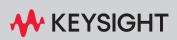
# D90103CKC IEEE 802.3ck Conformance Application -Methods of Implementation



METHODS OF IMPLEMENTATION

# Notices

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A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

# IEEE 802.3ck Conformance Application-At a Glance

The Keysight D90103CKC IEEE 802.3ck Conformance Application is an Ethernet test solution that covers the electrical timing parameters for PAM4 specification (IEEE 802.3ck).

The main features of the IEEE 802.3ck Conformance Application are:

- Complete coverage of specification-based chip-to-chip (C2C) and chip-to-module (C2M) tests, CR tests, and KR tests
- Data Analytics

The IEEE 802.3ck Conformance Application:

- Lets you select individual or multiple tests to run.
- · Lets you identify the device being tested and its configuration.
- · Shows you how to make oscilloscope connections to the device under test.
- Automatically checks for proper oscilloscope configuration.
- Automatically sets up the oscilloscope for each test.
- Allows you to determine the number of trials for each test.
- Provides detailed information of each test that has been run. The result of maximum 25 worst trials can be displayed at any one time.
- Creates a printable HTML report of the tests that have been run. This report includes pass/fail limits, margin analysis, and screen shots.

# Supported Hardware and Software

To run the automated tests on PAM4 signals using the IEEE 802.3ck Conformance Application, you need the following hardware and software:

# Hardware:

- Keysight UXR series Real-Time Infiniium Oscilloscope (Bandwidth 59 GHz and above)
- Keyboard, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Mouse, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Keysight also recommends using a second monitor to view the test application.

# Software:

- Infiniium Oscilloscope Software (For the minimum version of oscilloscope software, see the D90103CKC release notes)
- Keysight D90103CKC IEEE802.3ck Conformance Application

# Licenses:

• For the required licenses for the D90103CKC IEEE 802.3ck Conformance Application, refer to the Data Sheet.

# Contents

IEEE 802.3ck Conformance Application-At a Glance / 3

Supported Hardware and Software / 4

# 1 Installing the D90103CKC IEEE 802.3ck Conformance Application

Installing the Software / 10

#### Installing the License Key / 11

Using Keysight License Manager 5 / 11 Using Keysight License Manager 6 / 12

# 2 Preparing to Take Measurements

Calibrating the Oscilloscope / 16

Starting the Conformance Test Application / 17

Configuring Test App for test runs / 19

#### Exporting Measurement Results to Repository / 22

KS6800A Series Analytics Service Software / 28

# 3 C2C C2M Tests

#### A Note on Crosstalk Calibration for C2M Testing / 32

#### A Note on Difference Measurements (dvf, dRpeak, and dERL) / 33

#### PAM4 Transmitter Characteristics at TPOv / 35

Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q/PRBS9Q) / 36 Output Voltage Measurements EYE TPOv (pattern: PRBS13Q) / 39 Output Waveform Measurements TPOv (pattern: PRBS13Q) / 41 Main Voltage Measurements TPOv (pattern: PRBS13Q) / 50 Return Loss PNA/ENA Measurements / 52

#### PAM4 Host Output Characteristics at TP1a / 53

Host output electrical characteristics at TP1a / 53 Main Voltage Measurements TP1a (pattern: PRBS13Q) / 54 Transition Time Measurements TP1a (pattern: PRBS13Q) / 57 Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q) / 58 ERL TP1a / 60 Return Loss PNA/ENA Measurements / 61

#### PAM4 Module Output Characteristics at TP4 / 62

Module output electrical characteristics at TP4 / 62 Main Voltage Measurements TP4 (pattern: PRBS13Q) / 63 Transition Time Measurements TP4 (pattern: PRBS13Q) / 66 Signaling Rate and Eye Mask Measurements TP4 (pattern: PRBS13Q) / 68 ERL TP4 / 71 Return Loss PNA/ENA Measurements / 72

#### Utilities / 73

Utilities in IEEE Tests / 73

# 4 CR Tests

#### Transmitter characteristics for CR tests / 78

### Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/PRBS9Q) / 80

Signaling Rate / 80 JRMS / 80 J3u / 81 J3u03 / 81 Even-Odd Jitter / 82

#### Output Voltage Measurements EYE TP2 (pattern: PRBS13Q) / 83

Level - PRBS Pattern / 83 Level RMS - PRBS Pattern / 84 Level Separation Mismatch Ratio - RLM / 84

#### Output Waveform Measurements TP2 (pattern: PRBS13Q) / 85

Steady State Voltage Vf / 85 Linear Fit Pulse Peak Ratio / 85 Signal-to-noise-and-distortion ratio / 86 Signal-to-residual-intersymbol-interference ratio, SNRISI / 86 ERL / 86 abs Step Size Tests / 87 Coefficient Initialization / 92

#### Main Voltage Measurements TP2 (pattern: PRBS13Q) / 93

Differential Peak to Peak Output Voltage Test with TX Disabled / 93 DC Common Mode Output Voltage Test / 93 AC Common Mode Voltage, Low-frequency VCMLF / 94 AC Common Mode Voltage, Full-band VCMFB / 94 Differential Peak-to-Peak Output Voltage Test / 95

#### Return Loss PNA/ENA Measurements / 96

Common-mode to Common-mode Output Return Loss / 96 Common-mode to Differential Output Return Loss / 96

## 5 KR Tests

#### Transmitter characteristics for KR tests / 98

#### Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q/PRBS9Q) / 99

Signaling Rate / 99 JRMS / 99 J3u / 100 J3u03 / 100 Even-Odd Jitter / 101

#### Output Voltage Measurements EYE TPOv (pattern: PRBS13Q) / 102

Level - PRBS Pattern / 102 Level RMS - PRBS Pattern / 103 Level Separation Mismatch Ratio - RLM / 103

### Output Waveform Measurements TPOv (pattern: PRBS13Q) / 104

Steady State Voltage Vf / 104 Linear Fit Pulse Peak / 105 dVf / 105 dRpeak / 105 Signal-to-noise-and-distortion ratio / 106 Signal to AC common-mode noise ratio, SCMR / 106 Signal-to-residual-intersymbol-interference ratio, SNRISI / 106 ERL / 106 dERL / 107 abs Step Size Tests / 107

## Main Voltage Measurements TPOv (pattern: PRBS13Q) / 112

Differential Peak-to-Peak Output Voltage Test with TX Disabled / 112 DC Common Mode Output Voltage Test / 112 AC Common Mode Voltage, Low-frequency VCMLF / 113 Differential Peak-to-Peak Output Voltage Test / 113

## Return Loss PNA/ENA Measurements / 114

Common-mode to Common-mode Output Return Loss / 114

Keysight D90103CKC IEEE 802.3ck Conformance Application Methods of Implementation

Installing the D90103CKC IEEE 802.3ck Conformance Application

> Installing the Software 10 Installing the License Key 11

If you purchased the D90103CKC IEEE 802.3ck Conformance Application separate from your Infiniium oscilloscope, you must install the software and license key.



1

# Installing the Software

- 1 Make sure you have the minimum version of oscilloscope software (see the D90103CKC release notes) by selecting **Help > About Infinium...** from the main menu.
- 2 To obtain the D90103CKC Conformance Test Application, go to Keysight website: http://www.keysight.com/find/D90103CKC.
- 3 Navigate to the Visit Technical Support section and click the Drivers, Firmware and Software tab.
- 4 Click on the software's current version link and follow the instructions to download and install the latest version of the test application software.

# Installing the License Key

Refer to the D90103CKC IEEE 802.3ck Conformance Application Data Sheet to know about the various licenses pertaining to Keysight D90103CKC IEEE 802.3ck Conformance Application and also about the other licenses that are required to unlock some additional features.

To procure a license, you require the Host ID information that is displayed in the Keysight License Manager application installed on the same machine where you wish to install the license.

#### Using Keysight License Manager 5

To view and copy the Host ID from Keysight License Manager 5:

- 1 Launch Keysight License Manager on your machine, where you wish to run the Test Application and its features.
- 2 Copy the Host ID that appears on the top pane of the application. Note that x indicates numeric values.

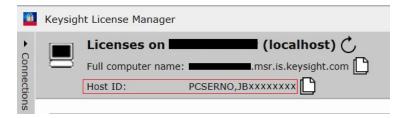
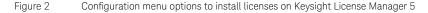


Figure 1 Viewing the Host ID information in Keysight License Manager 5

To install one of the procured licenses using Keysight License Manager 5 application,

- 1 Save the license files on the machine, where you wish to run the Test Application and its features.
- 2 Launch Keysight License Manager.
- 3 From the configuration menu, use one of the options to install each license file.

Why do I need these tools?	
Install License File	Ctrl+I
Install License from Text	Ctrl+T
View License Alerts	Ctrl+L
Explore Transport URLs	
About Keysight License Manager	



For more information regarding installation of procured licenses on Keysight License Manager 5, refer to Keysight License Manager 5 Supporting Documentation.

Using Keysight License Manager 6

To view and copy the Host ID from Keysight License Manager 6:

- 1 Launch Keysight License Manager 6 on your machine, where you wish to run the Test Application and its features.
- 2 Copy the Host ID, which is the first set of alphanumeric value (as highlighted in Figure 3) that appears in the Environment tab of the application. Note that x indicates numeric values.

Keysight License	Manager 6	
Home	Licensing Version	= Keysight License Manager Ver: 6.0.3 Date: Nov 9 2018
	Copyright	= © Keysight Technologies 2000-2018
Environment	AGILEESOFD SERVER CONFIG	_
	AGILEESOFD SERVER LOGFILE	= C:\ProgramData\Keysight\Licensing\Log\
View licenses		
	SERVER_LICENSE_FILE	
License usage	AGILEESOFD_LICENSE_FILE	= C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight
	FLO_LICENSE_FILE	= <u>C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight</u>
Borrow license	KAL_LICENSE_FILE	= <u>C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight</u>
	AGILEESOFD_DEBUG_MODE	
	FLEXLM_TIMEOUT	
	Default Hostid	= XXXXadXXXXbe XXbaXeaceXee
	Ethernet Address	= XXXXadXXXXbe XXbaXeaceXee
	UUID	=
	Physical MAC Address	= xxxxadxxxxbe PHY ETHER=xxbaxeacexee
	IP Address	= 127.0.0.1
	Computer/Hostname	=
	Username	-
	PATH	= C:\Program Files (x86)\Common Files\Intel\Shared Libraries\redist\intel6
	•	•
	🔽 Compact View	
		<u>R</u> efresh <u>C</u> lose <u>H</u> elp

Figure 3 Viewing the Host ID information in Keysight License Manager 6

To install one of the procured licenses using Keysight License Manager 6 application,

- 1 Save the license files on the machine, where you wish to run the Test Application and its features.
- 2 Launch Keysight License Manager 6.
- 3 From the Home tab, use one of the options to install each license file.

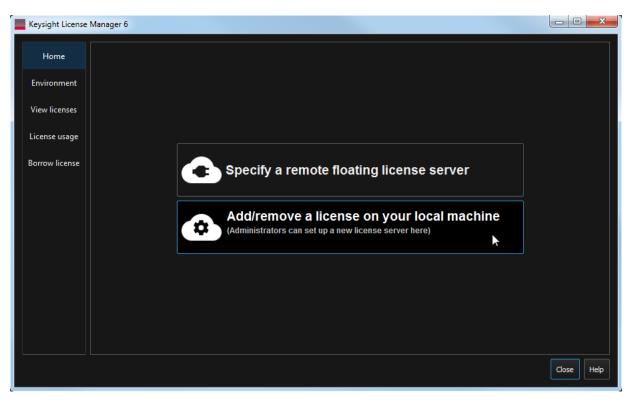


Figure 4 Home menu options to install licenses on Keysight License Manager 6

For more information regarding installation of procured licenses on Keysight License Manager 6, refer to Keysight License Manager 6 Supporting Documentation.

1 Installing the D90103CKC IEEE 802.3ck Conformance Application

Keysight D90103CKC IEEE 802.3ck Conformance Application Methods of Implementation

# 2 Preparing to Take Measurements

Calibrating the Oscilloscope 16 Starting the Conformance Test Application 17 Configuring Test App for test runs 19 Exporting Measurement Results to Repository 22

Before running the automated tests, you must calibrate the oscilloscope. After the oscilloscope has been calibrated, you are ready to start the D90103CKC IEEE 802.3ck Conformance Application and perform the measurements.



# Calibrating the Oscilloscope

If you haven't already calibrated the oscilloscope, follow the calibration instructions described within the Help manuals available with the oscilloscope you are using.



If the ambient temperature changes more than 5 degrees Celsius from the calibration temperature, internal calibration should be performed again. The delta between the calibration temperature and the present operating temperature is shown in the **Utilities > Calibration** menu.



If you switch cables between channels or other oscilloscopes, it is necessary to perform cable and probe calibration again. Keysight recommends that, once calibration is performed, you label the cables with the channel on which they were calibrated.

# Starting the Conformance Test Application

- 1 Ensure that the Device Under Test (DUT) is operating and set to desired test modes.
- 2 To start the Conformance Test Application, from the Infiniium software's main menu, select Analyze > Automated Test Apps > D90103CKC IEEE 802.3ck Electrical Tx Test App.
- 3 The Keysight D90103CKC IEEE 802.3ck Conformance Application appears.

🞽 IEEE 802.3 ck Application New Device1								
File View Tools Help								
Set Up Select Tests Configure Connect Run Automate Result	HTML Report	-						
Standard Option          Standard Option         100GAUI-1, 200GAUI-2, 400GAUI-4 C2C C2M         100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4         100GBASE-KR1, 200GBASE-KR2, and 400GBASE-KR4         Instrument Setup         Channels 1 and 2         Offline Waveform Setup         Channels 3 and 4         Measurement Setup         InfiniiSim Setup         Calibrate Scope Noise         Fixture Ref File Setup         Test Report Comments (Optional)         Device Identifier:         Device User Description:         Comments:	Select Lane Number Lane0 You may enter information here to be included in the report.	^						
Connect PNA								
Messages		Ţ						
Summaries (click for details) Filter Clear	Details							
2022-10-28 11:15:40:852 AM Ready								
o		۷						

Figure 5 The D90103CKC IEEE 802.3ck Conformance Application Main Window

The tabs in the main pane show the steps you take in running the automated tests:

	Table 1	Task flow under various tabs
--	---------	------------------------------

Tab Name	Task flow
Set Up	Lets you identify and set up the test environment, including information about the device under test. The Device Identifier, User Description, and Comments are all printed in the final HTML report. Select the Standard Option against which the DUT should be tested. In the Instrument Setup section, select the channel pair for performing measurement. Set up InfiniiSim with the InfiniiSim Setup button. InfiniiSim is used to de-embed any cables used in the test setup. For more information on how to perform de-embedding using InfiniiSim, see <i>Configuring InfiniiSim</i> in the Online Help for this application. With the Set Channel Skew button, the channels can be visually adjusted and skewed. With the Set Channel Skew button, the s-parameter file for the effective return loss can be specified. With the Fixture Ref File Setup button, the s-parameter file for the fixtures used can be specified. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture. See "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33. The Select Lane Number enables you to choose a lane for testing. Use the Connect PNA button to connect to a PNA device, respectively.
Select Tests	Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups.
Configure	Lets you configure test parameters (for example, channels used in test, Number of UI to test, scope bandwidth, etc.).
Connect	Shows you how to connect the oscilloscope to the device under test for the tests that are to be run.
Run	Starts the automated tests. If the connections to the device under test need to be changed while multiple tests are running, the tests pause, show you how to change the connection, and wait for you to confirm that the connections have been changed before continuing.
Automate	Lets you construct scripts of commands that drive execution of the application.
Results	Contains more detailed information about the tests that have been run. You can change the thresholds at which marginal or critical warnings appear.
HTML Report	Shows a conformance test report that can be printed.

# Configuring Test App for test runs

This section provides the primary steps that you must perform to run one or more conformance tests on the DUT, which is connected to Oscilloscope.

- 1 In the **Set Up** tab (shown in Figure 5), select the **Standard Option** to filter the test groups in accordance with the connected DUT.
- 2 As per your setup, configure the rest of the settings as described in Table 1 on page 18.
- 3 In the **Select Tests** tab, select one or more tests, which appear according to the configuration done under the **Set Up** tab. Each section of this manual displays the appearance of the **Select Tests** tab for each test type.
- 4 In the **Configure** tab, you may change the values assigned to one or more options to cater to the conformance requirements for the selected tests. By default, the D90103CKC IEEE 802.3ck Conformance Application sets optimum values for each configuration parameter.

🔟 IEEB	IEEE 802.3 ck Application New Device1									
File V	File View Tools Help									
Set Up	Select Tests	Configure	Run	Automate	Results	HTML Report				
Mode	Mode: 🔘 Compliance 🔵 Debug									
CONFIGURE	Use Optimized Use Optimized Use Optimized Use Optimized Use Optimized Use Optimized	y Method (F (PRBS13Q) dth Probabi y Method (F th (4e6) or (1) se (4th Ord se 3dB freq urce (FFE ir I CTLE gDC2 I C	) ility (1, irst O er Bes uency Scop for Ey for Sa for Fa for sian) No	a-5) (40GHz) e) e) Opening T ye Opening T ye Opening T ar-end Eye 0 ar-end Eye 0	P1a. (-2d Dpening T Opening T Opening T Opening TP Dpening TP Dpening T		B) 3) 3) 3)	(Click on a setting to the left)		

Figure 6 Configure Tab in the D90103CKC IEEE 802.3ck Conformance Application

- 5 In the Connect tab, view the instructions along with the connection digram to ensure that all requirements for the physical setup of the testing instruments and the DUT are met. Click Connection Completed to indicate to the Conformance Test Application that the required hardware setup is complete. The connection diagram for most of the tests matches the one shown in Figure 7. However, it is a good practice to verify the connection diagram and instructions displayed under this tab. The Conformance Test Application automatically indicates any changes in connections, if needed, during test runs.
- 6 Click **Run Tests** under this tab if you wish to start running tests. However, if you wish to modify the run settings before performing test runs, switch to the **Run** tab.

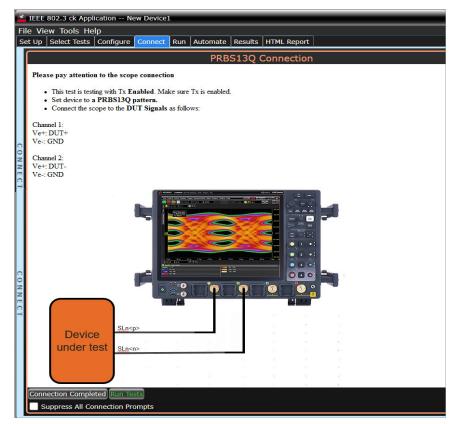


Figure 7 Connect Tab in the D90103CKC IEEE 802.3ck Conformance Application

- 7 In the **Run** tab, you may optionally modify one or more settings as described below, else click **Run** to start the test runs:
  - determine the number of times each test must be run,
  - · automate specific actions in case of events,
  - store results for certain type of test trials only,
  - send email notifications if the test runs pause or stop during runs.

	IEEE 802.3 ck Application New Device1
	ile View Tools Help
5	Set Up Select Tests Configure Connect Run Automate Results HTML Report
	Run Pause Sequencer Run tests Once
	Result Tags
	Configure
	Name value
	Event
	Detect events
RU	Store Mode
z	During run, store details for Worst 💙 trials (up to 25)
	Email
	Send email when run is paused or stopped
	Summary: - Run tests once - Store details for up to 25 worst trials (margin)

#### Figure 8

e 8 Run Tab in the D90103CKC IEEE 802.3ck Conformance Application

- 8 In the **Automate** tab, you may optionally configure automation scripts to perform specific actions/sequences within the Conformance Test Application.
- 9 In the **Results** tab, which appears automatically after test runs are complete, view the test results displayed for each selected test.
- 10 In the **HTML Report** tab, view a comprehensive report for each test within the Application. The Conformance Test Application enables exporting these results in CSV or HTML format for the purpose of analysis.

To perform a high-level analysis on each measurement data, you may upload the results to the Keysight KS6800A Series Analytics Software. Refer to "Exporting Measurement Results to Repository" on page 22 to understand an overview on the functionality of this feature.

# Exporting Measurement Results to Repository

The Upload Results To Repository feature is an add-on to the Keysight Test Application, where it expands the boundaries of storing and analyzing the measurement results to a wider audience, who may be based in multiple sites across various geographical locations. Along with the feature of exporting test results from the Test Application into your local disk in a CSV or HTML file format, you have the option to upload the test results to a Dataset on a Web Repository. Based on your requirements, you may either upload only a single measurement trial or upload huge volumes of measurement results to any Dataset.

Not only can remote users with an active Internet connection access these Datasets and the corresponding test results on the Web Repository, but they have the option to add and delete Datasets on the Web Server. In the Upload Results To Repository feature, you can even modify the Dataset properties, which are helpful especially when performing a graphical analysis of the uploaded data.

In combination with the *Keysight KS6800A Series Analytics Software*, the Upload Results To Repository feature provides a comprehensive solution to export, view and perform analysis of the measurement results, thereby resulting in qualitative data to ensure that the Device Under Test (DUT) is compliant to the industry standards.

Refer to the *Keysight KS6800A Series Analytics Software Online Help* for more information about the functionality of various features in this software.

To export measurement results to the Repository after the completion of test runs,

1 From the Test Application's main menu, click File > Export Results... > Repository.

File View Tools Help			
New Project			
Open Project	Þ		
Save Project			
Save Project As			
Save Project (Settings Only) As			
	~		
Export Results	Þ	CSV	
Export Results User Defined	•	CSV HTML	,
	•		,
User Defined	•	HTML	•
User Defined Print		HTML PDF	•

The Upload Results to Repository window appears.

2 In the **Connect to Server** pane of the **Datasets** tab, click **Connect...** to login to the Dataset Repository server.

Upload Re	sults To Repositor	У		<b>?</b>  -  ×
Datasets	Measurements	Properties		
Connect t	to Server ———			
Connect.				
Browse				
Select Da	taset — —			
	elect one below)			
Select				
Refresh				
Pending U	pload Summary			
	urements marked	for upload.)		
				Upload Close

3 In the **URL:** drop-down text field that appears, replace the default text with the actual IP address or the URL along with the port number, if applicable.

You may enter the URL of the Web Repository server, which may be a self-hosted server on your machine (http://localhost:5000/), a remote server or an authentication server. Note that all such URLs accessed via this window appear as a drop-down list in the **URL:** field.

4 Click the **Check** button to verify that the KS6800A Series Analytics service is available on the specified web address. Repeat this step each time you edit the web address.

Upload Res	sults To Repositor	<b>?</b>  _ X	
Datasets	Measurements	Properties	
-Connect t	o Server ——		
Connect	URL: https://a	ddress:port 🔽 Check	
Browse			
ОК			
OK Cancel			

- For unrestricted access to the Repository
  - a If the server does not require authentication and the KS6800A Series Analytics service is found on the specified web address, the version information is displayed adjacent to the **Check** button.

Upload Res	sults To Reposito	у			?
Datasets	Measurements	Properties			
-Connect t	o Server ——				
Connect.	URL: http://		:5000/ 🔽	Check Version 2.0.31	
Browse					
ок	ñ				
OK Cancel	f i				
Cancer	_				

- *b* If you click **OK**, the **Upload Results to Repository** window displays the connectivity status to the Dataset Repository.
- c Click **Browse**... to navigate directly to the URL.

Upload Res	sults To Repositor	r	? [ <sup>-</sup> ]×
Datasets	Measurements	Properties	
Connect t Connected Connect Browse	d to http://	:5000/	

- · For restricted access to the Repository
  - a If service is found on the specified URL but access to the web server is restricted based on authentication, the version information is displayed along with the text Authentication Required adjacent to the Check button. Also, the Username: and Password: fields appear. The OK button remains disabled until the authentication credentials are entered.
  - *b* Enter the user credentials in the respective fields, which are required for authentication to access those Datasets that have been created on the web server you are connecting to. For each URL that you access, the **Username**: drop-down box keeps a record and displays all user names used to access the respective URL.

Upload Res	ults To Repos	itory	2 -
Datasets	Measuremen	Its Properties	
Connect to	o Server —		
Connect	URL:	http://	Check Version 2.0.31, Authentication Required
Browse	Username:	LPUser	
	Password:	•••••	
ок			
Cancel	1		

- c Click **OK** to connect to the entered URL/IP address.
- The **Connect to Server** area displays the connection status along with the username.
- d Click Browse... to navigate directly to the URL.

Upload Re	Upload Results To Repository						
Datasets	Measurements	Properties					
Connect t Logged in Connect. Browse Logout	to: http://		:5000/ as LPUser				

- 5 In the **Select Dataset** area, click **Select**... to view the list of Datasets created on the connected repository. Click **Refresh** to update the list of Datasets that appear in the Test Application's user interface.
- 6 Select the Dataset name where you wish to upload measurement results to. Click **OK**.

Upload Re	sults To Repository	?   -   ×
Datasets	Measurements Properties	
Connect	to Server —	
Logged in	n to: http://	
Connect.		
Browse.		
Logout		
Select Da	taset	
Select	C11	A
	C14	ñ
Refresh	CSV-Import-Test1	
ОК	Example Measurements	
Cancel	eyes	
	Import11	
	JC4	U,
	JSON Import Test1	
	LP1	
	NewDataset1 Pareto	
		<b></b>
Pending U	pload Summary	
(No meas	urements marked for upload.)	
		Jpload Close

The **Select Dataset** area displays the selected Dataset as Active. The **Measurements** and **Properties** tabs are enabled after a Dataset is selected.

Upload Results To Repository	<b>?</b>
Datasets Measurements Properties	
Connect to Server	
Logged in to: http://	:5000/ as LPUser
Connect	
Browse	
Logout	
Select Dataset	
Active: Example Measurements Select Refresh	
Pending Upload Summary	
(No measurements marked for upload.)	
	Upload Close

- 7 Click the **Measurements** tab where the test results from the last test run are displayed.
- 8 You may select and export multiple test results to the repository. You may change the format for the display of measurement data using the drop-down options in the **Group by:** field.

Upload Results To Repository	
Datasets Measurements Properties	
Group by: Run Start Time	
Select Run Start Times* to include:	
Run Start Time Run Duration	
2019-03-06 03:19:10:895 00:00:22.0210	000
<	(Click on a Run Start Time to see measurements.)
*Each row contains results from a single executi	on of all checked tests; an N-Times or TestPlan execution
Pending Upload Summary	
(No measurements marked for upload.)	
	Upload Close

9 After selecting one or more measurements, either click Upload or switch to the Properties tab to associate one or more properties to the measurements that are being uploaded to the Web Server. To perform an enhanced analysis on the measurement data using the *KS6800A Series Analytics Service Software*, Keysight recommends assigning properties to the measurements.

Upload Results To Repository	
Datasets Measurements Properties	
Select Properties to Include (Optional):	
App-Defined	
Show properties from: 🔘 Selected measurements (Additional Info values from Results tab)	
Globals (Settings from Set Up, Configure and HTML Report tabs)	
Auto 🗹 Name Value Type Reported With Name In Repository	
Refresh	
/ User-Defined	
Add NameValue Type Name In Repository	
Remove	
	×
Pending Upload Summary	
On web server: http://xxxxxxxxx.cos.is.keysight.com:5000/ Append to Dataset: LPTestData1	
3 measurements from 1 group	
Time stamps will be marked UTC+05:30.	
======================================	
Measurement-reported: 0 of 0	
Global: 0 of 27 (Values captured at start of each run)	
Properties will be available in the Results Viewer for splitting and filtering graphs. (Red = Invalid value for type, Orange = Only first 128 characters will be uploaded)	
Upload	Close

10 Click the **Properties** tab to assign properties for your measurement results that you select to upload. By default, the **App-Defined** properties are selected to be uploaded in association with the measurement data, wherein only certain aspects of the selected measurements are uploaded. However, you may switch to **Globals** to include as properties one or more options configured under the rest of the tabs of the Conformance Test Application or define one or more custom property values to be associated with the selected measurement data.

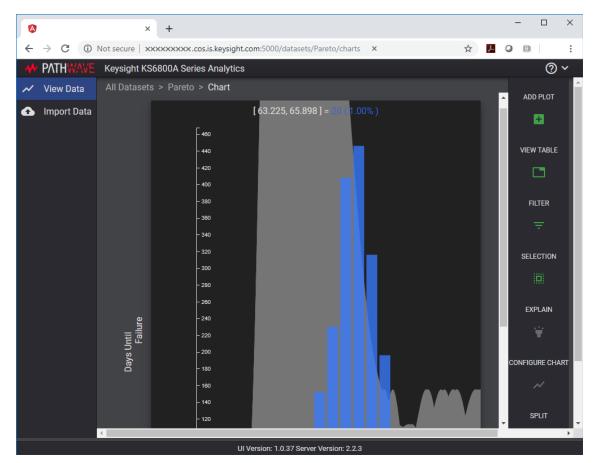
atasets 🛛	Measurements	Properties				
elect Prope	erties to Include	(Optional):				
App-Define	d					
Show prope	erties from: 🔵	Selected measure	nents (Additional Info va	alues fro	m Results tab)	
	۲	Globals	(Settings from Set	t Up, Co	nfigure and HTML F	Report tal
Auto 🗸	Name		Value	Туре	Location	Name In
Refresh	A Hidden Gr	oup Config	False	Text	Configure tab	False
	Clock Chann	el	Channel 2	Text	Configure tab	False
	Data Channe	el	Channel 1	Text	Configure tab	False
	Debug Mode	Used	No	Text	HTML Report tab	False
	Debug Only	Setting	Default	Text	Configure tab	False
on web serv ppend to D measuren ime stamp sesses pp-defined Measuren Global: 0	ver: http://xxxx Dataset: LPTestE ========= nents from 1 gro s will be marked ========== 1 properties: nent-reported: 0 of 27 (Values ca	oxxxxxx.cos.is.key pata1 = Measurements = up I UTC+05:30. = Properties ==== of 0 uptured at start of 0			hs.	

- 11 Click **Upload** to begin uploading measurement results.
- 12 Click **Close** to exit the **Upload Results to Repository** window and to return to the Conformance Test Application.

You may access the Dataset Repository using the Internet browser on your machine to view the measurement results graphically on the *KS6800A Series Analytics Service Software*.

KS6800A Series Analytics Service Software

The KS6800A Series Analytics Service software supports multiple data sources and also a wide range of data import clients. This web-based software provides various types of charts, such as Histogram, Box-and-Whisker, Line, Scatter, Eye Diagram and Constellation, each with split capability to enable data analysis. Once you upload the measurement results to a Dataset on the *KS6800A Series Analytics Service Software* via the **Upload Results to Repository** window of the Test Application, the measurement results can be viewed graphically as shown below:



For more information on the Data Analytics Web Service Software, visit KS6800A Series Analytics Service Software page on the Keysight website. You may refer to the Help manual provided within the software to understand the functionality of its features.

#### 2 Preparing to Take Measurements

Keysight D90103CKC IEEE802.3ck Conformance Application Methods of Implementation

# 3 C2C C2M Tests

PAM4 Transmitter Characteristics at TP0v 35 PAM4 Host Output Characteristics at TP1a 53 PAM4 Module Output Characteristics at TP4 62 Utilities 73

This section provides the Methods of Implementation (MOIs) for the IEEE PAM4 Transmitter Characteristics for 100GAUI-1, 200GAUI-2, and 400GGAUI-4 C2C C2M. Measurements are made at test points TPOv, TP1a, and TP4.



Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.



# A Note on Crosstalk Calibration for C2M Testing

The D90103CKC application does not provide calibration procedure for the crosstalk generator in case of C2M host or module testing. As mentioned in the specification, the user must perform crosstalk calibration at TP4 in case of host testing without making use of a reference receiver and with target differential peak-to-peak voltage of 845 mV and transition time of 8.5 ps. Similarly, the crosstalk calibration in case of module testing must be performed at TP1a without making use of a reference receiver and with target differential peak-to-peak voltage of 750mV and transition time of 10 ps for short mode and 15 ps for long mode.

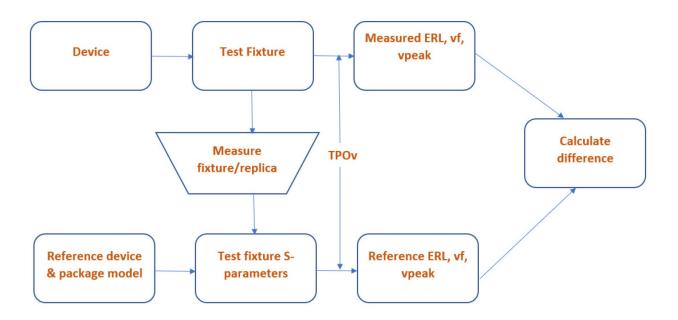
# A Note on Difference Measurements (dvf, dRpeak, and dERL)

The difference measurements dVf, dRpeak, and dERL are derived from the measured and the reference values. The measured values are obtained from the actual measurements done at TPOv. Actual measurements include the true transmitter and the fixture. The reference values are calculated using a reference transmitter and the fixture s-parameter. For the test point TPOv, the ERL s-parameter file is the actual package and the fixture (Stp and Sfixt), while the ref s-parameter file is just the fixture (Sfixt). For the other test points, the reference s-parameter file is the transmitter package and traces, and what leads to their respective test points.

The difference measurements are defined below:

- dvf is difference steady-state voltage, and is calculated as the difference between the measured steady state voltage and the reference steady state voltage. Refer to Equations 163A-6 and 163A-7 in the specification.
- dRpeak is the difference pulse peak ratio, and is calculated as the difference between the measured pulse peak ratio and the reference pulse peak ratio. Refer to Equations 163A-8, 163A-9, and 163A-10 in the specification.
- dERL is the difference ERL, and is calculated as the difference between the measured ERL and the reference ERL. Refer to Equation 163A-11 in the specification.

The following image illustrates the measurement methods for the difference measurements described above.



₹	IEEE	802.3 ck Appl	ication Ne	ew Device1	_						X
Fi	le Vie	ew Tools He	lp								
S	et Up	Select Tests	Configure	Connect	Run	Automate	Results	HTML F	Report		-
	Stan	dard Option —									
	0	100GAUI-1, 2	00GAUI-2, 4	400GAUI-4	C2C (	C2M					
		100GBASE-CR	1, 200GBAS	SE-CR2, an	d 400	GBASE-CR4					
	•	100GBASE-KR	1, 200GBAS	SE-KR2, an	d 400	GBASE-KR4					
	Instr	ument Setup									
	0	Channels 1 ar	nd 2	e Wavform	Cotu						
s		Channels 3 ar			Setu						
SET	Meas	surement Setu	р ———		_						
UP	Infi	niiSim Setup	Calibrate S	cope Noise	Fix	ERL File Se ture Ref File		Select L	ane Nui ne0 🔽		
	Test	Report Comme	ents (Option	ial) ——	<u> </u>						
	Dev	ice Identifier:									
	Dev	ice User Descr	iption:								
	Con	nments:								You may enter information here to be included in the report.	
	С	onnect PNA									
										 	۷
	lessage										+
s s	Summ	aries (click for	details) Fil	ter Clea	r			Details			
AC	2022-	aries (click for 10-28 11:15:	40:852 AM	Ready			¢	Applicat	tion init	and ready for use.	

# PAM4 Transmitter Characteristics at TPOv

See Table 2 for pass limits pertaining to 100GAUI-1, 200GAUI-2, and 400GAUI-4 C2C C2M tests at TP0v, which are specified in *IEEE P802.3ck<sup>TM</sup> /D3.3* (*Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling*) Annexure 120F, Table 120F-1.

#### Table 2 100GAUI-1, 200GAUI-2, and 400GAUI-4 C2C transmitter characteristics at TPOv

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		53.125 ± 50 ppm	GBd
Differential peak-to-peak output voltage <sup>a</sup> (max)	See Sec. 93.8.1.3 of the		
Transmitter disabled	IEEE specification	35	mV
Transmitter enabled		1200	mV
Common-mode voltage <sup>a</sup> (max)	See Sec. 93.8.1.3 of the IEEE specification	1	۷
Common-mode voltage <sup>a</sup> (min)	See Sec. 93.8.1.3 of the IEEE specification	0.2	V
Low-frequency peak-to-peak AC common-mode voltage, VCM <sub>LF</sub> (max)	See Sec. 120F.3.1.1 of the IEEE specification	32	mV
Signal to AC common-mode noise ratio, SCMR (min)	See Sec. 120F.3.1.2 of the IEEE specification	15	dB
Difference effective return loss, dERL (min)	See Sec. 120F.3.1.4 of the IEEE specification	-3	dB
Common-mode to common-mode return loss, RLcc (min)	See Sec. 162.9.4.9 of the IEEE specification	2	dB
Difference steady-state voltage, $dv_f$ (min)	See Sec. 163.9.2.4 of the IEEE specification	0	۷
Difference linear fit pulse peak, dR <sub>peak</sub> (min)	See Sec. 163A.3.2.1 of the IEEE specification	0	۷
Level separation mismatch ratio, $R_{LM}(min)$	See Sec. 162.9.4.2 of the IEEE specification	0.95	-
Output waveform <sup>b</sup>	See Sections		
absolute value of step size for all taps (min)	162.9.4.1.4	0.005	-
absolute value of step size for all taps (max)	162.9.4.1.4	0.025	-
value at min state for c(–3) (max)	162.9.4.1.5	-0.05	-
value at max state for $c(-3)$ (min)	162.9.4.1.5	0	-
value at min state for $c(-2)$ (max)	162.9.4.1.5	0	-
value at max state for $c(-2)$ (min)	162.9.4.1.5	0.1	-
value at min state for $c(-1)$ (max)	162.9.4.1.5	-0.3	-
value at max state for c(-1) (min)	162.9.4.1.5	0	-
value at min state for c(0) (max)	162.9.4.1.5	0.5	-
value at min state for c(1) (max)	162.9.4.1.5	-0.1	-
value at max state for c(1) (min)	162.9.4.1.5	0	-

Parameter	Reference	Value	Units
Signal-to-noise-and-distortion ratio SNDR (min)	See Sec.162.9.4.6 of the IEEE specification	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR <sub>ISI</sub> (min)	See Section 120F.3.1.3	28	dB
Output jitter	See Sections		
J <sub>RMS</sub> (max)	120F.3.1.6	0.023	UI
J4u (max)	120F.3.1.6	0.128	UI
J4u <sub>03</sub> (max)	120F.3.1.6	0.118	UI
Even-odd jitter (max)	120F.3.1.6	0.025	UI

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

b. The state of the transmit equalizer is controlled by management interface.

Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

M	IEEE	302.3 ck Application New Device1	
<u>F</u> il	e <u>V</u> ie	w <u>T</u> ools <u>H</u> elp	
Se	t Up	Select Tests Configure Connect Run Automate Results HTML Report	
	4	PAM4 IEEE Tests	
		PAM-4 Transmitter Characteristics at TP0v	
		Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)	
		✓ Signaling Rate	
		V JRMS	
		🖌 J4u	
		✓ J4u03	
		Ver-Odd Jitter	
S		Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)	
m		Output Waveform Measurements TP0v (pattern: PRBS13Q)	
Ē		Main Voltage Measurements TPOv (pattern: PRBS13Q)	
0		Return Loss PNA/ENA Measurements	
		PAM-4 Host Output Characteristics at TP1a	
TE		PAM-4 Module Output Characteristics at TP4	
S		Utilities	
SL			

Figure 9 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TPOv for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TPOv tests, see:

- "Signaling Rate" on page 36
- "JRMS" on page 37
- "J4u" on page 37
- "J4u03" on page 38
- "Even-Odd Jitter" on page 38

#### Signaling Rate

**Test Overview** The purpose of this test is to verify that the signaling rate meets the specified standards.

Pass Condition	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.							
Measurement	1 Obtain sample or acquire signal data.							
Algorithm	2 Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).							
	3 In the <b>Configure</b> tab, set <b>Signaling Rate</b> to 53.125 Gb/s.							
	4 Measure minimum and maximum data rate.							
	5 Report minimum and maximum values.							
	6 Compare the mean data rate value with the specified standards. Report the resulting value.							
JRM								
-								
Test Overview	The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.							
Pass Conditions	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.							
Measurement Algorithm	1 Obtain sample or acquire signal data.							
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.							

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the JRMS value to the specified standards.

J4u	
Test Overview	The purpose of this test is to verify that differential signal's J4 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
Pass Conditions	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.
Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the J4 value meets the specified standards.

J4u	03						
Test Overview	The purpose of this test is to verify that differential signal's J4u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.						
Pass Conditions	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.						
Measurement Algorithm	1 Obtain sample or acquire signal data.						
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.						

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the J4u03 value meets the specified standards.

#### Even-Odd Jitter

- Test Overview The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
   Pass Conditions Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.
   Measurement Algorithm 1 Obtain sample or acquire signal data.
   NOTE Signal must be of PRBS13Q or PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.
  - 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the Even-Odd Jitter value to the specified standards.

Output Voltage Measurements EYE TPOv (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

×.	IEEE 802.3 ck Application New Device1										
Eile	ile <u>Vi</u> ew Iools <u>H</u> elp										
Se	t Up	Sele	ect Tests	Configure	Connect	Run	Automate	Results	HTML Report	:	
		•	PAM4 IEE	E Tests							
		PAM-4 Transmitter Characteristics at TPOv									
			Jitte	r and Signal	ling Rate M	leasur	ements TPO	v (pattern	: PRBS13Q/PF	RB	8S9Q)
		1	🖌 Outp	out Voltage I	Measureme	ents E	/E TP0v (pa	ttern: PRE	3513Q)		
			🖌 Le	evel - PRBS	pattern						
	✓ Level RMS - PRBS pattern										
	✓ Level Separation Mismatch Ratio - RLM										
		<ul> <li>Output Waveform Measurements TP0v (pattern: PRBS13Q)</li> </ul>									
		Main Voltage Measurements TPOv (pattern: PRBS13Q)									
SE		Return Loss PNA/ENA Measurements									
SELEC		PAM-4 Host Output Characteristics at TP1a									
			PAM-4	Module Out	put Charac	teristic	s at TP4				
-			Utilities								

Figure 10 Selecting Output Voltage Measurements EYE Tests

Refer to the section PAM4 Transmitter Characteristics at TPOv for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TPOv (pattern: PRBS13Q) tests, see:

- "Level PRBS Pattern" on page 39
- "Level RMS PRBS Pattern" on page 40
- "Level Separation Mismatch Ratio RLM" on page 40

NOTE

# The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

#### Level - PRBS Pattern

**Test Overview** The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS13Q pattern.

**Pass Condition** Not applicable as the test result is considered as "Information Only".

# Measurement<br/>Algorithm1Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used<br/>for this test).

2 V<sub>0</sub>, V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub> are the mean signal levels of the symbols corresponding to the PAM4 symbol levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet

Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.

3 The mean level  $V_{mid}$  is defined by equation (120D-3), which is,

$$V_{mid} = (V_0 + V_3) / 2$$

4 Report this value for information-only purpose.

#### Level RMS - PRBS Pattern

**Test Overview** The purpose of this test is to obtain the of the RMS level of the signal with PRBS13Q pattern.

Pass Condition Not applicable as the test result is considered as "Information Only".

- Measurement 1 Run the Level PRBS Pattern test as a prerequisite to this test.
  - 2 The minimum signal level RMS is calculated, as defined in IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.
  - 3 Report this value for information-only purpose.

#### Level Separation Mismatch Ratio - RLM

**Test Overview** The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

Measurement Algorithm

Algorithm

- 1 Run the Level PRBS Pattern as a prerequisite to this test to calculate the mid-range level.
- 2 The mean signal levels are normalized so that  $V_0$  corresponds to -1,  $V_1$  to -ES1,  $V_2$  to ES2 and  $V_3$  to 1.
- 3 ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

$$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$$

$$ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$$

4 The level separation mismatch ratio  $R_{LM}$  is defined by equation (120D-5).

5 Report the calculated value.

Output Waveform Measurements TPOv (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

	IEEE	E 80	)2.3	ck App	olica	tion	N	lew	v Device	1			-				
F	ile View Tools Help																
s	iet Up	s	elec	t Tests	С	onfi	gure	C	Connect	Run	Automate	Results	HTML	. Report	:		-
	PAM4 IEEE Tests																
				PAM-4	Tra	insn	nitter	r Cł	haracte	istics	at TPOv						
				Jitte	er a	nd S	Signa	aling	g Rate I	leasu	ements TP	0v (patterr	n: PRBS	513Q/PF	RB:	59Q)	
				Out	put	Vol	tage	Me	easurem	ents E	YE TPOv (p	attern: PR	BS13Q	)			
				🖌 Out	put	Wa	vefor	rm	Measur	ement	s TPOv (pat	tern: PRBS	513Q)				
				🖌 S	Stea	dy-	State	e Vo	oltage \	f							
				🖌 L	ine	ar Fi	t Pu	lse	Peak								
				🖌 🗸	₫Vf												
				🗹 d	Rpe	eak											
Ē		✓ Signal-to-noise-and-distortion ratio															
E				🖌 S	Sign	al to	AC	cor	mmon-i	node r	oise ratio,	SCMR					
C				🖌 S	Sign	al-te	o-res	sidu	ual-inter	symbo	l-interferer	nce ratio, S	NRISI				
-				🖌 E	RL												
-				🖌 d	IERL												
E				🖌 a	bs :	Step	Siz	е									
Ē				Mai	n Vo	oltag	je M	eas	suremer	ts TPC	v (pattern:	PRBS13Q	)				
S				Ret	urn	Los	s PN	A/E	ENA Mea	surem	ents						
	•			PAM-4	Но	st O	utpu	it C	Characte	ristics	at TP1a						
	•			PAM-4	Mo	dule	Out	tpu	t Chara	cterist	cs at TP4						
	•			Utilitie	S												

Figure 11 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TPOv for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TPOv (pattern: PRBS13Q) tests, see:

- "Steady State Voltage Vf" on page 41
- "Linear Fit Pulse Peak" on page 42
- "dVf" on page 42
- "dRpeak" on page 42
- "Signal-to-noise-and-distortion ratio" on page 43
- "Signal to AC common-mode noise ratio, SCMR" on page 43
- "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 43
- "ERL" on page 43
- "dERL" on page 44
- "abs Step Size Tests" on page 44

#### Steady State Voltage V<sub>f</sub>

**Test Overview** The purpose of this test is to verify that the Steady State Voltage meets the specified standards.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

- Measurement<br/>Algorithm1Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this<br/>test).
  - 2 Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
  - 3 Calculate V<sub>f</sub> using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. N<sub>p</sub> = 200, D<sub>p</sub> = 4.
  - 4 Compare the specified standards to the resulting value.

Line	ear Fit Pulse Peak						
Test Overview	The purpose of this test is to verify that the Linear Fit Pulse meets the specified standards.						
	<b>NOTE</b> Run the <b>Steady-State Voltage Vf</b> test as a prerequisite to running the Linear Fit Pulse Peak test.						
Pass Conditions	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.						
Measurement Algorithm	<ol> <li>Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).</li> <li>Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.</li> <li>Calculate Linear Fit Pulse using the equations in section 85.8.3.3.5. The resulting value is the peak value of p(k). Np = 200, Dp = 4.</li> <li>Compare the specified standards to the resulting value.</li> </ol>						
dVf							
Test Overview	The purpose of this test is to verify that dVf meets the specified standards.						
Pass Conditions	Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.						
Measurement Algorithm	<ol> <li>The user enters the fixture s-parameter (S0) file by clicking the Fixture Ref File Setup button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.</li> <li>Calculate the reference transfer function using equation 163A-2.</li> <li>Calculate Vref(peak) as max of h(t).</li> <li>Calculate Vf(ref) using equation 163A-3.</li> <li>Calculate dVf using equation 163A-6.</li> <li>See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.</li> </ol>						
-10-							
dRp							
Test Overview Pass Conditions	The purpose of this test is to verify that dRpeak meets the specified standards. Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.						
Measurement Algorithm	<ol> <li>The user enters the fixture s-parameter (S0) file by clicking the Fixture Ref File Setup button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.</li> <li>Calculate the reference transfer function using equation 163A-2.</li> <li>Calculate Vref(peak) as max of h(t).</li> <li>Calculate Vf(ref) using equation 163A-3.</li> <li>Calculate dRpeak using equation 163A-7.</li> <li>See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.</li> </ol>						
	See also A Note on Difference Measurements (dvt, dkpeak, and dERL) on page 33.						

#### Signal-to-noise-and-distortion ratio

- **Test Overview** The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) meets the specified standards.
- **Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.
- Measurement<br/>Algorithm1Calculate SNDR using measurements from Level RMS PRBS pattern test and error from Linear<br/>Fit Pulse Peak test.
  - 2 Compare the resulting value of SNDR to the specified standards.

#### Signal to AC common-mode noise ratio, SCMR

- **Test Overview** The purpose of this test is to verify that the signal to AC common-mode noise ratio (SCMR) meets the specified standards.
- **Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.
- Measurement<br/>Algorithm1Calculate SCMR using measurement from Linear Fit Pulse peak and Full Band Pk-Pk AC Common<br/>mode voltage. The formula is 20log(Vpeak/VcmFB).
  - 2 Compare the resulting value of SCMR to the specified standards.

#### Signal-to-residual-intersymbol-interference ratio, SNRISI

- **Test Overview** The purpose of this test is to verify that the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:
  - 0 dB through -20 dB gDC and 4 dB through 0 dB gDC2.
- **Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.
- **Measurement** 1 Follow the procedure for Linear Fit Pulse peak to calculate p(k).
  - 2 Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.
  - 3 With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8)
  - 4 Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.
  - 5 The results is the highest SNRISI value.

#### ERL

Algorithm

**Test Overview** The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.

**Pass Condition** Not applicable as the test result is considered as "Information Only".

- Measurement Algorithm 1 In the Set Up tab of the Conformance Test Application, click ERL File Setup button to set up the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters).
  - 2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
  - 3 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

Test Overview       The purpose of this test is to verify that dERL meets the specified standards.         Pass Conditions       Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.         Measurement Algorithm       The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and helps in the ERL computation.         1       The user enters the initial ERL channel file by clicking the <b>ERL File Setup</b> button under the Setup tab.         2       The user enters the fixture s-parameter (S0) file by clicking the <b>Fixture Ref File Setup</b> button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.         3       The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL eref.         4       The difference between ERL TPOv and ERL ref is reported as the result.         5       The difference between ERL TPOv and ERL ref is reported as the result.         5       See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33. <b>abs Step Size Tests</b> To know about the measurement algorithm for each abs Step Size test, see:         • "abs Step Size for c(-3)" on page 44       • "abs Step Size for c(-2)" on page 45         • "abs Step Size for c(-1)" on page 45
standard option.         Measurement Algorithm       The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and helps in the ERL computation.         1       The user enters the initial ERL channel file by clicking the ERL File Setup button under the Setup tab.         2       The user enters the fixture s-parameter (S0) file by clicking the Fixture Ref File Setup button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.         3       The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.         4       The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TP0v measurement to compute ERL at TP0v.         5       The difference between ERL TP0v and ERL ref is reported as the result.         See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.         To know about the measurement algorithm for each abs Step Size test, see:
Algorithm       spreadsheets (available with the COM tool) as the input and helps in the ERL computation.         1       The user enters the initial ERL channel file by clicking the ERL File Setup button under the Setup tab.         2       The user enters the fixture s-parameter (S0) file by clicking the Fixture Ref File Setup button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.         3       The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.         4       The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv.         5       The difference between ERL TPOv and ERL ref is reported as the result.         See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.         Test Overview         The purpose of this test is to verify the abs Step Size test, see:         •       "abs Step Size for c(-3)" on page 44         •       "abs Step Size for c(-2)" on page 45         •       "abs Step Size for c(-1)" on page 45
<ul> <li>tab.</li> <li>2 The user enters the fixture s-parameter (S0) file by clicking the Fixture Ref File Setup button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.</li> <li>3 The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.</li> <li>4 The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv.</li> <li>5 The difference between ERL TPOv and ERL ref is reported as the result.</li> <li>See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.</li> </ul> <b>abs Step Size Tests Test Overview</b> The purpose of this test is to verify the abs Step Size. <ul> <li>a know about the measurement algorithm for each abs Step Size test, see:</li> <li>"abs Step Size for c(-3)" on page 44</li> <li>"abs Step Size for c(-2)" on page 45</li> <li>"abs Step Size for c(-1)" on page 45</li> </ul>
<ul> <li>the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.</li> <li>The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.</li> <li>The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv.</li> <li>The difference between ERL TPOv and ERL ref is reported as the result.</li> <li>See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.</li> </ul> <b>Test Overview</b> The purpose of this test is to verify the abs Step Size. <ul> <li>To know about the measurement algorithm for each abs Step Size test, see:</li> <li>"abs Step Size for c(-3)" on page 44</li> <li>"abs Step Size for c(-2)" on page 45</li> <li>"abs Step Size for c(-1)" on page 45</li> </ul>
<ul> <li>the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.</li> <li>4 The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv.</li> <li>5 The difference between ERL TPOv and ERL ref is reported as the result.</li> <li>See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.</li> </ul> <b>abs Step Size Tests Test Overview</b> The purpose of this test is to verify the abs Step Size. <ul> <li>To know about the measurement algorithm for each abs Step Size test, see:</li> <li>"abs Step Size for c(-2)" on page 44</li> <li>"abs Step Size for c(-1)" on page 45</li> </ul>
and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv. 5 The difference between ERL TPOv and ERL ref is reported as the result. See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33. abs Step Size Tests Test Overview The purpose of this test is to verify the abs Step Size. To know about the measurement algorithm for each abs Step Size test, see: • "abs Step Size for c(-3)" on page 44 • "abs Step Size for c(-2)" on page 45 • "abs Step Size for c(-1)" on page 45
See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.         abs Step Size Tests         Test Overview       The purpose of this test is to verify the abs Step Size.         To know about the measurement algorithm for each abs Step Size test, see:         • "abs Step Size for c(-3)" on page 44         • "abs Step Size for c(-2)" on page 45         • "abs Step Size for c(-1)" on page 45
abs Step Size Tests         Test Overview       The purpose of this test is to verify the abs Step Size.         To know about the measurement algorithm for each abs Step Size test, see:         • "abs Step Size for c(-3)" on page 44         • "abs Step Size for c(-2)" on page 45         • "abs Step Size for c(-1)" on page 45
Test Overview       The purpose of this test is to verify the abs Step Size.         To know about the measurement algorithm for each abs Step Size test, see:         "abs Step Size for c(-3)" on page 44         "abs Step Size for c(-2)" on page 45         "abs Step Size for c(-1)" on page 45
<ul> <li>"abs Step Size for c(-3)" on page 44</li> <li>"abs Step Size for c(-2)" on page 45</li> <li>"abs Step Size for c(-1)" on page 45</li> </ul>
<ul> <li>"abs Step Size for c(-3)" on page 44</li> <li>"abs Step Size for c(-2)" on page 45</li> <li>"abs Step Size for c(-1)" on page 45</li> </ul>
• "abs Step Size for c(-1)" on page 45
<ul> <li>"abs Step Size for c(0)" on page 46</li> </ul>
<ul> <li>"abs Step Size for c(1)" on page 46</li> </ul>
<ul> <li>"value at min. state for c(-3)" on page 47</li> </ul>
<ul> <li>"value at max. state for c(-3)" on page 47</li> </ul>
<ul> <li>"value at max. state for c(-2)" on page 47</li> </ul>
<ul> <li>"value at min. state for c(-2)" on page 48</li> </ul>
<ul> <li>"value at min. state for c(-1)" on page 48</li> </ul>
<ul> <li>"value at max. state for c(-1)" on page 48</li> </ul>
<ul> <li>"value at min. state for c(0)" on page 49</li> </ul>
<ul> <li>"value at min. state for c(1)" on page 49</li> </ul>
<ul> <li>"value at max. state for c(1)" on page 49</li> </ul>
abs Step Size for c(-3)

Test Overview The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.
 Pass Condition When abs Coefficient Step Size - c(-3) is greater than or equal to 5 m and less than or equal to 25 m.
 Measurement 1 Request Transmitter to be set to "PRESET" condition.

#### Measurement Algorithm

- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(-3) to the first step.

- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(-3) as base step value.
- 9 Request next c(-3) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with Np = 200, Dp = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### abs Step Size for c(-2)

Test Overview	The purpose of this test is to verify that the abs Step Size for c(-2) is within limits.								
Pass Condition	When abs Coefficient Step Size - $c(-2)$ is greater than or equal to 5 m and less than or equal to 25 m.								
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(-2) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Save coefficient c(-2) step.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5. with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5.</li> <li>Request next c(-2) step.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5. with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5.</li> <li>Request next c(-2) step.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.5. with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.5.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.5.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.5.</li> <li>Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.</li> </ol>								
abs	Step Size for c(-1)								
Test Overview	The purpose of this test is to verify that the abs Step Size for c(-1) is within limits.								
Pass Condition	When abs Coefficient Step Size - c(-1) is greater than or equal to 5 m and less than or equal to 25 m.								
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(-1) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Save coefficient c(-1) as base step value.</li> <li>Request next c(-1) step.</li> </ol>								
	· · ·								

10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.

- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### abs Step Size for c(0)

Test Overview	The purpose of this test is to verif	y that the abs Step Size for c(0) is within limits.
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**Pass Condition** When abs Coefficient Step Size - c(0) is greater than or equal to 5 m and less than or equal to 25 m.

- Measurement Algorithm
- 1 Request Transmitter to be set to "PRESET" condition.
  - 2 Capture full pattern of PRBS13Q at 32 points per UI.
  - 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
  - 4 Define r(m) from "PRESET" as per equation 136-1.
  - 5 Request to change c(0) to the first step.
  - 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
  - 7 Calculate coefficients c(i) using equation 136-2.
  - 8 Save coefficient c(0) as base step value.
  - 9 Request next c(0) step.
  - 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
  - 11 Calculate coefficients c(i) using equation 136-2.
  - 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
  - 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### abs Step Size for c(1)

Test Overview	The purpose of this test is to verify that the abs Step Size for c(1) is w	vithin limits.

**Pass Condition** When abs Coefficient Step Size - c(1) is greater than or equal to 5 m and less than or equal to 25 m.

- Measurement 1 Request Transmitter to be set to "PRESET" condition.
- Algorithm
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(1) to the first step.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(1) as base step value.
- 9 Request next c(1) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

Test Overview	Th	The purpose of this test is to verify that the value at min. state for c(-3) is within limits.								
Pass Condition	W	hen value at min. state for c(-3) is less than or equal to -50 m.								
Measurement Algorithm	1 2 3 4	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped. Capture full pattern of PRBS13Q at 32 points per UI. Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5. Define r(m) from "PRESET" as per equation 136-1.								
	5	Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minimum value.								
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.								
	7	Calculate coefficients c(i) using equation 136-2.								
	8	Report c(-3) value from step 7.								
valu	ie at	max. state for c(-3)								

#### **Test Overview** The purpose of this test is to verify that the value at max. state for c(-3) is within limits. Pass Condition When value at max. state for c(-3) is greater than or equal to 0 m. Measurement 1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated Algorithm during trial, steps 1-4 are skipped. 2 Capture full pattern of PRBS13Q at 32 points per UI. 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5. 4 Define r(m) from "PRESET" as per equation 136-1. 5 Request user to set c(-2), c(-1), and c(1) to zero. Increment both c(0) and c(-3) to their maximum value. 6 Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4. 7 Calculate coefficients c(i) using equation 136-2. 8 Report c(-3) value from step 7.

#### value at max. state for c(-2)

The purpose of this test is to verify that the value at max. state for c(-2) is within limits.								
When value at max. state for c(-2) is greater than or equal to 100 m.								
<ol> <li>Request Transmitter to be set to "PRESET" condition. If preset has already been calcula during trial, steps 1-4 are skipped.</li> </ol>								
Capture full pattern of	PRBS13Q at 32 points per UI.							
Calculate linear fit pul	se response at "PRESET" condition as per section 85.8.3.3.5.							
Define r(m) from "PRE	SET" as per equation 136-1.							
	-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum							
Calculate linear fit pul	se response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.							
7 Calculate coefficients c(i) using equation 136-2.								
Report c(-2) value fror	n step 7.							
Whe 1   2   3   4   5   6   7   7	<ul> <li>When value at max. state</li> <li>1 Request Transmitter to during trial, steps 1-4</li> <li>2 Capture full pattern of</li> <li>3 Calculate linear fit pull</li> <li>4 Define r(m) from "PRE</li> <li>5 Request user to set c(- value.</li> <li>6 Calculate linear fit pull</li> <li>7 Calculate coefficients</li> </ul>							

valu	at min. state for c(-2)
Test Overview	The purpose of this test is to verify that the value at min. state for c(-2) is within limits.
Pass Condition	When value at min. state for c(-2) is less than or equal to 0 m.
Measurement Algorithm	<ul> <li>Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request user to set c(-3), c(-1), and c(1) to zero. Decrement both c(0) and c(-2) to their minimum value.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Report c(-2) value from step 7.</li> </ul>
valu	at min. state for c(-1)
Test Overview	The purpose of this test is to verify that the value at min. state for c(-1) is within limits.
Pass Condition	Nhen value at min. state for c(-1) is less than or equal to -300 m.
Measurement Algorithm	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
	2 Capture full pattern of PRBS13Q at 32 points per UI.
	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4 Define r(m) from "PRESET" as per equation 136-1.
	5 Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.
	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.
	7 Calculate coefficients c(i) using equation 136-2.
	Report c(-1) value from step 7.
valu	at max. state for c(-1)
Test Overview	The purpose of this test is to verify that the value at max. state for c(-1) is within limits.
Pass Condition	When value at max. state for c(-1) is greater than or equal to 0 m.
Measurement Algorithm	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
-	2 Capture full pattern of PRBS13Q at 32 points per UI.

#### value at min. state for c(-2)

3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request user to set c(-3), c(-2), and c(1) to zero. Increment both c(0) and c(-1) to their maximum value.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with N\_p = 200, D\_p = 4.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(-1) value from step 7.

Test Overview	Th	e purpose of this test is to verify that the value at min. state for c(0) is within limits.
Pass Condition	W	hen value at min. state for c(0) is less than or equal to 500 m.
Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request user to decrement c(0) to minimum value.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.

### value at min. state for c(0)

7 Calculate coefficients c(i) using equation 136-2.

8 Report c(0) value from step 7.

# value at min. state for c(1)

valu	le at	t min. state for c(1)
Test Overview	Th	ne purpose of this test is to verify that the value at min. state for c(1) is within limits.
Pass Condition	W	'hen value at min. state for c(1) is less than or equal to -100 m.
Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.
	7	Calculate coefficients c(i) using equation 136-2.
	8	Report c(1) value from step 7.
valu	ue at	t max. state for c(1)
Test Overview	Th	ne purpose of this test is to verify that the value at max. state for $c(1)$ is within limits.
Pass Condition	W	hen value at max. state for c(1) is greater than or equal to 0 m.
Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request user to set c(-2), c(-1), and c(1) to zero. Increment both c(0) and c(1) to their maximum value.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.
	7	Calculate coefficients c(i) using equation 136-2.

8 Report c(1) value from step 7.

Main Voltage Measurements TPOv (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

	IEEE	E 8(	)2.3	ck App	lication Ne	ew Device1	_					
Fil	le Vi	iew	/ To	ols He	elp							
Se	et Up	S	elec	t Tests	Configure	Connect	Run	Automate	Results	HTML Report		-
	4	C	P/	M4 IEE	E Tests							
				PAM-4	Transmitter	Characteri	stics a	t TP0v				
				Jitte	r and Signal	ing Rate M	easur	ements TPO	v (patterr	: PRBS13Q/PRI	BS9Q)	
				Out	out Voltage M	leasureme	nts E	E TPOv (pat	ttern: PRI	BS13Q)		
				Out	out Waveform	n Measure	ments	TPOv (patte	ern: PRBS	513Q)		
		1		🖌 Mair	Voltage Me	asurement	s TPO	v (pattern: I	PRBS13Q	)		
				🖌 D	ifferential Pe	ak to Peak	Outp	ut Voltage T	est with 1	TX disabled		
				🖌 D	C Common I	Mode Outp	ut Vol	tage Test				_
				🖌 🖌	C Common I	Mode Volta	ge, Lo	w-frequency	VCMLF			
SE				🖌 D	ifferential Pe	ak to Peak	Outp	ut Voltage T	'est			
			- 1	Retu	Irn Loss PNA	/ENA Meas	urem	ents				1
EC				PAM-4	Host Output	Character	istics	at TP1a				
-				PAM-4	Module Out	out Charact	eristi	s at TP4				
	•			Utilities	5							

Figure 12 Selecting Main Voltage Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TPOv for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TPOv (pattern: PRBS13Q) tests, see:

- "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 50
- "DC Common Mode Output Voltage Test" on page 50
- "AC Common Mode Voltage, Low-Frequency VCMLF" on page 51
- "Differential Peak-to-Peak Output Voltage Test" on page 51

#### Differential Peak-to-Peak Output Voltage Test with TX Disabled

**Test Overview** The purpose of this test is to verify that when TX is disabled, the peak-to-peak voltage meets the specified standards.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

**Measurement** 1 Obtain a sample or acquire the signal data.

- 2 Ensure that TX is disabled on the acquired signal (no valid data transitions).
  - 3 Measure peak-to-peak voltage of the signal.
  - 4 Compare the maximum peak-to-peak voltage to the specified standards.

#### DC Common Mode Output Voltage Test

**Test Overview** The purpose of this test is to verify that the common mode signal meets the specified standards.



Algorithm

This measurement can be done only with dual single-ended connection but not with a differential probing connection.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

- **Measurement** 1 Obtain sample or acquire signal data.
  - 2 Verify that there is a signal and that the connection is dual single-ended.
  - 3 Set common mode signal using the common mode function.
  - 4 Measure minimum and maximum voltage of the common mode signal.
  - 5 Compare the voltage measurement to the specified standards.

#### AC Common Mode Voltage, Low-Frequency VCMLF

**Test Overview** The purpose of this test is to verify that the low-frequency AC common mode voltage of the signal meets the specified standards.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

#### Measurement Algorithm

Algorithm

Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Apply 100 MHz low pass filter.
- 5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-5</sup> of the measurement distribution.
- 6 Compare the voltage measurement to the specified standards.

#### Differential Peak-to-Peak Output Voltage Test

**Test Overview** The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q pattern meets the specified standards.

**Pass Condition** Refer to the section PAM4 Transmitter Characteristics at TPOv for the pass limits pertaining to each standard option.

- Measurement 1 Obtain sample or acquire signal data.
  - 2 Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
  - 3 Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
  - 4 Compare the maximum peak-to-peak voltage to the specified standards.

#### Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

		802.3	ck Appl	ication Ne	ew Device1	_					
File	Vie	w To	ols He	lp							
Set	Up	Selec	t Tests	Configure	Connect	Run	Automate	Results	HTML Repor		
		PA	M4 IEE	E Tests							
			PAM-4	Transmitter	Characteri	stics a	t TPOv				
	•	•	Jitte	r and Signal	ing Rate M	easur	ements TPO	v (pattern	: PRBS13Q/P	RBS9Q)	
	,	·	Outp	out Voltage M	Measureme	nts E	rE TP0v (pa	ttern: PRE	3S13Q)		
	•	<u>ا</u> ۱	Outp	out Waveform	m Measure	ments	TPOv (patte	ern: PRBS	513Q)		
	,	• <u> </u>	Main	Voltage Me	asurement	s TPO	v (pattern: I	PRBS13Q	)		
				rn Loss PNA							
		_	🖌 C	ommon-mod	de to Comn	non-n	node Output	Return L	oss		
S	PAM-4 Host Output Characteristics at TP1a										
m				Module Outp	put Charac	teristi	cs at TP4				
E	•		Utilities	;							

Figure 13 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section PAM4 Transmitter Characteristics at TPOv for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/ENA Measurements tests, see:

"Common-mode to Common-mode Output Return Loss" on page 52

#### Common-mode to Common-mode Output Return Loss

Measurement Algorithm

- 1 Ensure that the PNA/ENA is physically connected and calibrated.
  - 2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
  - 3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
  - 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
  - 5 Compare the reported values with the specification to check for conformance.

## PAM4 Host Output Characteristics at TP1a

This section provides the Methods of Implementation (MOIs) for the 100GAUI-1, 200GAUI-2, and 400GAUI-4 C2M tests at TP1a as specified in IEEE P802.3ck<sup>TM</sup> /D3.3 Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling), Annex 120G, Table 120G-1. Measurements are made at TP1a.



Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

Host output electrical characteristics at TP1a

#### Table 3 C2M host output characteristics at TP1a

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		53.125 ± 50 ppm	GBd
DC common-mode output voltage (max)	Sec. 120G.5.1	2.8	V
DC common-mode output voltage (min)	Sec. 120G.5.1	-0.3	V
Single-ended output voltage (max)	Sec. 120G.5.1	3.3	V
Single-ended output voltage (min)	Sec. 120G.5.1	-0.4	V
Peak-to-peak AC common-mode voltage (max) Low-frequency, VCM <sub>LF</sub> Full-band, VCM <sub>FB</sub>	Sec. 120G.5.1	32 80	mV
Differential peak-to-peak output voltage (max) Transmitter disabled Transmitter enabled	Sec. 120G.5.1	35 750	mV
Steady-state voltage, v <sub>f</sub> (max)	Sec. 120G.5.3	375	mV
Eye height (min)	Sec. 120G.3.1.5	10	mV
Vertical eye closure, VEC (max)	Sec. 120G.3.1.5	12	dB
Common-mode to differential-mode return loss, RLDC (min)	Sec. 120G.3.1.1	See Equation (120G-1)	dB
Effective return loss, ERL (min)	Sec. 120G.3.1.2	7.3	dB
Differential termination mismatch (max)	Sec. 120G.3.1.3	10	%
Transition time (min) Host is requesting short mode Host is requesting long mode	Sec. 120G.3.1.4	10 15	ps ps

Main Voltage Measurements TP1a (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

🔟 IEEE	02.3 ck Application New Device1	
File Vi	w Tools Help	
Set Up	Select Tests Configure Connect Run Automate Results HTML Report	
1	PAM4 IEEE Tests	
• •	PAM-4 Transmitter Characteristics at TP0v	
	PAM-4 Host Output Characteristics at TP1a	
	✓ Main Voltage Measurements TP1a (pattern: PRBS13Q)	
	✓ Differential Peak to Peak Output Voltage Test with TX disabled	
	✓ Differential Peak to Peak Output Voltage Test	
	✓ AC Common Mode Voltage, Low-frequency VCMLF	
	✓ AC Common Mode Voltage, Full-band VCMFB	
	V DC Common Mode Output Voltage Test	
SE	Single-Ended Output Voltage Test	
F .	Short Mode Requested	
EO	Long Mode Requested	
H	Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q)	
-	ERL TP1a	
m	Return Loss PNA/ENA Measurements	
L S	PAM-4 Module Output Characteristics at TP4	
s ,	Utilities	

Figure 15 Selecting Main Voltage Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Main Voltage Measurements TP1a (pattern: PRBS13Q) tests, see:

- "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 54
- "Differential Peak-to-Peak Output Voltage Test" on page 54
- "AC Common Mode Voltage, Low-Frequency VCMLF" on page 55
- "AC Common Mode Voltage, Full-band VCMFB" on page 55
- "DC Common Mode Output Voltage Test" on page 55
- "Single-ended Output Voltage Test" on page 56

#### Differential Peak-to-Peak Output Voltage Test with TX Disabled

**Test Overview** The purpose of this test is to verify that when TX is disabled, the peak-to-peak voltage must be less than or equal to 35mV.

**Pass Condition** Refer to Table 3.

Algorithm

- **Measurement** 1 Obtain a sample or acquire the signal data.
  - 2 Ensure that TX is disabled on the acquired signal (no valid data transitions).
  - 3 Measure peak-to-peak voltage of the signal.
  - 4 Compare the maximum peak-to-peak voltage to 35mV.

#### Differential Peak-to-Peak Output Voltage Test

**Test Overview** The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q pattern is less than or equal to 750 mV.

Pass Condition Refer to Table 3.

**Measurement** 1 Obtain sample or acquire signal data.

- 2 Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
- 3 Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
- 4 Compare the maximum peak-to-peak voltage with 750 mV.

#### AC Common Mode Voltage, Low-Frequency VCMLF

**Test Overview** The purpose of this test is to verify that the low-frequency AC common mode voltage of the signal is less than or equal to 32mV.



# This measurement can be done only with dual single-ended connection but not with a differential probing connection.

#### Pass Condition Refer to Table 3.

Measurement Algorithm

Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Apply 100 MHz low pass filter.
- 5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-5</sup> of the measurement distribution.
- 6 Compare the voltage measurement with 32mV.

#### AC Common Mode Voltage, Full-band VCMFB

**Test Overview** The purpose of this test is to verify that the full-band VCMFB AC common mode voltage of the signal is less than or equal to 80mV.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

#### Pass Condition Refer to Table 3.

Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-5</sup> of the measurement distribution.
- 5 Compare the voltage measurement with 80mV.

#### DC Common Mode Output Voltage Test

**Test Overview** The purpose of this test is to verify that the common mode signal is between -300mV and 2.8V.



This measurement can be done only with dual-single ended connection but not with a differential probing connection.

Pass Condition	Refer to Table 3.
Measurement Algorithm	<ol> <li>Obtain sample or acquire signal data.</li> <li>Set common mode signal using the common mode function.</li> <li>Measure minimum and maximum voltage of the common mode signal.</li> <li>Compare the voltage measurement to the range between -300mV and 2.8V.</li> </ol>
Sing	le-ended Output Voltage Test
Test Overview	The purpose of this test is to verify that the minimum voltage on a single-ended signal is greater than or equal to -400mV and that the maximum voltage is less than or equal to 3.3V.         NOTE       This measurement can be done only with dual single-ended connection but not with a differential probing connection.
Pass Condition	Refer to Table 3.
Measurement Algorithm	<ol> <li>Obtain sample or acquire signal data.</li> <li>Verify that there is a signal and that the connection is dual single-ended.</li> <li>Measure the minimum and maximum voltage on each single-ended signal.</li> <li>Compare the voltage measurements with the range between -400mV and 3.3V.</li> </ol>

Transition Time Measurements TP1a (pattern: PRBS13Q)

The Transition Time Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits vary in both the modes.

2	IEEE 8	02.3 ck Ap	plication N	ew Device1				-				
File	e Viev	/ Tools ⊦	lelp									
Set	t Up 🤇	elect Test	Configure	Connect	Run	Automate	Results	HTML	. Report			
SELECI	_	PAM4 IE PAM PAM Ma Sh V Sh	EE Tests 4 Transmitter 4 Host Output in Voltage Me ort Mode Requ Transition Tim 2 Minimum C 3 Monimum C 3 Minimum C 3 Minimum C 3 Minimum C	Characteri c Character asurement uested ne Measure Dutput Rise Dutput Fall ne Measure Dutput Rise Dutput Rise	stics a istics a ements Time Time ( ements Time Time (	t TP0v at TP1a (pattern: I : TP1a (patt (20%-80%) : TP1a (patt (20%-80%) (20%-80%) (20%-80%)	PRBS13Q ern: PRBS ) (Short) (Short) ern: PRBS ) (Long) (Long)	513Q) 513Q)				
			naling Rate a L TP1a	nd Eye Ma	sk Mea	surements	TP1a (pa	ttern: I	PRBS13C	2)		
EST	•		turn Loss PNA 4 Module Out;									

Figure 16 Selecting Transition Time Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Transition Time Measurements TP1a (pattern: PRBS13Q) tests, see:

- "Minimum Output Rise Time (20%-80%)" on page 57
- "Minimum Output Fall Time (20%-80%)" on page 57

#### Minimum Output Rise Time (20%-80%)

- **Test Overview** The purpose of this test is to verify that the minimum rise time is greater than or equal to 10ps for short mode and greater than or equal to 15ps for long mode.
- Pass Condition Refer to Table 3.

Algorithm

- **Measurement** 1 Obtain sample or acquire signal data.
  - 2 Verify that the signal is PRBS13Q.
    - 3 Find pattern 000333 for the rising edge.
    - 4 Measure rise time from 20% to 80% of the signal amplitude.
    - 5 Compare the minimum rise time with 10ps for short mode and 15ps for long mode.

#### Minimum Output Fall Time (20%-80%)

**Test Overview** The purpose of this test is to verify that the minimum fall time is greater than or equal to 10ps for short mode and greater than or equal to 15ps for long mode.

Pass Condition Refer to Table 3.

- . . . . . . .
- Measurement Algorithm
- 1 Obtain sample or acquire signal data.
- 2 Verify that the signal is PRBS13Q.
- 3 Find pattern 333000 for the falling edge.
- 4 Measure fall time from 20% to 80% of the signal amplitude.
- 5 Compare the minimum fall time with 10ps for short mode and 15ps for long mode.

Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

ile Vi	iew	v Tools Help
	_	Select Tests Configure Connect Run Automate Results HTML Report
1		PAM4 IEEE Tests
•		PAM-4 Transmitter Characteristics at TP0v
		PAM-4 Host Output Characteristics at TP1a
		Main Voltage Measurements TP1a (pattern: PRBS13Q)
		Short Mode Requested
		Long Mode Requested
		Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q)
		Signaling Rate
		V Eye Height
		Vertical Eye Closure
		ERL TP1a
		Return Loss PNA/ENA Measurements
•		PAM-4 Module Output Characteristics at TP4
•		Utilities

Figure 17 Selecting Signaling Rate and Eye Mask Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 58
- "Eye Height" on page 58
- "Vertical Eye Closure" on page 59

#### Signaling Rate

**Test Overview** The purpose of this test is to verify that the signaling rate mean is between 53.125 ±50ppm GBd.

Pass Condition Refer to Table 3.

Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
- 3 In the **Configure** tab, set **Signaling Rate** to 53.125 Gb/s.
- 4 Measure minimum, maximum and mean data rate.
- 5 Report minimum and maximum values.
- 6 Compare the mean data rate value with 53.125 ±50ppm GBd.
- 7 Report the resulting value.

#### Eye Height

**Test Overview** The purpose of this test is to verify that for a defined range of CTLE settings, the Eye Height is greater than or equal to 10 mV.

Pass Conditions	Refer to Table 3.
Measurement Algorithm	<ul> <li>For the optimal CTLE, you may approach in one of the following ways:</li> <li>This setting can be characterized and automatically set by using the Auto-tune CTLE, DFE Eye Opening TP1a under the Utilities in the Select Tests tab.</li> </ul>

- Manually select the optimal CTLE setting from the Use Optimized CTLE for Eye Opening drop-down
  options in the Configure tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
  See IEEE P802.3ck D2.1, Section 120G, Table 120G-12.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Eye Height at an Eye Height/Width Probability setting of 1E-5.
- 4 On the Oscilloscope,
  - a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Compare the Eye Height with 10mV. Report the resulting value.\

#### Vertical Eye Closure

**Test Overview** The purpose of this test is to measure the Vertical Eye Closure at EH5 (1E-5).

**Pass Conditions** Refer to Table 3.

Measurement

Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:

- This setting can be characterized and automatically set by using the Auto-tune CTLE, DFE Eye Opening 1a under the Utilities in the Select Tests tab.
- Manually select the optimal CTLE setting from the Use Optimized CTLE for Eye Opening drop-down
  options in the Configure tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Vertical Eye Closure at an Eye Height/Width Probability setting of 1E-5 (EH5).
- 4 On the Oscilloscope,
  - a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Measure and calculate AV as the mean value of logic 1 minus the mean value of logic 0 at the central 5% of the eye.
- 6 Calculate Vertical Eye Closure (VEC) using the equation:

VEC = 20log(AV/EH5)

7 Report the resulting value of Vertical Eye Closure.

#### ERL TP1a

The ERL Measurement procedure described in this section is performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

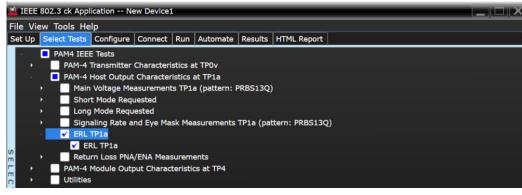


Figure 18 Selecting ERL Test

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm, see:

• "ERL TP1a" on page 60

#### ERL TP1a

- **Test Overview** The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.
- **Pass Condition** Refer to Table 3 for the pass limits pertaining to each standard option.
  - Measurement<br/>Algorithm1In the Set Up tab of the Compliance Test Application, click ERL File Setup button to set up the<br/>s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to<br/>create the s-parameters).
    - 2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
    - 3 Click **Run** under the **Run** tab. The Compliance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

M	IEEE	80	2.3 c	k Appli	cation N	ew Device1		_					
F	ile Vi	iew	Тоо	ls Hel	р								
s	et Up	S	elect	Tests	Configure	Connect	Run	Automate	Results	HTML Report			
	4		PAM	4 IEEE	Tests								
	•		P	AM-4 T	ransmitter	Characteri	stics a	t TPOv					
		PAM-4 Host Output Characteristics at TP1a											
		Main Voltage Measurements TP1a (pattern: PRBS13Q)											
		Short Mode Requested											
				Long	Mode Requ	lested							
				Signa	ling Rate a	nd Eye Ma	sk Me	asurements	TP1a (pa	ttern: PRBS130	5) 2		
				ERL T	'P1a								
			<ul> <li>✓</li> </ul>	Retur	n Loss PNA	VENA Meas	urem	ents					
SE				🖌 Co	mmon-mo	de to Differ	ential	Output Ret	urn Loss				
	•		P	AM-4 M	Iodule Out	put Charac	teristi	cs at TP4					
0	•		🗌 U	tilities									

Figure 19 Selecting Return Loss Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Return Loss PNA/ENA Measurements tests, see:

• "Common-mode to Differential Output Return Loss" on page 61

#### Common-mode to Differential Output Return Loss

Measurement Algorithm

- Ensure that the PNA/ENA is physically connected and calibrated.
   In the Set Up tab of the Conformance Test Application, click Connect PNA or Connect ENA to establish connectivity to the connected equipment.
- 3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
- 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
- 5 Compare the reported values with the specification to check for conformance.

## PAM4 Module Output Characteristics at TP4

This section provides the Methods of Implementation (MOIs) for the PAM4 100GAUI-1, 200GAUI-2, and 400GAUI-4 IEEE PAM4 Module Output Characteristics at TP4 as specified in *IEEE P802.3ck<sup>TM</sup>* /D3.3 (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) section 120G, Table 120G-3. Measurements are made at TP4.



Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

Module output electrical characteristics at TP4

#### Table 4 Module output characteristics at TP4

Parameter	Reference	Value	Units
Signaling rate, each lane (nominal)		53.125 <sup>a</sup>	GBd
Peak-to-peak AC common-mode voltage (max) Low-frequency, VCM <sub>LF</sub> Full-band, VCM <sub>FB</sub>	Sec. 120G.5.1	32 80	mV
Differential peak-to-peak output voltage (max) Short mode Long mode	Sec. 120G.5.1	600 845	mV mV
Eye height (min)	Sec. 120G.3.2.2	15	mV
Vertical Eye Closure, VEC (max)	Sec. 120G.3.2.2	12	dB
Common-mode to differential-mode return loss, RLdc (min)	Sec. 120G.3.1.1	Equation (120G-1)	dB
Effective Return Loss, ERL (min.)	Sec. 120G.3.2.3	8.5	dB
Transition time (min, 20% to 80%)	Sec. 120G.3.1.4	8.5	ps
DC common mode voltage (min)	Sec. 120G.3.2.4	-350	mV
DC common mode voltage (max)	Sec. 120G.3.2.4	2850	mV

Main Voltage Measurements TP4 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits might vary in both the modes.

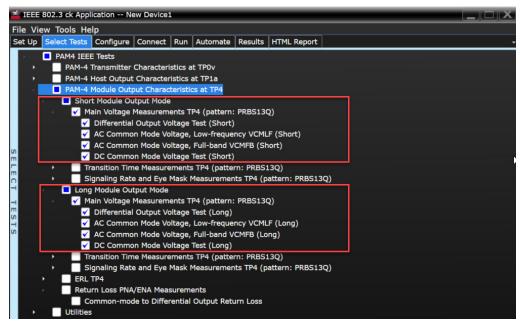


Figure 20 Selecting Main Voltage Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Main Voltage Measurements TP4 (pattern: PRBS13Q) tests, see:

- "Differential Output Voltage Test" on page 63
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 64
- "AC Common Mode Voltage, Full-band VCMFB" on page 64
- "DC Common Mode Voltage Test" on page 64

#### Differential Output Voltage Test

**Test Overview** The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q pattern is less than or equal to 600mV for short output mode and 845mV for long output mode.

Pass Condition Refer to Table 4.

Measurement 1

Algorithm

- Obtain sample or acquire signal data.
- 2 Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
- 3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
- 4 Compare the maximum peak-to-peak voltage to 600mV for short output mode and 845mV for long output mode.

#### AC Common Mode Voltage, Low-frequency VCMLF

**Test Overview** The purpose of this test is to verify that the low-frequency AC common-mode voltage of the signal is less than or equal to 32mV.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

#### Pass Condition Refer to Table 4.

Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Apply 100 MHz low pass filter.
- 5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-5</sup> of the measurement distribution.
- 6 Compare the voltage measurement with 32mV.

#### AC Common Mode Voltage, Full-band VCMFB

**Test Overview** The purpose of this test is to verify that the full-band AC common-mode voltage of the signal is less than or equal to 80mV.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Table 4.

Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-5</sup> of the measurement distribution.
- 5 Compare the voltage measurement with 80mV.

#### DC Common Mode Voltage Test

**Test Overview** The purpose of this test is to verify that the common-mode voltage of the signal is between -350mV and 2.85V.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

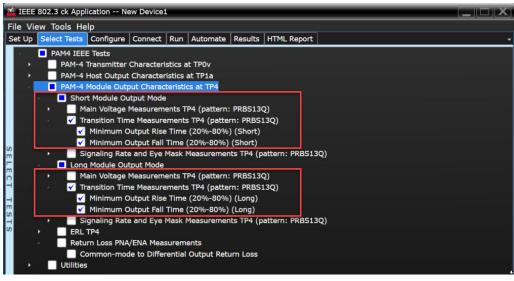
Pass Condition Refer to Table 4.

#### Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that there is a signal and that the connection is dual single-ended.
- 3 Set common mode signal using the common mode function.
- 4 Measure minimum and maximum voltage of the common mode signal.
- 5 Compare the voltage measurement to the range between -350mV and 2.85V.

Transition Time Measurements TP4 (pattern: PRBS13Q)

The Transition Time Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits do not vary in both the modes.





Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Transition Time Measurements TP4 (pattern: PRBS13Q) tests, see:

- "Minimum Output Rise Time (20%-80%)" on page 66
- "Minimum Output Fall Time (20%-80%)" on page 66

#### Minimum Output Rise Time (20%-80%)

Test OverviewThe purpose of this test is to verify that the minimum output rise time is greater than or equal to<br/>8.5ps.Pass ConditionRefer to Table 4.Measurement<br/>Algorithm1Obtain sample or acquire signal data.<br/>2Verify that the signal is PRBS13Q.

- 3 Find pattern 000333 for rising edge.
- 4 Measure rise time from 20% to 80% of the signal amplitude.
- 5 Compare the minimum rise time with 8.5ps.

#### Minimum Output Fall Time (20%-80%)

Test Overview	The purpose of this test is to verify that the minimum output fall time is greater than or equal to
	8.5ps.

Pass Condition Refer to Table 4.

#### Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Verify that the signal is PRBS13Q.
- 3 Find pattern 333000 for the falling edge.
- 4 Measure fall time from 20% to 80% of the signal amplitude.
- 5 Compare the minimum output fall time with 8.5ps.

Signaling Rate and Eye Mask Measurements TP4 (pattern: PRBS13Q)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits do not vary in both the modes.

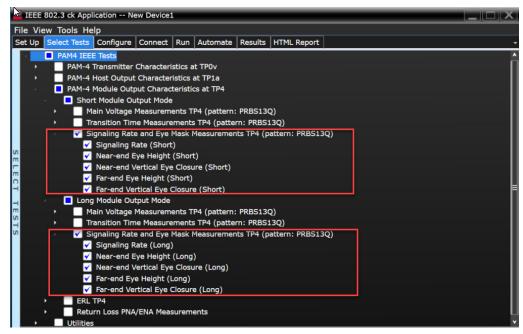


Figure 22 Selecting Signaling Rate and Eye Mask Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Signaling Rate and Eye Mask Measurements TP4 (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 68
- "Near-end Eye Height" on page 69
- "Near-end Vertical Eye Closure" on page 69
- "Far-end Eye Height" on page 70
- "Far-end Vertical Eye Closure" on page 70

#### Signaling Rate

**Test Overview** The purpose of this test is to verify that the signaling rate mean meets the specified standards.

**Pass Condition** Refer to Table 4.

Measurement

- 1 Obtain sample or acquire signal data.
- Algorithm
- Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists 2 (PRBS13Q must be used for this test).
- 3 In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
- 4 Measure minimum, maximum and mean data rate.
- 5 Report minimum and maximum values.
- 6 Compare the mean data rate value with 53.125 GBd.
- 7 Report the resulting value.

#### Near-end Eye Height

**Test Overview** The purpose of this test is to verify that for a defined range of CTLE settings, the Near-end Eye Height is greater than or equal to 15mV. The measurement is made either in short module output mode or long module output mode.

Pass Conditions Refer to Table 4.

Measurement

Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:

- This setting can be characterized and automatically set by using the Auto-tune Near-end CTLE, DFE Eye Opening TP4 Short or Auto-tune Near-end CTLE, DFE Eye Opening TP4 Long under the Utilities in the Select Tests tab.
- Manually select the optimal CTLE settings from the Use Optimized CTLE gDC for Near-end Eye
  Opening TP4 Short and Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short or Use Optimized
  CTLE gDC for Near-end Eye Opening TP4 Long and Use Optimized CTLE gDC2 for Near-end Eye Opening
  TP4 Long drop-down options in the Configure tab. The selected CTLE setting is called as
  'User-defined optimal CTLE'.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Near-end Eye Height at an Eye Height/Width Probability setting of 1E-5.
- 4 On the Oscilloscope,
  - a Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Compare the Near-end Eye Height with the specified limit. Report the resulting value.

#### Near-end Vertical Eye Closure

**Test Overview** The purpose of this test is to measure the Vertical Eye Closure at EH5 (1E-5). The measurement is made either in short module output mode or long module output mode.

Pass Conditions Refer to Table 4.

Measurement Algorithm

- 1 For the optimal CTLE, you may approach in one of the following ways:
  - This setting can be characterized and automatically set by using the Auto-tune Near-end CTLE, DFE Eye Opening TP4 Short or Auto-tune Near-end CTLE, DFE Eye Opening TP4 Long under the Utilities in the Select Tests tab.
  - Manually select the optimal CTLE settings from the Use Optimized CTLE gDC for Near-end Eye
    Opening TP4 Short and Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short or Use Optimized
    CTLE gDC for Near-end Eye Opening TP4 Long and Use Optimized CTLE gDC2 for Near-end Eye Opening
    TP4 Long drop-down options in the Configure tab. The selected CTLE setting is called as
    'User-defined optimal CTLE'.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Vertical Eye Closure at an Eye Height/Width Probability setting of 1E-5 (EH5).
- 4 On the Oscilloscope,
  - a Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Measure and calculate AV as the mean value of logic 1 minus the mean value of logic 0 at the central 5% of the eye.
- 6 Calculate Vertical Eye Closure (VEC) using the equation:

#### VEC = 20log(AV/EH5)

7 Report the resulting value of Vertical Eye Closure.

#### Far-end Eye Height

**Test Overview** The purpose of this test is to verify that for a defined range of CTLE settings, the Far-end Eye Height is greater than or equal to 15mV. The measurement is made either in short module output mode or long module output mode.

#### **Pass Conditions** Refer to Table 4.

Measurement

Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:

- This setting can be characterized and automatically set by using the Auto-tune Far-end CTLE Eye
  Opening TP4 Short or Auto-tune Far-end CTLE Eye Opening TP4 Long under the Utilities in the Select
  Tests tab.
- Manually select the optimal CTLE settings from the Use Optimized CTLE gDC for Far-end Eye
  Opening TP4 Short and Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short or Use Optimized
  CTLE gDC for Far-end Eye Opening TP4 Long and Use Optimized CTLE gDC2 for Far-end Eye Opening TP4
  Long drop-down options in the Configure tab. The selected CTLE setting is called as
  'User-defined optimal CTLE'.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Far-end Eye Height at an Eye Height/Width Probability setting of 1E-5.
- 4 On the Oscilloscope,
  - a Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Compare the Far-end Eye Height with 15mV. Report the resulting value.

#### Far-end Vertical Eye Closure

**Test Overview** The purpose of this test is to measure the Vertical Eye Closure at EH5 (1E-5). The measurement is made either in short module output mode or long module output mode.

Pass Conditions Refer to Table 4.

Measurement Algorithm

- 1 For the optimal CTLE, you may approach in one of the following ways:
  - This setting can be characterized and automatically set by using the Auto-tune Far-end CTLE Eye
    Opening TP4 Short or Auto-tune Far-end CTLE Eye Opening TP4 Long under the Utilities in the Select
    Tests tab.
  - Manually select the optimal CTLE settings from the Use Optimized CTLE gDC for Far-end Eye
    Opening TP4 Short and Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short or Use Optimized
    CTLE gDC for Far-end Eye Opening TP4 Long and Use Optimized CTLE gDC2 for Far-end Eye Opening TP4
    Long drop-down options in the Configure tab. The selected CTLE setting is called as
    'User-defined optimal CTLE'.
- 2 Obtain sample or acquire signal data.
- 3 Measure the Vertical Eye Closure at an Eye Height/Width Probability setting of 1E-5 (EH5).
- 4 On the Oscilloscope,
  - a Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 5 Measure and calculate AV as the mean value of logic 1 minus the mean value of logic 0 at the central 5% of the eye.
- 6 Calculate Vertical Eye Closure (VEC) using the equation:

#### VEC = 20log(AV/EH5)

7 Report the resulting value of Vertical Eye Closure.

#### ERL TP4

The ERL Measurement procedure described in this section is performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.



Figure 23 Selecting ERL Test

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm, see:

• "ERL TP4" on page 71

#### ERL TP4

Test Overview	The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.					
Pass Condition	Refer to Table 4 for the pass limits pertaining to each standard option.					
Measurement Algorithm	1 In the <b>Set Up</b> tab of the Compliance Test Application, click <b>ERL File Setup</b> button to set up the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters).					
	2 Click the <b>Select Tests</b> tab and check the ERL test to measure the effective return loss.					
	3 Click <b>Run</b> under the <b>Run</b> tab. The Compliance Test Application automatically calculates the					

3 Click **Run** under the **Run** tab. The Compliance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

×	IEEE 802.3 ck Application New Device1										
E	<u>F</u> ile <u>V</u> iew <u>T</u> ools <u>H</u> elp										
S	iet U	р	Sele	ct Tests	Configure	Connect	Run	Automate	Results	HTML Report	-
	PAM4 IEEE Tests										
	PAM-4 Transmitter Characteristics at TP0v										
	•	•		PAM-4	Host Output	Character	istics	at TP1a			
	4			PAM-4	Module Outp	out Charac	teristi	cs at TP4			
			•	Shor	t Module Ou	tput Mode					
	Long Module Output Mode										
	ERL TP4										
	Return Loss PNA/ENA Measurements										
	Common-mode to Differential Output Return Loss										
	→ Utilities										
SE											
-	Click a test's name to see its description)										
EO											
-											

Figure 24 Selecting Return Loss Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Return Loss PNA/ENA Measurements tests, see:

• "Common-mode to Differential Output Return Loss" on page 72

#### Common-mode to Differential Output Return Loss

- Measurement Algorithm
- 1 Ensure that the PNA/ENA is physically connected and calibrated.
  - 2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
  - 3 Click the Select Tests tab and check the tests to measure the Return Loss Measurements.
  - 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
  - 5 Compare the reported values with the specification to check for conformance.

#### Utilities

This section provides the Methods of Implementation (MOIs) for the Utilities tests to find the optimal CTLE Eye Opening.

Run the CTLE utility tests documented in this section before running the corresponding Eye Height tests. The following is the general sequence of steps to be followed:

1 Run the Utility called "Auto-tune CTLE, DFE Eye Opening TP1a" or "Auto-tune Near-end CTLE, DFE Eye Opening TP4" (for Near-end tests) or "Auto-tune Far-end CTLE, DFE Eye Opening TP4" (for Far-end tests) to determine the correct CTLE value to use in subsequent eye measurement tests. The Near-end and Far-end utilities can be run either in short or long module output mode. Run the Utility standalone (do not run with other tests). After running the utility, the applicable ones out of the following settings on the Configure tab

will be set with the optimal values:

- Use Optimized CTLE gDC for Eye Opening TP1a
- Use Optimized CTLE gDC2 for Eye Opening TP1a
- Use Optimized CTLE gDC for Near-end Eye Opening TP4 Short
- Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short
- Use Optimized CTLE gDC for Near-end Eye Opening TP4 Long
- Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Long
- Use Optimized CTLE gDC for Far-end Eye Opening TP4 Short
- Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short
- Use Optimized CTLE gDC for Far-end Eye Opening TP4 Long
- Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Long
- The following two methods can be used to find the optimum CTLE gDC and gDC2:
- Optimize CTLE using COM Method FFE is calculated and included in the measurement to find the optimized CTLE settings.
- Auto-Tune The measurement does not use FFE.

Configure appropriate settings using the COM tool settings and General settings configuration variables under the Utilities category in the Configure tab.

2 Deselect the Utility for subsequent tests and select the desired tests to be run. It is recommended to group tests that use the same pattern. The tests are run in order, from top to bottom.



# Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application matches the frequency of the acquired input signal.

Utilities in IEEE Tests

The procedure described in this section to find Optimal CTLE Eye Opening are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application

IEEE 802.3 ck Application New Device1									
Set Up	Select Tests	Configure	Connect	Run	Automate	Results	HTML Report		
PAM4 IEEE Tests									
→	PAM-4 1	Transmitter	Characteri	stics a	t TP0v				
•	PAM-4 I	lost Output	Character	istics a	at TP1a				
►	📃 PAM-4 I	Module Outp	out Charac	teristic	s at TP4				
- A	🖌 🖌 🖌								
	🖌 🖌	-tune CTLE,	DFE Eye O	pening	g TP1a				
	🖌 Auto	-tune Near-	end CTLE,I	OFE Ey	e Opening	FP4 (Shor	t)		
	🖌 🖌	-tune Far-er	nd CTLE Ey	e Ope	ning TP4 (S	hort)			
	🖌 Auto	-tune Near-	end CTLE,I	OFE Ey	e Opening	FP4 (Long	)		
Auto-tune Far-end CTLE Eye Opening TP4 (Long)									
Click a test's name to see its description)									

Figure 25 Selecting Utilities under the Select Tests Tab

#### Auto-tune CTLE, DFE Eye Opening TP1a

**Test Overview** The purpose of this test is to measure the eye height and VEC with CTLE and DFE settings at TP1a and report the optimal settings to use in Eye measurements. The optimal values are automatically set in the Configure tab after this test has run. The measurement is made either in short module output mode or long module output mode.

#### Measurement Algorithm

- 1 Obtain sample or acquire signal data.
- 2 Apply the Start CTLE gDC.
- 3 Apply the Start CTLE gDC2 that corresponds to the current gDC setting.
- 4 Set DFE to pulse response method and 4 taps.
- 5 Auto find the optimal DFE taps.
- 6 Measure eye height and VEC.
- 7 Step to next CTLE gDC2 value.
- 8 Auto find the optimal DFE taps.
- 9 Measure eye height and VEC.
- 10 Compare eye height and VEC results. Optimal eye is where eye height is greater than 10mV and the minimum VEC of any eye height greater than 15mV. (User can select if these comparison values are min/max or average in the Configure tab.)
- 11 Repeat steps 7-10 for the rest of the gDC2 settings available for the gDC setting.
- 12 Set to next gDC setting.
- 13 Repeat steps 7-10 for each gDC2 setting.
- 14 Repeat step 12-13 for each gDC setting If eye height and VEC are not improving after three more steps, app will stop loop and report the optimal CTLE gDC and gDC2 and DFE settings. (User can select to run all the gDC/gDC2 options in the Configure tab).

#### Auto-tune Far-end CTLE Eye Opening TP4

- **Test Overview** The purpose of this test is to measure the far-end eye height and far-end VEC with each CTLE setting at TP4 and report the optimal setting to use in Eye Height measurements. The optimal value is automatically set in the Configure tab after this test has run. The measurement is made either in short module output mode or long module output mode.
- **Measurement** The measurement algorithm for this test is same as for the previous test with the difference that the far-end channel response is applied to the eye.

#### Auto-tune Near-end CTLE Eye Opening TP4

- **Test Overview** The purpose of this test is to measure the near-end eye height and near-end VEC with each CTLE setting at TP4 and report the optimal setting to use in the Near-end Eye measurements. The optimal value is automatically set in the Configure tab after this test has run. The measurement is made either in short module output mode or long module output mode.
- MeasurementThe measurement algorithm for this test is same as for the previous test except that the gDC and<br/>gDC2 combinations and options are different.

#### 3 C2C C2M Tests

Keysight D90103CKC IEEE802.3ck Conformance Application Methods of Implementation

## 4 CR Tests

Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/PRBS9Q) 80 Output Voltage Measurements EYE TP2 (pattern: PRBS13Q) 83 Output Waveform Measurements TP2 (pattern: PRBS13Q) 85 Main Voltage Measurements TP2 (pattern: PRBS13Q) 93 Return Loss PNA/ENA Measurements 96

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4. Measurements are made at test point TP2.



Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application matches the frequency of the acquired input signal.



#### Transmitter characteristics for CR tests

See Table 5 for pass limits pertaining to 100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4 PAM4 tests, which are specified in *IEEE P802.3ck<sup>TM</sup> /D3.3* (*Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling*) section 162.9.4, Table 162-11.

#### Table 5 100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4 transmitter characteristics at TP2

Parameter	Reference	Value	Units
Signaling rate, each lane (range)	See Sec. 162.9.4.1 f the IEEE specification	53.125 ± 50 ppm	GBd
Differential pk-to-pk voltage with TX disabled <sup>a</sup>	See Sec. 93.8.1.3 of the IEEE specification	30	mV
DC common-mode voltage (max) <sup>a</sup>	See Sec. 93.8.1.3 of the IEEE specification	1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM <sub>LF</sub> Full-band, VCM <sub>FB</sub>	See Sec.162.9.4.4 of the IEEE specification	30 80	mV mV
Differential pk-to-pk voltage, v <sub>di</sub> (max) <sup>a</sup>	See Sec. 93.8.1.3 of the IEEE specification	1200	mV
Effective return loss, ERL (min)	See Sec. 162.9.4.8 of the IEEE specification	7.3	dB
Common-mode to common-mode return loss, RLcc (min)	See Sec. 162.9.4.9 of the IEEE specification	2	dB
Common-mode to differential-mode return loss, RLdc (min)	See Sec. 162.9.4.10 of the IEEE specification	See Equation (162–7)	dB
Transmitter steady-state voltage, v <sub>f</sub> (min) Transmitter steady-state voltage, v <sub>f</sub> (max)	See Sec. 162.9.4.1.2 of the IEEE specification	0.387 0.6	V
Linear fit pulse peak ratio, R <sub>peak</sub> (min)	See Sec. 162.9.4.1.2 of the IEEE specification	0.397	-
Level separation mismatch ratio $R_{LM}$ (min)	See Sec.162.9.4.1.2 of the IEEE specification	0.95	-
Transmitter output waveform <sup>a</sup>	See Sections		
absolute value of step size for all taps (min)	162.9.4.1.4	0.005	-
absolute value of step size for all taps (max)	162.9.4.1.4	0.025	-
value at minimum state for c(–3) (max)	162.9.4.1.5	-0.06	-
value at maximum state for c(–2) (min)	162.9.4.1.5	0.12	-
value at minimum state for c(–1) (max)	162.9.4.1.5	-0.34	-
value at minimum state for c(0) (max)	162.9.4.1.5	0.5	-
value at minimum state for c(1) (max)	162.9.4.1.5	-0.2	-
Signal-to-noise-and-distortion ratio, SNDR (min) <sup>c</sup>	See Sec.162.9.4.6 of the IEEE specification	31.5	dB
Signal-to-residual-intersymbol-interference ratio, ${\rm SNR}_{\rm ISI}$ (min)	See Sec. 162.9.4.3 of the IEEE specification	26.7	dB
Output jitter (max.)	See Sections		
JRMS	162.9.4.7	0.023	UI
J3u <sub>03</sub>	162.9.4.7	0.115	UI
J3u	162.9.4.7	0.125	UI
Even-odd jitter, pk-pk	162.9.4.7	0.025	UI

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

#### Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

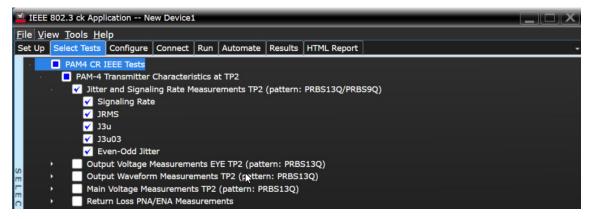


Figure 26 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section Transmitter characteristics for CR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 80
- "JRMS" on page 80
- "J3u" on page 81
- "J3u03" on page 81
- "Even-Odd Jitter" on page 82

#### Signaling Rate

**Test Overview** The purpose of this test is to verify that the signaling rate meets the specified standards.

**Pass Condition** Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.

Measurement	1	Obtain sample or acquire signal data.
Algorithm	2	Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).

- 3 In the Configure tab, set Signaling Rate to 53.125 Gb/s.
- 4 Measure minimum and maximum data rate.
- 5 Report minimum and maximum values.
- 6 Compare the mean data rate value with the specified standards. Report the resulting value.

#### JRMS

## **Test Overview** The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.							
Measurement Algorithm	1 Obtain sample or acquire signal data.							
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.							
	2 In the <b>Configure</b> tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.							
	3 On the Oscilloscope,							
	a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.							
	b Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.							
	c Set 4 <sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.							
	4 Compare and report the JRMS value to the specified standards.							
J3u								
Test Overview	The purpose of this test is to verify that differential signal's J3u meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.							
Pass Conditions	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.							
Measurement Algorithm	1 Obtain sample or acquire signal data.							
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.							
	2 In the <b>Configure</b> tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.							
	3 On the Oscilloscope,							
	<ul> <li>Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.</li> </ul>							
	<i>b</i> Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.							
	c Set 4 <sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.							
	4 Compare and report the J3u value meets the specified standards.							
J3u03								

**Test Overview** The purpose of this test is to verify that differential signal's J3u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.
Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the J3u03 value meets the specified standards.

#### Even-Odd Jitter

Test Overview	The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
Pass Conditions	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.
Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q/PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the Even-Odd Jitter value to the specified standards.

#### Output Voltage Measurements EYE TP2 (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

le Vie	ew To	ools He	lp						
et Up	Sele	ct Tests	Configure	Connect	Run	Automate	Results	HTML Report	
×	P/	AM4 CR	IEEE Tests						
		PAM-4	Transmitter	Characteri	stics a	it TP2			
	•	🗌 Jitte	r and Signal	ing Rate M	leasure	ements TP2	(pattern:	PRBS13Q/PRB	59Q)
	*	🖌 Outp	out Voltage M	leasureme	ents E\	'E TP2 (patt	ern: PRB	513Q)	
		🖌 Le	evel - PRBS	pattern					
		🖌 Le	evel RMS - P	RBS patte	rn				
		🖌 Le	evel Separat	ion Misma	tch Ra	tio - RLM			
	•	Outp	out Waveforr	n Measure	ments	TP2 (patter	n: PRBS1	.3Q)	
	•	📃 Main	Voltage Me	asurement	ts TP2	(pattern: PF	RBS13Q)		
	•	Retu	rn Loss PNA	/ENA Meas	surem	ents			

Figure 27 Selecting Output Voltage Measurements EYE Tests

Refer to the section Transmitter characteristics for CR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TP2 (pattern: PRBS13Q) tests, see:

- "Level PRBS Pattern" on page 83
- "Level RMS PRBS Pattern" on page 84
- "Level Separation Mismatch Ratio RLM" on page 84

NOTE

# The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

#### Level - PRBS Pattern

Test Overview	iew The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS pattern.							
Pass Condition	No	ot applicable as the test result is considered as "Information Only".						
Measurement Algorithm	1	Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used for this test).						
	2	$V_0$ , $V_1$ , $V_2$ and $V_3$ are the mean signal levels of the symbols corresponding to the PAM4 symbol						
		levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs <sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.						

3 The mean level  $V_{mid}$  is defined by equation (120D-3), which is,

 $V_{mid} = (V_0 + V_3) / 2$ 

4 Report this value for information-only purpose.

Level RMS - PRBS Pattern

Test Overview	The purpose of this test is to obtain the of the RMS level	of the signal with PRBS13Q pattern.

Pass Condition Not applicable as the test result is considered as "Information Only".

Measurement 1 Run the Level - PRBS Pattern test as a prerequisite to this test. Algorithm 2 The minimum sized Level PMS is calculated as defined in LEFE

- 2 The minimum signal level RMS is calculated, as defined in IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.
  - 3 Report this value for information-only purpose.

Level Separation Mismatch Ratio - RLM

Test Overview	The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.										
Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.										
Measurement Algorithm	<ol> <li>Run the Level - PRBS Pattern as a prerequisite to this test to calculate the mid-range level.</li> <li>The mean signal levels are normalized so that V<sub>0</sub> corresponds to -1, V<sub>1</sub> to -ES1, V<sub>2</sub> to ES2 and V<sub>3</sub> to 1.</li> <li>ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.</li> </ol>										
	$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$										

$$ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$$

4 The level separation mismatch ratio R<sub>I M</sub> is defined by equation (120D-5).

R<sub>IM</sub> = min [(3 x ES1), (3 x ES2), (2 - 3 x ES1), (2 - 3 x ES2)]

5 Report this value as the result.

#### Output Waveform Measurements TP2 (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

🔟 IEEE	802.	3 ck Ap	plication N	ew Device1	_	_	_		
File Vi	ew T	Fools H	lelp						
Set Up	Sele	ect Test	Configure	Connect	Run	Automate	Results	HTML Report	
1.0	P	Pam4 Cr	R IEEE Tests						
1.1		PAM-4	4 Transmitter	Characteri	stics a	t TP2			
		🗌 Jitt	er and Signal	ing Rate M	easure	ements TP2	(pattern:	PRBS13Q/PRB	3S9Q)
		Ou Ou	tput Voltage I	Measureme	nts E	E TP2 (patt	ern: PRB	S13Q)	
		🖌 Ou	tput Wavefor	m Measure	ments	TP2 (patter	m: PRBS1	13Q)	
			Steady-State	Voltage Vf					
		<b>~</b>	Linear Fit Pul	se Peak Rat	io				
		<ul> <li>Image: A second s</li></ul>	Signal-to-nois	se-and-dist	ortion	ratio			
10		1	Signal-to-resi	dual-inters	ymbol	-interferenc	e ratio, S	NRISI	
SE		<	ERL						
<b>_</b>		<ul> <li>Image: A second s</li></ul>	abs Step Size						
C		<ul> <li>Image: A second s</li></ul>	Coefficient In	itialization					
-		Ma	in Voltage Me	asurement	s TP2	(pattern: Pl	RBS13Q)		
-		Re	turn Loss PNA	/ENA Meas	urem	ents			

Figure 28 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section Transmitter characteristics for CR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TP2 (pattern: PRBS13Q) tests, see:

- "Steady State Voltage Vf" on page 85
- "Linear Fit Pulse Peak Ratio" on page 85
- "Signal-to-noise-and-distortion ratio" on page 86
- "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 86
- "ERL" on page 86
- "abs Step Size Tests" on page 87
- "Coefficient Initialization" on page 92

Steady State Voltage V<sub>f</sub>

Test Overview	The purpose of this test is to veri	fy that the Steady State Voltage	is between 0.387V and 0.6V.

**Pass Condition** Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.

- Measurement<br/>Algorithm1Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this<br/>test).
  - 2 Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
  - 3 Calculate V<sub>f</sub> using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. N<sub>p</sub> = 200, D<sub>p</sub> = 2.
  - 4 Compare and report the resulting value in the range between 0.387V and 0.6V.

Linear Fit Pulse Peak Ratio

**Test Overview** The purpose of this test is to verify that the Linear Fit Pulse Peak Ratio meets the specified standards.

### NOTE

Run the Steady-State Voltage Vf test as a prerequisite to running the Linear Fit Pulse Peak Ratio test.

Pass Conditions	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.
Massuramont	1 Check that signal is connected and proper data pattern eviate (DDRS120 must be used for this

### Measurement1Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this<br/>test).

- 2 Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
- 3 Calculate the transmitter output steady-state voltage, Vf and linear fit pulse response peak voltage, Vpeak.
- 4 Calculate the Linear Fit Pulse Ratio by dividing Vpeak with Vf.
- 5 Compare the resulting value to the specified standards.

#### Signal-to-noise-and-distortion ratio

Test Overview	The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) meets t specified standards.							
Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.							
Measurement Algorithm	1 Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.							
	2 Compare the resulting value of SNDR to the specified standards.							

Signal-to-residual-intersymbol-interference ratio, SNRISI

Test Overview	The purpose of this test is to verify that the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:						
	0 dB through -20 dB gDC and - 4 dB through 0 dB gDC2.						
Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.						
Measurement Algorithm	<ol> <li>Follow the procedure for Linear Fit Pulse peak to calculate p(k).</li> <li>Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.</li> <li>With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8)</li> <li>Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.</li> <li>The results is the highest SNRISI value.</li> </ol>						

ERL

Test Overview	The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.
Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.

MeasurementThe COM MATLAB script takes the user-specified s-parameter files and the configurationAlgorithmspreadsheets (available with the COM tool) as the input and help in the ERL computation.

- 1 In the Set Up tab of the Conformance Test Application, click ERL File Setup button to set up the s-parameter file (refer to Annex 93A.5.1 of the IEEE P802.3cd<sup>TM</sup> specification for more information about the standards defined to create the s-parameters).
- 2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
- 3 Click **Run** under the **Run** tab.
- 4 The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 162-13) and the user-specified S-parameter file for return loss at TPOv measurement to compute ERL at TP2. The computed ERL at TP2 is reported as the result.

#### abs Step Size Tests

#### **Test Overview** The purpose of this test is to verify the abs Step Size.

To know about the measurement algorithm for each abs Step Size test, see:

- "abs Step Size for c(-3)" on page 87
- "abs Step Size for c(-2)" on page 88
- "abs Step Size for c(-1)" on page 88
- "abs Step Size for c(0)" on page 88
- "abs Step Size for c(1)" on page 89
- "value at min. state for c(-3)" on page 89
- "value at max. state for c(-2)" on page 90
- "value at min. state for c(-1)" on page 90
- "value at min. state for c(0)" on page 90
- "value at min. state for c(1)" on page 91

#### abs Step Size for c(-3)

**Test Overview** The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.

#### **Pass Condition** When abs Coefficient Step Size - c(-3) is greater than or equal to 5 m and less than or equal to 25 m.

- Measurement Algorithm
- 1 Request Transmitter to be set to "PRESET" condition.
  - 2 Capture full pattern of PRBS13Q at 32 points per UI.
  - 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
  - 4 Define r(m) from "PRESET" as per equation 136-1.
  - 5 Request to change c(-3) to the first step.
  - 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
  - 7 Calculate coefficients c(i) using equation 136-2.
  - 8 Save coefficient c(-3) as base step value.
  - 9 Request next c(-3) step.
  - 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
  - 11 Calculate coefficients c(i) using equation 136-2.
  - 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
  - 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

abs	Step Size for c(-2)									
Test Overview	The purpose of this test is to verify that the abs Step Size for $c(-2)$ is within limits.									
Pass Condition	When abs Coefficient Step Size - c(-2) is greater than or equal to 5 m and less than or equal to 25 m.									
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(-2) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Save coefficient c(-2) as base step value.</li> <li>Request next c(-2) step.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.6 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate tinear fit pulse response as per section 85.8.3.6 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate to coefficients c(i) using equation 136-2.</li> <li>Calculate the step size as coefficient value from step 11 – coefficient value from step 7.</li> <li>Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.</li> </ol>									

abs Step Size for c(-1)

Test Overview	The purpose of this test is to verify that the abs Step Size for $c(-1)$ is within limits.							
Pass Condition	When abs Coefficient Step Size - $c(-1)$ is greater than or equal to 5 m and less than or equal to 25 m.							
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(-1) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> </ol>							
	<ul><li>8 Save coefficient c(-1) as base step value.</li><li>9 Request next c(-1) step.</li></ul>							
	10 Calculate linear fit pulse response as per section 85.8.3.3.5 with $N_p = 200$ , $D_p = 4$ .							
	<ol> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Calculate the step size as coefficient value from step 11 – coefficient value from step 7.</li> <li>Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.</li> </ol>							
abs	Step Size for c(0)							

Test Overview	The purpose of this test is to verify that the abs Step Size for c(0) is within limits.							
Pass Condition	When abs Coefficient Step Size - c(0) is greater than or equal to 5 m and less than or equal to 25m.							
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> </ol>							

- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(0) to the first step.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(0) as base step value.
- 9 Request next c(0) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

When abs Coefficient Step Size - c(1) is greater than or equal to 5 m and less than or equal to 25 m.

#### abs Step Size for c(1)

**Test Overview** The purpose of this test is to verify that the abs Step Size for c(1) is within limits.

Pass Condition

- 1 Request Transmitter to be set to "PRESET" condition.
- Measurement Algorithm
- r Request fransmitter to be set to PRESET condition.
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(1) to the first step.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(1) as base step value.
- 9 Request next c(1) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### value at min. state for c(-3)

Test Overview	The purpose of this test is to verify that the value at min. state for $c(-3)$ is within limits.								
Pass Condition	When value at min. state for c(-3) is less than or equal to -60 m.								
Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.							
	2	Capture full pattern of PRBS13Q at 32 points per UI.							
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.							
	4	Define r(m) from "PRESET" as per equation 136-1.							
	5	Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minimum value.							

6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .

- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(-3) value from step 7.

#### value at max. state for c(-2)

**Test Overview** The purpose of this test is to verify that the value at max. state for c(-2) is within limits.

**Pass Condition** When value at max. state for c(-2) is greater than or equal to 120 m.

Measurement Algorithm

- 1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request user to set c(-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum value.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(-2) value from step 7.

#### value at min. state for c(-1)

 Test Overview
 The purpose of this test is to verify that the value at min. state for c(-1) is within limits.

 Pass Condition
 When value at min. state for c(-1) is less than or equal to -340 m.

 Measurement Algorithm
 1
 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

 2
 Capture full pattern of PRBS13Q at 32 points per UI.
 3

 3
 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(-1) value from step 7.

#### value at min. state for c(0)

Test Overview	Th	The purpose of this test is to verify that the value at min. state for c(0) is within limits.								
Pass Condition	W	When value at min. state for c(0) is less than or equal to 500 m.								
Measurement Algorithm										
	2	2 Capture full pattern of PRBS13Q at 32 points per UI.								
	3	3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.								
	4 Define r(m) from "PRESET" as per equation 136-1.									
	5	5 Request user to decrement c(0) to minimum value.								
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with N <sub>p</sub> = 200, D <sub>p</sub> = 3.								

- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(0) value from step 7.

#### value at min. state for c(1)

**Test Overview** The purpose of this test is to verify that the value at min. state for c(1) is within limits.

**Pass Condition** When value at min. state for c(1) is less than or equal to -200 m.

- Measurement Algorithm
- 1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated
- during trial, steps 1-4 are skipped.
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 3.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(1) value from step 7.

#### Coefficient Initialization

#### **Test Overview** This test group consists of the following tests:

- Coefficient Initialization Preset 2 c(-3)
- Coefficient Initialization Preset 2 c(-2)
- Coefficient Initialization Preset 2 c(-1)
- Coefficient Initialization Preset 2 c(0)
- Coefficient Initialization Preset 2 c(1)
- Coefficient Initialization Preset 3 c(-3)
- Coefficient Initialization Preset 3 c(-2)
- Coefficient Initialization Preset 3 c(-1)
- Coefficient Initialization Preset 3 c(0)
- Coefficient Initialization Preset 3 c(1)
- Coefficient Initialization Preset 4 c(-3)
- Coefficient Initialization Preset 4 c(-2)
- Coefficient Initialization Preset 4 c(-1)
- Coefficient Initialization Preset 4 c(0)
- Coefficient Initialization Preset 4 c(1)
- · Coefficient Initialization Preset 5 c(-3)
- Coefficient Initialization Preset 5 c(-2)
- · Coefficient Initialization Preset 5 c(-1)
- Coefficient Initialization Preset 5 c(0)
- Coefficient Initialization Preset 5 c(1)

#### Pass Condition

Preset\Coefficient	c(-3)	c(-2)	c(-1)	c(0)	c(1)
Preset 2	0	0	0	0.5	0
	±0.0125	±0.0125	±0.0125	±0.0125	±0.0125
Preset 3	0	0	-0.075	0.75	0
	±0.0125	±0.0125	±0.0125	±0.0125	±0.0125
Preset 4	0	0.05	-0.2	0.75	0
	±0.0125	±0.0125	±0.0125	±0.0125	±0.0125
Preset 5	-0.025	0.075	-0.25	0.65	0
	±0.0125	±0.0125	±0.0125	±0.0125	±0.0125

#### Measurement Algorithm

1

2 Capture full pattern of PRBS13Q at 32 points per UI.

Request Transmitter to be set to "PRESET 1" condition.

- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request preset # (for each test).
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 3$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(#) value from step 7.

#### Main Voltage Measurements TP2 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

	E 80	2.3 c	k Appl	ication Ne	ew Device1	_			-	_	
<u>File</u> V	liew	Too	ls <u>H</u> e	lp					v.		
Set Up	S	elect	Tests	Configure	Connect	Run	Automate	Results	HTML	Report	
1		PAM	4 CR 1	IEEE Tests							
		P	AM-4 '	Transmitter	Characteri	stics a	t TP2				
			Jitter	r and Signal	ing Rate M	easur	ements TP2	(pattern:	PRBS1	3Q/PRB	3S9Q)
			Outp	out Voltage I	Measureme	nts E'	/E TP2 (patt	ern: PRB	513Q)		<b>&gt;</b>
			Outp	out Waveform	m Measure	ments	TP2 (patter	m: PRBS1	.3Q)		
		<ul> <li>✓</li> </ul>	Main	Voltage Me	asurement	s TP2	(pattern: Pl	RBS13Q)			
			🖌 Di	ifferential Pe	ak to Peak	Outp	ut Voltage T	est with T	X disa	bled	
			🖌 D(	C Common I	Mode Outp	ut Vol	tage Test				
(0)			🖌 🗸	C Common I	Mode Volta	ge, Lo	w-frequency	y VCMLF			
E			🖌 🗸	C Common I	Mode Volta	ge, Fu	II-band VCM	1FB			
5			🖌 Di	ifferential Pe	eak to Peak	Outp	ut Voltage T	ēst			
C	•		Retu	rn Loss PNA	/ENA Meas	urem	ents				

Figure 29 Selecting Main Voltage Measurement Tests

Refer to the section Transmitter characteristics for CR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TP2 (pattern: PRBS13Q) tests, see:

- "Differential Peak to Peak Output Voltage Test with TX Disabled" on page 93
- "DC Common Mode Output Voltage Test" on page 93
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 94
- "AC Common Mode Voltage, Full-band VCMFB" on page 94
- "Differential Peak-to-Peak Output Voltage Test" on page 95

Differential Peak to Peak Output Voltage Test with TX Disabled

Test Overview	The purpose of this test is to verify that when TX is disabled, the peak-to-peak voltage meets the specified standards.							
Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.							
Measurement Algorithm	<ol> <li>Obtain a sample or acquire the signal data.</li> <li>Ensure that TX is disabled on the acquired signal (no valid data transitions).</li> <li>Measure peak-to-peak voltage of the signal.</li> <li>Compare the maximum peak-to-peak voltage to the specified standards.</li> </ol>							

DC Common Mode Output Voltage Test

**Test Overview** The purpose of this test is to verify that the common mode signal meets the specified standards.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.					
Measurement Algorithm	1 2	Obtain sample or acquire signal data. Verify that there is a signal and that the connection is dual single-ended.				
		Set common mode signal using the common mode function.				
	4	Measure minimum and maximum voltage of the common mode signal.				
	5	Compare the voltage measurement to the specified standards.				

AC Common Mode Voltage, Low-frequency VCMLF

**Test Overview** The purpose of this test is to verify that the low-frequency AC common mode voltage of the signal meets the specified standards.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition	Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.
Measurement	1 Obtain sample or acquire signal data.
Algorithm	2 Verify that there is a signal and that the connection is dual single-ended.
	3 Set common mode signal using the common mode function.
	4 Apply 100 MHz low pass filter.
	5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10 <sup>-4</sup> of the measurement distribution.
	6 Compare the voltage measurement to the specified standards.

AC Common Mode Voltage, Full-band VCMFB

**Test Overview** The purpose of this test is to verify that the full-band AC common mode voltage of the signal meets the specified standards.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition	<b>s Condition</b> Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to standard option.						
Measurement	1 Obtain sample or acquire signal data.						
Algorithm	2	Verify that there is a signal and that the connection is dual single-ended.					
	3	Set common mode signal using the common mode function.					
	4	Calculate the peak-to-peak AC common-mode voltage range that includes all but $10^{-4}$ of the measurement distribution.					
	E	Compare the voltage measurement to the aposition standards					

5 Compare the voltage measurement to the specified standards.

Differential Peak-to-Peak Output Voltage Test

- **Test Overview** The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q pattern meets the specified standards.
- **Pass Condition** Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.
- Measurement Algorithm
- t 1 Obtain sample or acquire signal data.
  - 2 Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
  - 3 Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
  - 4 Compare the maximum peak-to-peak voltage to the specified standards.

#### Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or an ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

🔟 IEEE 802.3 ck Application New Device1								
<u>F</u> ile <u>V</u> iew <u>T</u> ools <u>H</u> elp								
Set Up Select Tests Configure Connect Run Automate Results HTML Repo	rt –							
<ul> <li>PAM4 CR IEEE Tests</li> <li>PAM-4 Transmitter Characteristics at TP2</li> <li>Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/P</li> <li>Output Voltage Measurements EYE TP2 (pattern: PRBS13Q)</li> </ul>	RBS9Q)							
<ul> <li>Output Waveform Measurements TP2 (pattern: PRBS13Q)</li> <li>Main Voltage Measurements TP2 (pattern: PRBS13Q)</li> <li>Return Loss PNA/ENA Measurements</li> <li>Common-mode to Common-mode Output Return Loss</li> <li>Common-mode to Differential Output Return Loss</li> </ul>								
(Click a test's name to see its description)	^							

Figure 30 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section Transmitter characteristics for CR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/ENA Measurements tests, see:

- "Common-mode to Common-mode Output Return Loss" on page 96
- "Common-mode to Differential Output Return Loss" on page 96

Common-mode to Common-mode Output Return Loss

Measurement 1 Ensure that the PNA/ENA is physically connected and calibrated.

Algorithm

Algorithm

- 2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
- 3 Click the Select Tests tab and check the tests to make the Return Loss Measurements.
- 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
- 5 Compare the reported values with the specification to check for conformance.

Common-mode to Differential Output Return Loss

- **Measurement** 1 Ensure that the PNA/ENA is physically connected and calibrated.
  - 2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
    - 3 Click the Select Tests tab and check the tests to make the Return Loss Measurements.
    - 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
    - 5 Compare the reported values with the specification to check for conformance.

Keysight D90103CKC IEEE802.3ck Conformance Application Methods of Implementation

## 5 KR Tests

Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q/PRBS9Q) 99 Output Voltage Measurements EYE TPOv (pattern: PRBS13Q) 102 Output Waveform Measurements TPOv (pattern: PRBS13Q) 104 Main Voltage Measurements TPOv (pattern: PRBS13Q) 112 Return Loss PNA/ENA Measurements 114

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4. Measurements are made at test point TPOv.



Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.



#### Transmitter characteristics for KR tests

See Table 6 for pass limits pertaining to 100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4 PAM4 tests, which are specified in *IEEE P802.3ck<sup>TM</sup> /D3.3* (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) section 163.9.2, Table 163-5.

#### Table 6 100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4 transmitter characteristics at TP0v

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125 ± 50 ppm	GBd
Differential peak-to-peak voltage <sup>a</sup> (max) Transmitter disabled Transmitter enabled	See Sec. 93.8.1.3 of the IEEE specification	30 1200	mV mV
DC Common-mode voltage <sup>a</sup> (max)	See Sec. 93.8.1.3 of the IEEE specification	1.0	V
DC Common-mode voltage <sup>a</sup> (min)	See Sec. 93.8.1.3 of the IEEE specification	0.2	V
Low-frequency peak-to-peak AC common-mode voltage, VCMLF (max)	See Sec. 162.9.4.4 of the IEEE specification	30	mV
Signal to AC common-mode noise ratio, SCMR (min)	See Sec. 163.9.2.6 of the IEEE specification	15	dB
Difference effective return loss, dERL (min)	163.9.2.2	-3	dB
Common-mode to common-mode return loss, RLcc (min)	162.9.2.3	3.25	dB
Difference steady-state voltage, dv <sub>f</sub> (min)	163.9.2.4	0	V
Difference linear fit pulse peak ratio, dR <sub>peak</sub> (min)	163.9.2.5	0	V
Level separation mismatch ratio, $R_{LM}$ (min)	162.9.4.2	0.95	-
Transmitter waveform <sup>b</sup> absolute value of step size for all taps (min) absolute value of step size for all taps (max) value at minimum state for c(-3) (max.)	See Sections 162.9.4.1.4 162.9.4.1.4 162.9.4.1.5	0.005 0.025 -0.06	- -
value at maximum state for c(-2) (min.) value at minimum state for c(-1) (max.) value at minimum state for c(0) (max.)	162.9.4.1.5 162.9.4.1.5 162.9.4.1.5	0.12 -0.34 0.5	- -
value at minimum state for c(1) (max.)	162.9.4.1.5	-0.2	-
Signal-to-noise-and-distortion ratio, SNDR (min)	162.9.4.6	32.5	dB
Signal-to-residual-intersymbol-interference ratio, $SNR_{ISI}\left(min\right)$	162.9.4.3	28	dB
Jitter (max) <sup>c</sup> JRMS J3u <sub>03</sub> J3u	See Sections 162.9.4.7 162.9.4.7 162.9.4.7	0.023 0.106 0.115	UI UI UI
Even-odd jitter, pk-pk	162.9.4.7	0.025	UI

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

b. Implementations are recommended to use the same step size for all coefficients.

c. J3u, JRMS, and even-odd jitter measurements are made with a single transmit equalizer setting selected to compensate for the loss of the transmitter package and TP0 to TP0v test fixture.

#### Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

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Set Up	Se	lect Te	sts 🕻	Configure	Connect	Run	Automate	Results	HTML Report			•
2 - 2	PAM4 KR IEEE Tests PAM4 Transmitter Characteristics at TP0v											
						leasur	ements TPO	v (patterr	1: PRBS13Q/PR	359Q)		
		×	Sigr	aling Rate	8							
		<ul> <li>✓</li> </ul>	🖌 JRM	s								
		<ul> <li>✓</li> </ul>	/ J3u									
		<ul> <li>✓</li> </ul>	J3u	03								
			Eve	n-Odd Jitt	er							
			Output	Voltage N	Measureme	ents E	YE TPOv (pa	ttern: PR	3S13Q)			
SE	Output Waveform Measurements TPOv (pattern: PRBS13Q)											
-	Main Voltage Measurements TP0v (pattern: PRBS13Q)											
EC	۲	F	Return	Loss PNA	/ENA Mea	surem	ents	509 N 607 C 66 N 77 C 77				

Figure 31 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section Transmitter characteristics for KR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TPOv (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 99
- "JRMS" on page 99
- "J3u" on page 100
- "J3u03" on page 100
- "Even-Odd Jitter" on page 101

#### Signaling Rate

**Test Overview** The purpose of this test is to verify that the signaling rate meets the specified standards.

**Pass Condition** Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement	1	Obtain sample or acquire signal data.
Algorithm	2	Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
	2	In the Configure tob, and Signaling Date to EQ 19E Ch /a

- 3 In the **Configure** tab, set **Signaling Rate** to 53.125 Gb/s.
- 4 Measure minimum and maximum data rate.
- 5 Report minimum and maximum values.
- 6 Compare the mean data rate value with the specified standards. Report the resulting value.

#### JRMS

Test Overview	The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All
	jitter tests are run in a single measurement. However, each test can be run individually.

**Pass Conditions** Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.
	2 In the <b>Configure</b> tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
	<ul> <li>On the Oscilloscope,</li> <li>a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.</li> </ul>
	b Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
	c Set 4 <sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
	4 Compare and report the JRMS value to the specified standards.
J3u	
Test Overview	The purpose of this test is to verify that differential signal's J3u meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.
Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report whether the J3u value meets the specified standards.

#### J3u03

Test Overview	The purpose of this test is to verify that differential signal's J3u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.
	2 In the <b>Configure</b> tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
	3 On the Oscilloscope,
	a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
	b Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
	c Set 4 <sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
	4 Compare and report whether the J3u03 value meets the specified standards.
Even-Odd Jit	ter
Test Overview	The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.
Measurement Algorithm	1 Obtain sample or acquire signal data.
NOTE	Signal must be of PRBS13Q or PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

- 2 In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.
- 3 On the Oscilloscope,
  - a Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.
  - *b* Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.
  - c Set 4<sup>th</sup> Order Bessel Thomson filter to 40 GHz with 3 dB gain.
- 4 Compare and report the Even-Odd Jitter value to the specified standards.

#### Output Voltage Measurements EYE TPOv (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

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<u>F</u> ile <u>V</u> ie	<u>File View Tools H</u> elp									
Set Up	Select	Tests	Configure	Connect	Run	Automate	Results	HTML Report	-	
	<ul> <li>PAM4 KR IEEE Tests</li> <li>PAM-4 Transmitter Characteristics at TP0v</li> <li>Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)</li> </ul>									
	<ul> <li>Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)</li> <li>Level - PRBS pattern</li> <li>Level RMS - PRBS pattern</li> </ul>									
	•	🔽 Le	vel Separat	ion Mismat	tch Ra		ern: PRBS	(13Q)		
	<ul> <li>Output Waveform Measurements TP0v (pattern: PRBS13Q)</li> <li>Main Voltage Measurements TP0v (pattern: PRBS13Q)</li> <li>Return Loss PNA/ENA Measurements</li> </ul>									
	(Click a test's name to see its description)									
	a test's	name	to see its de	escription)	1				Î	

Figure 32 Selecting Output Voltage Measurements EYE Tests

Refer to the section Transmitter characteristics for KR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TPOv (pattern: PRBS13Q) tests, see:

- "Level PRBS Pattern" on page 102
- "Level RMS PRBS Pattern" on page 103
- "Level Separation Mismatch Ratio RLM" on page 103



# The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

#### Level - PRBS Pattern

Test Overview	The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS13Q
	pattern.

Pass Condition Not applicable as the test result is considered as "Information Only".

- Measurement<br/>Algorithm1Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used<br/>for this test).
  - 2 V<sub>0</sub>, V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub> are the mean signal levels of the symbols corresponding to the PAM4 symbol levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.

3 The mean level  $V_{mid}$  is defined by equation (120D-3), which is,

$$V_{mid} = (V_0 + V_3) / 2$$

4 Report this value for information-only purpose.

Level RMS - PRBS Pattern

Algorithm

**Test Overview** The purpose of this test is to obtain the of the RMS level of the signal with PRBS13Q pattern.

**Pass Condition** Not applicable as the test result is considered as "Information Only".

Measurement 1 Run the Level - PRBS Pattern test as a prerequisite to this test.

- 2 The minimum signal level RMS is calculated, as defined in IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.
- 3 Report this value for information-only purpose.

Level Separation Mismatch Ratio - RLM

Test Overview	The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.	
Pass Condition	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.	
Measurement Algorithm	<ol> <li>Run the Level - PRBS Pattern as a prerequisite to this test to calculate the mid-range level.</li> <li>The mean signal levels are normalized so that V<sub>0</sub> corresponds to -1, V<sub>1</sub> to -ES1, V<sub>2</sub> to ES2 and V<sub>3</sub> to 1.</li> <li>ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs<sup>TM</sup> /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.</li> </ol>	
	$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$ $ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$	

4 The level separation mismatch ratio  $R_{LM}$  is defined by equation (120D-5).

R<sub>IM</sub> = min [(3 x ES1), (3 x ES2), (2 - 3 x ES1), (2 - 3 x ES2)]

5 Report this value.

#### Output Waveform Measurements TPOv (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

🗹 IEEB	E 802.3 ck Application New Device1
File Vi	iew Tools Help
Set Up	Select Tests Configure Connect Run Automate Results HTML Report
14	PAM4 KR IEEE Tests
-	PAM-4 Transmitter Characteristics at TP0v
	Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)
	Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)
	🕗 🔤 🔽 Output Waveform Measurements TP0v (pattern: PRBS13Q)
	✓ Steady-State Voltage Vf
	✔ Linear Fit Pulse Peak
	✓ dVf
	✓ dRpeak
m	🇹 Signal-to-noise-and-distortion ratio
	Signal to AC common-mode noise ratio, SCMR
0	Signal-to-residual-intersymbol-interference ratio, SNRISI
-	ERL ERL
-	
л С	≻ ✓ abs Step Size
	Main Voltage Measurements TP0v (pattern: PRBS13Q)
0	Return Loss PNA/ENA Measurements

Figure 33 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section Transmitter characteristics for KR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TPOv (pattern: PRBS13Q) tests, see:

- "Steady State Voltage Vf" on page 104
- "Linear Fit Pulse Peak" on page 105
- "dVf" on page 105
- "dRpeak" on page 105
- "Signal-to-noise-and-distortion ratio" on page 106
- "Signal to AC common-mode noise ratio, SCMR" on page 106
- "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 106
- "ERL" on page 106
- "dERL" on page 107
- "abs Step Size Tests" on page 107

#### Steady State Voltage V<sub>f</sub>

Test Overview	The purpose of this test is to determine the Steady State Voltage.		
Pass Condition	No	Not applicable as the test result is considered as "Information Only".	
Measurement Algorithm	1	Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).	
		Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern. Calculate V <sub>f</sub> using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of $p(k)/M$ . N <sub>p</sub> = 200, D <sub>p</sub> = 2.	
		or p((y) m) (p 200, 0p 2.	

Linear Fit Pulse Peak

**Test Overview** The purpose of this test is to determine the Linear Fit Pulse value.



Run the Steady-State Voltage Vf test as a prerequisite to running the Linear Fit Pulse Peak test.

Pass Conditions	Not applicable as the test result is considered as "Information Only".		
Measurement Algorithm	1 Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).		
	2 Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.		
	3 Calculate Linear Fit Pulse using the equations in section 85.8.3.3.5. The resulting value is the peak value of p(k). $N_p$ = 200, $D_p$ = 2.		
dVf			
Test Overview	The purpose of this test is to verify that dVf meets the specified standards.		
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.		
Measurement Algorithm	1 The user enters the fixture s-parameter (S0) file by clicking the <b>Fixture Ref File Setup</b> button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.		
	2 Calculate the reference transfer function using equation 163A-2.		
	3 Calculate Vref(peak) as max of h(t).		
	4 Calculate Vf(ref) using equation 163A-3.		
	5 Calculate dVf using equation 163A-6.		
	See Also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.		
dRpeak			
Test Overview	The purpose of this test is to verify that dRpeak meets the specified standards.		
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.		
Measurement Algorithm	1 The user enters the fixture s-parameter (S0) file by clicking the <b>Fixture Ref File Setup</b> button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.		
	2 Calculate the reference transfer function using equation 163A-2.		
	3 Calculate Vref(peak) as max of h(t).		
	4 Calculate Vf(ref) using equation 163A-3.		
	5 Calculate dRpeak using equation 163A-7.		
	See Also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.		

Signal-to-noise-and-distortion ratio

Test Overview	The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) meets the specified standards.	
Pass Condition	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.	
Measurement Algorithm	1 Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.	
	2 Compare the resulting value of SNDR to the specified standards.	

Signal to AC common-mode noise ratio, SCMR

- **Test Overview** The purpose of this test is to verify that the signal to AC common-mode noise ratio (SCMR) meets the specified standards.
- **Pass Condition** Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.
- Measurement<br/>Algorithm1Calculate SCMR using measurement from Linear Fit Pulse peak and Full Band Pk-Pk AC Common<br/>mode voltage. The formula is 20log(Vpeak/VcmFB).
  - 2 Compare the resulting value of SCMR to the specified standards.

Signal-to-residual-intersymbol-interference ratio, SNRISI

- Test Overview The purpose of this test is to verify that the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards: 0 dB through -20 dB gDC and 4 dB through 0 dB gDC2..
   Pass Condition Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.
   Measurement Algorithm 1 Follow the procedure for Linear Fit Pulse peak to calculate p(k).
   Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.
   With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8) 4 Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.
  - 5 The results is the highest SNRISI value.

ERL

Test Overview	The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.	
Pass Condition	Not applicable as the test result is considered as "Information Only".	
Measurement Algorithm	1	In the <b>Set Up</b> tab of the Conformance Test Application, click <b>ERL File Setup</b> button to set up the s-parameter file (refer to Annex 93A.5.1 of the IEEE P802.3cd <sup>TM</sup> specification for more information about the standards defined to create the s-parameters).
	2	Click the <b>Select Tests</b> tab and check the ERL test to measure the effective return loss.
	3	Click <b>Run</b> under the <b>Run</b> tab. The Conformance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

dERL

Test Overview	The purpose of this test is to verify that dERL meets the specified standards.		
Pass Conditions	Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.		
Measurement Algorithm	The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and helps in the ERL computation.		
	1 The user enters the initial ERL channel file by clicking the <b>ERL File Setup</b> button under the Setup tab.		
	2 The user enters the fixture s-parameter (S0) file by clicking the <b>Fixture Ref File Setup</b> button under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.		
	3 The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.		
	4 The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TPOv measurement to compute ERL at TPOv.		

5 The difference between ERL TPOv and ERL ref is reported as the result.

See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

#### abs Step Size Tests

Test Overview The purpose of this test is to verify the abs Step Size.

To know about the measurement algorithm for each abs Step Size test, see:

- "abs Step Size for c(-3)" on page 107
- "abs Step Size for c(-2)" on page 108
- "abs Step Size for c(-1)" on page 108
- "abs Step Size for c(0)" on page 109
- "abs Step Size for c(1)" on page 109
- "value at min. state for c(-3)" on page 109
- "value at max. state for c(-2)" on page 110
- "value at min. state for c(-1)" on page 110
- "value at min. state for c(0)" on page 110
- "value at min. state for c(1)" on page 111

#### abs Step Size for c(-3)

**Test Overview** The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.

**Pass Condition** When abs Coefficient Step Size - c(-3) is greater than or equal to 5 m and less than or equal to 25 m.

- 1 Request Transmitter to be set to "PRESET" condition.
- Measurement Algorithm
- Request fransmitter to be set to PRESET condition.
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(-3) to the first step.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(-3) as base step value.

- 9 Request next c(-3) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### abs Step Size for c(-2)

**Test Overview** The purpose of this test is to verify that the abs Step Size for c(-2) is within limits.

**Pass Condition** When abs Coefficient Step Size - c(-2) is greater than or equal to 5 m and less than or equal to 25 m.

Measurement Algorithm

- Request Transmitter to be set to "PRESET" condition.
   Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request to change c(-2) to the first step.
- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Save coefficient c(-2) as base step value.
- 9 Request next c(-2) step.
- 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 11 Calculate coefficients c(i) using equation 136-2.
- 12 Calculate the step size as coefficient value from step 11 coefficient value from step 7.
- 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 previous coefficient value from step 11.

#### abs Step Size for c(-1)

Test Overview	The purpose of this test is to verify that the abs Step Size for c(-1) is within limits.		
Pass Condition	When abs Coefficient Step Size - c(-1) is greater than or equal to 5 m and less than or equal to 25 m.		
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(-1) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Save coefficient c(-1) as base step value.</li> <li>Request next c(-1) step.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate to efficients c(i) using equation 136-2.</li> <li>Calculate to efficients c(i) using equation 136-2.</li> <li>Calculate to efficients c(i) using equation 136-2.</li> <li>Calculate the step size as coefficient value from step 11 – coefficient value from step 7.</li> <li>Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as</li> </ol>		

Test Overview	The purpose of this test is to verify that the abs Step Size for c(0) is within limits.		
Pass Condition	When abs Coefficient Step Size - c(0) is greater than or equal to 5 m and less than or equal to 25 m.		
Measurement Algorithm	<ol> <li>Request Transmitter to be set to "PRESET" condition.</li> <li>Capture full pattern of PRBS13Q at 32 points per UI.</li> <li>Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.</li> <li>Define r(m) from "PRESET" as per equation 136-1.</li> <li>Request to change c(0) to the first step.</li> <li>Calculate linear fit pulse response as per 85.8.3.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate coefficients c(i) using equation 136-2.</li> <li>Save coefficient c(0) as base step value.</li> <li>Request next c(0) step.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate linear fit pulse response as per section 85.8.3.5 with N<sub>p</sub> = 200, D<sub>p</sub> = 4.</li> <li>Calculate to coefficients c(i) using equation 136-2.</li> <li>Calculate to coefficients c(i) using equation 136-2.</li> <li>Calculate to coefficients c(i) using equation 136-2.</li> <li>Calculate the step size as coefficient value from step 11 – coefficient value from step 7.</li> <li>Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.</li> </ol>		

#### abs Step Size for c(0)

abs Step Size for c(1)

**Test Overview** The purpose of this test is to verify that the abs Step Size for c(1) is within limits. Pass Condition When abs Coefficient Step Size - c(1) is greater than or equal to 5 m and less than or equal to 25 m. Measurement 1 Request Transmitter to be set to "PRESET" condition. Algorithm 2 Capture full pattern of PRBS13Q at 32 points per UI. 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5. 4 Define r(m) from "PRESET" as per equation 136-1. 5 Request to change c(1) to the first step. 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ . 7 Calculate coefficients c(i) using equation 136-2. 8 Save coefficient c(1) as base step value. 9 Request next c(1) step. 10 Calculate linear fit pulse response as per section 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4. 11 Calculate coefficients c(i) using equation 136-2. 12 Calculate the step size as coefficient value from step 11 - coefficient value from step 7. 13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 - previous coefficient value from step 11.

#### value at min. state for c(-3)

Test Overview	The purpose of this tes	st is to verify that the value at	min. state for $c(-3)$ is within limits.

**Pass Condition** When value at min. state for c(-3) is less than or equal to -60 m.

Measurement

Algorithm du		during trial, steps 1-4 are skipped.	
2 Capture full pattern of PRBS13Q at 32 points per UI.		Capture full pattern of PRBS13Q at 32 points per UI.	
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.			
	4 Define r(m) from "PRESET" as per equation 136-1.		
	5 Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minin value.		
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p$ = 200, $D_p$ = 4.	
	7 Calculate coefficients c(i) using equation 136-2.		
	8	Report c(-3) value from step 7.	
valu	le at	max. state for c(-2)	
Test Overview	Th	e purpose of this test is to verify that the value at max. state for c(-2) is within limits.	
Pass Condition	W	hen value at max. state for c(-2) is greater than or equal to 120 m.	
Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.	
	2	Capture full pattern of PRBS13Q at 32 points per UI.	
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.	
	4	Define r(m) from "PRESET" as per equation 136-1.	
	5	Request user to set c(-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum value.	

1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated

- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(-2) value from step 7.

#### value at min. state for c(-1)

**Test Overview** The purpose of this test is to verify that the value at min. state for c(-1) is within limits.

**Pass Condition** When value at min. state for c(-1) is less than or equal to -340 m.

Measurement Algorithm

- Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
  - 2 Capture full pattern of PRBS13Q at 32 points per UI.
  - 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
  - 4 Define r(m) from "PRESET" as per equation 136-1.
  - 5 Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.
  - 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p = 200$ ,  $D_p = 4$ .
  - 7 Calculate coefficients c(i) using equation 136-2.
  - 8 Report c(-1) value from step 7.

#### value at min. state for c(0)

**Test Overview** The purpose of this test is to verify that the value at min. state for c(0) is within limits.

Measurement Algorithm

- 1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
  - 2 Capture full pattern of PRBS13Q at 32 points per UI.
  - 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
  - 4 Define r(m) from "PRESET" as per equation 136-1.
  - 5 Request user to decrement c(0) to minimum value.
  - 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
  - 7 Calculate coefficients c(i) using equation 136-2.
  - 8 Report c(0) value from step 7.

#### value at min. state for c(1)

1

**Test Overview** The purpose of this test is to verify that the value at min. state for c(1) is within limits.

**Pass Condition** When value at min. state for c(1) is less than or equal to -200 m.

during trial, steps 1-4 are skipped.

Measurement

- Algorithm
- 2 Capture full pattern of PRBS13Q at 32 points per UI.
- 3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
- 4 Define r(m) from "PRESET" as per equation 136-1.
- 5 Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.

Request Transmitter to be set to "PRESET" condition. If preset has already been calculated

- 6 Calculate linear fit pulse response as per 85.8.3.3.5 with  $N_p$  = 200,  $D_p$  = 4.
- 7 Calculate coefficients c(i) using equation 136-2.
- 8 Report c(1) value from step 7.

#### Main Voltage Measurements TPOv (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

🔟 IEEE	802.	3 ck Appl	ication Ne	ew Device1	_								
File Vie	ew I	ools <u>H</u> e	lp										
Set Up	Sele	ct Tests	Configure	Connect	Run	Automate	Results	HTML Report					
	PAM4 KR IEEE Tests PAM-4 Transmitter Characteristics at TPOv												
1.1													
	<ul> <li>Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)</li> </ul>												
	Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)     Output Waveform Measurements TP0v (pattern: PRBS13Q)     V Main Voltage Measurements TP0v (pattern: PRBS13Q)												
	✓ Differential Peak to Peak Output Voltage Test with TX disabled												
			C Common I			-							
0			C Common I										
Ē			ifferential Pe				Test						
	•	Retu	rn Loss PNA	/ENA Meas	urem	ents							

Figure 34 Selecting Main Voltage Measurement Tests

Refer to the section Transmitter characteristics for KR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TPOv (pattern: PRBS13Q) tests, see:

- "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 112
- "DC Common Mode Output Voltage Test" on page 112
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 113
- "Differential Peak-to-Peak Output Voltage Test" on page 113

Differential Peak-to-Peak Output Voltage Test with TX Disabled

Test OverviewThe purpose of this test is to verify that when TX is disabled, the peak-to-peak voltage meets the<br/>specified standards.Pass ConditionRefer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each<br/>standard option.Measurement<br/>Algorithm1Obtain a sample or acquire the signal data.<br/>2Ensure that TX is disabled on the acquired signal (no valid data transitions).<br/>3Measure peak-to-peak voltage of the signal.

4 Compare the maximum peak-to-peak voltage to the specified standards.

DC Common Mode Output Voltage Test

**Test Overview** The purpose of this test is to verify that the common mode signal meets the specified standards.



This measurement can be done only with dual single-ended connection but not with a differential probing connection.

**Pass Condition** Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

- Measurement1Obtain sample or acquire signal data.Algorithm2Verify that there is a signal and that there
  - 2 Verify that there is a signal and that the connection is dual single-ended.
  - 3 Set common mode signal using the common mode function.
  - 4 Measure minimum and maximum voltage of the common mode signal.
  - 5 Compare the voltage measurement to the specified standards.

AC Common Mode Voltage, Low-frequency VCMLF

**Test Overview** The purpose of this test is to verify that the low-frequency AC common mode voltage of the signal meets the specified standards.

NOTE

This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition		er to the section Transmitter characteristics for KR tests for the pass limits pertaining to each ndard option.					
Measurement	1	Obtain sample or acquire signal data.					
Algorithm	2	Verify that there is a signal and that the connection is dual single-ended.					
	3	Set common mode signal using the common mode function.					

- 4 Apply 100 MHz low pass filter.
- 5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10<sup>-4</sup> of the measurement distribution.
- 6 Compare the voltage measurement to the specified standards.

Differential Peak-to-Peak Output Voltage Test

Algorithm

- **Test Overview** The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q pattern meets the specified standards.
- **Pass Condition** Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.
- **Measurement** 1 Obtain sample or acquire signal data.
  - 2 Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
  - 3 Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
  - 4 Compare the maximum peak-to-peak voltage to the specified standards.

#### Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

File View Tools Help											
Set Up Select Tests Configure Connect Run Automate Results HTML Report											
PAM4 KR IEEE Tests											
PAM-4 Transmitter Characteristics at TP0v											
<ul> <li>Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)</li> </ul>											
Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)											
Output Waveform Measurements TP0v (pattern: PRBS13Q)											
Main Voltage Measurements TP0v (pattern: PRBS13Q)											
Return Loss PNA/ENA Measurements	j i										
✓ Common-mode to Common-mode Output Return Loss											

Figure 35 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section Transmitter characteristics for KR tests for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/ENA Measurements tests, see:

"Common-mode to Common-mode Output Return Loss" on page 114

Common-mode to Common-mode Output Return Loss

Measurement Algorithm

- 1 Ensure that the PNA/ENA is physically connected and calibrated.
- 2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
- 3 Click the Select Tests tab and check the tests to measure the Return Loss Measurements.
- 4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
- 5 Compare the reported values with the specification to check for conformance.