SuperSpeed USB

Revision 1.0
25, October, 2012

SuperSpeed USB
Tektronix MOI for Receiver tests using Tektronix AWG7000 series Arbitrary Waveform Generator.

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MODIFICATION RECORD

June6, 2009 (Version 0.5) INITIAL RELEASE
Mike Engbretson
July 16, 2009 (Version 0.6) format update.
Christopher Skach
Oct 10, 2009 (Version 0.7) Added External Error detection method using Tektronix API tool and ATE tool update.
Christopher Skach
April 16, 2010 (Version 0.8) Updated to support CTS ver 1.0 and removed ATE tool support
Christopher Skach
Dec 13, 2010 (Version 0.9) Added waveform calibration and Scope Error detector procedure. Removed internal loopback tests
Christopher Skach
Aug 26, 2011 (Version 0.91) Added Rx LFPS tests
Christopher Skach
Oct, 3 2011 (Version 0.92) Added detail using ATE for calibration
Christopher Skach
Dec 13, 2011 (Version 0.95) Updated Sj calibration to use SigTest and manual Pre-emphasis calibration
Christopher Skach
Oct 25, 2012 (Version 1.0) Added automation details for calibration. Removed ATE for calibration. Updated flow/ format.
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ACKNOWLEDGMENTS

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INTRODUCTION

The tests contained in this document are organized in order to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are separated into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality.

The test definitions themselves are intended to provide a high-level description of the motivation, resources, procedures, and methodologies specific to each test. Formally, each test description contains the following sections:

Purpose

This document outlines precise and specific procedures required to conduct compliance tests, as they pertain to receiver testing and automated calibration. This document covers the following tests which are all based around testing the receiver channel using a directly synthesized test composite patterns with a precise level of digital impairment using an Arbitrary Waveform Generator.

Detailed Tests

Test RX-01 – External Error Detection Receiver Jitter Test

Purpose: To verify that the Product Under Test (PUT) meets receiver tolerance specifications of the SuperSpeed USB Compliance Test Specification.

References:

USB Specification Revision 3.0
USB 3.0 CTS ver .99

Resource Requirements:

See Appendix A

Test Setup:

See Appendix B for detailed description

Use AWG USB3.0 Receiver Test Pattern library of stressed data patterns for each Rx test required. This library includes all stressed patterns including RJ, Dj including and excluding CIC/ISI and with sine Sj source frequencies of:

500 KHz
1MHz
2MHz
4.9MHz
10MHz
20MHz
33MHz
50MHz

Test Procedure:

See Appendix C for Detailed description

If necessary, use ancillary equipment to place the USB product-under-test (host or drive) in Loopback mode .
Note: In most cases the AWG will complete the entire process.

Once in Loopback mode, use sequencer or Automated Test to run specific test waveform in test suite.

To validate that the error counting HW is functioning properly, recall the error injector (1 Error)test pattern. Observe that the error counter increments by one every time the error waveform is generated. Clear the error counters back to 0 once this has been validated.

Recall the clean (no jitter) test pattern and run to observe that no error count increments are occurring for 10 sec of initial operation.

For each of the five sine jitter (SJ) frequencies defined, apply the appropriate Stressed test patterns outlined in table below by selecting it in the sequence menu. Perform the Symbol Error Count test for each frequency for a period of listed below. Record Symbol Error Count for each jitter frequency.

USB RX tests: Normative, Required for all PUTs.	**USB usage model:** 5Gbps(Gen3) + 0ppm -3dB of De-emphasis SSC Downspread 5000 ppm, 33KHz, Triangular	**SJ freq Amplitude Duration** 500KHz 400ps **6 sec** 1MHz 200ps **6 sec** 2MHz 100ps **6 sec**

		4.9MHz	40ps **6 sec**
		10MHz	40ps **6 sec**
		20MHz	40ps **6 sec**
		33MHz	40ps **6 sec**
		50MHz	40ps **6 sec**

Observable Results:

Error Counter must record no more than 1 errors over a specified period at each of the prescribed jitter frequencies. Record the number of observed errors at each of the three phases of this test. In the case where at least 1000 errors are observed during test execution, the test iteration may stop and specific test would report a failure due to high number of errors.

Waveform Calibration:

See appendix F

Accuracy:

Possible Problems: Not in loopback mode

Appendix A – Resource Requirements

A.1 Equipment for Performing external Error detection Tests RX01 (Normative)

1. Signal Generator
   AWG7102, AWG7122B or AWG7122C, option 6 (interleaved output with 20Gs/s or 24Gs/s sample rate) and opt 08 for AWG7122B/C (Fast Sequencing)
   AWG7122C recommended for all testing
2. Real-time Digital Oscilloscope
   MSO/DPO/DSA 70000B/C/D series 12.5GHz (or higher) (Used for automation, Error Detection and calibration)

3. Test Fixture
   USB test fixtures (TF-USB-AP, TF-USB-B-R, TF-USB-A-R)- SW mode or
   USB-IF Test fixtures for HW mode
   Note: Unlike the USB-IF test fixture the Tektronix fixture does not have DC Blocks on the RX inputs. When using the Tektronix test fixture, the test fixture must be used with DC blocks on the output of the AWG.

4. Cables/Connectors
   2) Matched SMA pairs (Tek PN 174-4944-XX)
   1) Standard GPIB cable
   1) .5 meter BNC cable (DSA – AWG Force Event)
   2) Short USB 3.0 cable (included with USB-IF Test Fixtures)
   1) 3 meter USB 3 Cable (HW mode) (included with USB-IF Test Fixtures)

5. Software
   Tektronix AWG7000 USB3.0 Receiver Test Pattern setup (for manual test)
   Tektronix SDX100 opt ISI, opt SSC (Required only for waveform creation)
   Tektronix DPOJET (for waveform calibration)
   Intel SigTest ver 3.2.3
   TekExpress TEKEXP USB-RMT (for automated testing)
6. External Error Detector
   Ellisys 280 USB3.0 Analyzer, Software and Drivers
   Recommended: Tektronix Ocilloscope Error Detector MSO/DPO/DSA70000B/C/D with opt

Appendix B – Test Setups

Connection Diagrams:

1. **Rx01 SW Channel Emulation using external scope error detector** - The test setup for Tx/Rx testing using Channel Emulation for the Cable, Tx Reference Channel, and Rx Reference Channel. The Signals are captured and applied at TP2.

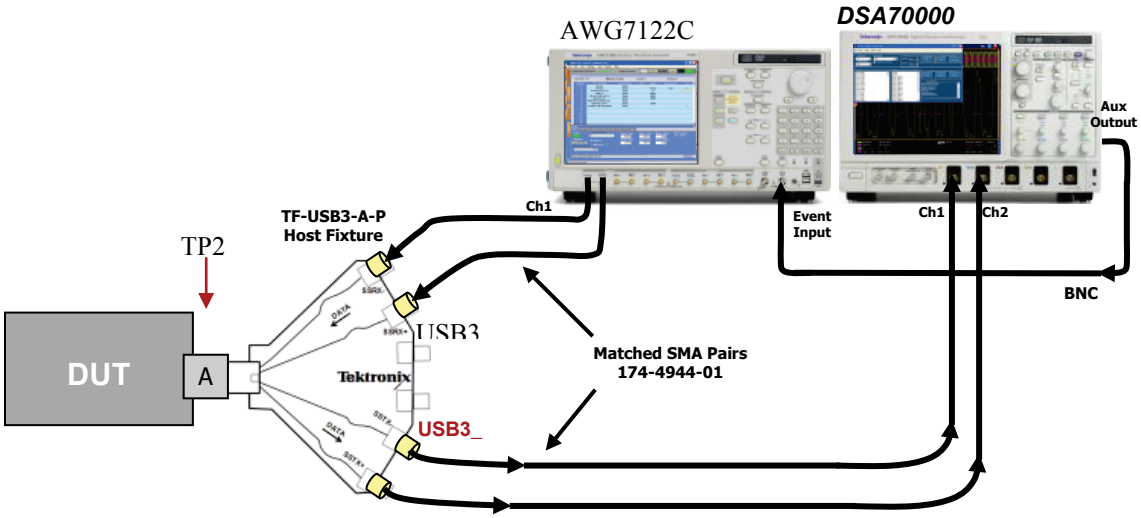
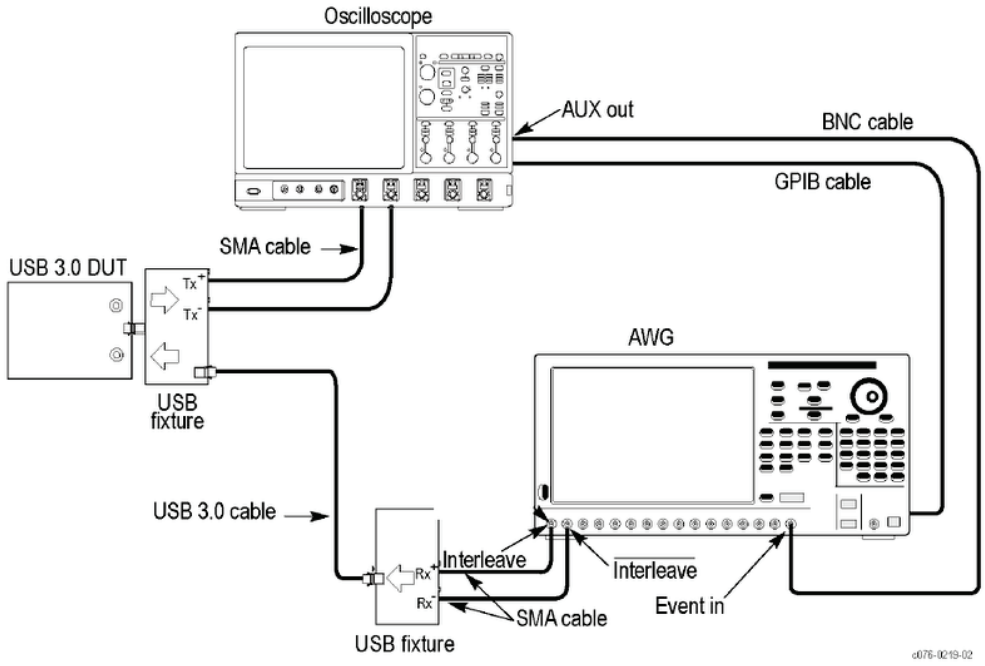


Figure 1: Setup for SW Channel Emulation

2. **Rx 01HW Channel Emulation using external scope error detector** - The test setup for Tx/Rx testing using Hardware Channel Emulation for the Cable, Tx Reference Channel, and Rx Reference Channel.

Device-Hardware Channel Emulation-Scope Error Detector



Host-Hardware Channel Emulation-Scope Error Detector

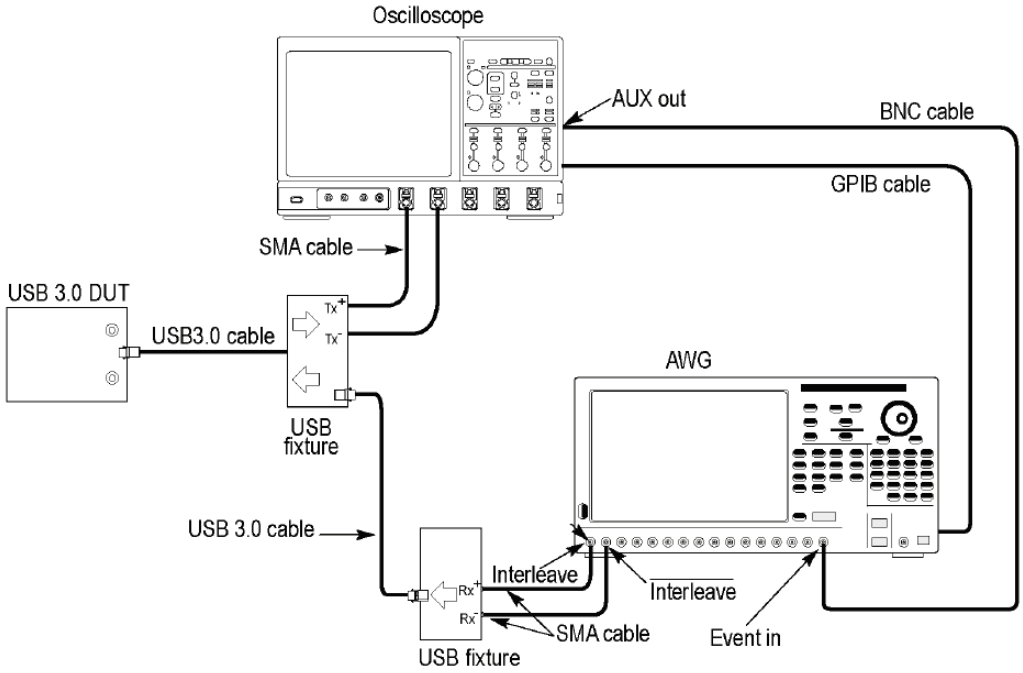
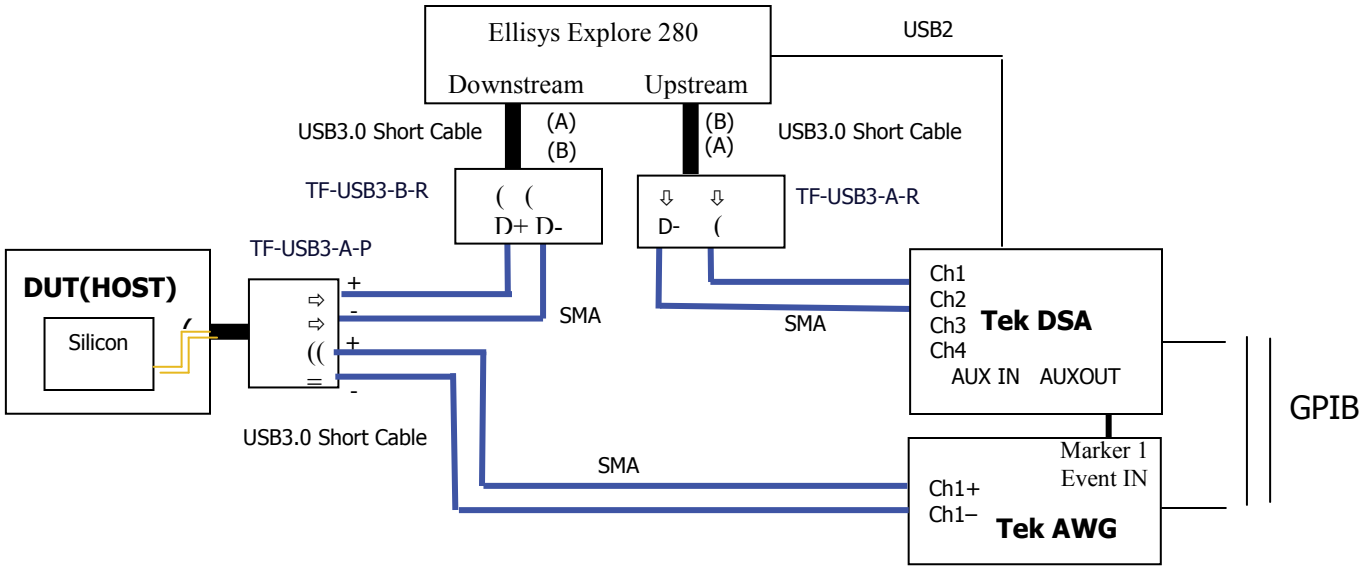


Figure 2: Setup for HW Channel Emulation



Note:
1.For Device test, Device is connected to Ellisys Downstream port as well
2.USB3 A&B receptacle fixtures may be included by Ellisys box

RX01 External BERT Test configuration used with Ellisys protocol analyzer

Appendix C – Manual Test using Scope Error Detector

The Tektronix USB 3.0 Receiver Manual Test using Scope Error Detector

1. Load USB3_HWManTest.AWG on AWG
2. Connect HW channel configuration
3. Make sure scope is in Single mode and AWG is running with Ch1 on.
4. Recall LFPS setup on scope
5. Power DUT

When the scope triggers, a trigger pulse is sent from the **AUX OUT** of the scope to the **Event Input** of the of the AWG. This will start the loopback initiation process and AWG sequence should be running on clean waveform.

The AWG's performs the following sequence to achieve loopback and perform Rx testing:

① Transmits 200 Polling LFPS patterns
② Transmits 65536 TSEQ with Sj of 500KHz at 400ps amplitude, SSC and 3dB of de-emphasis
③ Transmits 256 TS1s (only SSC and De-emphasis applied)
④ Transmits 256 TS2 with loopback set
⑤ Transmits BDATA with BRST
⑥ Transmits BDATA with no jitter to start test
⑦ Recall Error Det setup on scope and load error detection script using Open Choice Talker Listener interface.

```
Talker Listener Script: <<Script1>>
*rst
trig:a:type serial
trig:a:serial:source ch1
trig:a:serial:code s8b10b
trig:a:serial:standard usb3
trig:a setlevel
trig:a:serial:error:enable on
trig:a:serial:error:file:recall "c:\TekScope\ErrorDetector\UsbCP0_SKPsymbolErrorSetup.txt"
trig:a setlevel
trig:a:serial:error:symbol:test start
trig:a:serial:error:symbol:test clear
trig:a:serial:error:symbol:test stop
trig:a:serial:error:enable off
```

⑧ Step through script until error detector is activated
⑨ Test for No Errors using Scope Error counter
⑩ Jump to first jitter profile test waveform (press the Force Event front panel button)
⑪ Test for Errors using external Error counter and note error count
⑫ Jump to next frequency jitter waveform (press the Force Event front panel button)
⑬ Repeat 11-12 until all jitter profiles have been tested.

Appendix D – Waveform Calibration (Manual Procedure)

To improve impairment accuracy of generated waveforms, calibration procedure can be applied to waveform creation as follows. ***(The waveforms supplied as compliance test waveforms have been verified to meet required specifications, so waveform calibration is not required in most cases)***
Note*: The TekExpress USB-RMT software is available to automate this process.* Calibrate de-emphasis. Limits values are +5%.

1) Calibrate Rj
2) Calibrate Sj
3) Calibrate Amplitude
4) Verify Tj - First take calibrated Rj, and Computed Dj using Stressed-Eye pattern, and then compute Tj at 10^-12 BER using the equation Tj = 14.068 * Rj + Dj.
    - Recall Default Setups on Scope and AWG
    - Run Internal Calibration on Scope and AWG
    - Deskew Ch1/Ch2
    - Connect AWG' interleave outputs to Scope Ch1/Ch2 with phase-match SMA cable through HW or SW configuration.
    - Verify Ch1 and Ch2 are same amplitude (if using HW channel verify fixtures are not intermittent)

a. Calibrate de-emphasis

Scope settings for de-emphasis:

Channels used: Ch1, Ch2, Math1=Ch1-Ch2
BW setting 13GHz
Sample rate 50Gs/s
HORizontal:MODE MANual
HORIZONTAL:MAIN:SAMPLERATE 50e+9
HORIZONTAL:MODE:RECORDLENGTH 10000000
TRIGGER:A:TYPE EDGE
TRIGGER:A:LEVEL 0.05
HORIZONTAL:MAIN:POSITION 0
TRIGger:A SETLevel
HORIZONTAL:MAIN:POSITION 0
MATH1:DEFINE "CH1-CH2"
CH1:SCALE 80E-03
CH2:SCALE 80E-03
SELECT:CH1 ON
SELECT:CH2 ON
SELECT:MATH1 ON
MATH1:SCALE 30E-03
CH1:BANDWIDTH 13.0000E+09
CH2:BANDWIDTH 13.0000E+09

DPOJET settings for de-emphasis:

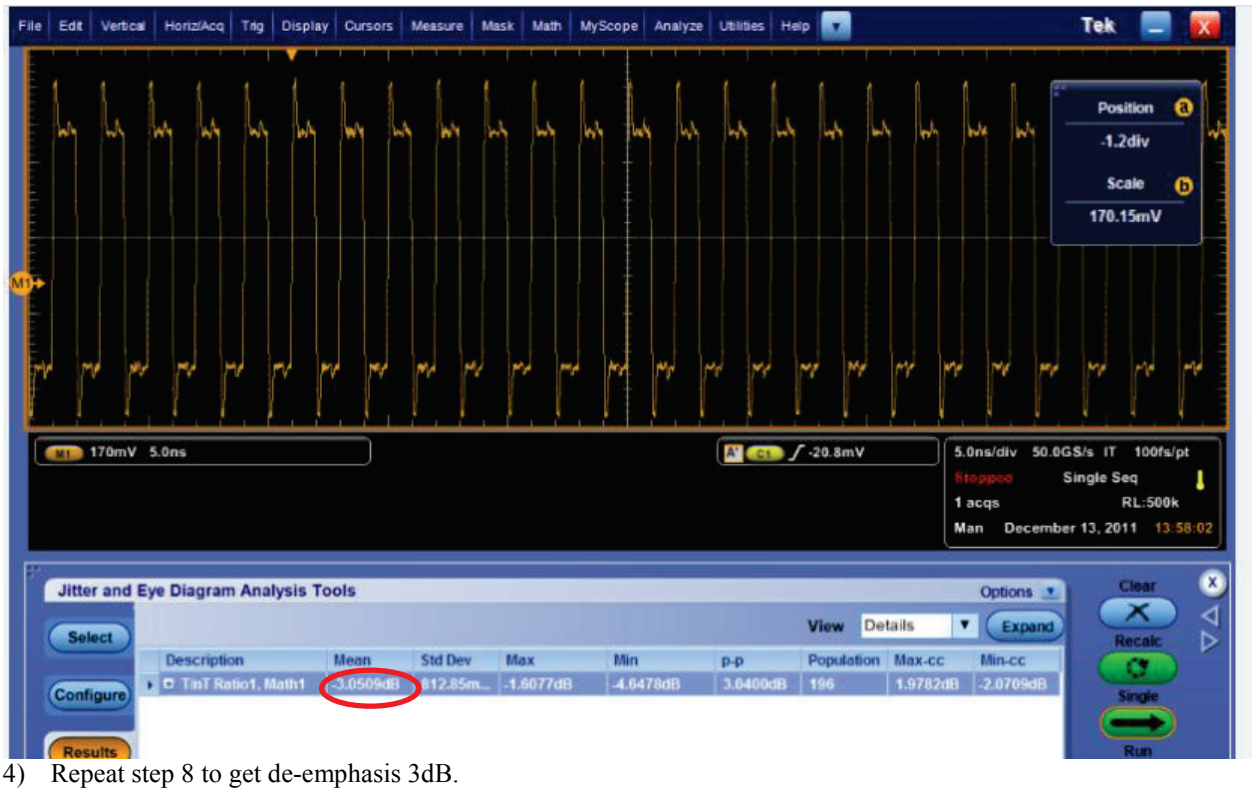
DPOJET:ADDMEAS TNTratio
DPOJET:MEAS1:SOURCE1 Math1
DPOJET:MEAS1:SIGNALType DATA
DPOJET:MEAS1:CLOCKRecovery:METHod CUSTOM
DPOJET:MEAS1:CLOCKRecovery:MODel Two
DPOJET:MEAS1:CLOCKRecovery:DAMPing 0.710
DPOJET:MEAS1:CLOCKRecovery:BWType LOOPBW
DPOJET:MEAS1:CLOCKRecovery:LOOPBandwidth 4.9e+6

DPOJET:MEAS1:CLOCKRecovery:DATARate 1
DPOJET:MEAS1:CLOCKRecovery:CLOCKBitrate 5E9

Meas1 Measurement: T/nT Ratio1
Source: Math1
Clock Recovery: Constant Clock – Mean (Advanced Nominal Data Rate = 5Gb/s)
In order to get DPOJET to recognize this slower clock pattern these commands need to be sent to the scope through the T\L command prompt.
DPOJET:MEAS1:SIGNALType DATA

1) Connect AWG interleave Ch + and – directly to scope CH1 and Ch2
2) Compile waveform by SerialXpress with initial settings (Note: Refer to SerialXpress online help manual for detailed steps to perform waveform compilation).
Pattern: Custom 0000011111 pattern selection in SerialXpress
Data Rate: 5Gbps
Sample Rate:20GS/s
Tr/Tf: 30ps (20-80%)
No SSC, No Rj/Sj, No ISI
Repetition Count: Manual 1
Device : Amplitude:±0.275V(0.550 pk-pkV)
Host: Amplitude:±0.350V(0.700 pk-pkV)
Pre / De-emphasis: 3.5dB (to compensate for cable loss)

3) Calibrate de-emphasis
Repeat changing de-emphasis and compiling until DPOJET T/nT Ratio1 measurement result of compiled waveform shows +5% (limit).



4) Repeat step 8 to get de-emphasis 3dB.

b. Calibrate Rj Using HW USBIF test boards with 3 meter cable

- **Device Setup**;
  i. Connect the + side of the AWG Interleave output to the + side of the Device Test Fixture # 2
  ii. Connect the – side of the AWG Interleave output to the – side of the Device Test Fixture #2
  iii. Connect the Type A Plug side of the 3 Meter cable from the USB-IF Test Fixture Kit to the top port of the Device Test Fixture #2
  iv. Connect the Type B Plug side of the 3 Meter cable from the USB-If Test Fixture Kit to the Device Test Fixture #1
  v. Connect the Type A Plug side of the short cable from the USB-IF Test Fixture Kit to the Device Test Fixture #1
  vi. Connect the Type B Plug side of the short cable to the Device Cal Fixture
  vii. Connect the + side of the Device Cal Fixture to Channel 1 of the Scope
  viii. Connect the – side of the Device Cal Fixture to Channel 2 of the Scope AWG Interleave +- ->
- **Host Setup**; Interleave +- -> Host Test Fixture # 2 -> 3Meter cable -> USB Host Fixture #1 -> USB Device Fixture #1 -> SMA + to Ch1 – to Ch2.

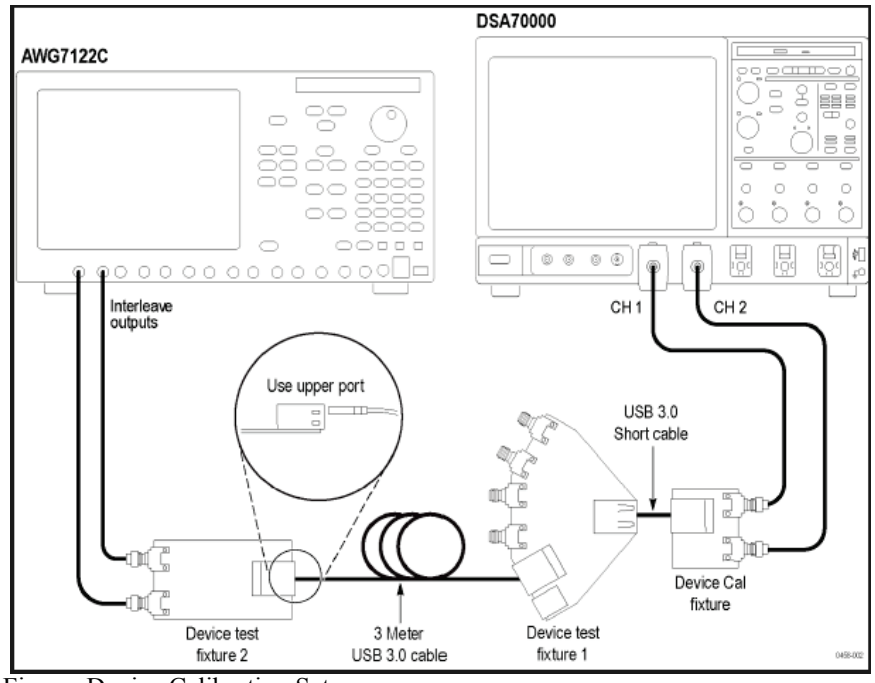


Figure: Device Calibration Setup

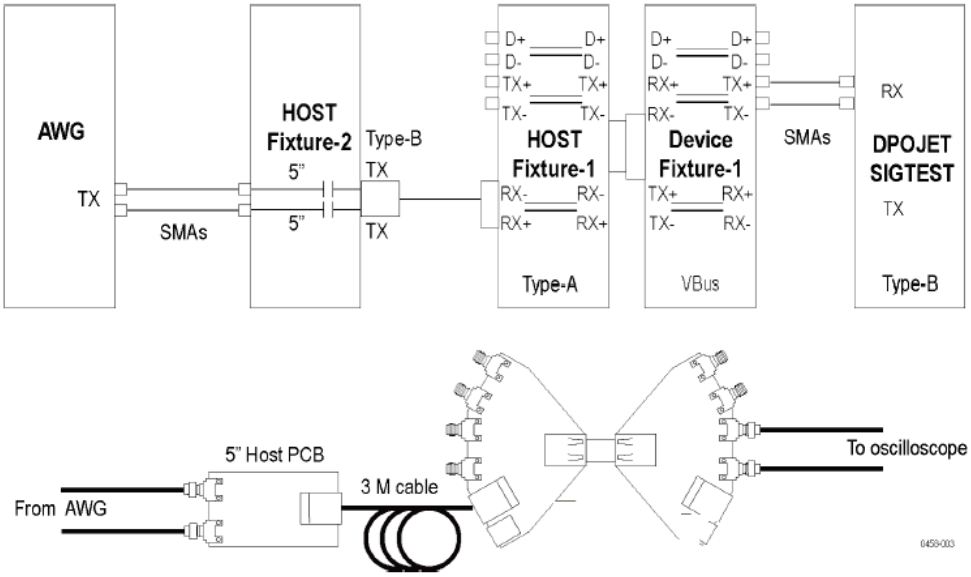


Figure: HOST calibration Setup

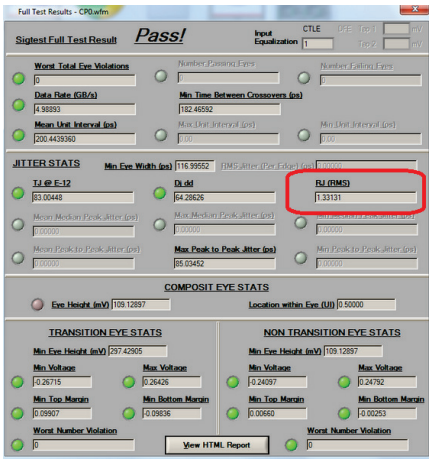
Scope setting for Rj using either SIGTEST or DPOJET.

Channels used:	Ch1, Ch2,
Bandwidth setting	13GHz
Sample rate	50Gs/s

HORizontal:MODE MANual
HORIZONTAL:MAIN:SAMPLERATE 50e+9
HORIZONTAL:MODE:RECORDLENGTH 5000000
TRIGGER:A:TYPE EDGE
TRIGGER:A:LEVEL 0.05
TRIGger:A SETLevel
HORIZONTAL:MAIN:POSITION 0
MATH1:DEFINE "CH1-CH2"
CH1:SCALE 20E-03
CH2:SCALE 20E-03
SELECT:CH1 ON
SELECT:CH2 ON
SELECT:MATH1 ON
MATH1:SCALE 30E-03
CH1:BANDWIDTH 13.0000E+09
CH2:BANDWIDTH 13.0000E+09

SIGTEST settings:

For Rj calibration using SIGTEST, save the raw wavefom without applying CTLE filter, and run this waveform in latest version of SIGTEST tool. Latest SIGTEST has in-built CTLE filter. Set the phase interval parameter in SIGTEST template file to 1 for stable results.

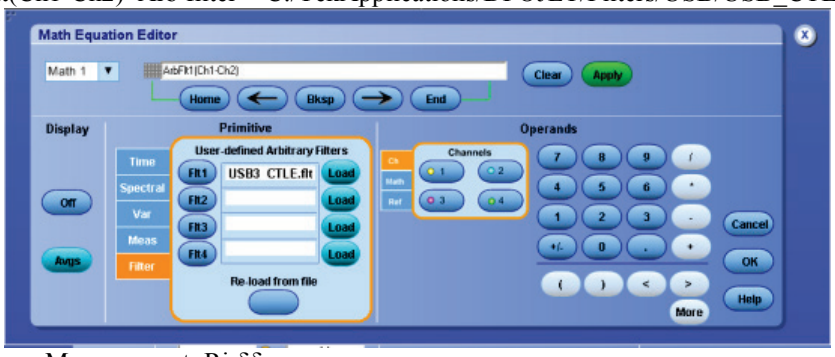


DPOJET settings for Rj:

Tests have shown that DPOJET and SigTest correlate very well for Rj

DPOJET:ADDMEAS RJDirac
DPOJET:MEAS1:SOURCE1 Math1
DPOJET:MEAS1:SIGNALType CLOCK
DPOJET:MEAS1:CLOCKRecovery:METHod CUSTOM
DPOJET:MEAS1:CLOCKRecovery:MODel Two
DPOJET:MEAS1:CLOCKRecovery:DAMPing 0.710
DPOJET:MEAS1:CLOCKRecovery:BWType LOOPBW
DPOJET:MEAS1:CLOCKRecovery:LOOPBandwidth 4.9e+6
DPOJET:MEAS1:CLOCKRecovery:DATARate 1
DPOJET:MEAS1:CLOCKRecovery:CLOCKBitrate 5E9
DPOJET:MEAS1:RJDJ:TYPE REPEating
DPOJET:MEAS1:RJDJ:WINDOwlength 2

Math1=ArbFlt(Ch1-Ch2) Arb filter = C:/TekApplications/DPOJET/Filters/USB/USB_CTLE.flt



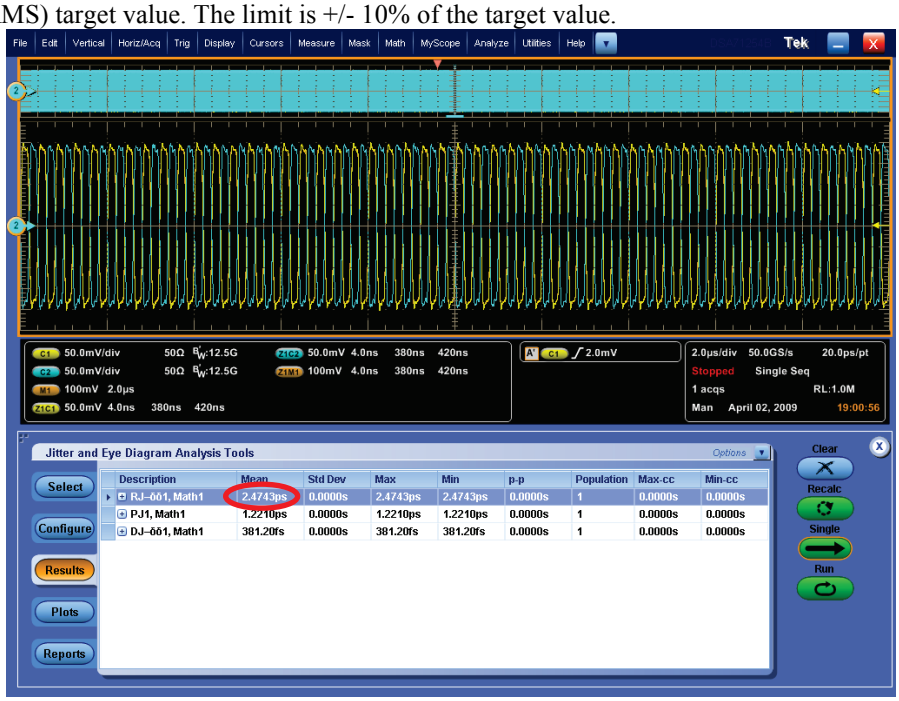
Meas1 Measurement: Rj-δδ
Source: Math1
Edges Signal Type Data
Clock Recovery: –PLL – Custom BW
Type II Damping = 710m Loop BW = 4.9MHz
RjDj: Arbitrary, 5UI, 400

Compile waveform by SerialXpress with initial settings (Note: Refer to SerialXpress online help manual for detailed steps to perform waveform compilation)

Data Rate: 5Gbps
Sample Rate:20GS/s
Encoding: None(NRZ), 8B10, RD+
Tr/Tf: 30ps (20-80%)
No SSC, No ISI
Repetition Count: 64K
Pre / De-emphasis: y.ydB ※ Use calibrated value in last step
※ y.y is obtained by step in Calibrate de-emphasis above
※ x.xx is obtained by step in below

Calibrate Rj

Repeat changing Rj and compiling until DPOJET Rj-dd1 measurement result of compiled waveform shows 2.4ps RMS (i.e 0.0121UI RMS) target value. The limit is +/- 10% of the target value.



c. Calibrate Sj Using HW USBIF test boards with 3 meter cable and SigTest Application

- **Device Setup**; AWG Interleave +- -> Device Test Fixture # 2 -> 3Meter cable from top of usb connector -> USB Device Fixture #1 -> short USB cable -> Dev Cal fixture -> SMA + to Ch1 – to Ch2.
- **Host Setup**; Interleave +- -> Host Test Fixture # 2 -> 3Meter cable -> USB Host Fixture #1 -> USB Device Fixture #1 -> SMA + to Ch1 – to Ch2.

Scope settings for Sj:

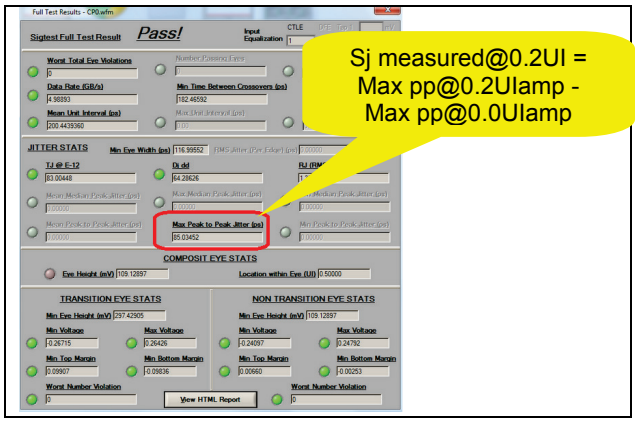
Channels used: Ch1, Ch2, Math1=Ch1-Ch2
BW setting 13GHz
Sample rate 50Gs/s
HORizontal:MODE MANual
HORIZONTAL:MAIN:SAMPLERATE 50e+9
HORIZONTAL:MODE:RECORDLENGTH 10000000
TRIGGER:A:TYPE EDGE
TRIGGER:A:LEVEL 0.08
HORIZONTAL:MAIN:POSITION 0
MATH1:DEFINE "CH1-CH2"
CH1:SCALE 50E-03

CH2:SCALE 50E-03
SELECT:CH1 ON
SELECT:CH2 ON
SELECT:MATH1 ON
MATH1:SCALE 150E-03
CH1:BANDWIDTH 13.0000E+09
CH2:BANDWIDTH 13.0000E+09

Compile waveform by SerialXpress with initial settings (Note: Refer to SerialXpress online help manual for detailed steps to perform waveform compilation).
Pattern: CP0_SKP
Data Rate: 5Gbps
Sample Rate:20GS/s
Tr/Tf: 30ps (20-80%)
No Rj, SSC or ISI
Repetition Count: Auto
Amplitude:±x.xxV(0.550V) ※ Device default, include loss of measurement path
Pre / De-emphasis: y.ydB ※ Use calibrated value in last step
***x.xx and y.y are obtained by step in Calibrate de-emphasis above

1) Using SerialXpress create CPO_SKP waveform with De-emphasis set and 0 Sj
2) Capture math waveform with no CTLE filter on scope
3) Save math waveform in specific directory as .wfm file
4) Open SigTest and Browse for .wfm file just saved
5) Select Verify Valid Data File
6) Set Technology to usb_3_5gb
   Use template USB_3_5gb_CP0 for Freq 10MHz – 50MHz (this uses a Jitter Corner freq of 5MHz)
7) Select Test
8) Read Max Pk to Pk value and note this value as 0 jitter.
9) Set SerialXpress Sj at .2UI at 50MHz
10) Repeat 2-8
11) Read Max Pk to Pk value and note this value, subtract the 0 jitter value from this value to get Sj value.
12) Repeat 1 – 11 for each Sj freq and note SDX calibrated values. (for lower freq the SigTest template will need to be changed for the roll off freq. In most cases you do not have to repeat getting 0 jitter value and use the same value for each iteration test.
13) Note each calibration value that will be used to build final waveforms in SDX.

SJ freq	**Amplitude**
500KHz	400ps
1MHz	200ps
2MHz	100ps
4.9MHz	40ps
10MHz	40ps
20MHz	40ps
33MHz	40ps
50MHz	40ps

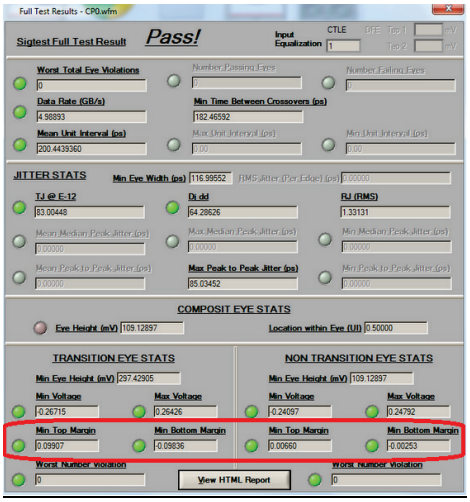


Optional: DPOJET Settings for Sj:
DPOJET:ADDMEAS PJ
DPOJET:MEAS1:SOURCE1 Math1
DPOJET:MEAS1:SIGNALType AUTO
DPOJET:MEAS1:RJDJ:TYPE ARBitrary
DPOJET:MEAS1:RJDJ:WINDOwlength 5
DPOJET:MEAS1:CLOCKRecovery:DATARate 1
DPOJET:MEAS1:CLOCKRecovery:CLOCKBitrate 5000000000
DPOJET:MEAS1:FILTers:HIGHPass:SPEC FIRST
DPOJET:MEAS1:FILTers:HIGHPass:FREQ 50000

d. Vertical Amplitude Adjust

After de-emphasis, Rj and Sj values are calibrated, SSC is applied to generate USB3 Rx test waveform by SerialXpress. No calibration needed for SSC.
SSC Downspread 5000 ppm, 33KHz, Triangular

14) Using SerialXpress (SDX) create CPO_SKP waveform with all calibrated jitter components added for specific Sj frequency at 50Mhz..
15) Capture math waveform with no CTLE filter on scope
16) Save math waveform in specific directory as .wfm file
17) Open SigTest and Browse for .wfm file just saved
18) Select Verify Valid Data File
19) Set Technology to usb_3_5gb
20) Set Template file to USB_3_5gb_CP0
21) Select Test
22) Capture EYE HEIGHT from SIGTEST results, as shown in below screenshot.
23) Vamp = min (Transition Margin, NON Transition Margin) + 100mV
    (Use smaller of two transition equations to get value)
24) Adjust Amplitude until calculated Vamp = 145mV for Device or 180mV for Host



Scope Settings for Stressed Eye:

Channels used:	Ch1, Ch2,
Bandwidth setting	13GHz
Sample rate	50Gs/s

HORizontal:MODE MANual
HORIZONTAL:MAIN:SAMPLERATE 50e+9
HORIZONTAL:MODE:RECORDLENGTH 10000000
TRIGGER:A:TYPE EDGE
TRIGGER:A:LEVEL 0.08
HORIZONTAL:MAIN:POSITION 0
MATH1:DEFINE "CH1-CH2"
CH1:SCALE 40E-03
CH2:SCALE 40E-03
SELECT:CH1 ON
SELECT:CH2 ON
SELECT:MATH1 ON
CH1:BANDWIDTH 13.0000E+09
CH2:BANDWIDTH 13.0000E+09

Optional: DPOJET Settings for Stressed-Eye:

DPOJET:ADDMEAS HEIght
DPOJET:MEAS1:SOURCE1 Math1
DPOJET:MEAS1:SIGNALType AUTO
DPOJET:MEAS1:CLOCKRecovery:METHod CUSTOM
DPOJET:MEAS1:CLOCKRecovery:MODel TWO
DPOJET:MEAS1:CLOCKRecovery:DAMPing 0.710
DPOJET:MEAS1:CLOCKRecovery:BWType LOOPBW
DPOJET:MEAS1:CLOCKRecovery:LOOPBandwidth 4900000
DPOJET:MEAS1:CLOCKRecovery:DATARate 1
DPOJET:MEAS1:CLOCKRecovery:CLOCKBitrate 5000000000
DPOJET:ADDPlot EYE,Meas1

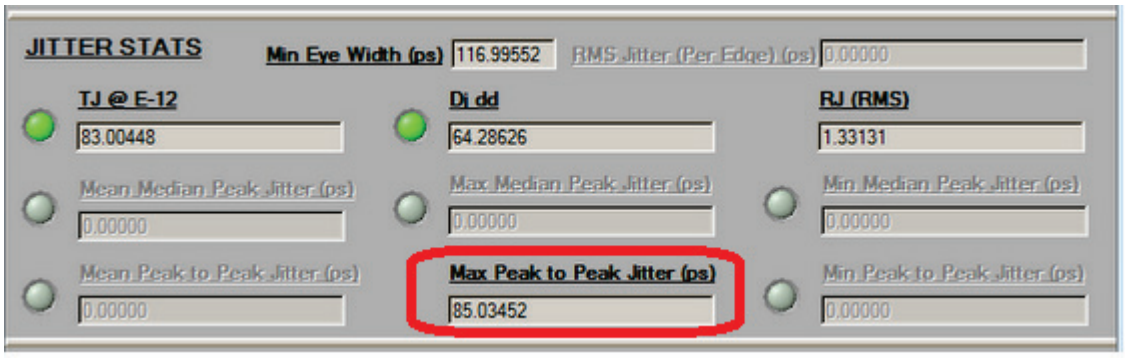
e. Tj Verification using SigTest

Scope setting for Tj

Channels used:	Ch1, Ch2,
Bandwidth setting	13GHz

Sample rate 50Gs/s
HORizontal:MODE MANual
HORIZONTAL:MAIN:SAMPLERATE 50e+9
HORIZONTAL:MODE:RECORDLENGTH 10000000
TRIGGER:A:TYPE EDGE
TRIGGER:A:LEVEL 0.08
HORIZONTAL:MAIN:POSITION 0
MATH1:DEFINE "CH1-CH2"
CH1:SCALE 40E-03
CH2:SCALE 40E-03
SELECT:CH1 ON
SELECT:CH2 ON
CH1:BANDWIDTH 13.0000E+09
CH2:BANDWIDTH 13.0000E+09

- Once Amplitude is set, Verify Tj value is between 85ps – 100 ps



Optional: DPOJET Settings for Tj:

DPOJET:CLEARALLMeas
DPOJET:ADDMEAS DJDirac
DPOJET:MEAS1:SOURCE1 Math1
DPOJET:MEAS1:SIGNALType DATA
DPOJET:MEAS1:CLOCKRecovery:METHod CUSTOM
DPOJET:MEAS1:CLOCKRecovery:MODel Two
DPOJET:MEAS1:CLOCKRecovery:DAMPing 0.710
DPOJET:MEAS1:CLOCKRecovery:BWType LOOPBW
DPOJET:MEAS1:CLOCKRecovery:LOOPBandwidth 4.9e+6
DPOJET:MEAS1:CLOCKRecovery:DATARate 1
DPOJET:MEAS1:CLOCKRecovery:CLOCKBitrate 5E9
DPOJET:MEAS1:RJDJ:TYPE ARBitrary
DPOJET:MEAS1:RJDJ:WINDOwlength 5

Appendix F – Fully-Automated Calibration Procedure using RMT software

Objective

Typically Rx calibration procedure is time consuming and requires precise computation of signal amplitudes (Eye Height), RJ, DJ values of the various signal paths is a key requirement. These values are used for the jitter-controlled generation of patterns which will be injected into DUT during loopback.

Calibration using Automation software.
The auto calibration function of USB-RMT automation software addresses receiver calibration requirements for the USB3.0 standard. Auto calibration compensates the patterns for specific jitter parameters (de-emphasis, Random jitter, sinusoidal jitter and stressed eye). The procedure sequences through all the patterns, with each pattern calibrated independently. These values are used for the jitter-controlled generation of patterns which will be injected into the DUT during loopback. The design engineer needs to ensure that the amount of jitter components (also known as target impairments) meets the compliance test specification within a certain tolerance range.

With USB-RMT software, the calibration is done by varying the target parameter through a pre-defined range and an uniform step size and computes the transfer function between the measured and input values. The signal generation for calibration is done using an AWG. The measurement methodology can be DPOJET and SigTest.

The calibration results can be viewed at any time as values or graphical plots. The application uses an appropriate polynomial fit algorithm for all the target values which gives the characteristic curve. The curve fit will be useful for estimation if any of the target values shows nonlinear nature. The respective calibrated values are derived from the characteristic curve.

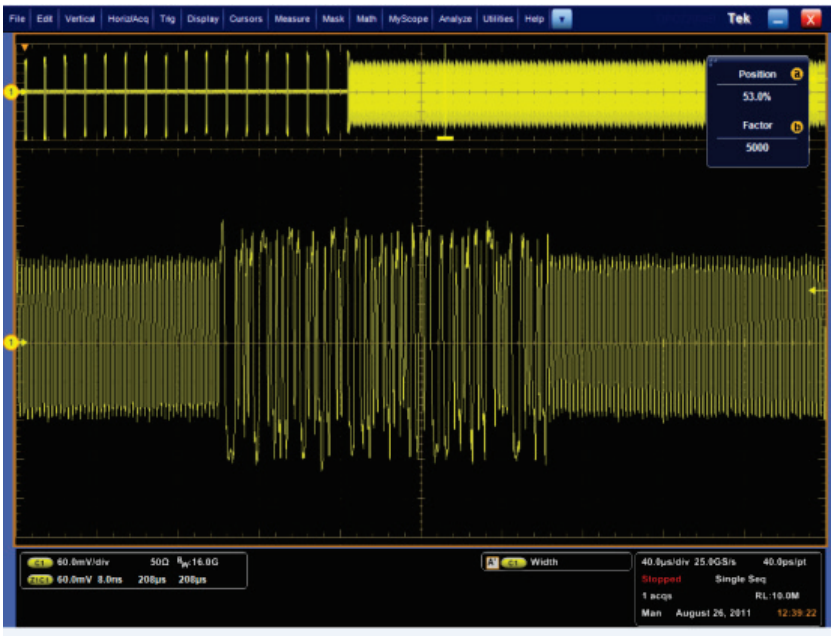
For more details on calibration using automated software, refer to online help manual of Tektronix USB-RMT software.

Appendix G – Rx LFPS Tests

Overview of Test Steps
- Connect the DUT to a simple breakout test fixture. Disconnect bus power if the DUT is a bus powered device.
- Power on the device under test (connect bus powered if DUT is a bus powered device) and let it pass through the Rx.Detect state to the Polling.LFPS substate.
- Trigger on the initial LFPS burst sent by the DUT and send LFPS signals to the DUT with the following parameters:
  - tPeriod 50 ns.
  - VTX-DIFF-PP-LFPS 800 mV.
  - Duty Cycle 50%
- The test passes if the device recognizes the LFPS and starts sending the TXEQ sequence.
- The test is repeated with the following parameters:
  - tPeriod 50 ns, VTX-DIFF-PP-LFPS 1200 mV, Duty Cycle 50%.
  - tPeriod 50 ns, VTX-DIFF-PP-LFPS 1000 mV, Duty Cycle 40%.
  - tPeriod 50 ns, VTX-DIFF-PP-LFPS 1000 mV, Duty Cycle 60%.

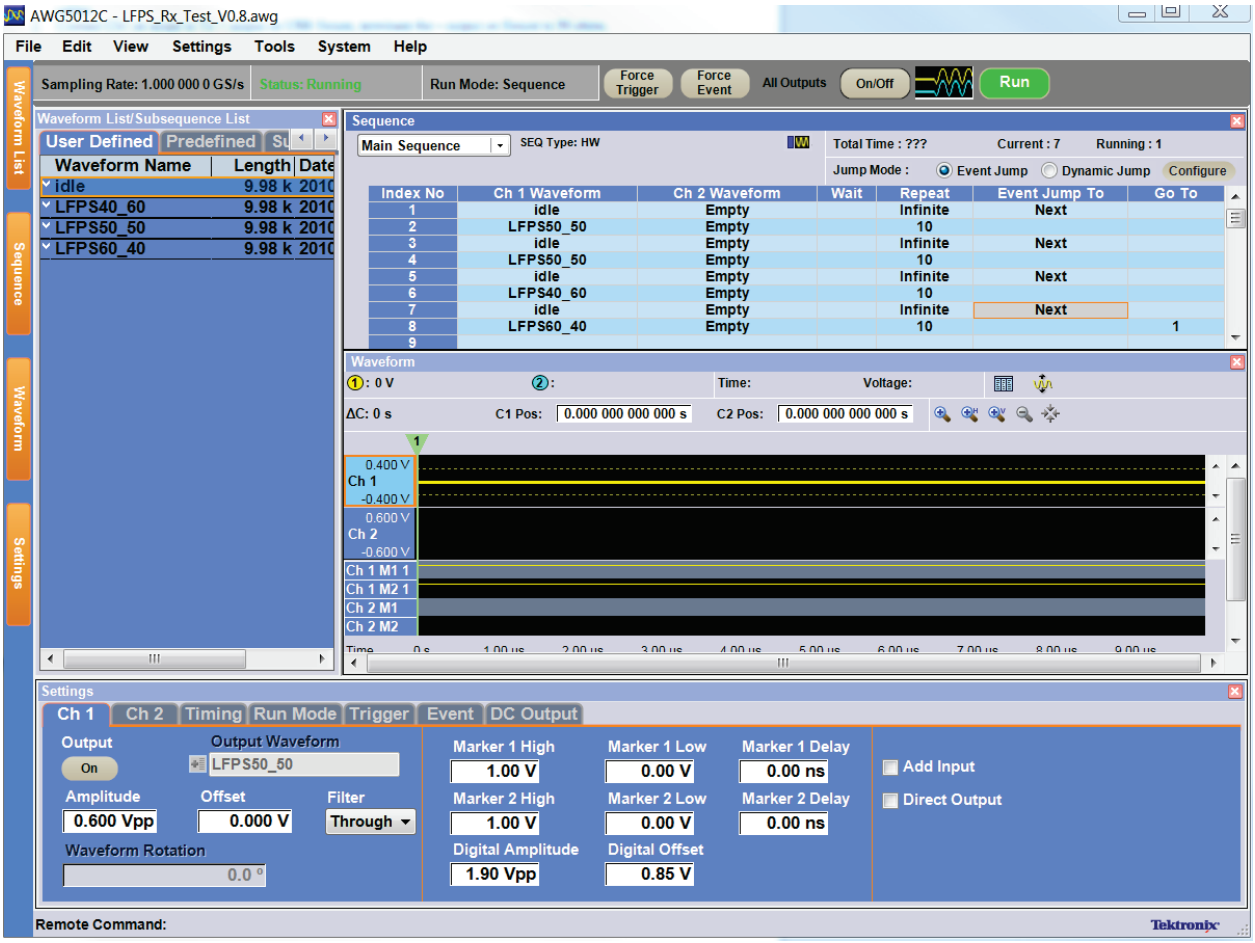
The Tektronix USB 3.0 Receiver LFPS tests
1. Connect Ch1 non interleave + and – connectors on AWG to USB3.0 fixture Rx inputs using matched SMA cables
2. Connect Ch1 on scope to Tx + output on USB fixture, terminate the – output on fixture to 50 ohms.
3. Connect BNC cable from scope Aux trig out on rear of instrument to AWG Event Input on front of AWG using a BNC cable
4. Open LFPS_Rx_Test.AWG on AWG
5. Recall USB_LFPS_Trig.set on scope
6. Make sure scope is in Single mode and AWG is running with Ch1 on and sequence is at running index 1.
7. Power DUT or apply VBUS
8. Plug USB fixture into DUT
9. Verify scope triggers on LFPS signal from DUT similar to display below (This confirms DUT is in compliance

with Rx LFPS specification) and AWG is running index 3.



10. Turn off power or remove VBUS on DUT
11. Change amplitude on AWG to .9V
12. Repeat steps 6 through 10 (AWG will automatically step through test sequence)

13. Change amplitude on AWG from .9V to .75V (Sequence should be running index 5)
14. Repeat steps 6-10 (AWG should now be running index 7)
15. Repeat steps 6-10


AWG5012C - LFPS_Rx_Test_V0.8.awg
File Edit View Settings Tools System Help
Sampling Rate: 1.000 000 0 GS/s
Status: Running
Run Mode: Sequence
Force Trigger
Force Event
All Outputs
On/Off
Run
Waveform List/Subsequence List
User Defined
Predefined
Waveform Name
Length
idle
LFPS40_60
LFPS50_50
LFPS60_40
Sequence
Main Sequence
SEQ Type: HW
Total Time : ???
Current : 7
Running : 1
Jump Mode :
Event Jump
Dynamic Jump
Configure
Index No
Ch 1 Waveform
Ch 2 Waveform
Wait
Repeat
Event Jump To
Go To
Waveform
Time:
Voltage:
ΔC: 0 s
C1 Pos:
C2 Pos:
Ch 1
Ch 2
Ch 1 M1 1
Ch 1 M2 1
Ch 2 M1
Ch 2 M2
Settings
Ch 1
Ch 2
Timing
Run Mode
Trigger
Event
DC Output
Output
On
Output Waveform
LFPS50_50
Amplitude
0.600 Vpp
Offset
0.000 V
Filter
Through
Waveform Rotation
Marker 1 High
1.00 V
Marker 1 Low
0.00 V
Marker 1 Delay
0.00 ns
Marker 2 High
1.00 V
Marker 2 Low
0.00 V
Marker 2 Delay
0.00 ns
Digital Amplitude
1.90 Vpp
Digital Offset
0.85 V
Add Input
Direct Output
Remote Command:
Tektronix