AE6920R Automotive Ethernet MultiGBASE-T1 Receiver Test Automation Software

KEYSIGHT

USER GUIDE

Notices

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Table of Contents

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List of Figures

List of Tables

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1 Introduction

Overview

The Keysight AE6920R Automotive Ethernet Receiver Test software is based on Bitifeye's "ValiFrame" test software, which is an automated compliance test tool enabling you to verify and debug the receiver characteristics of the IEEE 802.3ch compliant MultiGBASE-T1 PHY module.

This document describes the calibrations and test procedures conducted by ValiFrame for Automotive Ethernet MultiGBASE-T1 in detail.

The AE6920R Automotive Ethernet MultiGBASE-T1 software implements the compliance tests according to the requirements defined by the "IEEE MultiGBASE-T1 Physical Media Attachment Test Suite" in the OPEN Alliance TC15 specification. It also offers additional custom characterization tests to provide more details of the behavior of the DUT (Device Under Test) beyond the limits of compliance testing. The software runs on a standard Windows PC and controls the hardware test resources through appropriate interfaces such as LAN (Local Area Network).

Document History

First Edition (January 2025)

The first edition of this user guide describes the functionality of software version ValiFrame_AE6920R_1.0.0 based on “IEEE MultiGBASE-T1 Physical Media Attachment Test Suite” in the OPEN Alliance TC15 specification r13.

Support and Troubleshooting

If you encounter problems when running the software, check the log list at the bottom of the main window. The log file can be viewed by right-clicking within the log list section (see red frame in Figure 1-1). The log file is temporarily saved at C:\ProgramData\BitifEye\ValiFrameK1\Tmp. Note that all log information will be lost when the AE6920R ValiFrame application is terminated unless you save the log file elsewhere.

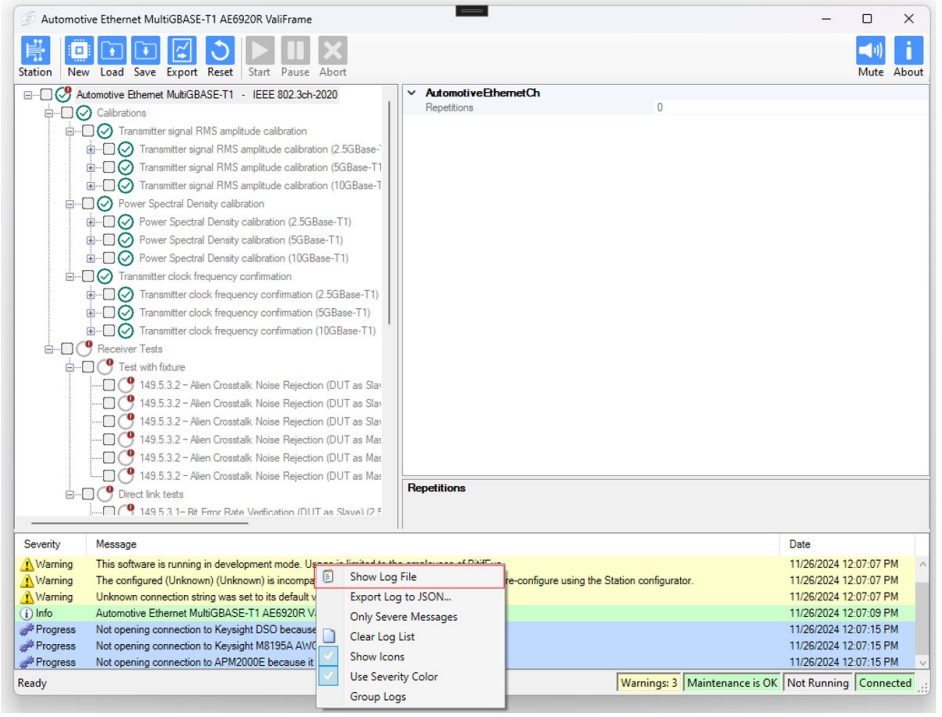

Figure 1-1 Accessing the log file

If a problem with an application persists, send the log file with the problem to Keysight support.

For Keysight support options, visit www.keysight.com/find/contactus.

2 Preparing to Take Measurements

Overview

The set of test instruments that are used for Automotive Ethernet MultiGBASE-T1 Receiver Test Automation are referred to as a Test Station or Station. The test station is controlled by a suitable PC and the AE6920R Automotive Ethernet MultiGBASE-T1 Rx Test Automation Software Platform.

Hardware and Software Requirements

The hardware and software requirements to run the AE6920R test are shown in Table 2-1.

Table 2-1 Hardware and Software Requirements to Run the AE6920R

Keysight Model/Option	Quantity	Description
AE6920R	1	MultiGbase-T1 (2.5G/5G/10G) Rx test SW with a license option
M8195A with Opt 001, Opt BU2, Opt 16G, Opt SEQ and M8195A driver firmware	1	65 Gsa/s Arbitary Waveform Generator
UXR0104B	1	UXR 10 GHz 4ch scope, for calibration purpose
APM2000E-CLK	1	MultiGbase-T1 tp MultiGbase-T Media Converter with Clock-in and Clock-out (Link Partner)
Keysight Serial Tools Driver | Keysight		Keysight serial toolsl driver SW, ver 2.30 or higher
DUT	1	IEEE 802.3ch compliant MultiGbase-T1 PHY
AE6090A	1	MultiGbase-T1 Noise Injection Fixture with SMA(m)-to-SMA(m) adapters, Qty 4
AE6960A	2	H-MTD-to-SMA Adapters
15443A	2	SMA(m)-to-SMA(m) cables, matched pair
	3	SMA(m)-to-MMCX(plug) cables (for connecting AWG and APM2000E-CLK)
	2	50 ohm SMA termination adapter

Downloading and Installing the ValiFrame Software

The AE6920R software consists of different software components:

1. Test Automation for the automated receiver compliance tests (ValiFrame software).
2. Keysight serial tools driver for APM2000E/-CLK version 2.3 or higher.

First download and install the BitifEye AE6920R ValiFrame Automotive Ethernet MultiGBASE-T1 Receiver Test software. Further details about this and the licenses required can be found in the N5991/AE6920R Getting Started Guide.

Link to download:

- AE6920R
- Serial Tools Driver

Starting the ValiFrame Software

Double-click the AEch ValiFrame (AE6920R) icon on the desktop (see Figure 2-1) to launch the app. Alternatively, to access the AE6920R ValiFrame app on a Windows 10-based PC, click **Start** > **BitifEye AEch AE6920R** > **AEch ValiFrame (AE6920R)**.

Figure 2-1 AE6920R Automotive Ethernet MultiGBASE-T1 ValiFrame icon

NOTE

- Before installing the Automotive Ethernet software, you need to first install the Keysight Serial Tools Driver package for accessing the APM2000E/-CLK Media Converter.
- The APM2000E/-CLK cannot be powered over USB. A 12 Vdc power supply provided with the APM2000E/-CLK must be used to power the device.

Normal Workflow

After the ValiFrame software has been installed, the normal procedure when testing a DUT is as listed below. More details about each step are provided in the following sections.

- **Start AE6920R ValiFrame app**

  (see Starting the ValiFrame Software)

- **Configure the station**

  (see Test Station Configuration)

  - Station configuration
  - Instrument configuration

NOTE The AE6920R comes with an integrated Configuration app in the AE6920R ValiFrame app.

- **Configure the DUT**

  (see Configuring the Product and Test Parameters)

- **Calibrate the system**
  - Select calibration procedure(s) (see Selecting Procedures)
  - Modify parameters (see Modifying Parameters)
  - View connection diagram and connect setup (see Connection Diagrams)
  - Run calibration procedure(s) (see Running Procedures)
  - Save/export calibration results (see Exporting Results)
- **Run test procedures**
  - Select test procedures (see Selecting Procedures)
  - Modify parameters (see Modifying Parameters)
  - View connection diagram and connect setup (see Connection Diagrams)
  - Run test procedure(s) (see Running Procedures)
  - Save/export test results (see Exporting Results)

Test Station Configuration

When the AE6920R ValiFrame app is launched, the main ValiFrame window opens as shown in Figure 2-2. Click **Station** (red frame in Figure 2-2) to open the Station Configurator window.

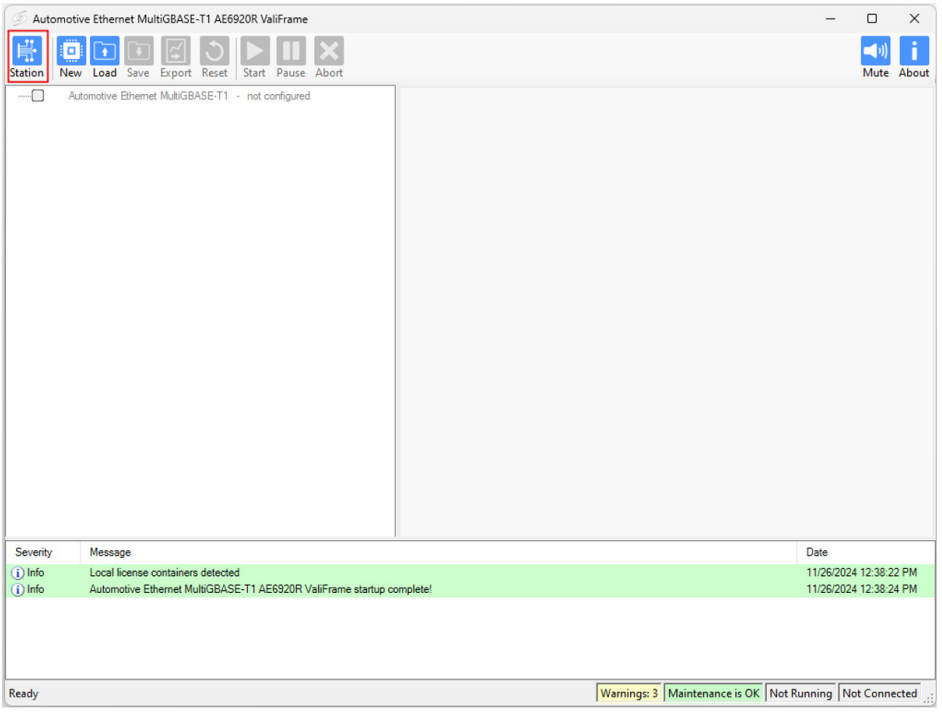

Figure 2-2 AE6920R ValiFrame main window

The Station Configuration window is shown in Figure 2-3.

Station Configuration

The Station Configurator shows the various options for instruments used for Automotive Ethernet MultiGBASE-T1 testing. The options are:

- Media Converter
- Noise Generator Type

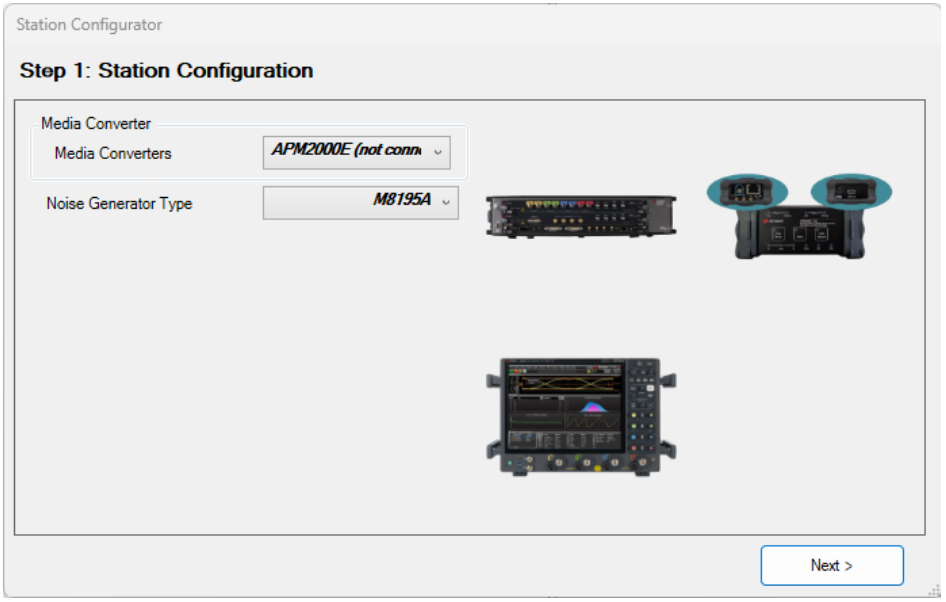

Figure 2-3 Station Configuration Window

Media Converter

The APM2000E/-CLK is used as the test pattern generator and link partner. The APM2000E/-CLK is configured to generate test pattern per IEEE 802.3ch Test Mode 7 and is used as a link partner for the DUT. The available options include all APM2000E devices connected to the PC or laptop over USB.

The APM2000E-CLK is the modified hardware from the APM2000E to expose clock signal input/output and clock source selection by user. The APM2000E-CLK is required to perform the receiver clock frequency tolerance test.

If you connect several APM2000E to the PC, select the one to use as a link partner by its serial number, displayed in brackets.

Noise Generator Type

A noise source is required. ValiFrame supports the following sources:

- M8195A Arbitrary Noise Generator with Opt 001 1 ch AWG,
- Opt BU2 2-slot chassis,
- Opt 16G 16GSa memory,
- Opt SEQ Sequencer.

Instrument Configuration

Once the AE6920R station is configured, the instrument addresses must be set up. An example of instrument configuration is shown in Figure 2-4.

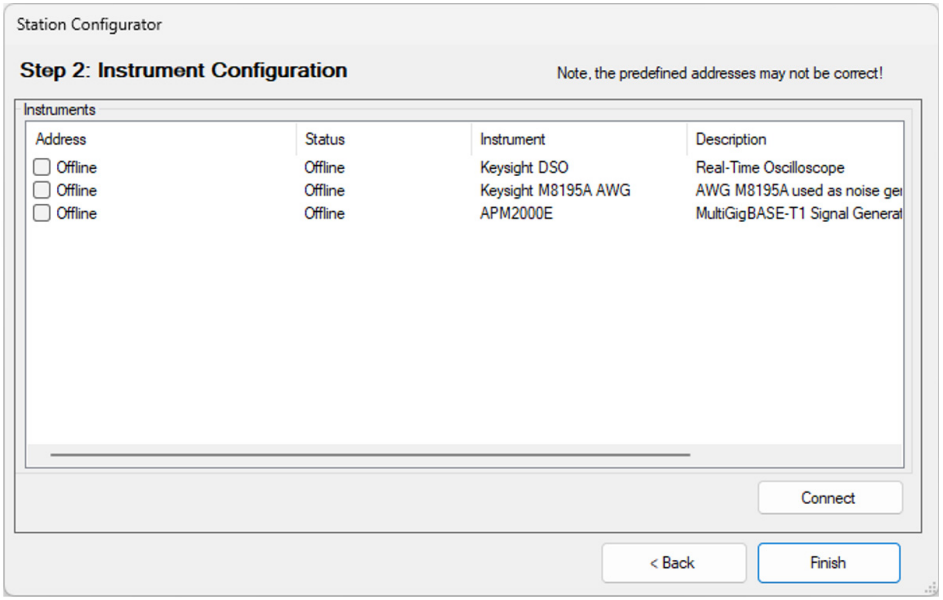

Figure 2-4 Instrument configuration window

After the installation process, all instruments are configured by default to be in the Offline mode. In the offline or simulation mode, the hardware does not need to be physically connected to the test controller PC. The ValiFrame software cannot connect to any instrument in this mode. In order to control the instruments that are connected to the PC, the instrument address must be entered. The address depends on the bus type used for the connection, for example, LAN or VISA.

Most of the instruments used in the Instrument Configuration part of the Station Configurator require a VISA connection. To determine the VISA address, run the "Keysight Connection Expert". which is part of the Keysight IO Libraries Suite. For each instrument, copy the address string from the Connection Expert entries and paste it as the instrument address in the Station Configurator.

After the address strings have been entered, click **Check Connections** to verify that the connections for the instruments are established properly. If there are any errors in the instrument address configuration, the Station Configurator displays a prompt to indicate so.

Click **Finish** to save the changes and close the Station Configurator.

NOTE

When starting a specific test station configuration for the first time, all instruments are set by default to the Offline mode. In this mode the test automation software does not connect to any instrument. Use this mode for demonstrations or checks only.

NO VALID DATA WILL BE PRODUCED.

You will need to repeat the station and instrument configuration whenever you change the instruments you are using or its connections.

Configuring the Product and Test Parameters

Once the Test Station has been configured, the next step is to configure the product and test parameters.

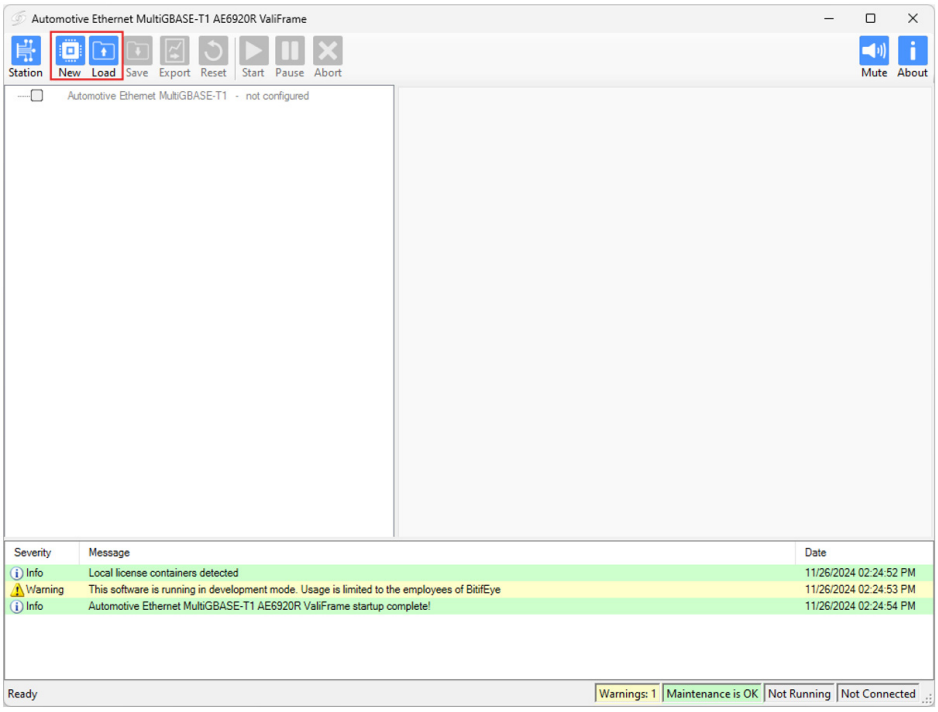

Figure 2-5 New and Load buttons in the main window

Opening a Previously Saved Project

If you have already configured the AE6920R ValiFrame software and saved the settings as a configuration or project file, you can click **Load** (Figure 2-5) to use the same station, product and test parameters again, which can save time.

Beginning a New Project

To begin a new project, click **New** (Figure 2-5), which opens the AE6920R Configure Product window (Figure 2-6).

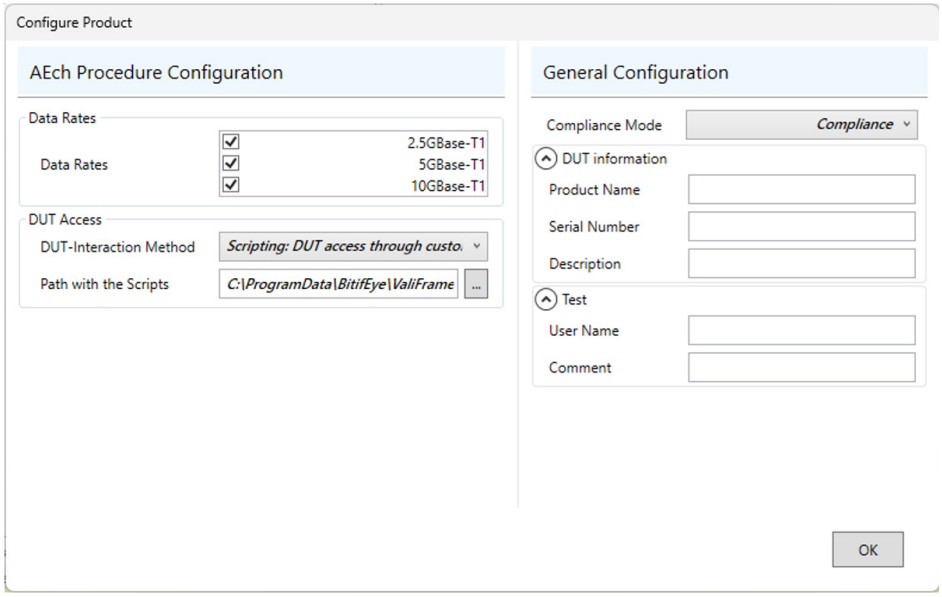

Figure 2-6 Configure DUT window

The Configure Product window allows you to select the DUT and receiver test parameters, such as data rates, DUT access method and Compliance/Expert mode. These parameters will be used later in the calibrations and test procedures.

3 Using the Software

Introduction to Using the Software

Once the DUT has been configured, click ‘OK’ in the AE6920R Configure DUT window. The Automotive Ethernet MultiGBASE-T1 AE6920R ValiFrame main window will appear (Figure 3-1).

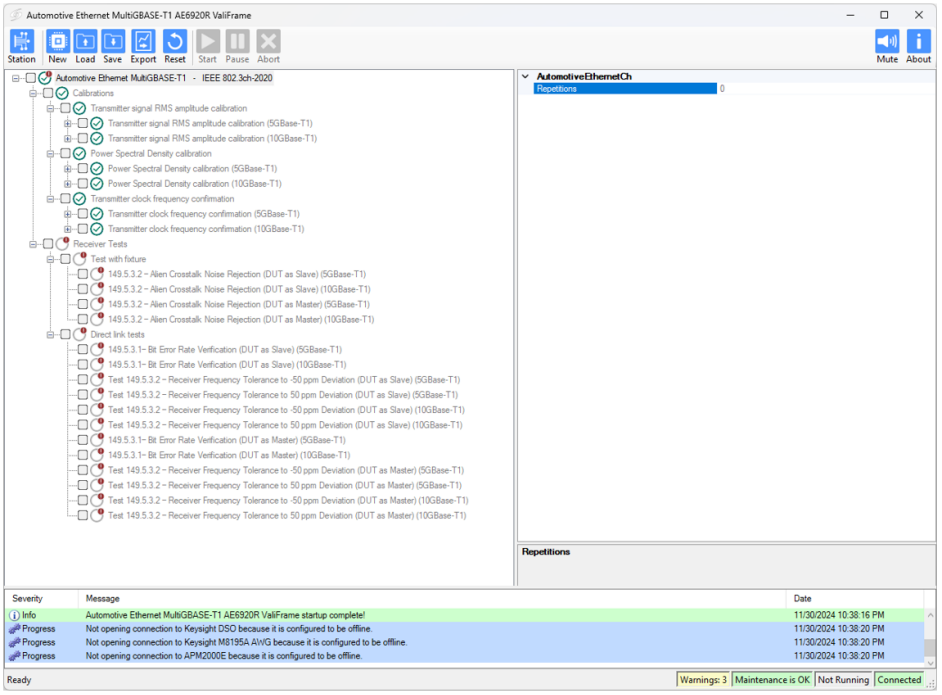

Figure 3-1 AE6920R ValiFrame Main window

ValiFrame Toolbar

Use the **Station** button to configure the Test Station. See Test Station Configuration.

Use **New** to open the AE6920R Configure DUT window. This allows you to configure a new DUT or change the DUT and test parameters. See Configuring the Product and Test Parameters

If you have already configured the AE6920R ValiFrame software for a particular product and saved the settings as a configuration file, you can click **Load** to use the same station, product and test parameters again, which can save time.

The **Save** button is used to save settings for a particular project. You can save the settings as either a ValiFrame configuration file (.vfc; this contains the changed parameters and the selected procedures) or a ValiFrame project file (.vfp; contains the same as the configuration file and in addition the results of the current run).

See the N5991/AE6920R Getting Started Guide for more details.

Use the **Export** button to save results of measurements. See Exporting Results for details.

Reset sets ALL parameters to their default values.

To start one or more procedures, select the corresponding check box(es). Then, the **Start** button is enabled and turns blue. Click Start to run the selected procedure(s).

Pause interrupts the current run at the end of the current step. When the test is paused, the Start button is relabelled **Step**.

You have two options when a procedure is paused.

- Click **Step** to continue the procedure and pause at the next step.

- Click **Pause** again to toggle the state of the Start/Step button. Then click **Start** to continue running the test until the end of the procedure.

The **Step** feature is useful for debugging purposes, for example to analyse the signal on the oscilloscope at each step. When a procedure is paused, a message in the bottom-left corner of the main window indicates which step has been reached.

Abort stops the current run and closes the procedure window.

ValiFrame produces a sound to indicate when a different state of the program has been reached. You can turn this off (and on again) using the **Mute** button.

The **About** button opens a window that provides details of the software, such as the version of ValiFrame that is being run, the Container ID of the computer and when the software maintenance will expire. The window can also be used to send a report to Support if you encounter persistent problems. For more details see the N5991/AE6920R Getting Started Guide.

Parts of the Main Window

All the relevant calibration and test procedures are listed in groups in a **procedure tree** (left side of the AE6920R ValiFrame main window, Figure 3-1), similarly to how they are organized in the PMA Test Suite, but with exceptions to ensure that reconnections are kept to a minimum.

The **parameter grid** in the right pane of the window shows the parameters that are related to the individual procedure or group of procedures selected on the left. The **log list** in the bottom pane of the window shows calibration and test status messages (regular progress updates as well as information, warnings and error messages).

The **status bar** at the very bottom provides information about how many critical errors have occurred, how many warnings have been sent, the status of the software maintenance license, whether a procedure is running, which step has been reached and whether the instruments were successfully connected.

CAUTION Before executing the calibration or test procedures, ensure that the Automotive Ethernet MultiGigBASE-T1 Station Configuration is conducted properly with all necessary instruments, such as the oscilloscope, set to "online". All calibrations can be run in offline mode, that is, without any instrument connected. The offline mode is intended for product demonstrations with simulated data. CALIBRATIONS RUN IN OFFLINE MODE DO NOT GENERATE VALID CALIBRATION DATA.

Selecting, Modifying and Running Tests

Selecting Procedures

The calibration and test procedure groups can be globally selected to run by clicking the check box next to the group name. Alternatively, one or more individual procedures can be selected by clicking the check boxes next to the procedure names. Click **Start** (Figure 3-2) to run the selected procedure(s).

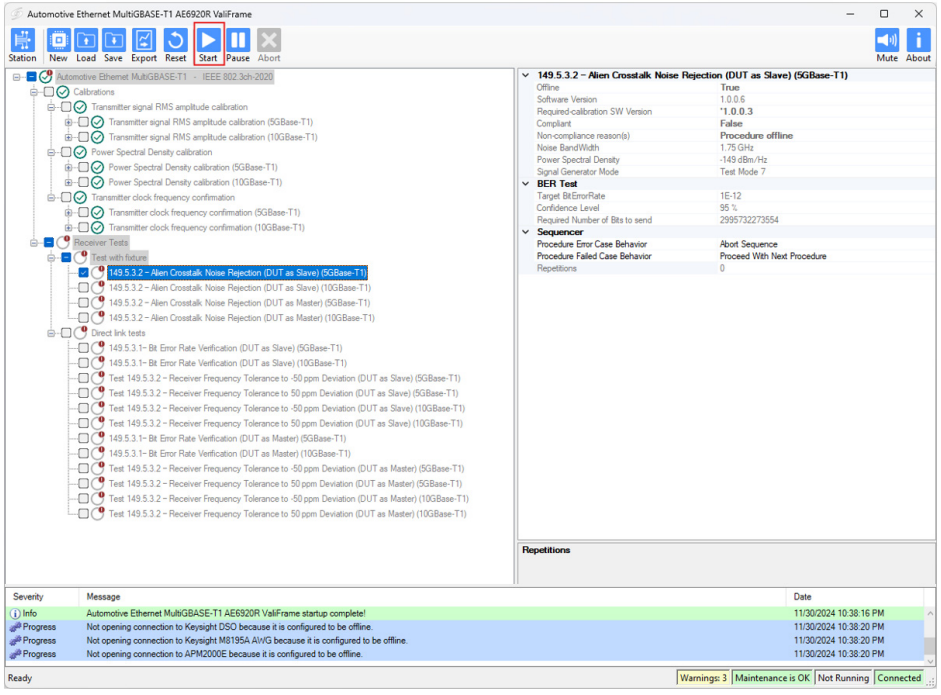

Figure 3-2 Selecting and starting procedures

Modifying Parameters

Most calibration and test procedures, as well as the groups containing them, have parameters that control the details of how the procedures are run. In compliance mode, most of these parameters are read-only. In expert mode, most of the parameters can be modified. To modify a parameter, first select a specific calibration or test procedure in the procedure tree, as shown in the left half of Figure 3-3. The corresponding parameters are displayed in a property list (parameter grid) in the right pane. These parameters can be configured only before the selected procedure is started. All of the selected test parameters are listed in the test results.

For more details about parameters, see AE6920R ValiFrame Parameters.

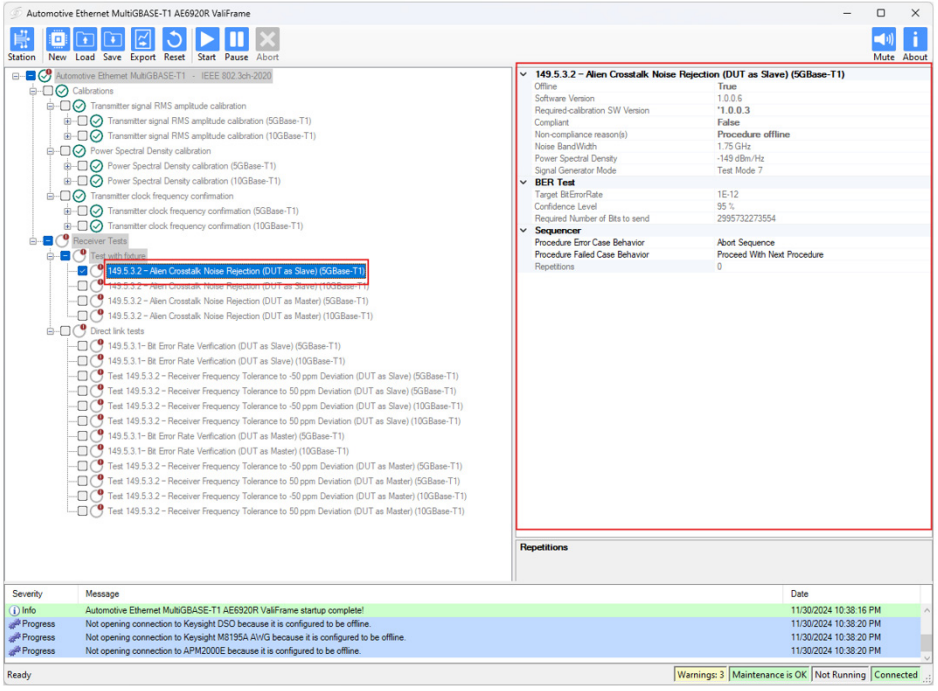

Figure 3-3 Modifying parameters

Running Procedures

To run the selected procedure, click the **Start** icon on the toolbar (see Figure 3-2). The procedures are run sequentially in the order shown in the procedure selection tree. Some procedures may require user intervention, such as changing cable connections or entering DUT parameters. The required action is prompted in pop-up dialog boxes.

To view the appropriate connection diagram, right-click the desired test or calibration. From the right-click menu, select **Show Connection...** from the menu. See also Connection Diagrams.

State Icons

Once the selected procedures have been run, the state icon next to a group or an individual procedure indicates the result (pass / fail / incomplete) and provides further information. For an explanation of the icon beside a particular procedure, right-click the procedure name and select **Show State Details...** (Figure 3-4). For more information about all state icons, refer to the N5991/AE6920R Getting Started Guide.

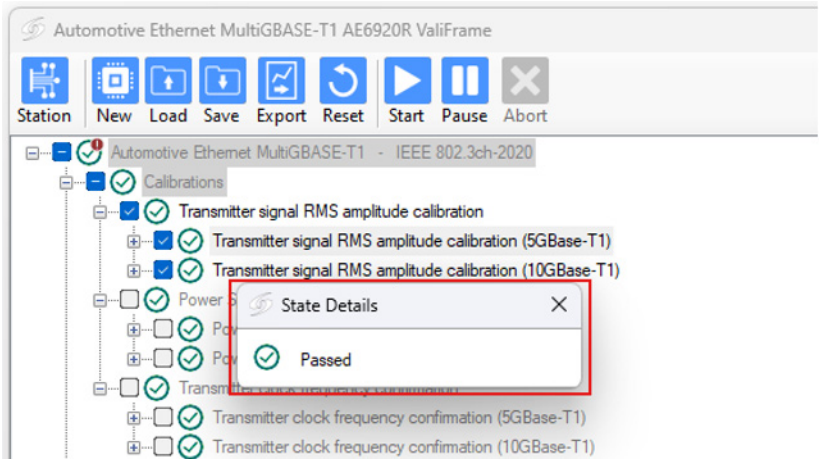

Figure 3-4 Icon representation

Connection Diagrams

To view the connection diagram for a particular set of instruments and procedure, right-click the desired test or calibration in the procedure tree. From the context menu select **Show Connection...**.

The window that opens consists of a connection diagram surrounded by five buttons, which are outlined in red and numbered in Figure 3-5.

1 **Export Mode**: Click here to change the positions of the individual instruments and cables in the connection diagram before exporting it. This is intended to increase the clarity of the connections.

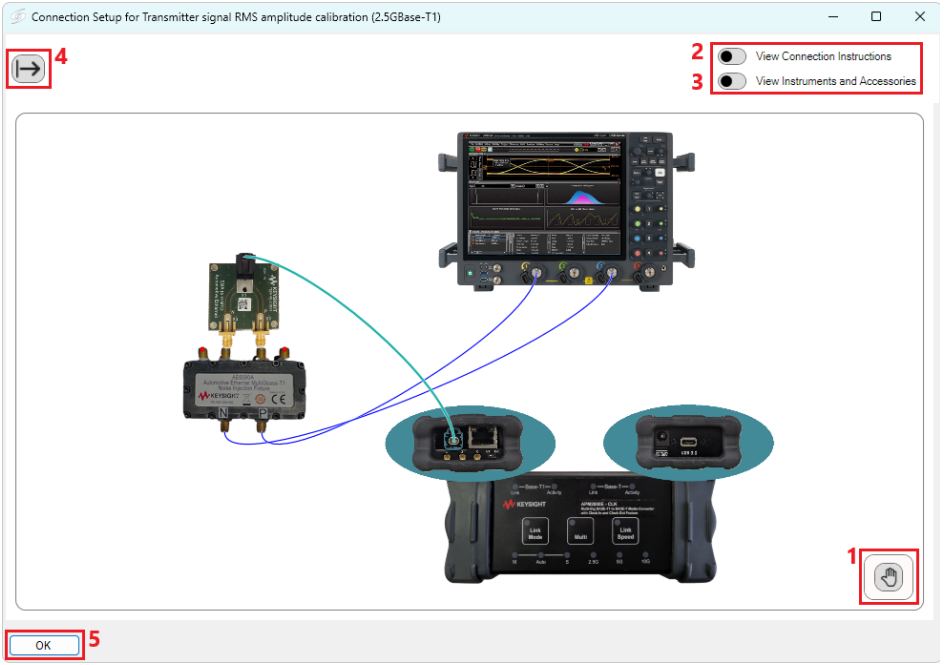

Figure 3-5 Connection diagram window - default view

2 **Connection Instructions**: Toggle to 'on' to view the connection instructions and further information. It is possible to open step-by-step instructions, where the connection currently being made is highlighted. Refer to Figure 3-6.

3 **Instruments and Accessories**: Toggle to 'on' to view the list of required instruments and accessories. Refer to Figure 3-6.

4 **Export**: Export the diagram as an HTML file. If the list of instruments and accessories is expanded, that will be included in the HTML report as well.

5 **OK**: Click here to close the connection diagram window.

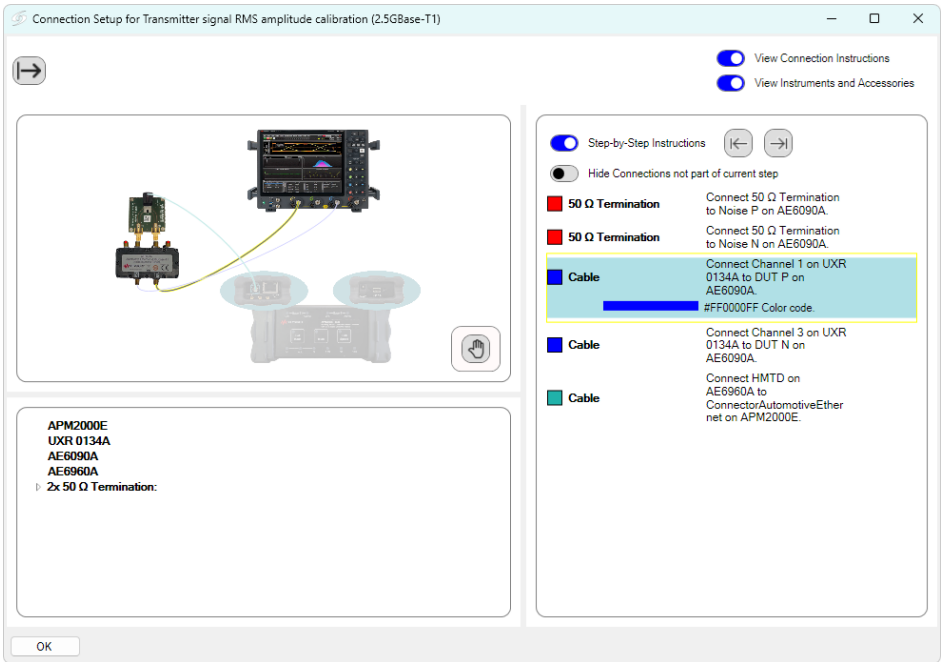

Figure 3-6 Connection diagram window with step-by-step instructions and list of instruments

Required Calibration Data

Some of the calibration procedures and most of the test procedures require calibration data that has been measured previously. You can see the calibration data required by a particular procedure by right clicking its name in the procedure tree and selecting 'Required Calibration Data...'. A list of the prerequisite calibrations pops up. Refer to Figure 3-7.

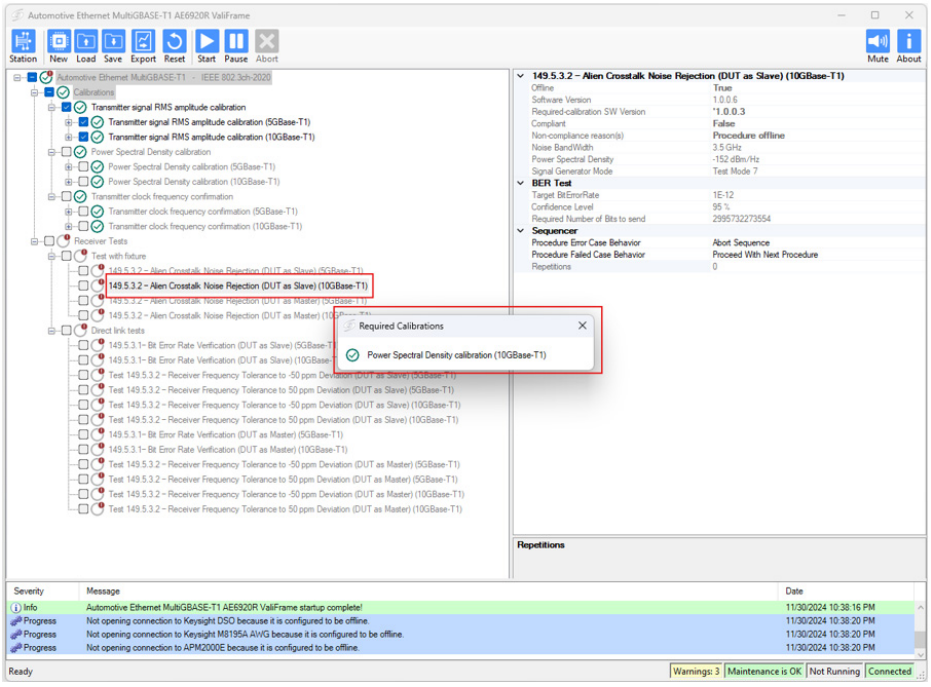

Figure 3-7 Example list of required calibrations

The icon next to the name of a calibration procedure in the list indicates whether the calibration has been run successfully (green), is incomplete (yellow), failed (red) or has not yet been run (gray).

AE6920R Data Structure

All the AE6920R internal data is saved on the PC's local disk in the application data folder ProgramData\BitifEye\ValiFrameK1\AutomotiveEthernetCh.

The AutomotiveEthernetCh data folder contains the following folders:

- Calibrations
- CalibrationsOffline
- Data
- Pattern
- Projects
- Settings
- SParameter

Calibrations

The calibration data is saved in the Calibrations folder. For each calibration procedure run, at least one calibration file is saved.

CalibrationsOffline

If the calibration was run in offline (simulation/demonstration) mode, the calibration data is saved in the CalibrationsOffline folder. Offline calibrations are for demonstration purposes only. They do not yield valid data.

Data

AE6920R does not save any files in the Data folder.

Pattern

AE6920R does not save any files in the pattern folder.

Projects

The Projects folder is the default folder for ValiFrame project (.vfp) and configuration (.vfc) files. These can be saved by clicking the **Save** icon in the AE6920R ValiFrame main window.

Settings

The Settings folder contains settings files. These will include the instrument connection setup, the Station Configuration setup and settings for the last configured DUT, for example, as well as settings related to the specification.

SParameter

AE6920R does not save any files in the SParameter folder.

Results

Run-Time Data Display

Most procedures generate data output. While the procedure is running, the data is displayed in a results viewer window, which opens automatically for each individual procedure.

Any results windows that are open during the procedure runs are closed automatically once the specific procedure is finished. As long as the ValiFrame software is running, each test result file (HTML page) can be reopened by double-clicking the respective procedure. However, the individual files are lost when the ValiFrame application is closed, unless you save the individual files or a collection of them.

Description of Results

In this User Guide, the descriptions of the calibration and test procedures include example descriptions of the results. In addition to a graph and a table, there is a text in each set of results that records the conditions under which the procedure was carried out, including a list of the instruments used and their associated firmware.

Exporting Results

For your convenience, all individual results are summarized in an HTML document at the end of the test run. All calibration and test data worksheets can be saved anytime in a workbook by clicking the **Export** button on the toolbar of the ValiFrame main window. More details can be found in the N5991/AE6920R Getting Started Guide.

Keysight recommends exporting results at least at the end of each ValiFrame run to avoid any data loss. If several calibration and test procedures are conducted during the same ValiFrame run, the resulting worksheets are combined in a workbook. If a test procedure is conducted without prior execution of calibration procedures in the same test run, only the test results will be saved to the workbook.

NOTE

As a safety feature, all calibration and test results are saved by default to the ValiFrame ‘Tmp’ directory (C:\ProgramData\BitifEye\ValiframeK1\ Tmp). The sub-folder ‘Results\AutomotiveEthernetCh Station’ contains the HTML files of the final results measured for each calibration and test procedure.

In addition to the calibration data HTML files, calibration data files are generated. These files are saved by default to the ValiFrame calibrations folder ‘C:\ ProgramData\BitifEye\ValiframeK1\AutomotiveEthernetCh\Calibrations’. If these calibrations are run again, the data file is overwritten. To save the calibration data files at each configuration, the files must be copied from this folder and saved manually in a different folder before the calibrations are rerun.

AE6920R ValiFrame Parameters

AE6920R Automotive Ethernet MultiGBASE-T1 ValiFrame parameters are of three types:

- Sequencer Parameters
- Common Parameters
- Procedure Parameters

Sequencer Parameters

The sequencer parameters control the flow of the test sequencer only, not the behavior of individual procedures. One of them, Repetitions, is available for all groups and all individual procedures in the procedure tree. The others are only available for individual procedures. Like all other parameters, the sequencer parameters are shown in the right half of the ValiFrame user interface and you may manually change them, as illustrated in Figure 3-8.

The sequencer parameters are described in Table A-1.

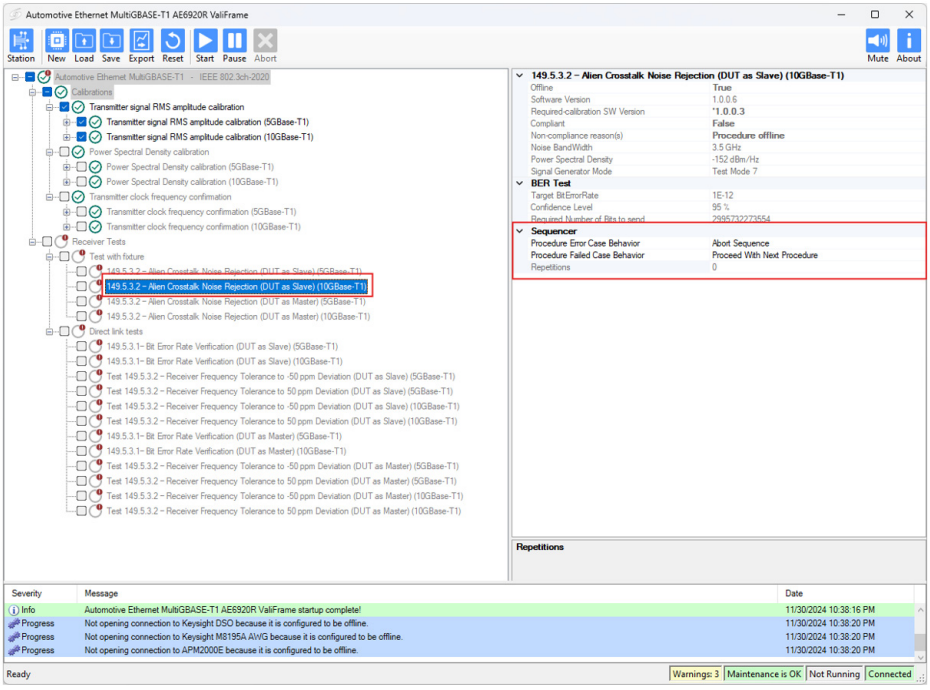

Figure 3-8 AE6920R ValiFrame sequencer parameters

Common Parameters

AE6929R ValiFrame does not have any common parameters – parameters that can be modified when a group is selected in the procedure tree – apart from Repetitions, which has been explained under Sequencer Parameters.

Procedure Parameters

The procedure parameters are all those parameters that are not part of either of the previously described categories. They are shown on the right-hand side of the ValiFrame user interface when the selected entry of the procedure tree on the left is an individual procedure. Their purpose is to modify the behaviour of that single procedure. Different procedures often have parameters with the same name, but configured settings always apply to the selected procedure. The meanings of parameters with identical names may differ slightly between procedures.

- The AE6920R parameters that are used in (nearly) all individual procedures are listed in Table A-2.
- The AE6920R calibration parameters that are available in Expert Mode and used in individual procedures are listed in Table A-3.
- The AE6920R receiver test parameters that are available in Expert Mode and used in individual procedures are listed in Table A-4.

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4 Calibrations

Overview

Before running any receiver test procedure, the Automotive Ethernet receiver test system must first be calibrated.

The DUT input ports give the ValiFrame calibration plane. The receiver test signal characteristics are typically affected by the signal transmission between the generator output ports and the DUT input ports. Thus, for any signal output parameter selected by the user (set value), the signal received at the DUT input ports (actual value) deviates from the set value. The ValiFrame calibration procedures compensate these deviations of the relevant signal output parameter actual values from the set values over the required parameter range.

The ValiFrame software includes all calibration procedures required for Automotive Ethernet receiver testing. The implemented ValiFrame calibration procedures are such that the calibration process is conducted as fast as possible and is automated as much as possible; for example, by minimizing the number of reconfigurations of the hardware connections.

AE6920R Calibration Procedures

Transmitter Signal RMS Amplitude Calibration

Availability

Signal Generator	APM2000E
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to measure the voltage amplitude of the APM2000E signal generator. The test automation sets the signal generator into a defined mode (Testmode5) and measures the RMS amplitude of the output signal after the fixture with a real-time oscilloscope. The measured value is used in the following calibration (Noise Signal Calibration). Assigned to the **Measured Tx Signal RMS** parameter, it is used to calculate the signal to noise ratio (SNR) there.

Connection Diagram

Figure 4-1 Connection diagram for Transmitter Signal RMS Amplitude Calibration

Result Description

RMS Amp-Cal

Calibrates the Transmitter Signal Amplitude for 2.5GBase-T1

----General----	
Offline	False
Software Version	1.0.0.3
Required-calibration SW Version	N/A
Compliant	True
----Instruments----	
Calibrated Instrument 1	Name: Keysight DSO ; Company: KEYSIGHT TECHNOLOGIES ; Model: UXR1104B ; SN: MY63230101 ; FW rev.: 11.60.00115 ; Description: Real-Time Oscilloscope ; Calibrated Instrument
Calibrated Instrument 2	Name: Keysight M8195A AWG ; Company: Keysight Technologies ; Model: M8195A ; SN: MY55A01429 ; FW rev.: 4.3.0.0-2 ; Description: AWG M8195A used as noise generator ; Calibrated Instrument
Calibrated Instrument 3	Name: APM2000E ; Company: Intrepid ; Model: APM2000E ; SN: SN R31001 ; FW rev.: 917 ; Description: MultiGigBASE-T1 Signal Generator ; Calibrated Instrument
----Scope----	
Number of UI to acquire	140.625 kUI
Scope Bandwidth	5 GHz
Time Base Scale of the scope	10 us

Measured Tx-Signal RMS [mV]
327

Figure 4-2 Example result for Transmitter Signal RMS Amplitude Calibration

– **Measured Tx-Signal RMS [mV]**: Measured value of the transmitter signal RMS amplitude.

Power Spectral Density Calibration

Availability

Noise Generator	M8195A AWG
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to calibrate the noise and the signal to noise ratio (SNR) of the setup. The test automation starts by applying small noise amplitudes and increases them with the defined step size. For every set value, measure the PSD at three frequency points of the spectrum, measures the noise floor and calculates the noise floor separation and the Noise amplitude. Repeat maximum capability of the noise generator.

Connection Diagram

Figure 4-3 Connection diagram for Power Spectral Density Calibration

Result Description

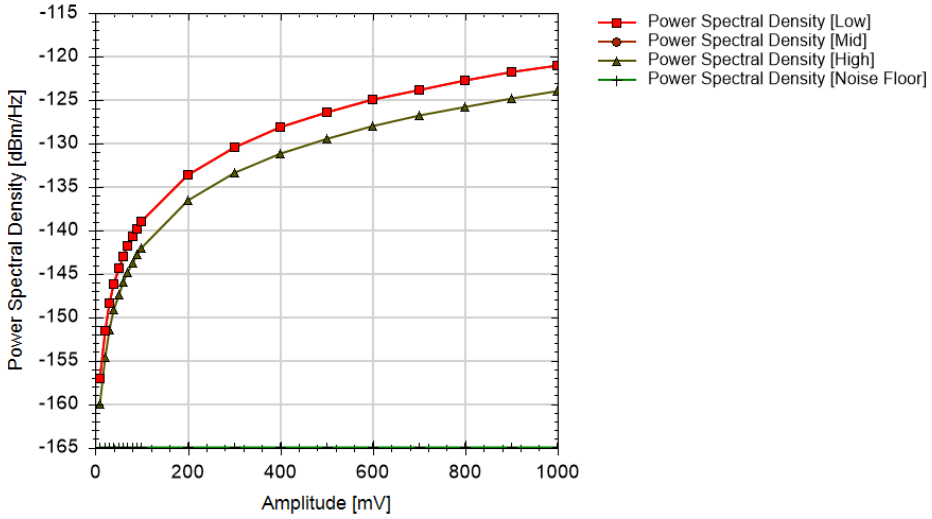
This procedure produces two sets of results, one for PSD against Amplitude and one for PSD against Boost Level. The text is the same for both and is shown only once here.

The stamp “Not Compliant” appears here because the results are a simulation and therefore not compliant.

PSD-Cal 2.5GBase-T1

[Not Compliant]

Calibrates the Power Spectral Density for 2.5GBase-T1



----General----	
Offline	True
Software Version	1.0.0.9
Required-calibration SW Version	N/A
Compliant	False
Non-compliance reason(s)	Procedure offline
----Generator----	
Measured Tx-Signal RMS	120 mV

----Instruments----	
Calibrated Instrument 1	Name: Keysight DSO ; Company: Keysight Technologies ; Model: DSO Series ; SN: Unknown ; FW rev.: Unknown ; Description: Real-Time Oscilloscope ; Calibrated Instrument
Calibrated Instrument 2	Name: APM2000E ; Company: Intrepid ; Model: Unknown ; SN: Unknown rev.: Unknown ; Description: MultiGigBASE-T1 Signal Generator ; C Instrument
Measurement Instrument 1	Name: Keysight M8195A AWG ; Company: Keysight Technologies ; Mode M8195A ; SN: Unknown ; FW rev.: Unknown ; Description: AWG M8195A noise generator ; Measurement Instrument
----Noise----	
3dB Rolloff at Bandwidth Frequency	True
----Scope----	
Time Base Scale of the scope	10 us

Amplitude [mV]	Power Spectral Density [Low] [dBm/Hz]	Power Spectral Density [Mid] [dBm/Hz]	Power Spectral Density [High] [dBm/Hz]	Power Spectral Density [Noise Floor] [dBm/Hz]	Roll-Off [dBm/Hz]	Noise Floor Separation [dBm/Hz]	Noise RMS [mV]
10.0	-157.0	-157.0	-160.0	-165.0	-3.0	5.0	0.100
20.0	-151.6	-151.6	-154.6	-165.0	-3.0	10.4	0.200
30.0	-148.4	-148.4	-151.4	-165.0	-3.0	13.6	0.300
40.0	-146.2	-146.2	-149.2	-165.0	-3.0	15.8	0.400
50.0	-144.4	-144.4	-147.4	-165.0	-3.0	17.6	0.500
60.0	-143.0	-143.0	-146.0	-165.0	-3.0	19.0	0.600
70.0	-141.8	-141.8	-144.8	-165.0	-3.0	20.2	0.700
80.0	-140.7	-140.7	-143.7	-165.0	-3.0	21.3	0.800
90.0	-139.8	-139.8	-142.8	-165.0	-3.0	22.2	0.900
100.0	-139.0	-139.0	-142.0	-165.0	-3.0	23.0	1.000
200.0	-133.6	-133.6	-136.6	-165.0	-3.0	28.4	2.000
300.0	-130.4	-130.4	-133.4	-165.0	-3.0	31.6	3.000
400.0	-128.2	-128.2	-131.2	-165.0	-3.0	33.8	4.000
500.0	-126.4	-126.4	-129.4	-165.0	-3.0	35.6	5.000
600.0	-125.0	-125.0	-128.0	-165.0	-3.0	37.0	6.000
700.0	-123.8	-123.8	-126.8	-165.0	-3.0	38.2	7.000
800.0	-122.7	-122.7	-125.7	-165.0	-3.0	39.3	8.000
900.0	-121.8	-121.8	-124.8	-165.0	-3.0	40.2	9.000
1000.0	-121.0	-121.0	-124.0	-165.0	-3.0	41.0	10.000

Figure 4-4 Example result for Power Spectral Density Calibration (Amplitude)

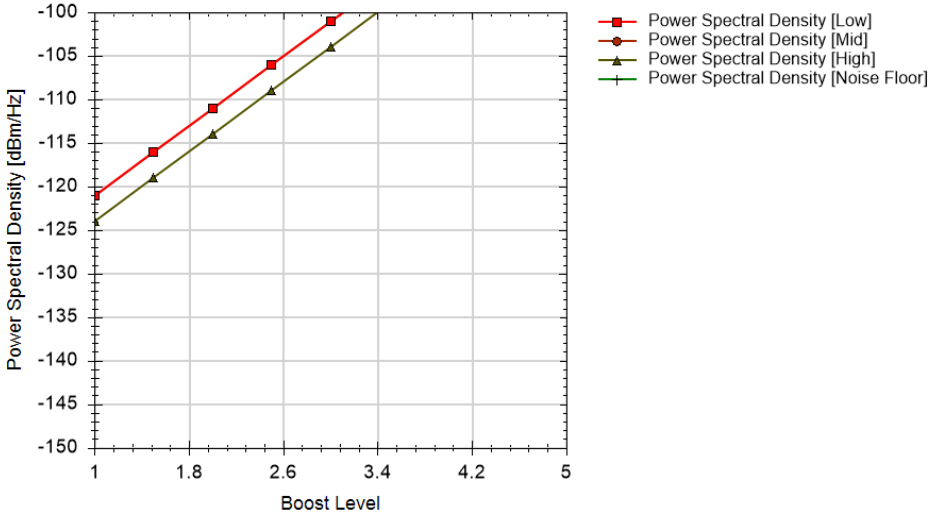
- **Amplitude [mV]**: The amplitude set on the noise generator.
- **Power Spectral Density [Low] [dBm/Hz]**: The PSD measured at 100 MHz.
- **Power Spectral Density [Mid] [dBm/Hz]**: The PSD measured between 100 MHz and noise Bandwidth – 200 MHz.

- **Power Spectral Density [High] [dBm/Hz]**: The PSD measured at Noise Bandwidth – 200 MHz.
- **Power Spectral Density [Noise Floor] [dBm/Hz]**: The PSD measured at the next decade from the noise bandwidth.
- **Roll-off [dBm/Hz]**: The PSD measured at the Noise Bandwidth.
- **Noise Floor Separation [dBm/Hz]**: The nominal difference between the noise floor measurement and the PSD [mid] measurement.
- **Noise RMS [mV]**: The RMS of the noise signal.

BoostLevel-Cal 2.5GBase-T1

[Not Compliant]

Calibrates the Power Spectral Density for 2.5GBase-T1



Boost Level []	Power Spectral Density [Low] [dBm/Hz]	Power Spectral Density [Mid] [dBm/Hz]	Power Spectral Density [High] [dBm/Hz]	Power Spectral Density [Noise Floor] [dBm/Hz]	Roll-Off [dBm/Hz]	Noise Floor Separation [dBm/Hz]	Noise RMS [mV]
1.0	-121.0	-121.0	-124.0	-165.0	-3.0	41.0	10.000
1.5	-116.0	-116.0	-119.0	-165.0	-3.0	46.0	10.000
2.0	-111.0	-111.0	-114.0	-165.0	-3.0	51.0	10.000
2.5	-106.0	-106.0	-109.0	-165.0	-3.0	56.0	10.000
3.0	-101.0	-101.0	-104.0	-165.0	-3.0	61.0	10.000
3.5	-96.0	-96.0	-99.0	-165.0	-3.0	66.0	10.000
4.0	-91.0	-91.0	-94.0	-165.0	-3.0	71.0	10.000
4.5	-86.0	-86.0	-89.0	-165.0	-3.0	76.0	10.000
5.0	-81.0	-81.0	-84.0	-165.0	-3.0	81.0	10.000

Figure 4-5 Example result for Power Spectral Density Calibration (Boost Level)

– **Boost Level**: The boost level applied to the signal before it is sent to the noise generator.

The other column heads have the same meanings as in Figure 4-4.

Transmitter Clock Frequency Confirmation

Availability

Clock Generator	M8195A AWG
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to calibrate the transmitter clock frequency and its deviation. The test automation does a sweep of the crystal clock frequency. For each step, measure the transmitter output frequency with a real-time oscilloscope.

The calibration passes if the output frequency range covers the range defined by the "Mean transmitter out frequency" ± "Clock frequency deviation".

Connection Diagram

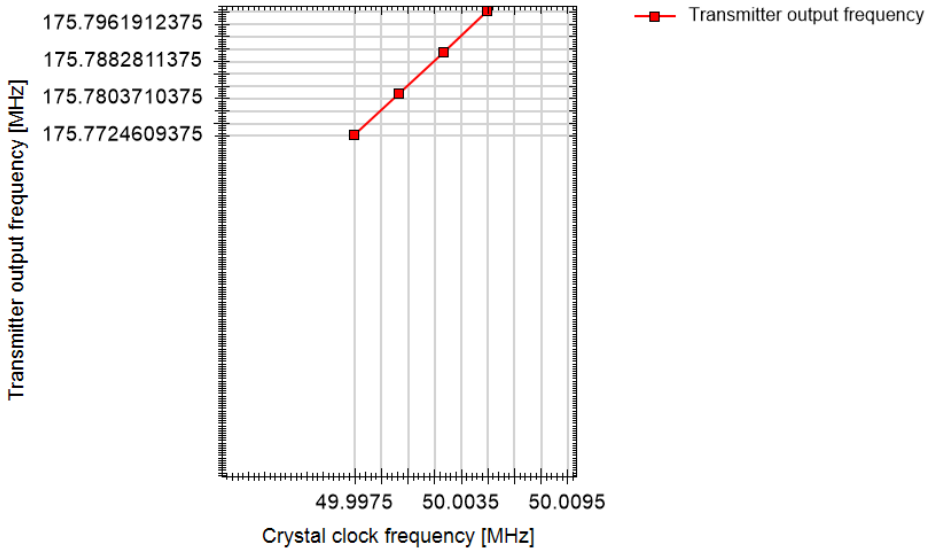
Figure 4-6 Connection Diagram for Transmitter Clock Frequency Confirmation

Result Description

TxClockFreq-Cal 2.5GBase-T1

[Not Compliant]

Confirms the transmitter clock frequency and its deviation for 2.5GBase-T1



----General----	
Offline	True
Software Version	1.0.0.9
Required-calibration SW Version	N/A
Compliant	False
Non-compliance reason(s)	Procedure offline
----Generator----	
Mean crystal frequency	50 MHz
Mean transmitter out frequency	175.78125 MHz
Clock frequency deviation	50 ppm
----Instruments----	
Calibrated Instrument 1	Name: Keysight DSO ; Company: Keysight Technologies ; Model: DSO Inf
Calibrated Instrument 2	Name: Keysight M8195A AWG ; Company: Keysight Technologies ; Model:
Calibrated Instrument 3	Name: APM2000E ; Company: Intrepid ; Model: Unknown ; SN: Unknown ;
----Scope----	
Number of UI to acquire	140.625 kUI
Scope Bandwidth	5 GHz
Time Base Scale of the scope	200 ns

Crystal clock frequency [MHz]	Transmitter output frequency [MHz]
49.9975	175.7725
50.0000	175.7813
50.0025	175.7900
50.0050	175.7988

Figure 4-7 Example result of Transmitter Clock Frequency Confirmation

- **Crystal clock frequency [MHz]**: The frequency set in the crystal clock
- **Transmitter output frequency [MHz]**: The frequency measured on the oscilloscope.

5 Receiver Tests

Overview

All tests should be run with the device set as Master and as Slave, as indicated in the procedure tree.

For Rx tests, the real-time oscilloscope is not needed and can stay unconnected.

The DUT shall maintain a BER of less than 10^{-12} for all three test cases.

NOTE The device configuration is not automatic. You are required to implement the batch scripts or set the device manually with an appropriate tool.

NOTE The receiver tests should be performed in the order that they appear in the procedure tree in the app (and as they are presented in this User Guide). This saves both time and reconnections.

AE6920A Receiver Test Procedures

Alien Crosstalk Noise Rejection

802.3ch Subclause 149.5.3.2

OPEN Alliance TC15 PMA Test Suite, Section 5.2.2

Availability

Noise Generator	M8195A AWG
Pattern Generator	APM2000E-CLK
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to verify that the DUT can maintain a bit error rate (BER) of less than 10^{-12} in the presence of a crosstalk noise source.

For this test, the noise source sends a Gaussian distribution signal with a bandwidth and a PSD as defined in the PMA Test Suite for the current speed grade. Either manually or through the scripts, configure the DUT to SLAVE/ MASTER. If testing in DUT access mode **Scripting** without loopback, reset the Bit Error Counter and Frame Error Counter. The test automation then injects noise crosstalk to the signal, and the BER test starts.

The duration of the BER test will be the time required to reach a specified confidence level (default: 95%). In very unlikely cases, it may take up to 2 hours. As long as the required number of transferred bits has not been reached, every error will cause the test to fail.

Connection Diagram

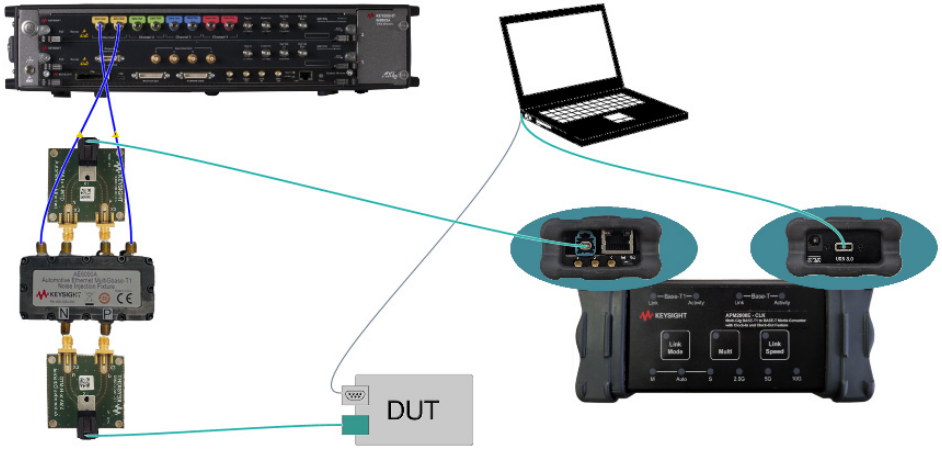


Figure 5-1 Connection diagram for Alien Crosstalk Noise Rejection test

Dependencies

Power spectral density calibration

Result Description

2.5GBit_xTalk-Noise_Slave

[Not Compliant]

AutomotiveEthernetCh

----General----	
Offline	True
Software Version	1.0.0.9
Required-calibration SW Version	1.0.0.9
Compliant	False
Non-compliance reason(s)	Procedure offline; Required cal not compliant: Power Spectral Density calibration (2.5GBase-T1); Required cal offline: Power Spectral Density calibration (2.5GBase-T1)
Noise BandWidth	875 MHz
Power Spectral Density	-146 dBm/Hz
----BER Test----	
Target BitErrorRate	1E-12
Confidence Level	95 %
Required Number of Bits to send	2995732273554

Result	Target BitErrorRate	Confidence Level [%]	Total sent bits []	Total sent frames []	Total received error bits []	Total received error frames []	BER measured on PHY
pass	1E-12	95.0	2997531305750	249794275	0	0	<3.3E-13

Figure 5-2 Example result for Alien Crosstalk Noise Rejection test

- **Result**: (Pass/Fail) Pass if the target bit error ratio is met, otherwise Fail.
- **Target Bit Error Rate**: The maximum bit error ratio that is allowed for a pass.
- **Confidence Level [%]**: The confidence level to be achieved.
- **Total sent bits**: The total number of bits that were sent during the test.
- **Total sent frames**: The total number of frames that were sent during the test.
- **Total received error bits**: The total number of error bits that were received during the test.
- **Total received error frames**: The total number of error frames that were received during the test.

Bit Error Rate Verification

802.3ch Subclause 149.5.3.1

OPEN Alliance TC15 PMA Test Suite, Section 5.2.1

Availability

Pattern Generator	APM2000E-CLK
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to verify that the DUT can maintain a BER of less than 10^{-10}, while having maximum channel length attached.

Either manually or through the scripts, configure the DUT to SLAVE/MASTER. If testing in DUT access mode **Scripting** without loopback, reset the Bit Error Counter and Frame Error Counter.

The duration of the BER test will be the time required to reach a specified confidence level (default: 95%). In very unlikely cases, it may take up to 2 hours. As long as the required number of transferred bits has not been reached, every error will cause the test to fail.

Connection Diagram

Figure 5-3 Connection diagram for Bit Error Rate Verification

Result Description

2.5GBit_BER_Slave

AutomotiveEthernetCh

```
----General----
Offline                          False
Software Version                 1.0.0.5
Compliant                        True
Target BitErrorRate              1E-12
Confidence Level                 95 %
Required Number of Bits to send  2995732273554
```

Result	Target BitErrorRate	Confidence Level [%]	Total sent bits []	Total sent frames []	Total received error bits []	Total received error frames []
pass	1E-12	95.0	2997325043500	249777086	0	0

Figure 5-4 Example result for Bit Error Rate Verification

- **Result**: (Pass/Fail) Pass if the target bit error ratio is met, otherwise Fail.
- **Target Bit Error Rate**: The maximum bit error ratio that is allowed for a pass.
- **Confidence Level [%]**: The confidence level to be achieved.
- **Total sent bits**: The total number of bits that were sent during the test.
- **Total sent frames**: The total number of frames that were sent during the test.
- **Total received error bits**: The total number of error bits that were received during the test.
- **Total received error frames**: The total number of error frames that were received during the test.

Receiver Frequency Tolerance

802.3ch Subclause 149.5.3.2

OPEN Alliance TC15 PMA, Section 5.2.3

Availability

Clock Generator	M8195A AWG
Pattern Generator	APM2000E-CLK
Mode	Compliance, Expert
Speed Grades	2.5GBASE-T1, 5GBASE-T1, 10GBASE-T1

Purpose and Method

The purpose of this procedure is to verify that the DUT can properly accept incoming data at a symbol rate deviation of ±50 ppm.

Either manually or through the scripts, configure the DUT to SLAVE/MASTER. If testing is done with **Scripting** without loopback, reset the Bit Error Counter and Frame Error Counter. The APM2000E clock is deviated by either +50 ppm or –50 ppm, depending on the test.

The duration of the BER test will be the time required to reach a specified confidence level (default: 95%). In very unlikely cases, it may take up to 2 hours. As long as the required number of transferred bits has not been reached, every error will cause the test to fail.

This test is optional in the TC15 PMA test suite.

Connection Diagram

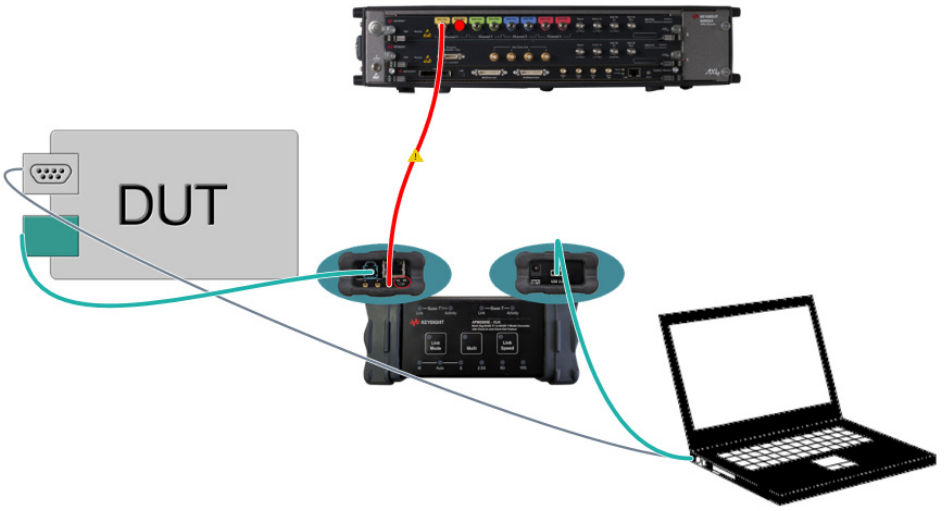


Figure 5-5 Connection Diagram for Receiver Frequency Tolerance test

Dependencies

Transmitter clock frequency confirmation

Result Description

2500MBit_BER_Master_-50ppm

AutomotiveEthernetCh

```
----General----
Offline                          False
Software Version                 1.0.0.5
Required-calibration SW Version  1.0.0.1
Compliant                        True
Symbol Rate                      1.40625 GBd
FrequencyDeviation               -50 ppm
----BER Test----
Target BitErrorRate              1E-12
Confidence Level                 95 %
Required Number of Bits to send  2995732273554
```

Result	Target BitErrorRate	Confidence Level [%]	Total sent bits []	Total sent frames []	Total received error bits []	Total received error frames []
pass	1E-12	95.0	3000555861749	250046321	0	0

Figure 5-6 Example result for Receiver Frequency Tolerance test

- **Result**: (Pass/Fail) Pass if the target bit error ratio is met, otherwise Fail.
- **Target Bit Error Rate**: The maximum bit error ratio that is allowed for a pass.
- **Confidence Level [%]**: The confidence level to be achieved.
- **Total sent bits**: The total number of bits that were sent during the test.
- **Total sent frames**: The total number of frames that were sent during the test.
- **Total received error bits**: The total number of error bits that were received during the test.
- **Total received error frames**: The total number of error frames that were received during the test.

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6 Scripting Details

Scripting Details

To run all the tests automatically, ValiFrame controls the DUT by calling batch scripts. These scripts are called at special points of the test sequence. Each script has a specific name reported in the ValiFrame Logging Window. Some scripts are used to set the DUT into a specific state (e.g. Set_LinkRole_Master.bat). Others are expected to return a value (e.g. Read_ErrorCounter.bat), which is read out of the DUT's PMA control registers.

The called scripts for data rate 2.5G are listed in Table 6-1.

Table 6-1 Scripts for Data Rate 2.5G

Procedures	Script-Method	
– Alien Crosstalk Noise Rejection – BER Verification – Receiver Frequency Tolerance	Set_LinkRole_Master_2P5G.bat	Should set DUT to master and 2.5GBASE-T1
	Set_LinkRole_Slave_2P5G.bat	Should set DUT to slave and 2.5GBASE-T1
	Reset_ErrorCounter.bat	Should reset DUT counters
	Read_ErrorCounter.bat	Should read the DUT RS FEC error counter

The called scripts for data rate 5G are listed in Table 6-2.

Table 6-2 Scripts for Data Rate 5G

Procedures	Script-Method	
– Alien Crosstalk Noise Rejection – BER Verification – Receiver Frequency Tolerance	Set_LinkRole_Master_5G.bat	Should set DUT to master and 5GBASE-T1
	Set_LinkRole_Slave_5G.bat	Should set DUT to slave and 5GBASE-T1
	Reset_ErrorCounter.bat	Should reset DUT counters
	Read_ErrorCounter.bat	Should read the DUT RS FEC error counter

The called scripts for data rate 10G are listed in Table 6-3.

Table 6-3 Scripts for Data Rate 10G

Procedures	Script-Method	
– Alien Crosstalk Noise Rejection – BER Verification – Receiver Frequency Tolerancet	Set_LinkRole_Master_10G.bat	Should set DUT to master and 10GBASE-T1
	Set_LinkRole_Slave_10G.bat	Should set DUT to slave and 10GBASE-T1
	Reset_ErrorCounter.bat	Should reset DUT counters
	Read_ErrorCounter.bat	Should read the DUT RS FEC error counter

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A ValiFrame Parameters

Overview

The parameters used in ValiFrame for AE6920R are divided here into:

- AE6920R ValiFrame Sequencer Parameters (Table A-1)
- AE6920R ValiFrame Parameters for Individual Procedures
  - AE6920R ValiFrame parameters that appear in (practically) all individual procedures (Table A-2).
  - AE6920R ValiFrame parameters for individual calibrations (Table A-3)
  - AE6920R ValiFrame parameters for individual receiver tests (Table A-4)

NOTE

- **If the value of a parameter appears in boldface type in the parameter grid of the GUI, this indicates that the value is not the default value.**
- **If a parameter is read-only (gray) in the parameter grid, it can often be set when configuring the DUT.**

AE6920R Sequencer Parameters

The parameter ‘Repetitions’ appears when you click a group node in the procedure tree, e.g., Calibration or Test with fixture, or an individual procedure. The other sequencer parameters are available for each individual procedure.

Table A-1 ValiFrame Sequencer Parameters

Parameter Name	Description
Procedure Error Case Behavior	– “Proceed With Next Procedure” - If an error occurs in the test or calibration procedure, continue by running the next procedure in the sequence. – “Abort Sequence” - Abort further running of the sequence.
Procedure Failed Case Behavior	– “Proceed With Next Procedure” - If the test or calibration procedure fails, continue by running the next procedure in the sequence. – “Abort Sequence” - Abort further running of the sequence.
Repetitions	The number of times that the group or procedure will be repeated. If the value is '0', it runs only once.

AE6920R Parameters for Individual Procedures

AE6920R Parameters Used in All Individual Procedures

Table A-2 lists the parameters that are used in (practically) all procedures. They appear at the top of the parameter grid and are listed here in the order in which they appear. They are mainly related to whether the procedure is compliant.

Table A-2 AE6920R Parameters for All Individual Procedures

Parameter Name	Description
Offline	– If True, the test automation software is not connected to any instrument. This mode should be used for demonstrations and checks only. It is not valid for calibrations or measurements. – If False, the software is connected to instruments and produces valid data. It is read-only in the parameter grid. It can be set in the Instrument Configuration step of the Station Configurator.
Software version	The version of the AE6920R ValiFrame software currently being used.
Compliant	– Read-only in the parameter grid. This indicates whether the procedure you are running is compliant with the test/IEEE specification. – False is also shown if you are working offline or if any of the prerequisite calibrations were not performed in compliant conditions. – If the value is False, an additional property (Non-compliance reason(s)) is shown to indicate why the data is not compliant
Non-compliance reason(s)	Possible reasons include: the required calibrations were run offline, with unreleased software, with old firmware.

AE6920R ValiFrame Parameters for Individual Calibrations

The parameters for individual calibrations listed in the following tables are in addition to the parameters that are used in (practically) all procedures, which are listed in Table A-2. In each category, the parameters are listed alphabetically.

Table A-3 AE6920R Parameters for Individual Calibrations

Category / Parameter Name	Description/Procedures
Scope	
Number of UI to acquire	Scope capture length in Unit Intervals. – Transmitter Signal RMS Amplitude Calibration – Transmitter Clock Frequency Confirmation
Scope bandwidth	Bandwidth set on the scope. – Transmitter Signal RMS Amplitude Calibration
Time Base Scale of the scope	Time base scale set on the scope. – Transmitter Signal RMS Amplitude Calibration – Power spectral density calibration – Transmitter Clock Frequency Confirmation
Generator	
Measured-Tx Signal RMS	Set to the measured value from the previous calibration. – Power spectral density calibration
Mean crystal frequency	The frequency of the external clock. – Transmitter Clock Frequency Confirmation
Mean transmitter out frequency	The desired frequency for the signal output. – Transmitter Clock Frequency Confirmation
Clock frequency deviation	The desired frequency deviation for the signal output. – Transmitter Clock Frequency Confirmation
Noise	
3dB roll off at Bandwidth frequency	Noise spectrum should have about 3dB roll off at the bandwidth frequency. – Power spectral density calibration

AE6920R ValiFrame Parameters for Individual Receiver Tests

The parameters for individual Rx tests listed in the following tables are in addition to the parameters that are used in (practically) all procedures, which are listed in Table A-2. In each category, the parameters are listed alphabetically.

Table A-4 AE6920R Parameters for Individual Receiver Tests

Category / Parameter Name	Description/Procedures
No Category Name	
Frequency Deviation	The deviation added to the symbol rate of the data output signal – Receiver Frequency Tolerance to –50 ppm Deviation
Noise BandWidth	Bandwidth of the noise signal – Alien Crosstalk Noise rejection
Power Spectral Density	The amount of power of the noise per frequency interval – Alien Crosstalk Noise rejection
Signal Generator Mode	Mode of operation for AMP2000E – Alien Crosstalk Noise rejection – Bit Error Rate Verification – Receiver Frequency Tolerance to –50 ppm Deviation
Symbol Rate	The symbol rate of the data output signal – Receiver Frequency Tolerance to –50 ppm Deviation
BER Test	
Confidence Level	The confidence level used in the BER test – Alien Crosstalk Noise rejection – Bit Error Rate Verification – Receiver Frequency Tolerance to –50 ppm Deviation

Table A-4 AE6920R Parameters for Individual Receiver Tests (continued)

Category / Parameter Name	Description/Procedures
Required Number of Bits to send	The number of bits transmitted – Alien Crosstalk Noise rejection – Bit Error Rate Verification – Receiver Frequency Tolerance to –50 ppm Deviation
Target BitErrorRate	The target BER that determines if the test pass or not – Alien Crosstalk Noise rejection – Bit Error Rate Verification – Receiver Frequency Tolerance to –50 ppm Deviation

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B Acronyms and Abbreviations

This Appendix contains a list of acronyms and abbreviations used in this User Guide.

List of Acronyms

Acronym	Definition
A	
AE	Automotive Ethernet
AWG	Arbitrary Waveform Generator
B	
BER	Bit Error Ratio
C	
CLK	Clock
D	
DUT	Device Under Test
H	
HTML	HyperText Markup Language
L	
LAN	Local Area Network
LP	Link Partner
P	
PC	Personal Computer
ppm	Parts Per Million
R	
RMS	Root Mean Squared
RS FEC	Reed Solomon Forward Error Correction
RX	Receiver
S	
SNR	Signal-to-Noise-Ratio
T	

Acronym	Definition
TX	Transmitter
U	
USB	Universal Serial Bus
V	
VISA	Virtual Instrument System Architecture

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