*. For more information, see the USB 3.0 standards web site at www.usb.org.

Required Equipment and Software

In order to run the USB 3.0 Electrical Compliance Test Application, you need the following equipment and software:

- U7243A USB 3.0 Electrical Compliance Test Application software.
- 80000B or 90000A Series Infiniium Digital Storage Oscilloscope (DSO). Agilent recommends using 13 GHz and higher bandwidth oscilloscope, with at least 1M memory depth.
- Version 5.71 or greater of Infiniium software (80000B Series oscilloscope) OR
- Version 1.40 or greater of Infiniium software (90000A Series oscilloscope).
- Agilent also recommends using a second monitor to view the automated test application.
- Precision BNC to SMA adapter, quantity = 2.
- 50 ohm coaxial cable (24 inches or shorter), quantity = 2 OR
- 1169A Infiniimax probe, quantity = 2.

- U7242A USB 3.0 test fixture.
- Keyboard, quantity = 1 (provided with Agilent Infiniium oscilloscope).
- Mouse, quantity = 1 (provided with Agilent Infiniium oscilloscope).

Below is the required license:

- U7243A USB 3.0 Electrical Compliance Test Application license.
- E2688A Serial Data Analysis and Clock Recovery software (optional).
- N5401A EZJIT Plus software (optional).

In This Book

This manual describes the tests that are performed by the USB 3.0 Electrical Compliance Test Application in more detail; it contains information from (and refers to) the *Universal Serial Bus (USB) 3.0 Specification revision 1.0* and it describes how the tests are performed.

- Chapter 1, “Installing the USB 3.0 Electrical Compliance Test Application” shows how to install and license the automated test application software (if it was purchased separately).
- Chapter 2, “Preparing to Take Measurements” shows how to start the USB 3.0 Electrical Compliance Test Application and gives a brief overview of the required preparation and how the application is used.
- Chapter 3, “Near End (TP0) Transmitter Eye Tests” contains the details of the this Near End, TP0 tests as specified in the *Universal Serial Bus (USB) 3.0 Specification revision 1.0*.
- Chapter 4, “Far End (TP1) Transmitter Eye Tests” contains the details of the this Far End, TP1 tests as specified in the *Universal Serial Bus (USB) 3.0 Specification revision 1.0*.
- Chapter 5, “Calibrating the 80000B and 90000A Series Infiniium Oscilloscopes” describes how to calibrate the oscilloscope in preparation for running the USB3.0 automated tests.

See Also

- The USB 3.0 Electrical Compliance Test Application’s online help, which describes:
  - Creating or opening a test project.
  - Setting up tests.
  - Selecting tests.
  - Configuring selected tests.
  - User-defined compliance limits
  - Connecting the oscilloscope to the DUT.
  - Running tests.
  - Viewing test results.
  - Viewing/printing the HTML test report.
  - Saving test projects.

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1
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If you purchased the U7243A USB 3.0 Electrical Compliance Test Application separately, you need to install the software and license key.

Installing the Software

1 Make sure you have version 5.71 or greater of the Infiniium oscilloscope software (80000B Series oscilloscope) OR version 1.40 or greater of the Infiniium oscilloscope (90000A Series oscilloscope) by choosing **Help>About Infiniium...** from the main menu.
2 To obtain the USB 3.0 Electrical Compliance Test Application, go to Agilent website: http://www.agilent.com/find/usb.

   The link for USB 3.0 Electrical Compliance Test Application will appear. Double-click on it and follow the instructions to download and install the application software.

Installing the License Key

1 Request a license code from Agilent by following the instructions on the Entitlement Certificate.

   You will need the oscillocope's "Option ID Number", which you can find in the **Help>About Infiniium...** dialog.
2 After you receive your license code from Agilent, choose **Utilities>Install Option License...**.
3 In the Install Option License dialog, enter your license code and click **Install License**.
4 Click **OK** in the dialog that tells you to restart the Infiniium oscilloscope application software to complete the license installation.
5 Click **Close** to close the Install Option License dialog.

6 Choose **File>Exit**.

7 Restart the Infiniium oscilloscope application software to complete the license installation.

2
Preparing to Take Measurements

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Before running the USB 3.0 Electrical Compliance Test Application automated tests, you should calibrate the oscilloscope. Once the oscilloscope has been calibrated, you are ready to start the USB 3.0 Electrical Compliance Test Application and perform the measurements.

Calibrating the Oscilloscope

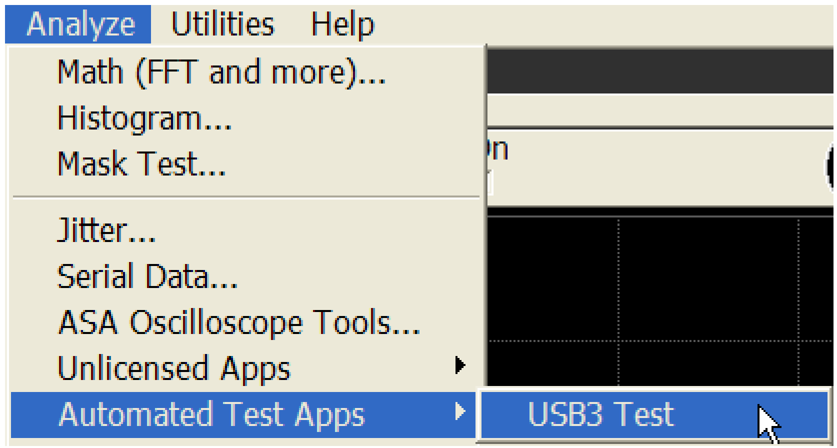
If you haven't already calibrated the oscilloscope, see Chapter 5, "Calibrating the 80000B and 90000A Series Infiniium Oscilloscopes".

NOTE If the ambient temperature changes more than 5 degrees Celsius from the calibration temperature, internal calibration should be performed again. The delta between the calibration temperature and the present operating temperature is shown in the Utilities>Calibration menu.

NOTE If you switch cables or probes between channels or other oscilloscopes, it is necessary to perform cable and probe calibration again. Agilent recommends that, once calibration is performed, you label the cables with the channel for which they were calibrated.

Starting the USB 3.0 Electrical Compliance Test Application

1 From the Infiniium oscilloscope's main menu, choose Analyze>Automated Test Apps>USB3.0 Test.



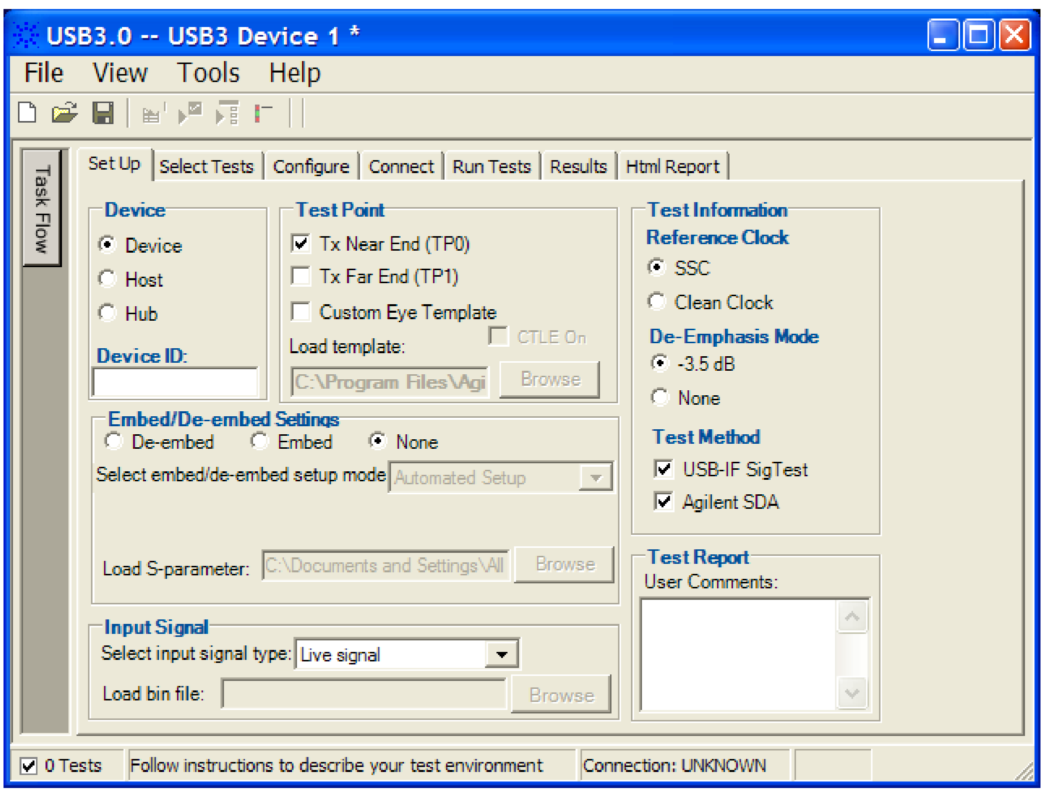


Figure 1 The USB 3.0 Electrical Compliance Test Application

NOTE If USB 3.0 Test does not appear in the Automated Test Apps menu, the USB 3.0 Electrical Compliance Test Application has not been installed (see Chapter 1, “Installing the USB 3.0 Electrical Compliance Test Application”).

Figure 1 shows the USB 3.0 Electrical Compliance Test Application main window. The task flow pane and the tabs in the main pane, show the steps you take in running the automated tests:

Set Up	Lets you identify the test environment, including information about the device being tested and types of input signals to test, either life signal captured from the oscilloscope or pre-recorded signal saved into the waveform files.
Select Tests	Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups.
Configure	Lets you configure the test parameters (e.g. test type).
Connect	Shows you how to connect the oscilloscope to the device under test for the tests to be run.
Run Tests	Starts the automated tests. If the connections to the device under test need to be changed while multiple tests are running, the tests pause, show you how to change the connection, and wait for you to confirm that the connections have been changed before continuing.
Results	Contains more detailed information about the tests that have been run. You can change the thresholds at which marginal or critical warnings appear.
HTML Report	Shows a compliance test report that can be printed.

Online Help Topics

For information on using the USB 3.0 Electrical Compliance Test Application, see its online help (which you can access by choosing Help>Contents... from the application's main menu).

The USB 3.0 Electrical Compliance Test Application's online help describes:

- Starting the USB 3.0 Electrical Compliance Test Application
  - To view/minimize the task flow pane
  - To view/hide the toolbar
- Creating or opening a test project.
- Setting up tests.
- Selecting tests.
- Configuring selected tests.
- Defining user-defined compliance limits.
- Connecting the oscilloscope to the DUT.
- Running tests.
- Viewing test results.
  - To delete the trials.
  - To show reference images and flash mask hits.
  - To change the display settings.
  - To change margin thresholds and report trial display.
  - To change the user prompt option.
  - To change the loading and auto-recovery option.
- Viewing/Exporting/Printing the HTML test report.
- Saving test projects.

Setting Up the USB 3.0 Test Environment

Prior to making any USB 3.0 measurements, setup the oscilloscope and the test environment as described below.

1. Preset the oscilloscope.
2. Find the optimum vertical scale for each channel (2 channels for single-ended connection).
   a. Find range = Vmax - Vmin
   b. Find offset = (Vmax + Vmin)/2
   c. Set the new range and offset
   d. Repeat the previous steps three times to obtain an optimum scale
3. Form a differential signal for single-ended connection by subtracting D+ channel from D- channel. Assign differential channel to FUNCTION 1.
4. If Signal Check is enabled in the configuration tab, perform signal pattern validity check:
   a. Measure min and max pulse width of the differential signal
   b. There are 2 types of test pattern; CP1 and CP0
   c. CP1 test pattern = D10.2 which is 010101 0101
   d. CP0 test pattern = D0.0 which is 0110001011
   e. To verify CP1 test pattern:
   - Check that nominal pulse width is 200ps
   f. To verify CP0 test pattern:
   - -Check that nominal maximum pulse width is 3 x 200ps
   - -Check that nominal minimum pulse width is 200ps
5. Set the memory depth and sample rate:
   a. Set sample rate to 40Gsa/s
   b. Calculate the number of points per UI = Sample rate/5Gb/s
   - Number of points = 40G/5G = 8 points per UI
   c. If de-embed or embed option is enabled, limit the memory depth to 2M
   d. If de-embed or embed option is disabled, calculate the memory depth as:
   - Memory depth = Number of points per UI X Number of UIs to test
   e. Set the calculated memory depth

f If the memory depth is insufficient, calculate the number of acquisitions required to achieve the essential number of UIs to test:

- Number of acquisitions = $\frac{\text{(Number of UIs to test)}}{\text{(Actual mem depth / Number of point per UI)}}$

6 Set time range as (1/Sample rate) X Memory depth.

7 Set flag to indicate that the oscilloscope has been set up. The entire steps above should only be called once for each test run.

8 If the de-embed option is enabled, perform the signal de-embed as follows:

- Enable UDF function - "Deconvolve"
- Assign UDF to FUNCTION 3 by using source from FUNCTION 1 (differential source)
- Point S-parameter file to the user-defined file location
- Turn off FUNCTION 1 and turn on FUNCTION 3

9 If the embed option is enabled, perform the signal embed:

- Enable UDF function - "Convolve"
- Assign UDF to FUNCTION 3 by using source from FUNCTION 1 (differential source)
- Point S-parameter file to the user-defined file location
- Turn off FUNCTION 1 and turn on FUNCTION 3

Setting Up and Connecting USB 3.0 Test Fixture

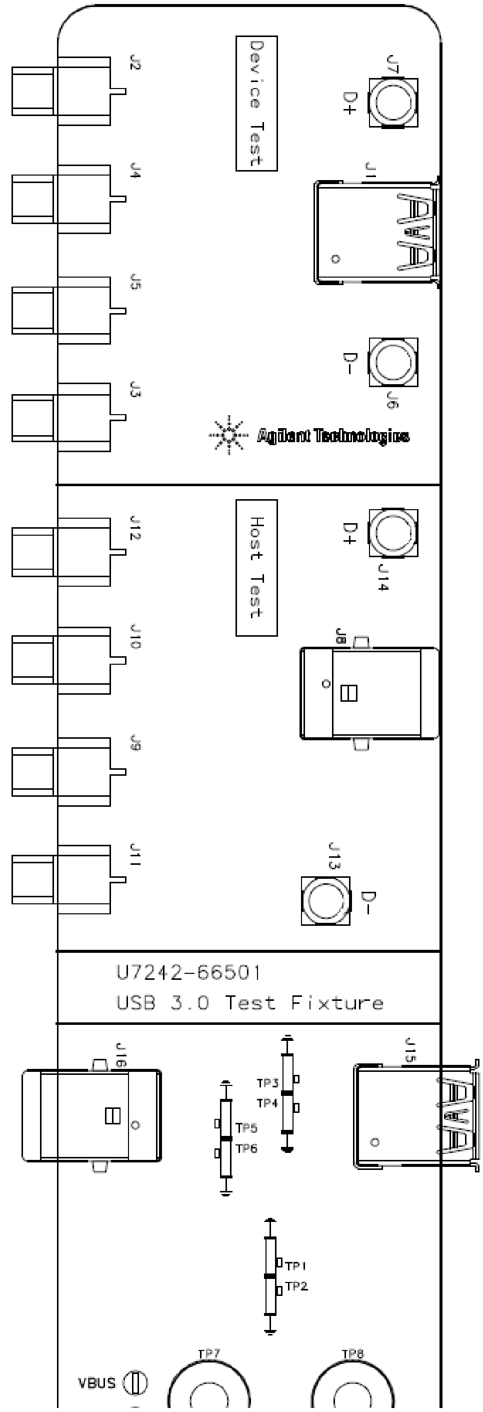


Figure 2 Block Diagram of U7242A USB 3.0 Test Fixture

The U7242A USB 3.0 test fixture is required to perform the USB 3.0 electrical compliance test measurements. The fixture helps you to easily access the USB 3.0 test signals.

The connection to this test fixture depends on the type of device under test (DUT):

For Device test:

1 Connect DUT to J1 by using 4 inches USB 3.0 Standard-A to Standard-B cable.
2 Connect J6 and J7 to the oscilloscope to measure USB 2.0 signal.
3 Connect J2 and J3 to the oscilloscope to measure the SuperSpeed (USB 3.0) Transmitter signal.
4 Connect J4 and J5 to the oscilloscope to measure the SuperSpeed (USB 3.0) Receiver signal.

For Host test:

1 Connect DUT to J8 by using 4 inches USB 3.0 Standard-A to Standard-B cable.
2 Connect J13 and J14 to the oscilloscope to measure USB 2.0 signal.
3 Connect J11 and J12 to the oscilloscope to measure the SuperSpeed (USB 3.0) Transmitter signal.
4 Connect J9 and J10 to the oscilloscope to measure the SuperSpeed (USB 3.0) Receiver signal.

For Hub test:

- The connection for hub test depends on the type of hub:
  - Upstream hub follows the connection as per the Device test.
  - Downstream hub follows the connection as per the Host test.

3
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This section provides the Methods of Implementation (MOIs) for Near End (TP0) Transmitter Eye tests using an Agilent 80000B or 90000A Series Infiniium oscilloscope, USB 3.0 test fixture and USB 3.0 Electrical Compliance Test Application.

Connection for Near End (TP0) Transmitter Eye Tests

When performing the Near End (TP0) Transmitter Eye tests, the USB 3.0 Electrical Compliance Test Application will prompt you to make proper connections. The connections for the Near End (TP0) Transmitter Eye tests may look similar to the following diagram. Refer to the Connection tab in USB 3.0 Electrical Compliance Test Application for more details.

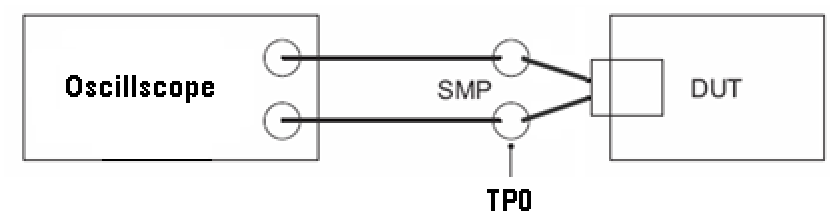
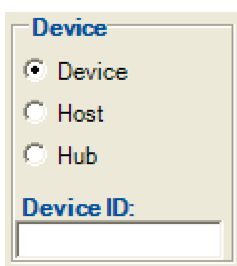


Figure 3 Connection for Near End (TP0) Transmitter Eye Tests

You may connect the SMP to SMA cables to any of the oscilloscope channels. You can identify the channels used for each signal in the Configuration tab of the USB 3.0 Electrical Compliance Test Application. (The channels shown in Figure 3 is just an example).

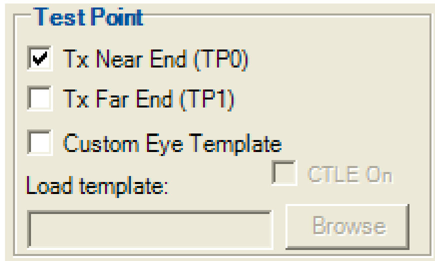
Test Procedure

1 Start the automated test application as described in "Starting the USB 3.0 Electrical Compliance Test Application" on page 15.
2 In the USB3.0 Electrical test application, click the Set Up tab.
3 Under the Device information group, select the type of device under test. Enter the device ID for reporting purpose.

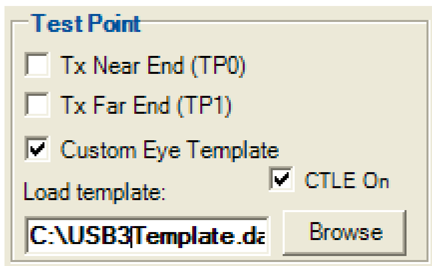


4 Under the Test Point group, select the test point to perform the test. The Near End (TP0) tests allows you to perform transmitter tests at the

near end test point, TP0. This test point references Table 6-9, 6-10 and Table 6-11 of the USB 3.0 Specification.



5 For Custom Eye Template, you may load your own eye template:



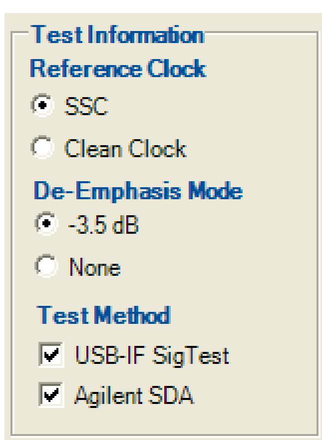
6 Check the "CTLE On" checkbox to enable the tests with CTLE. This enables the equalization function when there are long cables and channels that cause the eye at the receiver to close.

7 Under the Test Information group, you can specify the test parameters - reference clock, de-emphasis mode and test method:

   a Reference Clock - defines whether the device under test uses either Spread Spectrum Clocking (SSC) or clean clock.

   b De-emphasis mode - defines whether the transmitter signals include de-emphasis.

   c Test method - Defines either to use SigTest dll or Agilent's SDA and EZJIT+ software, to perform the test analysis. Checking both checkboxes enable both test modes.



If both E2688A Serial Data Analysis and N5401A EZJIT Plus options are not available, the “Agilent SDA” checkbox will be disabled. If either one of the license options is available, then the checkbox is enabled.

As mentioned earlier, if only the E2688A Serial Data Analysis option is available, the “Agilent SDA” checkbox is enabled, however only the following SDA tests are available:

- Near End/Far End Template Tests (SDA)
- Near End/Far End Peak-to-Peak Differential Output Voltage Test (SDA)

Similarly, if only the N5401A EZJIT Plus option is available, the “Agilent SDA” checkbox is also enabled but only the following SDA tests are available:

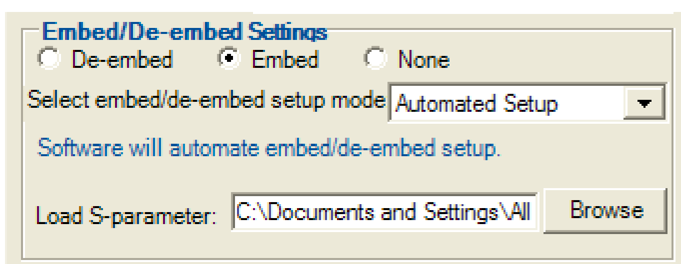
- Near End/Far End RMS Random Jitter (SDA)
- Near End/Far End Maximum Deterministic Jitter (SDA)
- Near End/Far End Total Jitter At BER-12 (SDA)

8 Under the Embed/De-embed Settings group, you can define if the signal embed/de-embed is required. You may want to perform power de-embedding to compensate loss from the test fixture and probes. Similarly, you may also perform signal embed to simulate power loss conditions. You should provide the S-parameter file of the system under test to perform signal power embed or de-embed:

a Embed - This option calls for the UDF function "Convolve". FUNCTION 3 is assigned to "Convolve" FUNCTION 1, which is the differential source.

b De-embeded - This option calls for the UDF function "Deconvolve". FUNCTION 3 is assigned to "Deconvolve" FUNCTION 1, which is the differential source.

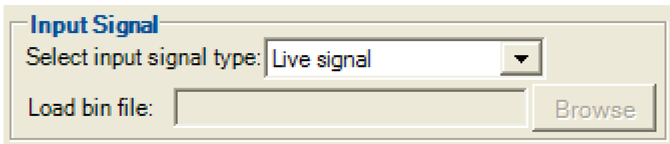
c None - No embed or de-embed takes place and the original differential source on FUNCTION 1 is used to perform the analysis.



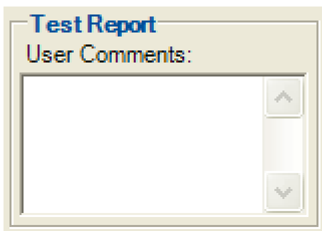
9 Under the Input Signal group, you may decide either to capture life signal from the oscilloscope or load a pre-recorded signal to be tested:

a Live Signal - Live signal is captured and analyzed directly from the oscilloscope.

b Recorded Signal - Pre-recorded waveform saved as waveform file (*.bin) format is loaded and analyzed. Only tests carried out by the USB-IF Sigtest are available with this option.



10 Under the Test Report group, you may enter comments to be included in the test report.



11 Click the Select Tests tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

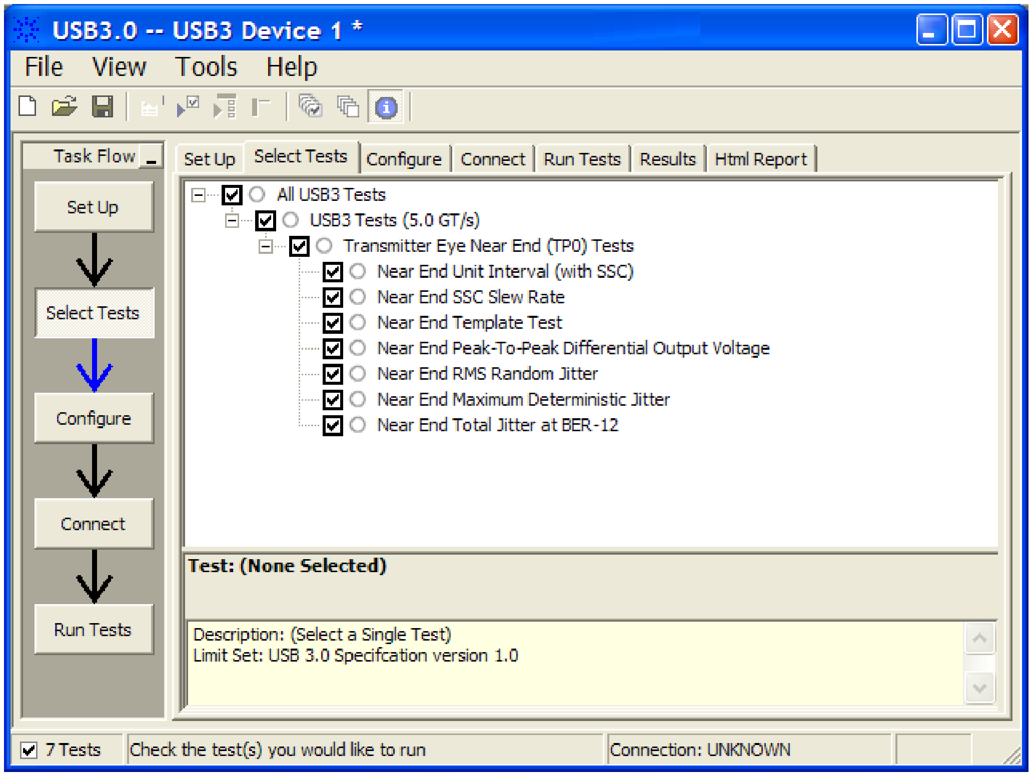


Figure 4 Selecting Near End (TP0) Transmitter Eye Tests

12 Set up the test parameters in the configuration options, run the test, and view the test results.

Near End Unit Interval Test Method of Implementation

The purpose of this test is to verify that the unit interval measured at the TP0 of the transmitter is within the conformance limits specified in Table 6-10 (without SSC) and Table 6-9 (with SSC) of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 1 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of $\pm$ 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX\text{-}DIFF\text{-}PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX\text{-}DIFF\text{-}PP\text{-}LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX\text{-}DE\text{-}RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.
$R_{TX\text{-}DIFF\text{-}DC}$	DC differential impedance	72 (min) 120 (max)	Ω	
$V_{TX\text{-}RCV\text{-}DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an "off" receiver's input goes below ground.
$C_{AC\text{-}COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification.

Table 2 SSC Parameters

Symbol	Description	Limits		Units	Note
		Min	Max		
$t_{SSC\text{-}MOD\text{-}RATE}$	Modulation Rate	30	33	kHz	
$t_{SSC\text{-}FREQ\text{-}DEVIATION}$	SSC deviation	+0/-4000	+0/-5000	ppm	1,2

NOTE:

1 The data rate is modulated from 0ppm to -5000ppm of the nominal data rate frequency and scales with data rate.

2 This is measured below 2 MHz only.

Table 6-9 translates to:

Max Unit Interval = 200.0ps + 5300ppm = 201.06ps

Min Unit Interval = 200.0ps - 300ppm = 199.94ps

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.
2 Save the oscilloscope settings prior to turning on the measurement trending. The saved settings will be reloaded at the end of this test so that the next test does not need to perform the steps described in "Setting Up the USB 3.0 Test Environment" again.
3 Split the oscilloscope's display into 2 graticules: the top displays the source waveform and the bottom displays the unit interval trend waveform.
4 Turn on the unit interval measurement.
5 Enable the jitter mode to view measurement trends. Enable the measurement trend to trend the unit interval measurement with 3499 smoothing points.
6 Assign FUNCTION 4 to magnify the measurement trend at a factor of 1. Autoscale FUNCTION 4 so that the full signal is displayed.
7 Measure the average of FUNCTION 4 to obtain the average unit interval.
8 Measure the max of FUNCTION 4 to get the maximum unit interval.
9 Measure the min of FUNCTION 4 to get the minimum unit interval.
10 Compare the test result with the compliance test limit.
11 Reload the saved oscilloscope settings before proceeding to the next test.

Pass Condition

The measured average unit interval at TP0 is within the limits specified in Table 6-10 (without SSC) and Table 6-9 (with SSC) of the USB 3.0 Specification.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters and Table 6-9 SSC Parameters in the *USB 3.0 Specification, version 1.0.*

Near End SSC Slew Rate Test Method of Implementation

The purpose of this test is to ensure that the combination of SSC and all other jitter sources within the bandwidth of the CDR does not exceed the allowed slew rate. The peak of the period jitter must not exceed $T_{CDR\_SLEW\_MAX}$ listed in Table 6-10 of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 3 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of ± 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.
$R_{TX-DIFF-DC}$	DC differential impedance	72 (min) 120 (max)	Ω	
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an “off” receiver’s input goes below ground.
$C_{AC-COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification.

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Save the oscilloscope settings prior to turning on the measurement trending. The saved settings will be reloaded at the end of this test so

that the next test does not need to perform the steps described in "Setting Up the USB 3.0 Test Environment" again.

3 Split the oscilloscope's display into 2 graticules: the top displays the source waveform and the bottom displays the unit interval trend waveform.

4 Turn on the unit interval measurement.

5 Enable the jitter mode to view the measurement trends. Enable the measurement trend to trend the unit interval measurement with 3499 smoothing points.

6 Assign FUNCTION 4 to magnify the measurement trend at a factor of 1. Autoscale FUNCTION 4 so that the full signal is displayed.

7 Read the measurement trend waveform into the memory.

8 The saved waveform is analyzed by using MATLAB. For the algorithm to determine the slew rate, refer to white paper *USB 3.0 CDR Model White Paper, revision 0.5* available at www.usb.org.

9 Compare the test result with the compliance test limit.

10 Reload the saved oscilloscope settings before proceeding to the next test.

Pass Condition

The maximum slew rate must not exceed the slew rate limit in Table 6-10 of the USB 3.0 Specification.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters in the *USB 3.0 Specification, version 1.0*.

Near End Template Test Method of Implementation

The purpose of this test is to perform an eye mask test at TP0 by using the specifications specified in Section 6.7.1, Tables 6-10 and 6-11 of the USB 3.0 specification.

Table 6-10 specifies that Differential p-p Tx Voltage Swing should be 0.8-1.2V.

Table 6-11 specifies that Transmitter Eye is 0.625 UI, which is the total jitter.

Table 6-11 also specifies that deterministic jitter is 0.205 UI.

Therefore, the near end transmitter eye test uses the following limits:

- Upper/Lower rail = 1.2Vmax, i.e. +/- 0.6V
- Diamond upper/lower = 0.8Vmin, i.e. +/- 0.4V
- Diamond width

  = Transmitter eye specified in Table 6-11

  = 0.625 UI/2 = +/-0.3125UI

Test Definition Notes from the Specification

Table 4 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of ± 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.

Table 5 Transmitter Informative Electrical Parameters at Silicon Pads

Symbol	Parameter	5.0 GT/s	Units	Parameter
$t_{MIN-PULSE-Dj}$	Deterministic min pulse	0.96	UI	Tx pulse width variation that is deterministic.
$t_{MIN-PULSE-Tj}$	Tx min pulse	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj.
t_{TX-EYE}	Transmitter Eye	0.625 (min)	UI	Includes all jitter sources.
$t_{TX-DJ-DD}$	Tx deterministic jitter	0.205 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX-PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	pf	Parasitic capacitance to ground
R_{TX-DC}	Transmitter DC common mode impedance	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA:

- Turn on the color grade display.
- Enable the mask test and load the mask. The mask template can be found at:

C:\Program Files\Agilent\Infiniium\Apps\USB3Test\app\masks\USBMask_NearEnd.msk

- Set up the clock recovery by using 2nd order PLL with data rate of 5Gb/s, loop bandwidth of 4.9MHz and damping factor of 0.707.
- Enable Real Time Eye to fold the waveform.

4 Compare the test result with the compliance test limit.

Pass Condition

The test passes if the waveform does not violate the mask.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters and Table 6-11 Transmitter Informative Electrical Parameters at Silicon Pads in the *USB 3.0 Specification, version 1.0*.

Near End Peak-to-Peak Differential Output Voltage Test Method of Implementation

The purpose of this test is to verify that the peak-to-peak differential output voltage, $V_{TX-DIFF-PP}$ measured at TP0 is within the limits as specified in Table 6-10 of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 6 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of ± 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.
$R_{TX-DIFF-DC}$	DC differential impedance	72 (min) 120 (max)	Ω	
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an "off" receiver's input goes below ground.
$C_{AC-COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification.

Measurement Algorithm

1. Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.
2. Using the USB-IF SigTest:
   - Acquire and save the waveform into

C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA:

- Turn on the color grade display.
- Set up the clock recovery by using 2nd order PLL with data rate of 5Gb/s, loop bandwidth of 4.9MHz and damping factor of 0.707.
- Enable the Real Time Eye to fold the waveform.
- Measure the min and max value of the waveform.
- The peak differential voltage is

Peak diff voltage = Max voltage - Min voltage

4 Compare the test result with the compliance test limit.

Pass Condition

The measured peak-to-peak differential output voltage is within the limit as specified in Table 6-10 of the USB 3.0 specification.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters in the *USB 3.0 Specification, version 1.0*.

Near End RMS Random Jitter Test Method of Implementation

The purpose of this test is to verify that the measured RMS random jitter, Rj measured at TP0 is within the limits as specified in Table 6-11 of the USB 3.0 specification.

Rj Total is computed as the Root Sum Square of the individual Rj components.

Table 6-11 specifies that Transmitter Eye is 0.625 UI which is the total jitter.

Table 6-11 also specifies that deterministic jitter is 0.205 UI.

Therefore, the near end jitter limits uses the following calculation:

- Tj = 1UI - 0.625UI = 0.375UI
- Dj = 0.205UI
- Rj = (Tj - Dj)/14.068 = (0.375 - 0.205)/14.068 = 0.013UI

Test Definition Notes from the Specification

Table 7 Transmitter Informative Electrical Parameters at Silicon Pads

Symbol	Parameter	5.0 GT/s	Units	Parameter
$t_{MIN-PULSE-Dj}$	Deterministic min pulse	0.96	UI	Tx pulse width variation that is deterministic.
$t_{MIN-PULSE-Tj}$	Tx min pulse	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj.
t_{TX-EYE}	Transmitter Eye	0.625 (min)	UI	Includes all jitter sources.
$t_{TX-DJ-DD}$	Tx deterministic jitter	0.205 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX-PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	pf	Parasitic capacitance to ground
R_{TX-DC}	Transmitter DC common mode impedance	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Rj reading

4 Compare the test result with compliance test limit.

Pass Condition

The measured RMS random jitter, Rj measured at TP0 is within the limit as specified in Table 6-11 of the USB 3.0 specification.

Test References

See Table 6-11 Transmitter Informative Electrical Parameters at Silicon Pads in the *USB 3.0 Specification, version 1.0*.

Near End Maximum Deterministic Jitter Test Method of Implementation

The purpose of this test is to verify that the measured deterministic jitter, Dj measured at TP0 is within the limits as specified in Table 6-11 of the USB 3.0 specification.

Dj is computed using the Dual Dirac method.

Table 6-11 specifies that deterministic jitter is 0.205 UI.

Test Definition Notes from the Specification

Table 8 Transmitter Informative Electrical Parameters at Silicon Pads

Symbol	Parameter	5.0 GT/s	Units	Parameter
$t_{MIN-PULSE-Dj}$	Deterministic min pulse	0.96	UI	Tx pulse width variation that is deterministic.
$t_{MIN-PULSE-Tj}$	Tx min pulse	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj.
t_{TX-EYE}	Transmitter Eye	0.625 (min)	UI	Includes all jitter sources.
$t_{TX-DJ-DD}$	Tx deterministic jitter	0.205 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX-PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	pf	Parasitic capacitance to ground
R_{TX-DC}	Transmitter DC common mode impedance	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

  C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Dj reading

4 Compare the test result with compliance test limit.

Pass Condition

The measured maximum deterministic jitter, Dj measured at TP0 is within the limit as specified in Table 6-11 of the USB 3.0 specification.

Test References

See Table 6-11 Transmitter Informative Electrical Parameters at Silicon Pads in the *USB 3.0 Specification, version 1.0*.

Near End Total Jitter at BER-12 Test Method of Implementation

The purpose of this test is to verify that the measured total jitter, Tj measured at TP0 is within the limits as specified in Table 6-11 of the USB 3.0 specification.

Tj at a 10^{-12} BER is calculated as 14.068 x Rj + Dj.

Table 6-11 specifies that Transmitter Eye is 0.625 UI. Total jitter is 1UI - Transmitter eye = 1 - 0.625 = 0.375 UI.

Test Definition Notes from the Specification

Table 9 Transmitter Informative Electrical Parameters at Silicon Pads

Symbol	Parameter	5.0 GT/s	Units	Parameter
$t_{MIN\text{-}PULSE\text{-}Dj}$	Deterministic min pulse	0.96	UI	Tx pulse width variation that is deterministic.
$t_{MIN\text{-}PULSE\text{-}Tj}$	Tx min pulse	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj.
$t_{TX\text{-}EYE}$	Transmitter Eye	0.625 (min)	UI	Includes all jitter sources.
$t_{TX\text{-}DJ\text{-}DD}$	Tx deterministic jitter	0.205 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX\text{-}PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	pf	Parasitic capacitance to ground
$R_{TX\text{-}DC}$	Transmitter DC common mode impedance	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

  C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Rj and Dj reading
- Calculate total jitter Tj using formula:

Tj = 14.068 * Rj + Dj

4 Compare the test result with compliance test limit.

Pass Condition

The measured total jitter, Tj measured at TP0 is within the limit as specified in Table 6-11 of the USB 3.0 specification.

Test References

See Table 6-11 Transmitter Informative Electrical Parameters at Silicon Pads in the *USB 3.0 Specification, version 1.0*.

4
Far End (TP1) Transmitter Eye Tests

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Far End RMS Random Jitter Test Method of Implementation 60
Far End Maximum Deterministic Jitter Test Method of Implementation 62
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This section provides the Methods of Implementation (MOIs) for Far End (TP1) Transmitter Eye tests using an Agilent 80000B or 90000A Series Infiniium oscilloscope, USB 3.0 test fixture and USB 3.0 Electrical Compliance Test Application.

Connection for Far End (TP1) Transmitter Eye Tests

When performing the Far End (TP1) Transmitter Eye tests, the USB 3.0 Electrical Compliance Test Application will prompt you to make proper connections. The connections for the Far End (TP1) Transmitter Eye tests may look similar to the following diagram. Refer to the Connection tab in USB 3.0 Electrical Compliance Test Application for more details.

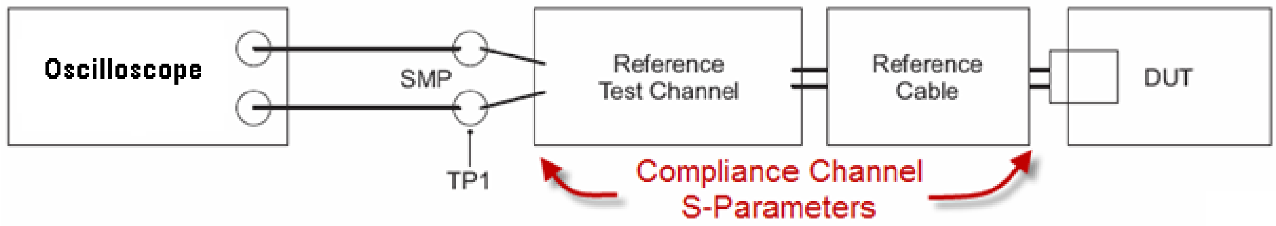


Figure 5 Connection for Far End (TP1) Transmitter Eye Tests

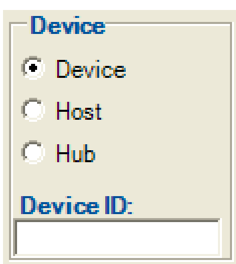
You may connect the SMP to SMA cables to any of the oscilloscope channels. You can identify the channels used for each signal in the Configuration tab of the USB 3.0 Electrical Compliance Test Application. (The channels shown in Figure 5 is just an example).

Test Procedure

1 Start the automated test application as described in "Starting the USB 3.0 Electrical Compliance Test Application" on page 15.

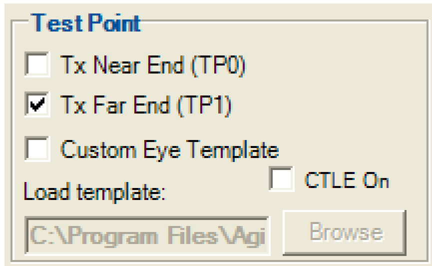
2 In the USB3.0 Ethernet test application, click the Set Up tab.

3 Under the Device information group, select the type of device under test. Enter the device ID for reporting purpose.

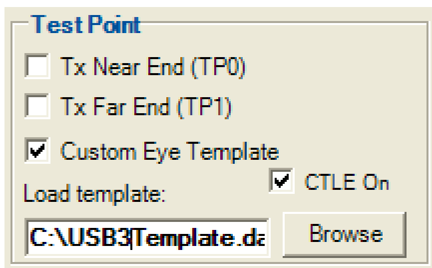


4 Under the Test Point group, select the test point to perform the test. The Far End (TP1) tests allows you to perform transmitter tests at the

far end test point, TP1. This test point references Table 6-9, Table 6-10 and Table 6-12 of the USB 3.0 Specification.



5 For Custom Eye Template, you may load your own eye template:



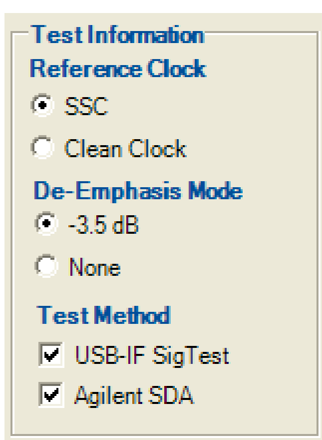
6 Check the “CTLE On” checkbox to enable the tests with CTLE. This enables the equalization function when there are long cables and channels that cause the eye at the receiver to close.

7 Under the Test Information group, you can specify the test parameters - reference clock, de-emphasis mode and test method:

a Reference Clock - defines whether the device under test uses either Spread Spectrum Clocking (SSC) or clean clock.

b De-emphasis mode - defines whether the transmitter signals include de-emphasis.

c Test method - Defines either to use SigTest dll or Agilent's SDA and EZJIT+ software, to perform the test analysis. Checking both checkboxes enable both test modes.



If both E2688A Serial Data Analysis and N5401A EZJIT Plus options are not available, the “Agilent SDA” checkbox will be disabled. If either one of the license options is available, then the checkbox is enabled.

As mentioned earlier, if only the E2688A Serial Data Analysis option is available, the “Agilent SDA” checkbox is enabled, however only the following SDA tests are available:

- Near End/Far End Template Tests (SDA)
- Near End/Far End Peak-to-Peak Differential Output Voltage Test (SDA)

Similarly, if only the N5401A EZJIT Plus option is available, the “Agilent SDA” checkbox is also enabled but only the following SDA tests are available:

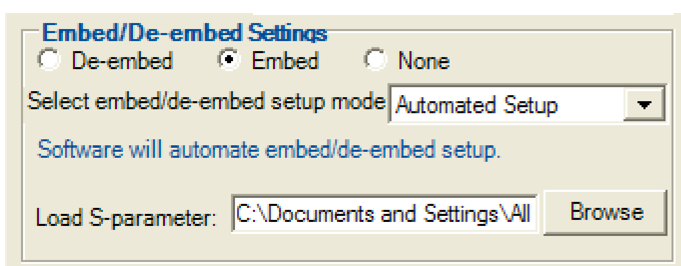
- Near End/Far End RMS Random Jitter (SDA)
- Near End/Far End Maximum Deterministic Jitter (SDA)
- Near End/Far End Total Jitter At BER-12 (SDA)

8 Under the Embed/De-embed Settings group, you can define if the signal embed/de-embed is required. You may want to perform power de-embedding to compensate loss from the test fixture and probes. Similarly, you may also perform signal embed to simulate power loss conditions. You should provide the S-parameter file of the system under test to perform signal power embed or de-embed:

 a Embed - This option calls for the UDF function "Convolve". FUNCTION 3 is assigned to "Convolve" FUNCTION 1, which is the differential source.

 b De-embeded - This option calls for the UDF function "Deconvolve". FUNCTION 3 is assigned to "Deconvolve" FUNCTION 1, which is the differential source.

 c None - No embed or de-embed takes place and the original differential source on FUNCTION 1 is used to perform the analysis.

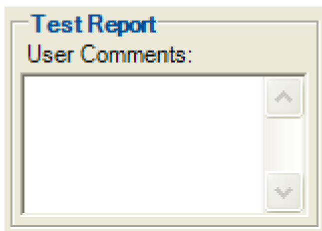


9 Under the Input Signal group, you may decide either to capture life signal from the oscilloscope or load a pre-recorded signal to be tested:

a Life Signal - Live signal is captured and analyzed directly from the oscilloscope.

b Recorded Signal - Pre-recorded waveform saved as waveform file (*.bin) format is loaded and analyzed. Only tests carried out by the USB-IF Sigtest are available with this option.

10 Under the Test Report group, you may enter comments to be included in the test report.



11 Click the Select Tests tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

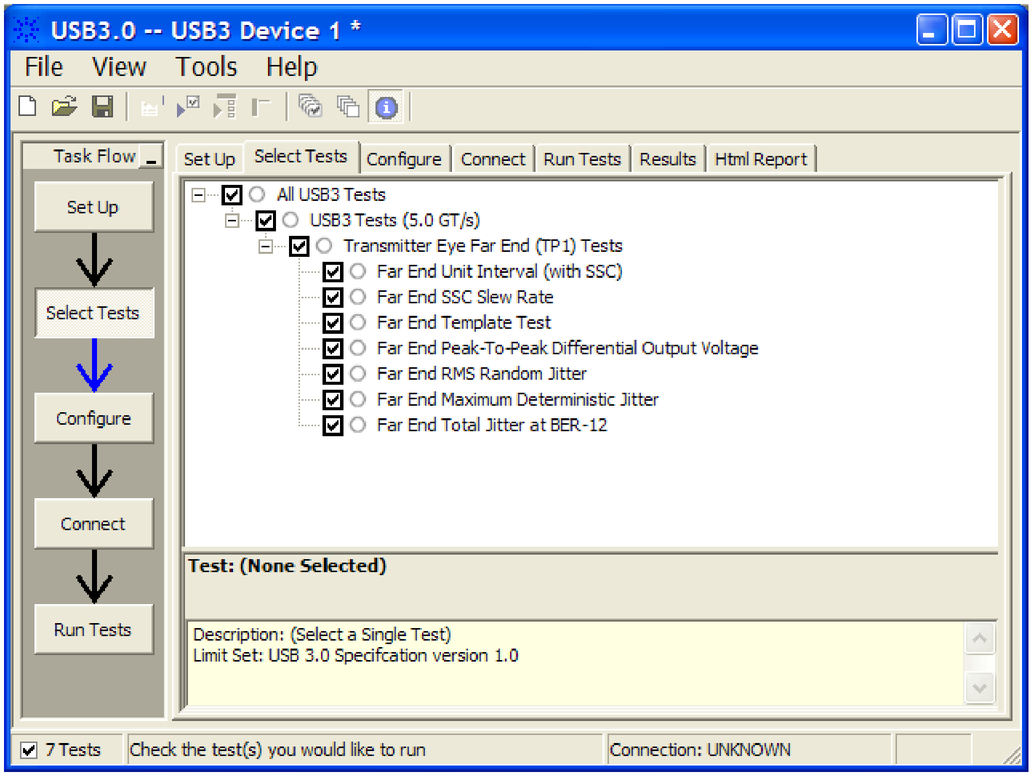


Figure 6 Selecting Far End (TP1) Transmitter Eye Tests

12 Set up the test parameters in the configuration options, run the test, and view the test results.

Far End Unit Interval Test Method of Implementation

The purpose of this test is to verify that the unit interval measured at the transmitter far end (TP1) of the transmitter is within the conformance limits specified in Table 6-10 (without SSC) and Table 6-9 (with SSC) of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 10 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of ± 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX\text{-}DIFF\text{-}PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX\text{-}DIFF\text{-}PP\text{-}LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX\text{-}DE\text{-}RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.
$R_{TX\text{-}DIFF\text{-}DC}$	DC differential impedance	72 (min) 120 (max)	Ω	
$V_{TX\text{-}RCV\text{-}DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an “off” receiver’s input goes below ground.
$C_{AC\text{-}COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification.

Table 11 SSC Parameters

Symbol	Description	Limits		Units	Note
		Min	Max		
$t_{SSC\text{-}MOD\text{-}RATE}$	Modulation Rate	30	33	kHz	
$t_{SSC\text{-}FREQ\text{-}DEVIATION}$	SSC deviation	+0/-4000	+0/-5000	ppm	1,2

NOTE:

1 The data rate is modulated from 0ppm to -5000ppm of the nominal data rate frequency and scales with data rate.

2 This is measured below 2 MHz only.

Table 6-9 translates to:

Max Unit Interval = 200.0ps + 5300ppm = 201.06ps

Min Unit Interval = 200.0ps - 300ppm = 199.94ps

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Save the oscilloscope settings prior to turning on the measurement trending. The saved settings will be reloaded at the end of this test so that the next test does not need to perform the steps described in “Setting Up the USB 3.0 Test Environment“ again.

3 Split the oscilloscope's display into 2 graticules: the top displays the source waveform and the bottom displays the unit interval trend waveform.

4 Turn on the unit interval measurement.

5 Enable the jitter mode to view measurement trends. Enable the measurement trend to trend the unit interval measurement with 3499 smoothing points.

6 Assign FUNCTION 4 to magnify the measurement trend at a factor of 1. Autoscale FUNCTION 4 so that the full signal is displayed.

7 Measure the average of FUNCTION 4 to obtain the average unit interval.

8 Measure the max of FUNCTION 4 to get the maximum unit interval.

9 Measure the min of FUNCTION 4 to get the minimum unit interval.

10 Compare the test result with the compliance test limit.

11 Reload the saved oscilloscope settings before proceeding to the next test.

Pass Condition

The measured average unit interval at TP1 is within the limits specified in Table 6-10 (without SSC) and Table 6-9 (with SSC) of the USB 3.0 Specification.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters and Table 6-9 SSC Parameters in the *USB 3.0 Specification, version 1.0*.

Far End SSC Slew Rate Test Method of Implementation

The purpose of this test is to ensure that the combination of SSC and all other jitter sources within the bandwidth of the CDR does not exceed the allowed slew rate. The peak of the period jitter must not exceed $T_{CDR\_SLEW\_MAX}$ listed in Table 6-10 of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 12 Transmitter Normative Electrical Parameters

Symbol	Parameter	5.0 GT/s	Units	Parameter
UI	Unit Interval	199.94 (min) 200.06 (max)	ps	The specified UI is equivalent to a tolerance of ± 300ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p.
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	V	There is no de-emphasis requirement in this mode. De-emphasis is implementation-specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	dB	Nominal is 3.5 dB.
$R_{TX-DIFF-DC}$	DC differential impedance	72 (min) 120 (max)	Ω	
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an “off” receiver’s input goes below ground.
$C_{AC-COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification.

Measurement Algorithm

1 Make the connections as described in “Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Save the oscilloscope settings prior to turning on the measurement trending. The saved settings will be reloaded at the end of this test so

that the next test does not need to perform the steps described in "Setting Up the USB 3.0 Test Environment" again.

3 Split the oscilloscope's display into 2 graticules: the top displays the source waveform and the bottom displays the unit interval trend waveform.
4 Turn on the unit interval measurement.
5 Enable the jitter mode to view the measurement trends. Enable the measurement trend to trend the unit interval measurement with 3499 smoothing points.
6 Assign FUNCTION 4 to magnify the measurement trend at a factor of 1. Autoscale FUNCTION 4 so that the full signal is displayed.
7 Read the measurement trend waveform into the memory.
8 The saved waveform is analyzed by using MATLAB. For the algorithm to determine the slew rate, refer to white paper *USB 3.0 CDR Model White Paper, revision 0.5* available at www.usb.org.
9 Compare the test result with the compliance test limit.
10 Reload the saved oscilloscope settings before proceeding to the next test.

Pass Condition

The maximum slew rate must not exceed the slew rate limit in Table 6-10 of the USB 3.0 Specification.

Test References

See Table 6-10 Transmitter Normative Electrical Parameters in the *USB 3.0 Specification, version 1.0.*

Far End Template Test Method of Implementation

The purpose of this test is to perform an eye mask test at TP1 by using the eye mask template as specified in Section 6.7.3, Tables 6-12 of the USB 3.0 specification.

Table 6-12 specifies that minimal eye height should be 100mV.

Table 6-12 also specifies that total jitter is 0.66 UI.

Therefore, the Near End transmitter eye test uses the following limits:

- Upper/Lower rail = 1.2Vmax, i.e. +/-0.6V
- Diamond upper/lower = 100mVmin, i.e. +/-0.05V
- Diamond width

  = 1UI - Total jitter

  = 1UI - 0.66UI = 0.34UI = 0.34UI/2 = +/-0.17UI

Test Definition Notes from the Specification

Table 13 Normative Transmitter Eye Mask at Test Point TP1

Signal Characteristics	Minimal	Nominal	Maximum	Units	Note
Eye Height	100		1200	mV	2,4
Dj			0.43	UI	1,2,3
Rj			0.23	UI	1,2,3,5
Tj			0.66	UI	1,2,3

NOTES:

1. Measured over 10^6 consecutive UI and extrapolated to 10^{-12} BER.
2. Measured after receiver equalization function.
3. Measured at end of reference channel and cables at TP1.
4. The eye height is to be measured at the maximum opening (at the center of the eye width ±0.05UI).
5. The Rj specification is calculated as 14.069 times the RMS random jitter for 10^{-12} BER.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA:

- Turn on the color grade display.
- Enable the mask test and load the mask. The mask template can be found at:

C:\Program Files\Agilent\Infiniium\Apps\USB3Test\app\masks\USBMask_FarEnd.msk

- Set up the clock recovery by using 2nd order PLL with data rate of 5Gb/s, loop bandwidth of 4.9MHz and damping factor of 0.707.
- Enable Real Time Eye to fold the waveform.

4 Compare the test result with the compliance test limit.

Pass Condition

The test passes if the waveform does not violate the mask.

Test References

See Table 6-12 Normative Transmitter Eye Mask at Test Point TP1 in the *USB 3.0 Specification, version 1.0*.

Far End Peak-to-Peak Differential Output Voltage Test Method of Implementation

The purpose of this test is to verify that the peak differential output voltage measured at TP1 meets the minimum eye height as specified in Table 6-12 of the USB 3.0 specification.

Test Definition Notes from the Specification

Table 14 Normative Transmitter Eye Mask at Test Point TP1

Signal Characteristics	Minimal	Nominal	Maximum	Units	Note
Eye Height	100		1200	mV	2,4
Dj			0.43	UI	1,2,3
Rj			0.23	UI	1,2,3,5
Tj			0.66	UI	1,2,3

NOTES:

1. Measured over 10^6 consecutive UI and extrapolated to 10^{-12} BER.

2. Measured after receiver equalization function.

3. Measured at end of reference channel and cables at TP1.

4. The eye height is to be measured at the maximum opening (at the center of the eye width ±0.05UI).

5. The Rj specification is calculated as 14.069 times the RMS random jitter for 10^{-12} BER.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA:

- Turn on the color grade display.
- Set up the clock recovery by using 2nd order PLL with data rate of 5Gb/s, loop bandwidth of 4.9MHz and damping factor of 0.707.
- Enable the Real Time Eye to fold the waveform.
- Measure the min and max value of the waveform.
- The peak differential voltage is

Peak diff voltage = Max voltage - Min voltage

4 Compare the test result with the compliance test limit.

Pass Condition

The measured peak differential output voltage measured at TP1 meets the minimum eye height as specified in Table 6-12 of the USB 3.0 specification.

Test References

See Table 6-12 Normative Transmitter Eye Mask at Test Point TP1 in the *USB 3.0 Specification, version 1.0*.

Far End RMS Random Jitter Test Method of Implementation

The purpose of this test is to verify that the measured RMS random jitter, Rj measured at TP1 is within the limits as specified in Table 6-12 of the USB 3.0 specification.

Rj Total is computed as the Root Sum Square of the individual Rj components.

Test Definition Notes from the Specification

Table 15 Normative Transmitter Eye Mask at Test Point TP1

Signal Characteristics	Minimal	Nominal	Maximum	Units	Note
Eye Height	100		1200	mV	2,4
Dj			0.43	UI	1,2,3
Rj			0.23	UI	1,2,3,5
Tj			0.66	UI	1,2,3

NOTES:

1. Measured over 10^6 consecutive UI and extrapolated to 10^{-12} BER.

2. Measured after receiver equalization function.

3. Measured at end of reference channel and cables at TP1.

4. The eye height is to be measured at the maximum opening (at the center of the eye width $\pm$0.05UI).

5. The Rj specification is calculated as 14.069 times the RMS random jitter for 10^{-12} BER.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

  C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Rj reading

4 Compare the test result with compliance test limit.

Pass Condition

The measured RMS random jitter, Rj measured at TP1 is within the limit as specified in Table 6-12 of the USB 3.0 specification.

Test References

See Table 6-12 Normative Transmitter Eye Mask at Test Point TP1 in the *USB 3.0 Specification, version 1.0*.

Far End Maximum Deterministic Jitter Test Method of Implementation

The purpose of this test is to verify that the measured deterministic jitter, Dj measured at TP1 is within the limits as specified in Table 6-12 of the USB 3.0 specification.

Dj is computed by using the Dual Dirac method.

Test Definition Notes from the Specification

Table 16 Normative Transmitter Eye Mask at Test Point TP1

Signal Characteristics	Minimal	Nominal	Maximum	Units	Note
Eye Height	100		1200	mV	2,4
Dj			0.43	UI	1,2,3
Rj			0.23	UI	1,2,3,5
Tj			0.66	UI	1,2,3

NOTES:

1. Measured over 10^6 consecutive UI and extrapolated to 10^{-12} BER.

2. Measured after receiver equalization function.

3. Measured at end of reference channel and cables at TP1.

4. The eye height is to be measured at the maximum opening (at the center of the eye width ±0.05UI).

5. The Rj specification is calculated as 14.069 times the RMS random jitter for 10^{-12} BER.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

  C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Dj reading

4 Compare the test result with compliance test limit.

Pass Condition

The measured maximum deterministic jitter, Dj measured at TP1 is within the limit as specified in Table 6-12 of the USB 3.0 specification.

Test References

See Table 6-12 Normative Transmitter Eye Mask at Test Point TP1 in the *USB 3.0 Specification, version 1.0*.

Far End Total Jitter at BER-12 Test Method of Implementation

The purpose of this test is to verify that the measured total jitter, Tj measured at TP1 is within the limits as specified in Table 6-12 of the USB 3.0 specification.

Tj at a 10^{-12} BER is calculated as 14.068 x Rj + Dj.

Test Definition Notes from the Specification

Table 17 Normative Transmitter Eye Mask at Test Point TP1

Signal Characteristics	Minimal	Nominal	Maximum	Units	Note
Eye Height	100		1200	mV	2,4
Dj			0.43	UI	1,2,3
Rj			0.23	UI	1,2,3,5
Tj			0.66	UI	1,2,3

NOTES:

1. Measured over 10^6 consecutive UI and extrapolated to 10^{-12} BER.

2. Measured after receiver equalization function.

3. Measured at end of reference channel and cables at TP1.

4. The eye height is to be measured at the maximum opening (at the center of the eye width $\pm$0.05UI).

5. The Rj specification is calculated as 14.069 times the RMS random jitter for 10^{-12} BER.

Measurement Algorithm

1 Make the connections as described in "Setting Up the USB 3.0 Test Environment" on page 19. The horizontal and vertical scales of the oscilloscope are adjusted as described in there.

2 Using the USB-IF SigTest:

- Acquire and save the waveform into

  C:\Documents and Settings\All Users\Application Data\Agilent\Infiniium\Apps\USB3Test\Project\USB3.bin

- Call the USB SigTest to analyze the saved waveform

3 Using the Agilent SDA (in this case, the EZJIT+):

- Enable Jitter mode on EZJIT+.
- Perform RjDj measurements by using the following setup:

BER: E-12

Pattern length: arbitrary

Leading coefficient: -2

Lagging coefficient: 5

Rj Bandwidth: Narrow

- Setup clock recovery:

2nd Order PLL, data rate of 5Gb/s, loop bandwidth of 4.9MHz, damping factor of 0.707

- Get Rj and Dj reading
- Calculate total jitter Tj using formula:

Tj = 14.068 * Rj + Dj

4 Compare the test result with compliance test limit.

Pass Condition

The measured total jitter, Tj measured at TP1 is within the limit as specified in Table 6-12 of the USB 3.0 specification.

Test References

See Table 6-12 Normative Transmitter Eye Mask at Test Point TP1 in the *USB 3.0 Specification, version 1.0*.

5
Calibrating the 80000B and 90000A Series Infiniium Oscilloscopes

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Self Calibration 68

This section describes the Agilent 80000B and 90000A Series Infiniium oscilloscopes calibration procedures.

To Run the Self Calibration

NOTE Let the Oscilloscope Warm Up Before Adjusting. Warm up the oscilloscope for 30 minutes before starting calibration procedure. Failure to allow warm up may result in inaccurate calibration.

The self calibration uses signals generated in the oscilloscope to calibrate channel sensitivity, offsets, and trigger parameters. You should run the self calibration

- yearly, or according to your periodic needs,
- when you replace the acquisition assembly or acquisition hybrids,
- when you replace the hard drive or any other assembly,
- when the oscilloscope's operating temperature (after the 30 minute warm-up period) is more than ±5 °C different from that of the last calibration.

To calibrate the Infiniium oscilloscope in preparation for running the USB 3.0 automated tests, you need the following equipment:

Table 18 Equipment Required

Equipment	Critical Specifications	Agilent Part Number
Adapters (2 supplied with oscilloscope except for the DSO90254A)	3.5 mm (f) to precision BNC No substitute	Agilent 54855-67604

Table 18 Equipment Required

Equipment	Critical Specifications	Agilent Part Number
Cable Assembly	50 Ω characteristic impedance BNC (m) connectors ~ 36 inches (91 cm) to 48 inches (122 cm) long	Agilent 8120-1840
Cable Assembly (supplied with oscilloscope except for the DSO90254A which can use a good quality BNC cable)	No substitute	Agilent 54855-61620
10 MHz Signal Source (required for time scale calibration)	Frequency accuracy better than 0.4 ppm	Agilent 53131A with Opt. 010

Self Calibration

NOTE Calibration time: It will take approximately 1 hour to run the self calibration on the oscilloscope, including the time required to change cables from channel to channel.

1 Let the Oscilloscope Warm Up Before Running the Self Calibration.

   The self calibration should only be done after the oscilloscope has run for 30 minutes at ambient temperature with the cover installed. Calibration of an oscilloscope that has not warmed up may result in an inaccurate calibration.

2 Pull down the Utilities menu and Select Calibration.

3 Click the check box to clear the Cal Memory Protect condition.

   You cannot run self calibration if this box is checked. See Figure 7.

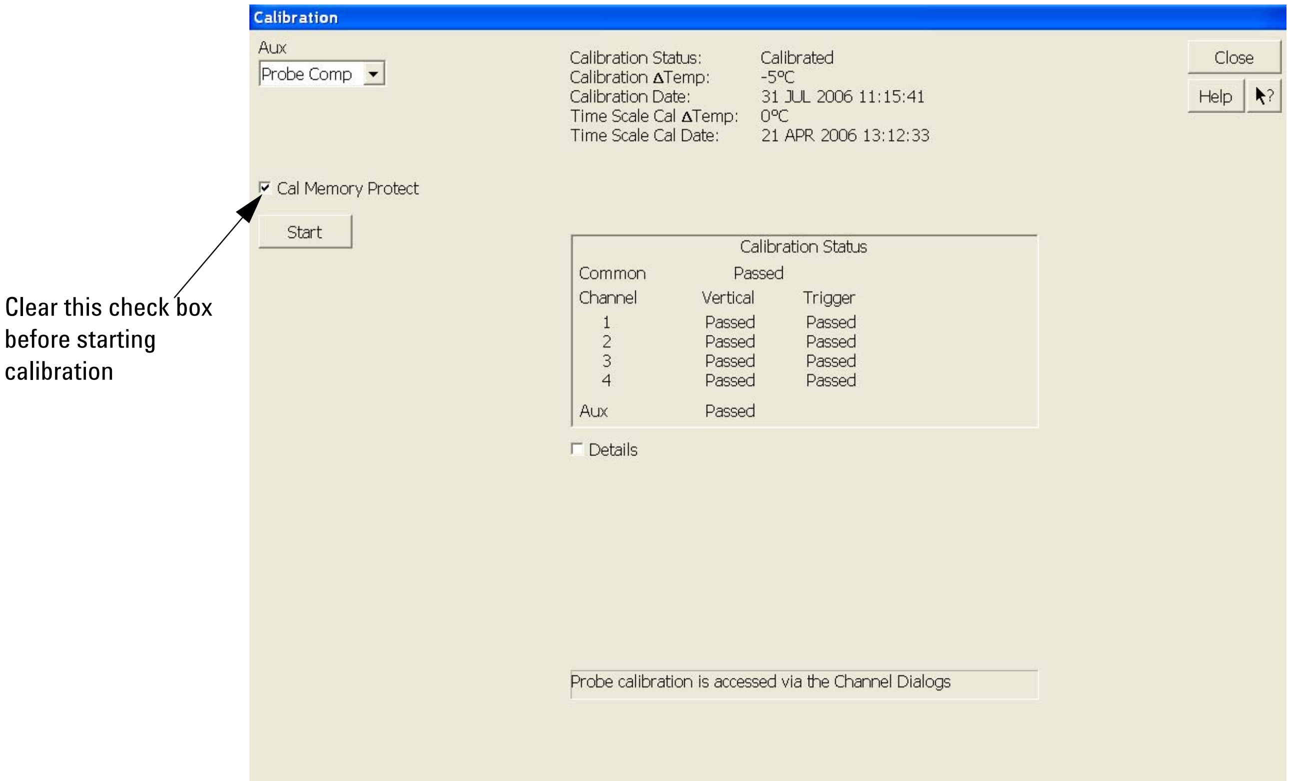

Figure 7 Oscilloscope Calibration Window

4 Click Start, then follow the instructions on the screen.

The routine will ask you to do the following things in sequence:

a Decide if you want to perform the Time Scale Calibration. Your choices are:

- Standard Calibration - Time scale calibration will not be performed. Time scale calibration factors from the previous time scale calibration will be used and the 10 MHz reference signal will not be required. The remaining calibration procedure will continue.
- Standard Calibration and Time Scale Calibration - Performs the time scale calibration. This option requires you to connect a 10 MHz reference signal to channel 1 that meets the following specifications. Failure to use a reference signal that meets this specification will result in an inaccurate calibration.

  Frequency: 10 MHz ±0.4 ppm = 10 MHz ±4 Hz

  Amplitude: 0.2 Vpeak-to-peak to 5.0 Vpeak-to-peak

  Wave shape: Sine or Square

- Standard Calibration and Reset Time Scale Calibration - Factory time scale calibration factors will be used. The 10 MHz reference signal will not be required. The remaining calibration procedure will continue.

b Disconnect everything from all inputs and Aux Out.

c Connect the calibration cable from Aux Out to channel 1.

- You must use the 54855-61620 cable assembly with two 54855-67604 adapters for all oscilloscopes except for the DSO90254A which can use a good quality BNC cable. Failure to use the appropriate calibration cable will result in an inaccurate calibration.

d Connect the calibration cable from Aux Out to each of the channel inputs as requested.

e Connect the 50 Ù BNC cable from the Aux Out to the Aux Trig on the front panel of the oscilloscope.

f A Passed/Failed indication is displayed for each calibration section. If any section fails, check the calibration cables and run the oscilloscope Self Test in the Utilities menu.

g After the calibration procedure is completed, click Close.

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