USB4 SIGTEST User Manual

Date:	February , 2023
Revision:	0.86

Revision History:

Revision	Issue Date	Comments
0.5	Feb 2022	GEN2-3 – no change Added guidance for GEN4 TX tests: UI, SSC, Jitter, Vertical voltage tests, ACCM
0.7	Mar 2022	Added guidance for GEN4 TX tests: EI, RL, IRL Added guidance for GEN4 RX tests: RX calibration at TP3', RL, IRL
0.72	Apr 2022	Added guidance for GEN4 RX tests: RX calibration at TP3
0.83	Dec 2022	Editorial Added GEN4 RX/TX frequency variation tests Added Swing Attenuation analysis for presets40/41 in GEN4 TX txffe test Removed GEN4 TX TX_PULSE_PEAK Measurement in ui_jitter_vertical test report
0.85	Jan 2023	Improved GEN4 txffe analysis accuracy Fixed GEN4 TX_ISI_MARGIN analysis
0.86	Feb 2023	Editorial Fixing EI test – Vpeak instead of ptp

1   Contents

1   Introduction

SigTest is the USB4 post-processing analysis software tool. SigTest is capable of rendering the signal quality measurements captured with the Oscilloscope. The post processed parameters are checked against the specified pass/fail criteria.

2   Installation and execution:

1. System requirements:
   Minimum memory: 32GB RAM
   Recommended memory: 48GB RAM and higher.
2. Install Matlab Runtime Compiler MCR R2021b.
3. Run the executable .exe file:
   a) Create folder, for example "SigTest_USB4_CTS"
   b) Place the USB4_SigTest.exe into the folder "SigTest_USB4_CTS"
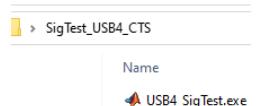
   c) Open PowerShell window from the folder created in #1 by pressing SHIFT + Right mouse button and then press on "Open PowerShell window here"
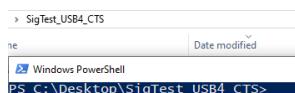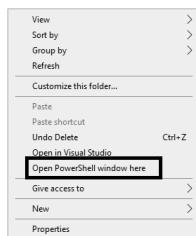
3 Usage

3.1 Command template

USB4_SigTest.exe technology test_mode test_point cts_test_name wdir file1 file2 report_name de_embedding

3.2 Input arguments list

1. technology = **gen2_rounded/gen2_legacy/gen3_rounded/gen3_legacy/gen4**

   SigTest supports all USB4 bitrates:
   gen2_rounded = 10Gb/s
   gen3_rounded = 20Gb/s
   gen2_legacy = 10.3125Gb/s
   **gen3_legacy** = 20.625Gb/s
   gen4 = 25.6Gb/s

2. test_mode = **tx/rx**
   tx – SigTest supports the transmitter Router Assembly compliance tests.
   rx – SigTest supports the receiver Router Assembly stressed eye calibration.

3. test_point = **tp2/tp3_prime/tp3**
   SigTest supports the Router Assembly compliance tests at following test points.
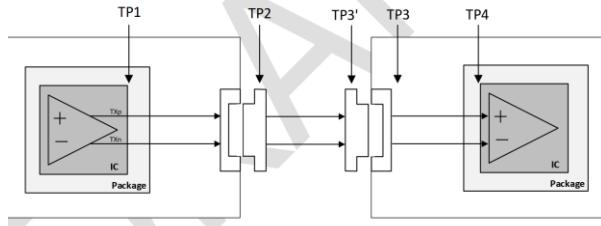
   tp2 - transmitter Router Assembly compliance test point, which requires the de-embedding of 1 m coax cable.
   tp3 - transmitter Router Assembly compliance test point, which requires the de-embedding of 1 m coax cable and embedding of 2m/0.8m passive cable for Gen2/Gen3 respectively.
   tp3_prime (TP3' in the screenshot above) - receiver Router Assembly stressed eye calibration test point. No de-embedding / embedding is required.
   tp3 - receiver Router Assembly stressed eye calibration test point, which requires the de-embedding of 1 m coax cable.
   Note: de-embedding of 1 m coax cable is currently deferred for Gen4 testing. Work in progress to integrate de-embedding process in SigTest

4.
   Gen2-3 cts_test_name =
   ui_ssc_eye/rise_fall_time/jitter/ac_common_mode/transmitter_equalization/electrical_idle_voltage/tx_frequency_variation_training/tp3

ui_ssc_eye – the test done using PRBS31 pattern and includes the following transmitter compliance tests: Minimum Unit Interval, SSC_Down_Spread_Range, SSC_Down_Spread_Rate, SSC_Phase_Deviation, SSC_Slew_Rate, Eye Diagram Measurement (including eye height and eye width measurements).
Test Methods in the CTS section Gen2: 3.3.2.4, 3.3.3.4, 3.3.4.4, 3.3.5.4, 3.3.6.4, 3.3.17.4 Gen3: 3.4.2.4, 3.4.3.4, 3.4.4.4, 3.4.5.4, 3.4.6.4, 3.4.17.4
rise_fall_time – the test done using SQ128 pattern and includes the following transmitter compliance tests: Rise Time, Fall Time.
Test Method in the CTS section Gen2: 3.3.8.4 Gen3: 3.4.8.4
jitter - the test done using PRBS15 pattern and includes the following transmitter compliance tests: Total Jitter, UJ, UDJ, DDJ, UDJ_LF, DCD.
Test Methods in the CTS section Gen2: 3.3.10.4, 3.3.11.4, 3.3.12.4, 3.3.13.4, 3.3.14.4, 3.3.15.4 Gen3: 3.4.10.4, 3.4.11.4, 3.4.12.4, 3.4.13.4, 3.4.14.4, 3.4.15.4
ac_common_mode – the test done using PRBS31 pattern and includes the following transmitter compliance test: AC_CM.
Test Method in the CTS section Gen2: 3.3.16.4 Gen3: 3.4.16.4
transmitter_equalization - the test done using SQ128 pattern and includes the following transmitter compliance test: Pre-shoot and De-emphasis for all USB4 v1 (GEN2-3) presets.
Test Method in the CTS section Gen2: 3.3.1.4 Gen3: 3.4.1.4
electrical_idle_voltage - the test done when the DUT is in electrical idle mode and includes the following transmitter compliance test: V_ELEC_IDLE.
Test Method in the CTS section Gen2: 3.3.9.4 Gen3: 3.4.9.4
tx_frequency_variation_training - the test done using several patterns PRBS31, SQ128, SQ4 as described in the CTS section 3.3.7.4 and includes the following transmitter compliance test: INIT_FREQ_VARIATION, DELTA_FREQ_200ns, DELTA_FREQ_1000ns.
Test Method in the CTS section Gen2: 3.3.7.4 Gen3: 3.4.7.4
tp3 - the test done using several patterns PRBS31, PRBS15 as described in the CTS section Gen2: 3.3.18.4, 3.3.19.4, 3.3.20.4, 3.3.21.4 Gen3: 3.4.18.4, 3.4.19.4, 3.4.20.4, 3.4.21.4

<u>Gen4</u> cts_test_name =
txffe_test/ui_jitter_vertical/ac_common_mode/electrical_idle_voltage/rl /calibration

cts_test_name description embedded per command

5. wdir = waveform_directory
   wdir – the full path to the waveform location

   Captured waveform can be provided in differential or single ended format
6. Captured waveform in Differential Format case:
   file1 = waveform_name.bin/ waveform_name.trc/ waveform_name.wfm
   waveform_name – the waveform full name, including the waveform format that represent the scope vendor:
   waveform_name.bin – KS Scope
   waveform_name.trc – Lecroy Scope
   waveform_name.wfm – TEK Scope
   file2 = **none** – this input parameter shall be "none" in this SigTest revision

7. Captured waveform in Single Ended Format case:

file1 = waveform_name_p.bin/ waveform_name_p.trc/ waveform_name_p.wfm
waveform_name_p is Single Ended P signal
file2 = waveform_name_n.bin/ waveform_name_n.trc/ waveform_name_n.wfm
waveform_name_n is Single Ended N signal

8. report_name = **report_name**
    report_name – any relevant report name chosen by operator.

9. de_embedding = **none**
    none – this input parameter shall be "none" in this SigTest revision.

4 Scope settings

4.1 Data acquisition setting

1. Sampling Rate ≥ 80GSa/s for Gen2/Gen3/Gen4
2. The evaluated record length shall be 500μs per channel
3. No CDR, no average, no interpolation and no equalization shall be applied
4. The scope BW shall be 16GHz for Gen2, 21GHz for Gen3, 25G for Gen4
5. Adjust vertical scale to fit signal into scope screen
6. The saved waveforms for all Router Assembly compliance transmitter and receiver tests shall be differential (for example: CH1 - CH3), except of the waveform for **ac_common_mode** test that shall be common (for example: (CH1 + CH3)/2)
7. The waveforms shall include the correct test pattern type per test according to the CTS and the tests pattern length, otherwise the test will interrupt and exit

4.2 Cable assembly de-embedding/embedding

a. **USB4-V2 (GEN2-GEN3):**The waveforms shall include the De-embedding and Embedding depend on the Router Assembly compliance test point and the test mode as following:
    Test mode: Tx, Test point: TP2
    ➢ De-embedding of the cable from the plug test fixture to the scope
    Test mode: Tx, Test point: TP3
    ➢ De-embedding of the cable from the plug test fixture to the scope and the embedding of Type-C cable 2m for Gen2, 0.8m for Gen3 speeds
    Test mode: Rx, Test point: TP3_Prime
    ➢ No de-embedding and no embedding shall be applied
    Test mode: Rx, Test point: TP3
    De-embedding of the cable connecting from the last receptacle to the scope

b. **USB4-V2 (GEN4):** No Oscilloscope de-embedding/embedding is required at this point. Next SigTest version will include de-embedding analysis. Cable assembly connecting DUT to Oscilloscope shall be measured using Network

analyzer. S-parameter file will be used for further de-embedding in SigTest tool

5 GEN2-3 Router Assembly Transmitter Testing

5.1 General notes

a) All setups and test procedures shall be the same as described in the USB4 Electrical - Router Assembly Compliance Test Specification paragraph 3.

b) The SigTest post processed results shall replace the scope application calculations.

5.2 TP2

1. cts_test_name - **ui_ssc_eye**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp2 ui_ssc_eye
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\ tp2_prbs31.bin none ui_ssc_eye none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Minimum Unit Interval Measurement
SSC Down Spread Range Measurement
SSC Down Spread Rate Measurement
SSC Phase Deviation Measurement
SSC Slew Rate Measurement
Eye Diagram Measurement
Loading File tp2_prbs31.bin ....
Writing tie_period_frequency_gen2_rounded_tp2_ui_ssc_eye.jpg
Writing eye_diagram_gen2_rounded_tp2_ui_ssc_eye.jpg
Writing result to .\ui_ssc_eye_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name

ui_ssc_eye_result_21-Oct-2020.csv

eye_diagram_gen2_rounded_tp2_ui_ssc_eye.jpg

tie_period_frequency_gen2_rounded_tp2_ui_ssc_eye.jpg

USB4_SigTest.exe

1.1. The .CSV file ui_ssc_eye_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded								
Date:	21-Oct-20							
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\								
File: tp2_prbs31.bin								
Minimum Unit Interval Measurement [pS]:	PASS	UI Min Min	100.016081	UI Min Max	100.019604	CTS: UI Min Min	99.97	CTS: UI Min Max	100.03
SSC Down Spread Range Measurement[%]:	PASS	Min SSC_Down_Spread_Range	0.451389	Max SSC_Down_Spread_Range	0.458343	CTS: Min SSC_Down_Spread_Range	0.4	CTS: Max SSC_Down_Spread_Range	0.5
SSC Down Spread Rate Measurement[KHz]:	PASS	Min SSC Down Spread Rate	30.716886	Max SSC Down Spread Rate	30.887801	CTS: Min SSC Down Spread Rate	30	CTS: Max SSC Down Spread Rate	33
SSC Phase Deviation Measurement [ns p-p]:	PASS	SSC Phase Deviation	18.959192	CTS: Min SSC Phase Deviation	2.5	CTS: Max SSC Phase Deviation	22		
SSC Slew Rate Measurement [ppm/us]:	PASS	SSC Slew Rate	550.560944	CTS: SSC Slew Rate	1250				
Eye Diagram Measurement:	PASS	Eye: Count of Violation	0	EyeWidth [pS]	89.281492	EyeHeight[mV]	593.984185		
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.975472	Drift [PPM]	-2452.82				

1.2. The .jpg file eye_diagram_gen2_rounded_tp2_ui_ssc_eye.jpg
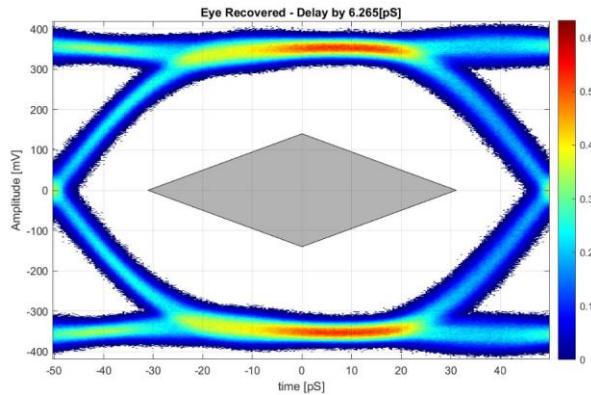
1.3. The .jpg file tie_period_frequency_gen2_rounded_tp2_ui_ssc_eye.jpg
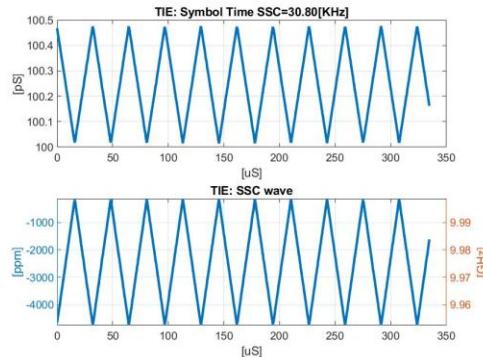
2. cts_test_name - **rise_fall_time**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp2 rise_fall_time
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\ tp2_sq128.bin none
gen2_rounded_rise_fall_time none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Rise/Fall Time Measurement
Loading File tp2_sq128.bin ....
Writing result to .\rise_fall_time_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name
rise_fall_time_result_21-Oct-2020.csv
USB4_SigTest.exe

2.1. The .CSV file gen2_rounded_rise_fall_time_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded						
Date:		21-Oct-20				
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\						
File: tp2_sq128.bin						
Rise-Time Measurement[pS]:		PASS	Rise Time	33.009421	CTS: Min Rise Time	10
Fall-Time Measurement[pS]:		PASS	Fall Time	32.982458	CTS: Min Fall Time	10

3. cts_test_name – **jitter**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp2 jitter
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\ tp2_prbs15.bin none jitter none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Total Jitter Measurement
UJ  Measurement
UDJ Measurement
DDJ Measurement
Low Frequency UDJ Measurement
DCD Measurement
Loading File tp2_prbs15.bin ....
Writing tj_bathtub_gen2_rounded_tp2_jitter.jpg
Writing histogram_pj_rj_ddj_gen2_rounded_tp2_jitter.jpg
Writing result to .\jitter_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

| Name |
| --- |
| jitter_result_21-Oct-2020.csv |
| histogram_pj_rj_ddj_gen2_rounded_tp2_jitter.jpg |
| tj_bathtub_gen2_rounded_tp2_jitter.jpg |
| USB4_SigTest.exe |

3.1. The .CSV file jitter_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded					
Date:	21-Oct-20				
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\					
File: tp2_prbs15.bin					
Total Jitter (BER=1e-13) Measurement UIp-p:	PASS	Tj	0.168537	CTS: Max TJ	0.38
UJ Measurement UIp-p:	PASS	UJ Jitter UIp-p	0.090646	CTS: Max UJ	0.31
UDJ Measurement UIp-p:	PASS	UDJ jitter UIp-p	0.031796	CTS: Max UDJ	0.17
UDJ LF Measurement UIp-p:	PASS	UDJ LF jitter UIp-p	0.018213	CTS: Max UDJ LF	0.04
DDJ Measurement UIp-p:	PASS	DDJ jitter UIp-p	0.077891	CTS: Max DDJ	0.15
DCD Measurement UIp-p:	PASS	DCD jitter UIp-p	0.015579	CTS: Max DCD	0.03
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.975472	Drift [PPM]	-2452.85

3.2.   The .jpg file histogram_pj_rj_ddj_gen2_rounded_tp2_jitter.jpg
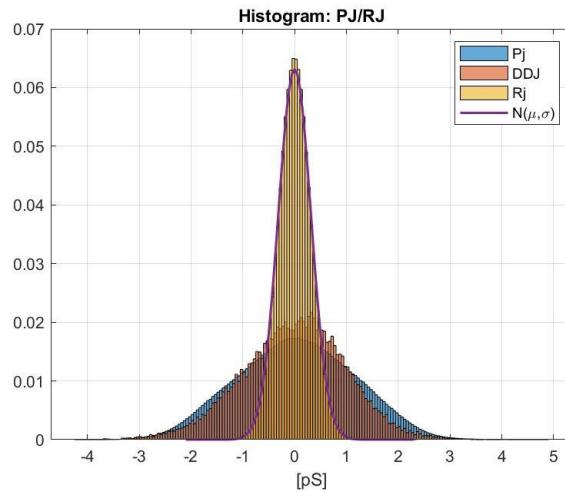
3.3.   The .jpg file tj_bathtub_gen2_rounded_tp2_jitter.jpg
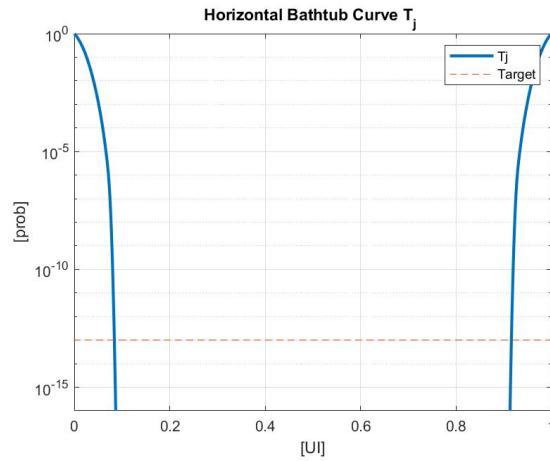
4.   cts_test_name - **ac_common_mode**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp2 ac_common_mode
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\ tp2_prbs31_common.bin none
ac_common_mode none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
AC Common Mode Measurement
Loading File tp2_prbs31_common.bin ....
Writing result to .\ac_common_mode_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name

ac_common_mode_result_21-Oct-2020.csv
USB4_SigTest.exe

4.1. The .CSV file ac_common_mode_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded					
Date:	21-Oct-20				
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\					
File: tp2_prbs31_common.bin					
AC CM Measurement:	PASS	AC CM: Vac [mVp2p]	81.2	CTS: Max AC CM [mVp2p]	100

5. cts_test_name - **electrical_idle_voltage**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp2 electrical_idle_voltage
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\ tp2_eidle.bin none electrical_idle_voltage
none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Electrical Idle Voltage Measurement
Loading File tp2_eidle.bin ....
Writing result to .\electrical_idle_voltage_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name

electrical_idle_voltage_result_21-Oct-2020.csv
USB4_SigTest.exe

5.1. The .CSV file electrical_idle_voltage_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded					
Date:	21-Oct-20				
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\					
File: tp2_eidle.bin					
Electrical Idle Voltage Measurement[mV]:	PASS	V_ELEC_IDLE	1.663508	CTS: Max V_ELEC_IDLE	20

6. cts_test_name - **transmitter_equalization**

Notes:

a) The saved waveforms for each preset shall be located in the same folder.
b) The waveforms names shall be the same as in the screenshot below.
c) SIGEST is capable of analyzing partial presets set. (preset0 and preset15 must be included)

SigTest_CTS > Waveforms > TP2 > TxEq

preset_0_preshoot_off_deemphasis_off.bin	preset_0_preshoot_off_deemphasis_on.bin	preset_0_preshoot_on_deemphasis_off.bin
preset_0_preshoot_on_deemphasis_on.bin	preset_1_preshoot_off_deemphasis_on.bin	preset_1_preshoot_on_deemphasis_off.bin
preset_1_preshoot_on_deemphasis_on.bin	preset_2_preshoot_off_deemphasis_on.bin	preset_2_preshoot_on_deemphasis_off.bin
preset_2_preshoot_on_deemphasis_on.bin	preset_3_preshoot_off_deemphasis_on.bin	preset_3_preshoot_on_deemphasis_off.bin
preset_3_preshoot_on_deemphasis_on.bin	preset_4_preshoot_off_deemphasis_on.bin	preset_4_preshoot_on_deemphasis_off.bin
preset_4_preshoot_on_deemphasis_on.bin	preset_5_preshoot_off_deemphasis_on.bin	preset_5_preshoot_on_deemphasis_off.bin
preset_5_preshoot_on_deemphasis_on.bin	preset_6_preshoot_off_deemphasis_on.bin	preset_6_preshoot_on_deemphasis_off.bin
preset_6_preshoot_on_deemphasis_on.bin	preset_7_preshoot_off_deemphasis_on.bin	preset_7_preshoot_on_deemphasis_off.bin
preset_7_preshoot_on_deemphasis_on.bin	preset_8_preshoot_off_deemphasis_on.bin	preset_8_preshoot_on_deemphasis_off.bin
preset_8_preshoot_on_deemphasis_on.bin	preset_9_preshoot_off_deemphasis_on.bin	preset_9_preshoot_on_deemphasis_off.bin
preset_9_preshoot_on_deemphasis_on.bin	preset_10_preshoot_off_deemphasis_on.bin	preset_10_preshoot_on_deemphasis_off.bin
preset_10_preshoot_on_deemphasis_on.bin	preset_11_preshoot_off_deemphasis_on.bin	preset_11_preshoot_on_deemphasis_off.bin
preset_11_preshoot_on_deemphasis_on.bin	preset_12_preshoot_off_deemphasis_on.bin	preset_12_preshoot_on_deemphasis_off.bin
preset_12_preshoot_on_deemphasis_on.bin	preset_13_preshoot_off_deemphasis_on.bin	preset_13_preshoot_on_deemphasis_off.bin
preset_13_preshoot_on_deemphasis_on.bin	preset_14_preshoot_off_deemphasis_on.bin	preset_14_preshoot_on_deemphasis_off.bin
preset_14_preshoot_on_deemphasis_on.bin	preset_15_preshoot_off_deemphasis_off.bin	preset_15_preshoot_off_deemphasis_on.bin
preset_15_preshoot_on_deemphasis_off.bin	preset_15_preshoot_on_deemphasis_on.bin	

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen3_rounded tx tp2 transmitter_equalization
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\TxEq\ " " none transmitter_equalization
none

Report files location:

6.1. The .CSV file transmitter_equalization_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen3_rounded							
Date:		21-Oct-20					
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP2\TxEq\							
File:							
Transmitter Equalization Test:							
Preset#		Pre-shoot	De-emphasis	Pre-shoot[dB]	De-emphasis[dB]	CTS: Pre-shoot[dB]	CTS: De-emphasis[dB]
	0	PASS	PASS	0	0	0	0
	1	PASS	PASS	0	-1.4	0	-1.9
	2	PASS	PASS	0	-3.3	0	-3.6
	3	PASS	PASS	0	-4.4	0	-5
	4	PASS	PASS	0	-7.7	0	-8.4
	5	PASS	PASS	0.7	0	0.9	0
	6	PASS	PASS	0.8	-1.6	1.1	-1.9
	7	PASS	PASS	1.2	-3.8	1.4	-3.8
	8	PASS	PASS	1.4	-5.2	1.7	-5.8
	9	PASS	PASS	2.4	-7.8	2.1	-8
	10	PASS	PASS	1.4	0	1.7	0
	11	PASS	PASS	1.8	-1.9	2.2	-2.2
	12	PASS	PASS	2.2	-3	2.5	-3.6
	13	PASS	PASS	3.2	-6.3	3.4	-6.7
	14	PASS	PASS	4.2	0.2	3.6	0
	15	PASS	PASS	1.4	-1.4	1.7	-1.7
Swing				Swing[dB]	CTS: Min Swing[dB]	CTS: Max Swing[dB]	
PASS				3.3	2.5	4.5	

7. cts_test_name – **tx_frequency_variation_training**

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen3_rounded tx tp2 tx_frequency_variation_training
C:\Desktop\SigTest_USB4_CTS\Waveforms\ tx_frequency_variation_training.bin none
tx_frequency_variation_training none

```
Running SIGTEST : Technology : GEN3_ROUNDED, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
TX Frequency Variation Training Measurement
Loading File tx_frequency_variation_training.bin ...
Writing clock_switch_analysis_gen3_rounded_tp2_tx_frequency_variation_training.jpg
Writing result to .\tx_frequency_variation_training_result_25-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name

- tx_frequency_variation_training_result_22-Oct-2020.csv
- clock_switch_analysis_gen3_rounded_tp2_tx_frequency_variation_training.jpg
- USB4_SigTest.exe

7.1. The .csv file tx_frequency_variation_training_result_22-Oct-2020.csv

Electrical Compliance Test Specification for gen3_rounded							
Date:	22-Oct-20						
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\							
File: tx_frequency_variation_training.bin							
TX Frequency Variation Training Measurement:							
INIT_FREQ_VARIATION:	PASS	INIT_FREQ_VARIATION result:	60.724875	CTS: Min INIT_FREQ_VARIATION	-300	CTS: Max INIT_FREQ_VARIATION	300
DELTA_FREQ_200nS:	PASS	DELTA_FREQ_200nS result:	190.715962	CTS: Max DELTA_FREQ_200nS	1400		
DELTA_FREQ_1000nS:	PASS	DELTA_FREQ_1000nS result:	673.97266	CTS: Max DELTA_FREQ_1000nS	2200		
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	19.949354	Drift [PPM]	-2532.28		

7.2. The .jpg file
clock_switch_analysis_gen3_rounded_tp2_tx_frequency_variation_training.jpg
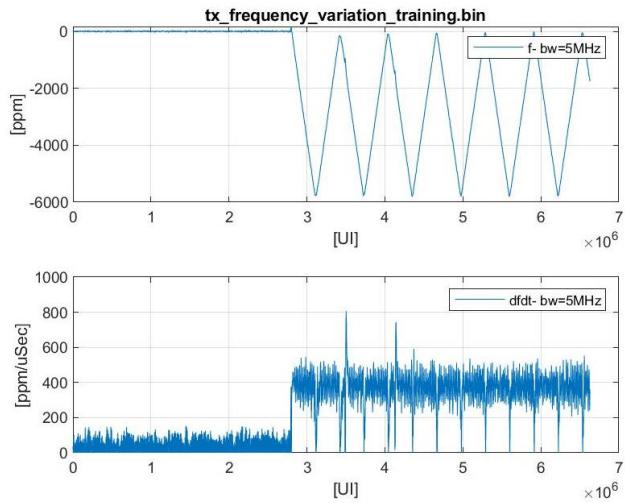
5.3 TP3

8. cts_test_name – **tp3**

Notes:

   a) Save 5 waveforms with PRBS31 pattern using the scope configuration above.
   b) Save 1 waveform with PRBS15 pattern using the scope configuration above.
   c) The saved waveforms for each trial shall be in the same folder.
      1 trial – prbs15 and 5 trials – prbs31.
   d) The waveforms names shall be the same as in the screenshot below.

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded tx tp3 tp3
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\ tp3.bin none eye_jitter none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : TX, TestPoint : TP3
The following tests are in progress ...
Total Jitter TP3 Measurement
UJ  TP3 Measurement
UDJ TP3 Measurement
Eye Diagram TP3 Measurement
Loading File tp3_prbs31_trial_1.bin ...
Loading File tp3_prbs31_trial_2.bin ...
Loading File tp3_prbs31_trial_3.bin ...
Loading File tp3_prbs31_trial_4.bin ...
Loading File tp3_prbs31_trial_5.bin ...
Loading File tp3_prbs31_trial_2.bin ...
Writing eye_diagram_gen2_rounded_tp3_eye_jitter.jpg
Loading File tp3_prbs15.bin ...
Writing tj_bathtub_gen2_rounded_tp3_eye_jitter.jpg
Writing histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitter.jpg
Writing result to .\eye_jitter_result_25-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

Name

- eye_jitter_result_21-Oct-2020.csv
- histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitter.jpg
- tj_bathtub_gen2_rounded_tp3_eye_jitter.jpg
- eye_diagram_gen2_rounded_tp3_eye_jitter.jpg
- USB4_SigTest.exe

8.1. The .CSV file eye_jitter_result_21-Oct-2020.csv

| Electrical Compliance Test Specification for gen2_rounded															
Date:		21-Oct-20													
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\															
File: tp3.bin															
Total Jitter (BER=1e-13) Measurement UIp-p:	PASS	TJ	0.299601	CTS: Max TJ	0.6										
UJ Measurement UIp-p:	PASS	UJ Jitter UIp-p	0.093693	CTS: Max UJ	0.31										
UDJ Measurement UIp-p:	PASS	UDJ Jitter UIp-p	0.034974	CTS: Max UDJ	0.17										
Eye Diagram Measurement:	PASS	Eye: Count of Violation	0	EyeWidth [pS]	81.841387	EyeHeight[mV]	207.027864								
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.975465	Drift [PPM]	-2453.53										
CTLE-Adc[dB]	CTLE-DC Gain[dB]	DFE[mV]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Avg. Height[mV]	Avg. Width[pS]	Area[mV*pS]
1	0	50	1.409	0.783	0.285	1.175	0.318	1.175	1.457	0.783	0.313	0.783	0.76	0.94	0.64
0.891	1	48.2	142.647	62.262	129.546	59.129	140.216	63.437	141.373	61.479	136.547	61.479	138.07	61.557	8504.51
0.794	2	42	170.9	71.269	162.341	70.877	172.953	70.485	172.992	70.485	168.59	70.485	169.56	70.72	11990.66
0.708	3	36.7	197.61	78.317	191.643	77.925	199.418	79.883	198.652	80.275	194.414	79.1	196.35	79.1	15533.05
0.631	4	32	208.352	82.233	205.568	80.667	206.991	81.058	208.858	82.233	205.37	83.016	207.03	81.841	16943.65
0.562	5	27.8	196.69	80.275	195.141	82.233	197.331	83.016	199.43	82.625	194.586	81.45	196.64	81.92	16108.95
0.501	6	24	185.353	76.751	182.983	76.359	185.388	79.883	185.091	79.492	181.683	74.01	184.1	77.299	14283.46
0.447	7	20.7	170.463	70.877	168.146	72.443	172.005	72.443	171.527	71.269	168.334	72.052	170.09	71.817	12215.55
0.398	8	17.8	154.847	66.57	153.365	67.744	156.741	67.744	156.386	67.744	154.618	67.744	155.19	67.509	10476.95
0.355	9	15.2	138.71	62.262	139.772	61.87	142.913	63.045	140.059	63.828	140.079	63.045	140.31	62.81	8813.04
Optimal CTLE: 4															

8.2.   The .jpg file eye_diagram_gen2_rounded_tp3_eye_jitters.jpg
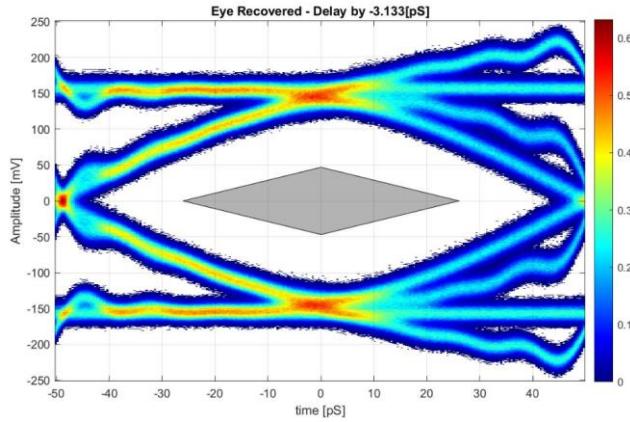
8.3.   The .jpg file histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitters.jpg

8.4.   The .jpg file tj_bathtub_gen2_rounded_tp3_eye_jitters.jpg

Horizintal Bathtub Curve T_j
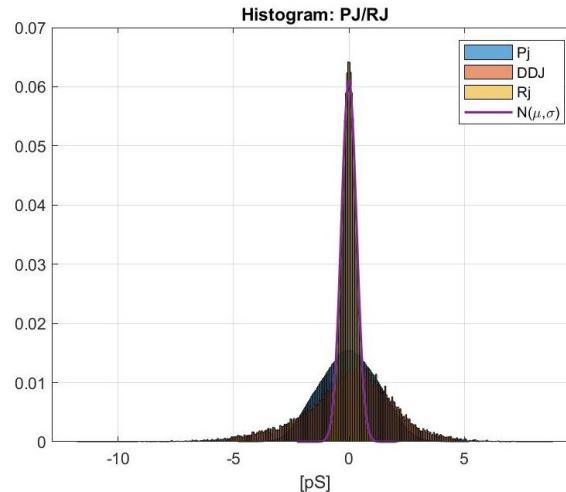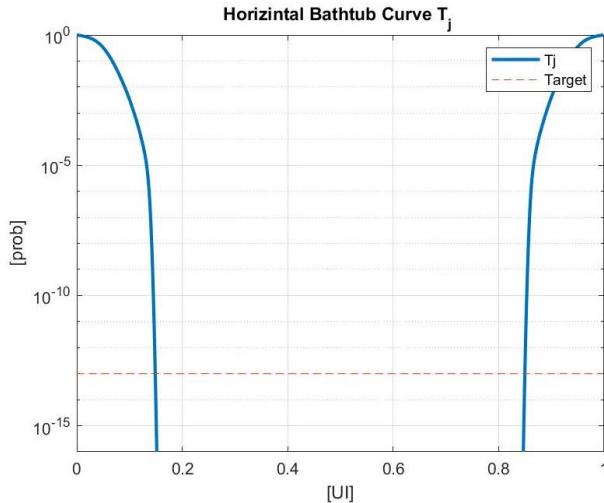
6 GEN4 Router Assembly Transmitter Testing

6.1 Oscilloscope intrinsic noise cancelation

See Appendix C of USB4 GEN4 CTS document for scope intrinsic noise measurement procedure.

scope_intrinsic_noise file shall be located in wdir (waveforms location)

6.2 TP2

The following section describes the usage of USB4 SigTest commands for TX GEN4 according to cts_test_name

6.2.1 txffe_test

This function reads all TXFFE preset files and estimates the transmitter TXFFE coefficients for all USB4 v2 GEN4 presets. The SIGTEST also reports for the best TXFFE preset in terms of minimum DDJ peak to peak. SIGEST is capable of analyzing partial presets set (preset0 must be included)

Run the following command from the PowerShell window:

Command example:
```
.\USB4_SigTest.exe gen4 tx tp2 txffe_test
C:\SigTest_USB4_CTS\Waveforms\txffe\ pam3_prts7_preset_.trc none
txffe_test_report_result none
```

```
PS C:\SigTest_USB4_CTS> .\USB4_SigTest.exe gen4 tx tp2 txffe_test C:\SigTest_USB4_CTS\Waveforms\txffe\ pam3_prts7_preset
_.trc none txffe_test_report_result none
***** SIGTEST Version: 0.83 ******
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
TX-FFE Test
Loading Files: pam3_prts7_preset_0.trc ...
```

Report files location:

| Name	Date modified	Type	Size
Waveforms	17/12/2022 10:21	File folder	
tmp_sndr.txt	16/12/2022 17:25	Text Document	1 KB
txffe_test_report_result_eye_diagram_gen4_tp2.jpg	16/12/2022 18:33	JPG File	182 KB
txffe_test_report_result_result.csv	16/12/2022 18:33	Microsoft Excel Co...	5 KB
USB4_SigTest.exe	16/12/2022 15:14	Application	5,532 KB

8.5. The .csv file txffe_test_report_result_result.csv as a results example

Electrical Compliance Test Specification for GEN4
Date: 16-Dec-22
DIR: C:\SigTest_USB4_CTS\Waveforms\txffe\
File: pam3_prts7_preset_.trc
Transmitter Equalization Test:

preset_number	TXFFE_Failer	TXFFE(-2)	TXFFE(-1)	TXFFE(0)	TXFFE(1)	c(-2)	c(-1)	c(0)	c(1)	MaxErr	DDJ[UIp2p]
0	PASS	0	0	1	0	0	0	1	0	0	0.628906
1	PASS	0	0	0.95	-0.05	-0.002218	0.009598	0.929405	-0.05878	0.020595	0.578125
2	PASS	0	0	0.9	-0.1	-0.001167	0.005334	0.89132	-0.10218	0.00868	0.570312
3	PASS	0	0	0.85	-0.15	-0.002083	0.009318	0.833265	-0.15533	0.016735	0.582031
4	PASS	0	-0.05	0.95	0	-0.000093	-0.05299	0.944854	0.002059	0.005146	0.628906
5	PASS	0	-0.05	0.9	-0.05	-0.002123	-0.04632	0.895819	-0.05573	0.005734	0.578125
6	PASS	0	-0.05	0.85	-0.1	-0.001143	-0.04975	0.849076	-0.10003	0.001143	0.5625
7	PASS	0	-0.05	0.8	-0.15	-0.001857	-0.04837	0.796583	-0.15319	0.003417	0.601562
8	PASS	0	-0.1	0.9	0	-0.002853	-0.09417	0.899546	-0.00343	0.005828	0.652344
9	PASS	0	-0.1	0.85	-0.05	-0.003585	-0.09233	0.847961	-0.05613	0.007673	0.605469
10	PASS	0	-0.1	0.8	-0.1	-0.002801	-0.09552	0.80035	-0.10133	0.004478	0.578125
11	PASS	0	-0.1	0.75	-0.15	0.000008	-0.10487	0.749504	-0.14562	0.004873	0.605469
12	PASS	0	-0.15	0.85	0	-0.003267	-0.1476	0.84777	-0.00137	0.003267	0.675781
13	PASS	0	-0.15	0.8	-0.05	-0.004181	-0.146	0.795063	-0.05475	0.004937	0.625
14	PASS	0	-0.15	0.75	-0.1	-0.004523	-0.14598	0.747156	-0.10234	0.004523	0.589844
15	PASS	0	-0.15	0.7	-0.15	0.000008	-0.15794	0.696896	-0.14516	0.007935	0.859375
16	PASS	0.025	-0.15	0.825	0	0.026806	-0.15594	0.806122	0.011131	0.018878	0.671875
17	PASS	0.025	-0.15	0.775	-0.05	0.021451	-0.14556	0.7767	-0.05629	0.00629	0.613281
18	PASS	0.025	-0.15	0.725	-0.1	0.023933	-0.15207	0.726231	-0.09777	0.002231	0.605469
19	PASS	0.025	-0.15	0.675	-0.15	0.026376	-0.15768	0.671286	-0.14466	0.007682	0.875
20	PASS	0	-0.2	0.8	0	-0.002073	-0.19561	0.800331	0.001989	0.004392	0.722656
21	PASS	0	-0.2	0.75	-0.05	-0.004567	-0.19103	0.749677	-0.05473	0.008972	0.671875
22	PASS	0	-0.2	0.7	-0.1	-0.00269	-0.1959	0.702454	-0.09896	0.004105	0.8125
23	PASS	0	-0.2	0.65	-0.15	-0.002958	-0.19589	0.648898	-0.15226	0.004114	1
24	PASS	0.025	-0.2	0.775	0	0.02174	-0.19191	0.783321	-0.00303	0.008321	0.722656
25	PASS	0.025	-0.2	0.725	-0.05	0.022516	-0.19404	0.729402	-0.05404	0.005958	0.65625
26	PASS	0.025	-0.2	0.675	-0.1	0.027751	-0.20444	0.676412	-0.0914	0.008601	0.828125
27	PASS	0.025	-0.2	0.625	-0.15	0.024719	-0.19878	0.62532	-0.15118	0.001217	1
28	PASS	0.05	-0.2	0.75	0	0.051806	-0.19858	0.742619	0.006993	0.007381	0.730469
29	PASS	0.05	-0.2	0.7	-0.05	0.047801	-0.19238	0.703519	-0.0563	0.00762	0.671875
30	PASS	0.05	-0.2	0.65	-0.1	0.049822	-0.19676	0.653078	-0.10035	0.003244	0.878906
31	PASS	0.05	-0.2	0.6	-0.15	0.050925	-0.19825	0.598836	-0.15199	0.001985	1
32	PASS	0	-0.25	0.75	0	-0.005947	-0.24134	0.748659	-0.00406	0.008663	0.796875
33	PASS	0	-0.25	0.7	-0.05	-0.004514	-0.24538	0.696702	-0.0534	0.004619	0.8125
34	PASS	0.025	-0.25	0.725	0	0.020255	-0.2441	0.731802	-0.00384	0.006802	0.777344
35	PASS	0.025	-0.25	0.675	-0.05	0.023357	-0.24982	0.675696	-0.05113	0.001643	0.800781
36	PASS	0.05	-0.25	0.7	0	0.04903	-0.24833	0.702038	0.000602	0.002038	0.800781
37	PASS	0.05	-0.25	0.65	-0.05	0.049934	-0.25058	0.648788	-0.0507	0.001212	0.84375
38	PASS	0.075	-0.25	0.675	0	0.074867	-0.2474	0.677385	-0.00035	0.002603	0.851562
39	PASS	0.075	-0.25	0.625	-0.05	0.076085	-0.24949	0.622467	-0.05196	0.002533	0.878906
40	PASS	0	-0.1	0.4	0	0.000499	-0.10552	0.384281	0.009701	0.015719	0.84375
41	PASS	0	0	0.5	0	-0.002195	0.004046	0.49065	0.003109	0.00935	0.722656

Preset Swing Attenuation [dB]:

Preset 40	PASS	VSWING_RATIO	6.55 CTS: Min Swing Attenuation [dB]	5 CTS: Max Swing Attenuation [dB]	7
Preset 41	PASS	VSWING_RATIO	6.29 CTS: Min Swing Attenuation [dB]	5 CTS: Max Swing Attenuation [dB]	7

Informative:	Best TXFFE	6	Min. DDJ	0.5625 [UIp2p]
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.56218 Drift [PPM]	-1477.24
Informative:	EyeHeight	197.87 [mV]		
Informative:	EyeWidth	17.115127 [pS]		

In this example the best TX FFE preset is 6. The corresponding waveform shall be used for ui_jitter_vertical test
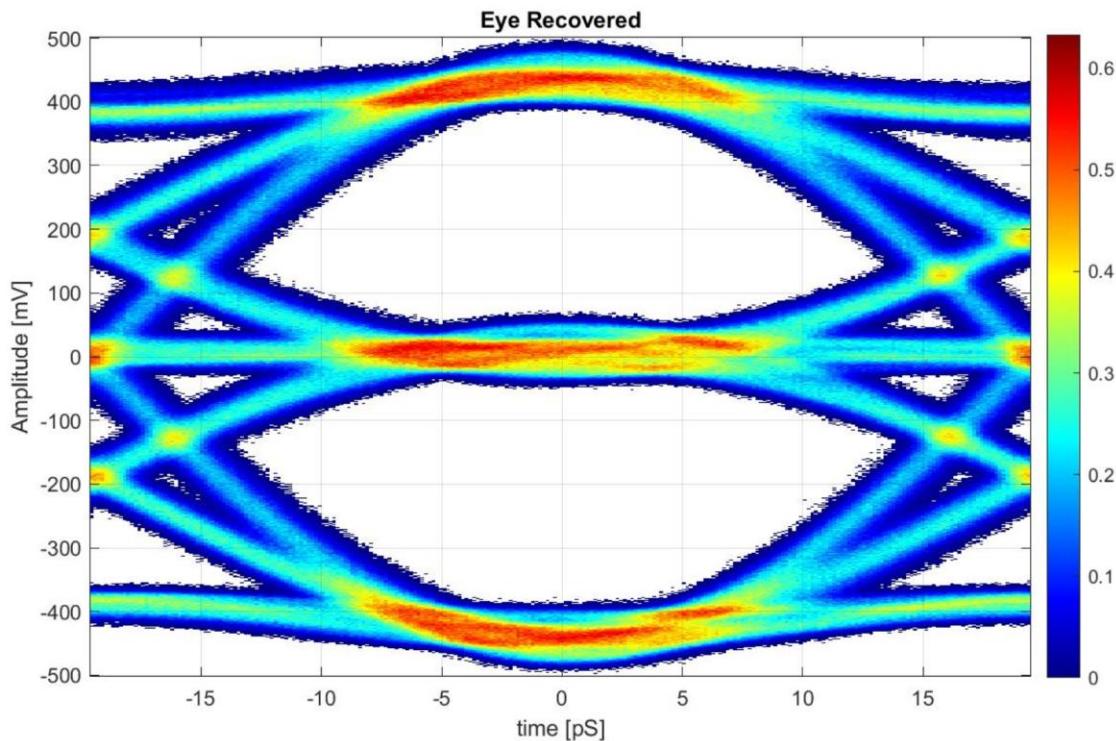
6.2.2 ui_jitter_vertical

This function calculates USB4 v2 GEN4 Transmitter Specification parameters (at TP2) such as UI, SSC, Jitter and Vertical performance using the best TXFFE preset signal waveform (reported in txffe_test)

Run the following command from the PowerShell window:

Command example:
.\USB4_SigTest.exe gen4 tx tp2 ui_jitter_vertical
C:\SigTest_USB4_CTS\Waveforms\txffe\ pam3_prts7_preset_19.trc none
ui_ssc_jitter_vertical_report_result none

```
PS C:\SigTest_USB4_CTS> .\USB4_SigTest.exe gen4 tx tp2 ui_jitter_vertical C:\SigTest_USB4_CTS\Waveforms\txffe\ pam3_prts
7_preset_19.trc none ui_ssc_jitter_vertical_report_result none
***** SIGTEST Version: 0.83 *****
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
USB4 Gen4: UI,SSC,Jitters and Vertical
Loading Files: pam3_prts7_preset_19.trc ...
Loading Files: scope_intrinsic_noise.trc ...
>> SSC Estimated:
>> SSC Frequency 30.994223[Khz]
>> SSC Amplitude Harmonics[pS]:0.048208, 0.000338, 0.005536,
Writing ui_ssc_jitter_vertical_report_result_tie_period_frequency_gen4_tp2.jpg
>> UI min = -2930.442853[ppm] ,max=-13.047601[ppm]
Writing ui_ssc_jitter_vertical_report_result_tj_bathtub_gen4_tp2.jpg
Writing ui_ssc_jitter_vertical_report_result_histogram_pj_rj_ddj_gen4_tp2.jpg
>>> PRTS LOCKED !!!
Number of symbol: #11505151,BER: = 2.894358e-05 (Swapped: BER=9.999831e-01)
Informative:Intrinsic Scope Noise = 1.901[mV-rms]
TX LEVELS MISMATCH = 1.000
TX LEVEL = +256.2[mV]
TX LEVEL = -0.1[mV]
TX LEVEL = -256.5[mV]
V_Steady-State = +201.4[mV]
TX_PULSE_PEAK = +256.4[mV]
TX_SNDR  = 32.5[dB]
TX_ISI_MARGIN  = 12.4[dB]
TX Budget: Dist=2.7[mV], Noise=5.4[mV] total= 6.1[mV]
PAM-3,Eye(1):EyeHeight=47.4[mV], EyeWidth=0.133[UI]=5.2[pS]
PAM-3,Eye(2):EyeHeight=29.2[mV], EyeWidth=0.105[UI]=4.1[pS]
PAM-3:EyeHeight=29.2[mV], EyeWidth=0.105[UI]=4.1[pS]
Writing ui_ssc_jitter_vertical_report_result_eye_diagram_gen4_tp2.jpg
Writing result to .\ui_ssc_jitter_vertical_report_result_result.csv
The tests are completed
```

Report files location:

Waveforms	16/12/2022 17:10	File folder	
tmp_sndr.txt	16/12/2022 17:25	Text Document	1 KB
ui_ssc_jitter_vertical_report_result_eye_diagram_gen4_tp2.jpg	16/12/2022 17:26	JPG File	200 KB
ui_ssc_jitter_vertical_report_result_histogram_pj_rj_ddj_gen4_tp2.jpg	16/12/2022 17:25	JPG File	45 KB
ui_ssc_jitter_vertical_report_result_result.csv	16/12/2022 17:26	Microsoft Excel Co...	2 KB
ui_ssc_jitter_vertical_report_result_tie_period_frequency_gen4_tp2.jpg	16/12/2022 17:25	JPG File	85 KB
ui_ssc_jitter_vertical_report_result_tj_bathtub_gen4_tp2.jpg	16/12/2022 17:25	JPG File	45 KB
USB4_SigTest.exe	16/12/2022 15:14	Application	5,532 KB

Note: scope_intrinsic_noise.bin/trc/wfm shall be placed at the same location as best preset waveform

8.7. The .csv file ui_ssc_jitter_vertical_report_result.csv as a results example

Electrical Compliance Test Specification for GEN4								
Date:	06-Feb-22							
DIR:	C:\EV_WORK\USB4SIG\main\run_pam3							
File:	pam3_prts7_preset_19.trc							
Minimum Unit Interval Measurement [pS]:	PASS	UI Min Min	39.061388	UI Min Max	39.062231	CTS: UI Min Min	39.0508	CTS: UI Min Max	39.0742
SSC_Down_Spread_Range Measurement[%]:	FAIL	Min SSC_Down_Spread_Range	0.296948	Max SSC_Down_Spread_Range	0.300794	CTS: Min SSC_Down_Spread_Range	0.2	CTS: Max SSC_Down_Spread_Range	0.3
SSC_Down_Spread_Rate Measurement[KHz]:	PASS	Min SSC_Down_Spread_Rate	30.932407	Max SSC_Down_Spread_Rate	31.101453	CTS: Min SSC_Down_Spread_Rate	30	CTS: Max SSC_Down_Spread_Rate	33
SSC_Phase_Deviation Measurement [ns p-p]:	PASS	SSC_Phase_Deviation	12.973242	CTS: Min SSC_Phase_Deviation	2.5	CTS: Max SSC_Phase_Deviation	15.5		
SSC_Slew_Rate Measurement [ppm/us]:	PASS	SSC_Slew_Rate	223.598872	CTS:MAX SSC_Slew_Rate	500			
UJ Measurement UIp-p:	PASS	UJ Jitter UIp-p	0.145603	CTS: Max UJ	0.17			
UDJ Measurement UIp-p:	PASS	UDJ jitter UIp-p	0.027259	CTS: Max UDJ	0.075			
UDJ LF Measurement UIp-p:	PASS	UDJ LF jitter UIp-p	0.007856	CTS: Max UDJ LF	0.03			
DCD Measurement UIp-p:	PASS	DCD jitter UIp-p	0.000513	CTS: Max DCD	0.02			
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.562139	Drift [PPM]	-1478.94			
Vertical Analysis Test:								
TX_SNDR Measurement [dB]:	PASS	TX_SNDR [dB]	32.541019	CTS: Min TX_SNDR	32.5			
TX_LEVELS_MISMATCH Measurement:	PASS	TX_LEVELS_MISMATCH	0.999616	CTS: Min TX_LEVELS_MISMATCH	0.975			
V_SWING Measurement [mV]:	FAIL	V_SWING	503.590461	CTS: Min V_SWING	390	CTS: Max V_SWING	500	
TX_ISI_MARGIN Measurement[dB](TXFFE=19):	PASS	TX_ISI_MARGIN	12.428694	CTS: Min TX_ISI_MARGIN	11.5			
TX Noise Budget:	Distortion	AWGN	Total					
Measured[mVrms]:	2.7	5.4	6.05					
Informative:	EyeHeight	29.23	[mV]					
Informative:	EyeWidth	4.125975	[pS]					

8.8.   The SIGTEST saves the following plots (.jpg format)

Horizontal Bathtub Curve T$_J$

Eye Recovered

TIE: Symbol Time SSC=31.02[KHz]

TIE: SSC wave

Histogram: PJ/RJ
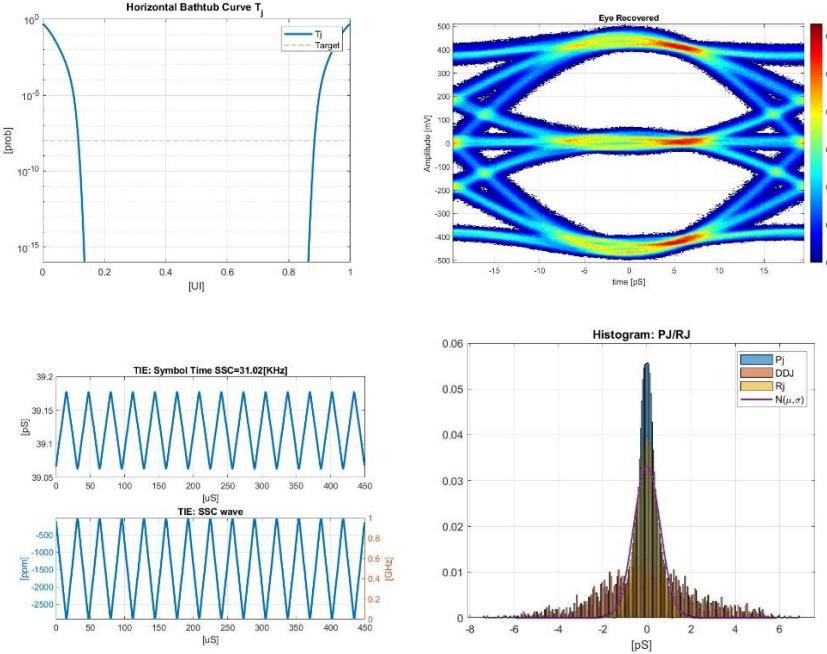
6.2.3 tx_frequency_variation

This function calculates USB4 v2 GEN4 Tx Frequency Variation parameters

Run the following command from the PowerShell window:

Command example:

```
.\USB4_SigTest.exe gen4 tx tp2 frequency_variation_training
C:\EV_WORK\USB4SIG\main\USB4_SigTest\Waveforms\
tx_frequency_variation.bin none tx_frequency_variation_report none
```

```
PS C:\EV_WORK\USB4SIG\main\USB4_SigTest> .\USB4_SigTest.exe gen4 tx tp2 frequency_variation_training  C:\EV_WORK\USB4SIG
\main\USB4_SigTest\Waveforms\ tx_frequency_variation.bin none tx_frequency_variation_report none
***** SIGTEST Version: 0.83 *****
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Frequency Variation Training Measurement
Loading File: C:\EV_WORK\USB4SIG\main\USB4_SigTest\Waveforms\tx_frequency_variation.bin ....
>> Warning: *** no clock switch point found ***
clock switch detection by threshold= 1   and by fft=0

Warning: <<< clock switch detection by fft and thresholds differ >>>
> In find_peaks_tx (line 272)
In clk_sw_analyzer (line 409)
In digital_signal_analyzer (line 869)
In sigtest (line 198)
Writing tx_frequency_variation_report_tx_clock_switch_analysis_gen4_tp2.jpg
Writing result to .\tx_frequency_variation_report_result.csv
The tests are completed
```

Report files location:

tx_frequency_variation_report_result.csv	05/12/2022 16:05	Microsoft Excel C...	1 KB
tx_frequency_variation_report_tx_clock_switch_analysis_gen4_tp2.jpg	05/12/2022 16:05	JPG File	52 KB
USB4_SigTest.exe	04/12/2022 14:44	Application	5,522 KB
Waveforms	05/12/2022 16:03	File folder	

The .csv file tx_frequency_variation_report_result.csv as a results example

Electrical Compliance Test Specification for GEN4						
Date:	05-Dec-22					
DIR:	C:\EV_WORK\USB4SIG\main\USB4_SigTest\Waveforms\					
File:	tx_frequency_variation.bin					
TX Frequency Variation Training Measurement:						
INIT_FREQ_VARIATION:	PASS	INIT_FREQ_VARIATION result:	299.557693	CTS: Min INIT_FREQ_VARIATION	-300 CTS: Max INIT_FREQ_VARIATION	300
DELTA_FREQ_200nS:	PASS	DELTA_FREQ_200nS result:	578.571019	CTS: Max DELTA_FREQ_200nS	600	
DELTA_FREQ_1000nS:	PASS	DELTA_FREQ_1000nS result:	895.301998	CTS: Max DELTA_FREQ_1000nS	900	
FREQ_OVERSHOOT:	PASS	FREQ_OVERSHOOT result:	595.098731	CTS: Max FREQ_OVERSHOOT	600	
STEADY_STATE_FREQ_VARIATION:	FAIL	STEADY_STATE_FREQ_VARIATION result:	-303.252925	CTS: Min STEADY_STATE_FREQ_VARIATION	-300 CTS: Max STEADY_STATE_FREQ_VARIATION	300
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.598735	Drift [PPM]	-49.41	

The SIGTEST saves the following plot (.jpg format)

tx_frequency_variation.bin
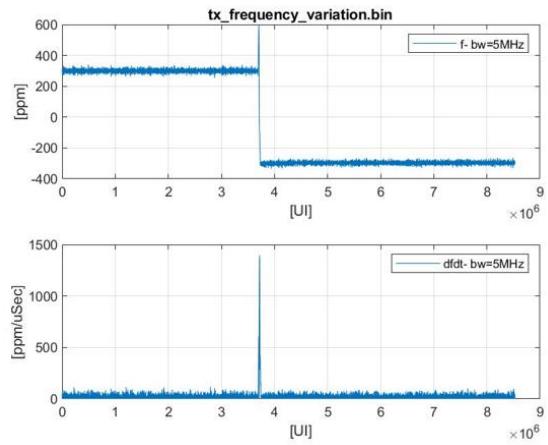
6.2.4 electrical_idle_voltage

This function calculates Electrical Idle voltage while the DUT is in electrical idle mode and includes the following transmitter compliance test: V_ELEC_IDLE

Run the following command from the PowerShell window:

Command example:
`.\USB4_SigTest.exe gen4 tx tp2 electrical_idle_voltage C:\SigTest\Waveforms\ tx_gen4_eidle.bin none eidle_report none none`

```
PS C:\SigTest> .\USB4_SigTest.exe gen4 tx tp2 electrical_idle_voltage C:\SigTest\Waveforms\ tx_gen4_eidle.bin none eidle
_report none none
***** SIGTEST Version: 0.72 ******
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Electrical Idle Voltage Measurement
Loading File: C:\SigTest\Waveforms\tx_gen4_eidle.bin ....
Loading File: C:\SigTest\Waveforms\scope_intrinsic_noise.bin ....
Writing result to .\eidle_report_result.csv
The tests are completed
```

Report file location:
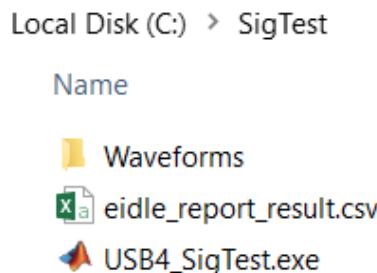
Local Disk (C:) > SigTest

Name

📁 Waveforms

📊 eidle_report_result.csv

📄 USB4_SigTest.exe

eidle_report_result.csv as a result example

Electrical Compliance Test Specification for GEN4					
Date:	07-Mar-22				
DIR:	C:\SigTest\Waveforms\				
File:	tx_gen4_eidle.bin				
Electrical Idle Voltage Measurement[mV]:	PASS	V_ELEC_IDLE	11.29415	CTS: Max V_ELEC_IDLE	20

6.2.5 ac_common_mode

This function calculates AC_CM using PRTS7 pattern and includes the following transmitter compliance test: AC_CM

Run the following command from the PowerShell window:

Command example:
```
sigtest.exe gen4 tx tp2 ac_common_mode
C:\EV_WORK\USB4SIG\main\run_pam3\ pam3_prts7_preset_acommon.bin none
ac_common_mode_results none
```

```
C:\EV_WORK\USB4SIG\main\run_pam3>sigtest.exe gen4 tx tp2 ac_common_mode C:\EV_WORK\USB4SIG\main\run_pam3\ pam3_prts7_preset_4common.bin none ac_common_mode_results none
Opening log file:  C:\Users\bbublil\AppData\Local\Temp\java.log.51644
***** SIGTEST Version: 0.70 ******
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
AC Common Mode Measurement
Loading File pam3_prts7_preset_4common.bin ...
Loading File scope_intrinsic_noise.bin ...
Writing result to .\ac_common_mode_results_result.csv
The tests are completed
```

5.1.   The .csv file ac_common_mode_report_result.csv as a results example

Electrical Compliance Test Specification for GEN4					
Date:	6-Feb-22				
DIR:	C:\EV_WORK\USB4SIG\main\run_pam3\				
File:	pam3_prts7_preset_4common.bin				
AC CM Measurement:	PASS		AC CM: Vac [mVp2p]	82.1 CTS: Max AC CM [mVp2p]	100

6.2.6 rl

This function calculates Return Loss (rl) and Integrated Return Loss (irl) for TX lanes
Expected inputs for For TX RL and IRL analysis are s2p file and signal waveform of the best
TXFFE preset in terms of minimum DDJ peak to peak (same signal waveform which is used
for **ui_jitter_vertical**). In case no signal waveform file provided the function will still
calculate RL and IRL, although IRL spec limit and pass/fail criteria should be ignored as no
ISI_Margin result presents

1. Run the following command from the PowerShell window:

Command example:

```
.\USB4_SigTest.exe gen4 tx tp2 rl C:\SigTest\Waveforms\
pam3_prts7_preset_19.bin none rl_report none
pam3_prts7_preset_19_s2p.s2p
```

Command example w/o signal waveform file:

```
.\USB4_SigTest.exe gen4 tx tp2 rl C:\SigTest\Waveforms\ none none
rl_report none pam3_prts7_preset_19_s2p.s2p
```

```
PS C:\SigTest> .\USB4_SigTest.exe gen4 tx tp2 rl C:\SigTest\Waveforms\ pam3_prts7_preset_19.bin
 none rl_report none pam3_prts7_preset_19_s2p.s2p
***** SIGTEST Version: 0.72 ******
Running SIGTEST : Technology : GEN4, TestMode : TX, TestPoint : TP2
The following tests are in progress ...
Transmitter Return Loss & Integrated Return Loss
Loading File: C:\SigTest\Waveforms\pam3_prts7_preset_19.bin ....
Loading File: C:\SigTest\Waveforms\scope_intrinsic_noise.bin ....
Informative:Intrinsic Scope Noise = 1.473[mV-rms]
TX LEVELS MISMATCH = 0.999
TX LEVEL = +165.6[mV]
TX LEVEL = -0.2[mV]
TX LEVEL = -165.6[mV]
V_Steady-State = +187.7[mV]
TX_PULSE_PEAK = +165.6[mV]
TX_SNDR  = 34.7[dB]
TX_ISI_MARGIN  = 12.0[dB]
TX Budget: Dist=2.7[mV], Noise=1.4[mV] total= 3.0[mV]
Error After ISI reduction Statistic information:
Reading S parameters File: C:\SigTest\Waveforms\pam3_prts7_preset_19_s2p.s2p ..
IRL=-36.0[dB]
Writing rl_report_transmitter_differential_tx12_return_loss_gen4_tp2.jpg
Writing result to .\rl_report_result.csv
The tests are completed
```

2. report file location:

Local Disk (C:) > SigTest

Name

- 📁 Waveforms
- 📊 rl_report_result.csv
- 🖼️ rl_report_transmitter_differential_tx12_return_loss_gen4_tp2.jpg
- 📄 tmp_sndr.txt
- 🔺 USB4_SigTest.exe
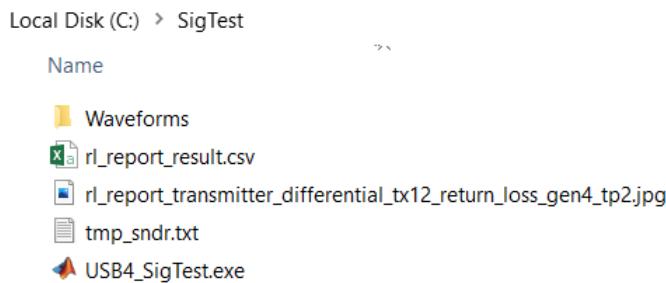
3. rl_report_result.csv as a result example

Electrical Compliance Test Specification for GEN4						
Date:	08-Mar-22					
DIR:	C:\SigTest\Waveforms\					
File:	pam3_prts7_preset_19.bin					
Transmitter Return Loss & Integrated Return Loss						
IRL:	PASS	IRL[dB]:	-35.962857	CTS: Max IRL	-14.714878	
Informative:	TX_ISI_Margin[dB]	12				
Informative:	Sdd22 MASK:	PASS				
Informative:	Sdd22 max[dB]	-12.5	Margin[dB]	4	Fmax[GHz]	0.730062
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.563502	Drift [PPM]	-1425.7	

- Sdd22 max[dB] indicates closest to spec mask absolute RL result
- Sdd22 MASK indicates RL pass/fail criteria
- Margin[dB] indicates the delta between absolute RL result to spec mask
- Fmax[GHz] indicates the frequency of the closest to spec mask absolute RL result
- IRL[dB] indicates calculated IRL
- IRL indicates IRL pass/fail criteria
- CTS: Max IRL indicates the IRL spec limit calculated using corresponding TX_ISI_Margin[dB]

4. rl_report_transmitter_differential_tx12_return_loss_gen4_tp2.jpg
   Return Loss plot with spec mask
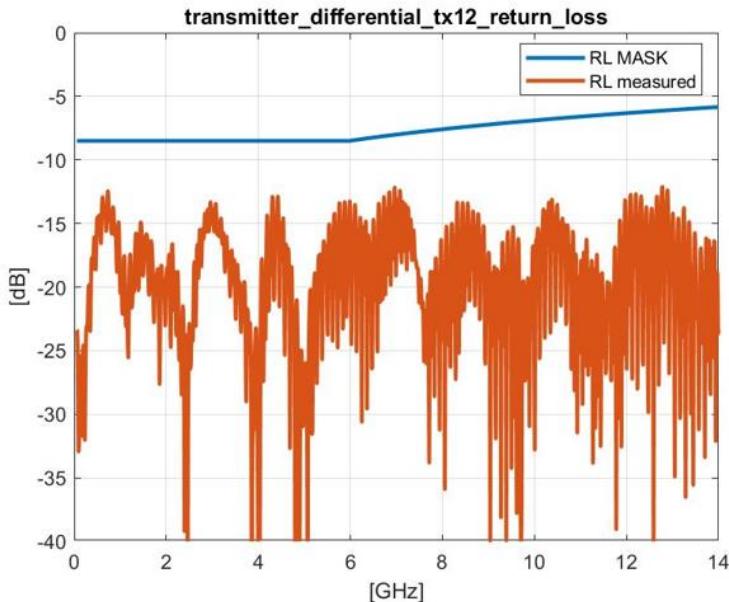
7 GEN2-3 Router Assembly Receiver stressed eye calibration

7.1 General notes

a) The receiver stressed eye calibration procedure shall be the same as described in the USB4 Electrical - Router Assembly Compliance Test Specification paragraph 4.

b) The SigTest post processed results shall replace the scope application calculations.

7.2 TP3' – Case1

1. cts_test_name – **jitter**

The test below shall be used for the following calibrations:

a) 4.2.1.1 Data Dependent Jitter - DDJ calibration
b) 4.2.1.3 Random Jitter - RJ calibration
c) 4.2.1.4 Periodic Jitter - PJ calibration
d) 4.2.1.5 Total Jitter - TJ calibration

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded rx tp3_prime jitter
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\
TP3_Prime_Gen2_Rounded_prbs15.bin none jitters none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
Data Dependent Jitter - DDJ Calibration
Random Jitter - RJ Calibration
Periodic Jitter - PJ Calibration
Total Jitter - TJ Calibration
Loading File TP3_Prime_Gen2_Rounded_prbs15.bin ....
Writing tj_bathtub_gen2_rounded_tp3_prime_jitters.jpg
Writing histogram_pj_rj_ddj_gen2_rounded_tp3_prime_jitters.jpg
Writing result to .\jitters_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

☐ Name

📊 jitters_result_21-Oct-2020.csv
🖼 histogram_pj_rj_ddj_gen2_rounded_tp3_prime_jitters.jpg
🖼 tj_bathtub_gen2_rounded_tp3_prime_jitters.jpg
📄 USB4_SigTest.exe
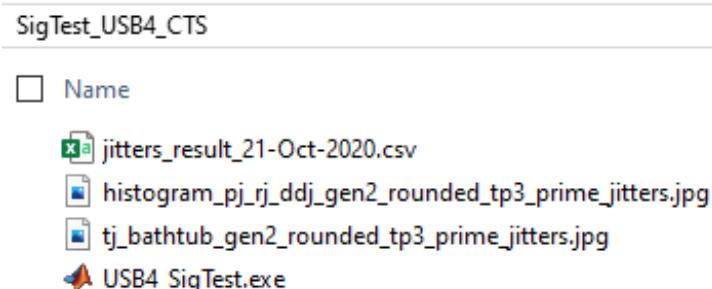
1.1.   The csv. File jitters_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded					
Date:		21-Oct-20			
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\					
File: TP3_Prime_Gen2_Rounded.bin					
Total Jitter (BER=1e-12) Measurement UIp-p:	Tj	0.363443			
PJ Jitter Measurement mUI:	PJ-rms	58.981258			
RJ Jitter Measurement mUI:	RJ-rms	12.812331			
DDJ Measurement UIp-p:	DDJ jitter UIp-p	0.038398			
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.974974	Drift [PPM]	-2502.56

The .jpg file histogram_pj_rj_ddj_gen2_rounded_tp3_prime_jitters.jpg
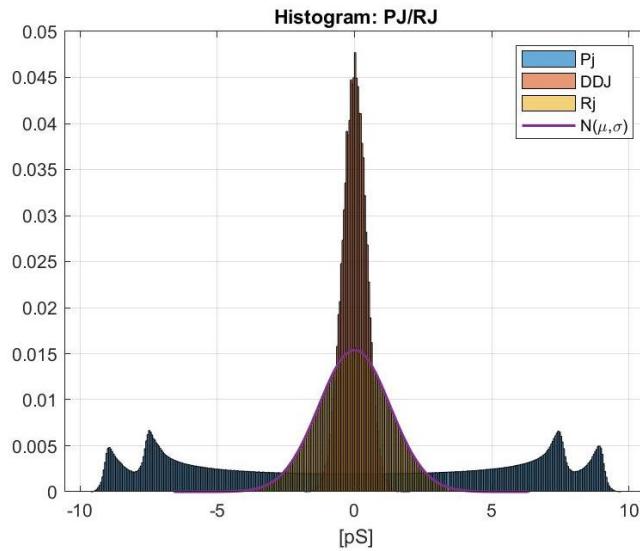
The .jpg file tj_bathtub_gen2_rounded_tp3_prime_jitters.jpg
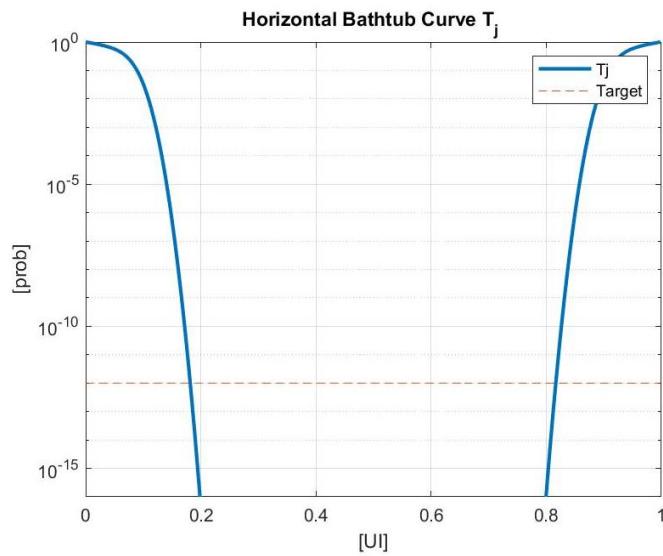
2. cts_test_name – **ac_common_mode**

The test below shall be used for the following calibration:

a) 4.2.1.2 AC Common Mode Measurements

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded rx tp3_prime ac_common_mode
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\
TP3_Prime_Gen2_Rounded_prbs31_common.bin none ac_common_mode none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
AC Common Mode - Calibration
Loading File TP3_Prime_Gen2_Rounded_prbs31_common.bin ....
Writing result to .\ac_common_mode_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

☐ Name

📊 ac_common_mode_result_21-Oct-2020.csv
📐 USB4_SigTest.exe

2.1. The .csv file ac_common_mode_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded		
Date:	21-Oct-20	
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\		
File: TP3_Prime_Gen2_Rounded_prbs31_common.bin		
AC CM Measurement:	AC CM: Vac [mVp2p]	81.2

3. cts_test_name – **ui_ssc_eye**

The test above shall be used for the following calibration:

a) 4.2.1.6 Input Eye Diagram

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded rx tp3_prime ui_ssc_eye
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\
TP3_Prime_Gen2_Rounded_prbs31.bin none eye none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
Input Eye Diagram - Calibration
Loading File TP3_Prime_Gen2_Rounded_prbs31.bin ....
Writing eye_diagram_gen2_rounded_tp3_prime_eye.jpg
Writing result to .\eye_result_21-Oct-2020.csv
The tests are completed
```

Report files location:

SigTest_USB4_CTS

☐ Name

    📊 eye_result_21-Oct-2020.csv
    🖼 eye_diagram_gen2_rounded_tp3_prime_eye.jpg
    ◢ USB4_SigTest.exe
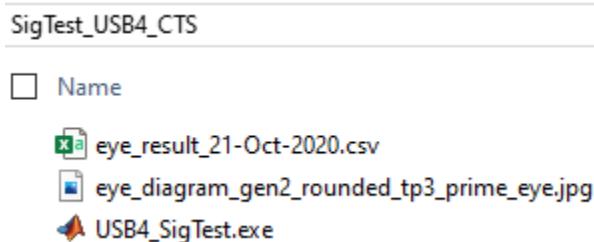
3.1.   The .csv file eye_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded					
Date:	21-Oct-20				
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\					
File: TP3_Prime_Gen2_Rounded_prbs31.bin					
Eye Diagram Measurement:	EyeWidth [pS]	89.281492	EyeHeight[mV]	593.984184	
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.975472	Drift [PPM]	-2452.82

3.2.   The .jpg file eye_diagram_gen2_rounded_tp3_prime_eye.jpg

Eye Recovered - Delay by 6.265[pS]
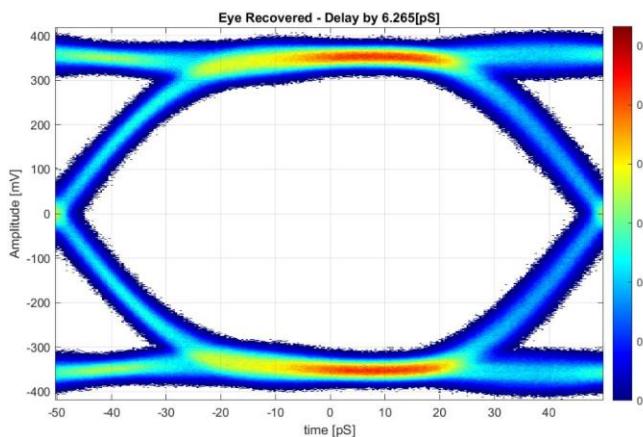
4. cts_test_name – **frequency_variation_training**

there is a need to calibrate the RX SSC profile to meet CTS requirement.

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded rx tp3_prime frequency_variation_training

C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_prime\
rx_frequency_variation_training.bin none rx_clk_switch_cal none

```
***** SIGTEST Version: 0.6 ******
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
TX Frequency Variation Training Measurement
Loading File rx_frequency_variation_training.bin ...
Writing rx_clock_switch_analysis_gen2_rounded_tp3_prime_rx_clk_switch_cal.jpg
Writing result to .\rx_clk_switch_cal_result_21-Jul-2021.csv
The tests are completed
```

Report files location:

Name	Date modified	Type	Size
rx_clk_switch_cal_result_21-Jul-2021.csv	7/21/2021 3:40 PM	Microsoft Excel C...	2 KB
rx_clock_switch_analysis_gen2_rounded_tp3_prime_rx_clk_switch_cal.jpg	7/21/2021 3:40 PM	JPG File	75 KB
histogram_rx_ri_ddj_gen2_rounded_tp3_jitter.jpg	7/21/2021 2:22 PM	JPG File	48 KB

4.1. The .csv file rx_clk_switch_cal_result_21-Jul-2021.csv

Electrical Compliance Test Specification for gen2_rounded						
Date:21-Jul-2021						
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_prime\						
File: rx_frequency_variation_training.bin						
RX Frequency Variation Training Measurement:						
INIT_FREQ_VARIATION:	PASS	RX_INIT_FREQ_VARIATION result:	298.659135	CTS: Min RX_INIT_FREQ_VARIATION	-300	CTS: Target INIT_FREQ_VARIATION	300
DELTA_FREQ_200nS:	PASS	RX_DELTA_FREQ_200nS result:	-1389.83096	CTS: Abs target RX_DELTA_FREQ_200	1400	
DELTA_FREQ_1000nS:	PASS	RX_DELTA_FREQ_1000nS result:	-2189.70318	CTS: Abs target RX_DELTA_FREQ_100(	2200	
FREQ_OVERSHOOT:	PASS	RX_FREQ_OVERSHOOT result:	1593.431124	CTS: Target RX_FREQ_OVERSHOOT	1600	
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.981822	Drift [PPM]	-1817.76	

4.2. The .jpg file rx_clock_switch_analysis_gen2_rounded_tp3_prime_rx_clk_switch_cal.jpg
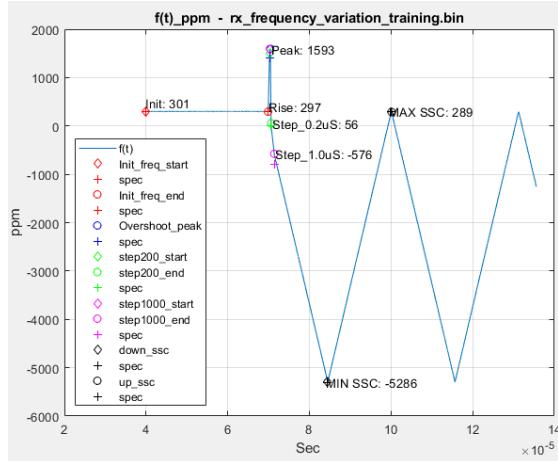
Note – there is a need to calibrate RX SSC profile for RX frequency variation training test over TP3, the usage is the same except the test point

.\USB4_SigTest.exe gen3_legacy rx **tp3** frequency_variation_training
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\ rx_frequency_variation_training.bin
none rx_clk_switch_cal_tp3 none

All same but over results the overshoot limit is 1400ppm

	A	B	C	D	E	F	G	H
1	Electrical Compliance Test Specification for gen3_legacy							
2	Date:21-Jul-2021							
3	DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\							
4	File: rx_frequency_variation_training.bin							
5	RX Frequency Variation Training Measurement:							
6	INIT_FREQ_VARIATION:	PASS	RX_INIT_FREQ_VARIATION result:	299.818	CTS: Min RX_INIT_FREQ_VARIATION	-300	CTS: Target INIT_FREQ_VARIATION	300
7	DELTA_FREQ_200nS:	PASS	RX_DELTA_FREQ_200nS result:	-1386.11	CTS: Abs target RX_DELTA_FREQ_200nS	1400		
8	DELTA_FREQ_1000nS:	PASS	RX_DELTA_FREQ_1000nS result:	-2184.71	CTS: Abs target RX_DELTA_FREQ_1000nS	2200		
9	FREQ_OVERSHOOT:	PASS	RX_FREQ_OVERSHOOT result:	1389.743	CTS: Target RX_FREQ_OVERSHOOT	1400		
10	Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	20.58823	Drift [PPM]	-1782.83		
11								
12								

7.3 TP3 – Case2

   4. cts_test_name – **tp3**

The test below shall be used for the following calibration:

   a) 4.2.2.1 Input Eye Diagram

Notes:

   e) Save 5 waveforms with PRBS31 pattern using the scope configuration above.
   f) Save 1 waveform with PRBS15 pattern using the scope configuration above.
   g) The saved waveforms for each trial shall be in the same folder.
      1 trial – prbs15 and 5 trials – prbs31.
   h) The waveforms names shall be the same as in the screenshot below.

Run the following command from the PowerShell window:

.\USB4_SigTest.exe gen2_rounded rx tp3 tp3
C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\Rx\ tp3.bin none eye_jitters none

```
Running SIGTEST : Technology : GEN2_ROUNDED, TestMode : RX, TestPoint : TP3
The following tests are in progress ...
Receiver TP3 Input Eye Diagram Calibration
Loading File tp3_prbs31_trial_1.bin ...
Loading File tp3_prbs31_trial_2.bin ...
Loading File tp3_prbs31_trial_3.bin ...
Loading File tp3_prbs31_trial_4.bin ...
Loading File tp3_prbs31_trial_5.bin ...
Loading File tp3_prbs31_trial_2.bin ...
Writing eye_diagram_gen2_rounded_tp3_eye_jitters.jpg
Loading File tp3_prbs15.bin ...
Writing tj_bathtub_gen2_rounded_tp3_eye_jitters.jpg
Writing histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitters.jpg
Writing result to .\eye_jitters_result_25-Oct-2020.csv
The tests are completed
```


Report files location:

> SigTest_USB4_CTS

  ☐ Name

    eye_jitters_result_21-Oct-2020.csv
    histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitters.jpg
    tj_bathtub_gen2_rounded_tp3_eye_jitters.jpg
    eye_diagram_gen2_rounded_tp3_eye_jitters.jpg
    USB4_SigTest.exe
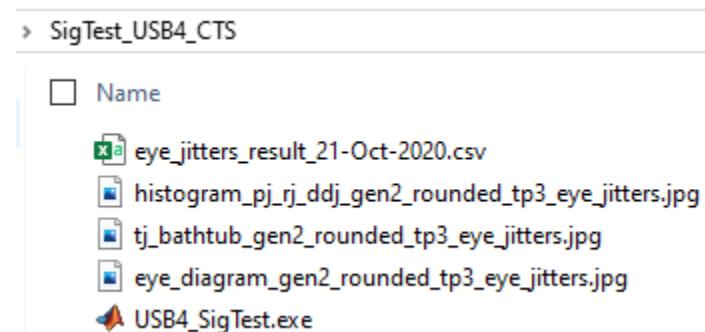
4.1. The .csv file eye_jitters_result_21-Oct-2020.csv

Electrical Compliance Test Specification for gen2_rounded															
Date:	25-Oct-20														
DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\Rx\															
File: tp3.bin															
Eye Diagram Measurement:	EyeWidth [pS]	81.841387	EyeHeight[mV]	207.027864											
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	9.975465	Drift [PPM]	-2453.53										
CTLE-Adc[dB]	CTLE-DC Gain[dB]	DFE[mV]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Eye Height[mV]	EYE Width[pS]	Avg. Height[mV]	Avg. Width[pS]	Area[mV*pS]
1	0	50	1.409	0.783	0.285	1.175	0.318	1.175	1.457	0.783	0.313	0.783	0.76	0.94	0.64
0.891	1	48.2	142.647	62.262	129.546	59.129	140.216	63.437	141.373	61.479	136.547	61.479	138.07	61.557	8504.51
0.794	2	42	170.9	71.269	162.341	70.877	172.953	70.485	172.992	70.485	168.59	70.485	169.56	70.72	11990.66
0.708	3	36.7	197.61	78.317	191.643	77.925	199.418	79.883	198.652	80.275	194.414	79.1	196.35	79.1	15533.05
0.631	4	32	208.352	82.233	205.568	80.667	206.991	81.058	208.858	82.233	205.37	83.016	207.03	81.841	16943.65
0.562	5	27.8	196.69	80.275	195.141	82.233	197.331	83.016	199.43	82.625	194.586	81.45	196.64	81.92	16108.95
0.501	6	24	185.353	76.751	182.983	76.359	185.388	79.883	185.091	79.492	181.683	74.01	184.1	77.299	14233.46
0.447	7	20.7	170.463	70.877	168.146	72.443	172.005	72.443	171.527	71.269	168.334	72.052	170.09	71.817	12215.35
0.398	8	17.8	154.847	66.57	153.365	67.744	156.741	67.744	156.386	67.744	154.618	67.744	155.19	67.509	10476.95
0.355	9	15.2	138.71	62.262	139.772	61.87	142.913	63.045	140.059	63.828	140.079	63.045	140.31	62.81	8813.04
Optimal CTLE: 4															

4.2. The .jpg file histogram_pj_rj_ddj_gen2_rounded_tp3_eye_jitters.jpg
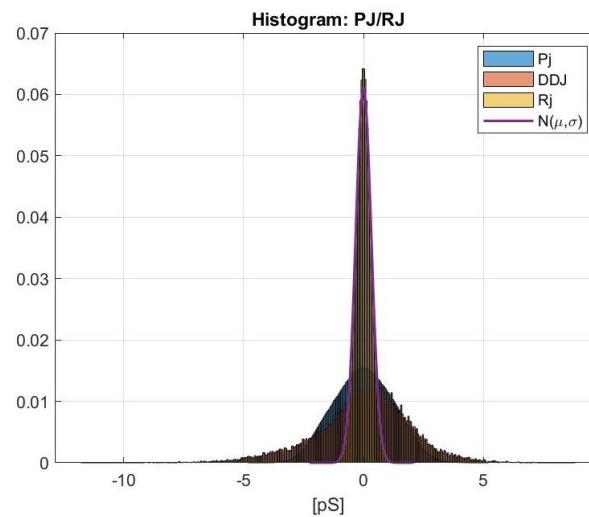
4.3. The .jpg file tj_bathtub_gen2_rounded_tp3_eye_jitters.jpg

4.4.   The .jpg file eye_diagram_gen2_rounded_tp3_eye_jitters.jpg

Eye Recovered - Delay by -3.133[pS]
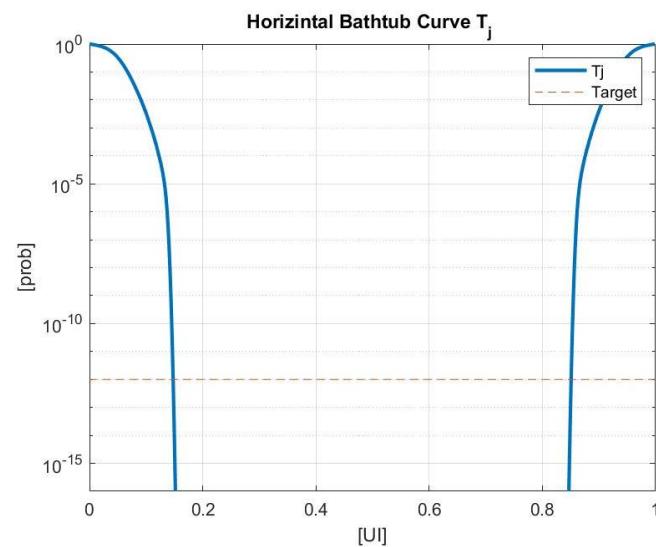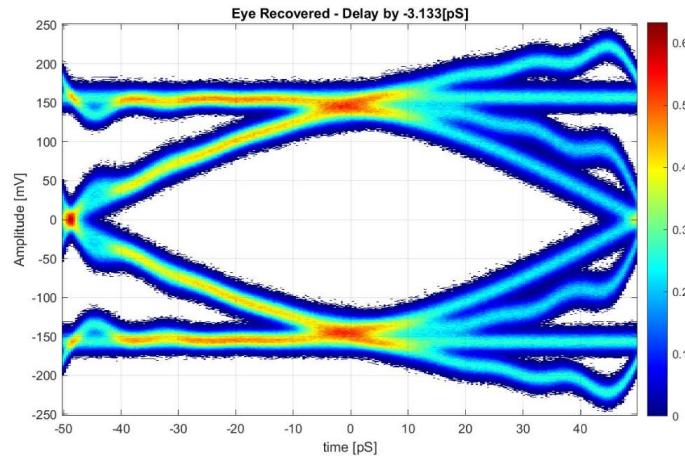
8 GEN4 Router Assembly Receiver Testing

8.1 General notes

This section describes commands list for Receiver testing

8.2 Oscilloscope intrinsic noise cancelation

See Appendix D of USB4 GEN4 CTS document for scope intrinsic noise measurement procedure.

scope_intrinsic_noise_p and scope_intrinsic_noise_n files shall be located in wdir (waveforms location)

8.3 GEN4 Router Assembly Receiver stressed signal calibration

This section describes commands list to be used for TP3' calibration for case1, BERT output calibration for case2, channel calibration to worst case condition for TP3

8.3.1 TP3' for Case1 and BERT output calibration for Case2

This procedure shall be used for RX calibration purpose for both TP3' and BERT output calibration.
Input signal for analysis are two single ended signal waveforms (p and n). Output report for analysis includes all calibration components as defined in spec. Waveform file names shall include prefixes: "p_..." and "n_..."

1. cts_test_name – **calibration**
2. test_point = **tp3_prime**

1. Run the following command from the PowerShell window:

Command example:

```
.\USB4_SigTest.exe gen4 rx tp3_prime calibration C:\SigTest\Waveforms\
p_prts7_preset_0.bin n_prts7_preset_0.bin calibration_report none
```

```
PS C:\SigTest> .\USB4_SigTest.exe gen4 rx tp3_prime calibration C:\SigTest\Waveforms\ p_prts7_preset_0.bin n_prts7_prese
t_0.bin calibration_report none
****** SIGTEST Version: 0.72 ******
Running SIGTEST : Technology : GEN4, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
USB4 gen4:Calibration ACCM,Jitters and Vertical
Loading File P: C:\SigTest\Waveforms\p_prts7_preset_0.bin & File N:C:\SigTest\Waveforms\n_prts7_preset_0.bin ....
Loading File: C:\SigTest\Waveforms\scope_intrinsic_noise.bin ....
Writing calibration_report_tj_bathtub_gen4_tp3_prime.jpg
Writing calibration_report_histogram_pj_rj_ddj_gen4_tp3_prime.jpg
Informative:Intrinsic Scope Noise = 3.431[mV-rms]
TX LEVELS MISMATCH = 0.975
TX LEVEL = +526.1[mV]
TX LEVEL = -8.8[mV]
TX LEVEL = -518.0[mV]
V_Steady-State = +514.4[mV]
TX_PULSE_PEAK = +526.1[mV]
TX_SNDR  = 32.4[dB]
TX_ISI_MARGIN   = 19.4[dB]
TX.Budget: Djst=3.2[mV], Noise=12.3[mV] total= 12.7[mV]
Writing result to .\calibration_report_result.csv
The tests are completed
PS C:\SigTest>
```

2. Report files location:

Local Disk (C:) › SigTest

Name

- 📁 Waveforms
- 🖼 calibration_report_histogram_pj_rj_ddj_gen4_tp3_prime.jpg
- 📊 calibration_report_result.csv
- 🖼 calibration_report_tj_bathtub_gen4_tp3_prime.jpg
- 📄 tmp_sndr.txt
- 🛩 USB4_SigTest.exe

3. calibration_report_result.csv report file as an example

Electrical Compliance Test Specification for GEN4					
Date:	07-Mar-22				
DIR:	C:\SigTest\Waveforms\				
Files:	p_prts7_preset_0.bin	n_prts7_preset_0.bin			
AC CM Measurement:	AC CM: Vac [mVp2p]	85.1			
PJ Jitter Measurement mUIp-p:	PJ-p-p	86.968214			
RJ Jitter Measurement mUIrms:	RJ-rms	6.044195			
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.561618	Drift [PPM]	-1499.28
Vertical Analysis Test:					
TX_SNDR Measurement [dB]:	TX_SNDR [dB]	32.367073			
TX_LEVELS_MISMATCH Measurement:	TX_LEVELS_MISMATCH	0.97538			
V_SWING Measurement [mVp-p]:	V_SWING-p-p	1028.8			

4. calibration_report_histogram_pj_rj_ddj_gen4_tp3_prime.jpg

Histogram: PJ/RJ

5. calibration_report_tj_bathtub_gen4_tp3_prime.jpg

Horizontal Bathtub Curve T_j
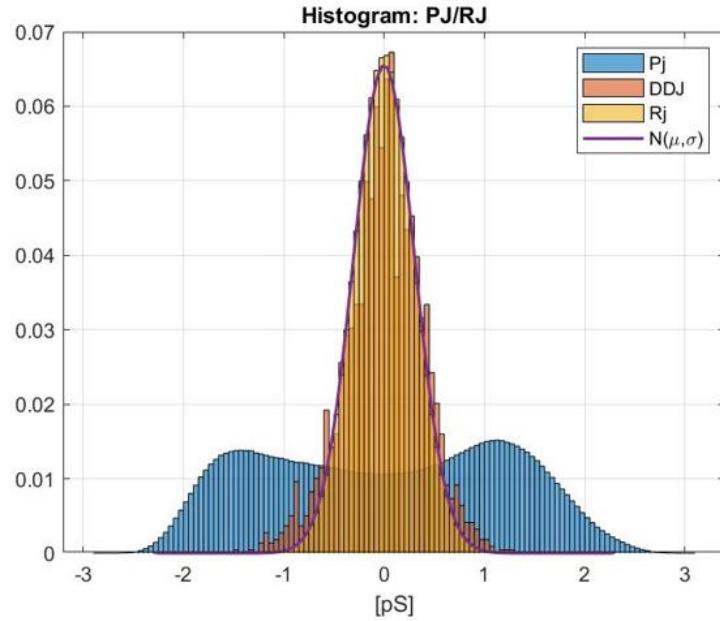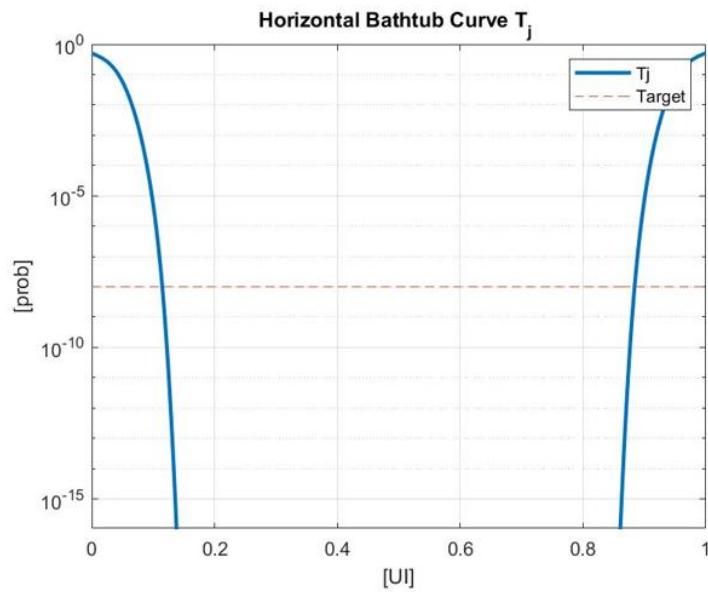
8.3.2 Channel calibration to worst case condition

This procedure shall be used for RX calibration purpose for channel calibration to worst case condition.

Input files for analysis are:
- Test_Channel.s4p
- BERT_Sdd22.s2p
- BERT_Sdd21.[scope format]
- complementary (folder)

Local Disk (C:) > SigTest > Waveforms

Name

📁 complementary
📄 BERT_Sdd21.bin
📄 BERT_Sdd22.s2p
📄 Test_Channel.s4p
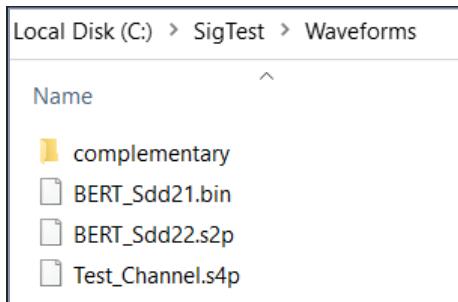
The file names shall be as listed above. The location of the files shall be specified in command line (see command line example below). The complementary folder provided as zip file along with SigTest code and includes all required files for ECOM analyzer

Output excel report includes two calibration components as defined in CTS:
- TX_SJ_increase [SJ magnitude increase]
- V_SWING [Voltage swing]

1. cts_test_name – **calibration**
2. test_point = **tp3**

1. Run the following command from the PowerShell window:

Command example:

```
.\USB4_SigTest.exe gen4 rx tp3 calibration C:\SigTest\Waveforms\
BERT_Sdd21.bin none
channel_calibration_to_worst_case_condition_result_result.csv none
none
```

```
PS C:\SigTest> .\USB4_SigTest.exe gen4 rx tp3 calibration C:\SigTest\Waveforms\ BERT_Sdd21.bin none channel_calibration_
to_worst_case_condition_result none none
***** SIGTEST Version: 0.72 ******
Running SIGTEST : Technology : GEN4, TestMode : RX, TestPoint : TP3
The following tests are in progress ...
USB4 gen4:Channel calibration to worst case condition
Loading File: C:\SigTest\Waveforms\BERT_Sdd21.bin ....
run_eCOM_from_s4p 1.0
Call for eCOM for channel 0
Load config data from spreadsheet...
Load channel s4p files:     1    2    3    4
Skip Cascading Tx die-loading with channel...
Skip Cascading Rx die-loading with channel...
Skip Cascading Tx die-loading with channel...
Skip Cascading Rx die-loading with channel...
Skip Cascading Tx die-loading with channel...
Skip Cascading Rx die-loading with channel...
Skip Cascading Tx die-loading with channel...
Skip Cascading Rx die-loading with channel...
Apply Tx and Rx termination...
Apply Tx filter...
Apply Rx filter...
Calculate IL_fit_at_Nq, IMR, and IXT...
Get channel impulse responses...
Get Tx FFE presets...
Get Rx CTLE impulse responses. This may take some time...
Apply TX FFE Get to CTLE impulse responses. This may take some time...
Start to find the optimal EQ. This may take some time ...
    Process CTLE Index:    1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
                          21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
                          41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
                          61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
                          81 82 83 84 85 86 87 88 89 90 91
Process the tie-breakers ...
Try TX FFE = 0.025,-0.2,0 and CTLE DC Gain = -12,-5:  eCOM_h= -0.185 dB and eCOM_w = -0.010 dB
Try TX FFE = 0.025,-0.2,0 and CTLE DC Gain = -12,-4:  eCOM_h= 0.018 dB and eCOM_w = 0.010 dB
Try TX FFE = 0.025,-0.2,0 and CTLE DC Gain = -12,-6:  eCOM_h= -0.499 dB and eCOM_w = -0.181 dB
Try TX FFE = 0.025,-0.2,-0.05 and CTLE DC Gain = -11,-4:  eCOM_h= -0.071 dB and eCOM_w = 0.000 dB
Try TX FFE = 0.025,-0.2,-0.05 and CTLE DC Gain = -12,-4:  eCOM_h= -0.159 dB and eCOM_w = -0.037 dB
PASS ... eCOM_h = 0.018 dB
Finish statistical analysis!
Finish
===>>> ECOM=0.02dB (Initial ECOM=0.02dB)
===>>> Tx Swing=0.40 [V-peak],  TX_SJ Increase=0.000 [UI]
Writing result to .\channel_calibration_to_worst_case_condition_result_result.csv
The tests are completed
```

2. Report files location:

Local Disk (C:) > SigTest

Name

📁 Waveforms

📊 channel_calibration_to_worst_case_condition_result_result.csv

📄 USB4_SigTest.exe
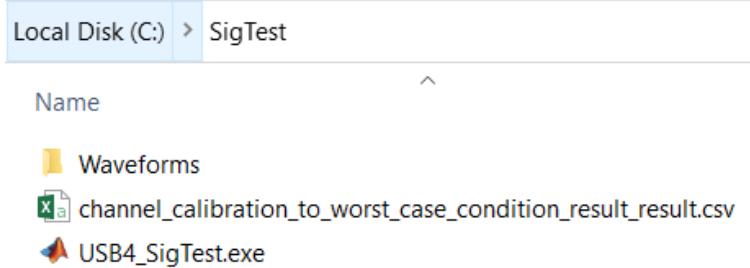
3. channel_calibration_to_worst_case_condition_result_result.csv

Electrical Compliance Test Specification for GEN4					
Date:	08-Apr-22				
DIR:	C:\SigTest\Waveforms\				
File:	BERT_Sdd21.bin				
Calibrate to:	TX_SJ_increase [mUIp-p]	0			
Calibrate to:	V_SWING [mVp-p]	800			
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.599956	Drift [PPM]	-1.73

8.4 TP3'

8.4.1 rx_frequency_variation

This function shall be used for USB4 v2 GEN4 Rx Frequency Variation profile calibration

Run the following command from the PowerShell window:

Command example:
```
.\USB4_SigTest.exe gen4 rx tp3_prime frequency_variation_training
C:\SigTest_USB4_CTS\Waveforms\
rx_frequency_variation_gen4_tp3_prime.bin none
rx_frequency_variation_calibration_tp3_prime none
```

```
PS C:\SigTest_USB4_CTS> .\USB4_SigTest.exe gen4 rx tp3_prime frequency_variation_training C:\SigTest_USB4_CTS\Waveforms\
 rx_frequency_variation_gen4_tp3_prime.bin none rx_frequency_variation_calibration_tp3_prime none
***** SIGTEST Version: 0.83 ******
Running SIGTEST : Technology : GEN4, TestMode : RX, TestPoint : TP3_PRIME
The following tests are in progress ...
Frequency Variation Training Measurement
Loading File: C:\SigTest_USB4_CTS\Waveforms\rx_frequency_variation_gen4_tp3_prime.bin ....
Writing rx_frequency_variation_calibration_tp3_prime_rx_clock_switch_analysis_gen4_tp3_prime.jpg
Writing result to .\rx_frequency_variation_calibration_tp3_prime_result.csv
The tests are completed
```

Report files location:

📁 Waveforms	16/12/2022 16:51	File folder	
📄 rx_frequency_variation_calibration_tp3_prime_result.csv	16/12/2022 16:56	Microsoft Excel Co...	2 KB
📄 rx_frequency_variation_calibration_tp3_prime_rx_clock_switch_analysis_gen4_tp3_prime.jpg	16/12/2022 16:56	JPG File	73 KB
🔺 USB4_SigTest.exe	16/12/2022 15:14	Application	5,532 KB

The .csv file rx_frequency_variation_calibration_tp3_prime_result.csv as a results example

Electrical Compliance Test Specification for GEN4						
Date:	16-Dec-22					
DIR:	C:\SigTest_USB4_CTS\Waveforms\					
File:	rx_frequency_variation_gen4_tp3_prime.bin					
RX Frequency Variation Training Measurement:						
INIT_FREQ_VARIATION:	PASS	RX_INIT_FREQ_VARIATION result:	299.534768	CTS: Min RX_INIT_FREQ_VARIATION	275	CTS: Max RX_INIT_FREQ_VARIATION	325
DELTA_FREQ_200nS:	PASS	RX_DELTA_FREQ_200nS result:	578.571019	CTS: Min RX_DELTA_FREQ_200nS	575	CTS: Max RX_DELTA_FREQ_200nS	625
DELTA_FREQ_1000nS:	PASS	RX_DELTA_FREQ_1000nS result:	895.301998	CTS: Min RX_DELTA_FREQ_1000nS	875	CTS: Max RX_DELTA_FREQ_1000nS	925
FREQ_OVERSHOOT:	PASS	RX_FREQ_OVERSHOOT result:	595.098731	CTS: Min RX_FREQ_OVERSHOOT	575	CTS: Max RX_FREQ_OVERSHOOT	625
STEADY_STATE_FREQ_VARIATION:	PASS	STEADY_STATE_FREQ_VARIATION result:	-302.754177	CTS: Min STEADY_STATE_FREQ_VARIATION	-325	CTS: Max STEADY_STATE_FREQ_VARIATION	-275
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.598735	Drift [PPM]	-49.41	

The SIGTEST saves the following plot (.jpg format)

f(t)_ppm - rx_frequency_variation_gen4_tp3_prime.bin

8.4.2 rl

This function calculates Return Loss (rl) and Integrated Return Loss (irl) for RX lanes
Expected input for RX RL and IRL analysis is s2p file only, no signal waveform is required

1. Run the following command from the PowerShell window:

Command example:
```
.\USB4_SigTest.exe gen4 rx tp2 rl C:\SigTest\Waveforms\ none none
rl_report none pam3_prts7_preset_19_s2p.s2p
```

```
PS C:\SigTest> .\USB4_SigTest.exe gen4 rx tp2 rl C:\SigTest\Waveforms\ none none rl_report none
 pam3_prts7_preset_19_s2p.s2p
***** SIGTEST Version: 0.72 ******
Running SIGTEST : Technology : GEN4, TestMode : RX, TestPoint : TP2
The following tests are in progress ...
Receiver Return Loss & Integrated Return Loss
Reading S parameters File: C:\SigTest\Waveforms\pam3_prts7_preset_19_s2p.s2p ..
IRL=-36.0[dB]
Writing rl_report_receiver_differential_rx12_return_loss_gen4_tp2.jpg
Writing result to .\rl_report_result.csv
The tests are completed
```

2. report file location:

Local Disk (C:) > SigTest

Name

📁 Waveforms
🖼 rl_report_receiver_differential_rx12_return_loss_gen4_tp2.jpg
📊 rl_report_result.csv
🔺 USB4_SigTest.exe

3. rl_report_result.csv as a result example

Electrical Compliance Test Specification for GEN4							
Date:	08-Mar-22						
DIR:	C:\SigTest\Waveforms\						
File:	none						
Receiver Return Loss & Integrated Return Loss							
IRL:	PASS	IRL[dB]:	-35.962857	CTS: Max IRL	-14.5		
Informative:	Sdd11 MASK:	PASS					
Informative:	Sdd11 max[dB]	-12.5	Margin[dB]	4	Fmax[GHz]	0.730062

- Sdd11 max[dB] indicates closest to spec mask absolute RL result
- Sdd11 MASK indicates RL pass/fail criteria
- Margin[dB] indicates the delta between absolute RL result to spec mask
- Fmax[GHz] indicates the frequency of the closest to spec mask absolute RL result
- IRL[dB] indicates calculated IRL
- IRL indicates IRL pass/fail criteria
- CTS: Max IRL indicates the IRL spec limit

4. rl_report_receiver_differential_rx12_return_loss_gen4_tp2.jpg
   Return Loss plot with spec mask
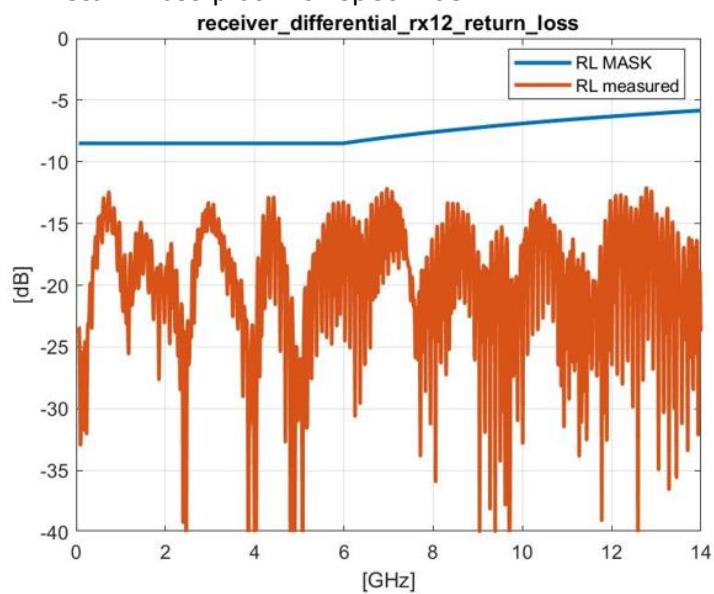
8.5 TP3

8.5.1 rx_frequency_variation

This function shall be used for USB4 v2 GEN4 Rx Frequency Variation profile calibration

Run the following command from the PowerShell window:

Command example:

```
.\USB4_SigTest.exe gen4 rx tp3 frequency_variation_training
C:\SigTest_USB4_CTS\Waveforms\ rx_frequency_variation_gen4_tp3.bin
none rx_frequency_variation_calibration_tp3 none
```

```
PS C:\SigTest_USB4_CTS> .\USB4_SigTest.exe gen4 rx tp3 frequency_variation_training C:\SigTest_USB4_CTS\Waveforms\ rx_fr
equency_variation_gen4_tp3.bin none rx_frequency_variation_calibration_tp3 none
***** SIGTEST Version: 0.83 ******
Running SIGTEST : Technology : GEN4, TestMode : RX, TestPoint : TP3
The following tests are in progress ...
Frequency Variation Training Measurement
Loading File: C:\SigTest_USB4_CTS\Waveforms\rx_frequency_variation_gen4_tp3.bin ....
Writing rx_frequency_variation_calibration_tp3_rx_clock_switch_analysis_gen4_tp3.jpg
Writing result to .\rx_frequency_variation_calibration_tp3_result.csv
The tests are completed
```

Report files location:

Waveforms	16/12/2022 17:02	File folder	
rx_frequency_variation_calibration_tp3_result.csv	16/12/2022 17:01	Microsoft Excel Co...	2 KB
rx_frequency_variation_calibration_tp3_rx_clock_switch_analysis_gen4_tp3.jpg	16/12/2022 17:01	JPG File	72 KB
USB4_SigTest.exe	16/12/2022 15:14	Application	5,532 KB

The .csv file rx_frequency_variation_report_result.csv as a results example

Electrical Compliance Test Specification for GEN4							
Date:	16-Dec-22						
DIR:	C:\SigTest_USB4_CTS\Waveforms\						
File:	rx_frequency_variation_gen4_tp3.bin						
RX Frequency Variation Training Measurement:							
INIT_FREQ_VARIATION:	PASS	RX_INIT_FREQ_VARIATION result:	299.534768	CTS: Min RX_INIT_FREQ_VARIATION	275	CTS: Max RX_INIT_FREQ_VARIATION	325
DELTA_FREQ_200nS:	PASS	RX_DELTA_FREQ_200nS result:	578.571019	CTS: Min RX_DELTA_FREQ_200nS	575	CTS: Max RX_DELTA_FREQ_200nS	625
DELTA_FREQ_1000nS:	PASS	RX_DELTA_FREQ_1000nS result:	895.301998	CTS: Min RX_DELTA_FREQ_1000nS	875	CTS: Max RX_DELTA_FREQ_1000nS	925
FREQ_OVERSHOOT:	PASS	RX_FREQ_OVERSHOOT result:	595.098731	CTS: Min RX_FREQ_OVERSHOOT	575	CTS: Max RX_FREQ_OVERSHOOT	625
STEADY_STATE_FREQ_VARIATION:	PASS	STEADY_STATE_FREQ_VARIATION result:	-302.754177	CTS: Min STEADY_STATE_FREQ_VARIATION	-325	CTS: Max STEADY_STATE_FREQ_VARIATION	-275
Informative: Symbol Rate [GHz]:	NONE	Symbol Rate	25.598735	Drift [PPM]	-49.41		

The SIGTEST saves the following plot (.jpg format)

f(t)_ppm - rx_frequency_variation_gen4_tp3.bin