Tektronix

Tektronix PCI Express
TekRxTest Suite Datasheet

Improve accuracy and precision of PCI Express Gen6 Receiver Stressed Eye Calibration with Tektronix automation software. Remove the complexity of receiver testing with a step-by-step user interface designed by industry leaders engaged in the standards bodies to drive the latest specifications to maturity. Industry engagement ensures our software will evolve in-step with the technology. Achieving the correct balance of simplicity and user control has been at the forefront of the design team to ensure your device can complete link training with the correct calibrated stress and be efficiently tested with optimized PHY settings.

Perform PLL Bandwidth tests for Gen 3/4/5 supporting tests with compliance (P0 to P10) and jitter measurement (toggle) patterns. Incorporates software CTLE with higher accuracy for high loss channel cases.

Applications

- PCI Express 64 GT/s, 32 GT/s, and 16 GT/s
- Gen6/Gen5 Base Specification (silicon validation) and Gen4/Gen5 CEM Specification (system verification and compliance)
- Root Complex and Non-Root Complex silicon
- Systems (motherboards and servers), Add-in Cards, Switches, and Bridges, Extension Devices (retimers and redrivers)

Features and benefits

General

- Receiver automation software for Tektronix DPO70000SX Series Real Time Scopes and Anritsu MP1900A BERT
- Wizard based user interface for each step of calibration and test
- Pop-up user tips to simplify decision making

- Latest industry tool support (SigTest and Seasim)
- Calibration and test reports

PCI Express Gen6 (64 GT/s)

- Stressed Eye Calibration (64 GT/s)
  - Base
  - TP3 – AC/DC Balance, Amplitude, 4 Tap Tx Equalization, Sinusoidal Jitter tones, and Random Jitter
  - TP2 – DMI, CMI, Preset and CTLE Selection, Stressed Eye
  - Automated Scope Noise Compensation for SJ and RJ calibration

PCI Express Gen5 (32 GT/s)

- Stressed Eye Calibration (32 GT/s) and
  - Base & CEM
  - TP3 – AC/DC Balance, Amplitude, Tx Equalization, Sinusoidal Jitter tones, and Random Jitter
  - TP2 – DMI, CMI, Preset and CTLE Selection, Stressed Eye, Automated loopback through Configuration and Recovery
- Insertions Loss computation powered by Seasim Statistical Simulation Tool
- Rx Link Equalization (32 GT/s)
- Tx Link Equalization (32 GT/s)
- Jitter Tolerance (32 GT/s)
- Advanced debug mode for troubleshooting LEQ tests

PCI Express Gen4 (16 GT/s)

- Stressed Eye Calibration (32 GT/s)
  - CEM and Base
  - TP1 – AC/DC Balance, Amplitude, Tx Equalization, Sinusoidal Jitter tones, and Random Jitter
- TP2 – DMI, CMI, Preset and CTLE Selection, Stressed Eye, Automated loopback through Configuration and Recovery
- Insertions Loss computation powered by Seasim Statistical Simulation Tool
- Rx Link Equalization (16 GT/s)
- Tx Link Equalization (16 GT/s)
- Jitter Tolerance (16 GT/s)
- Advanced debug mode for troubleshooting LEQ tests

PCI Express PLL Bandwidth and Peaking

- PCI Express PLL Bandwidth and Peaking automation software for Tektronix DPO70000SX Series Real-Time Oscilloscopes and Anritsu MP1900A BERT
- Support for Gen 3/4/5 Tx PLL testing
- Support for Anritsu SI PPG (NRZ) and PAM4 PPG
- Similar software look and feel as the Receiver test suite
- Supports testing with compliance (P0 to P10) and jitter measurement (toggle) patterns
- Software CTLE improves accuracy for high loss channel cases
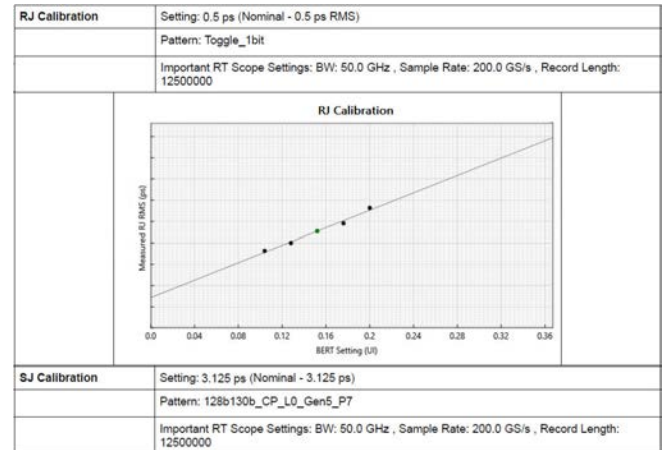
Stressed Eye Calibration

Calibration of the stressed eye signal, generated by the BERT's PPG, is important to ensure the receiver is tested in alignment with the PCI-SIG specifications with the proper amount of impairments. New challenges at 64 GT/s demand the fully automated approach taken by the Tektronix PCI Express Receiver Test Suite to avoid alternative tedious and error-prone approaches. Let the domain expertise and experience of the Tektronix engineers guide you through the steps of calibration starting with accurate TP3 measurements and ending with an end of channel eye diagram easily obtained within the tolerances required. Engineers will spend less time calibrating and more time collecting meaningful data on receiver performance and margin.

TP3 calibration

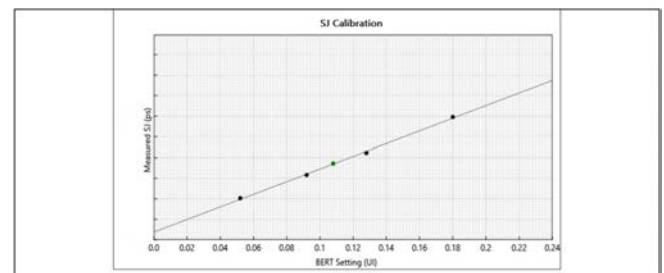### PCI Express Gen6 (64 GT/s)/Gen5 (32 GT/s)

The TP3 (cable from BERT PPG to oscilloscope) is mandatory for all devices to ensure tolerances are met at the defined reference plane. The Tektronix PCI Express Receiver Test Suite wizard will guide the user through all the necessary steps to ensure the pre-channel signal matches the specification requirements to ensure future calibration steps are completed with ease.

1. AC-DC Balance – Small amounts of Tx EQ de-emphasis are enabled to balance low and high-frequency sections of the pattern at a common reference plane.
2. Amplitude – The differential voltage swing is required to be within 720 – 800 mV.
3. Tx Equalization Presets – Calibration of pre-shoot 1, pre-shoot 2 (Gen6 only), and de-emphasis is required to ensure true preset levels are used for testing receivers.
4. IL Measurement – Channel insertion loss is calculated using Seasim between TP1 and TP3 (loss before the TP3 reference is computed here for later removal).
5. RJ – Random Jitter (RJ) is calibrated to be 0.25 ps [Gen6], 0.5 ps [Gen5] (RMS value) nominally.
6. SJ – Sinusoidal Jitter (Sj) is calibrated over the required range of 1-3 ps [Gen6] / 1-5 ps [Gen5] (p-p) at 100 MHz frequency.

RJ and SJ calibration for Gen5

7. SJ@210 MHz – This calibration is required for JTOL measurements with some calibrations

SJ@210 MHz calibration for Gen5

8. Multi-tone SJ – For JTOL measurements where up to maximum 14 frequencies are used, calibration for frequencies other than 100 MHz is required to be performed.

Automatic characterization and precise calibration of presets, RJ, and SJ along with the important parameters used for calibration like pattern type, scope, BERT settings, regression line slopes, and intercept for reference.

TP1 calibration

PCI Express Gen4 (16 GT/s)

The TP1 (cable from BERT PPG to scope) is mandatory for all devices to ensure tolerances are met at the defined reference plane. Tek Tektronix PCI Express Receiver Test Suite wizard will guide the user through all the necessary steps to pre-channel signal is true to the specification requirements to ensure future calibration steps complete with ease.
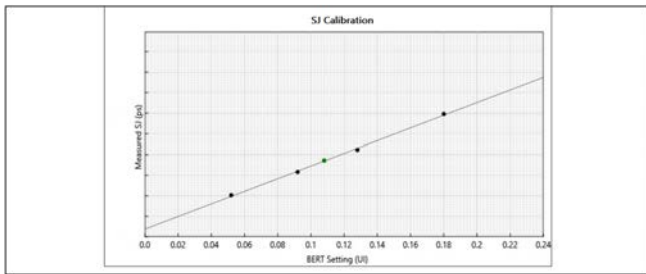
1. AC-DC Balance – Small amounts of Tx EQ de-emphasis are enabled to balance low and high-frequency sections of the pattern at a common reference plane.
2. Amplitude – The differential voltage swing is required to be within 720 – 800 mV.

3. Tx Equalization Presets – Calibration of pre-shoot and de-emphasis is required to ensure true preset levels are used for testing receivers.

4. IL Measurement – Channel insertion loss is calculated using Seasim between TP3 and TP1 (loss before the TP3 reference is computed here for later removal).

5. RJ – Random Jitter (RJ) is calibrated to be 1 ps (RMS value) nominally.

RJ Calibration	Setting: 0.5 ps (Nominal - 0.5 ps RMS)
	Pattern: Toggle_1bit
	Important RT Scope Settings: BW: 50.0 GHz , Sample Rate: 200.0 GS/s , Record Length: 12500000

SJ Calibration	Setting: 3.125 ps (Nominal - 3.125 ps)
	Pattern: 128b130b_CP_L0_Gen5_P7
	Important RT Scope Settings: BW: 50.0 GHz , Sample Rate: 200.0 GS/s , Record Length: 12500000

RJ calibration for Gen4

6. SJ – Sinusoidal Jitter (SJ) is calibrated over the required range of 5-10 ps (p-p) including the nominal SJ specification of 0.1 UI (or 6.25 ps) at 100 MHz frequency.

7. SJ@210 MHz – This calibration is required for JTOL measurements with some calibrations.

SJ@210 MHz calibration for Gen4

8. Multi-tone SJ – For JTOL measurements where up to maximum of 14 frequencies are used, calibration for frequencies other than 100 MHz is required to be performed.

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PCIe5.0 CEM Receiver Calibration Report
TP1 Calibration Results

Test Details	
Unique ID	[Example_TP1_Calibration]
Date/Time	05 October 2020, 11:56 PM
Generated By	Tektronix

Additional Comments
No Comments

Test Equipment	
BERT	ANRITSU, MP1900A, 6261788378
Rx Test SW Version	6.0.1.28
RT Scope	TEKTRONIX, DPO77002SX, B321456
RT Scope FW Version	10.11.0 Build 30
TekRxService Version	2.8.0.8
DPOJET Version	10.2.0.17

Result Summary	
TP1 Calibration	Unique ID: [Example_TP1_Calibration]
	Balanced De-emphasis: -1.8 dB
	Differential Amplitude: 800.0 mV
	SJ Setting: 0.1 UI p-p @ 100 MHz (Nominal SJ 3.125 ps / 0.1 UI p-p)
	RJ Setting: 0.16 UI p-p (Nominal RJ 0.5 ps RMS / 0.016 UI p-p)
	SJ@210 MHz Regression Line Parameters: Slope = - / Intercept = -
	Multi-tone SJ Calibration performed for 7 frequencies

TP1 Calibration Details	
AC-DC Balance	Setting De-emphasis: -1.8 dB
	Pattern: 64ones_64zeros_128bit10
	Important RT Scope Settings: BW: 50.0 GHz , Sample Rate: 200.0 GS/s , Record Length: 5000
Amplitude Calibration	Pattern: 64ones_64zeros_128bit10
Preset Calibration	Pattern: 64ones_64zeros_128bit10
	Important RT Scope Settings: BW: 50.0 GHz , Sample Rate: 200.0 GS/s , Record Length: 5000

Example Report:

Automatic characterization and precise calibration of presets, RJ, and SJ along with the important parameters used for calibration like pattern type, scope, BERT settings, regression line slopes, and intercept for reference.

TP2 calibration

PCI Express Gen6 (64 GT/s), Gen5 (32 GT/s), and Gen4 (16GT/s)

The TP2 (end of channel) calibration is a complex process requiring a deep understanding of the BERT, Real Time Oscilloscope, post-processing tools, and the PCIe specifications. The Tektronix PCI Express Receiver Test Suite will remove the complexity and ensure the desired results are achieved through user-friendly automation. Time to complete TP2 is critical, so efficient techniques have been implemented to ensure an accurate stressed eye is achieved within a reasonable time scale. From calibration of DMI (differential mode interference modeling cross-talk) to the fine granularity adjustments to SJ and DMI necessary to find the stressed eye solutions space, our automation software will guide you through this otherwise daunting task.

1. DMI – The differential mode interference is required to be calibrated within 5-25 mV (p-p) [Gen6] / 5-30 mV (p-p) [Gen5] / 10-25 mV (p-p) [Gen4] by capturing the 2.1 GHz sinusoidal output for a duration of 40 ns.

2. CMI – The common-mode interference is required to be calibrated for a nominal voltage of 75 mV (p-p) [Gen6] / 150 mV (p-p) [Gen5] by capturing the 120 MHz sinusoidal output for a duration of 62.5 us.

3. Channel insertion loss for DMI/CMI and eye diagram measurements computed with Seasim (TP1 to TP2/TP2P for 16 GT/s and TP3 to TP2/TP2P for 32 GT/s and 64 GT/s).

4. Channel Selection based on optimal Tx EQ Preset and Rx CTLE – Base Specification compliant for Eye Area criteria.

5. Stressed-Eye calibration – Fine-tuning of the eye using amplitude, SJ, and DMI is utilized to place the stressed eye within allowed tolerances.

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PCIe6.0 Base Receiver Calibration Report

Non-Root Complex TP2 Calibration Results

Details	
Unique ID	TP2NRC_Cal01072022
Date/Time	30 June 2022, 9:12 PM
Generated By	Tektronix

Additional Comments
No Comments

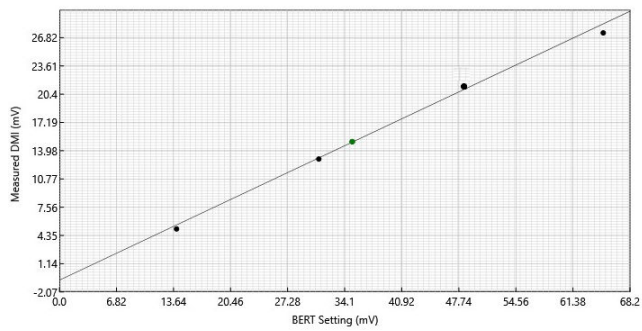| Test Equipment	
BERT	ANRITSU, MP1900A, 6261788378
BERT FW Version	8.03.14
Rx Test SW Version	6.3.2.57
Analysis SW Version	Sigtest Version 5.1.04, Seasim Version 1.06
RT Scope	TEKTRONIX, DPO77002SX, B321456
RT Scope FW Version	10.12.0 Build 26
TekRxService Version	3.0.0.10
DPOJET Version	10.3.0.5

Calibration Summary	
TP2 Calibration	Unique ID: TP2NRC_Cal01072022
	Full Channel Loss: 30.472 dB, Loss Mode: Automatic
	DMI/CMI Loss: 28.572 dB
	Selected Preset: Q8
	Selected CTLE: 10.0 dB
	ISI Pair: Replica 4 and Lane 3
	Status: Converged
	Final Calibrated EW: 3.2 ps (2.825 ps ≤ Target EW ≤ 3.425 ps)
	Final Calibrated EH: 5.6 mV (5.5 mV ≤ Target EH ≤ 6.5 mV)
	Final SJ Stress Level: 1.813 ps / 0.06 UI p-p BERT Setting (1 ps ≤ SJ Sweep ≤ 3 ps)
	Final DMI Stress Level: 9.0 mV / 22 mV BERT Setting (5 mV ≤ DMI Sweep ≤ 25 mV)
	Final Amplitude Level: 800.0 mV (Differential) / 586 mV (Single-Ended) BERT Setting
	SJ@210 MHz Setting during JTOL test: 0.01 UI p-p
	(Calibrated Value of SJ (ps) required to achieve the target stressed eye width minus 1.563 ps)
	Final CMI Stress Level: 75.0 mV / 112 mV BERT Setting
TP3 Calibration	Unique ID: TP3-3062022-Cal
	Balanced De-emphasis: -0.3 dB
	Differential Amplitude: 800.0 mV / Single - Ended Amplitude setting: 586 mV
	SJ Setting: 0.052 UI p-p @ 100 MHz (Nominal SJ 1.563 ps / 0.1 UI p-p)
	RJ Setting: 0.104 UI p-p (Nominal RJ 0.25 ps RMS / 0.016 UI p-p)
	SJ@210 MHz Regression Line Parameters: Slope = 33.491, Intercept = -0.081
	Multi-tone SJ Calibration performed for 7 frequencies

CMI	Setting: 112 mV (Nominal - 75.0 mV)
	Pattern: Electrical_Idle
	Important RT Scope Settings: BW: 33.0 GHz, Sample Rate: 200.0 GS/s, Record Length: 12.5M
	Regression Line Parameters: Slope = 0.681, Intercept = -0.909
CMI	Setting: 112 mV (Nominal - 75.0 mV)
	Pattern: Electrical_Idle
	Important RT Scope Settings: BW: 33.0 GHz, Sample Rate: 200.0 GS/s, Record Length: 12.5M
	Regression Line Parameters: Slope = 0.681, Intercept = -0.909

AIC TP2 calibration results

AIC CMI calibration result

AIC DMI calibration result

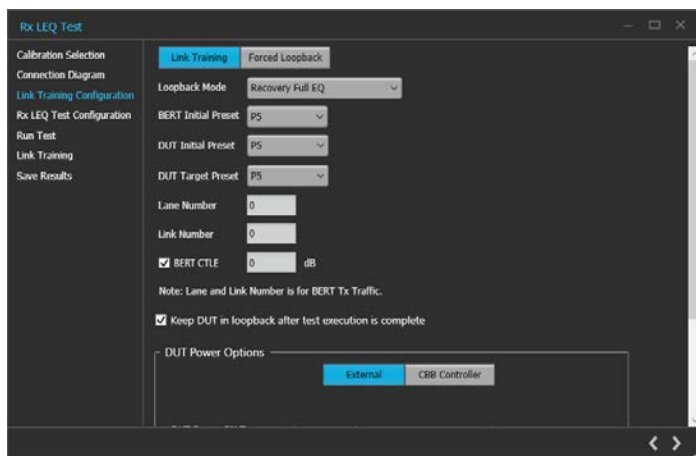| Stressed Eye Calibration	Final SJ Stress Level: 1.813 ps				
	Final DMI Stress Level: 9.0 mV				
	Final Amplitude Level: 800.0 mV				
	Pattern: Toggle_512bits_PAM4				
Index	SJ (ps)	DMI (mV)	Amp (mV)	Eye Width (ps)	Eye Height (mV)
1	1.563	15	800	2.188	3.555
2	1.563	15	800	2.031	3.359
3	1.563	15	800	1.719	2.989
4	1.563	15	800	2.344	3.965
5	1.563	15	800	2.656	3.801
6	1.563	15	800	2.344	3.587
7	1.563	15	800	1.719	2.986
8	1.563	15	800	1.719	2.771
9	1.563	15	800	2.031	3.516
10	1.563	15	800	2.188	3.638
AVERAGE	1.563	15	800	2.094	3.417
11	1.563	13	800	2.812	4.452
12	1.563	13	800	2.5	4.253
13	1.563	13	800	2.344	3.914
14	1.563	13	800	2.812	4.857
15	1.563	13	800	2.969	4.655
16	1.563	13	800	2.812	4.485
17	1.563	13	800	2.344	3.878
18	1.563	13	800	2.344	3.675
19	1.563	13	800	2.656	4.461
20	1.563	13	800	2.656	4.582
AVERAGE	1.563	13	800	2.625	4.321
21	1.563	11	800	3.281	5.337
22	1.563	11	800	3.125	5.137
23	1.563	11	800	2.812	4.786
24	1.563	11	800	3.281	5.743
25	1.563	11	800	3.594	5.569
26	1.563	11	800	3.281	5.375
27	1.563	11	800	2.812	4.808
28	1.563	11	800	2.812	4.568
29	1.563	11	800	3.125	5.343
30	1.563	11	800	3.125	5.467
AVERAGE	1.563	11	800	3.125	5.213
31	1.563	9	800	3.594	6.209
32	1.563	9	800	3.438	6.053
33	1.563	9	800	3.281	5.685
34	1.563	9	800	3.75	6.615
35	1.563	9	800	4.062	6.465
36	1.563	9	800	3.594	6.249
37	1.563	9	800	3.281	5.677
38	1.563	9	800	3.281	5.447
39	1.563	9	800	3.438	6.21
40	1.563	9	800	3.594	6.334
AVERAGE	1.563	9	800	3.531	6.094
41	1.813	9	800	3.281	5.732
42	1.813	9	800	3.125	5.513
43	1.813	9	800	2.969	5.166
44	1.813	9	800	3.438	6.057
45	1.813	9	800	3.75	6.06
46	1.813	9	800	3.281	5.798
47	1.813	9	800	2.969	5.148
48	1.813	9	800	2.969	4.927
49	1.813	9	800	3.125	5.66
50	1.813	9	800	3.281	5.792
AVERAGE	1.813	9	800	3.219	5.585
SELECTED	1.813	9	800	3.219	5.585

Stressed eye calibration result

Automated TP2 calibration plots and stressed eye calibration details along with other important parameters like pattern type, scope and BERT settings, and regression line slopes and intercept for reference.
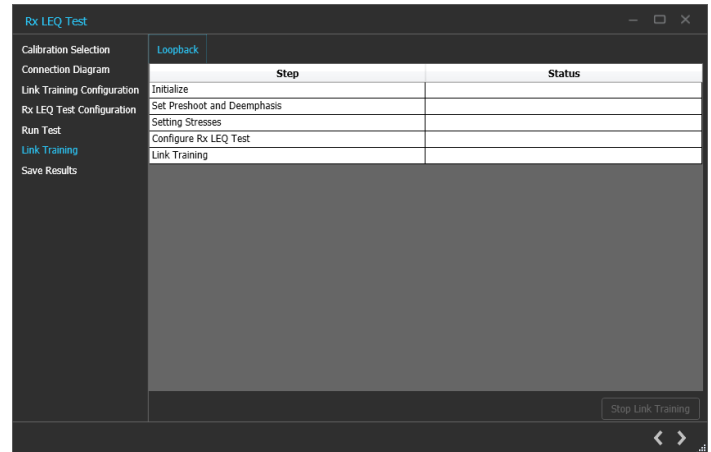
6. Stressed eye calibration supported using Sigtest (Gen4 / Gen5) and Seasim (Gen5 / Gen6).

7. Eye height
   - 6 ± 0.5 mV @ BER E-6 [Gen6]
   - 15 ± 1.5 mV @ BER E-12 [Gen5 and Gen4]

8. Eye Width
   - 3.125 ± 0.3 ps @ BER E-6 [Gen6]
   - 9.375 ± 0.5 ps @ BER E-12 [Gen5]
   - 18.75 ± 0.5 ps @ BER E-12 [Gen4]

Link training

Prior to receiver testing, the device-under-test (DUT) must be placed into loopback, where the signal digitized at the Rx latch is re-transmitted by the corresponding Tx giving visibility into a possible bit or burst errors. Entering the loopback test mode requires a complex dance through the Link Training Status State Machine (LTSSM) between the BERT and DUT. The Tektronix PCI Express Receiver Test Suite automates this sequence allowing loopback through configuration (short path) and loopback through recovery (full training of the link Tx & Rx) for different levels of receiver testing. Relevant parameters are exposed to allow user control over this process without unnecessary complexity.
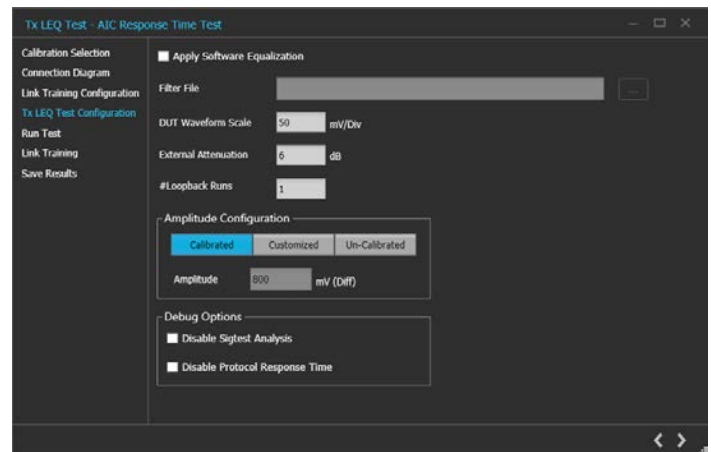

Link Training configuration

Flexible link training and loopback control

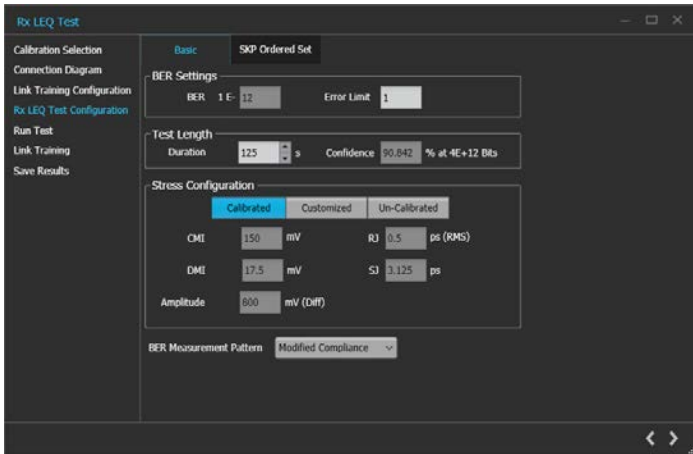## Receiver and transmitter link equalization testing

PCI Express compliance at 32 GT/s and 16 GT/s requires performing a Receiver Link Equalization test (checking analog Rx performance with a stressed signal after full link training) and a Transmitter Link Equalization test (ensuring key digital timing limits are achieved when an Rx makes Tx change requests to its link partner).

The Tektronix PCI Express Receiver Test Suite controls the BERT and RT Oscilloscope during these required tests to provide efficient test results with minimal overhead and control only where needed.
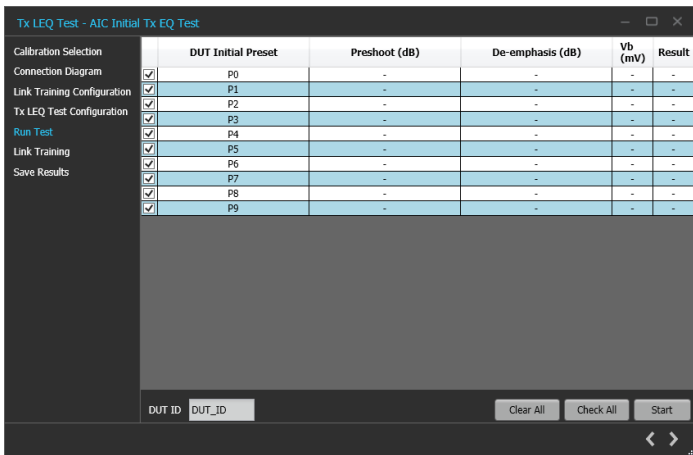
The advanced debug mode provides additional troubleshooting capability for LEQ tests, allowing customised stressors, Tx presets, custom patterns, auto-search CTLE, and CDR tuning.
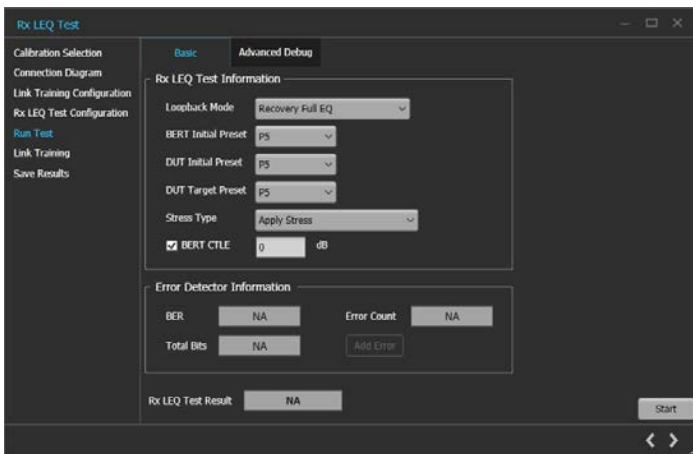

Tx-LEQ test configuration

Rx-LEQ test configuration

Tx-LEQ execution page

Rx-LEQ execution page

CEM Receiver Compliance Test Report
AIC LEQ Response Time Test Results

Test Details

Unique ID	TxLEQResponse_Run2
Date/Time	11 December 2020, 1:06 PM
Generated By	SQE

Additional Comments

NA

Test Equipment

BERT	ANRITSU, MP1900A, 6261788378
BERT FW Version	4.09.41
Rx Test SW Version	6.0.1.142
RT Scope	TEKTRONIX, DPO77002SX, B321456
RT Scope FW Version	10.12.0 Build 1

Test Results

DUT Initial Preset	Target Preset/Coeff		Preshoot (dB)	De-Emph (dB)	Vb (mV) (Informative)	Electrical Response Time (ns)	Protocol Response Time (ns) (informative)	DUT Reported Coefficients	Result
P4	P0	Preset	0.000	-5.95	206.4	55.49	166.6	(0,47,16)	Pass
P4		Coeff	0.000	-5.96	206.4	85.55	143.4	-	Pass
P4	P1	Preset	0.000	-3.54	272.7	97.94	155.2	(0,52,11)	Pass
P4		Coeff	0.000	-3.56	272.1	89.05	161.1	-	Pass
P4	P2	Preset	0.000	-4.37	247.7	62.48	165.4	(0,50,13)	Pass
P4		Coeff	0.000	-4.39	247.2	82.64	151.9	-	Pass
P7	P3	Preset	0.000	-2.38	311.6	119.0	161.6	(0,55,8)	Pass
P7		Coeff	0.000	-2.38	311.4	97.28	146.3	-	Pass
P7	P4	Preset	0.000	0.000	409.9	107.7	154.2	(0,63,0)	Pass
P7		Coeff	0.000	0.000	410.1	98.04	144.7	-	Pass
P7	P5	Preset	1.708	0.000	336.7	121.2	155.6	(6,57,0)	Pass
P7		Coeff	1.712	0.000	336.7	99.07	156.0	-	Pass
P7	P6	Preset	2.380	0.000	311.6	110.6	164.6	(8,55,0)	Pass
P7		Coeff	2.396	0.000	311.2	106.0	148.4	-	Pass
P4	P7	Preset	3.130	-5.79	172.7	95.89	166.6	(7,45,11)	Pass
P4		Coeff	3.094	-5.77	173.1	58.44	154.9	-	Pass
P4	P8	Preset	3.694	-3.69	203.6	96.18	162.6	(8,47,8)	Pass
P4		Coeff	3.725	-3.71	202.8	93.49	152.7	-	Pass
P7	P9	Preset	3.540	0.000	272.7	117.5	158.6	(11,52,0)	Pass
P7		Coeff	3.551	0.000	272.4	99.82	149.7	-	Pass

Tx-LEQ AIC Response time test results

<table>
<tr><td colspan="2" align="center">**Tektronix**</td></tr>
<tr><td colspan="2" align="center">**PCIe5.0 CEM Receiver Compliance Test Report**</td></tr>
<tr><td colspan="2" align="center">**System Rx LEQ Test Results**</td></tr>
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Test Details	
Unique ID	RxLEQ_Pattern
Date/Time	19 October 2020, 3:10 AM
Generated By	SQE

Additional Comments
ClockPattern

Test Equipment	
BERT	ANRITSU, MP1900A, 6261788378
BERT FW Version	4.03.13
Rx Test SW Version	6.0.1.62

Calibration Summary	
TP2 Calibration	Unique ID: [Example_TP2_AIC_Calibration]
	Full Channel Loss: 36 dB
	Status: Converged
	Final Calibrated EW: 9.375 ps (8.875 ps ≤ Target EW ≤ 9.875 ps)
	Final Calibrated EH: 15.5 mV (13.5 mV ≤ Target EH ≤ 16.5 mV)
	Final SJ Stress Level: 3.125 ps (1 ps ≤ SJ Sweep ≤ 5 ps)
	Final DMI Stress Level: 10 mV (5 mV ≤ DMI Sweep ≤ 30 mV)
	Final Amplitude Level: 800 mV (Differential)
	Final CMI Stress Level: 150.0 mV
TP1 Calibration	Unique ID: [Example_TP1_Calibration]
	Differential Amplitude: 800.0 mV
	SJ Setting: 0.1 UI p-p @ 100 MHz (Nominal SJ 3.125 ps / 0.1 UI p-p)
	RJ Setting: 0.16 UI p-p (Nominal RJ 0.5 ps RMS / 0.016 UI p-p)

Test Configuration	
Rx LEQ Test	Loopback Type: Recovery Full EQ
	Link Training Status: Successful
	BERT Initial Preset: P6
	DUT Initial Preset: P9
	DUT Target Preset: P9
	Link #: 0 , Lane #: 0
	CTLE @ ED: 0 dB
	BER Measurement Pattern: RxLEQ_Pattern
	Error Limit: 1
	Test Duration: 125 s
	Test Confidence: 26.42% at 0E+00 Bits
	Stress Configuration: Un-calibrated
	Stress Type: Apply Stress
	RJ: 0.03 UI
	SJ: 0.030 UI
	DMI: 2.00 mV
	CMI: 2.00 mV
	Amplitude: 800.0 mV

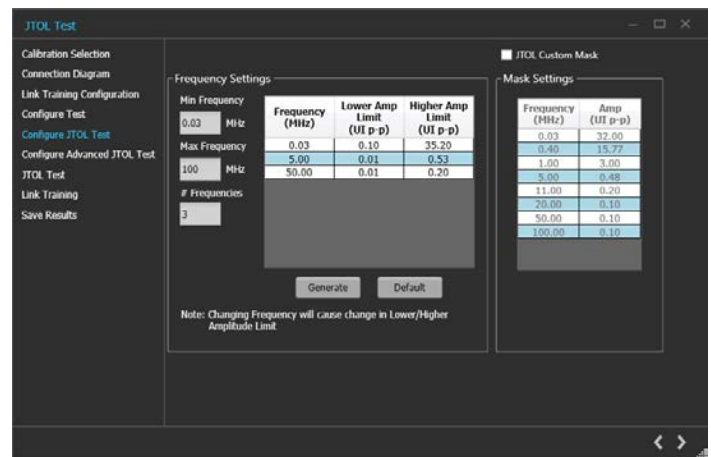| Rx LEQ Test Results	
Status	PASS
BER	0.0000E-11
Error Count	0
Initial BERT Preset	P6
Final BERT Preset	P5
Final BERT Coefficients	(2, 22, 0)

AIC Rx LEQ test results

Remote control protocol

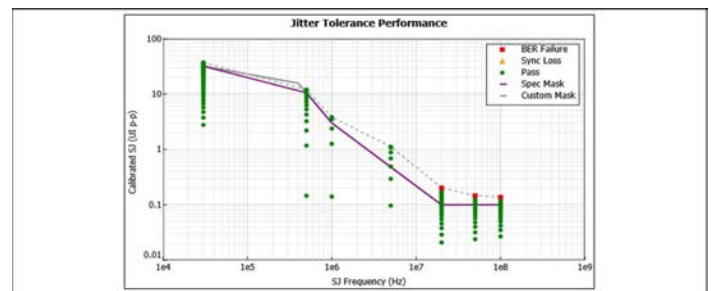The test software can be operated remotely through SCPI commands; allows seamless integration of custom test flow.

Jitter Tolerance (JTOL) test

Jitter tolerance (JTOL) testing requires sweeping numerous calibrated SJ tones from low to high amplitude to see how the receiver-under-test CDR tracks the stress (typically in the presence of other noise & jitter sources). Custom JTOL pass/fail masks can be configured while testing with different search algorithms (upward linear, logarithmic, etc. …). The Tektronix PCI Express Receiver Test Suite allows engineers minimal setup with quick and descriptive test reports.

JTOL test configuration settings

Both the custom mask and the specification mask are provided in the JTOL test to have a better understanding of the DUT performance, especially at the design stage. The Receiver solution performs an automatic back channel equalization and sampling point optimization ensures to ensure the best conditions for the DUT transmitted data traffic to be accurately comprehended at the BERT receiver to ensure the correct determination of BER performance.

JTOL test result with specification

JTOL Test — □ ×

Basic | SKP Ordered Set

Calibration Selection
Connection Diagram
Link Training Configuration
Configure Test
Configure JTOL Test
Configure Advanced JTOL Test
JTOL Test
Link Training
Save Results

BER Settings
BER   1 E- 12   Error Limit 1

Test Length
Duration 125 s   Confidence 90.842 % at 4E+12 Bits

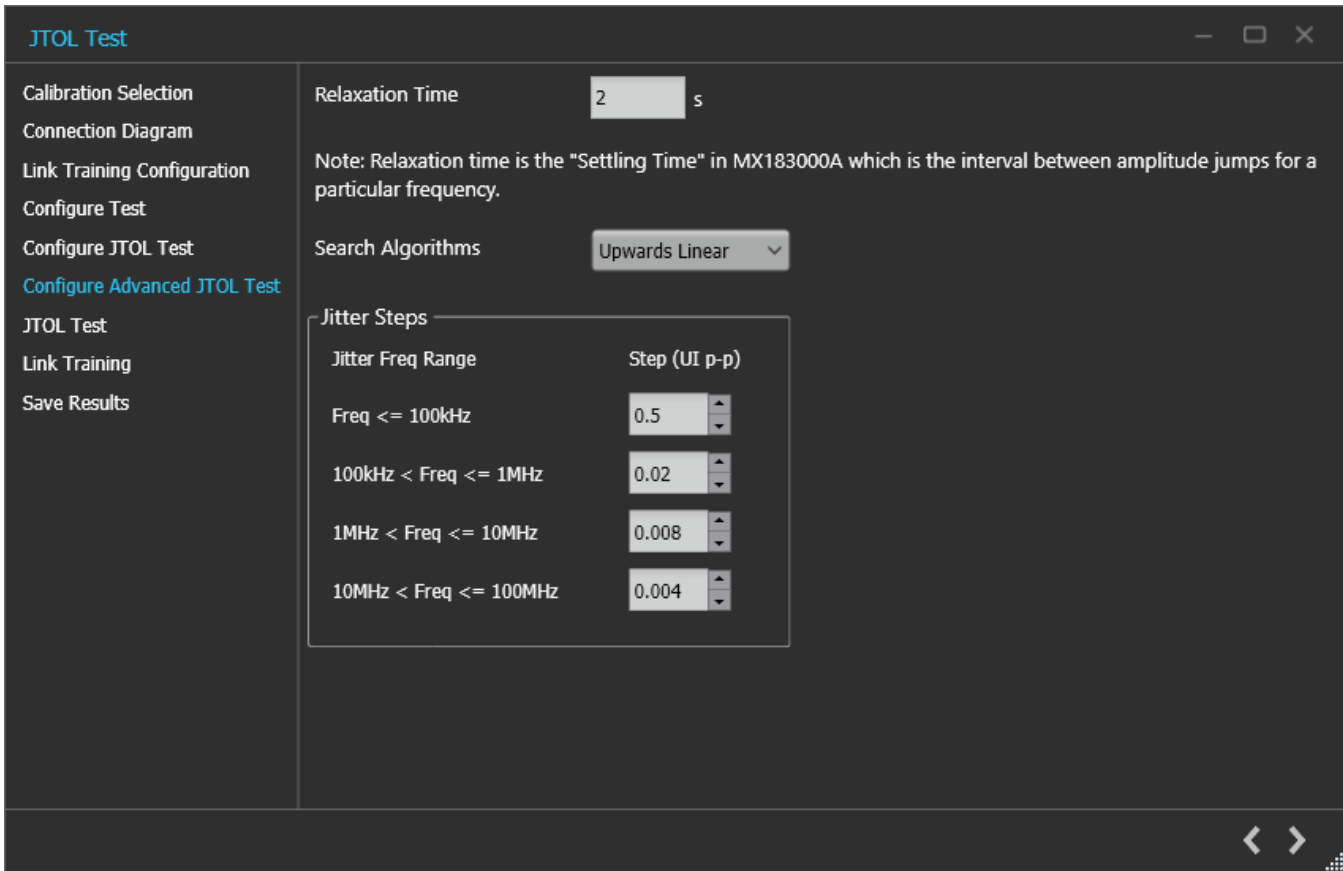**Stress Configuration**
Calibrated | Customized | Un-Calibrated

CMI 150 mV   RJ 0.5 ps (RMS)
DMI 17.5 mV   SJ 3.125 ps
Amplitude 800 mV (Diff)

BER Measurement Pattern Modified Compliance ∨

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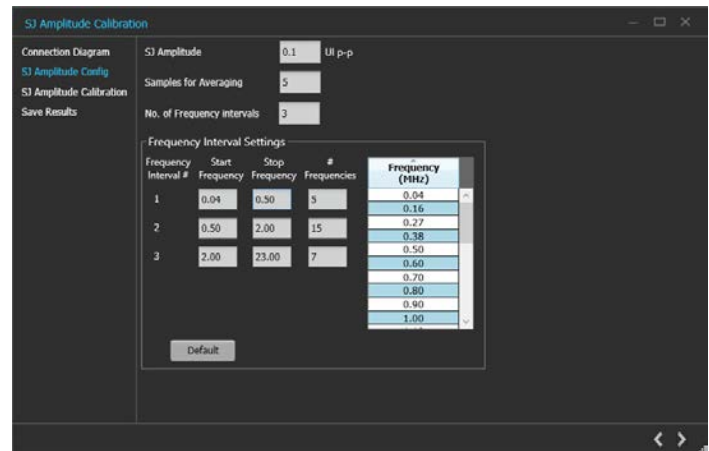*Error detector and stress settings for JTOL*

Different margin search algorithm settings for JTOL test

PCIe PLL Bandwidth and Peaking

This test verifies that the Add-In Card Tx PLL has the correct bandwidth and peaking. Providing a 100 MHz reference clock to the DUT with a calibrated amount of SJ allows us to measure how much SJ passes through the DUT's Tx PLL for a certain SJ tone. Performing this process across multiple tones allows the construction of the PLL frequency response to measure both bandwidth and peaking.

SJ Amplitude Calibration for Gen 5/4/3

- Calibration of SJ amplitude to modulate the 100 MHz Refclk used by DUT's Tx PLL
- Adjustable SJ amplitude
- User-controlled SJ frequency selection to ensure adequate resolution at peaking & 3dB point
- Increased averaging can be used to minimize variation (5 recommended)
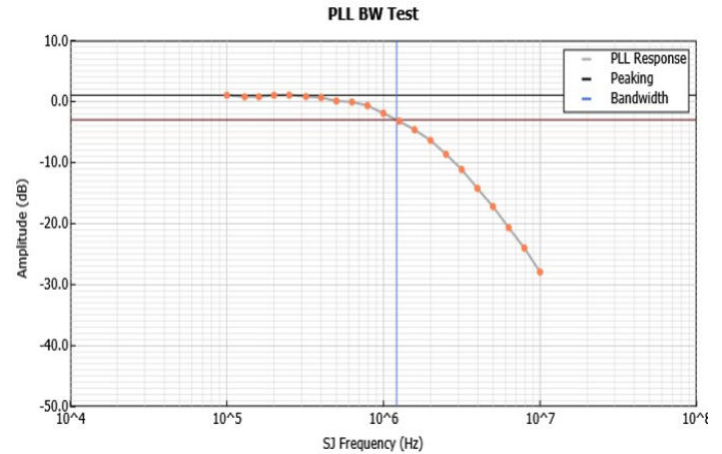- Software CTLE ensures support for higher loss channels and various DUT Tx patterns

SJ amplitude calibration

Result Summary

SJ Amplitude Cal SJ Amplitude: 0.2 UI p-p

Samples for averaging: 5

Frequency (MHz)	Run1 (ps)	Run2 (ps)	Run3 (ps)	Run4 (ps)	Run5 (ps)	Average (ps)
0.04	6.275	6.321	6.355	6.43	6.385	6.353
0.08	6.405	6.308	6.256	6.242	6.304	6.303
0.10	5.996	6.162	6.07	6.356	6.366	6.19
0.20	6.355	6.372	6.402	6.36	6.242	6.346
0.25	6.2	6.148	6.267	6.395	6.124	6.227
0.30	6.152	6.412	6.353	6.206	6.354	6.295
0.35	6.17	6.516	6.307	6.23	6.466	6.338
0.40	6.477	6.28	6.285	6.362	6.458	6.372
0.45	6.122	6.109	6.074	6.58	6.108	6.199
0.50	6.398	6.068	6.353	6.272	6.524	6.323
0.60	6.162	6.157	6.241	6.228	6.435	6.245
0.65	6.395	6.505	6.49	6.409	6.245	6.409
0.70	6.341	6.181	6.34	6.518	6.288	6.334
0.75	6.353	6.267	6.307	6.366	6.209	6.3
0.80	6.134	6.145	6.346	6.227	6.121	6.195
0.85	6.264	6.226	6.187	6.257	6.247	6.236
0.90	6.177	6.237	6.153	6.317	6.337	6.244
0.95	5.969	6.086	6.107	6.253	6.181	6.119
1.00	6.191	6.402	6.273	6.309	6.405	6.316

Result Summary

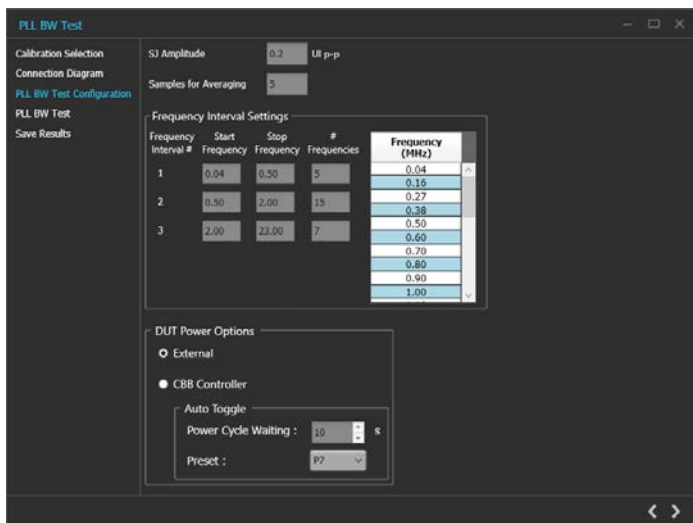*Test results*

PLL Bandwidth and Peaking measurements

- Bandwidth and peaking reported for selected data rates
- DUT Tx can transmit compliance patterns or jitter measurement (toggle) patterns
- Consistent DSP algorithm used for SJ calibration and DUT testing
- Test report with PLL bandwidth, peaking, frequency response plot, and individual measurements

PLL Bandwidth test

Ordering information

PCIe Gen6 Base Software Options

Item	Description	Type
RXSW-FL1-PCIE6	License; PCI Gen 6 Rx BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating 1-Year Subscription	Software
RXSW-FLP-PCIE6	License; PCI Gen 6 Rx BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating Perpetual	Software
RXSW-NL1-PCIE6	License; PCI Gen 6 Rx BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked 1-Year Subscription	Software
RXSW-NLP-PCIE6	License; PCI Gen 6 Rx BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked Perpetual	Software

PCIe Gen5 Base and CEM Software Options

Models - SX >= 50 GHz DPS + DPO

Item	Description	Type
RXSW-NL1-PCIE5	License; PCI Gen 5 Rx CEM and BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked 1-Year Subscription	Software
RXSW-NLP-PCIE5	License; PCI Gen 5 Rx CEM and BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked Perpetual	Software
RXSW-FL1-PCIE5	License; PCI Gen 5 Rx CEM and BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating 1-Year Subscription	Software
RXSW-FLP-PCIE5	License; PCI Gen 5 Rx CEM and BASE Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating Perpetual	Software

PCIe Gen5 Pre-compliance Fixture Options

Item	Description	Type
TF-PCIE5-CEM-X16	PCIe Gen5 X1/X4/X8/X16 Electrical Test Fixture, Supports X1/X4/X8/X16 configuration includes ISS Board, CBB (System Board), CLB X1-X16, CLB X4-X8, 4 MMPX cables, and 4 MMPX to 2.92 mm cables	Fixture
TF-PCIE5-CEM-X1	PCIe Gen5 X1/X16 Electrical Test Fixture, Supports X1/X16 configuration includes ISS Board, CBB (System Board), CLB X1-X16, 4 MMPX cables, and 4 MMPX to 2.92 mm cables	Fixture

PCIe Gen4 Base and CEM Software Options

Models >= 25 GHz and Above (DPO72504DX, DPO73304DX, DPO70KDX)

Item	Description	Type
RXSW-NL1-PCIE4C	License; PCI Gen 4 Base and CEM Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked 1-Year Subscription	Software
RXSW-NLP-PCIE4C	License; PCI Gen 4 Base and CEM Automation Software for Tektronix oscilloscopes and Anritsu BERT; Node-Locked Perpetual	Software
RXSW-FL1-PCIE4C	License; PCI Gen 4 Base and CEM Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating 1-Year Subscription	Software

Table continued…

Item	Description	Type
RXSW-FLP-PCIE4C	License; PCI Gen 4 Base and CEM Automation Software for Tektronix oscilloscopes and Anritsu BERT; Floating Perpetual	Software

Overall Setup list:

PCIe Gen6 Base Rx

Item	Vendor	Type	R/O	Quantity	Description	Notes
DPS75004SX	Tektronix	Equipment	Required	1	Dual-Stack 50 GHz Sx oscilloscope	50 GHz or better
DPO7RFK2	Tektronix	Tektronix accessory	Required	2	Attenuator kit	Attenuator kit + DC blocks
103047400	Tektronix	Tektronix accessory	Required	2	Connector savers (1.85 mm)	1.85 mm oscilloscope channel input connection
Anritsu MP1900A [1]	Anritsu	3rd party equipment	Required	1	Bit Error Rate Tester (BERT)	Configuration provided by 3rd party
DJA	Tektronix	Equipment SW option	Required	1	DPOJET advanced option	DPOJET advanced Jitter, Eye and Timing Analysis SW option
PAMJET-E	Tektronix	Equipment SW option	Required	1	PAM4 tool	PCIe Gen6 PAM4 measurement
PAMJET PCIe Option	Tektronix	Equipment SW option	Required	1	PAMJET PCIe Option	
PMCABLE1M	Tektronix	Tektronix accessory	Required	2	Cable pair; 2.92-to-2.92 mm, Straight, 1.5 ps phase-matched, 40 GHz	Equipment connections to fixtures and DUT
174-6659-01	Tektronix	Tektronix accessory	Required	1	Cable pair; SMA - SMP cable pair	Refclk connection between DUT and BERT
C7035	CentricRF	3rd party	Optional	4	Right Angle Male-Female 2.92 mm adapter	Cable management
RXSW-FL1-PCIE6	Tektronix	SW option	Required	1	PCI Gen 6 Rx BASE automation software for Tektronix oscilloscopes and Anritsu BERT License	Floating 1-Year Subscription OR
RXSW-FLP-PCIE6						Floating Perpetual OR
RXSW-NL1-PCIE6						Node-Locked 1-Year Subscription OR
RXSW-NLP-PCIE6						Node-Locked Perpetual

PCIe Gen5 Base Rx

Item	Vendor	Type	R/O	Quantity	Description	Notes
DPS75004SX	Tektronix	Equipment	Required	1	Dual-Stack 50 GHz Sx Scope	50 G or better[2]
DPO7RFK2	Tektronix	Tektronix accessory	Required	2	Attenuator kit	Attenuator kit + DC blocks
103047400	Tektronix	Tektronix accessory	Required	2	Connector savers (1.85 mm)	1.85 mm scope channel input connection

Table continued…

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[1] Configuration for BERT provided by 3rd party vendor.

[2] If ATI channels will be used for refclk measurements they will need Option Key 4 (50 XL)

Item	Vendor	Type	R/O	Quantity	Description	Notes
Anritsu MP1900A[6]	Anritsu	3rd party equipment	Required	1	Bit Error Rate Tester (BERT)[3]	Configuration provided by 3rd party
DJA	Tektronix	Equipment SW option	Required	1	DPOJET advanced option	DPOJET advanced option
SDLA64	Tektronix	Equipment SW option	Required	1	Serial Data Link Analysis (SDLA) Software	Serial Data Link Analysis (SDLA) Software
174-6659-01	Tektronix	Tektronix accessory	Required	1 pr	Cable; SMA - SMP cable pair	Refclk connection between DUT & BERT
PMCABLE1M	Tektronix	Tektronix accessory	Required	2 pr	Cable; 2.92-to-2.92 mm, Straight, 1.5 ps phase-matched, 40 GHz	Equipment connections to relica channel & DUT
Gen5 Base Test Fixture Set	PCI-SIG	Test fixtures	Required	1	Gen 5 Base Rev3 Test Fixtures[4]	Rev3 is Meg6 material with MMPX connectors[5]
RXSW-FL1-PCIE5 or RXSW-FLP-PCIE5 or RXSW-NL1-PCIE5 or RXSW-NLP-PCIE5	Tektronix	SW option	Required	1	PCIe Gen5 Receiver Software	License;PCI Gen 5 Rx CEM and BASE automation software for Tektronix scopes and Anritsu BERT; Floating 1-Year Subscription OR Floating Perpetual OR Node-Locked 1-Year Subscription OR Node-Locked Perpetual

PCIe Gen5 CEM LEQ

Item	Vendor	Type	R/O	Quantity	Description	Notes
DPS75004SX	Tektronix	Equipment	Required	1	Dual-Stack 50 GHz Sx scope	50 G or better[2]
DPO7RFK2	Tektronix	Tektronix accessory	Required	2	Attenuator kit	Attenuator kit + DC blocks
103047400	Tektronix	Tektronix accessory	Required	2	Connector savers (1.85 mm)	1.85 mm scope channel input connection
Anritsu MP1900A[6]	Anritsu	3rd party equipment	Required	1	Bit Error Rate Tester (BERT) [3]	Configuration provided by 3rd party
DJA	Tektronix	Equipment SW option	Required	1	DPOJET advanced option	DPOJET advanced option
SDLA64	Tektronix	Equipment SW option	Required	1	Serial Data Link Analysis (SDLA) software	Serial Data Link Analysis (SDLA) software
PMCABLE1M	Tektronix	Tektronix accessory	Required	2 pr	Cable; 2.92-to-2.92 mm, straight, 1.5 ps phase-matched, 40 GHz	Equipment connection to fixtures and DUT

Table continued…

[3] Cables required for connection between BERT modules shall be included for the 3rd party vendor
[4] Gen5 BaseTest Fixtures are not backwards compatible for Gen3 & Gen4 Base Rx
[5] It is assumed MMPX cables and MMPX to SMA adaptor cables for test fixture connections are included with the fixture kit
[6] Configuration for BERT provided by 3rd party vendor

Item	Vendor	Type	R/O	Quantity	Description	Notes
174-6663-01	Tektronix	Tektronix accessory	Required	1 pr	Cable; 2.92-to-2.92 mm, straight, 1.5 ps phase-matched, 500 mm, 40 GHz	Signal connection between scope and BERT for Tx LEQ
174-6666-01	Tektronix	Tektronix accessory	Required	2 pr	Cable; SMA-to-SMA, Right Angle-Right Angle, 500 mm	Signal connection between scope and BERT for Tx LEQ & Trigger
174-6659-01	Tektronix	Tektronix accessory	Required	1 pr	Cable; SMA - SMP cable pair	Refclk connection between DUT & BERT
MPR40M	Fairview Microwave	3rd party	Required	2	Power divider	Split signal from DUT Tx to the scope and Error Detector
C7035	CentricRF	3rd party	Optional	4	Right Angle Male-Female 2.92 mm adapter	Cable management
C7049	CentricRF	3rd party	Required	3	2.92 mm Male to 2.92 mm Male adaptor	Power divider output to scope input
Redriver	3rd party	3rd party equipment	Optional	1	Active Gen5 Redriver (back channel equalization)[7]	High loss back channels (DUT Tx to Error Detector) may need EQ
PowerUSB - Basic	PowerUSB	3rd party	Optional	1	Power USB Power Strip	Automate DUT power cycle
TF-PCIE5-CEM-X16	Tektronix or PCI-SIG	Test fixtures	Required	1	Gen 5 CEM Test fixtures[8]	Tektronix fixtures are not officially approved by PCI-SIG[5]
RXSW-FL1-PCIE5 or RXSW-FLP-PCIE5 or RXSW-NL1-PCIE5 or RXSW-NLP-PCIE5	Tektronix	SW option	Required	1	PCIe Gen5 Receiver software	License;PCI Gen 5 Rx CEM and BASE automation software for Tektronix scopes and Anritsu BERT; Floating 1-Year Subscription OR Floating Perpetual OR Node-Locked 1-Year Subscription OR Node-Locked Perpetual

PCIe Gen4 Base

Item	Vendor	Type	R/O	Quantity	Description	Notes
DPO70KSX/DX	Tektronix	Equipment	Required	1	Bandwidth >= 25 GHz Scope	25 G or better^{1}
Anritsu MP1900A	Anritsu	3rd party equipment	Required	1	Bit Error Rate Tester (BERT)^{2}	Configuration provided by 3rd party
DJA	Tektronix	Equipment SW option	Required	1	DPOJET advanced option	DPOJET advanced option
174-6659-01	Tektronix	Tektronix accessory	Required	1 pr	Cable; SMA - SMP cable pair	Refclk connection between DUT & BERT

Table continued…

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7   Another matched pair of cables (e.g. 174-6663-xx) will be required if the Active redriver is used for Rx or Tx LEQ

8   Gen5 CEM Test Fixtures are not backwards compatible for Gen3 & Gen4 CEM Rx

Item	Vendor	Type	R/O	Quantity	Description	Notes
PMCABLE1M	Tektronix	Tektronix accessory	Required	2 pr	Cable; 2.92-to-2.92 mm, Straight, 1.5 ps phase-matched, 40 GHz	Equipment connections to replica channel & DUT
Gen4 Base Test Fixture Set	PCI-SIG	Test fixtures	Required	1	Gen 4 Base Rev3 Test Fixtures^{3}	Provided by PCI-SIG
RXSW-FL1-PCIE4C	Tektronix	SW option	Required	1	PCIe Gen4 Receiver Software	Gen4 BASE and CEM Rx test software - Floating, Time Based, 1 year
RXSW-FLP-PCIE4C						Gen4 BASE and CEM Rx test software - Floating, Perpetual
RXSW-NL1-PCIE4C						Gen4 BASE and CEM Rx test software - Node Locked, Time Based, 1 year
RXSW-NLP-PCIE4C						Gen4 BASE and CEM Rx test software - Node-Locked, Perpetual

PCIe Gen4 CEM

Item	Vendor	Type	R/O	Qty	Description	Notes
DPO72504DX, DPO73304SX	Tektronix	Equipment	Required	1	≥25 GHz minimum bandwidth oscilloscope	
DJA	Tektronix	Option	Required	1	DPOJET Advanced option	DPOJET advanced Jitter, Eye & Timing Analysis SW option
MP1900A	Anritsu	Equipment	Required	Pick 1	Anritsu ≥16 Gb/s BERT, add RXSW-XXX-PCIE4C RX software	NRZ or PAM4 Config can be used for Gen3/4/5
BSX240	Tektronix				Tektronix 24 Gb/s BERT, options TXEQ, STR, add BSXSICOMB and BSXPCI4CEM software	
174-6659-00	Tektronix	Tek Accessories	Required	1	Cable pair; 2.92 mm-to-SMP, Right Angle, 1ps matched, 1000 mm, 20 GHz	PCIe refclk from BSX to CBB (AIC) or Pcie refclk out of CLB to BSX refclk input (rear).
174-6663-01	Tektronix	Tek Accessories	Required	0 or 1	Cable pair; 2.92 mm to 2.92 mm, Straight, 1.5 ps matched, 500 mm, 40 GHz	Power divider out to Error Detector in
174-6665-00	Tektronix	Tek Accessories	Required	1	Cable; 2.92 mm to 2.92 mm, Right Angle-Right Angle, 300 mm, 20 GHz	BSX Subrate clock out to BSX Error Detector clock in.

Table continued…

Item	Vendor	Type	R/O	Qty	Description	Notes
174-6666-01	Tektronix	Tek Accessories	Required	1	Cable; SMA-to-SMA, Right Angle-Right Angle, 500 mm, 20 GHz	BSX Pattern Trigger out to TekScope Aux input
PMCABLE1M	Tektronix	Tek Accessories	Required	2 or 3	Cable pair; 2.92 mm to 2.92 mm, Straight, 1.5 ps matched, 1000 mm, 40 GHz	BSX TX out to DUT RX in and DUT TX out to Power Divider input.
SMP Terminator	Fairview Microwave	3rd Party	Required	Depends	50 Ohm (Female)	Quantity depends on the number of unused lane. x1 = Qty 0, x4 = Qty 6, x8 = Qty 14, x16 = Qty 30.
MPR40-2	Fairview Microwave	3rd Party	Required	2	2-Way Power Divider 2.92 mm Connectors, 40 GHz	Or equivalent
SM3242	Fairview Microwave	3rd Party	Required	2	Adapter, 2.92 mm Male to 2.92 mm Male	Power divider output to TekScope input
SD3473	Fairview Microwave	3rd Party	Required	2	DC Block, 26.5 GHz	Or equivalent
ATX Power supply	Corsair	3rd Party	Required	1	ATX power supply for System board power	As required for DUT power. Any vendor ATX power supply will work.
PCIe Gen 4 Test Fixtures	PCI-SIG	3rd Party	Required	1	Gen4 CBB, CLB and Variable ISI board	Available only from PCI-SIG directly
SMP-SMP Cables	PCI-SIG	3rd Party	Required	4	SMP-SMP cables	
SMA-SMP (2.6")	PCI-SIG	3rd Party	Required	4	SMP-SMP cables	
Power USB – Basic	Power USB	3rd Party	Optional	1	Power USB power strip	For DUT reset automation. Not compatable with 240 VAC systems
AH54192A	Anritsu	3rd Party	Optional	1	PCIe Gen4 Active Redriver (back channel equalization)	High loss back channels (DUT Tx to Error Detector) may need Active Equalization
C7035	Centric RF	3rd Party	Recommended	6	Adapter; 2.92 mm Right Angle Male-Female	BERT I/O and Power Divider output to BSX Eror Detector
RXSW-NLP-PCIE4C	Tektronix	Software	Required	Pick 1	Gen4 RX CEM and BASE test software - Node-Locked, Perpetual	
RXSW-NL1-PCIE4C					Gen4 RX CEM and BASE test software - Node Locked, Time Based, 1 year	
RXSW-FLP-PCIE4C					Gen4 RX CEM and BASE test software - Floating, Perpetual	
RXSW-FL1-PCIE4C					Gen4 RX CEM and BASE test software - Floating, Time Based, 1 year	

PCI PLL Bandwidth (Gen 5/4/3)

Item	Vendor	Type	R/O	Quantity	Description
MP1900A	Anritsu	Equipment	Required	1	≥32 Gb/s BERT
DPS73304SX	Tektronix	Equipment	Required	1	Single Stack 33 GHz or better (e.g. Dual-Stack 50 GHz SX oscilloscope)
DPO7AFP	Tektronix	Equipment	Optional	1	Auxiliary Front Panel
DPO7RFK2	Tektronix	Tektronix Accessory	Required	2	Attenuator Kit
PMCABLE1M	Tektronix	Tektronix Accessory	Required	2	Cable pair; 2.92-to-2.92 mm, Straight, 1.5 ps matched, 1000 mm, 40 GHz
DJA	Tektronix	Option	Required	1	DPOJET Advanced option
TF-PCIE5-CEM-X1[9]	Tektronix or PCI-SIG	Test Fixtures	Required	1	Gen 5 CEM Test Fixtures
TF-PCIE5-CEM-X16[9]	Tektronix or PCI-SIG	Test Fixtures	Required		
RXSW-NLP-PLLBW-PCEG5 or RXSW-NL1-PLLBW-PCEG5 or RXSW-FLP-PLLBW-PCEG5 or RXSW-FL1-PLLBW-PCEG5	Tektronix	Software	Required	1	License;PCIe Gen 5/4/3 PLL BW Software; Perpetual; Node-Locked OR 1 year subscription; Node-Locked OR Perpetual; Floating OR 1 year subscription; Floating

Host system software requirements   Microsoft Windows 10

CE Marking Not Applicable.

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

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[9] It is assumed MMPX cables and MMPX to SMA adaptor cables for test fixture connections are included with the fixture kit

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit *www.tek.com*.

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