

# **Universal Serial Bus 4 (USB4™)**

## **Router Assembly**

### **Electrical Compliance Test Specification**

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## CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b><u>911</u></b>
<b>2</b>	<b>TEST EQUIPMENT .....</b>	<b><u>1012</u></b>
2.1	OVERVIEW .....	<u>1012</u>
2.2	TEST EQUIPMENT REQUIREMENTS .....	<u>1012</u>
2.2.1	Test Point Access Boards .....	<u>1012</u>
2.2.2	Real Time Scopes .....	<u>1012</u>
2.2.3	Pattern Generator .....	<u>1012</u>
2.2.4	Network Analyzer .....	<u>1113</u>
2.2.5	Signal Generator .....	<u>1113</u>
2.2.6	Accessories .....	<u>1113</u>
<b>3</b>	<b>ROUTER ASSEMBLY TRANSMITTER TESTING .....</b>	<b><u>1245</u></b>
3.1	TRANSMITTER TEST SETUP .....	<u>1316</u>
3.2	CONNECTING TO THE DUT.....	<u>1419</u>
3.3	GEN2 ROUTER ASSEMBLY TRANSMITTER COMPLIANCE .....	<u>1520</u>
3.3.1	Gen2 Transmitter Equalization .....	<u>1520</u>
3.3.2	Gen2 Minimum Unit Interval Measurement .....	<u>1725</u>
3.3.3	Gen2 SSC Down Spread Range Measurement .....	<u>1826</u>
3.3.4	Gen2 SSC Down Spread Rate Measurement.....	<u>1927</u>
3.3.5	Gen2 SSC Phase Deviation Measurement .....	<u>2028</u>
3.3.6	Gen2 SSC Slew Rate Measurement.....	<u>2129</u>
3.3.7	Gen2 TX Frequency Variation Training Measurement.....	<u>2230</u>
3.3.8	Gen2 Rise/Fall Time Measurement.....	<u>2432</u>
3.3.9	Gen2 Electrical Idle Voltage Measurement .....	<u>2533</u>
3.3.10	Gen2 Total Jitter Measurement .....	<u>2634</u>
3.3.11	Gen2 UJ Measurement .....	<u>2736</u>
3.3.12	Gen2 UDJ Measurement.....	<u>2838</u>
3.3.13	Gen2 DDJ Measurement.....	<u>2939</u>
3.3.14	Gen2 Low Frequency UDJ Measurement .....	<u>3040</u>
3.3.15	Gen2 DCD Measurement .....	<u>3141</u>
3.3.16	Gen2 AC Common Mode Measurement.....	<u>3242</u>
3.3.17	Gen2 Eye Diagram Measurement .....	<u>3343</u>
3.3.18	Gen2 Total Jitter TP3 Measurement .....	<u>3545</u>
3.3.19	Gen2 UJ TP3 Measurement .....	<u>3647</u>
3.3.20	Gen2 UDJ TP3 Measurement.....	<u>3749</u>
3.3.21	Gen2 Eye Diagram TP3 Measurement .....	<u>3851</u>
3.4	GEN3 ROUTER ASSEMBLY TRANSMITTER COMPLIANCE .....	<u>4053</u>
3.4.1	Gen3 Transmitter Equalization .....	<u>4053</u>
3.4.2	Gen3 Minimum Unit Interval Measurement .....	<u>4258</u>
3.4.3	Gen3 SSC Down Spread Range Measurement .....	<u>4359</u>
3.4.4	Gen3 SSC Down Spread Rate Measurement.....	<u>4461</u>
3.4.5	Gen3 SSC Phase Deviation Measurement .....	<u>4562</u>
3.4.6	Gen3 SSC Slew Rate Measurement.....	<u>4663</u>
3.4.7	Gen3 TX Frequency Variation Training Measurement.....	<u>4764</u>
3.4.8	Gen3 Rise/Fall Time Measurement.....	<u>4966</u>
3.4.9	Gen3 Electrical Idle Voltage Measurement .....	<u>5067</u>
3.4.10	Gen3 Total Jitter Measurement .....	<u>5168</u>
3.4.11	Gen3 UJ Measurement .....	<u>5270</u>
3.4.12	Gen3 UDJ Measurement.....	<u>5372</u>
3.4.13	Gen3 DDJ Measurement.....	<u>5473</u>

3.4.14	Gen3 Low Frequency UDJ Measurement .....	5574
3.4.15	Gen3 DCD Measurement .....	5676
3.4.16	Gen3 AC Common Mode Measurement.....	5777
3.4.17	Gen3 Eye Diagram Measurement .....	5878
3.4.18	Gen3 Total Jitter TP3 Measurement .....	6080
3.4.19	Gen3 UJ TP3 Measurement .....	6182
3.4.20	Gen3 UDJ TP3 Measurement.....	6284
3.4.21	Gen3 Eye Diagram TP3 Measurement .....	6386
3.5	TRANSMITTER RETURN LOSS GEN2 AND GEN3 .....	6588
3.5.1	Transmitter Differential Return Loss .....	6588
3.5.2	Transmitter Common Mode Return Loss .....	6790
<b>4</b>	<b>ROUTER ASSEMBLY RECEIVER TESTING .....</b>	<b>6992</b>
4.1	RECEIVER TEST SETUP .....	7194
4.2	RECEIVER STRESSED EYE CALIBRATION .....	7295
4.2.1	Stressed Electrical Signal for TP3' (Case 1): .....	7295
4.2.2	Stressed Electrical Signal for TP3 (Case 2): .....	80103
4.3	RECEIVER BER TEST PROCEDURE .....	82107
4.3.1	BER at TP3' .....	83109
4.3.2	BER at TP3 .....	85111
4.4	RECEIVER MULTI ERROR-BURST TEST .....	86113
4.4.1	Multi Error-Burst Gen3 .....	86113
4.5	RECEIVER SIGNAL FREQUENCY VARIATIONS TRAINING TEST .....	87114
4.5.1	Signal Frequency Variations calibration for TP3' (Case 1): .....	87114
4.5.2	Signal Frequency Variations calibration for TP3 (Case 2): .....	87115
4.5.3	Signal Frequency Variations Training Gen2 and Gen3 for TP3'.....	88116
4.5.4	Signal Frequency Variations Training Gen2 and Gen3 for TP3.....	89117
4.6	RECEIVER RETURN LOSS GEN2 AND GEN3.....	91118
4.6.1	Receiver Differential Return Loss.....	91118
4.6.2	Receiver Common Mode Return Loss .....	93120
<b>5</b>	<b>ROUTER ASSEMBLY SIDEBAND SIGNAL TESTING .....</b>	<b>95122</b>
5.1	ROUTER ASSEMBLY SBTX AND SBRX SPECIFICATIONS .....	95122
5.1.1	SBTX High Voltage Measurement .....	98125
5.1.2	SBTX Low Voltage Measurement .....	99127
5.1.3	SBTX Rise/Fall time Measurement .....	100128
5.1.4	SBX UI Duration Measurement.....	101130
5.1.5	SBRX High Voltage Detection Measurement.....	102131
5.1.6	SBRX Low Voltage Detection Measurement.....	103133
<b>APPENDIX A</b>	<b>– SCOPE CONFIGURATIONS .....</b>	<b>104134</b>
A.1	SCOPE BW LIMIT .....	104134
A.2	TP3 EMBEDDING FILE .....	104134
<b>APPENDIX B</b>	<b>– USB4 RX TP3 TRACE CALIBRATION .....</b>	<b>105139</b>
B.1	GEN2 CONFIGURATION.....	105139
B.2	GEN3 CONFIGURATION.....	105140
<b>APPENDIX C</b>	<b>– JITTER TERM DEFINITION .....</b>	<b>107141</b>
C.1	HIGH LEVEL OF TOTAL JITTER DECOMPOSITION .....	107141
C.2	DDJ <u>107141</u>	
C.3	DCD <u>108142</u>	

## **APPENDIX D – INTEROPERABILITY WITH THUNDERBOLT™ 3 (TBT3) SYSTEMS**

**~~109~~143**

D.1	GEN2 AND GEN3 ROUTER ASSEMBLY TRANSMITTER COMPLIANCE .....	<del>109</del> 143
D.1.1	Gen2 and Gen3 SSC Down Spread Rate Measurement .....	<del>109</del> 143
D.1.2	Gen2 and Gen3 SSC Phase Deviation Measurement .....	<del>109</del> 143
D.1.3	Gen2 Minimum Unit Interval Measurement .....	<del>109</del> 143
D.1.4	Gen3 Minimum Unit Interval Measurement .....	<del>110</del> 144
D.1.5	Gen2 Average Unit Interval Measurement .....	<del>110</del> 144
D.1.6	Gen2 and Gen3 TX Frequency Variation Training Measurement .....	<del>110</del> 145
D.2	GEN2 AND GEN3 ROUTER ASSEMBLY RECEIVER COMPLIANCE.....	<del>111</del> 145

## **APPENDIX E – APPLYING DFE METHOD.....~~112~~147**

## **APPENDIX F – TRANSMITTER PRESET CALIBRATION .....~~113~~148**

F.1	PRESET CALIBRATION .....	<del>113</del> 148
F.1.1	Reference.....	<del>113</del> 148
F.1.2	Objective .....	<del>113</del> 148
F.1.3	Method .....	<del>113</del> 148

## **APPENDIX G – MECHANICAL .....~~114~~150**

G.1	USB TYPE-C RECEPTACLE MINIMUM SPACING .....	<del>114</del> 150
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# Table of Figures

Figure 1. USB4 TX Compliance Points Definition .....	<del>12</del> 15
Figure 2. Transmitter TP2/TP3 Test Setup .....	<del>13</del> 17
Figure 3. Transmitter Return Loss Test Setup.....	<del>66</del> 89
Figure 4. USB4 RX Compliance Points Definition .....	<del>69</del> 92
Figure 5. USB4 RX Tolerance Test Topologies.....	<del>70</del> 93
Figure 6. Receiver Calibration Setup – TP3'.....	<del>71</del> 94
Figure 7. Receiver Calibration Setup – TP3 .....	<del>80</del> 104
Figure 8. Receiver Test Setup at TP3'.....	<del>82</del> 108
Figure 9. Receiver BER testing flow .....	<del>84</del> 110
Figure 11. Receiver Return Loss Test Setup .....	<del>92</del> 119
Figure 12 - Router Assembly Low-Speed Signals .....	<del>95</del> 122
Figure 13 - Figure of Sideband TX/RX Signal Testing .....	<del>96</del> 123
Figure 14 - Figure of Sideband TX/RX Signal Testing Using Voltage Meter .....	<del>97</del> 124
Figure 15. USB4 RX TP3 Trace Calibration Setup for Gen2 .....	<del>105</del> 139
Figure 16. USB4 RX TP3 Trace Calibration Setup for Gen3 .....	<del>105</del> 140

## Acronyms

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Acronym	Definition
BER	Bit Error Rate
BW	Band Width
CDR	Clock Data Recovery
DUT	Device Under Testing
NVM	Non Volatile Memory
PJ	Periodic Jitter
SSC	Spread Spectrum Clock
TJ	Total Jitter
UI	Unit Interval
UJ	Uncorrelated Jitter
UDJ	Uncorrelated Deterministic Jitter
RJ	Random Jitter
ISI	Inter Symbol Interference
DDJ	Data dependent Jitter
PPM	Parts Per Million
PRBS	Pseudo Random Bit Sequence
IL	Insertion Loss



# 1 Introduction

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This document contains the specification of procedures, tools and criteria for testing electrical compliance of Router Assembly according to the Universal Serial Bus 4 (USB4™) Specification, Version 1.0 and Universal Serial Bus 4 (USB4™) Specification, Version 2.0.

This CTS is detailing the post-processing that should be done over the saved waveform from the scope. Since USB4 SigTest is published all post-processing for Router Assembly Transmitter testing and Receiver calibration must be done using the published USB4 SigTest.

This CTS is aligned to USB4 SigTest rev0.98 and USB4 SigTest User Manual rev0.98  
All details how the use the SigTest is written over the USB4 SigTest User Manual rev0.98

## 2 Test Equipment

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### 2.1 Overview

All equipment used for testing shall comply with the requirement lists specified below.

This includes the primary equipment that is used in the USB4 authorized test centers and may also be used by the end user for self-testing.

Other configurations and equipment may be used for self-testing as long as that equipment and the processes meet all of the stated and implied requirements and permit an equivalent level of testing.

### 2.2 Test Equipment Requirements

All test equipment requires calibration to ensure accurate and repeatable results. Equipment shall be calibrated prior to, and if necessary, during the test procedure.

#### 2.2.1 Test Point Access Boards

To gain access to the required signals, a variety of test point access boards are required. Test Point Access boards provide test points for the pins on the USB4 USB Type-C connector and an easy way to control the DUT.

Recommended Test Equipment:

1. Wilder USB4v1 Plug and receptacle Test fixtures (including LSx)
2. Wilder USB4 Micro-Controller Test Module with USB cable
3. Control PC \ Scope running the latest USB4 SW Electrical Test Tool (ETT)

#### 2.2.2 Real Time Scopes

Required Test Equipment Capabilities:

- DC to 21GHz, -3db bandwidth or greater
- 80G sample/sec Sampling rate or greater, sampling 2 channels simultaneously
- Sample memory: 50M samples per channel or greater
- De-embedding capability
- High impedance probe

#### 2.2.3 Pattern Generator

Generate USB4 signal with a variety of patterns, jitter injection capability.

Required Test Equipment Capabilities:

- Data rates  $\geq 20\text{Gbps}$
- Data patterns: PRBS15, PRBS31, Square wave
- Differential swing range: 0 – 2Vp-p in 10mV steps
- Rise Time  $\geq 10\text{ps}$  (20%-80%)
- Intrinsic jitter  $\leq 400\text{fS RMS}$
- Random Jitter profile no smaller than 500MHz
- Equalization

- Ability to create RX clk switch SSC profile as requested in the USB4 base spec
- SSC spread deviation from 0.03% down to -0.53%

*Note: For Interoperability with Thunderbolt™ 3 (TBT3) Systems the SSC spread deviation shall be from 0.04% down to -0.54%.*

- Injection of 1 SJ sources

## **2.2.4 Network Analyzer**

Required Test Equipment Capabilities:

- 2 ports used simultaneously
- 10MHz–20GHz bandwidth
- Dynamic range > 50db
- Time domain option
- The de-embedding files (s4P) should be up to 20GHz

## **2.2.5 Signal Generator**

Required Test Equipment Capabilities:

- Frequency range of at least 10–400MHz
- Output power of  $\pm 15\text{dBm}$

## **2.2.6 Accessories**

### **2.2.6.1 Low Insertion Loss Phase Matched Cable:**

Required Test Equipment Capabilities for 1m RF cable:

- Phase matched max of  $\pm 5^\circ$  @ 40GHz
- Max IL in 10GHz < 1.5dB

*Note: Any length of cable is permitted up to 1m unless written otherwise.*

### **2.2.6.2 DC Block**

Required Test Equipment Capabilities:

- DC Blocks with bandwidth of at least 33GHz
- 1 dB Insertion Loss to 40GHz
- Capacitance of 135nF–265nF (220nF is recommended)

### **2.2.6.3 USB4 Passive and Active Cables**

- USB Type-C 0.8m (Gen3 supported) and 2m (Gen2 supported) passive cables as described in the USB4 Specification. The cables should be e-marked.
- USB4 Active cable. The Active cable should be e-marked.

### **2.2.6.4 Termination**

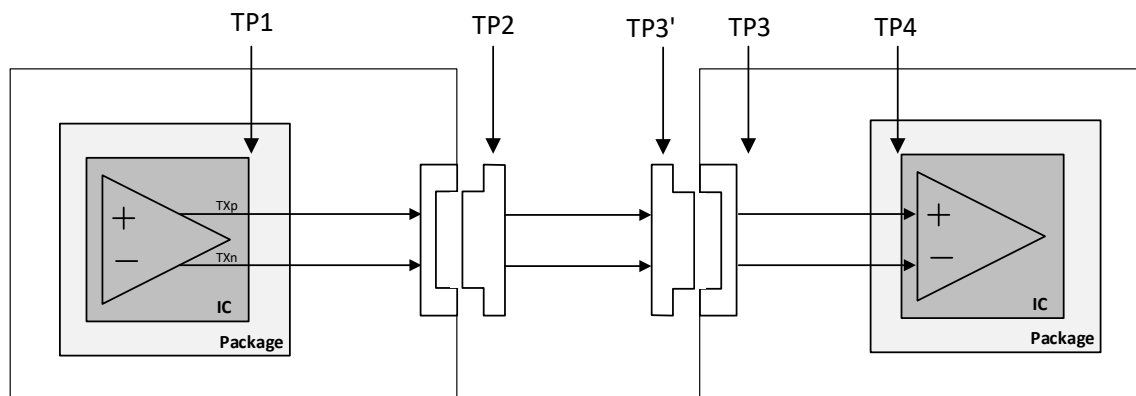
Required Test Equipment Capabilities:

- Impedance 50ohm
- Frequency DC to 20GHz

### 3 Router Assembly Transmitter Testing

- Router Assembly transmitter compliance testing is defined at the output of a “golden” plug fixture at the TP2 reference point and at the output of a “golden” receptacle fixture at the TP3 reference point.
- TP2 - Reference measurement point located at the USB Type-C plug connected to the Router Assembly TX output. Used as a reference point for defining Router Assembly TX.
- TP3- Reference measurement point located at USB Type-C receptacle output on the far-end side of passive cable. Used as a reference point for passive installations. All the measurements at this point shall be done while applying reference equalization.
- All measurements shall be referenced to the TP2/TP3 compliance point.
- Calibration shall be applied in cases where direct measurement is not feasible.
- As written in the Introduction – all post processing is done using the USB4 SigTest.
- If more than 1 port is supported, the other port should be linked to other USB4 device.

The following sections provide detailed information on the setup and testing of the USB4 parameters. In the event of a discrepancy, the USB4 Specification prevails.

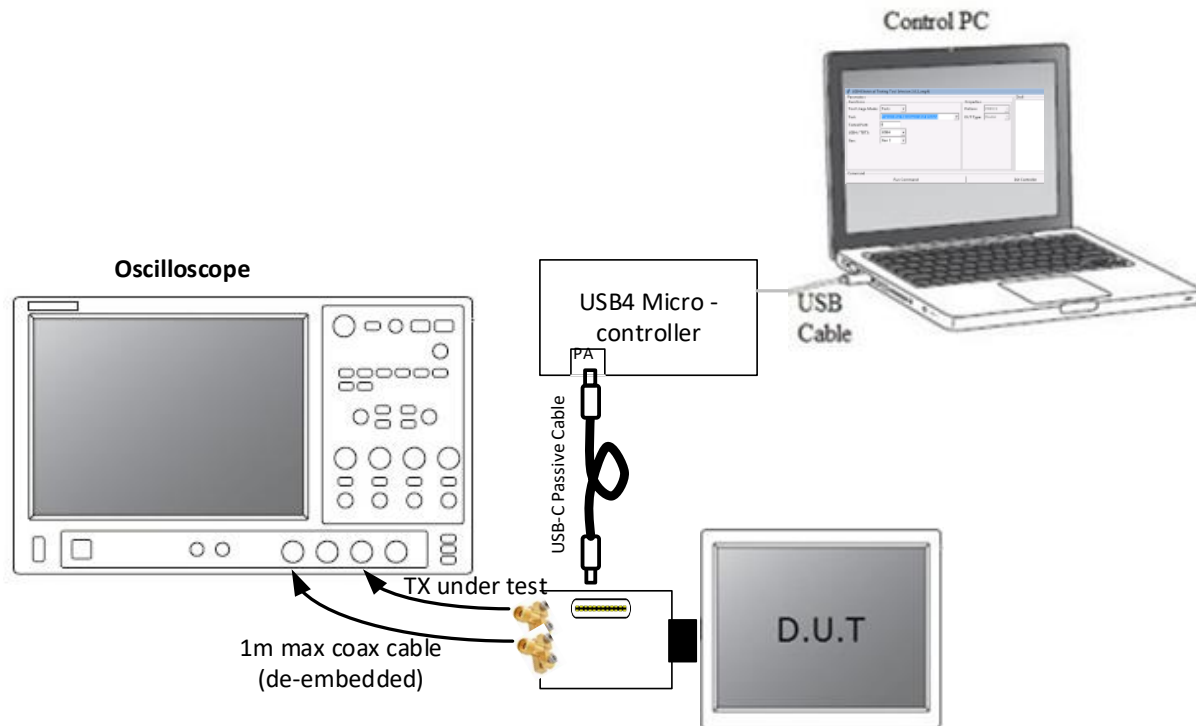


**Figure 1. USB4 TX Compliance Points Definition**

### 3.1 Transmitter Test Setup

The following figure shows the connections to the DUT and control PC used for Transmitter testing. The last RF cables from the USB Type-C plug to the scope shall be de-embedded.

*Note: Before beginning any test or data acquisition, the Oscilloscope must be warmed, and calibrated. The cables used for measurement shall be de-embedded (4 port). For all tests the signal must be vertical tuned to be opened.*



**Figure 2. Transmitter TP2/TP3 Test Setup**

## 3.2 Connecting to the DUT

1. Connect Lane under test TX\_P, TX\_N to the Oscilloscope.
2. Connect the Low speed signals from the USB4 test Fixture to the USB4 Micro-controller PA using a USB Type-C passive cable.
3. The USB4 Micro-controller is connected to control PC via USB cable, running the latest USB4 SW Electrical Test Tool (ETT).

*Note: The Transmitter Router Assembly is tested with the default preset. It is recommended that the default preset will be the one that causing the transmitted signal to be with minimum DDJ. See F.*

## 3.3 Gen2 Router Assembly Transmitter Compliance

Note: Refer to Sections [3.13.1](#) and [3.23.2](#) for test setup.

### 3.3.1 Gen2 Transmitter Equalization

#### 3.3.1.1 Reference

USB4v1 Specification, Table 3-3 and section 3.4.1.4 Table 3-5

USB4v2 Specification, Table 3-2 and section 3.1.3.1.4 Table 3-4

Preset Number	Pre-shoot [dB]	De-emphasis [dB]	Informative Filter Coefficients		
			C <sub>-1</sub>	C <sub>0</sub>	C <sub>1</sub>
0	0	0	0	1	0
1	0	-1.9	0	0.90	-0.10
2	0	-3.6	0	0.83	-0.17
3	0	-5.0	0	0.78	-0.22
4	0	-8.4	0	0.69	-0.31
5	0.9	0	-0.05	0.95	0
6	1.1	-1.9	-0.05	0.86	-0.09
7	1.4	-3.8	-0.05	0.79	-0.16
8	1.7	-5.8	-0.05	0.73	-0.22
9	2.1	-8.0	-0.05	0.68	-0.27
10	1.7	0	-0.09	0.91	0
11	2.2	-2.2	-0.09	0.82	-0.09
12	2.5	-3.6	-0.09	0.77	-0.14
13	3.4	-6.7	-0.09	0.69	-0.22
14	3.6	0	-0.17	0.83	0
15	1.7	-1.7	-0.05	0.55	-0.05

**Transmit Equalization Presets Table**

#### 3.3.1.2 Requirement

Transmitter swing  $3.5 \pm 1$ dB (for preset 15 only).

Pre-shoot, de-emphasis  $\pm 1$ dB for the Presets specified in the Transmit Equalization Preset Table above.

#### 3.3.1.3 Test Objective

Confirm that the transmitter equalization falls within the limits of the USB4 Specification.

#### 3.3.1.4 Test Method

1. Set preset 0.
2. Choose a supported USB4 Gen2 speed.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with pre-shoot and with de-emphasis. If a Re-Timer

is placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with pre-shoot and with de-emphasis based on local clock without SSC modulation on all lanes.

5. Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125µs per channel.
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
6. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with no pre-shoot and with de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with no pre-shoot and with de-emphasis based on local clock without SSC modulation on all lanes.
7. Save the waveform as detailed in #5
8. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with pre-shoot but with no de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with pre-shoot and with no de-emphasis based on local clock without SSC modulation on all lanes.
9. Save the waveform as detailed in #5
10. Repeat steps 4- 9 for all Presets in the Transmit Equalization Preset Table.
11. Set the DUT to Preset 0.
12. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with no pre-shoot and with no de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with no pre-shoot and with no de-emphasis based on local clock without SSC modulation on all lanes.
13. Save the waveform as detailed in #5
14. Set the DUT to Preset 15.
15. Repeat step #12-13 with Preset 15
16. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.6
17. If Pre-shoot is not within  $\pm 1$ dB of the matching value in the Transmit Equalization Preset Table then **Fail**.
18. If De-emphasis is not within  $\pm 1$ dB of the matching value in the Transmit Equalization Preset Table then **Fail**.
19. If Swing < 2.5 dB or Swing > 4.5 dB then **Fail**.
20. Repeat the test for all remaining USB4 lanes.



## 3.3.2 Gen2 Minimum Unit Interval Measurement

### 3.3.2.1 Reference

UI - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

### 3.3.2.2 Requirement

$99.97\text{ps} \leq \text{Minimum Unit Interval} \leq 100.03\text{ps}$ .

### 3.3.2.3 Test Objective

Confirm that the Minimum Unit Interval under all conditions does not exceed minimum or maximum limits of the USB4 Specification during steady-state.

### 3.3.2.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If Max Minimum UI  $> 100.03\text{ps}$  **or** Min Minimum UI  $< 99.97\text{ps}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.3 Gen2 SSC Down Spread Range Measurement

#### 3.3.3.1 Reference

SSC\_Down\_Spread\_Range - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

#### 3.3.3.2 Requirement

$0.4\% \leq \text{SSC\_Down\_Spread\_Range} \leq 0.5\%$ .

#### 3.3.3.3 Test Objective

Confirm that the Dynamic range of SSC down-spreading during steady-state falls within the limits of the USB4 Specification.

#### 3.3.3.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If Max SSC\_Down\_Spread\_Range > 0.5% **or** Min SSC\_Down\_Spread\_Range < 0.4% then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.4 Gen2 SSC Down Spread Rate Measurement

#### 3.3.4.1 Reference

SSC\_Down\_Spread\_Rate - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

#### 3.3.4.2 Requirement

$30\text{KHz} \leq \text{SSC\_Down\_Spread\_Rate} \leq 33\text{KHz}$ .

#### 3.3.4.3 Test Objective

Confirm that the SSC down-spreading modulation rate during steady-state falls within the limits of the USB4 Specification.

#### 3.3.4.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If  $30\text{KHz} > \text{Min SSC\_Down\_Spread\_Rate}$  **or**  $\text{Max SSC\_Down\_Spread\_Rate} > 33\text{KHz}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.5 Gen2 SSC Phase Deviation Measurement

#### 3.3.5.1 Reference

SSC\_Phase\_Deviation - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

#### 3.3.5.2 Requirement

$2.5\text{ns p-p} \leq \text{SSC\_Phase\_Deviation} \leq 22\text{ns p-p}$ .

#### 3.3.5.3 Test Objective

Confirm that the Phase jitter associated with the SSC modulation during steady-state falls within the limits of the USB4 Specification.

#### 3.3.5.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If  $\text{SSC\_Phase\_Deviation} < 2.5\text{ns p-p}$  or  $\text{SSC\_Phase\_Deviation} > 22\text{ns p-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.3.6 Gen2 SSC Slew Rate Measurement

### 3.3.6.1 Reference

SSC\_Slew\_Rate - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.3.6.2 Requirement

SSC\_Slew\_Rate  $\leq$  1250 ppm/ $\mu$ s.

### 3.3.6.3 Test Objective

Confirm that the SSC Slew Rate during steady-state falls within the limits of the specification.

### 3.3.6.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform and post process it with an appropriate software:
  - Sampling Rate  $\geq$  80GSa/s.
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu$ s per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If SSC\_Slew\_Rate > 1250 ppm/ $\mu$ s then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.3.7 Gen2 TX Frequency Variation Training Measurement

### 3.3.7.1 Reference

TX\_FREQ\_VARIATIONS\_TRAINING –

USB4v1 Specification, Table 3-3 and section 3.4.1.1 Table 3-4

USB4v2 Specification, Table 3-2 and section 3.1.3.1.1 Table 3-3

### 3.3.7.2 Requirement

TX\_FREQ\_VARIATIONS\_TRAINING:

- $-300 \leq \text{INIT\_FREQ\_VARIATION} \leq 300 \text{ ppm}$
- $\text{DELTA\_FREQ\_200ns} \leq 1400 \text{ ppm}$
- $\text{DELTA\_FREQ\_1000ns} \leq 2200 \text{ ppm}$
- $\text{FREQ\_OVERSHOOT} \leq 1400 \text{ ppm}$

### 3.3.7.3 Test Objective

Confirm that the Frequency variation during Link training falls within the limits of the specification.

*Note: This test shall be applied only when the DUT contains Re-Timer.*

### 3.3.7.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. For emulating link training, DUT shall be configured such that the Router transmitting PRBS31 with SSC modulation on all lanes.
3. The Re-Timer placed near the USB Type-C connector shall be configured to transmit SQ2 based on local clock without SSC modulation on all lanes. If additional Re-Timer exist in the DUT, it shall be configured to transmit SQ4 based on local clock without SSC modulation on all lanes.
4. Initiate clock switch from local clock to recovered clock for the Re-Timer placed near the USB Type-C connector.
5. The cables from the plug test fixture to the scope shall be de-embedded.
6. Capture the clock switch period during three stages: pre-clock switch, clock switch and post-clock switch in a single waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
7. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.7
8. If additional Re-Timer exist in the DUT, then the 2<sup>nd</sup> clock switch needs to be analyzed as well from the saved waveform in step 6 above.
9. Repeat this procedure 20 times and report the worst captured waveform.

10. If INIT\_FREQ\_VARIATION > 300 ppm **or** INIT\_FREQ\_VARIATION < -300 ppm **or** FREQ\_OVERSHOOT > 1400 ppm **or** DELTA\_FREQ\_200ns > 1400 ppm **or** DELTA\_FREQ\_1000ns > 2200 ppm then **Fail**
11. Repeat the test for all remaining USB4 lanes.

## 3.3.8 Gen2 Rise/Fall Time Measurement

### 3.3.8.1 Reference

RISE\_FALL\_TIME - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.3.8.2 Requirement

Rise Time and Fall Time  $\geq 10\text{ps}$ .

### 3.3.8.3 Test Objective

Confirm that the rise time and fall time on the USB4 differential signals falls within the limits of the USB4 Specification.

### 3.3.8.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's (SQ128) on all lanes with SSC turned on. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 based on local clock without SSC modulation on all lanes.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Evaluate 4Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 4Mpts. The evaluated record length shall be 50 $\mu\text{s}$  per channel.
  - Scope BW shall be 21GHz.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.2
6. If  $T_{\text{RISE}} < 10\text{ps}$  **or**  $T_{\text{FALL}} < 10\text{ps}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.



### 3.3.9 Gen2 Electrical Idle Voltage Measurement

#### 3.3.9.1 Reference

V\_ELEC\_IDLE - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

#### 3.3.9.2 Requirement

$V\_ELEC\_IDLE \leq 20\text{mV}$ .

#### 3.3.9.3 Test Objective

Confirm that the TX peak voltage during transmit electrical idle do not exceed the limits of the USB4 Specification.

#### 3.3.9.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT to be in electrical idle mode.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the differential waveform  $V_{TX-P} - V_{TX-N}$  from the scope:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - V\_ELEC\_IDLE test can be tested over one lane at the time (SPEC limitation).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.5
6. If  $V\_ELEC\_IDLE > 20\text{mV}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.10 Gen2 Total Jitter Measurement

#### 3.3.10.1 Reference

TJ - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

#### 3.3.10.2 Requirement

Total Jitter  $\leq 0.38U_{Ip-p}$ .

#### 3.3.10.3 Test Objective

Confirm that the transmitter Total Jitter falls within the limits of the USB4 Specification.

#### 3.3.10.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If TJ > 0.38U<sub>Ip-p</sub> then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.11 Gen2 UJ Measurement

#### 3.3.11.1 Reference

UJ - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

#### 3.3.11.2 Requirement

Sum of uncorrelated DJ and RJ components  $\leq 0.31U_{Ip-p}$ .

#### 3.3.11.3 Test Objective

Confirm that the transmitter Sum of uncorrelated DJ and RJ components falls within the limits of the USB4 Specification.

#### 3.3.11.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $UJ > 0.31U_{Ip-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.12 Gen2 UDJ Measurement

#### 3.3.12.1 Reference

UDJ - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

#### 3.3.12.2 Requirement

Deterministic jitter that is uncorrelated to the transmitted data  $\leq 0.17\text{UIp-p}$ .

#### 3.3.12.3 Test Objective

Confirm that the transmitter Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

#### 3.3.12.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If UDJ  $> 0.17\text{UIp-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.13 Gen2 DDJ Measurement

#### 3.3.13.1 Reference

DDJ - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

#### 3.3.13.2 Requirement

Data Dependent jitter  $\leq 0.15UI_p$ .

#### 3.3.13.3 Test Objective

Confirm that the transmitter Data Dependent jitter falls within the limits of the USB4 Specification.

#### 3.3.13.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If DDJ > 0.15UI<sub>p</sub> then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.14 Gen2 Low Frequency UDJ Measurement

#### 3.3.14.1 Reference

UDJ\_LF -       USB4v1 Specification, Table 3-6  
                  USB4v2 Specification, Table 3-5

#### 3.3.14.2 Requirement

$UDJ\_LF \leq 0.04U_{Ip-p}$ .

#### 3.3.14.3 Test Objective

Confirm that the transmitter low frequency Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

#### 3.3.14.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $UDJ\_LF > 0.04U_{Ip-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.15 Gen2 DCD Measurement

#### 3.3.15.1 Reference

DCD - USB4v1 Specification, Table 3-6  
USB4v2 Specification, Table 3-5

#### 3.3.15.2 Requirement

$DCD \leq 0.03UI_{p-p}$ .

#### 3.3.15.3 Test Objective

Confirm that the Even-odd jitter associated with Duty-Cycle-Distortion falls within the limits of the USB4 Specification.

#### 3.3.15.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $DCD > 0.03UI_{p-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.3.16 Gen2 AC Common Mode Measurement

#### 3.3.16.1 Reference

AC\_CM -       USB4v1 Specification, Table 3-6  
                  USB4v2 Specification, Table 3-5

#### 3.3.16.2 Requirement

AC\_CM ≤ 100mVp-p.

#### 3.3.16.3 Test Objective

Confirm that the transmitter common mode on the USB4 differential signals falls within the limits of the USB4 Specification.

#### 3.3.16.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate ≥ 80GSa/s.
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5μs per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - No CDR, no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.4
6. If V<sub>AC-CM</sub> > 100mVp-p then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

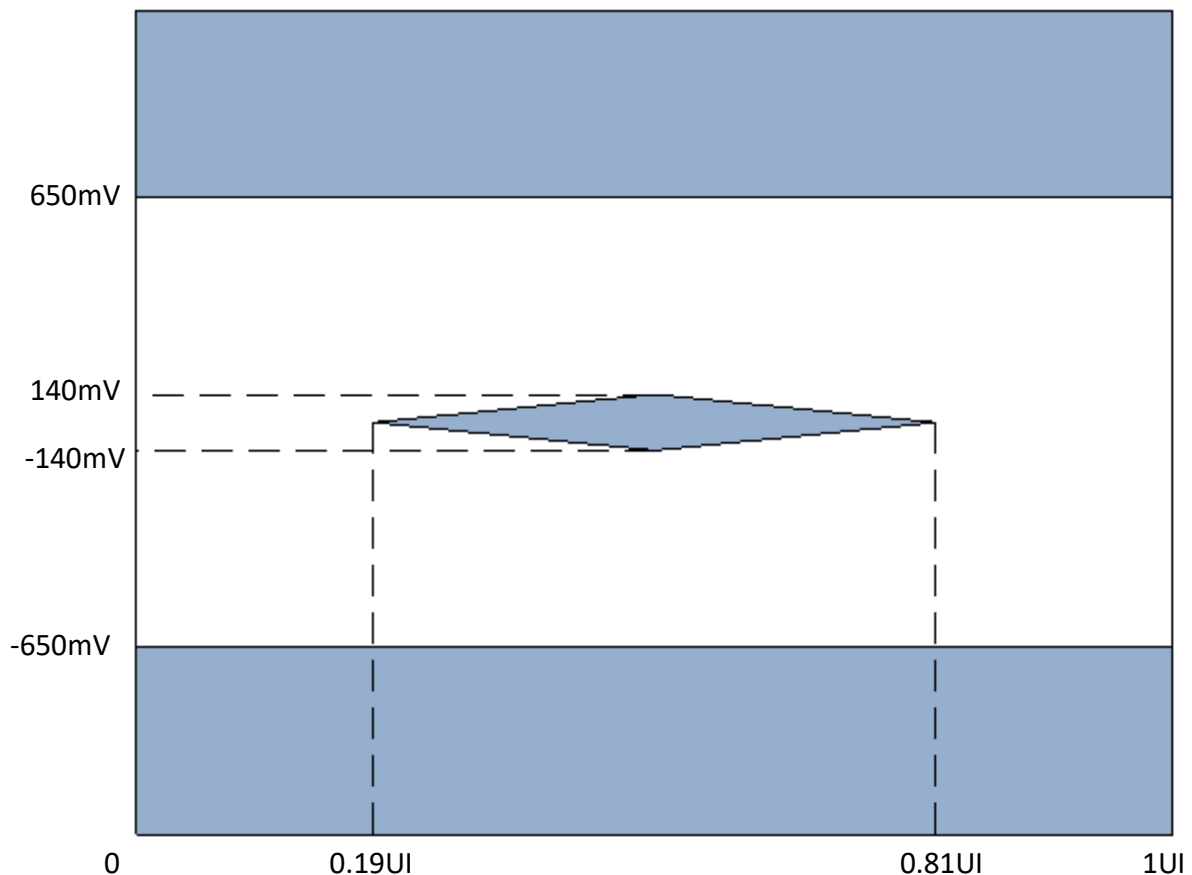


### 3.3.17 Gen2 Eye Diagram Measurement

#### 3.3.17.1 Reference

Eye Diagram Mask –USB4v1 Specification, Table 3-6, Figure 3-15 – TX Mask Notations  
USB4v2 Specification, Table 3-5, Figure 3-15 – TX Mask Notations

#### 3.3.17.2 Requirement



#### 3.3.17.3 Test Objective

Confirm that the differential signal on each USB4 differential lane has an eye opening that exceeds the limits on the eye opening in the USB4 Specification.

#### 3.3.17.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .

- Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125μs per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
  6. If any part of the waveform hits the mask, then **Fail**.
  7. Repeat the test for all remaining USB4 lanes.

### 3.3.18 Gen2 Total Jitter TP3 Measurement

#### 3.3.18.1 Reference

TJ - USB4v1 Specification, Table 3-7  
USB4v2 Specification, Table 3-6

#### 3.3.18.2 Requirement

Total Jitter  $\leq 0.60U_{Ip-p}$ .

#### 3.3.18.3 Test Objective

Confirm that the transmitter Total Jitter falls within the limits of the USB4 Specification.

#### 3.3.18.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 2m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If TJ > 0.60U<sub>Ip-p</sub> then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

### 3.3.19 Gen2 UJ TP3 Measurement

#### 3.3.19.1 Reference

UJ – USB4v1 Specification, Table 3-7  
USB4v2 Specification, Table 3-6

#### 3.3.19.2 Requirement

Sum of uncorrelated DJ and RJ components  $\leq 0.31U_{Ip-p}$ .

#### 3.3.19.3 Test Objective

Confirm that the transmitter Sum of uncorrelated DJ and RJ components falls within the limits of the USB4 Specification.

#### 3.3.19.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 2m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If UJ > 0.31U<sub>Ip-p</sub> then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

## 3.3.20 Gen2 UDJ TP3 Measurement

### 3.3.20.1 Reference

UDJ - USB4v1 Specification, Table 3-7  
USB4v2 Specification, Table 3-6

### 3.3.20.2 Requirement

Deterministic jitter that is uncorrelated to the transmitted data  $\leq 0.17U_{Ip-p}$ .

### 3.3.20.3 Test Objective

Confirm that the transmitter Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

### 3.3.20.4 Test Method

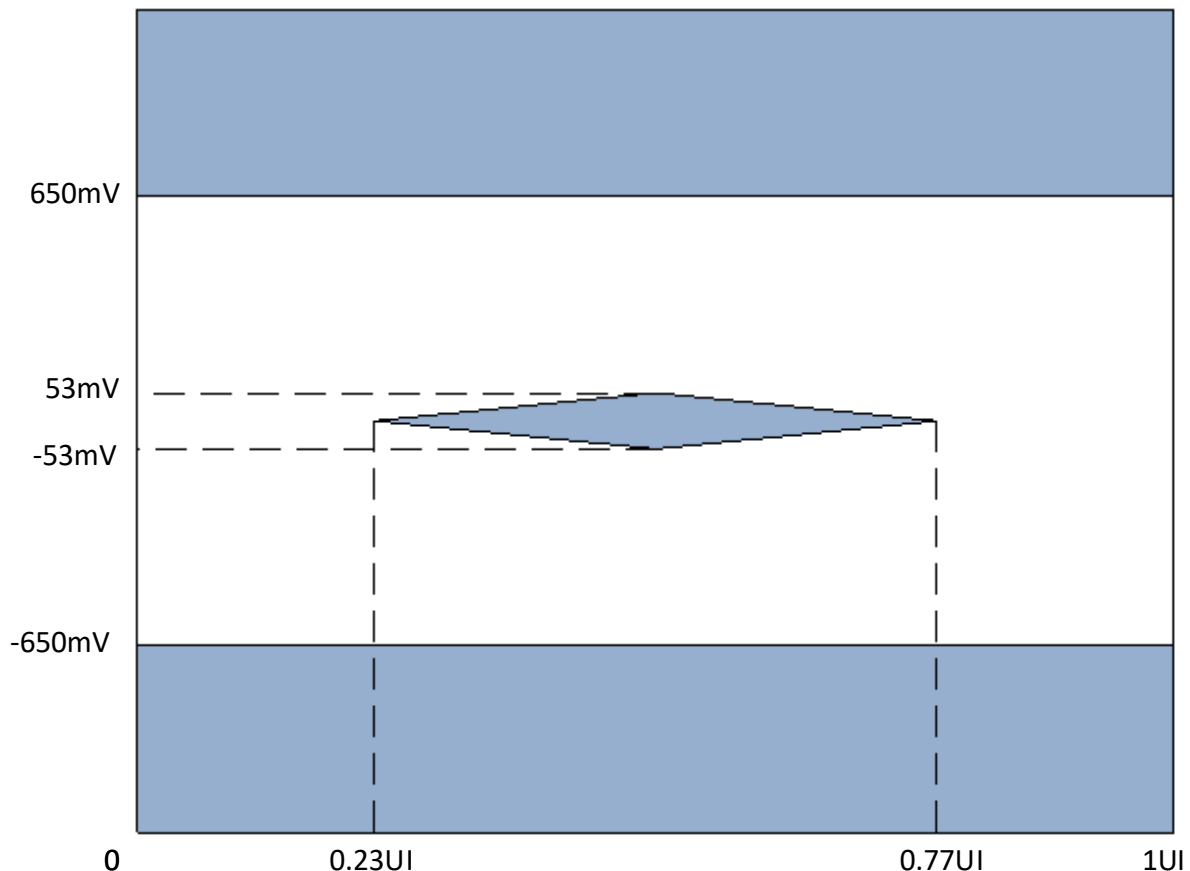
1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 2m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If UDJ  $> 0.17U_{Ip-p}$  then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

### 3.3.21 Gen2 Eye Diagram TP3 Measurement

#### 3.3.21.1 Reference

Eye Diagram Mask – USB4v1 Specification, Table 3-7, Figure 3-15 – TX Mask Notations  
USB4v2 Specification, Table 3-6, Figure 3-15 – TX Mask Notations

#### 3.3.21.2 Requirement



#### 3.3.21.3 Test Objective

Confirm that the differential signal on each USB4 differential lane has an eye opening that exceeds the limits on the eye opening in the USB4 Specification.

#### 3.3.21.4 Test Method

1. Choose a supported USB4 Gen2 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The USB Type-C 2m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .

- Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125µs per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
  7. If any part of the waveform hits the mask, then **Fail**.
  8. Repeat the test for all remaining USB4 lanes.

## 3.4 Gen3 Router Assembly Transmitter Compliance

*Note: Refer to Sections [3.13.1](#) and [3.23.2](#) for test setup.*

### 3.4.1 Gen3 Transmitter Equalization

#### 3.4.1.1 Reference

USB4v1 Specification, Table 3-3 and section 3.4.1.4 Table 3-5

USB4v2 Specification, Table 3-2 and section 3.1.3.1.4 Table 3-4

#### 3.4.1.2 Requirement

Transmitter swing  $3.5 \pm 1\text{dB}$  (for preset 15 only).

Pre-shoot, de-emphasis  $\pm 1\text{dB}$  for the presets in the Transmit Equalization Preset Table above.

#### 3.4.1.3 Test Objective

Confirm that the transmitter equalization falls within the limits of the USB4 Specification.

#### 3.4.1.4 Test Method

1. Set preset 0.
2. Choose a supported USB4 Gen3 speed.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with pre-shoot and with de-emphasis. If a Re-Timer is placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with pre-shoot and with de-emphasis based on local clock without SSC modulation on all lanes.
5. Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125 $\mu\text{s}$  per channel.
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
6. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with no pre-shoot and with de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with no pre-shoot and with de-emphasis based on local clock without SSC modulation on all lanes.
7. Save the waveform as detailed in #5
8. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with pre-shoot but with no de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall



be configured to transmit SQ128 with pre-shoot and with no de-emphasis based on local clock without SSC modulation on all lanes.

9. Save the waveform as detailed in #5
  10. Repeat steps 4- 9 for all Presets in the Transmit Equalization Preset Table.
  11. Set the DUT to Preset 0.
  12. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's on all lanes with SSC turned on with no pre-shoot and with no de-emphasis. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 with no pre-shoot and with no de-emphasis based on local clock without SSC modulation on all lanes.
  13. Save the waveform as detailed in #5
  14. Set the DUT to Preset 15.
  15. Repeat step #12-13 with Preset 15
  16. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.6
  17. If Pre-shoot is not within  $\pm 1$ dB of the matching value in the Transmit Equalization Preset Table then **Fail**.
  18. If De-emphasis is not within  $\pm 1$ dB of the matching value in the Transmit Equalization Preset Table then **Fail**.
  19. If Swing < 2.5 dB or Swing > 4.5 dB then **Fail**.
- Repeat the test for all remaining USB4 lanes

## 3.4.2 Gen3 Minimum Unit Interval Measurement

### 3.4.2.1 Reference

UI - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

### 3.4.2.2 Requirement

$49.985\text{ps} \leq \text{Minimum Unit Interval} \leq 50.015\text{ps}$ .

### 3.4.2.3 Test Objective

Confirm that the Minimum Unit Interval under all conditions does not exceed minimum or maximum limits of the USB4 Specification.

### 3.4.2.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If Max Minimum UI  $> 50.015\text{ps}$  **or** Min Minimum UI  $< 49.985\text{ps}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.3 Gen3 SSC Down Spread Range Measurement

#### 3.4.3.1 Reference

SSC\_Down\_Spread\_Range - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

#### 3.4.3.2 Requirement

$0.4\% \leq \text{SSC\_Down\_Spread\_Range} \leq 0.5\%$ .

#### 3.4.3.3 Test Objective

Confirm that the Dynamic range of SSC down-spreading falls within the limits of the USB4 Specification.

#### 3.4.3.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If Max SSC\_Down\_Spread\_Range > 0.5% **or** Min SSC\_Down\_Spread\_Range < 0.4% then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.4.4 Gen3 SSC Down Spread Rate Measurement

### 3.4.4.1 Reference

SSC\_Down\_Spread\_Rate - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.4.4.2 Requirement

$30\text{KHz} \leq \text{SSC\_Down\_Spread\_Rate} \leq 33\text{KHz}$ .

### 3.4.4.3 Test Objective

Confirm that the SSC down-spreading modulation rate during steady-state falls within the limits of the USB4 Specification.

### 3.4.4.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If  $30\text{KHz} > \text{Min SSC\_Down\_Spread\_Rate}$  **or**  $\text{Max SSC\_Down\_Spread\_Rate} > 33\text{KHz}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.5 Gen3 SSC Phase Deviation Measurement

#### 3.4.5.1 Reference

SSC\_Phase\_Deviation -     USB4v1 Specification, Table 3-3  
                                  USB4v2 Specification, Table 3-2

#### 3.4.5.2 Requirement

$2.5\text{ns p-p} \leq \text{SSC\_Phase\_Deviation} \leq 22\text{ns p-p}$ .

#### 3.4.5.3 Test Objective

Confirm that the SSC Phase Deviation falls within the limits of the USB4 Specification during steady-state.

#### 3.4.5.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If  $\text{SSC\_Phase\_Deviation} < 2.5\text{ns p-p}$  or  $\text{SSC\_Phase\_Deviation} > 22\text{ns p-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.4.6 Gen3 SSC Slew Rate Measurement

### 3.4.6.1 Reference

SSC\_Slew\_Rate - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.4.6.2 Requirement

SSC\_Slew\_Rate  $\leq$  1250 ppm/ $\mu$ s.

### 3.4.6.3 Test Objective

Confirm that the SSC Slew Rate during steady-state falls within the limits of the specification.

### 3.4.6.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq$  80GSa/s.
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu$ s per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If SSC\_Slew\_Rate > 1250 ppm/ $\mu$ s then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.4.7 Gen3 TX Frequency Variation Training Measurement

### 3.4.7.1 Reference

TX\_FREQ\_VARIATIONS\_TRAINING –

USB4v1 Specification, Table 3-3 and section 3.4.1.1 Table 3-4

USB4v2 Specification, Table 3-2 and section 3.1.3.1.1 Table 3-3

### 3.4.7.2 Requirement

TX\_FREQ\_VARIATIONS\_TRAINING:

- $-300 \leq \text{INIT\_FREQ\_VARIATION} \leq 300$  ppm
- $\text{DELTA\_FREQ\_200ns} \leq 1400$  ppm
- $\text{DELTA\_FREQ\_1000ns} \leq 2200$  ppm
- $\text{FREQ\_OVERSHOOT} \leq 1400$  ppm

### 3.4.7.3 Test Objective

Confirm that the Frequency variation during Link training falls within the limits of the specification.

*Note: This test shall be applied only when the DUT contains Re-Timer.*

### 3.4.7.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. For emulating link training, DUT shall be configured such that the Router transmitting PRBS31 with SSC modulation on all lanes.
3. The Re-Timer placed near the USB Type-C connector shall be configured to transmit SQ2 based on local clock without SSC modulation on all lanes. If additional Re-Timer exist in the DUT, it shall be configured to transmit SQ4 based on local clock without SSC modulation on all lanes.
4. Initiate clock switch from local clock to recovered clock for the Re-Timer placed near the USB Type-C connector.
5. The cables from the plug test fixture to the scope shall be de-embedded.
6. Capture the clock switch period during three stages: pre-clock switch, clock switch and post-clock switch in a single waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
7. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.7
8. If additional Re-Timer exist in the DUT, then the 2<sup>nd</sup> clock switch needs to be analyzed as well from the saved waveform in step 6 above.

9. Repeat this procedure 20 times and report the worst captured waveform.
10. If  $\text{INIT\_FREQ\_VARIATION} > 300 \text{ ppm}$  **or**  $\text{INIT\_FREQ\_VARIATION} < -300 \text{ ppm}$  **or**  $\text{FREQ\_OVERSHOOT} > 1400 \text{ ppm}$  **or**  $\text{DELTA\_FREQ\_200ns} > 1400 \text{ ppm}$  **or**  $\text{DELTA\_FREQ\_1000ns} > 2200 \text{ ppm}$  then **Fail**.
11. Repeat the test for all remaining USB4 lanes.



## 3.4.8 Gen3 Rise/Fall Time Measurement

### 3.4.8.1 Reference

RISE\_FALL\_TIME - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.4.8.2 Requirement

Rise Time and Fall Time  $\geq 10\text{ps}$ .

### 3.4.8.3 Test Objective

Confirm that the rise times and fall times on the USB4 differential signals falls within the limits of the USB4 Specification.

### 3.4.8.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output alternating square pattern of 64 0's and 64 1's (SQ128) on all lanes with SSC turned on. If a Re-Timer placed near the USB Type-C connector, then the Re-Timer transmitter shall be configured to transmit SQ128 based on local clock without SSC modulation on all lanes.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Evaluate 4Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 4Mpts. The evaluated record length shall be 50 $\mu\text{s}$  per channel.
  - Scope BW shall be 21GHz.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.2
6. If  $T_{\text{RISE}} < 10\text{ps}$  **or**  $T_{\text{FALL}} < 10\text{ps}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.4.9 Gen3 Electrical Idle Voltage Measurement

### 3.4.9.1 Reference

V\_ELEC\_IDLE - USB4v1 Specification, Table 3-3  
USB4v2 Specification, Table 3-2

### 3.4.9.2 Requirement

$V\_ELEC\_IDLE \leq 20\text{mV}$ .

### 3.4.9.3 Test Objective

Confirm that the TX peak voltage during transmit electrical idle do not exceed the limits of the USB4 Specification.

### 3.4.9.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT to be in electrical idle mode.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the differential waveform  $V_{TX-P} - V_{TX-N}$  from the scope:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125 $\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - V\_ELEC\_IDLE test can be tested over one lane at the time (SPEC limitation).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.5
6. If  $V\_ELEC\_IDLE > 20\text{mV}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.10 Gen3 Total Jitter Measurement

#### 3.4.10.1 Reference

TJ - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

#### 3.4.10.2 Requirement

Total Jitter  $\leq 0.46U_{Ip-p}$ .

#### 3.4.10.3 Test Objective

Confirm that the transmitter Total Jitter falls within the limits of the USB4 Specification.

#### 3.4.10.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If TJ > 0.46U<sub>Ip-p</sub> then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.11 Gen3 UJ Measurement

#### 3.4.11.1 Reference

UJ - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

#### 3.4.11.2 Requirement

Sum of uncorrelated DJ and RJ components  $\leq 0.31U_{Ip-p}$ .

#### 3.4.11.3 Test Objective

Confirm that the transmitter Sum of uncorrelated DJ and RJ components falls within the limits of the USB4 Specification.

#### 3.4.11.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $UJ > 0.31U_{Ip-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## 3.4.12 Gen3 UDJ Measurement

### 3.4.12.1 Reference

UDJ - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

### 3.4.12.2 Requirement

Deterministic jitter that is uncorrelated to the transmitted data  $\leq 0.17\text{UIp-p}$ .

### 3.4.12.3 Test Objective

Confirm that the transmitter Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

### 3.4.12.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If UDJ  $> 0.17\text{UIp-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.13 Gen3 DDJ Measurement

#### 3.4.13.1 Reference

DDJ - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

#### 3.4.13.2 Requirement

Data Dependent jitter  $\leq 0.21U_{Ip-p}$ .

#### 3.4.13.3 Test Objective

Confirm that the transmitter Data Dependent jitter falls within the limits of the USB4 Specification.

#### 3.4.13.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If DDJ > 0.21U<sub>Ip-p</sub> then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.14 Gen3 Low Frequency UDJ Measurement

#### 3.4.14.1 Reference

UDJ\_LF -        USB4v1 Specification, Table 3-8  
                  USB4v2 Specification, Table 3-7

#### 3.4.14.2 Requirement

$UDJ\_LF \leq 0.07U_{Ip-p}$ .

#### 3.4.14.3 Test Objective

Confirm that the transmitter low frequency Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

#### 3.4.14.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $UDJ\_LF > 0.07U_{Ip-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.15 Gen3 DCD Measurement

#### 3.4.15.1 Reference

DCD - USB4v1 Specification, Table 3-8  
USB4v2 Specification, Table 3-7

#### 3.4.15.2 Requirement

$DCD \leq 0.03UI_{p-p}$ .

#### 3.4.15.3 Test Objective

Confirm that the Even-odd jitter associated with Duty-Cycle-Distortion falls within the limits of the USB4 Specification.

#### 3.4.15.4 Test Method

1. Choose a supported USB4 Gen3.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
  - Adjust vertical scale to fit signal into scope screen.
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.3
6. If  $DCD > 0.03UI_{p-p}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.



## 3.4.16 Gen3 AC Common Mode Measurement

### 3.4.16.1 Reference

AC\_CM -       USB4v1 Specification, Table 3-8  
                  USB4v2 Specification, Table 3-7

### 3.4.16.2 Requirement

AC\_CM ≤ 100mVp-p.

### 3.4.16.3 Test Objective

Confirm that the transmitter common mode on the USB4 differential signals falls within the limits of the USB4 Specification.

### 3.4.16.4 Test Method

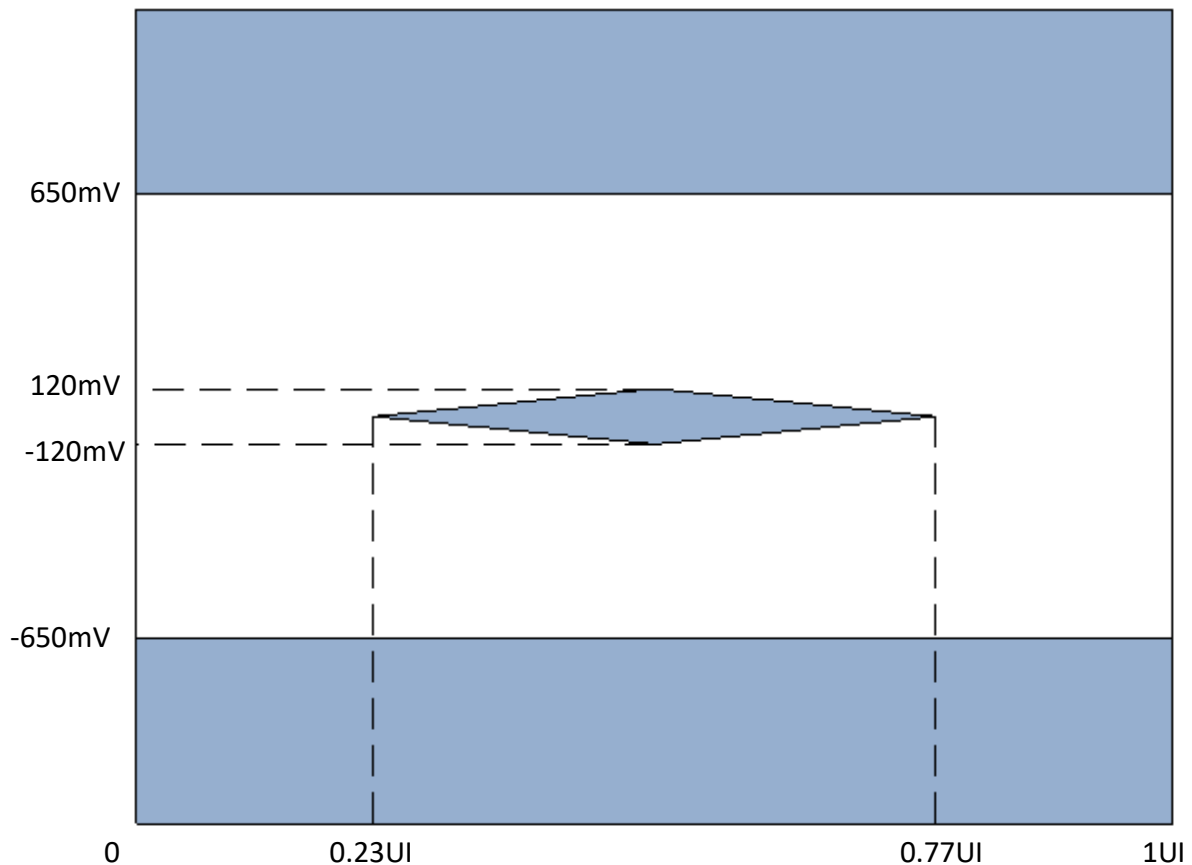
1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate ≥ 80GSa/s.
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5μs per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - No CDR, no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.4
6. If V<sub>AC-CM</sub> > 100mVp-p then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

### 3.4.17 Gen3 Eye Diagram Measurement

#### 3.4.17.1 References

Eye Diagram Mask – USB4v1 Specification, Table 3-8, Figure 3-15 – TX Mask Notations  
USB4v2 Specification, Table 3-7, Figure 3-15 – TX Mask Notations

Requirement



#### 3.4.17.2 Test Objective

Confirm that the differential signal on each USB4 differential lane has an eye opening that exceeds the limits on the eye opening in the USB4 Specification.

#### 3.4.17.3 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .

- Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125µs per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
  6. If any part of the waveform hits the mask, then **Fail**.
  7. Repeat the test for all remaining USB4 lanes.

### 3.4.18 Gen3 Total Jitter TP3 Measurement

#### 3.4.18.1 Reference

TJ - USB4v1 Specification, Table 3-9  
USB4v2 Specification, Table 3-8

#### 3.4.18.2 Requirement

Total Jitter  $\leq 0.60U_{Ip-p}$ .

#### 3.4.18.3 Test Objective

Confirm that the transmitter Total Jitter falls within the limits of the USB4 Specification.

#### 3.4.18.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 0.8m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If TJ > 0.60U<sub>Ip-p</sub> then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

## 3.4.19 Gen3 UJ TP3 Measurement

### 3.4.19.1 Reference

UJ – USB4v1 Specification, Table 3-9  
USB4v2 Specification, Table 3-8

### 3.4.19.2 Requirement

Sum of uncorrelated DJ and RJ components  $\leq 0.31U_{Ip-p}$ .

### 3.4.19.3 Test Objective

Confirm that the transmitter Sum of uncorrelated DJ and RJ components falls within the limits of the USB4 Specification.

### 3.4.19.4 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 0.8m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If UJ > 0.31U<sub>Ip-p</sub> then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

## 3.4.20 Gen3 UDJ TP3 Measurement

### 3.4.20.1 Reference

UDJ - USB4v1 Specification, Table 3-9  
USB4v2 Specification, Table 3-8

### 3.4.20.2 Requirement

Deterministic jitter that is uncorrelated to the transmitted data  $\leq 0.17U_{Ip-p}$ .

### 3.4.20.3 Test Objective

Confirm that the transmitter Uncorrelated Deterministic Jitter falls within the limits of the USB4 Specification.

### 3.4.20.4 Test Method

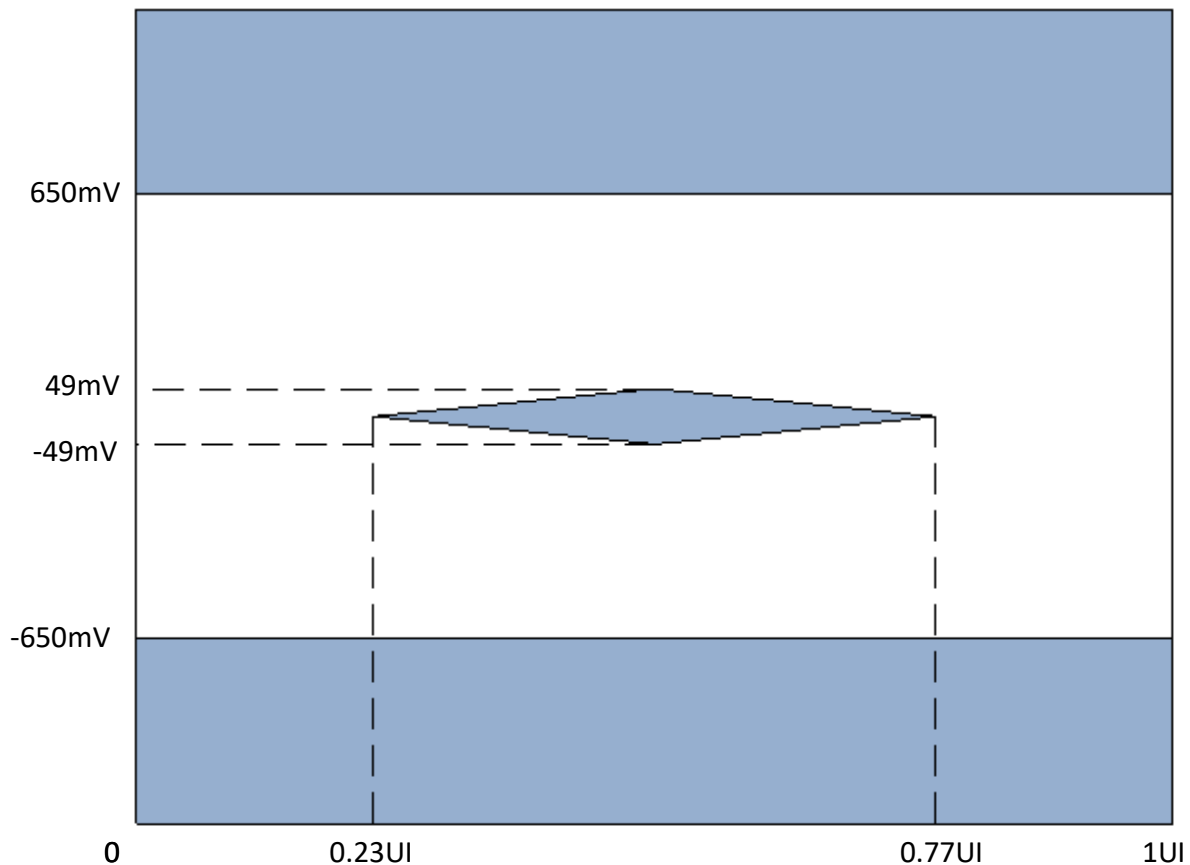
1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS15 on all lanes with SSC turned on.
3. The USB Type-C 0.8m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80GSa/s$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu s$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
7. If UDJ > 0.17U<sub>Ip-p</sub> then **Fail**.
8. Repeat the test for all remaining USB4 lanes.

### 3.4.21 Gen3 Eye Diagram TP3 Measurement

#### 3.4.21.1 Reference

Eye Diagram Mask – USB4v1 Specification, Table 3-9, Figure 3-15 – TX Mask Notations  
USB4v2 Specification, Table 3-8, Figure 3-15 – TX Mask Notations

Requirement



#### 3.4.21.2 Test Objective

Confirm that the differential signal on each USB4 differential lane has an eye opening that exceeds the limits on the eye opening in the USB4 Specification.

#### 3.4.21.3 Test Method

1. Choose a supported USB4 Gen3 speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The USB Type-C 0.8m cable is embedded in SigTest.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .

- Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125µs per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.3.1
  7. If any part of the waveform hits the mask, then **Fail**.
  8. Repeat the test for all remaining USB4 lanes.



## 3.5 Transmitter Return Loss Gen2 and Gen3

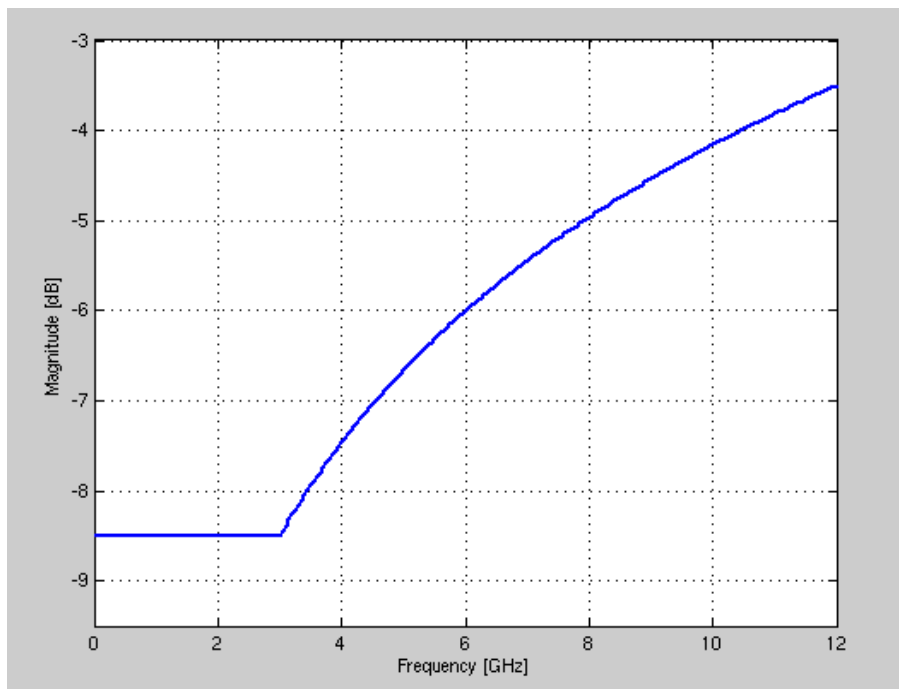
### 3.5.1 Transmitter Differential Return Loss

#### 3.5.1.1 Reference

RL\_DIFF - USB4v1 Specification, Table 3-3 and section 3.4.1.2  
USB4v2 Specification, Table 3-2 and section 3.1.3.1.2

#### 3.5.1.2 Requirement

$$SDD11(f) = \begin{cases} -8.5 & 0.05 < f_{GHz} \leq 3 \\ -3.5 + 8.3 \cdot \log_{10}\left(\frac{f_{GHz}}{12}\right) & 3 < f_{GHz} \leq 12 \end{cases}$$



#### 3.5.1.3 Test Objective

Confirm that the Differential Return loss falls within the limits of the USB4 Specification.

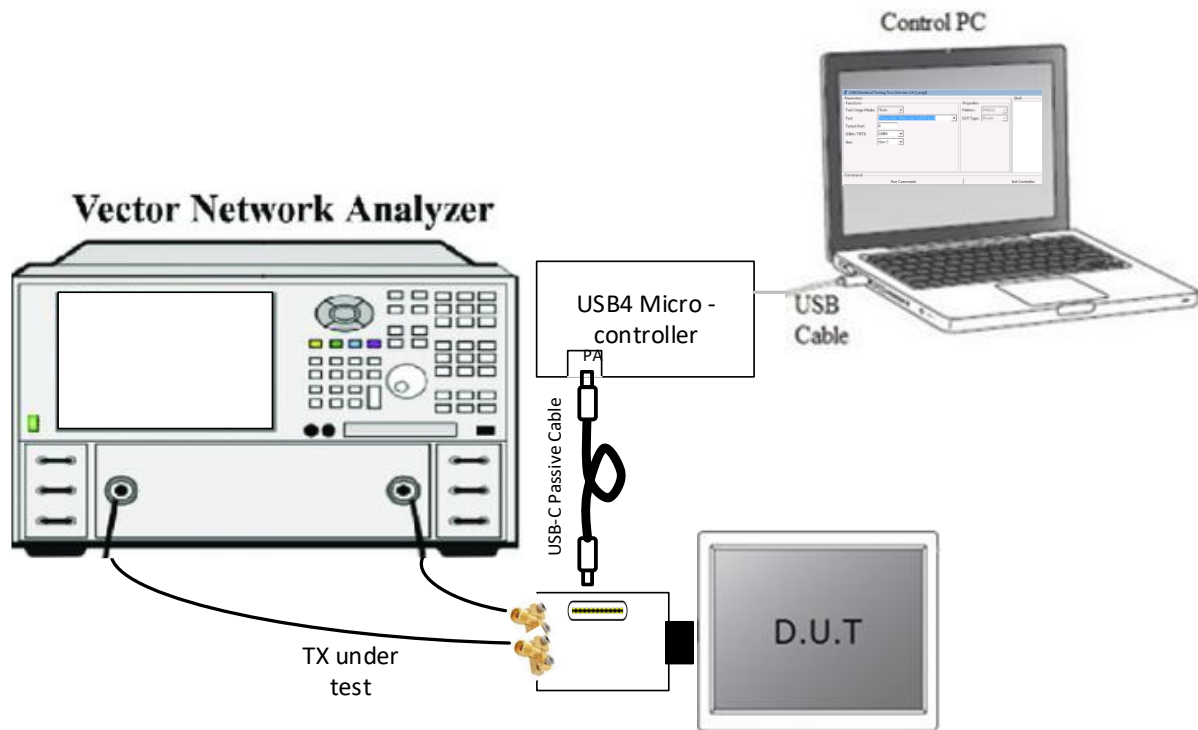
#### 3.5.1.4 Test Method

1. Choose a supported USB4 speed to start with.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. Setup the Network Analyzer with measurement:

*Note: As the extra loss and distortion elements may be compensated by physical or mathematical means, use gating option to compensate for the parts of the fixture that are with 100ohm impedance. No de-embedding or gating to the mated USB Type-C connector or the TF traces.*

- Frequency range of 50MHz to 12GHz

- IF BW of 1KHz
  - At least 1600 points
  - Impedance 85 ohm differential
  - Define the Topology to Bal
  - Define the measurement at SDD11.
4. Calibrate the network analyzer and test cables using a 2-port auto calibration kit.
  5. Connect Lane under test TX\_P, TX\_N to the Network Analyzer.



**Figure 3. Transmitter Return Loss Test Setup**

6. Measure the Differential R. Loss with the Network Analyzer.
7. If Differential Return loss violated the above requirement, then **Fail**.
8. Repeat the test for all remaining USB4 lanes.
9. Repeat the test for all supported USB4 Gen2 and Gen3 speeds.

## 3.5.2 Transmitter Common Mode Return Loss

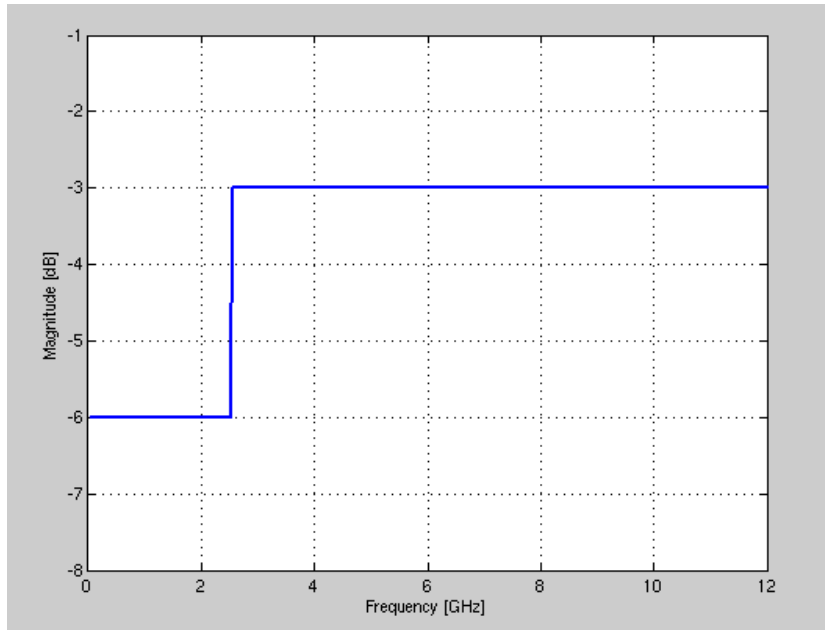
### 3.5.2.1 Reference

RL\_COMM - USB4v1 Specification, Table 3-3 and section 3.4.1.3

USB4v2 Specification, Table 3-2 and section 3.1.3.1.3

### 3.5.2.2 Requirement

$$\text{SCC11}(f) = \begin{cases} -6 & 0.05 < f_{\text{GHz}} \leq 2.5 \\ -3 & 2.5 < f_{\text{GHz}} \leq 12 \end{cases}$$



### 3.5.2.3 Test Objective

Confirm that the Common Mode Return loss falls within the limits of the USB4 Specification.

### 3.5.2.4 Test Method

1. Choose a supported USB4 speed to start with.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. Setup the Network Analyzer with measurement:

*Note: As the extra loss and distortion elements may be compensated by physical or mathematical means, use gating option to compensate for the parts of the fixture that are with 100ohm impedance. No de-embedding or gating to the mated USB Type-C connector or the TF traces.*

- Frequency range of 50MHz to 12GHz
- IF BW of 1KHz
- At least 1600 points
- Impedance 85 ohm differential
- Define the Topology to Bal

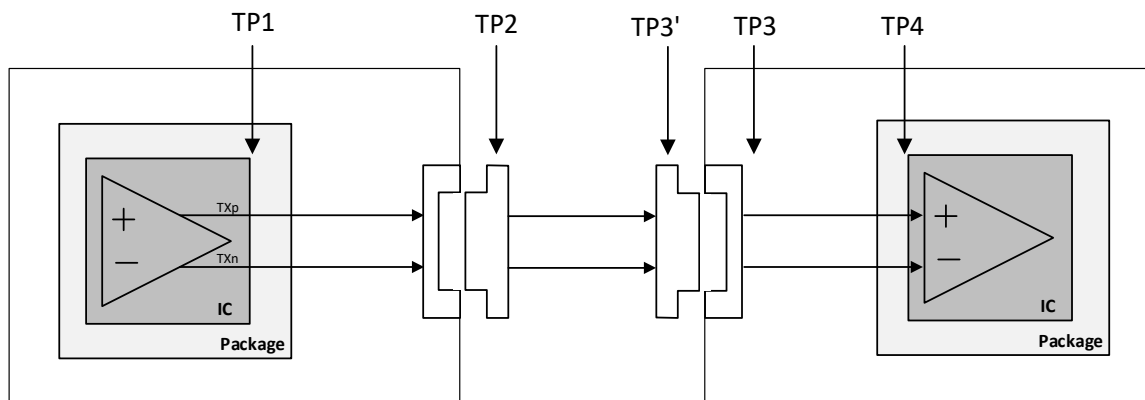
- *Define the measurement at SCC11.*
4. Calibrate the network analyzer and test cables using a 2-port auto calibration kit.
  5. Connect Lane under test TX\_P, TX\_N to the Network Analyzer.
  6. Measure the Common Mode R. Loss with the Network Analyzer.
  7. If Common Mode Return loss violated the above requirement, then **Fail**.
  8. Repeat the test for all remaining USB4 lanes.
  9. Repeat the test for all supported USB4 Gen2 and Gen3 speeds.

## 4 Router Assembly Receiver Testing

This section describes the tests required to verify whether the USB4 Receiver is compliant with the USB4 Specification.

The following sections provide detailed information on the setup and testing of the USB4 parameters. In the event of a discrepancy, the USB4 Specification prevails.

- Router Assembly receiver compliance testing is defined at the output of a “golden” plug fixture at the TP3’ reference point and at the output of a “golden” receptacle fixture at the TP3 reference point.
- TP3’- Reference measurement point located at the plug side of the Router Assembly RX input.
- TP3- Reference measurement point located at USB Type-C receptacle output on the far-end side of passive cable. Used as a reference point for passive installations.
- All measurements shall be referenced to the TP3’/TP3 compliance point.
- Calibration shall be applied in cases where direct measurement is not feasible.
- As written in the Introduction – all post processing for RX calibration stressed eye and RX Signal Frequency Variations profile is done using the USB4 SigTest.



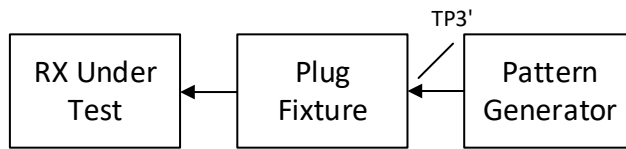
**Figure 4. USB4 RX Compliance Points Definition**

The ability of a Router Assembly input to tolerate the worst-case incoming signal is examined using a stressed receiver test. A Router Assembly receiver shall operate at BER of  $1E-12$  or lower without forward-error-correction nor pre-coding applied when a stressed signal is driven at its input. Tolerance testing shall be performed with down-spreading of the clock enabled and while all ports are active in USB4 mode. There are two test setups that shall be used for evaluating the Router Assembly receiver tolerance:

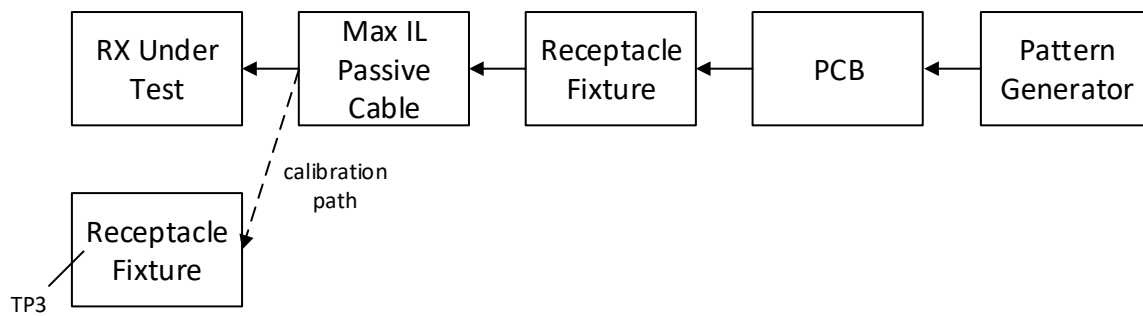
“Case1”, which addresses installations with low Insertion-Loss

“Case2”, which addresses installations with maximum Insertion-Loss

Case 1:



Case 2:

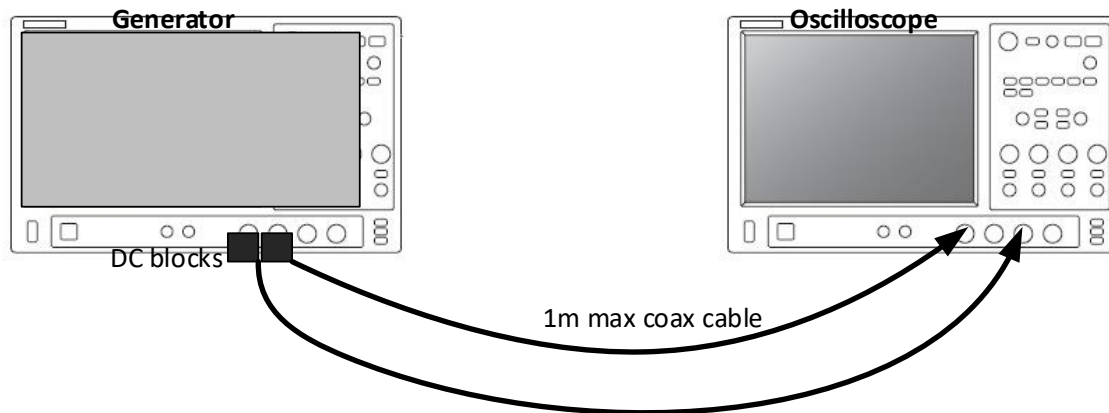


**Figure 5. USB4 RX Tolerance Test Topologies**

## 4.1 Receiver Test Setup

There are two physical setups required for Receiver testing, the Calibration Setup and the Test Setup.

*Note: Before beginning any test or data acquisition, the Generator and Scope must be warmed and calibrated.*



**Figure 6. Receiver Calibration Setup – TP3'**

## 4.2 Receiver Stressed Eye Calibration

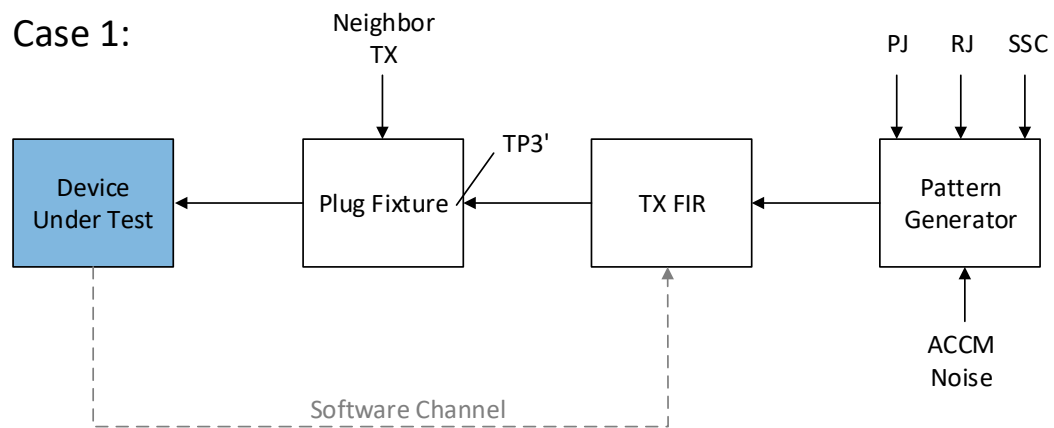
The USB4 Specification outlines a minimum Receiver Eye Diagram which is measured at the USB Type-C connector at the plug side.

The following procedure describes how to calibrate the USB4 minimum Receiver Eye Diagram.

Connect the test setup to the Scope as in Figure 6 above.

1. Connect the DATA+/DATA- Output of the Generator to DC block directly.
2. Connect pair of phase matched cables from the DC blocks to the oscilloscope (maximum 1m length).

### 4.2.1 Stressed Electrical Signal for TP3' (Case 1):



Set the SSC on the pattern generator to be:

- SSC with modulation wave shape triangle
- Modulation frequency for both Gen2 and Gen3 is 32KHz:
- Spread deviation from +300ppm up to -5300ppm



#### **4.2.1.1 Data Dependent Jitter**

##### **4.2.1.1.1 Reference**

USB4v1 Specification, Table 3-3 and section 3.4.1.4 Table 3-5

USB4v2 Specification, Table 3-2 and section 3.1.3.1.4 Table 3-4

##### **4.2.1.1.2 Requirement**

Data Dependent Jitter – Minimum possible DDJ.

##### **4.2.1.1.3 Test Method**

1. Choose a supported USB4 speed to start with in the Generator.
2. Configure Generator transmit PRBS15 with SSC turned on and all jitter components turned off.
3. Configure Generator amplitude to fit into the Receiver Eye Mask.
4. Configure the Generator to preset 0.
5. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.1
7. Repeat the measurement for all 16 presets, except preset 15 that are in Table 3-5.
8. Configure the Generator to the preset that provides the lowest DDJ.

## **4.2.1.2 AC Common Mode Measurements**

### **4.2.1.2.1 Reference**

AC\_CM - USB4v1 Specification, Section 3.5.2.  
USB4v2 Specification, Section 3.1.4.2.

### **4.2.1.2.2 Requirement**

AC common mode voltage - 100mVp-p.

### **4.2.1.2.3 Test Method**

1. Configure Generator transmit PRBS31 with SSC turned on and all jitter components turned off.
2. Configure ACCM frequency to 400MHz. Tune ACCM amplitude in the Generator to reach 100mVp-p over the oscilloscope.
3. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be 337.5 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - No CDR, no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
4. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.2
5. Configure ACCM amplitude to get  $V_{\text{AC-CM}}$  of 100mVp-p.
6. Turn off the ACCM noise before calibrating the RJ.

### **4.2.1.3 Random Jitter**

#### **4.2.1.3.1 Reference**

RJ - USB4v1 Specification, Tables 3-11, 3-12.  
USB4v2 Specification, Tables 3-10, 3-11.

#### **4.2.1.3.2 Requirement**

Random Jitter - 0.14UIp-p Referenced to 1E-12 statistics.

#### **4.2.1.3.3 Test Method**

1. Turn Generator RJ generator on (PRBS15) with SSC on.
2. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
3. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.1
4. Tune RJ in the Generator to reach 0.14UIp-p over the oscilloscope.
5. Turn off the RJ noise before calibrating the PJ.

#### **4.2.1.4 Periodic Jitter**

##### **4.2.1.4.1 Reference**

PJ - USB4v1 Specification, Tables 3-11, 3-12.  
USB4v2 Specification, Tables 3-10, 3-11.

##### **4.2.1.4.2 Requirement**

Periodic Jitter - 0.17UIp-p.

##### **4.2.1.4.3 Test Method**

1. Turn Generator sinusoidal jitter (PJ) frequency to 1MHz generator on (PRBS15) with SSC on.
2. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
3. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.1
4. Tune PJ in the Generator to reach 0.17UIp-p over the oscilloscope (PJp-p).

#### 4.2.1.5 Total Jitter

##### 4.2.1.5.1 Reference

TJ - USB4v1 Specification, Tables 3-11, 3-12.  
USB4v2 Specification, Tables 3-10, 3-11.

##### 4.2.1.5.2 Requirement

Total Jitter - 0.35UIp-p for Gen2, 0.38UIp-p for Gen3, Referenced to BER = 1E-12 statistics.

##### 4.2.1.5.3 Test Method

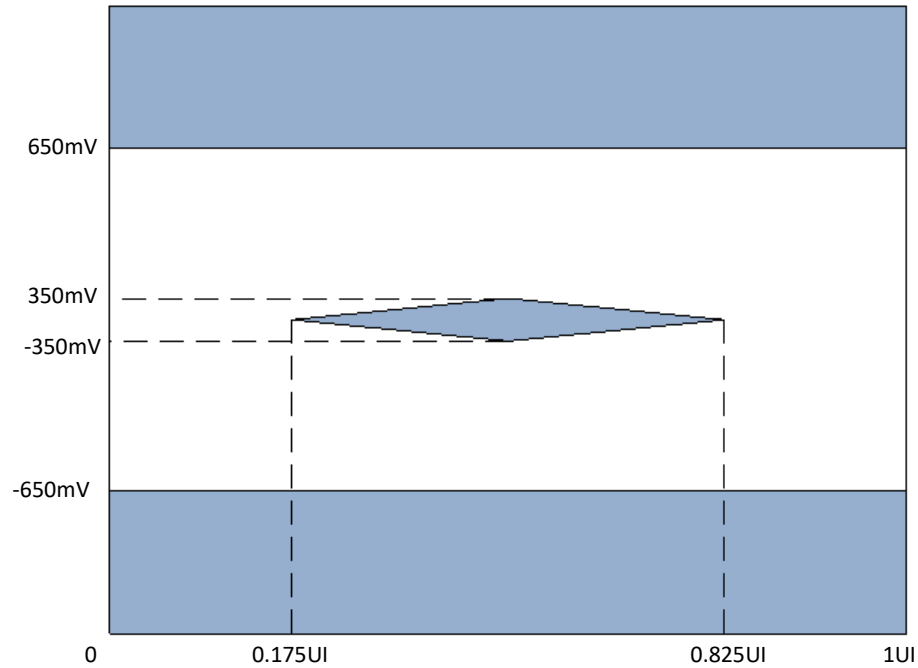
1. Configure Generator transmit PRBS15 with SSC turned on and all jitter components turned on including the ACCM noise.
2. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used.
  - Scope BW shall be as specified in Section [A.1A.1](#).
3. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.1
4. Verify TJ of  $0.35 \pm 0.0125\text{UIp-p}$  for Gen2 or  $0.38 \pm 0.025\text{UIp-p}$  for Gen3, if not, tune the total jitter by adjusting the RJ component for PJ frequencies 1MHz, 2MHz, 10 MHz and 50MHz and by adjusting the PJ component for frequency of 100MHz.

#### 4.2.1.6 Input Eye Diagram

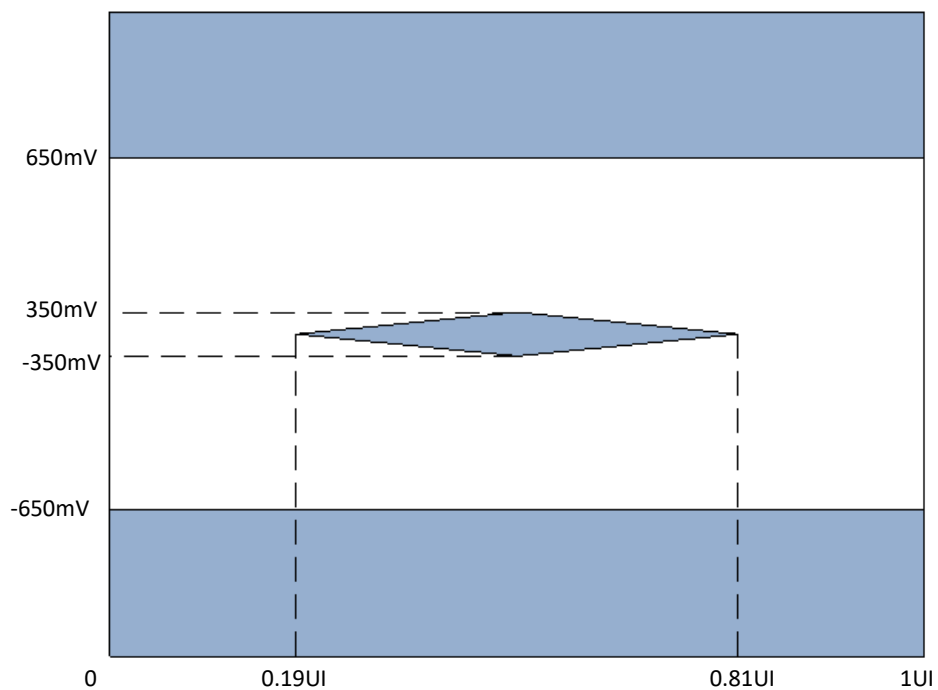
##### 4.2.1.6.1 Reference

USB4v1 Specification, Tables 3-11, 3-12.

USB4v2 Specification, Tables 3-10, 3-11.



**Router Assembly Gen2 Input Eye Notation**



**Router Assembly Gen3 Input Eye Notation**

#### 4.2.1.6.2 Requirement

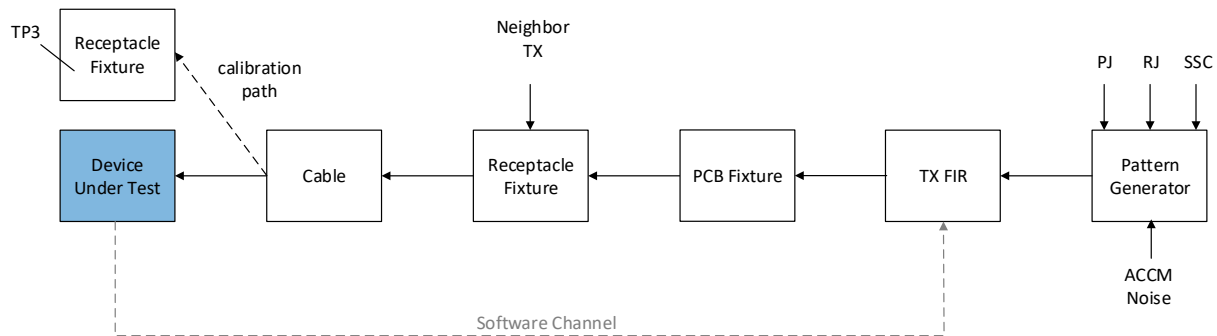
Inner Eye height of 700mVp-p.

#### 4.2.1.6.3 Test Method

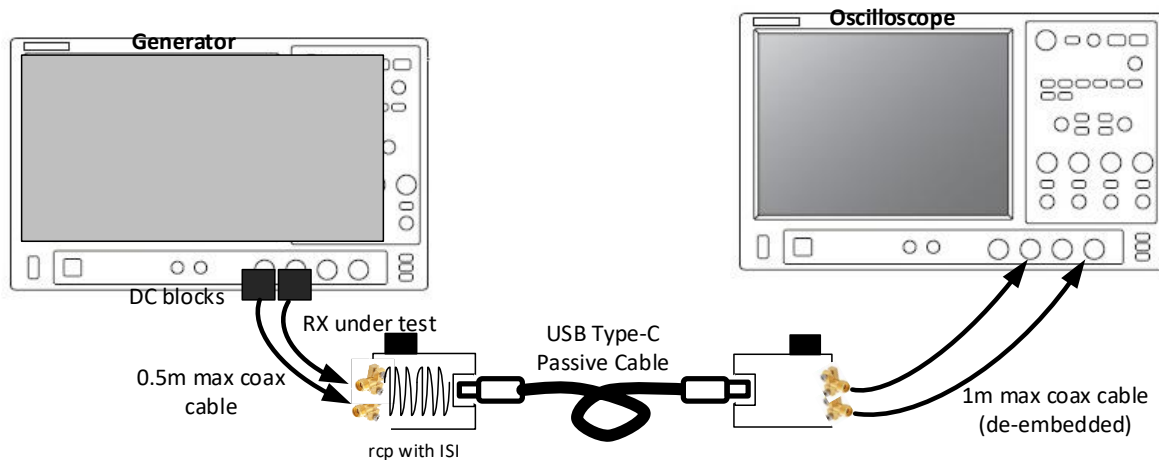
1. Configure Generator transmit PRBS31 with SSC turned on and all jitter components turned on including the ACCM noise.
2. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 10Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 10Mpts. The evaluated record length shall be 125 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
3. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.3
4. Compare the data eye to the TP3' eye diagram mask:
5. If any part of the waveform hits the mask or if the eye is not minimal, Tune the Generator amplitude.
6. If Amplitude tune was needed, check all jitter and noise components again.
7. Save setup for the chosen speed TP3', min eye as **Test Case 1**.
8. Repeat the steps in 4.2.1.4 Periodic Jitter, 4.2.1.5 Total Jitter and 4.2.1.6 Input Eye Diagram above for all PJ frequencies: 1MHz, 2MHz, 10MHz, 50MHz and 100MHz.
9. Repeat the calibration in Sections [4.2.1.14.2.1.1](#) to [4.2.1.64.2.1.6](#) for all supported USB4 Gen2 and Gen3 speeds.

## 4.2.2 Stressed Electrical Signal for TP3 (Case 2):

Case 2:



- The trace added shall be calibrated according to [Appendix B](#)~~Appendix C~~.
- Cables connecting from the last receptacle to the scope shall be de-embedded. The length of the cable shall be maximum 1m.
- TP3 Calibration start point is TP3' test setup that was calibrated for **Test Case 1**.



**Figure 7. Receiver Calibration Setup – TP3**

Notes:

1. The DC block shall be connected to the Generator directly.
2. As there is no reliable solution for Total Jitter measurements at TP3 in the market, calibration is done referring to Eye measurements only.



### 4.2.2.1 Input Eye Diagram

#### 4.2.2.1.1 Reference

USB4v1 Specification, Tables 3-11, 3-12.

USB4v2 Specification, Tables 3-10, 3-11.

#### 4.2.2.1.2 Requirement

As there is no reliable solution for Total Jitter measurements at TP3 in the market, calibration is done referring to Eye measurements only:

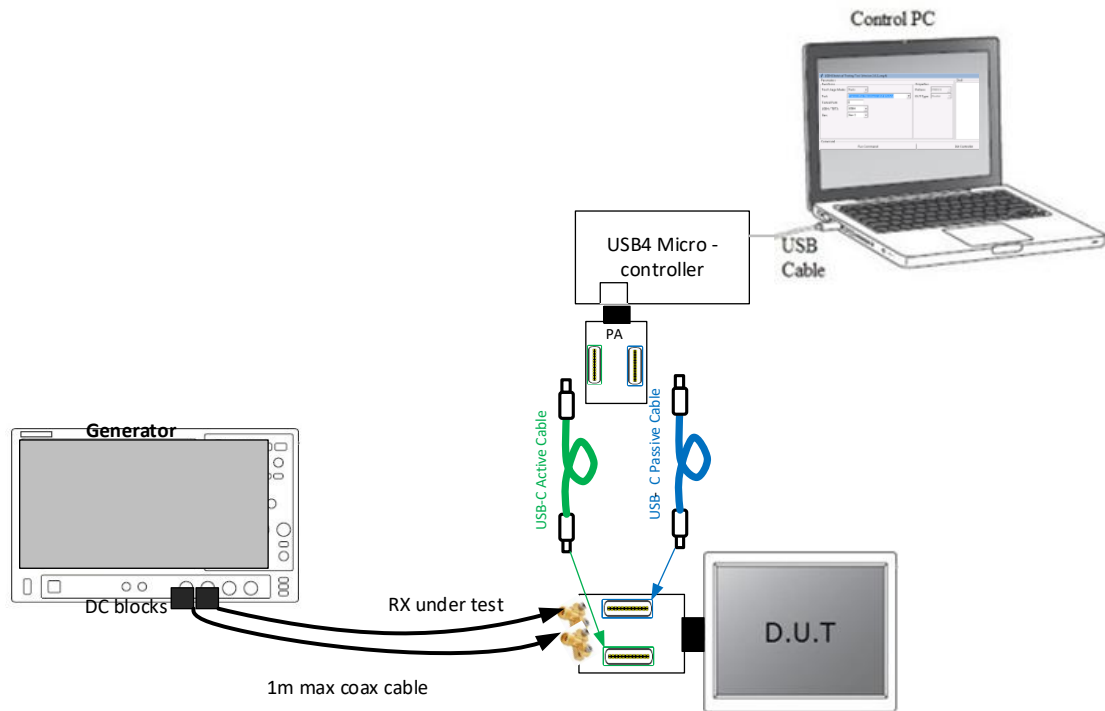
- Inner eye height within  $106 \pm 10\text{mV}$  diff p-p for Gen2,  $98 \pm 10\text{mV}$  diff p-p for Gen3.
- Eye width within  $0.54 \pm 0.025\text{UI}$  p-p for Gen2,  $0.54 \pm 0.05\text{UI}$  p-p for Gen3.

#### 4.2.2.1.3 Test Method

1. Choose a supported USB4 speed to start with.
2. Recall Test Case 1 calibrated setup that was saved in Section [4.2.1.6.34.2.1.6.3](#).
3. Configure Generator transmit PRBS31/PRBS15 with SSC turned on and all jitter components turned on including the ACCM noise (as tuned for TP3').
4. Configure the Generator to preset 0.
5. Capture the waveform 5 times for PRBS31 and 1 time for PRBS15:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be  $500\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.3.1
7. If needed, tune the Eye height to be  $106 \pm 10\text{mV}$  diff p-p for Gen2 and  $98 \pm 10\text{mV}$  diff p-p for Gen3 by adjusting the Generator amplitude
8. If needed, tune the Eye width to  $0.54 \pm 0.025\text{UI}$  p-p for Gen2,  $0.54 \pm 0.05\text{UI}$  p-p for Gen3 by adjusting the PJ component for frequency of 100MHz and adjusting the RJ component for all other frequencies 1MHz, 2MHz, 10MHz and 50MHz.
  - a.
9. Save Test Case 2.
10. Repeat the steps above for all the PJ frequencies: 1MHz, 2MHz, 10MHz, 50MHz and 100MHz.
11. Repeat the calibration above for all supported USB4 Gen2 and Gen3 speeds.

### 4.3 Receiver BER Test Procedure

After calibrating the stressed eye as described in the previous section, follow the following procedure to test the Receiver which is done with an internal error detector.



**Figure 8. Receiver Test Setup at TP3'**

## 4.3.1 BER at TP3'

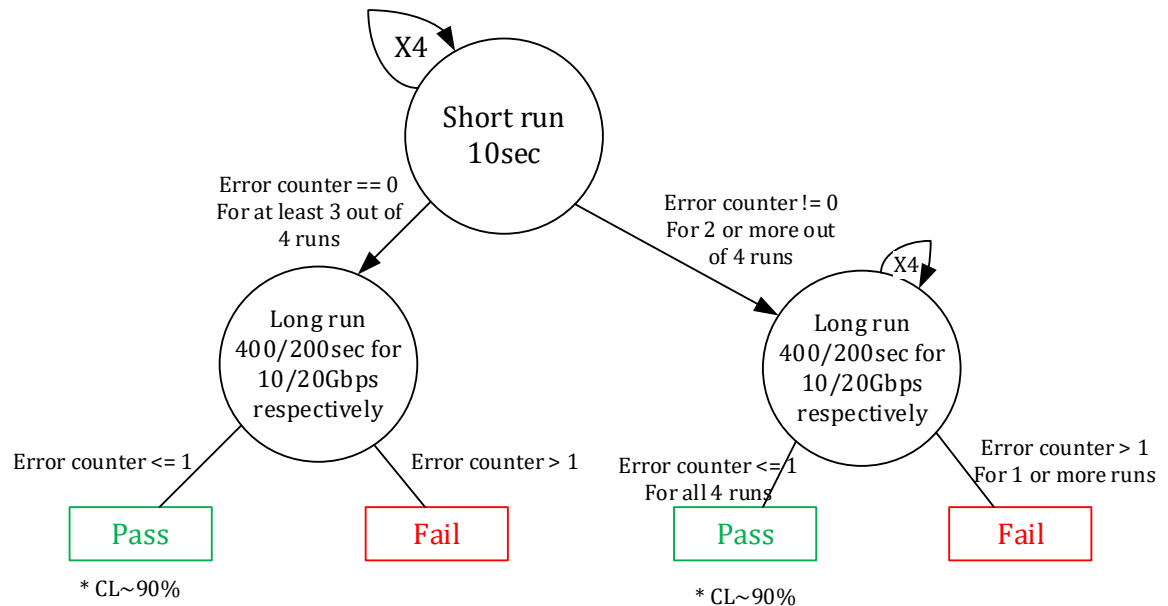
### 4.3.1.1 Reference

Refer to Figure 8 to connect the DUT for Receiver testing.

### 4.3.1.2 Test Method

1. Plug the test fixture into the DUT Receptacle:
  - a. Connect the positive lane that was connected to the scope during calibration to Lane under test of the test fixture positive lane.
  - b. Connect the negative lane that was connected to the scope during calibration to Lane under test of the test fixture negative lane.
  - c. Connect a USB Type-C Passive cable from the Passive receptacle connector over the test fixture to the Low speed united coupon Passive receptacle connector that is connected to the USB4 Micro-controller PA.
  - d. Connect a USB Type-C Active cable from the Active receptacle connector over the test fixture to the Low speed united coupon Active receptacle connector that is connected to the USB4 Micro-controller PA.
  - e. The USB4 Micro-controller is connected to control PC via USB cable, running the latest USB4 SW Electrical Test Tool (ETT).
2. Recall Test Case 1 calibrated setup that was saved in Section ~~4.2.1.6.3~~4.2.1.6.3.
3. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
4. Initiate negotiation with the preset chosen in calibration.
5. Change the preset in the Generator according to the newly requested preset.
6. Configure DUT for the next negotiation step with the new preset.
7. Change the preset in the Generator according to the newly requested preset.
8. Configure DUT for the next negotiation step with the new preset.
9. If needed, change the preset in the Generator according to the newly requested preset.
10. Run BER test for 30sec. Inject 3 errors from the Generator. Read the error counter, if the error count = 3 than continue to next step, otherwise check if the lane under test is connected to the Generator or any other setup issue.
11. Repeat steps 1-8 above again and then:
  - a. Run BER test.
  - b. Record error count for 10sec (Short run).
12. Repeat steps 1-8 three more times and record the error count for 10 secs for each cycle (you will have a Total error count of 4 cycles).
13. Repeat steps 1-8 above again and then:
  - a. Record the error count for Gen2 400sec and Gen3 200sec (Long run).

- b. Verify the error count.
14. If the error count = 0 for at least 3 out of 4 short runs & error count ≤ 1 for the long run, then **Pass** else (error count > 1 for the long run) **Fail**.
15. If the error count ≠ 0 for at least 2 or more out of 4 short runs repeat step 13 three more times (total 4 times):
  - a. If the error count ≤ 1 for all 4 long runs, then **Pass** else, **Fail**.
  - b. .
16. Repeat all the steps above for each PJ: 1MHz, 2MHz, 10MHz, 50MHz and 100MHz.
17. Repeat all the steps above for each Lane (each lane must be tested using each PJ frequency).
18. Repeat the test above for all supported USB4 Gen2 and Gen3 speeds. For each supported speed, every lane must be tested for every PJ frequency.



**Figure 9. Receiver BER testing flow**

### 4.3.2 BER at TP3

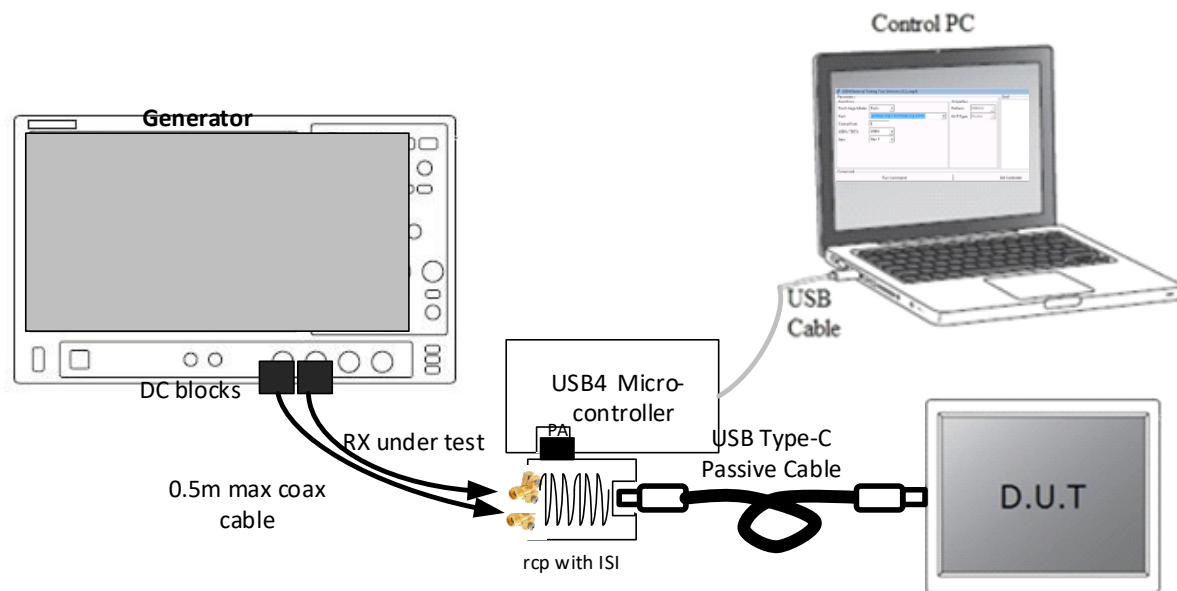


Figure 10. Receiver Test Setup at TP3

#### 4.3.2.1 Reference

Refer to 10 to connect the DUT for Receiver testing.

#### 4.3.2.2 Test Method

- Remove Test fixture 2 (from the calibration setup)
  - Plug the USB Type-C cable into the DUT Receptacle.
  - Connect the Test fixture plug directly to the USB4 Micro-controller PA.
  - The USB4 Micro-controller is connected to control PC via USB cable, running the latest USB4 SW Electrical Test Tool (ETT).
1. Recall Test Case 2 calibrated setup that was saved in Section [4.2.2.1.34.2.2.1.3](#).
  2. Use the same BER test method flow as detailed in 4.3.1 #3-18 steps.

## **4.4 Receiver Multi Error-Burst Test**

### **4.4.1 Multi Error-Burst Gen3**

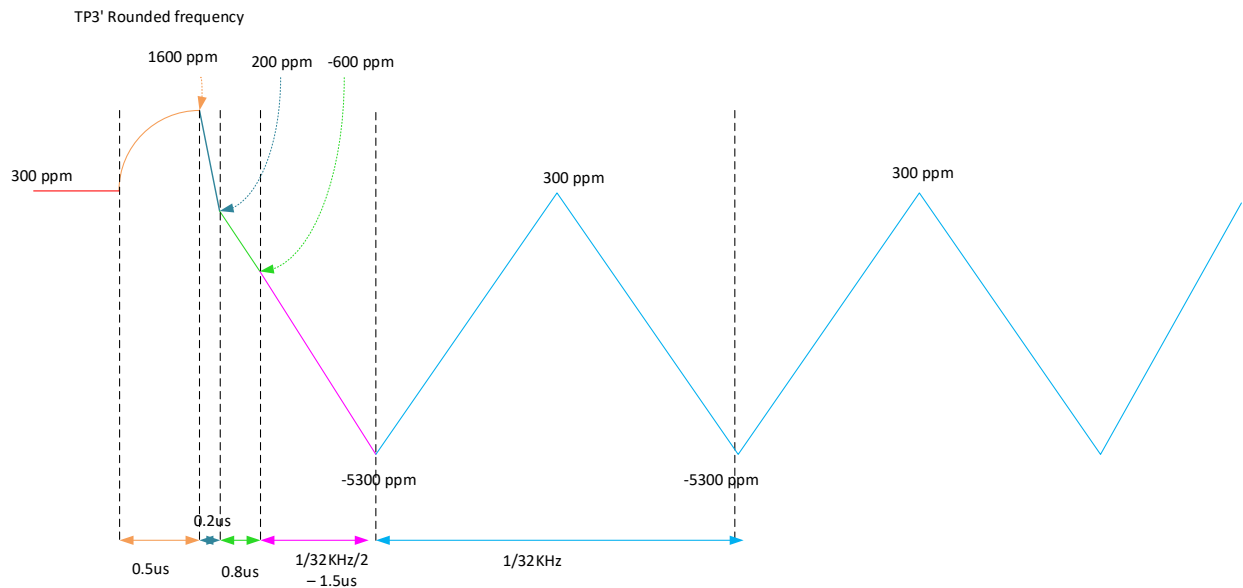
TBD

## 4.5 Receiver Signal Frequency Variations Training Test

### 4.5.1 Signal Frequency Variations calibration for TP3' (Case 1):

#### 4.5.1.1 Calibration Method

1. Connect the setup as showing in Figure 6 and follow section 4.1 and 4.2
2. Choose a supported USB4 speed to start with.
3. Recall Test Case 1 calibrated setup for PJ 100MHz that was saved in Section [4.2.2.1.34.2.1.6.3](#).
4. Configure Generator transmit PRBS15.
5. Turn off Generator periodic SSC modulation as saved in the recalled setup. Turn on and tune the clk-switch SSC modulation profile to be as in the following figure. All other ingredients stay the same.



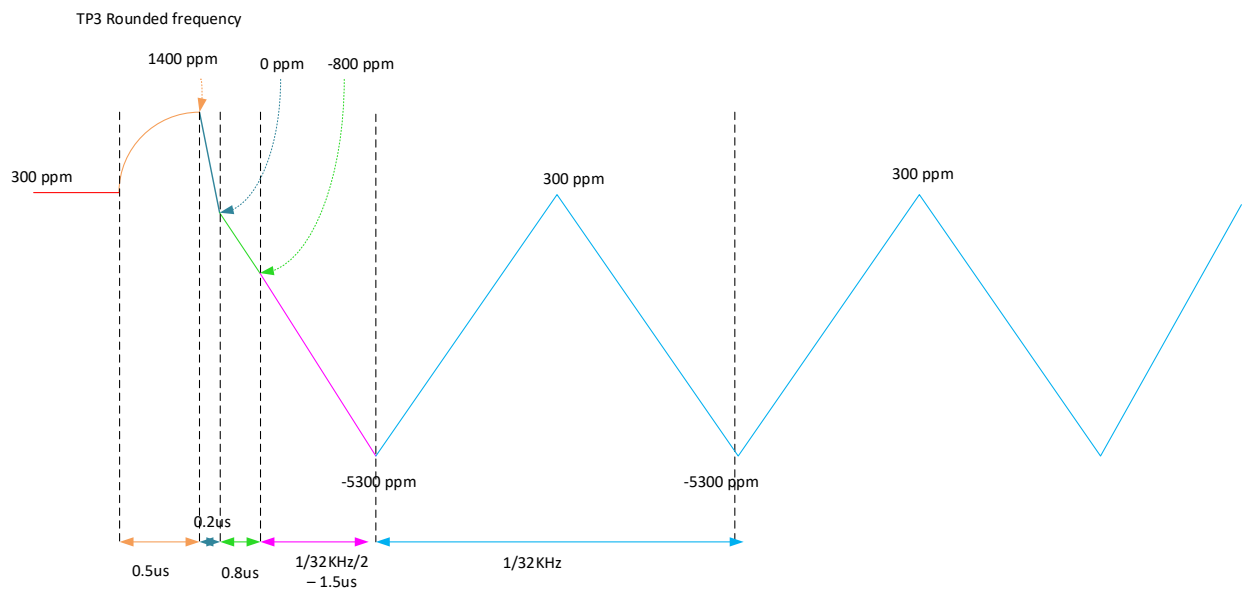
6. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
7. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.4
8. Save setup for the chosen speed TP3', as **RX clk-switch Test Case 1**.
9. Repeat the calibration for all supported USB4 Gen2 and Gen3 speeds.

### 4.5.2 Signal Frequency Variations calibration for TP3 (Case 2):

#### 4.5.2.1 Calibration Method

1. Connect the setup as showing in Figure 6

2. Choose a supported USB4 speed to start with.
3. Recall Test Case 2 calibrated setup for PJ 100MHz that was saved in Section [4.2.2.1.34-2.2.1.3](#).
4. Configure Generator transmit PRBS15.
5. Turn off Generator periodic SSC modulation as saved in the recalled setup. Turn on and tune the clk-switch SSC modulation profile to be as in the following figure. All other ingredients stay the same.



6. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - Adjust vertical scale to fit signal into scope screen.
7. Run SigTest as detailed in USB4\_SigTest\_User\_manual 7.2.4
8. Save setup for the chosen speed TP3, as **RX clk-switch Test Case 2**.
9. Repeat the calibration for all supported USB4 Gen2 and Gen3 speeds.

### 4.5.3 Signal Frequency Variations Training Gen2 and Gen3 for TP3'

#### 4.5.3.1 Reference

USB4v1 Specification, Table 3-10

USB4v2 Specification, Table 3-9

#### 4.5.3.2 Requirement

The probability for BER shall be  $1\text{E}-6$  or less.



#### 4.5.3.3 Test Objective

Confirm that the Receiver don't lose lock and record errors when frequency variation is applied.

#### 4.5.3.4 Test Method

1. Use the same test setup as in [Figure 8](#).
2. Choose a supported USB4 speed to start with.
3. Recall **RX clk-switch Test Case 1** calibrated setup for PJ 100MHz that was saved in Section [4.2.2.1.34.5.1.1](#).
4. Turn off Generator special SSC modulation as saved in the recalled setup.
5. Configure DUT transmitter to output PRBS31 on all lanes.
6. Initiate negotiation with the preset chosen in calibration.
7. Change the preset in the Generator according to the newly requested preset.
8. Configure DUT for the next negotiation step with the new preset.
9. Change the preset in the Generator according to the newly requested preset.
10. Configure DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the Generator according to the newly requested preset.
12. Run BER test. The ETT will pop-up a window asking, "to turn on clk-switch over the Generator". Before clicking OK, turn on the special SSC profile over the Generator.
13. Record Error Count for 10sec.
14. If  $BER \leq 1E-6$  then **Pass**.
15. If  $BER > 1E-6$  then **Fail**.
16. Repeat all the steps above for each Lane 20 times.
17. Repeat the test above for all supported USB4 Gen2 and Gen3 speeds.

### 4.5.4 Signal Frequency Variations Training Gen2 and Gen3 for TP3

#### 4.5.4.1 Reference

USB4v1 Specification, Table 3-3

USB4v2 Specification, Table 3-2

#### 4.5.4.2 Requirement

The probability for BER shall be  $1E-6$  or less.

#### 4.5.4.3 Test Objective

Confirm that the Receiver don't lose lock and record errors when frequency variation is applied.

#### 4.5.4.4 Test Method

1. Use the same test setup as in [Figure 9](#).
2. Choose a supported USB4 speed to start with.
3. Recall **RX clk-switch Test Case 2** calibrated setup for PJ 100MHz that was saved in Section [4.2.2.1.34.5.2.1](#).
4. Turn off Generator special SSC modulation as saved in the recalled setup.
5. Configure DUT transmitter to output PRBS31 on all lanes.
6. Initiate negotiation with the preset 0.
7. Change the preset in the Generator according to the newly requested preset.
8. Configure DUT for the next negotiation step with the new preset.
9. Change the preset in the Generator according to the newly requested preset.
10. Configure DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the Generator according to the newly requested preset.
12. Run BER test. The ETT will pop-up a window asking, "to turn on clk-switch over the Generator". Before clicking OK, turn on the special SSC profile over the Generator.
13. Record Error Count for 10sec.
14. If  $BER \leq 1E-6$  then **Pass**.
15. If  $BER > 1E-6$  then **Fail**.
16. Repeat all the steps above for each Lane 20 times.
17. Repeat the test above for all supported USB4 Gen2 and Gen3 speeds.

## 4.6 Receiver Return Loss Gen2 and Gen3

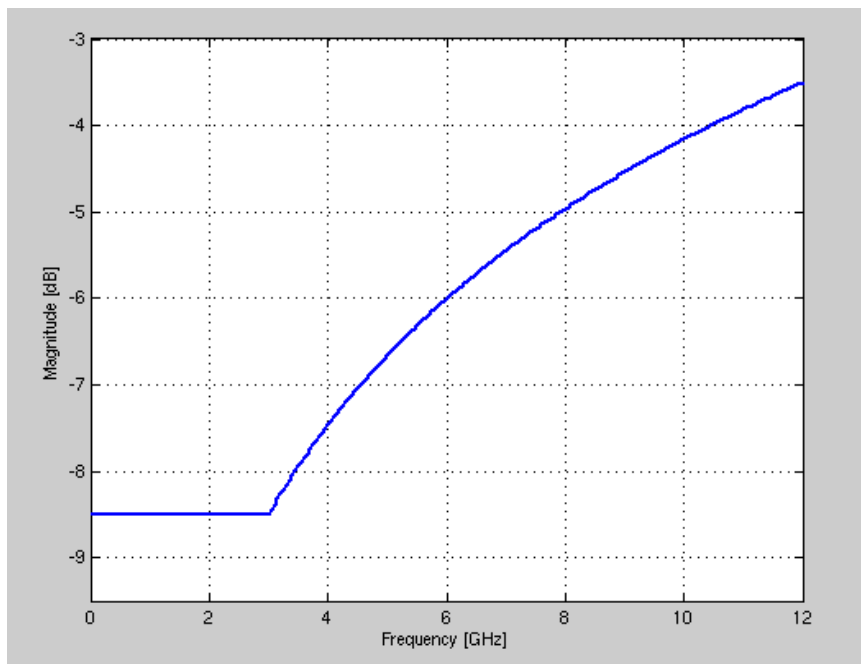
### 4.6.1 Receiver Differential Return Loss

#### 4.6.1.1 Reference

RL\_DIFF - USB4v1 Specification, Table 3-10 and section 3.5.1.1  
USB4v2 Specification, Table 3-9 and section 3.1.4.1.1

#### 4.6.1.2 Requirement

$$SDD22(f) = \begin{cases} -8.5 & 0.05 < f_{GHz} \leq 3 \\ -3.5 + 8.3 \cdot \log_{10}\left(\frac{f_{GHz}}{12}\right) & 3 < f_{GHz} \leq 12 \end{cases}$$



#### 4.6.1.3 Test Objective

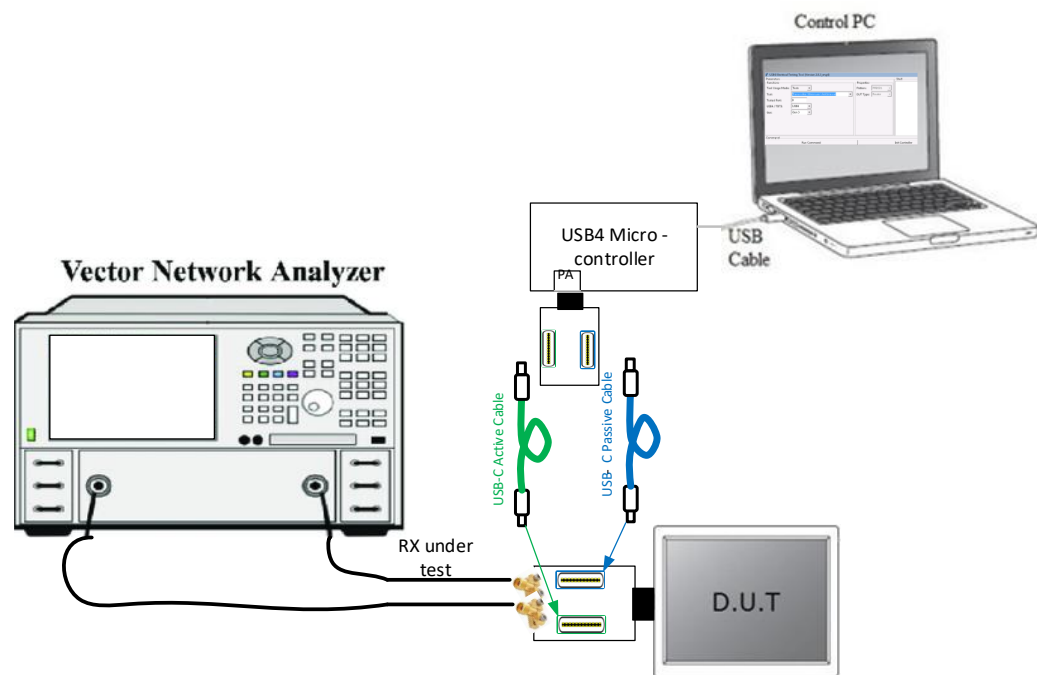
Confirm that the Return loss falls within the limits of the USB4 Specification.

#### 4.6.1.4 Test Method

1. Choose a supported USB4 speed to start with.
2. Configure DUT transmitter to output PRBS31 and enable RX on all lanes with SSC turned on.
3. Setup the Network Analyzer with measurement:

*Note: As the extra loss and distortion elements may be compensated by physical or mathematical means, use gating option to compensate for the parts of the fixture that are with 100ohm impedance. No de-embedding or gating the mated USB Type-C connector or the TF traces.*

- Frequency range of 50MHz to 12GHz
  - IF BW of 1KHz
  - At least 1600 points
  - Impedance 85 ohm differential
  - Define the Topology to Bal
  - Define the measurement at SDD22.
4. Calibrate the network analyzer using a 2-port auto calibration kit.
  5. Connect a USB Type-C Passive cable from the Passive receptacle connector over the test fixture to the Low speed united coupon Passive receptacle connector that is connected to the USB4 Micro-controller PA.
  6. Connect a USB Type-C Active cable from the Active receptacle connector over the test fixture to the Low speed united coupon Active receptacle connector that is connected to the USB4 Micro-controller PA.
  7. Connect Lane under test RX\_P, RX\_N to the Network Analyzer.



**Figure 11. Receiver Return Loss Test Setup**

8. Measure the Return Loss with the Network Analyzer.
9. If Return loss violated the above requirement, then **Fail**.
10. Repeat the test for all remaining USB4 lanes.
11. Repeat the test for all supported USB4 Gen2 and Gen3 speeds.

## 4.6.2 Receiver Common Mode Return Loss

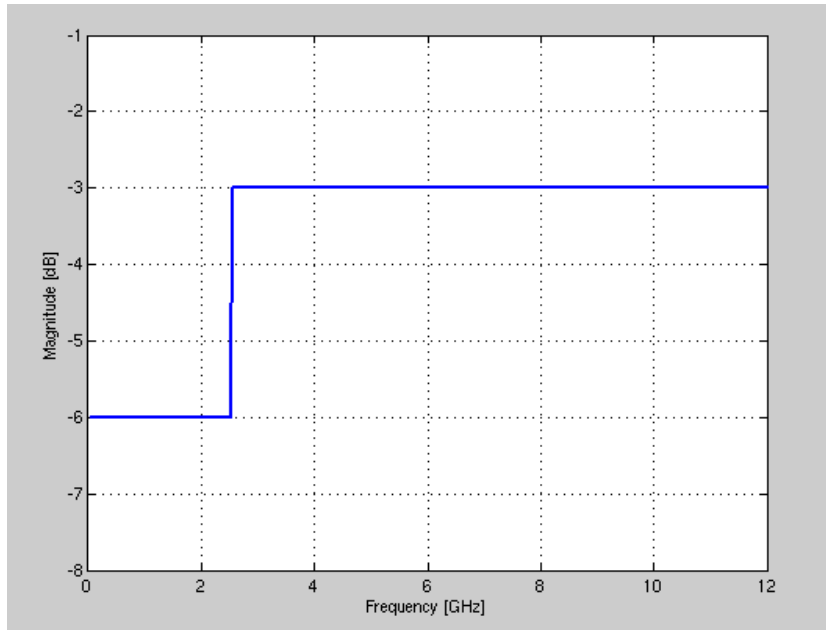
### 4.6.2.1 Reference

RL\_COMM - USB4v1 Specification, Table 3-10 and section 3.5.1.2

USB4v2 Specification, Table 3-9 and section 3.1.4.1.2

### 4.6.2.2 Requirement

$$SCC22(f) = \begin{cases} -6 & 0.05 < f_{GHz} \leq 2.5 \\ -3 & 2.5 < f_{GHz} \leq 12 \end{cases}$$



### 4.6.2.3 Test Objective

Confirm that the Common Mode Return loss falls within the limits of the USB4 Specification.

### 4.6.2.4 Test Method

1. Choose a supported USB4 speed to start with.
2. Configure DUT transmitter to output PRBS31 and enable RX on all lanes with SSC turned on.
3. Setup the Network Analyzer with measurement:

*Note: As the extra loss and distortion elements may be compensated by physical or mathematical means, use gating option to compensate for the parts of the fixture that are with 100ohm impedance. No de-embedding or gating the mated USB Type-C connector or the TF traces.*

- Frequency range of 50MHz to 12GHz
- IF BW of 1KHz
- At least 1600 points
- Impedance 85 ohm differential

- *Define the Topology to Bal*
  - *Define the measurement at SCC22.*
4. Calibrate the network analyzer using a 2-port auto calibration kit.
  5. Connect a USB Type-C Passive cable from the Passive receptacle connector over the test fixture to the Low speed united coupon Passive receptacle connector that is connected to the USB4 Micro-controller.
  6. Connect a USB Type-C Active cable from the Active receptacle connector over the test fixture to the Low speed united coupon Active receptacle connector that is connected to the USB4 Micro-controller.
  7. Connect Lane under test RX\_P, RX\_N to the Network Analyzer.
  8. Measure the Return Loss with the Network Analyzer.
  9. If Return loss violated the above requirement, then **Fail**.
  10. Repeat the test for all remaining USB4 lanes.
  11. Repeat the test for all supported USB4 Gen2 and Gen3 speeds.

## 5 Router Assembly Sideband Signal Testing

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The Sideband link is used for initial link configuration.

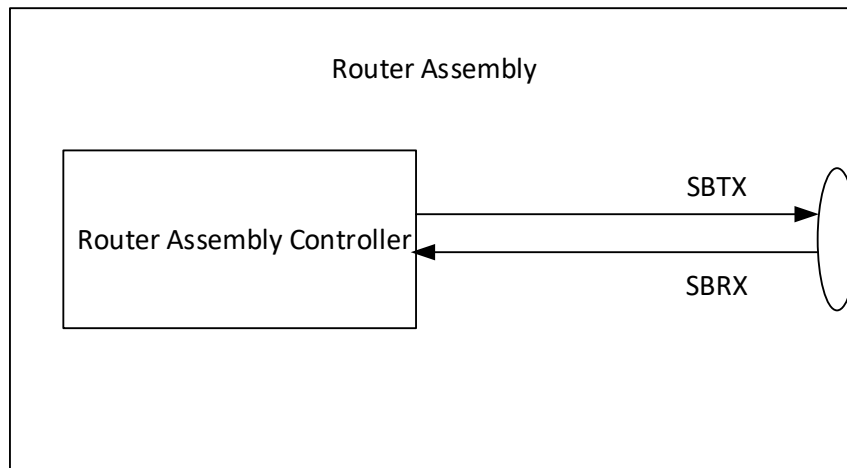
Sideband Link transactions are sent and received over the SBTX and SBRX wires.

The SBTX/SBRX lines are connected to SBU1/SBU2 on the USB Type-C connector after negotiation to the USB4 Alternate Mode has occurred. SBTX and SBRX are a UART interface which operates at a 1MHz baud rate. The local UART bus between Router Assembly and near cable end or Device and near cable end shall function when high speed USB4 traffic is present to enable debug and link training to work properly.

Figure 12 indicates the Low-Speed signals for a Router Assembly.

All Router Assembly shall meet the Low-Speed Link requirements defined Section [5.15.1](#).

Sideband signal parameters are defined at the connector.



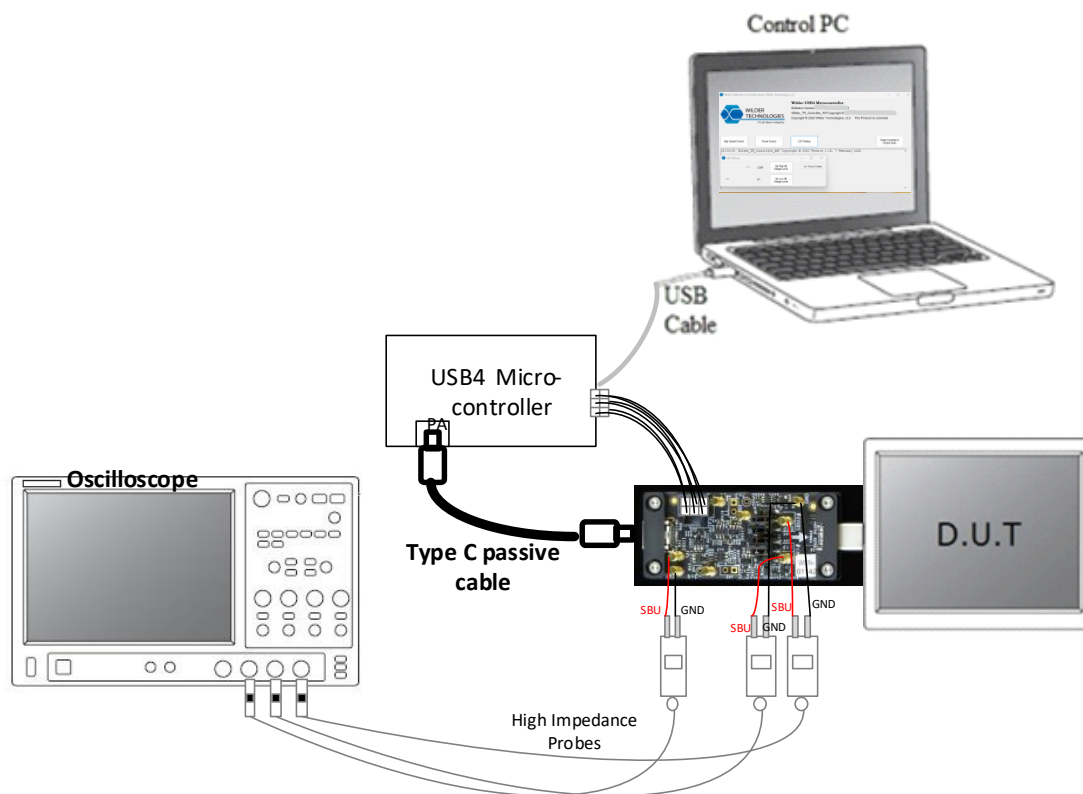
**Figure 12 - Router Assembly Low-Speed Signals**

### 5.1 Router Assembly SBTX and SBRX Specifications

Low Speed Signal testing shall be done for each port in the DUT.

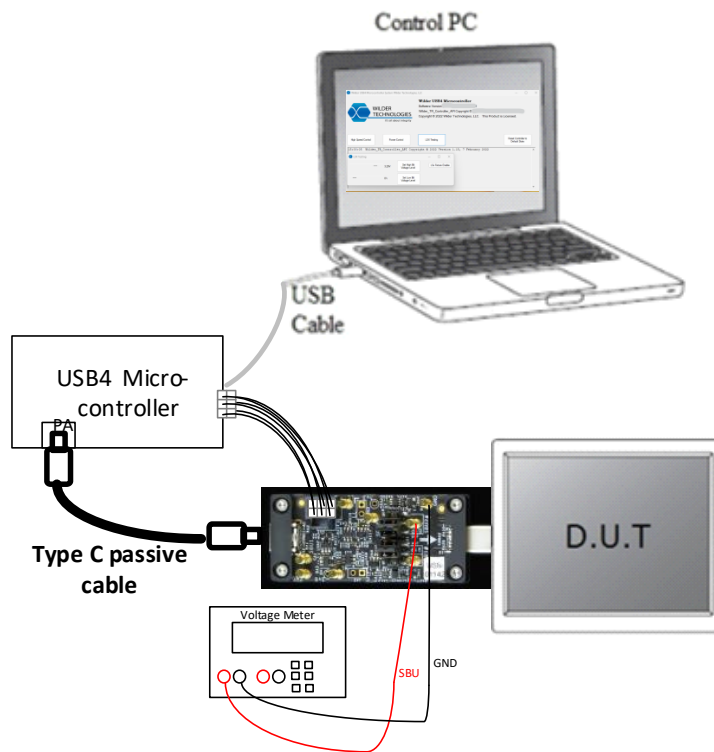
The SBTX, SBRX signals are going through SBU1, SBU2 pins over the USB Type-C connector.

For all setups the DUT shall be connected via USB4 Test Fixture with USB4 u-controller in order to establish link.



**Figure 13 - Figure of Sideband TX/RX Signal Testing**





**Figure 14 - Figure of Sideband TX/RX Signal Testing Using Voltage Meter**

## 5.1.1 SBTX High Voltage Measurement

### 5.1.1.1 Reference

SBTX<sub>VOH</sub> - USB4v1 Specification Table 3-1  
USB4v2 Specification Table 3-32

### 5.1.1.2 Requirement

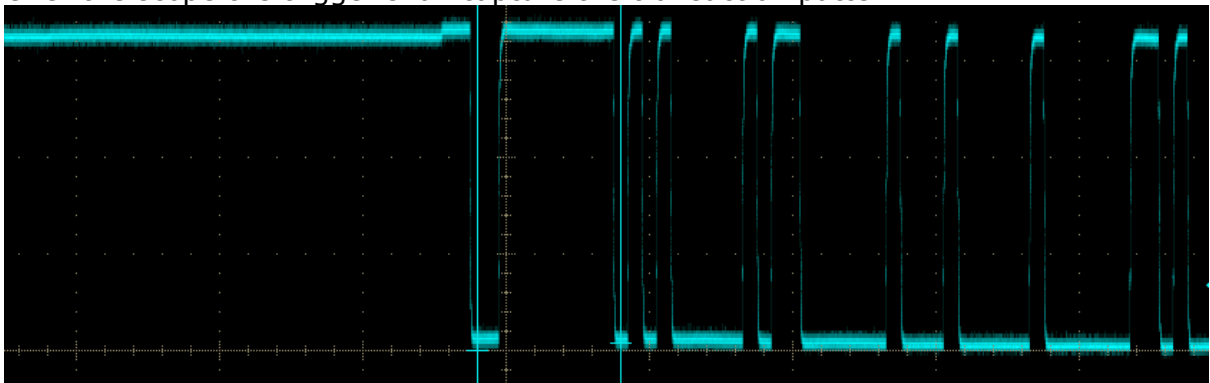
$2.4V \leq \text{SBTX}_{\text{VOH}} \leq 3.47V$  for steady state mode  
 $2.4V \leq \text{SBTX}_{\text{VOH}} \leq 3.52V$  for transaction mode

### 5.1.1.3 Test Objective

Confirm that the parameter measured under all conditions does not exceed minimum or maximum limits of the specification

### 5.1.1.4 Test Method

1. Connect a voltage meter/DMM to SBU1 header in the USB4 Test Fixture (Figure 14).
2. Power up the DUT.
3. Measure the voltage.
4. If SBTX<sub>VOH</sub> < 2.4V or >3.47V then **Fail**.
5. Connect a scope with high impedance probe to the SBU1 header in the USB4 Test Fixture (Figure 13).
6. In the scope use a trigger based on pulse width, negative polarity, trigger when the pulse width <10μs and threshold of 600mV.
7. Horizontal scale = 10μs per square, vertical scale = 1V per square.
8. Power up the DUT.
9. Over the scope the trigger shall capture the transaction pattern.



10. Measure the high/low value of the "1" amplitude for a bit inside the transaction. Over/undershoot shall be ignored.
11. If SBTX<sub>VOH</sub> < 2.4V or >3.52V then **Fail**.

## 5.1.2 SBTX Low Voltage Measurement

### 5.1.2.1 Reference

SBTX<sub>VOL</sub> -      USB4v1 Specification Table 3-1  
                      USB4v2 Specification Table 3-32

### 5.1.2.2 Requirement

$-0.05V \leq \text{SBTX}_{\text{VOL}} \leq 0.4V$ .

### 5.1.2.3 Test Objective

Confirm that the parameter measured under all conditions does not exceed minimum or maximum limits of the specification

### 5.1.2.4 Test Method

1. Connect a voltage meter/DMM to SBU1 header in the USB4 Test Fixture (Figure 14).
2. DUT shall be in power down.
3. Measure the voltage.
4. If SBTX<sub>VOL</sub> < -0.05V or >0.4V then **Fail**.
5. Connect a scope with high impedance probe to the SBU1 header in the USB4 Test Fixture (Figure 13).
  - In the scope use a trigger based on pulse width, negative polarity, trigger when the pulse width <10µs and threshold of 600mV.
  - Horizontal scale = 10µs per square, vertical scale = 1V per square.
6. connect link partner to the DUT.
7. Over the scope the trigger shall capture the transaction pattern.
8. Measure the high/low value of the "0" amplitude for a bit inside the transaction. Over/undershoot shall be ignored.
9. If SBTX<sub>VOL</sub> < -0.05V or >0.4V then **Fail**.

## 5.1.3 SBTX Rise/Fall time Measurement

### 5.1.3.1 Reference

SBX<sub>TRTF</sub> - USB4v1 Specification Table 3-1  
USB4v2 Specification Table 3-32

### 5.1.3.2 Requirement

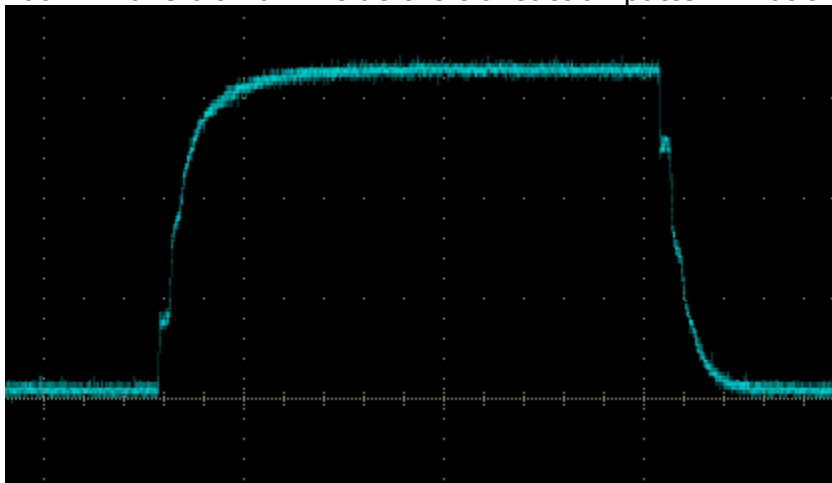
$3.5\text{ns} \leq \text{SBX}_{\text{TRTF}} \leq 65\text{ns}$

### 5.1.3.3 Test Objective

Confirm that the parameter measured under all conditions does not exceed minimum or maximum limits of the specification.

### 5.1.3.4 Test Method

1. Connect the DUT via USB4 Test Fixture with USB4 u-controller in order to establish link.
2. The measurement shall be in transaction only and not from power down to up (or the opposite).
3. Connect a scope with high impedance probe to the SBU1 header for SBTX test in the USB4 Test Fixture (Figure 13).
  - In the scope use a trigger based on pulse width, negative polarity, trigger when the pulse width <10µs and threshold of 600mV.
  - Horizontal scale = 10µs per square, vertical scale = 1V per square.
4. Power up the DUT.
5. Over the scope the trigger shall capture the transaction pattern.
6. Zoom in one bit from inside the transaction pattern. Not the 1<sup>st</sup> or the last bit.



7. Measure the rise and fall time (10%-90%) for SBTX.
8. If  $\text{SBX}_{\text{TRTF}} < 3.5\text{ns}$  or  $\text{SBX}_{\text{TRTF}} > 65\text{ns}$  then **Fail**.

## 5.1.4 SBX UI Duration Measurement

### 5.1.4.1 Reference

SBX\_UI - USB4v1 Specification Table 3-1  
USB4v2 Specification Table 3-32

### 5.1.4.2 Requirement

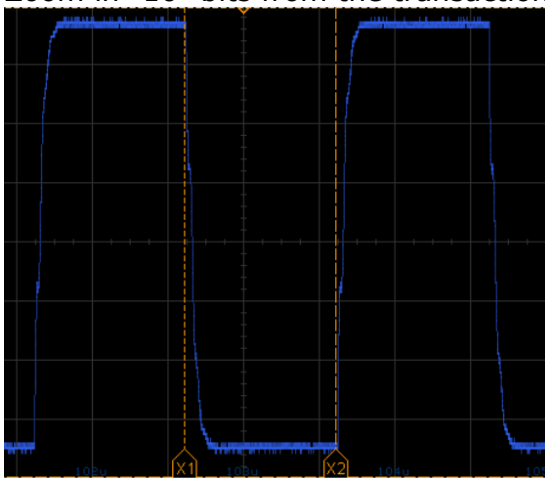
$970\text{ns} \leq \text{SBX\_UI} \leq 1030\text{ns}$ .

### 5.1.4.3 Test Objective

Confirm that the parameter measured under all conditions does not exceed minimum or maximum limits of the specification.

### 5.1.4.4 Test Method

1. Connect the DUT via USB4 Test Fixture with USB4 u-controller in order to establish link.
2. The measurement shall be in transaction, over the transaction pattern.
3. Connect a scope with high impedance probe to the SBU1 header for SBTX in the USB4 Test Fixture (Figure 13).
4. In the scope use a trigger based on pulse width, negative polarity, trigger when the pulse width  $< 10\mu\text{s}$  and threshold of 600mV.
5. Horizontal scale =  $10\mu\text{s}$  per square, vertical scale = 1V per square.
6. Power up the DUT
7. Over the scope the trigger shall capture the transaction pattern.
8. Zoom in "10" bits from the transaction pattern.



9. Measure the duration from falling edge of the "1" to the rising edge of "0", named SBX\_UI.
10. If  $\text{SBX\_UI} < 970\text{ns}$  or  $> 1030\text{ns}$  then **Fail**.

## 5.1.5 SBRX High Voltage Detection Measurement

### 5.1.5.1 Reference

SBRX<sub>VIH</sub> -      USB4v1 Specification Table 3-1  
                         USB4v2 Specification Table 3-32

### 5.1.5.2 Requirement

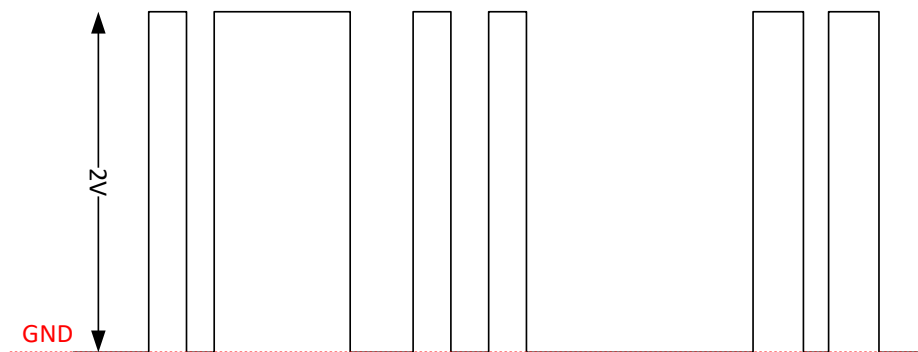
$2.0V \leq SBRX_{VIH} \leq 3.77V$ .

### 5.1.5.3 Test Objective

Confirm that the DUT can detect the SBRX signal in the minimum limit of the specification.

### 5.1.5.4 Test Method

1. Connect the DUT via USB4 LSXX Test Fixture with USB4 u-controller and set '1' bit amplitude to 3.3V and '0' bit amplitude to 0V in order to establish link. See figure 13.
2. Establish there is a link.
3. Reduce the '1' bit amplitude to 2.0V.



4. If Link is lost, then **Fail**.

## 5.1.6 SBRX Low Voltage Detection Measurement

### 5.1.6.1 Reference

SBRX<sub>VIL</sub> - USB4v1 Specification Table 3-1  
USB4v2 Specification Table 3-32

### 5.1.6.2 Requirement

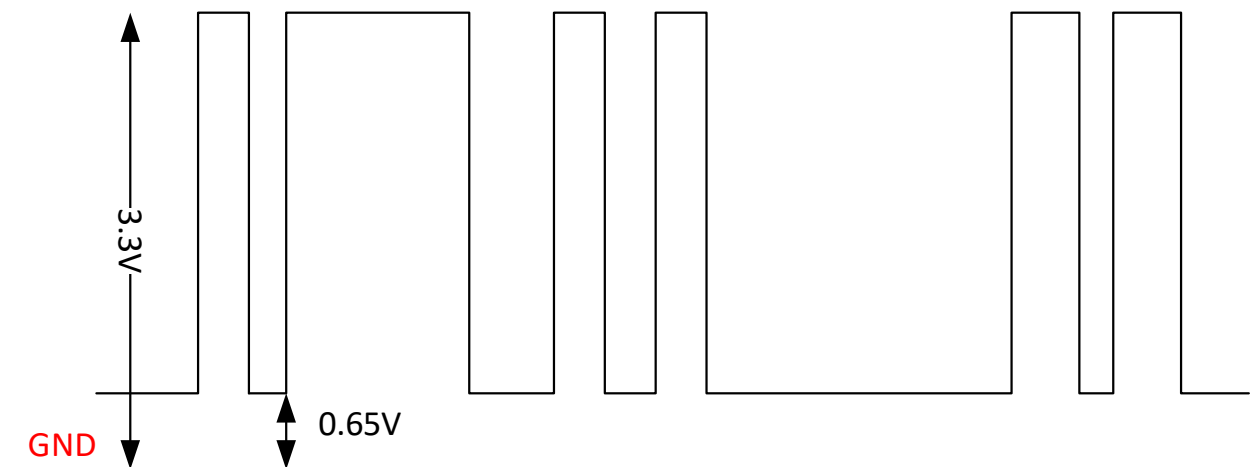
$-0.3V \leq \text{SBRX}_{VIL} \leq 0.65V$ .

### 5.1.6.3 Test Objective

Confirm that the DUT can detect the SBRX signal in the minimum limit of the specification.

### 5.1.6.4 Test Method

1. Connect the DUT via USB4 LSXX Test Fixture with USB4 u-controller and set '1' bit amplitude to 3.3V and '0' bit amplitude to 0V in order to establish link (Figure 13).
2. Establish there is a link.
3. Increase the '0' bit amplitude to 0.65V.



4. If Link is lost, then **Fail**.

## Appendix A – Scope Configurations

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### A.1 Scope BW Limit

- Gen 2 Configuration: Scope BW shall be 16 GHz.
- Gen 3 Configuration: Scope BW shall be 21 GHz.

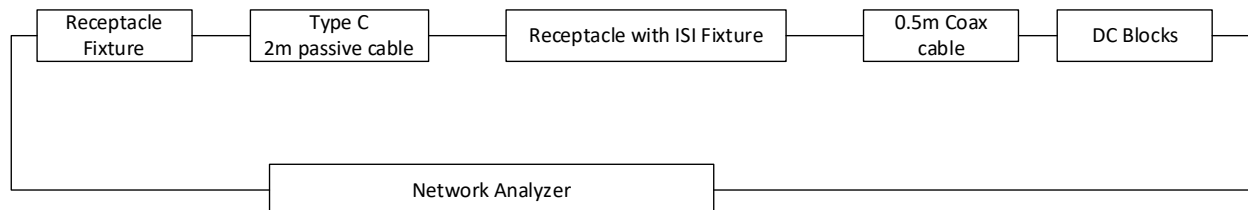
### A.2 TP3 Embedding File

- For Gen 2 use USB4\_2m.s4p - the file can be found on <https://usb.org/>.
- For Gen 3 use USB4\_0p8m.s4p - the file can be found on <https://usb.org/>.



## Appendix B – USB4 RX TP3 Trace Calibration

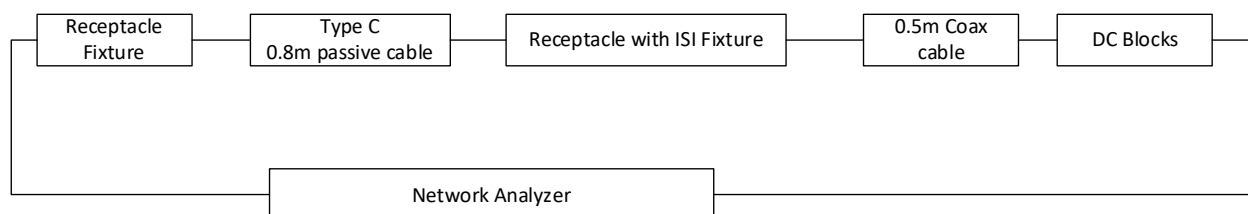
### B.1 Gen2 Configuration



**Figure 15. USB4 RX TP3 Trace Calibration Setup for Gen2**

- The trace added shall be combined from a DDJ (PCB, embedded in receptacle test fixture) and a USB Type-C 2m cable.
- The USB Type-C 2m cable insertion loss with the fixtures shall be  $13.5 \pm 0.5\text{dB}$  at 5GHz and the total channel insertion loss shall be 17.5 to 18.5 dB at 5GHz for the entire channel .
- IL shall be dominated by the PCB and the 2m passive cable, the length of the RF cable shall be short as possible ,recommended 0.5m coax cable, in any case, no more than 1m.
- 2 lanes shall meet the above requirement, if only 1 lane meet the above requirements, then it shall be marked. The marked lane shall be used for RX testing.
- The chosen lane used for RX calibration shall be the lane with minimum IL (minimum of IL absolute value).

### B.2 Gen3 Configuration



**Figure 16. USB4 RX TP3 Trace Calibration Setup for Gen3**

- The trace added shall be combined from a DDJ (PCB, embedded in receptacle test fixture) and a USB Type-C 0.8m cable.
- The USB Type-C 0.8m cable insertion loss with the fixtures shall be  $10.5 \pm 0.5\text{dB}$  at 10GHz and the total channel insertion loss shall be 16 to 17 dB at 10GHz for the entire channel .

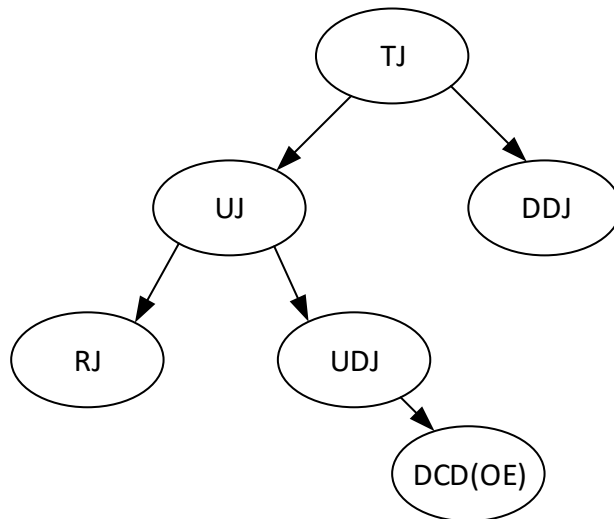
- IL shall be dominated by the PCB and the 0.8m passive cable, the length of the RF cable shall be short as possible, recommended 0.5m coax cable , in any case, no more than 1m.
- 2 lanes shall meet the above requirement, if only 1 lane meet the above requirements, then it shall be marked. The marked lane shall be used for RX testing.
- The chosen lane used for RX calibration shall be the lane with minimum IL (minimum of IL absolute value).

## Appendix C – Jitter Term Definition

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### C.1 High Level of Total Jitter Decomposition

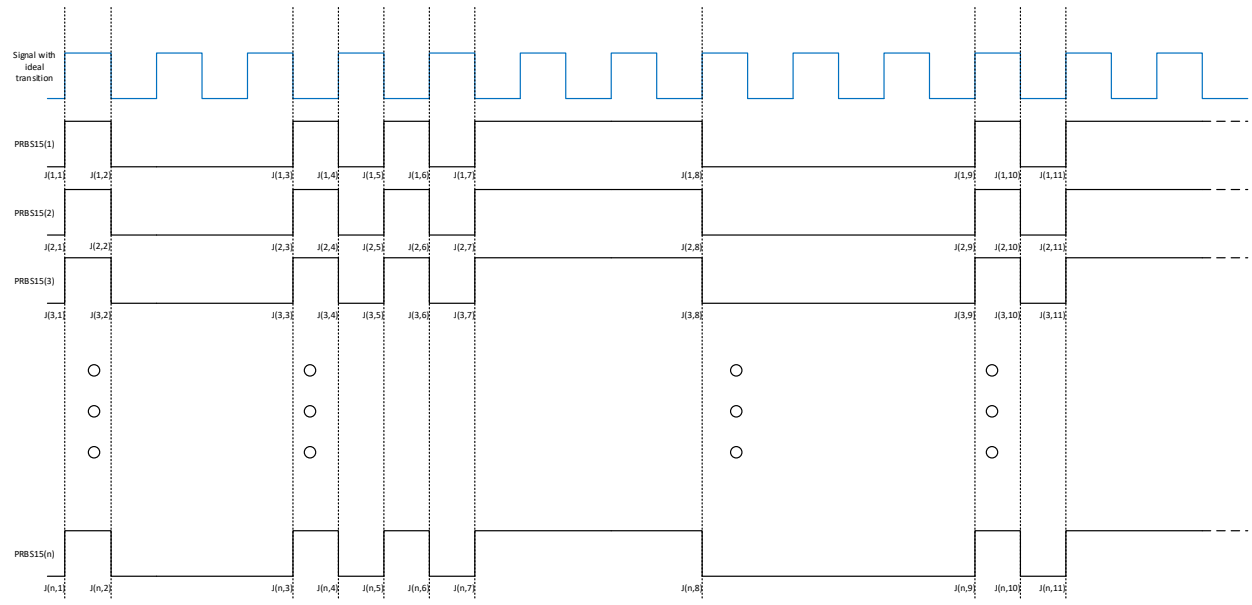
As detailed in the USB4 Specification, TJ break down will look as the following diagram:



### C.2 DDJ

A repeating PRBS15 pseudo-random test pattern is used.

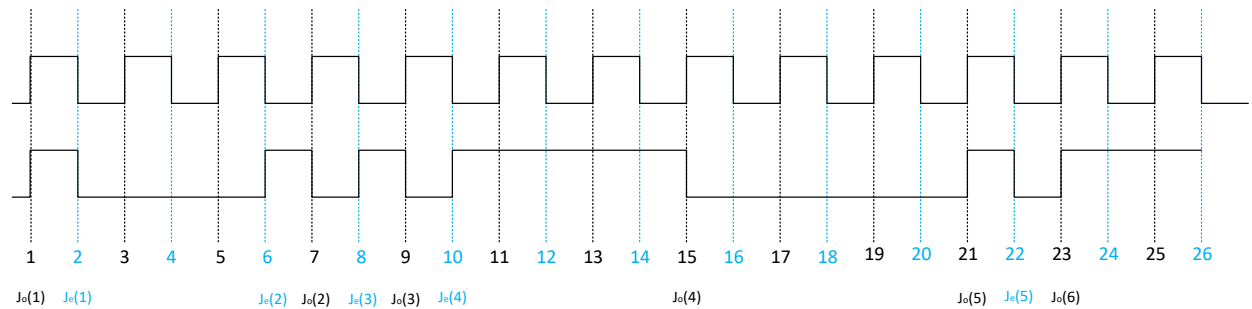
Synchronize the pattern repetition and average the crossing times sufficiently per each specific zero-crossing to remove the effects of uncorrelated jitter. The mean time of each crossing is then compared to the expected time of the crossing, and a set of 16,384 timing variations is determined. DDJ is the range (max-min) of the timing variations. Keep track of the signs (early/late) of the variations.



$$DDJ = \text{Max}_i \left\{ \text{average}_m [J(m, i)] \right\} - \text{Min}_i \left\{ \text{average}_m [J(m, i)] \right\}$$

### C.3 DCD

DCD mean even-odd jitter. The deviation of the time of each transition from an ideal clock at the signaling rate is measured. Even-odd jitter is defined as the magnitude of the difference between the average deviation of all even-numbered transitions and the average deviation of all odd-numbered transitions, where determining if a transition is even or odd is based on possible transitions but only actual transitions are measured and averaged.



$$DCD = \text{abs}[\text{average}(J_o) - \text{average}(J_e)]$$

## Appendix D – Interoperability with Thunderbolt™ 3 (TBT3) Systems

---

When TBT3 Mode is established, an Adapter shall run at a TBT3-Compatible speed.

A Router Assembly shall support TBT3-Compatible Gen2 Speed (10.3125Gbps). A Router Assembly may also optionally support TBT3-Compatible Gen3 Speed (20.625Gbps).

### D.1 Gen2 and Gen3 Router Assembly Transmitter Compliance

A Router Assembly Transmitter shall meet the specifications described in this CTS, except for the following set of parameters that shall be used instead of the values specified above. Listed just the gap from the above in Section 33 and Section 44.

#### D.1.1 Gen2 and Gen3 SSC Down Spread Rate Measurement

##### D.1.1.1 Reference

SSC\_Down\_Spread\_Rate - USB4 Specification Table 13-1.

##### D.1.1.2 Requirement

$30\text{KHz} \leq \text{SSC\_Down\_Spread\_Rate} \leq 37\text{KHz}$

Test Objective and Test Method stay the same.

#### D.1.2 Gen2 and Gen3 SSC Phase Deviation Measurement

##### D.1.2.1 Reference

SSC\_Phase\_Deviation - USB4 Specification Table 13-1.

##### D.1.2.2 Requirement

$\text{SSC\_Phase\_Deviation} \leq 22\text{ns p-p.}$

Test Objective and Test Method stay the same.

#### D.1.3 Gen2 Minimum Unit Interval Measurement

##### D.1.3.1 Reference

UI USB4 Specification Table 13-1.

##### D.1.3.2 Requirement

$96.9406\text{ps} \leq \text{Minimum Unit Interval} \leq 96.9988\text{ps.}$

Test Objective and Test Method stay the same.

## D.1.4 Gen3 Minimum Unit Interval Measurement

### D.1.4.1 Reference

UI USB4 Specification Table 13-1.

### D.1.4.2 Requirement

$48.4703\text{ps} \leq \text{Minimum Unit Interval} \leq 48.4994\text{ps}$

Test Objective and Test Method stay the same.

## D.1.5 Gen2 Average Unit Interval Measurement

### D.1.5.1 Reference

UI USB4 Specification, Section 13-1.

### D.1.5.2 Requirement

$97.1348\text{ps} \leq \text{Average Unit Interval} \leq 97.2420\text{ps}$ .

### D.1.5.3 Test Objective

Confirm that the Average Unit Interval under all conditions does not exceed minimum or maximum limits of the USB4 Specification.

### D.1.5.4 Test Method

1. Choose a supported USB4 Gen2 10.3125GHZ speed.
2. Configure DUT transmitter to output PRBS31 on all lanes with SSC turned on.
3. The cables from the plug test fixture to the scope shall be de-embedded.
4. Capture the waveform and process it with the oscilloscope:
  - Sampling Rate  $\geq 80\text{GSa/s}$
  - Evaluate 27Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 27Mpts. The evaluated record length shall be  $337.5\mu\text{s}$  per channel.
  - No CDR, no average and no interpolation to be used.
  - Adjust vertical scale to fit signal into scope screen.
  - Scope BW shall be as specified in Section [A.1A.1](#).
5. Run SigTest as detailed in USB4\_SigTest\_User\_manual 5.2.1
6. If Max Average Unit Interval  $> 97.2420\text{ps}$  **or** Min Average Unit Interval  $< 97.1348\text{ps}$  then **Fail**.
7. Repeat the test for all remaining USB4 lanes.

## D.1.6 Gen2 and Gen3 TX Frequency Variation Training Measurement

Frequency variation testing during Link training for TBT3 frequencies is not needed.

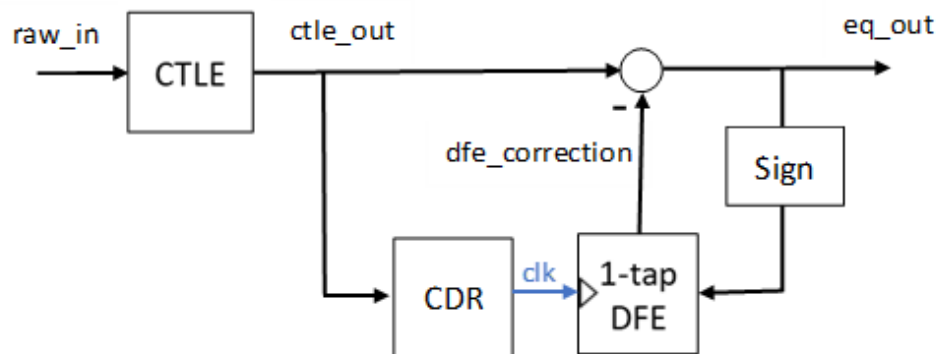
## D.2 Gen2 and Gen3 Router Assembly Receiver Compliance

Three items differ from Section [44](#):

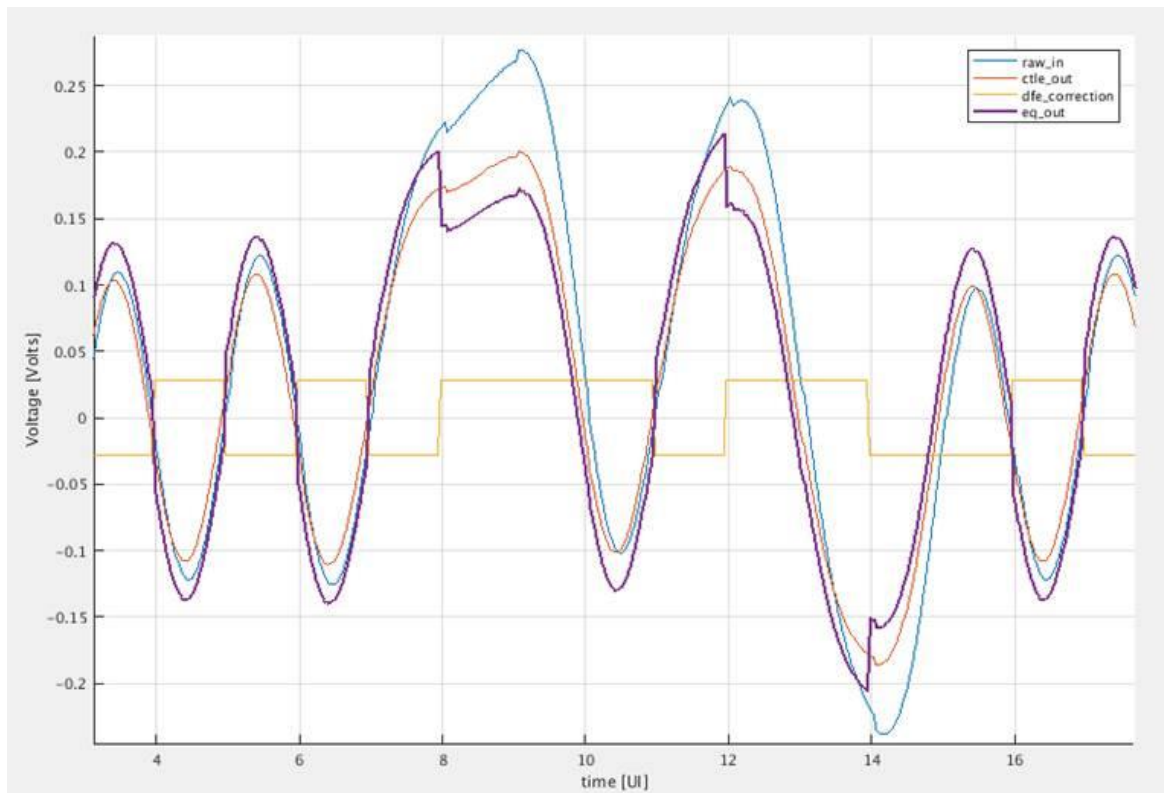
1. SSC profile that shall be added from the pattern generator is as following:
  - SSC with modulation wave shape triangle
  - Modulation frequency for both Gen2 and Gen3 is 36KHz:
  - Spread deviation from +400ppm up to -5400ppm
2. Signal Frequency Variations Training test for TBT3 frequencies is not needed
3. Additional receiver "Case 2a" test setup shall be supported, addressing optical interconnects with limiting modules. Case 2a setup is identical to Case 2 setup described in Section [4.2.24.2.2](#), except that the passive cable is replaced with worst case limiting optical cable (corresponding to the USB Type-C Specification). A receiver shall operate at BER of 1E-12 or lower with neither Forward Error Correction nor Pre-Coding applied when a stressed signal is driven at its input.

## Appendix E – Applying DFE Method

USB4 eye measurements at TP3 shall be performed using reference RX equalization function comprised of CTLE and DFE, as described in figure below. The eye shall be characterized after convolving the raw input signal with the CTLE function and subtracting the DFE correction implemented as constant voltage timed by the CDR clock aligned to the CTLE output. The DFE correction extends as a constant voltage from the mid-point between the UI clock and the previous clock to the mid-point between the UI clock and the next clock. In this way, the DFE correction is applied half a UI before the data sampling and changes again half a UI after the data sampling.



Waveforms example:





## Appendix F – Transmitter Preset Calibration

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### F.1 Preset Calibration

#### F.1.1 Reference

USB4 Specification Table 3-5.

#### F.1.2 Objective

Find and use the optimized preset as a default power-up value for the platform.

#### F.1.3 Method

1. Connect the DUT according to Figure 2.
2. Choose a USB4 speed to start with.
3. Configure DUT transmitter to output PRBS15, preset 0 on all lanes with SSC turned on.
4. The cables from the plug test fixture to the scope shall be de-embedded.
5. Capture the waveform:
  - Sampling Rate  $\geq 80\text{GSa/s}$ .
  - Evaluate 40Mpts per channel when using 80GSa/s. For higher sample rate use memory depth in the same ratio to 40Mpts. The evaluated record length shall be 500 $\mu\text{s}$  per channel.
  - no average and no interpolation to be used
  - Scope BW shall be as specified in Section [A.1A.1](#).
6. Capture DDJ results for lane 0.
7. Repeat the test for all remaining USB4 transmit presets until Preset 15 of the Transmitter Equalization Preset Table above.
8. Repeat the test for all remaining USB4 lanes.
9. For each lane, find the best preset in term of DDJ and use this preset as a default power-up value.
10. Repeat the procedure above for all supported USB4 speeds.

## Appendix G – Mechanical

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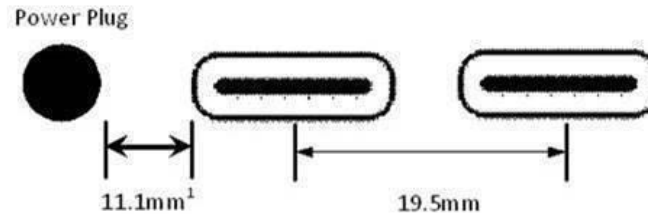
### G.1 USB Type-C Receptacle Minimum Spacing

USB4 Electrical CTS is performed by using Test Fixtures.

While performing the tests the battery life of the Router Assembly is reduced.

USB4 test fixtures enable charging the Router Assembly via the micro-controller unless it's not enabled in the tested Router Assembly.

For USB Type-C Receptacle that not support charging, there is a need for minimum spacing between USB Type-C Receptacle to the next USB Type-C Receptacle and to the next Power Plug. The following pictures illustrating the needed minimum spacing.



1. Spacing includes plastic molding of power plug cable