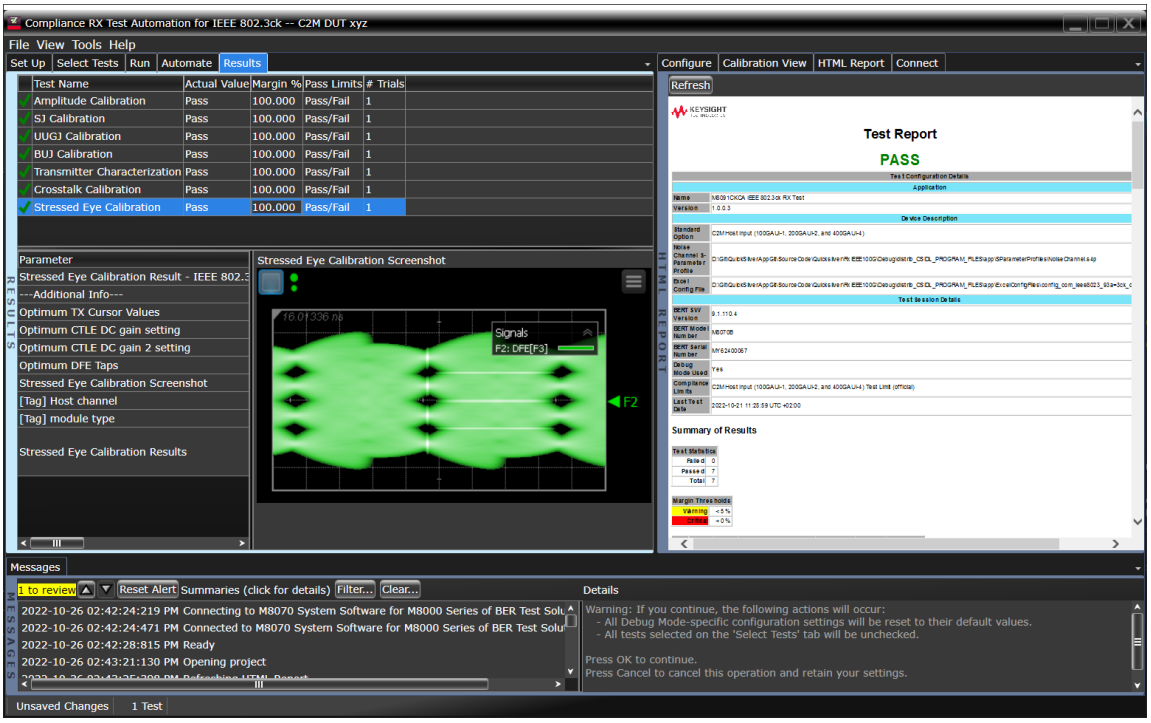
M8091CKCA

Electrical receiver conformance test application for IEEE 802.3ck

Introduction

The M8091CKCA electrical receiver conformance test application enables accurate and repeatable receiver test procedures following the IEEE 802.3ck Draft 3.3 recommendations to ensure interoperability between datacom interfaces with a lane rate of 106 Gbps. The test procedures are based on the Channel Operating Margin (COM) method for chip-to-chip (C2C) testing and on the stressed eye method for chip-to-module (C2M) testing.



KEYSIGHT

Key Features

- 100GAUI-1, 200GUI-2, 400GAUI-4 C2C and C2M interfaces testing following recommendations from IEEE 802.3ck (Draft 3.3)

  Annex 120F Chip-to-Chip (C2C)

  - 120F.3.2.4 Receiver Interference Tolerance Test
  - 120F.3.2.5 Receiver Jitter Tolerance Test

  Annex 120G Chip-to-Module (C2M) Host & Module Input

  - 120G.3.3.5 Host Stressed Input Test
  - 120G.3.4.3 Module Stressed Input Test
- C2M test coverage includes near-end and far-end host input test and module input test with high- and low-loss channel
- Guided setup, automated stressed signal calibration and pre-conformance measurement
- HTML test report
- Remote control & data analytics
- Choose between node-locked, transportable, network, USB-dongle perpetual license

Description

The M8091CKCA electrical receiver conformance test application is designed to assist and simplify the stressed signal calibration used for testing the inputs of IEEE 802.3ck Draft 3.3 chip-to-chip (C2C) and chip-to-module (C2M) electrical interfaces using either a Keysight M8040A 64Gbaud Higher Performance BERT or a Keysight M8050A 120Gbd High-Performance BERT combined with a Keysight Digital Communication Analyzer (DCA) time-equivalent oscilloscope or Infiniium UXR real-time oscilloscope. It reduces user interaction to a minimum and performs all required calibration routines and compliance testing automatically by remote-controlling all required instruments. At the same time, it offers flexibility to test different scenarios within or beyond the standard recommendations.

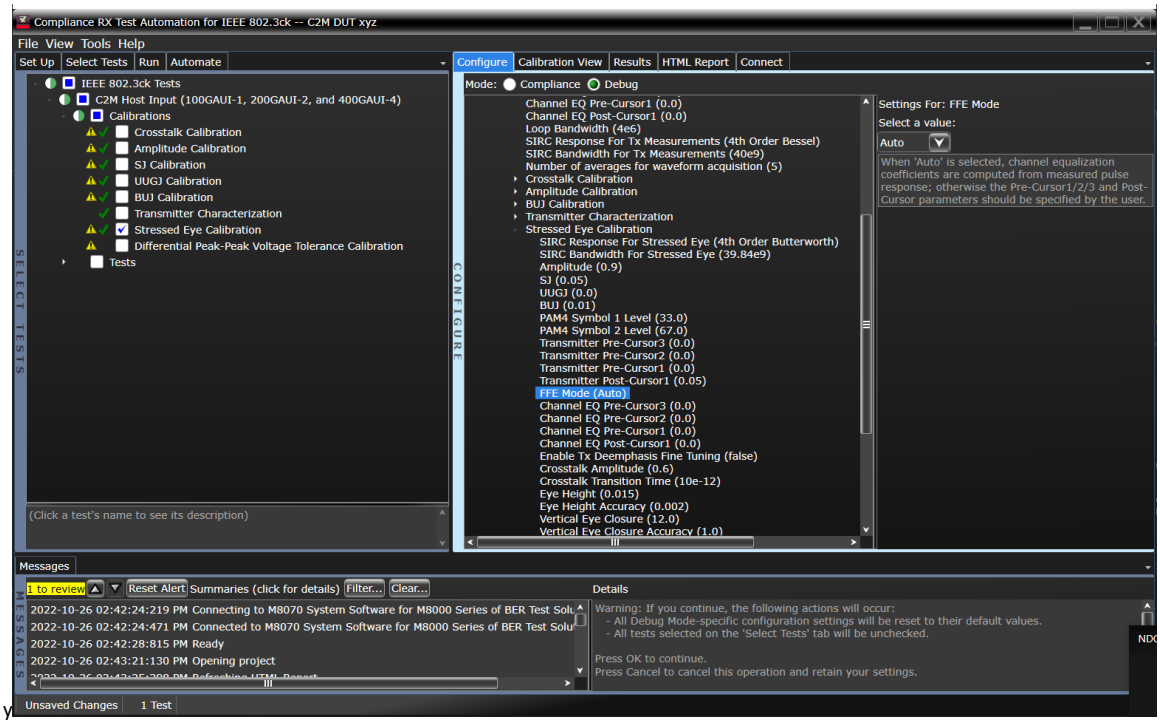


Figure 1. Graphical user interface of the M8091CKCA IEEE 802.3ck conformance receiver test application

The test application utilizes the same framework as other Keysight conformance test applications, thus reducing the training time and offering the functionalities remote control, scripting, and automated pdf or HTML-based test report generation. The user is guided by means of diagrams as well as text to minimize errors. Results of the individual calibration steps and tests are presented in tabular form as well as graphical form, where appropriate. Calibrations and test results can be stored in projects and recalled later.

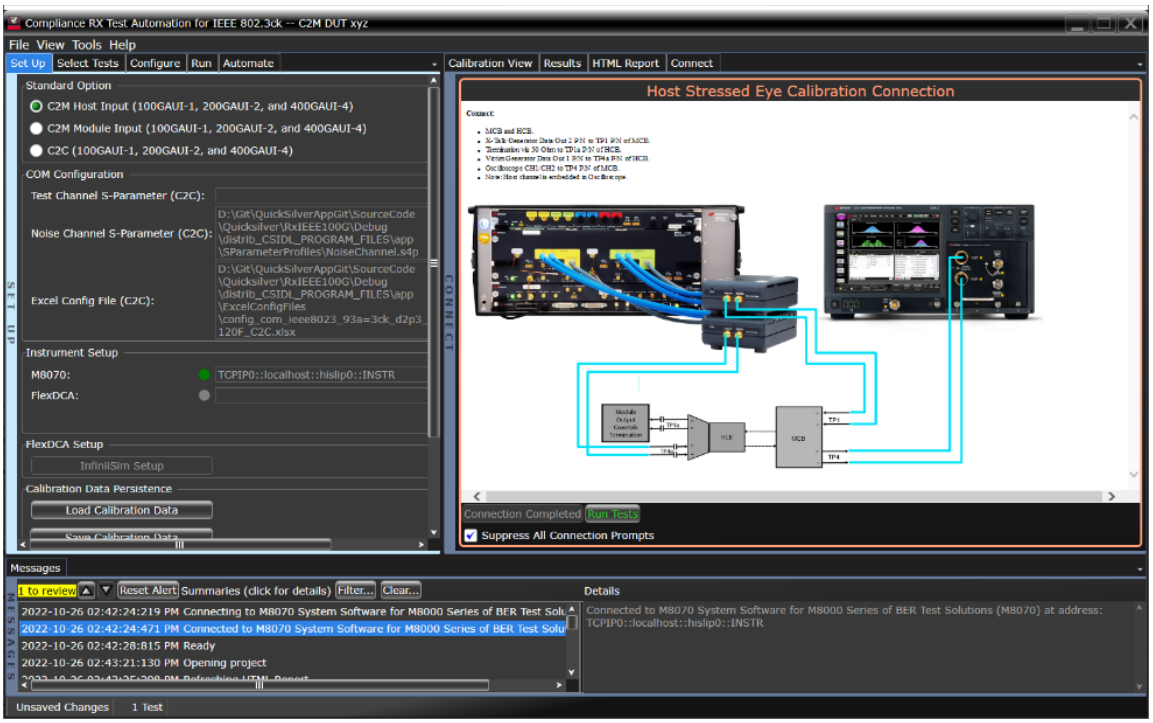


Figure 2. Connection diagram for chip-to-module, C2M host input test calibration

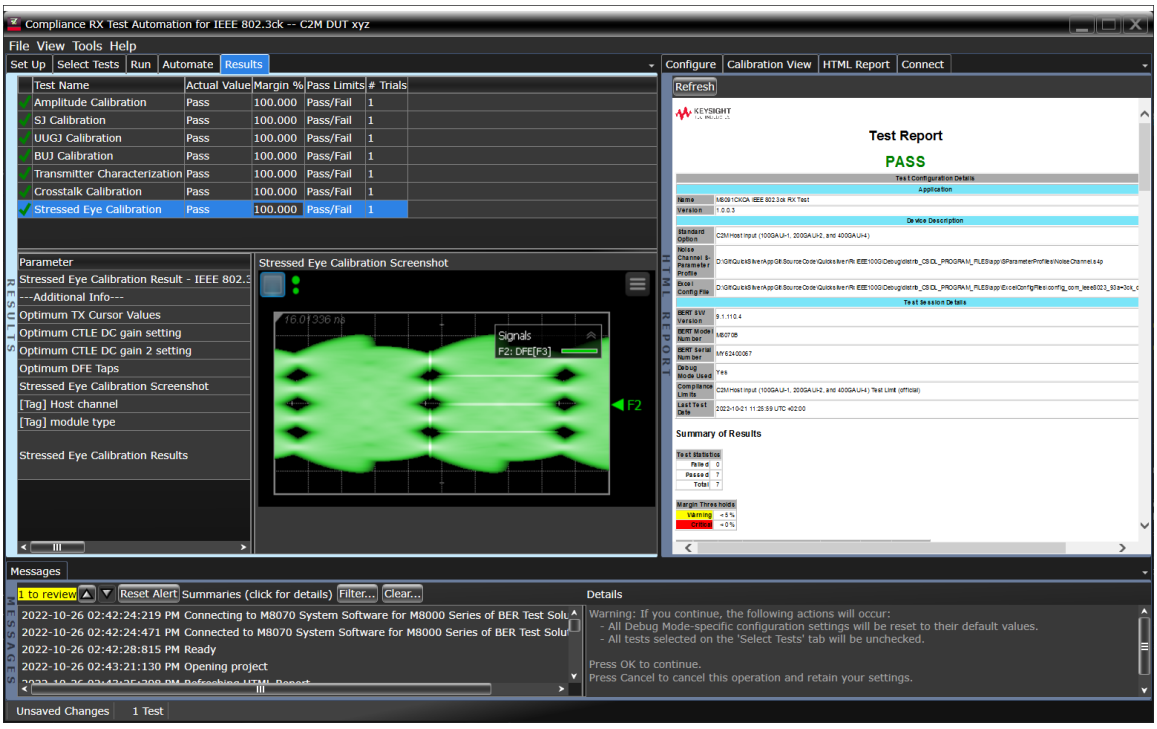


Figure 3. Results of a C2M calibration

RESULTS

Parameter	Value
Transmitter Measurements - IEEE 802.3ck PAM4 C2M Host TP0a	Pass
---Additional Info---	
Transition Time	9 ps
Output Jitter Measurement	(See image)
Linear Fit Pulse Response(Np=200)	(See image)
[Tag] Host channel	N/A
[Tag] module type	N/A

Transmitter Measurements

Measurement Name	Status	Measured Value	Margin %	Pass Limits
Jrms	Pass	18.8 mUI	18.3 %	<= 23.0 mUI
J4u	Pass	104.0 mUI	18.8 %	<= 128.0 mUI
Level mismatch ratio RLM	Pass	0.95	0.0 %	>= 0.95
Signal-to-noise-and-distortion ratio(Np=200)	Pass	36.53 dB	12.4 %	>= 32.50 dB

RESULTS

Parameter	Value
Stressed Eye Calibration Result - IEEE 802.3ck PAM4 C2M Host TP4	Pass
---Additional Info---	
Optimum TX Cursor Values	(0,0.04,-0.17,0.75,0.04)
Optimum CTLE DC gain setting	-3.0 dB
Optimum CTLE DC gain 2 setting	-2.0 dB
Optimum DFE Taps	(0.152426,0.025403,0.011767,0.01452)
Stressed Eye Calibration Screenshot	(See image)
[Tag] Host channel	far end
[Tag] module type	short

Stressed Eye Calibration Results

Standard Parameter	Status	Target	Measured	Instrument Parameter	Nominal	Actual
EH5	Pass	15 mV	15 mV	Amplitude	900 mV	599 mV
VEC5	Pass	12dB	11.6dB	RJ	0.00000 UI	21.27 mUI

Figure 4. Results of the reference transmitter characterization (top) and stressed eye calibration for chip-to-module host input (bottom)

Calibrations and Tests Covered by M8091CKCA

100GAUI-1, 200GAUI-2, 400GAUI-4 C2C (chip-to-chip)

The chip-to-chip C2C test procedures defined in IEEE 802.3ck, Draft 3.3, Annex 120F rely on the Channel Operating Margin (COM) method [1]. COM was first introduced to measure the performance margin of a channel and then extended to digital systems. Interoperability of digital receiver can be expressed in terms of COM requirements. COM is calculated using channel 4-ports S-parameters (for victim and aggressor lanes) as well as the noise and equalization functionality of the considered transmitter and receiver. The resulting COM metric is the ratio of the signal amplitude (after equalization) to the noise and crosstalk peak-to-peak amplitude measured during a time interval depending on the target BER.

IEEE 802.3ck C2C receiver test calibration procedure consists of three steps [2].

1. *System calibration*: Calibrate the equipment used to generate the victim transmitter and the broadband noise (once per setup configuration).

2. *Channel characterization*: S-parameter measurements using a network analyzer.

1 IEEE Standard for Ethernet, IEEE 802.3, Annex 93A.
2 For more details on these standards, refer to IEEE Standard for Ethernet, IEEE 802.3, Annex 120F.

3. *COM-related calibration*: The following steps are performed to complete the COM model

    a. Verify channel compliance based on S-parameter analysis.

    b. Measure transmitter characteristics (jitter & electrical characteristics), which can be adjusted to test different scenarios.

    c. Compute the amount of broadband noise required for a specific channel operating margin (usually 3dB) and inject it into the noise path to test the receiver (BER measurement for different levels of noise or jitter)

After calibration, the C2C receiver interference tolerance test and receiver jitter tolerance test can be performed.

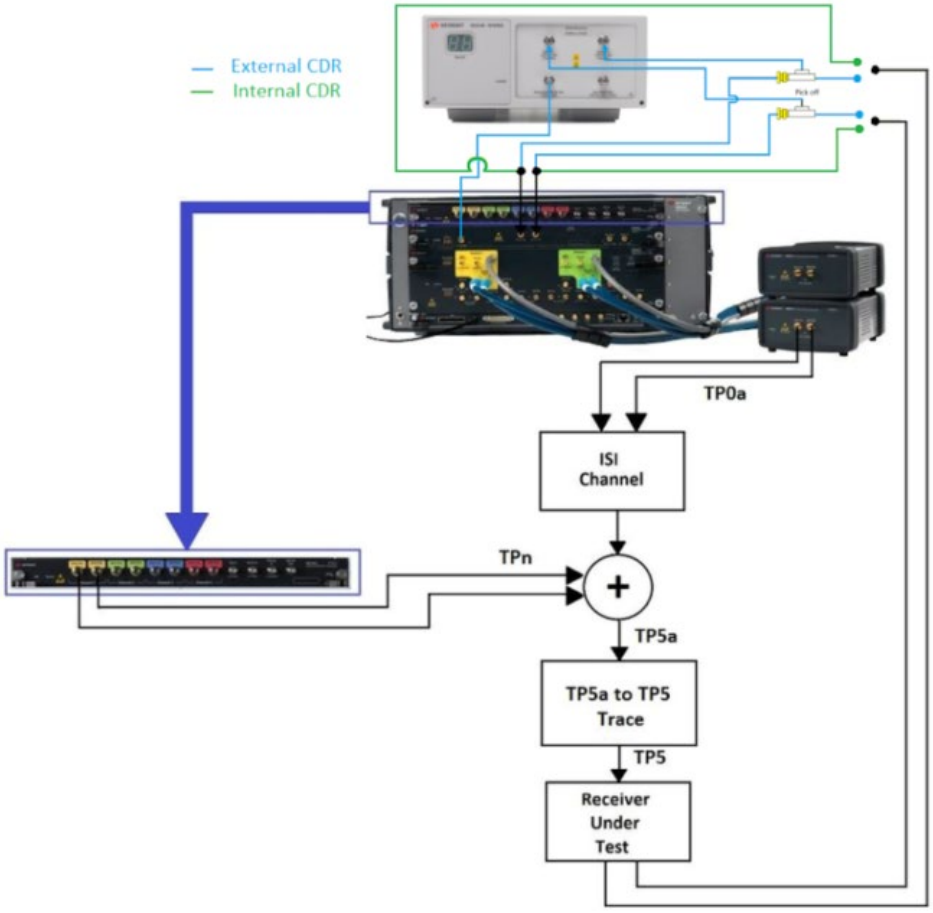


Figure 5. Setup configuration for C2C receiver interference tolerance test

Please note that this receiver conformance test application covers only the tests for Inference Tolerance (120F.3.2.4) and Jitter Tolerance (120F.3.2.5). Other test parameters such as Difference Effective Return Loss, dERL (120F.3.2.2) and Differential to Common-mode Return Loss (120F.3.2.3) are not covered within this test application. The dERL (120F.3.2.2) can be measured with the N1091CKCA electrical TX test application for IEEE802.3ck that applies the same ERL methodology and with reference to the same procedure in 93A.5 with the values in Table 120G-2 and Table 120G-7.

100GAUI-1, 200GAUI-2, 400GAUI-4 C2M (chip-to-module)

The M8091CKCA implements both *host* and *module stressed input test* procedures defined in IEEE 802.3ck, Draft 3.3, Annex 120G. The procedure is based on the stressed eye method, where the metrics of the test signal such as eye height (EH) and vertical eye closure (VEC) are adjusted at the output of the mated host compliance board (HCB) or module compliance board (MCB) connection towards values defined in the standard by tuning the transmitter amplitude, de-emphasis, and jitter profile. When carried out manually, this calibration procedure is very time-consuming. The M8091CKCA receiver test application performs this task automatically.

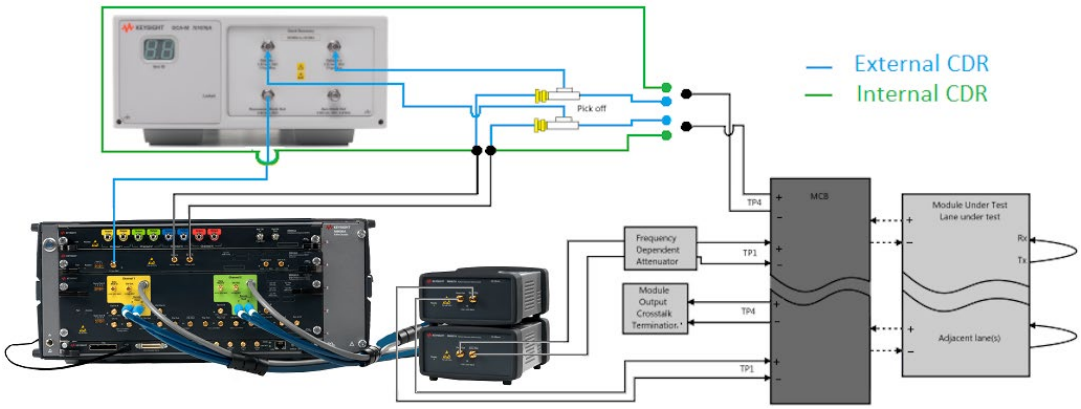


Figure 6. Setup configuration for C2M module stressed input test

IEEE C2M receiver test calibration procedure consists of the following steps:

1. *Crosstalk calibration* [3]: The aggressor lane slew time and amplitude are adjusted to meet the specified target. A third-party source can be used as an aggressor channel. In this case, the calibration must be carried out manually.

2. *System calibration*: Calibrate the amplitude and jitter (sinusoidal, BUJ, UUGJ) of the pattern generator used to generate the victim transmitter (optional, recommended once per setup configuration).

3. *Transmitter characterization*: In this step, the transmitter characteristics (rise time, SNDR, jitter profile) are measured and compared to the requirements for compliant transmitters. Note that different transmitter profiles can be used as starting points for the stressed eye calibration (optional, recommended once per setup configuration).

4. *Stressed signal calibration*: The transmitter de-emphasis and receiver equalizer are first optimized. This step is optional but highly recommended to ensure successful calibration. Otherwise, optimal Tx-de-emphasis settings must be provided by the user. After this, the signal amplitude and random jitter are adjusted to meet the target Eye Height (EH), defined at 1e-5 probability and Vertical Eye Closure (VEC) metrics.

3 The requirements of the Crosstalk Calibration for the Host and Module Stressed Inputs cannot be met with the M8045A pattern generator. Please refer to the Release Notes for more information and workaround.

C2M stressed input test calibration recommendations

C2M stress mix and calibration targets (Draft 3.3)

	Module input test	Host input test
Sinusoidal Jitter (refer to table 120G-9)	50 mUI	
Random Jitter (RJ) and Bounded Uncorrelated Jitter (BUJ)	inject if required to meet EH and VEC targets	
VEC (refer to table 120G-8 & 120G-10)	12-12.5 dB	
EH refer to table 120G-8 & 120G-10)	10 mV	15 mV

Input voltage tolerance test for C2M host input and C2M module input

The host and module input voltage tolerance test procedures as defined in IEEE 802.3ck, Draft 3.3, Annex 120G validate the acceptance of the differential input peak-to-peak amplitudes produced by the extreme operating conditions from the transmitter. Please note that this receiver conformance test application covers only the Chip-to-Module (C2M) Stressed Input Test[4] (120G.3.3.5 for host input & 120G.3.4.3 for module input) and Peak-to-Peak Voltage Tolerance Test (120G.5.1 for both host input & module input).

Other test parameters such as the Effective Return Loss, ERL (120G.3.3.4 for host input & 120G.3.4.4 for module Input) are not covered within this test application. The ERL measurement can be measured with the N1091CKCA electrical Tx test application for IEEE 802.3ck that applies same ERL methodology and with reference to the same procedure in 93A.5 with the values in Table 120G-6 and Table 120G-9. Note that the test channel S-parameter file is required for the ERL measurement, which needs to be measured manually.

4 We recommend using the automated transmitter de-emphasis optimization and a VEC accuracy of 1 dB to ensure a successful calibration.

Configuration Guide

The table below shows the required equipment for each standard option under IEEE 802.3ck Annex 120F (chip-to-chip, C2C) and 120G (chip-to-module, C2M). Required instrument configuration and required software options are listed in the following section.

Equipment type	C2M	C2C
Victim pattern generator	M8045A or M8042A	
Crosstalk generator	2nd channel of M8045A/M8042A or third-party crosstalk generator	N.A.
Interference source	N.A.	M8054A or M8196A or M8194A
Victim error detector	M8046A or M8043A or DCI (DUT Control Interface available in M8070ADVB)	
Clock recovery	M8046A – 0A4/ 0A5 (internal CDR)	
Oscilloscope	N1000A + N1060A DCA-X or UXR-series oscilloscopes with 59 GHz bandwidth & above	

Minimum required instrument configuration

The options marked * are recommended but not mandatory.

M8000 BERT system

M8040A-BU2 or M8050A-BU2 or M8050A-BU4 [5]	Bundle consisting of one M9505A 5-slot AXIe Chassis with USB option Bundle consisting of one M9505A 5-slot AXIe Chassis with USB option Bundle consisting of two M9505A 5-slot AXIe Chassis with USB
M8070B	System software for M8000 Series of BER test solutions (version 10.0.160.6 or later)

Choose between M8040A or M8050A BERT platform

	M8040A
M8045A	
◦ M8045A-G64	Pattern generator and clock module 32/64 Gbaud, 3 slot AXIe Pattern Generator one Channel NRZ, Data Rate up to 64 GBaud (Requires Remote Head, e.g., M8057B)
◦ M8045A-0G2*	Second Channel, Hardware and License (requires M8057B Remote Head)
◦ M8045A-801	Short cable, 1.85 mm (m) to 1.85 mm (m) (2 for each M8057B recommended)
◦ M8045A-0G3	Advanced Jitter Sources for Receiver Characterization, Module-wide License
◦ M8045A-0G4	De-emphasis, Module-wide License
◦ M8045A-0P3	PAM-4 Encoding up to 34 GBaud, Module-wide License
◦ M8045A-0P6	PAM-4 Extension up to 64 GBaud, Module-wide License
◦ M8057B-FG	Remote Head for M8045A Pattern Generator, 1 Channel
◦ M8045A-803	Short cable, 1.85 mm (m) to 1.85 mm (m) (2 for each M8057B recommended)

5 A two-chassis approach is required for the M8050A-based configuration covering C2M and C2C when an external error detector is required.

		M8050A
M8042A		Pattern Generator Module 32/64/120 GBd, 2 or 3-slot AXIe Pattern Generator NRZ and PAM4, 1 Channel, 2-slot AXIe Modu (requires M8058A Remote Head)
◦	M8042A-0G1	
◦	M8042A-G64	Pattern Generator, 64 GBd for NRZ and PAM4, module-wide License
◦	M8042A-0G4	De-emphasis, module-wide License
◦	M8042A-0G2*	Pattern Generator NRZ and PAM4, 2 Channel, 3-slot AXIe Module (requires M8058A Remote Head)
M8058A		Remote Head, 32/64 GBd for M8042A Pattern Generator
◦	M8058A-801	Matched Cable Pair, 1.85 mm (m) to 1.85 mm (m), 2 ps, 0.15 m
M8009A		Clock Generator Module with Jitter Modulation, 60 GHz, 1 slot AXIe
◦	M8009A-061	
◦	M8009A-0G3	Advanced Jitter Modulation for up to two Channels, License

Configure the error analyzer [6]

M8046A		Analyzer module, 32/64 Gbaud 1-slot AXIe
◦	M8046A-A64	Analyzer, one Channel, Data Rate up to 64 GBaud, NRZ
◦	M8046A-0A4*	Clock recovery for 32 Gbaud, License
◦	M8046A-0A5*	Clock recovery for Extension up to 64 Gbaud License
◦	M8046A-0P3	PAM-4 decoding up to 32 GBaud, License
◦	M8046A-0P6	PAM-4 Extension up to 58 GBaud, License
◦	M8046A-0A3	Equalizer License
◦	M8046A-802*	Matched cable pairs, two matched cable pairs are required
◦	M8046A-801	Cable 2.92 mm (m) to 2.92 mm (m), 0.5 m for clock input, Qty 1
M8043A		Analyzer Module 32/64 Gbaud, NRZ and PAM4 2-slot AXIe
◦	M8043A-0A3	Equalizer License
◦	M8043A-A64	Analyzer, one Channel, Data Rate up to 64 GBaud, NRZ and PAM4

N1076B/N1078A [7]		
◦	N107xx-264	Supported input rates 125 MBd to 64 GBd
◦	N1076B-CR1	Clock Recovery Phase Matching Kit for N076B Electrical
◦	N1076B-2PB	Microwave Pick-off Tee 1.85 mm connectors, matched pair
◦	11900B	2.4 mm female to 2.4 mm female adapter
◦	83059A	Coaxial Adapter, 3.5 mm Male-Male

Select an interference source for the C2C application

6 Not required if internal error counters of the device under test are used.
7 Choose on external N107xx Clock Recovery if M8046A-A04/-A05 options not selected. Not required when DUT internal error counter is used.

M8194A	120 GSa/s Arbitrary Waveform Generator
◦ M8194A-001	Arbitrary Waveform Generator, 1 Channel 120 GSa/s
M8196A	92 GSa/s Arbitrary Waveform Generator
◦ M8196A-001	Arbitrary Waveform Generator 1 Channel 92 GSa/s
M8054A	Interference Source 32 GHz

DCA-X mainframe and precision waveform analyzer configuration

N1000A	DCA-X Wide-Bandwidth Oscilloscope Mainframe
◦ N1000A-PLK	Pattern Lock Trigger Hardware Model
N1060A	Precision Waveform Analyzer
◦ N1060A-050	Two 50 GHz channels
◦ N1060A-EVA	Equalizer Integrated variable
◦ N1060A-264	Supported input rates 125 MBd to 64 GBd
◦ N1060A-PTB	Precision Timebase Ultra/Low Random Jitter
◦ N1060A-JSA	Jitter Spectrum Analysis and Clock Recovery Emulation

UXR

• UXR059A/B	59GHz, Infiniium UXR-Series real-time Oscilloscope
D9020ASIA	Advanced signal integrity software (EQ, InfiiniSimAdv, crosstalk)
D9010PAMA	Pulse amplitude modulation PAM-N analysis software
D9020JITA	Jitter, vertical and phase noise analysis software for 90000, V-, Z- and UXR-series oscilloscopes

Accessories & fixtures (recommended)

M8195A-810	Cable, 2.92 mm (m) to 2.92 mm (m), length-0.85 m (for combining SI and RI)
M8195A-820	Coaxial termination 50 Ω DC to 26.5 GHz, 3.5 mm (male) (2 required)
SP0602A	Wilder OSFP 112G/800G MCB 1.85 mm Receptacle Test Adapter
SP0603A	Wilder OSFP 112G/800G HCB Plug 1.85 mm Test Adapter
SP0606A	Wilder QSFP-DD 112G/800G MCB 1.85 mm Receptacle Test Adapter
SP0607A	Wilder QSFP-DD 112G/800G HCB Plug 1.85 mm Test Adapter
M8045A-802 [8]	Matched directional coupler pair, 50 GHz, 13 dB, 2.4 mm
-	Wilder DCOM-ISI-112G-9CH-36F-1.85, Datacom ISI 112G 9-Channel Board for (C2M and C2C low-loss and high-loss)
M8067A-001	ISI Channel Board Three Traces 6.2, 11.7, and 17.1 inches, 1.85 mm Connectors (for C2M and C2C high-loss)

8 For C2C application

Software configuration	
M8070ADVB-1xx	Advanced Measurement Package for M8000 Series of BERT Test Solutions (node locked, transportable, floating or USB license, revisions 9.1 or later)
M8091CKCA-1xx	Pre-compliance RX Test Automation for IEEE 802.3ck (node-locked, transportable floating or USB license)
N1010100A	Research and Development Package for FlexDCA-DCA-X mainframe minimum configuration [9]

Additional ordering information	
S1201A CSI Bundle	S1201A IEEE 802.3ck Tx and Rx Conformance Test Solution

Minimum PC configuration

The PC running the application should meet the following requirements

PC Hardware requirements

- Operating system: Microsoft Windows 10 (64 bit), Version 1809 or newer
- Memory: 8 GB RAM minimum
- Monitor resolution: WXGA+ (1440 x 900) minimum

PC Software requirements

- Microsoft Office 2019 or higher
- Microsoft .NET Framework 4.7.1 or newer
- Keysight IO Library Suite Rev. 18.1
- Keysight License Manager 5 and Keysight License Manager 6
- Keysight M8070B system software for M8000 series
  - Ver.10.0.160.6
  - M8070ADVB Advanced Measurement Package for M8000 Series Ver. 1.6.180.2
  - M8194A soft front panel version 2.0.31.0 or later or M8196A soft front panel version 2.1.1.0
- Keysight DCA-X oscilloscope FW rev. A.07.41.27
- Keysight UXR oscilloscope FW rev. 11.50.00601
- MATLAB compiler runtime R2017a (9.2)

9 Corresponding legacy DCA options: N1010AT-200/-201/-0EP/-SIM

Remote Programming

The M8091CKCA Conformance Receiver Test Application for IEEE 802.3ck is part of Keysight's Digital Test Apps and can be programmed via ARSL, any .NET language. For more information, see www.keysight.com/find/rpi.

Data Analytics Enabled

This test application supports data exporting with support from the Keysight KS6800A Data Analytics Software. For more information see www.keysight.com/find/data-analytics.

Related products

The N1091CKCA Electrical TX Test Software for IEEE 802.3ck (100/200/400 Gb/s) for sampling oscilloscopes offers automated transmitted testing for IEEE PAM-4 based electrical outputs.

The D90103CKC Electrical TX Test Software for IEEE 802.3ck (100/200/400 Gb/s) for real-time oscilloscopes offers automated transmitter testing for IEEE PAM4-based electrical outputs.

The N4917BSCB Optical Receiver Stress Test Application addresses test needs for optical input test of transceiver modules for IEEE 400GBASE-based optical interfaces.

The N19301B PLTS Base Analysis is the industry standard for signal integrity measurements and data post-processing of high-speed interconnects, such as cables, backplanes, PCBs and connectors.