Anritsu Advancing beyond

USB3.2 LFPS Rx Testing Method of Implementation (MOI)

Signal Quality Analyzer-R MP1900A

Table of Contents

1. Introduction

This document describes the procedure of USB3.2 LFPS Rx calibration and testing, which corresponds to the following items in the USB CTS standard.

Electrical Compliance testing Specification Enhanced SuperSpeed Universal Serial Bus

TD. 1. 2 Low Frequency Periodic Signaling RX testing

This document provides details on:

1. Calibrating the MP1900A LFPS signal amplitude with a real-time oscilloscope
2. Performing LFPS Rx tests using the calibrated values.

Note: The setup connection depends on the amplitude of the LFPS for testing. See Sections 3 and 4 for details.

2. Equipment

Model number	Product name	Qty.	Description
MP1900A	Signal Quality Analyzer-R	1	MU181000B (Synthesizer) / MU181500B (Jitter Modulation Source) / MU195020A (SI PPG) / MU195040A (SI ED) / MU195050A (Noise Generator) Standard configuration
---	Real-time oscilloscope	1	For compatibility with USB 3.2 Rx tests, the following specifications are recommended: Bandwidth: 16 GHz Sampling rate: 80 GS / s
RC4DAT-6G-60	4CH P-ATT	1	Variable attenuator made by Mini-Circuits Product details: https://www.minicircuits.com/WebStore/dashboard.html?model=RC4DAT-6G-60 User Guide: https://www.minicircuits.com/app/AN49-011.pdf Control software: https://www.minicircuits.com/softwaredownload/RUDAT_CD.zip
USB31CET USB31AET	Testing Fixture	1	Available on the USB-IF site http://www.usb.org/developers/estoreinfo/
J1551A	Coaxial skew match cable 0.8 m	4	
J1624A	Coaxial cable 0.3 m	4	MU181000B standard accessory
J1625A	Coaxial cable 1 m	1	
J1627A	GND connection cable	1	MP1900A standard accessory
K240B	Power divider	2	

3. Calibration

Observe the differential signal with real-time oscilloscope and adjust the LFPS Vdiff-pp until the target amplitude is achieved.

3.1 1000 mVpp/1200 mVpp LFPS signal calibration

3.1.1 Calibration connection diagram

Connect the setup as shown in the figure below.

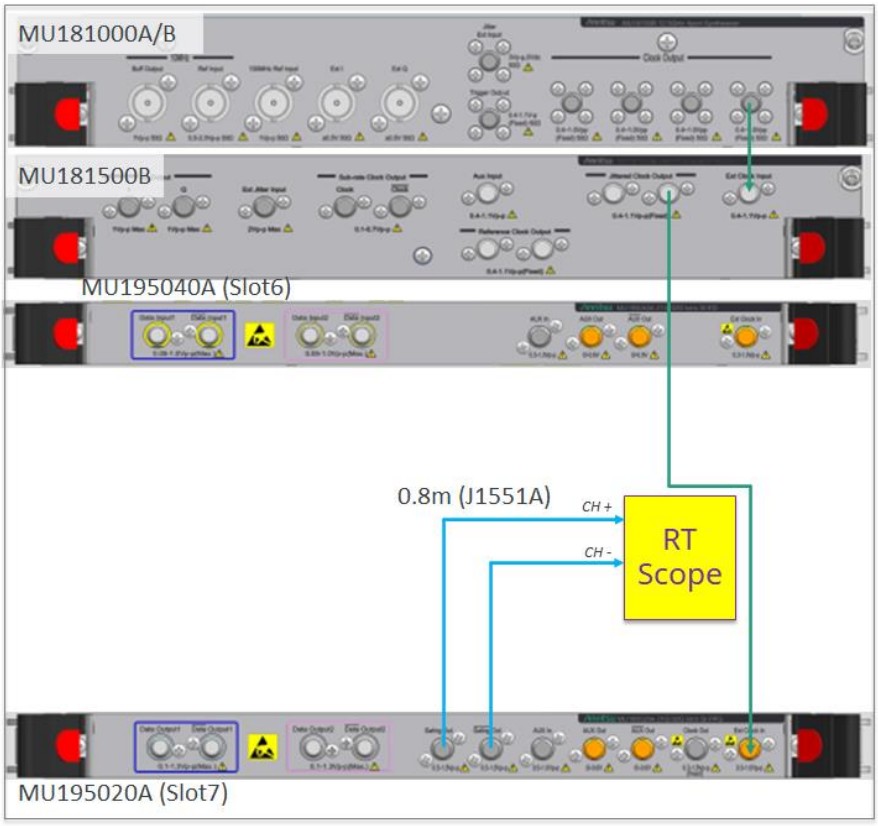
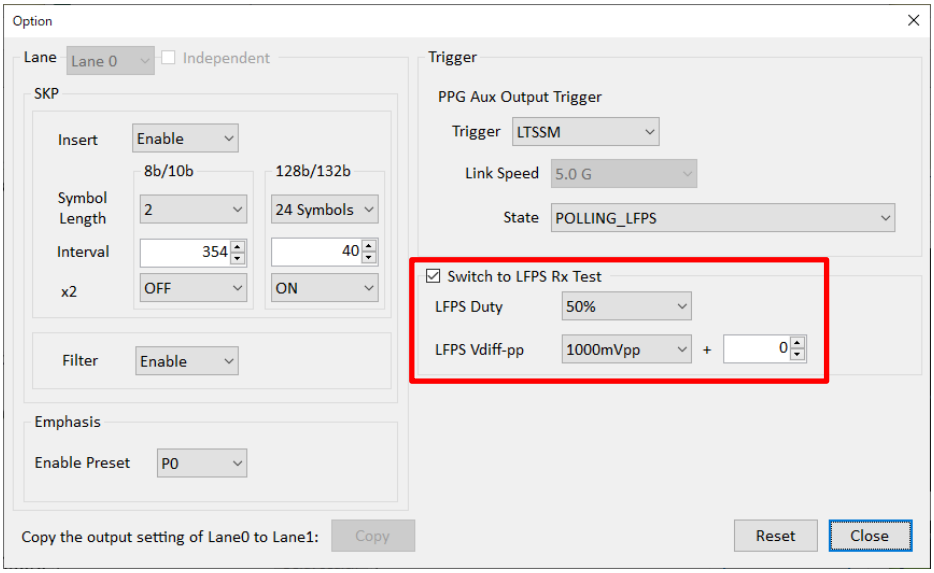


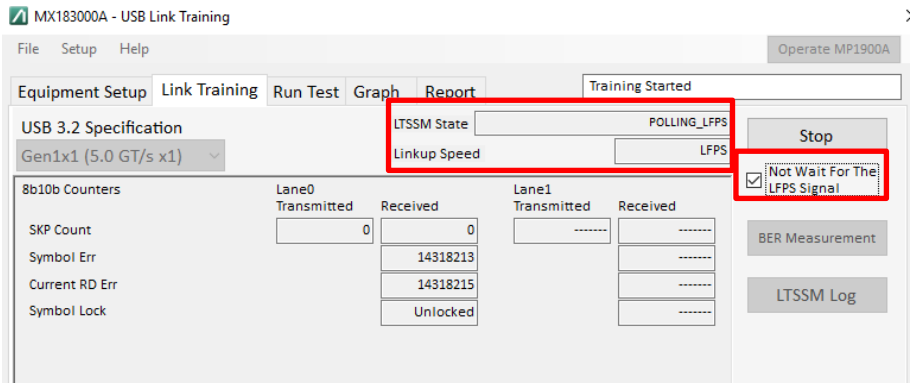
Figure 3.1.1-1 1000 mVpp/1200 mVpp LFPS signal calibration connection

3.1.2 1000 mVpp/1200 mVpp Calibration procedure

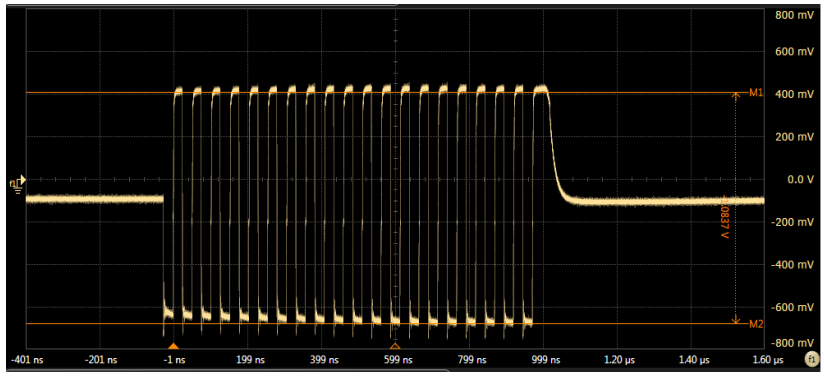
- Start MX183000A USB Link Training and click Connect.
- Click Option button on the Link Training tab.
- Make the following settings on the Option screen and press Close.
  - ➢ Switch to LFPS Rx test: ON
  - ➢ LFPS Duty: 50%
  - ➢ LFPS Vdiff-pp: 1000 mVpp



- Check “Not Wait For The LFPS Signal” on the Link Training tab.
- Press the Link Start button on the Link Training tab.
- The LTSSM State becomes POLLING_LFPS and the LFPS signal is output.



- Measure the differential amplitude with real-time oscilloscope.



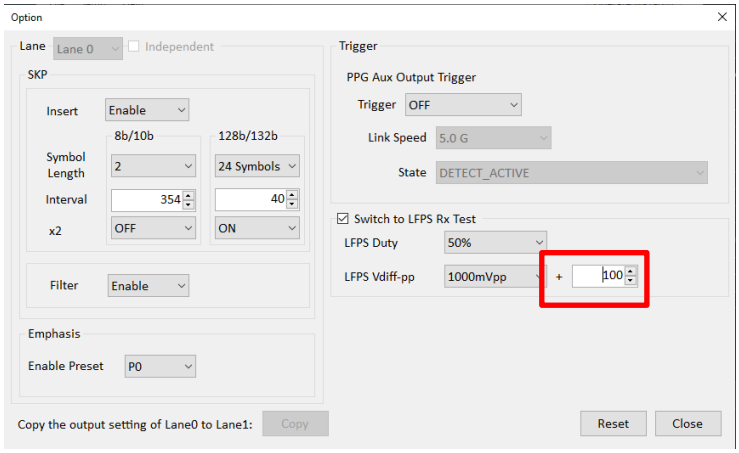
Markers

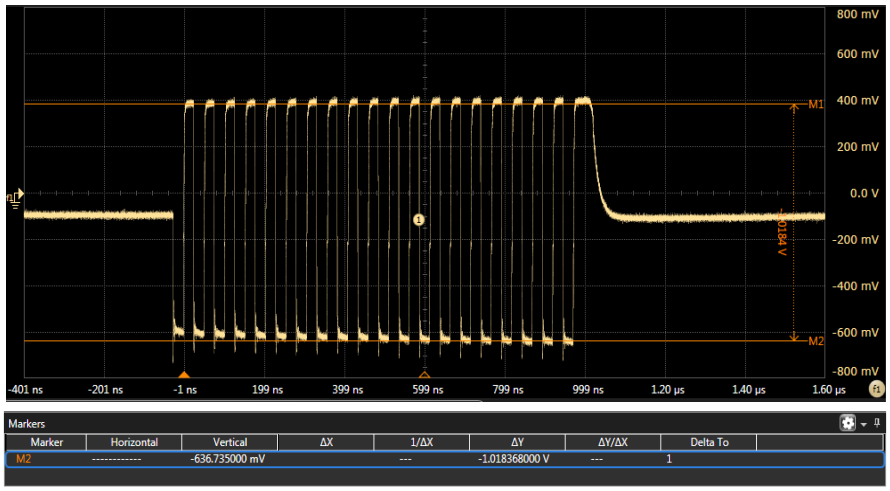
Marker	Horizontal	Vertical	ΔX	1/ΔX	ΔY	ΔY/ΔX	Delta To
M1	----------	406.123000 mV		---		---	--
M2	----------	-677.552000 mV		---	-1.083675000 V	---	1

- To fine-tune the amplitude, click the Option button.

Adjust the numerical value in the textbox on the right side of the LFPS Vdiff-pp, and calibrate the LFPS signal with the real-time oscilloscope so that the differential amplitude of the LFPS signal is 1000 mVpp. Record the adjustment value as [Cal-1000].

➢ LFPS Vdiff-pp Tweak: 100





- Repeat the procedure above with 1200 mVpp and record the adjustment value as [Cal-1200].

3.2 90/100/200/300/800 mVpp LFPS signal calibration

3.2.1 Calibration connection diagram

Connect the setup as shown in the figure below. Connect the Gating Output of MU195020A to Channel 1 of 4CH P-ATT and the XGating Output to Channel 2.

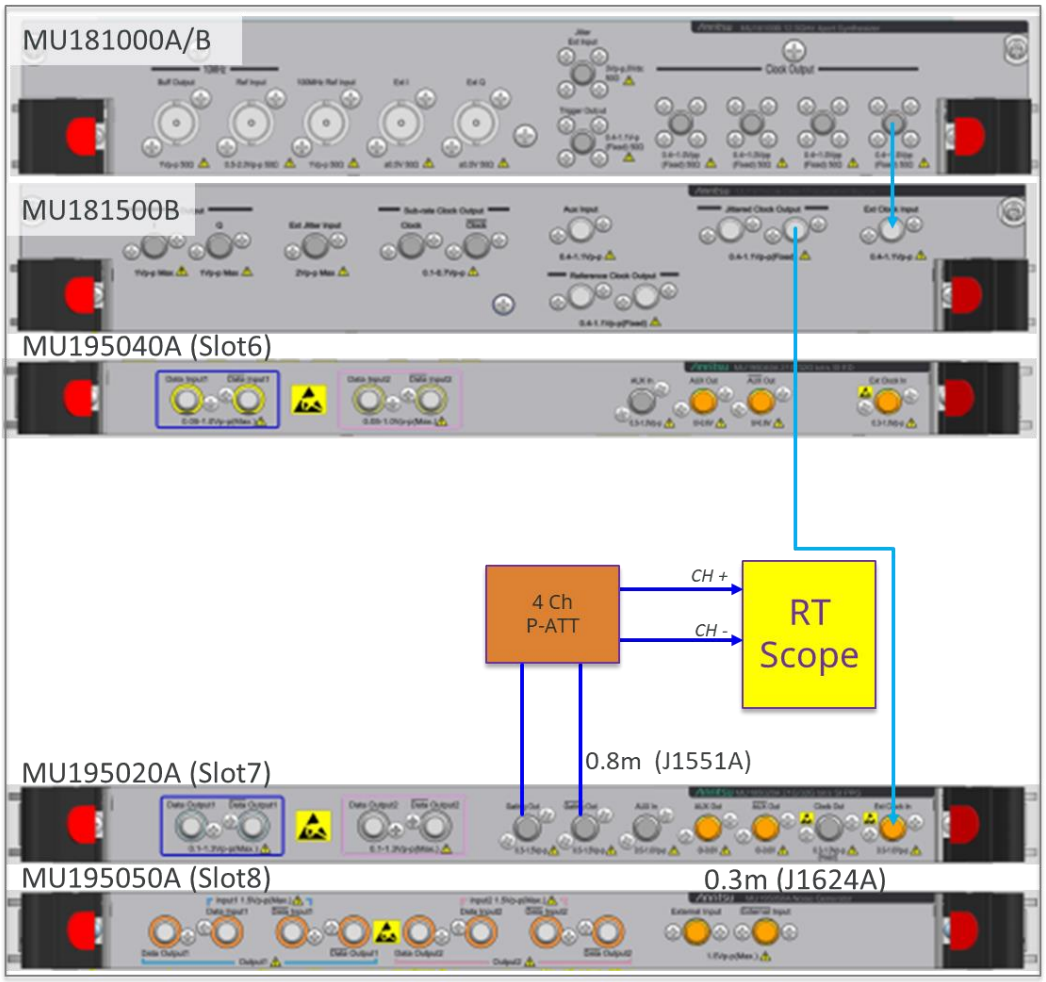
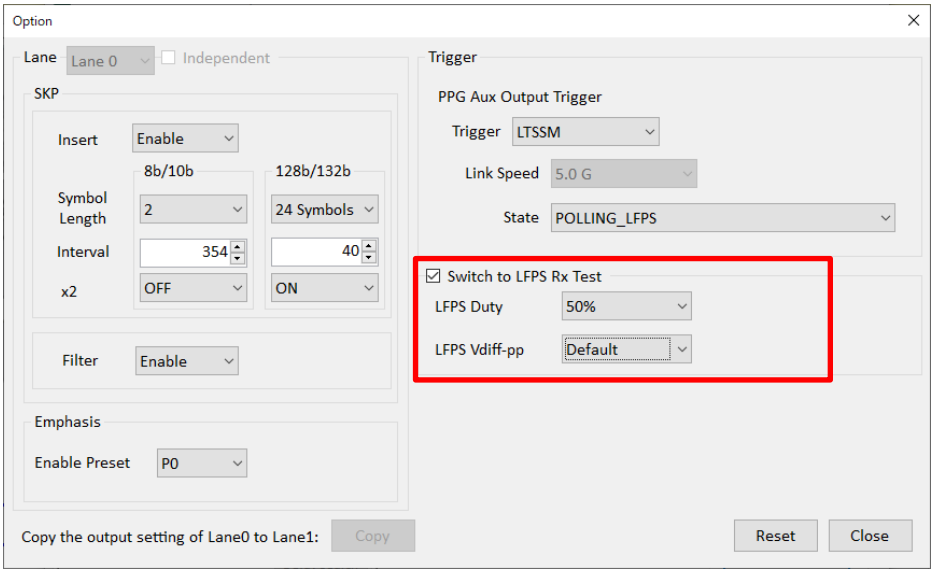


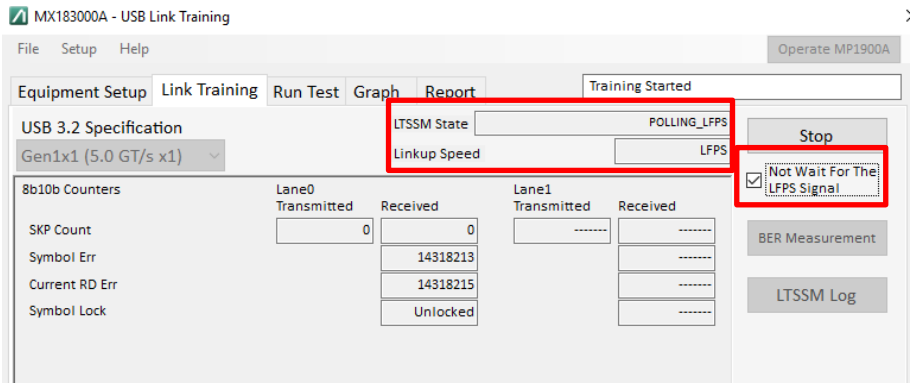
Figure 3.2.1-1 90/100/200/300/800 mVpp LFPS signal calibration connection

3.2.2 Calibration of LFPS signal amplitude 90/100/200/300/800 mVpp

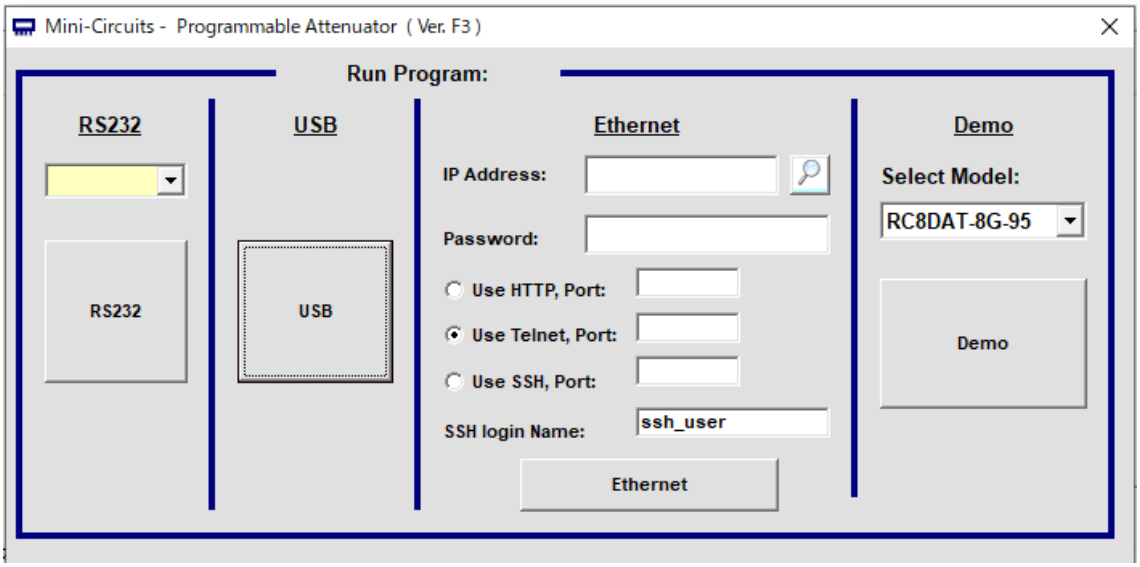
- Start MX183000A and click Connect.
- Click Option button on the Link Training tab.
- Make the following settings on the Option screen and press Close.
  - ➢ Switch to LFPS Rx test: ON
  - ➢ LFPS Duty: 50%
  - ➢ LFPS Vdiff-pp: Default



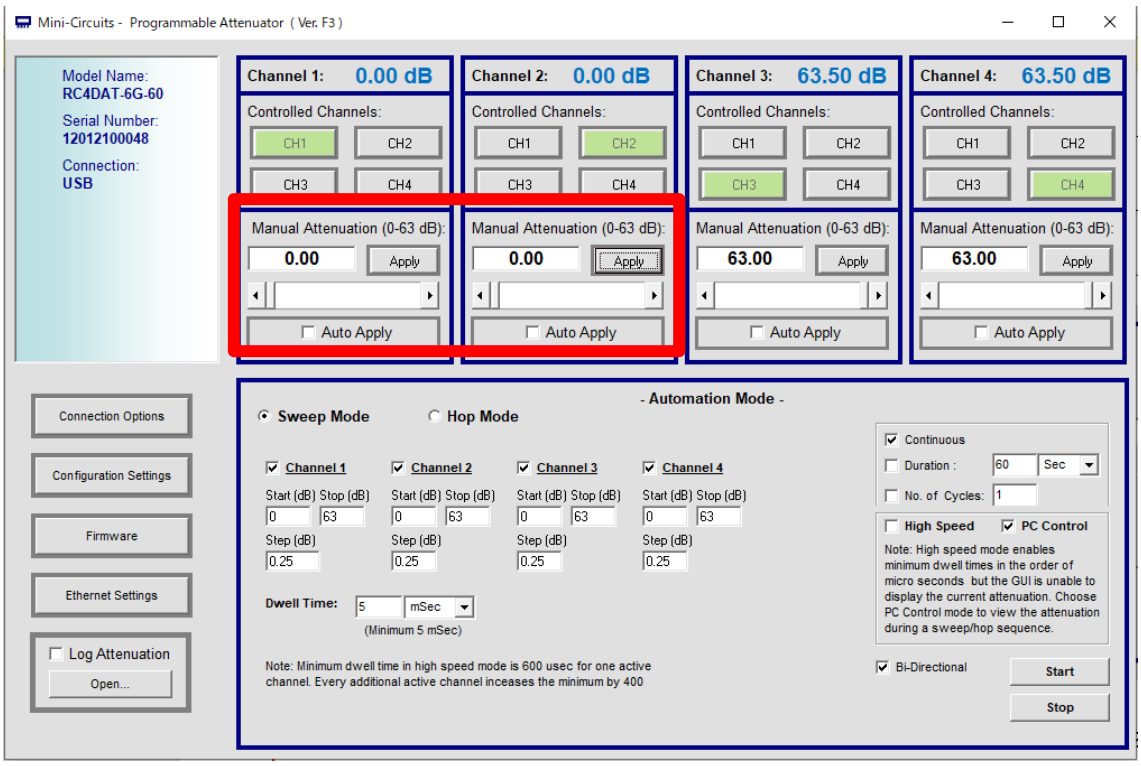
- Check “Not Wait For The LFPS Signal” on the Link Training tab.
- Press the Link Start button on the Link Training tab.
- The LTSSM State becomes POLLING_LFPS and the LFPS signal is output.



- Install the 4CH P-ATT control software according to *Section 2.2 Installation* of the User Guide.
- Follow the steps indicated in *Section 3.1 Starting the GUI Program* of the User Guide to connect to 4CH P-ATT. USB cable or Ethernet cable can be used for connection.



- After connecting, the Attenuation can be changed in the screen below. Keep the LFPS Vdiff-pp of MX183000A as Default, change only 4CH P-ATT Attenuation, and calibrate to the target amplitude.



- This control software can be controlled by remote commands. For details, refer to the Programming Manual found in the link below.
  https://www.minicircuits.com/softwaredownload/Prog_Manual-6-Programmable_Attenuator.pdf
- The recommended attenuation at the start of each adjustment can be found in the following table. The Attenuation value should be set to both Channel 1 and Channel 2. Record the calibrated values as [Cal-xxx].

Target amplitude	Initial Attenuation value	Calibrated value (variable name)
90 mVpp	23 dB	[Cal-90]
100 mVpp	22 dB	[Cal-100]
200 mVpp	16 dB	[Cal-200]
300 mVpp	13 dB	[Cal-300]
800 mVpp	3 dB	[Cal-800]

4. LFPS Rx Test

4.1 Testing connection diagram

The following connection diagram shows the physical setup for performing 1000 mV and 1200 mV LFPS signal test.

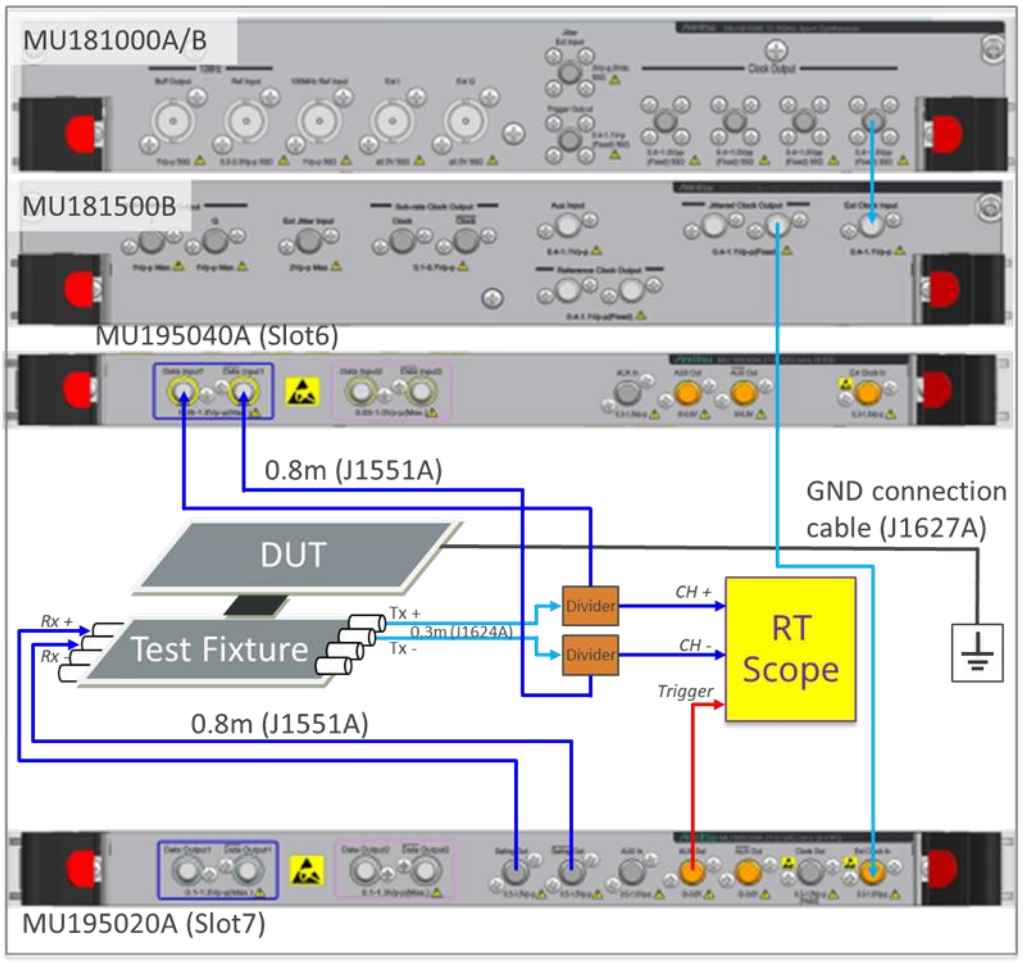


Figure 4.1-1 1000 mV and 1200 mV LFPS signal testing connection

The following connection diagram shows the physical setup for performing 90 mV, 100 mV, 200 mV, 300 mV, and 800 mV LFPS signal test.

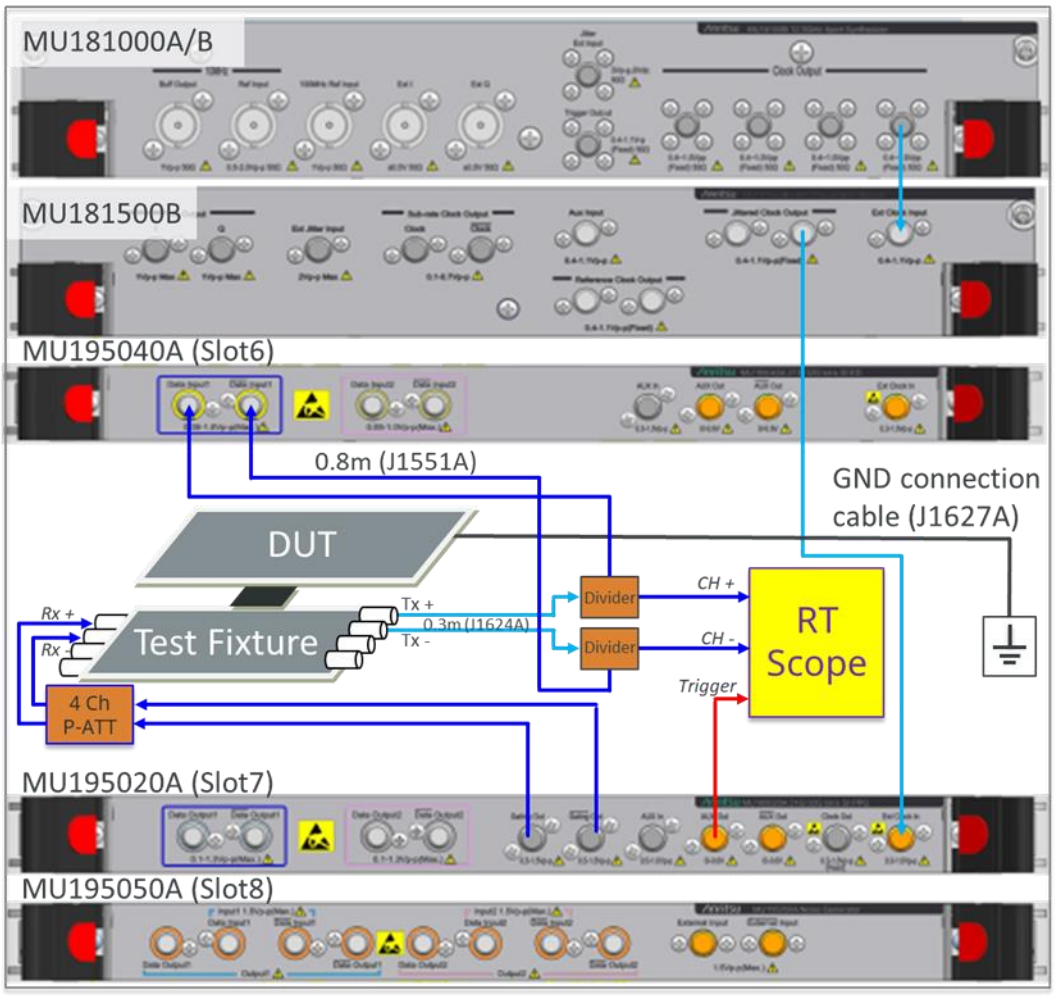


Figure 4.1-2 90 mV, 100 mV, 200 mV, 300 mV, and 800 mV LFPS signal testing connection

4.2 Test Procedure

The procedure for LFPS Rx testing is defined in the standard as follows. The succeeding subsections describe the procedure according to the item numbers from the standard.

LFPS_Rx_Tx_Low_Power_Compliance_Update_Rev5.pdf

TD.1.2 LFPS Rx Goal:

This test verifies that the DUT low frequency periodic signal receiver recognizes LFPS signaling with voltage swings and duty cycles that are at the limits of what the specification allows. The link test specification includes test that vary additional LFPS parameters to test the LFPS receiver.

Overview of Test Steps

The test performs the following steps.

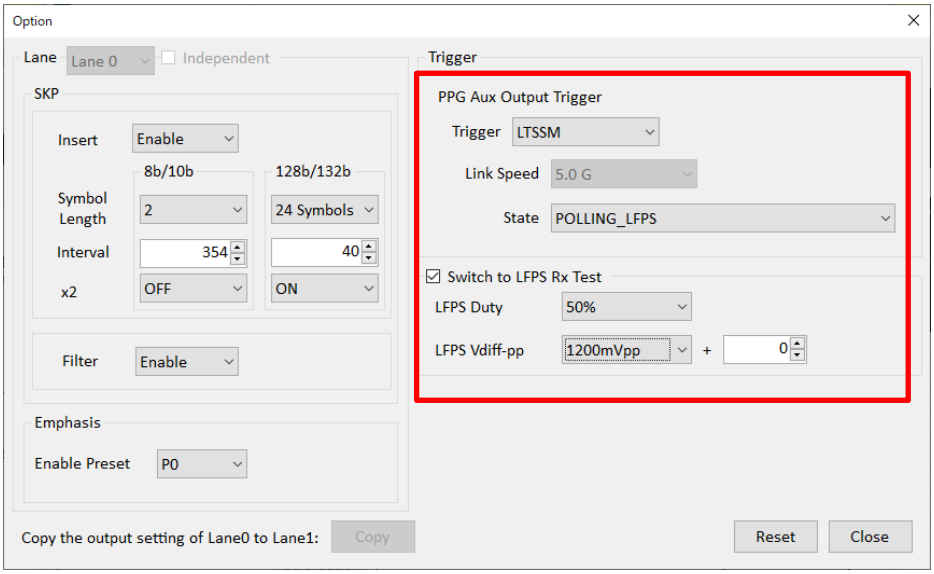
1. Connect the DUT to a simple breakout test fixture. Disconnect bus power if the DUT is a bus powered device.
2. Power on the device under test (connect bus powered if DUT is a bus powered device) and let it pass through the Rx.Detect state to the Polling.LFPS substate.
3. Trigger on the initial LFPS burst sent by the DUT and send LFPS signals to the DUT with the following parameters:
    a. tPeriod 50 ns.
    b. VTX-DIFF-PP-LFPS 800 mV.
    c. Duty Cycle 50%
4. The test passes if the device recognizes the LFPS and starts sending the TXEQ sequence following initial LFPS without reverting to Electrical Idle and new LFPS cycle.
5. The test is repeated with the following parameters:
    a. tPeriod 50 ns, VTX-DIFF-PP-LFPS 1200 mV, Duty Cycle 50%.
    b. tPeriod 50 ns, VTX-DIFF-PP-LFPS 1000 mV, Duty Cycle 40%.
    c. tPeriod 50 ns, VTX-DIFF-PP-LFPS 1000 mV, Duty Cycle 60%.
6. To verify Rx LFPS Detect Threshold (VRX-LFPS-DET-DIFFp-p) (as specified in Table 6-22) the following test is performed:
    a. If the DUT reacts to voltages below “Min Spec” or does not react to voltages above “Max Spec” it would produce a result of fail.

$V_{RX\text{-}LFPS\text{-}DET\text{-}DIFFp\text{-}p}$	LFPS Detect Threshold	100 (min) 300 (max)	100 (min) 300 (max)	mV	Below the minimum is noise. Must wake up above the maximum.

7. Repeat steps 1 and 2 above
8. Trigger on the initial LFPS burst sent by the DUT and send LFPS signals to the DUT with the following parameters and register DUT response on oscilloscope:
    a. tPeriod 50 ns, VRX-LFPS-DET-DIFFp-p 100 mV, Duty Cycle 50%. **Normative**
    b. tPeriod 50 ns, VRX-LFPS-DET-DIFFp-p 200 mV, Duty Cycle 50%. (**Characterization - Informative**)
    c. tPeriod 50 ns, VRX-LFPS-DET-DIFFp-p 300 mV, Duty Cycle 50%. **Normative**
    d. tPeriod 50 ns, VRX-LFPS-DET-DIFFp-p 90 mV, Duty Cycle 50%. (**Characterization - Informative**)

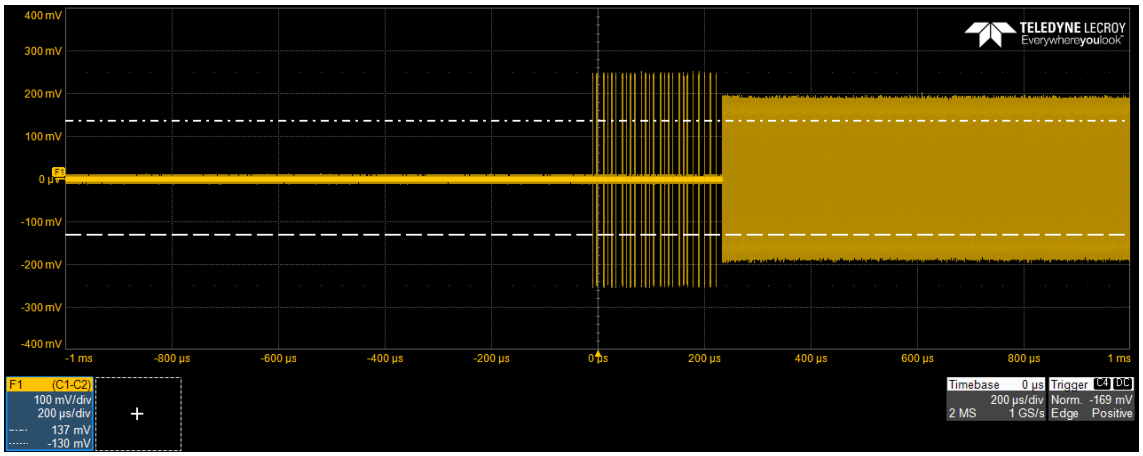
4.2.1 Testing 5.a. 1200 mV, Duty Cycle 50%

- Connect the setup as shown in Figure 4.1-1.
- Set the trigger channel of real-time oscilloscope to AUX Input, which is connected to MU195020A AUX Output.
- Set the trigger condition of real-time oscilloscope to rising edge.
- Start MX183000A and click Connect.
- Select Gen1x1 in the USB3.2 Specification on the Link Training tab, then click the Option button.
- Make the following settings on the Option screen and press Close.
  - Trigger: LTSSM
  - State: POLLING_LFPS
  - Switch to LFPS Rx test: ON
  - LFPS Duty: 50%
  - LFPS Vdiff-pp: 1200 mV
  - Numerical input textbox: Set the value of [Cal-1200]

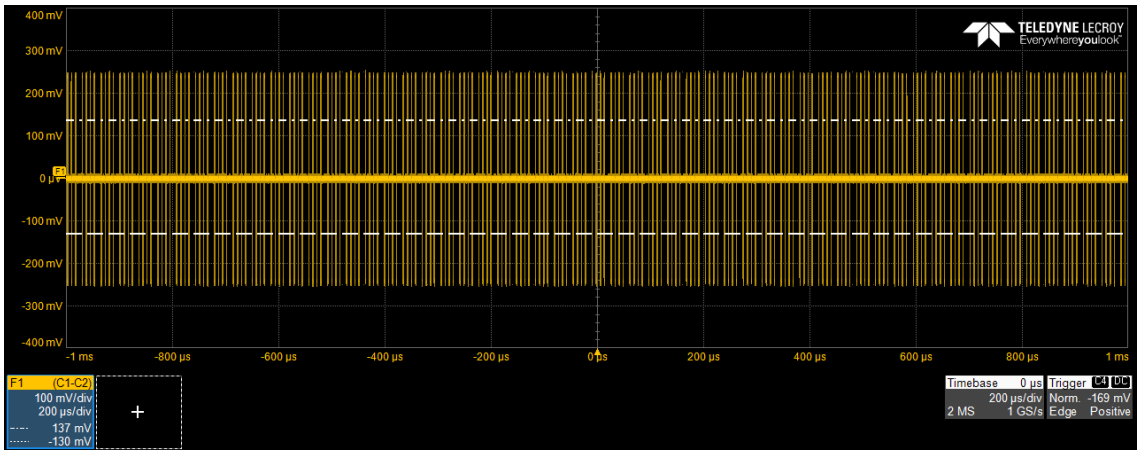


- Uncheck “Not Wait For The LFPS Signal” on the Link Training tab.
- Press the Link Start button on the Link Training tab.
- Insert the test fixture into the DUT.

- Capture the waveform with the real-time oscilloscope.
  - If it transitions to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Passed.

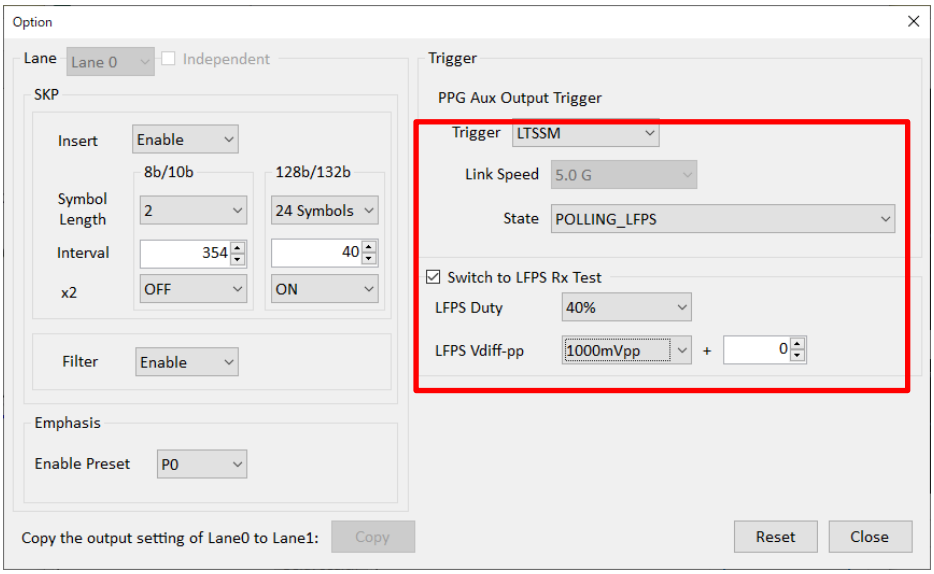


  - If it doesn't transition to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Failed.



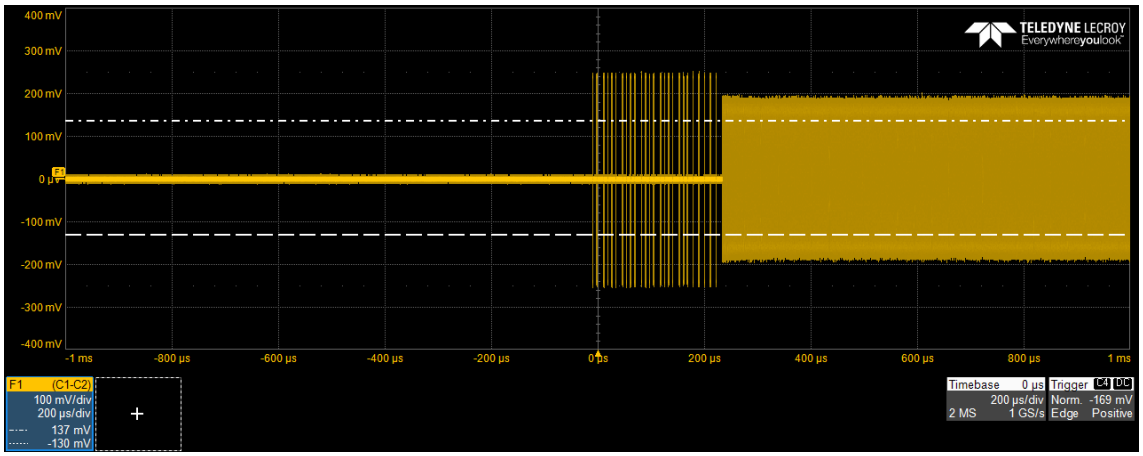
4.2.2 Testing 5.b 1000 mV, Duty Cycle 40% and 5.c 1000 mV, Duty Cycle 60%

- Connect the setup as shown in Figure 4.1-1.
- Set the trigger channel of real-time oscilloscope to AUX Input, which is connected to MU195020A AUX Output.
- Set the trigger condition of real-time oscilloscope to rising edge.
- Start MX183000A and click Connect.
- Select Gen1x1 in the USB3.2 Specification on the Link Training tab, then click the Option button.
- Make the following settings on the Option screen and press Close.
  - Trigger: LTSSM
  - State: POLLING_LFPS
  - Switch to LFPS Rx test: ON
  - LFPS Duty: 40%
  - LFPS Vdiff-pp: 1000 mV
  - Numerical input textbox: Set the value of [Cal-1000]

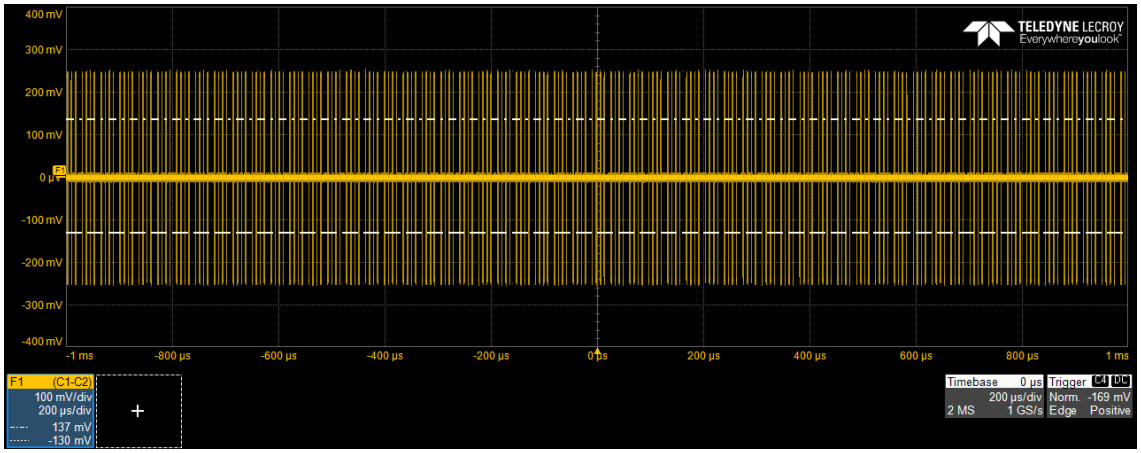


- Uncheck “Not Wait For The LFPS Signal” on the Link Training tab.
- Press the Link Start button on the Link Training tab.
- Insert the test fixture into the DUT.

- Capture the waveform with the real-time oscilloscope.
  - If it transitions to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Passed.



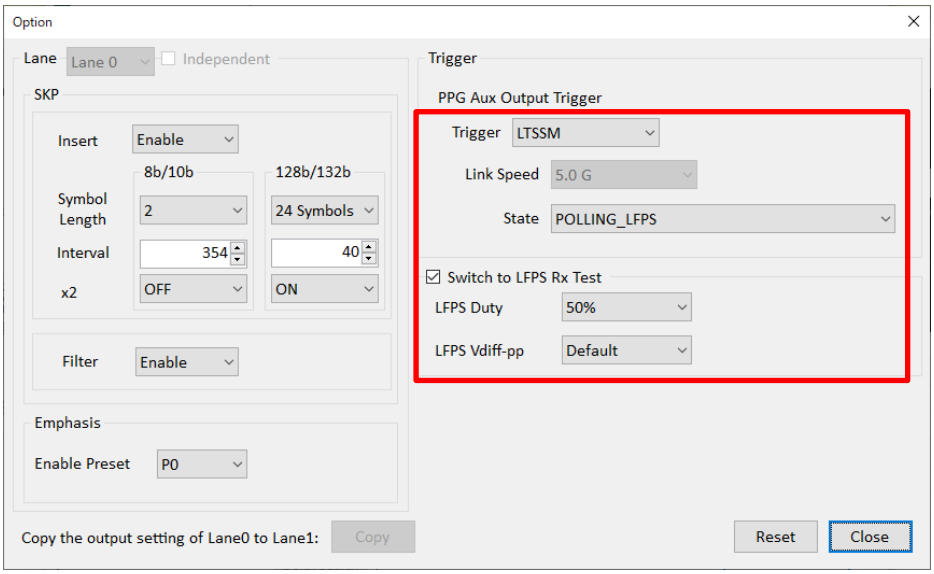
  - If it doesn't transition to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Failed.



- Repeat the procedures above with LFPS Duty **60%**.

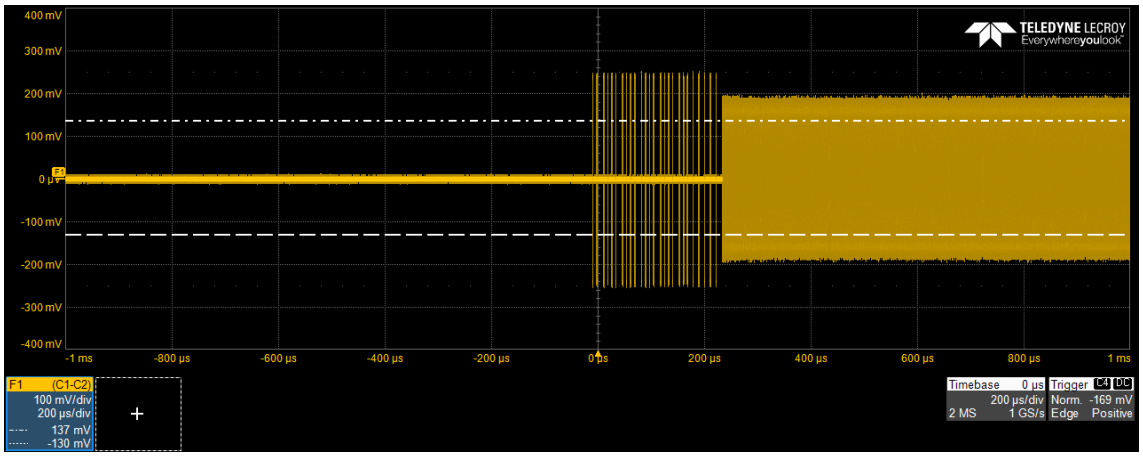
4.2.3 Testing 3.a 800 mV, Duty Cycle 50%

- Connect the setup as shown in Figure 4.1-2.
- Set the trigger channel of real-time oscilloscope to AUX Input, which is connected to MU195020A AUX Output.
- Start MX183000A and click Connect.
- Select Gen1x1 in the USB3.2 Specification on the Link Training tab, then click the Option button.
- Make the following settings on the Option screen and press Close.
  - Trigger: LTSSM
  - State: POLLING_LFPS
  - Switch to LFPS Rx test: ON
  - LFPS Duty: 50%
  - LFPS Vdiff-pp: Default

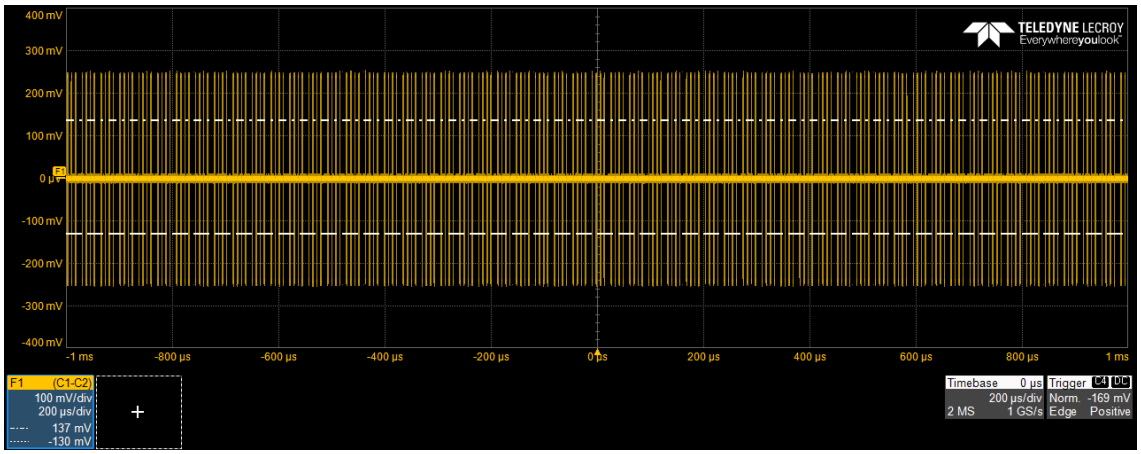


- Uncheck “Not Wait For The LFPS Signal” on the Link Training tab.
- Set the setting value of [Cal-800] in the 4CH P-ATT.
- Press the Link Start button on the Link Training tab.
- Insert the test fixture into the DUT.

- Capture the waveform with the real-time oscilloscope.
  - If it transitions to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Passed.

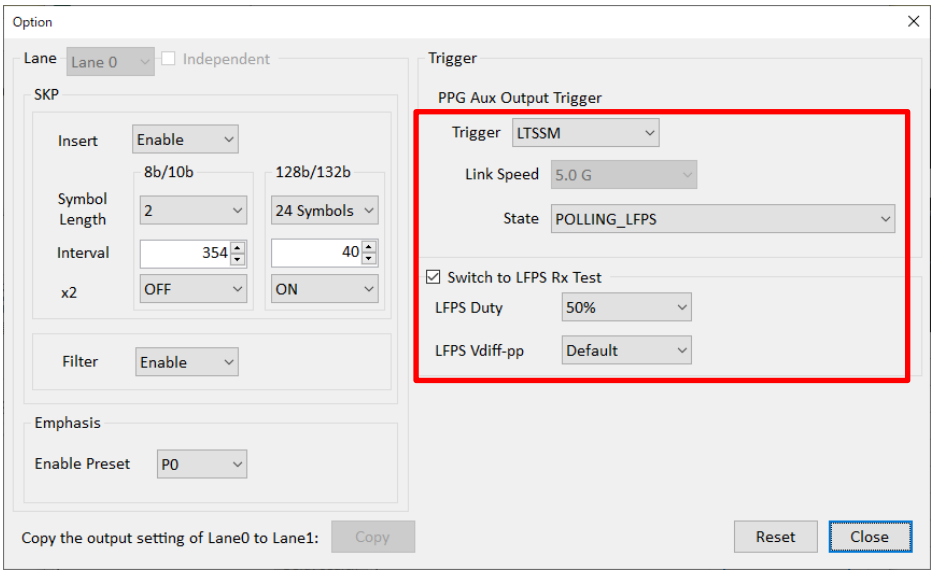


  - If it doesn't transition to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Failed.



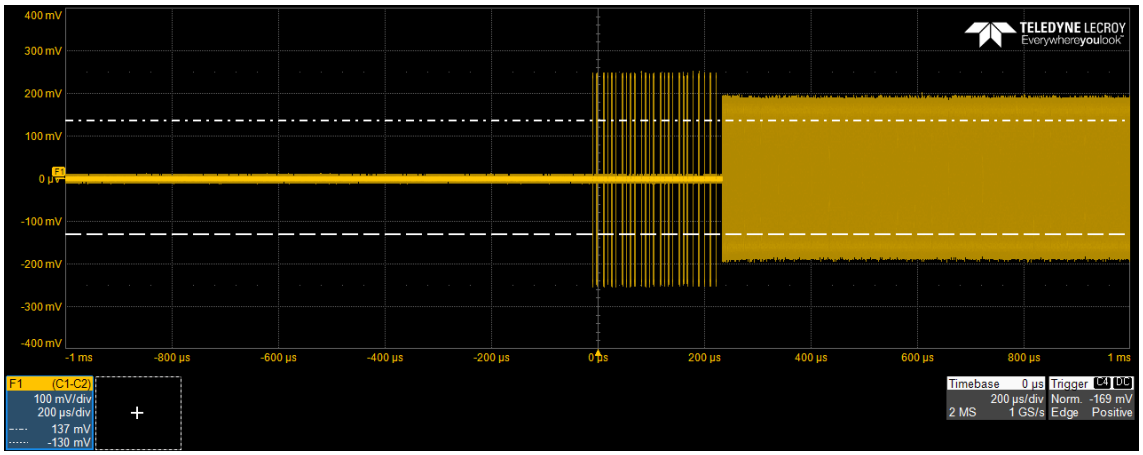
4.2.4 Testing 8.a / 8.b / 8.c / 8.d 90 mV to 300 mV, Duty Cycle 50%

- Connect the setup as shown in Figure 4.1-2.
- Set the trigger channel of real-time oscilloscope to AUX Input, which is connected to MU195020A AUX Output.
- Start MX183000A and execute Connect.
- Select Gen1x1 in the USB3.2 Specification on the Link Training tab, then click the Option button.
- Make the following settings on the Option screen and press Close.
  - Trigger: LTSSM
  - State: POLLING_LFPS
  - Switch to LFPS Rx test: ON
  - LFPS Duty: 50%
  - LFPS Vdiff-pp: Default

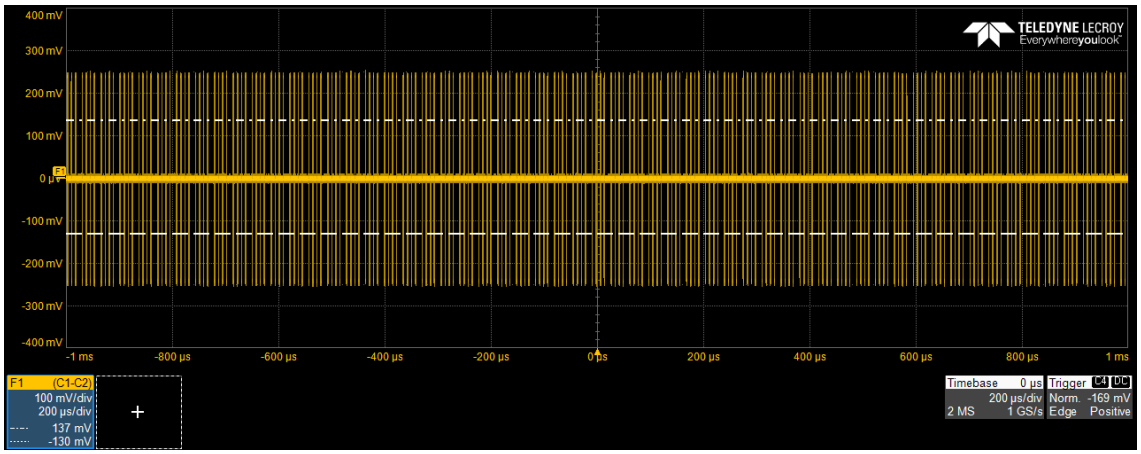


- Uncheck “Not Wait For The LFPS Signal” on the Link Training tab.
- Set the setting value of [Cal-100] in the 4CH P-ATT.
- Press the Link Start button on the Link Training tab.
- Insert the test fixture into the DUT.

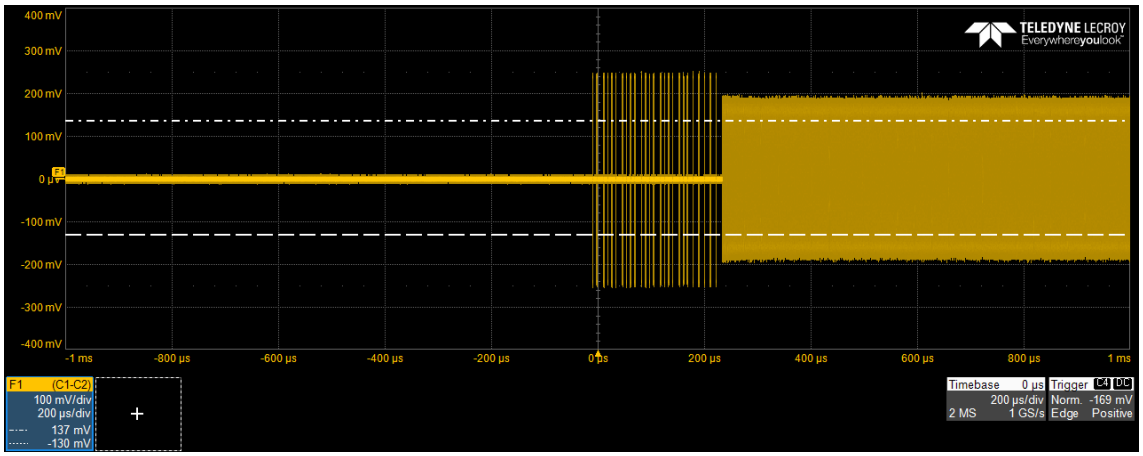
- Capture the waveform with real-time oscilloscope.
- In the case of [Cal-300]
  - ➢ If it transitions to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Passed.



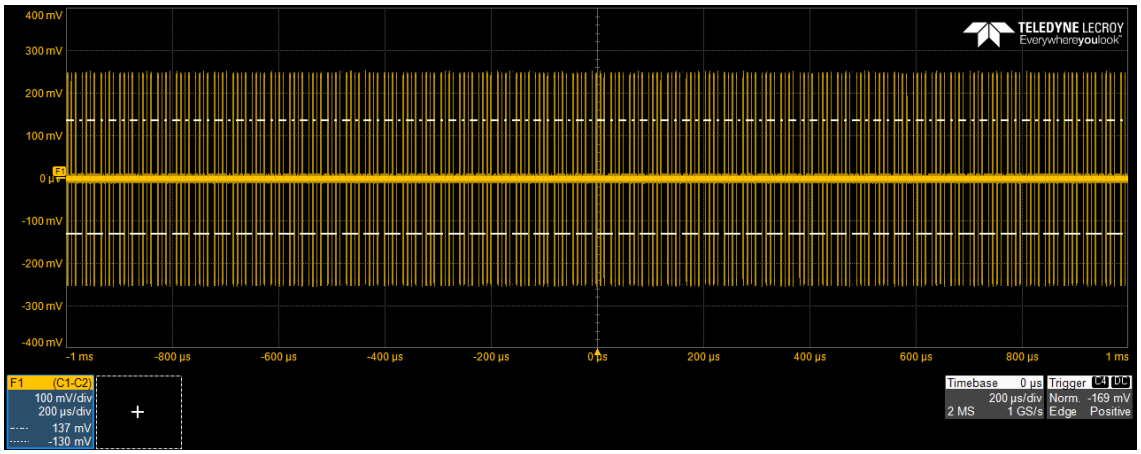
  - ➢ If it doesn't transition to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Failed.



- In the case of [Cal-100] and [Cal-90]
  - If it transitions to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Failed.



  - If it doesn't transition to the 5 Gbps signal from the LFPS signal as shown below, this test is considered Passed.



- Repeat the procedures above with [Cal-90] / [Cal-200] / [Cal-300] of 4CH P-ATT.
  Note: [Cal-90] / [Cal-200] is an informative test and is not normative.

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Specifications are subject to change without notice.

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