S8704A Protocol Conformance Toolset

Features and Capabilities

Introduction

Around the world, commercial development and deployment of 5G technology is accelerating to address a wide range of exciting use cases for consumers and industry verticals. This means device manufacturers need to gain early continuous access to the latest Radio Frequency (RF), Radio Resource Management (RRM) and protocol conformance 3GPP test specifications for timely 5G NR device certification. Conformance tests adopted by certification bodies such as GCF (Global Certification Forum) and PTCRB help ensure commercial 5G and LTE devices comply to the latest 3GPP release 15 specifications and operate as expected on mobile networks.

S8704A Protocol Conformance Toolset is part of Keysight's 5G Network Emulation Solution portfolio that addresses the entire device development workflow – from early design, to acceptance and manufacturing. S8704A Protocol Conformance Toolset enables you to certify new designs across both FR1 (sub-6 GHz) and FR2 (mmWave).

What is S8704A Protocol Conformance Toolset?

S8704A Protocol Conformance Toolset (PCT) gives you access to the latest 3GPP defined 5G, including USIM/USAT, IMS, LBS, LTE and C-V2X protocol conformance tests. It provides an easy-to-use Graphical User Interface in which you can create campaigns of tests, set PICS/PIXIT parameters, view logs and create reports.

In this document we will describe the graphical user interface and functionality provided by S8704A Protocol Conformance Toolset in more detail. We will also describe the hardware platform on which S8704A Protocol Conformance Toolset is run.

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Who Benefits from Using S8704A Protocol Conformance Toolset?

- Operators who want to make sure that the devices they offer are GCF/PTCRB certified.
- Device manufacturers to ensure their devices are certified before launch to market.
- Chipset manufactures for pre-certification.
- Test houses and test labs that run tests for GCF/PTCRB certification.

GCF and PTCRB Certification

The third generation partnership project (3GPP) is a collaboration between groups of telecommunications standards associations that produce the technical specifications that set the requirements that a chipset or device manufacturer needs to comply to. The 3GPP conformance specifications cover three main classes of test cases for ensuring new devices work correctly with the Radio Access Network (RAN).

- Protocol
- Radio Frequency (RF)
- Radio Resource Management (RRM)

GCF and PTCRB are industry certification bodies that mandate a selection of 3GPP test cases a chipset or device manufacturer needs to declare compliance with in order for their device to be considered certified by respective certification body.

Once the test cases are selected by GCF/PTCRB for certification, Keysight implements the corresponding test specifications within the S8704A Protocol Conformance Toolset and works with 3GPP and a selection of leading chipset and device vendors to verify that the 3GPP test specifications correctly verify the underlying 5G, LTE and C-V2X functionality and make sure that Keysight's interpretation is correct. Once any issues with the 3GPP test specifications are resolved, Keysight requests an external accredited Validation Organisation to independently validate the correctness of the overall Keysight S8704A Conformance Toolset solution for compliance to the 3GPP specifications and GCF/PTCRB requirements. If successful, the Validation Organisation submits the results of their testing to GCF and PTCRB, requesting approval that S8704A Protocol Conformance Toolset can be used for formal certification testing.
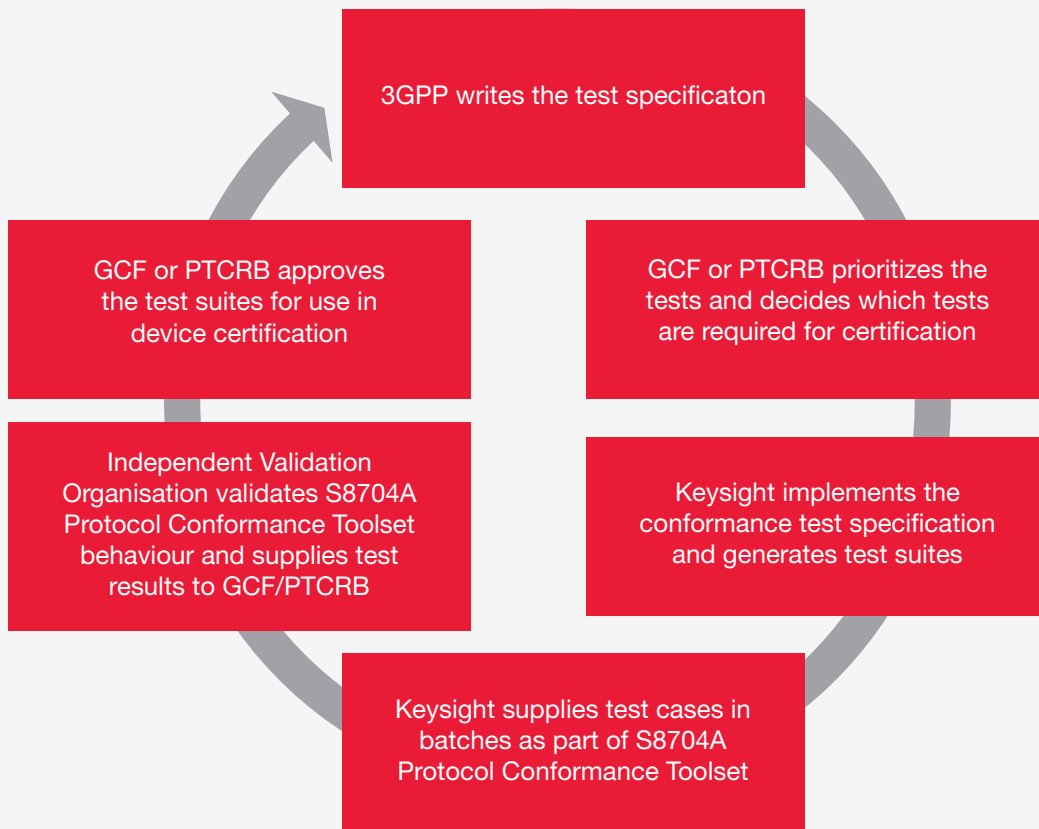
Figure 1: From requirement to validation

S8704A Protocol Conformance Toolset

Keysight's S8704A Protocol Conformance Toolset provides up-to-date and comprehensive access to 5G including USIM/USAT, IMS, LBS, LTE and C-V2X protocol conformance test cases as defined in 3GPP test specifications:

- 3GPP TS 38.523-1: 5GS test cases
- 3GPP TS 31.121: USIM test cases
- 3GPP TS 31.124: USAT test cases
- 3GPP TS 36.523-1: LTE and C-V2X test cases
- 3GPP TS 34.229-1/5: IMS test cases
- 3GPP TS 37.901: LTE Data Throughput Performance test cases
- 3GPP TS 37.571-2: LBS test cases

These test cases are based on the latest available TTCN-3 implementation from 3GPP RAN5 required for device certification and support all 3GPP defined frequency bands in both sub-6 GHz (FR1) and mmWave (FR2) frequency.

Test cases and test suites

A conformance test case is an executable script, which has been created to verify a test case as defined in the 3GPP technical specification. 3GPP related test cases are usually named after the section of the specification on which they are based. For example, the 5G test case 10.2.1.2. tests section 10.2.1.2 in 38.523-1.

The purpose of S8704A Protocol Conformance Toolset is to run these test cases to certify the device. For debugging purposes, it is possible to also create development test suites by modifying Keysight test suites. This provides access to the TTCN-3 editor to make some small modifications such as change the value of a parameter. These modified test cases can then be run to debug any test failures.

Test case management

In S8704A Protocol Conformance Toolset all test cases that have been installed will be displayed in the tool. These test cases can be run individually or as part of a test case campaign where several scripts are run sequentially.

When using S8704A Protocol Conformance Toolset, users can easily execute tasks along the tabs at the top from left to right, see Figure 2. In S8704A Protocol Conformance Toolset test case campaigns are created by first creating a Test Project and then associating one or more Test Plans to each Test Project. A Test Project includes information about a device such as manufacturer, model number, hardware and software versions, SIM manufacturer and PICS parameters. There will always be one Test Project per device.
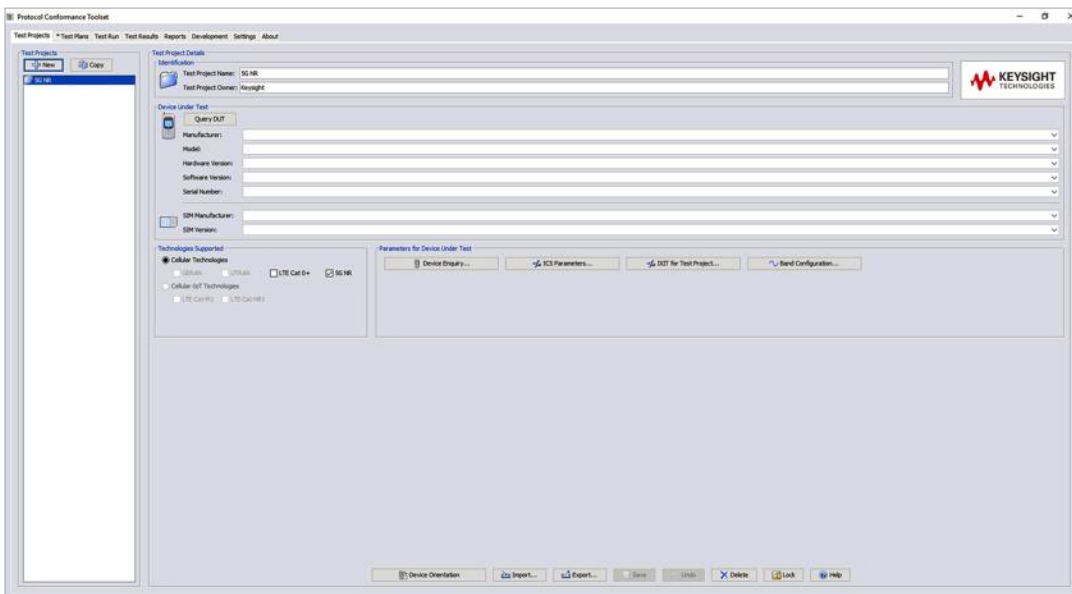

Figure 2: Creating a Test Project

A Test Plan is a sequence of test cases that can be executed against the selected Test Project. A Test Plan is created by moving test cases from left to right using arrows as can be seen in Figure 3. Each Test Project can be linked to one or more Test Plans. There is no limit to the number of Test Projects that you can create.

Test cases can be grouped by test suite, batch or test group. For each test case the test specification, number of transceivers, GCF/PTCRB status, test suite, batch and type of SIM card to be used is displayed.

The following facilities are available for managing test cases in test plans:

- Filtering of test cases by number of cells required, GCF work item/PTCRB RFT, category and Keysight validation status, see Figure 3.
- Test cases are color coded, for example, pink means the test case is not applicable to the device's capability and red means a license has not been purchased.
- For each test case you can view information about the test case such as description, number of cells required and GCF/PTCRB validation status. An xml file can be imported (use Import functionality) to show the latest GCF/PTCRB validation status. This also allows the latest known issues to be displayed in the tool. The xml file is uploaded daily onto Keysight Software Manager so that you can keep the validation status and known issues up to date in the tool.
- The Optimise functionality allows the test cases to be sorted to optimize the execution time.
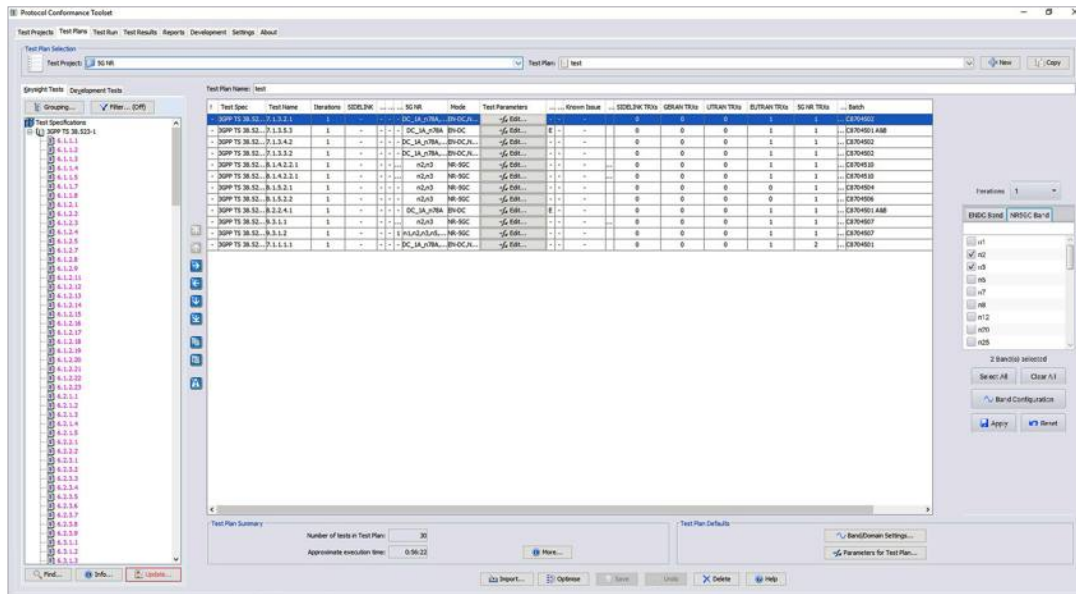- Running test cases against multiple bands.

Figure 3: Create and configure a test plan

Simplified management of PICS/PIXIT parameters

The **PICS** (Protocol Implementation Conformance Statement) is a list of features supported on the device under test, and typically determine which test cases are applicable for the device. The **PIXIT** (Protocol Implementation eXtra Information for Testing) are parameters that can be used to modify certain run-time behavior of the test cases within the constraints of the specification requirements.

For each Test Project, PICS/PIXIT parameters can be set in the Parameter Editor. This can be done manually or by using Device Enquiry, a feature that queries the device for its capabilities and automatically sets the PICS parameter value. This significantly facilitates the setting of PICS parameters and saves the user a significant amount of time.

PICS and PIXIT parameters can be set at different levels: Test Project, Test Plan and Test Case level where for example setting the parameter at test case level will override what is being set at test plan and test project level. By setting the color of the parameter field in the Parameter Editor, it is possible to see the level at which a parameter has been set.

Technology	Parameter Name	Data Type	Value	Description	Spec. Name	Table Name
★ TTCN3	pc_1xCSfallback	Boolean	FALSE	Support of 1xCS fallback	36.523-2	A.4.2.1.1-1/3
★ TTCN3	pc_1xRTT	Boolean	FALSE	UE supports CDMA2000 1xRTT band class	36.523-2	A.4.1-1/4
★ TTCN3	pc_4Layer_spatial_mux_tm3_tm4	Boolean	FALSE	Support of 4 layer spatial multiplexing with transmission mode 3 and transmission mode 4	36.523-2	A.4.4-1/159
☆ TTCN3	pc_5GCN	Boolean	FALSE	UE Supports 5GS Core	38.508-2	A.4.1-5
☆ TTCN3	pc_5GCN_N3AN	Boolean	FALSE	UE supports 5GS Core over non-3GPP Access Network	38.508-2	Table A.4.1-5/2
★ TTCN3	pc_ACL	Boolean	FALSE	Support of ACL	31.121	A.1/15
☆ TTCN3	pc_APN_RateControl	Boolean	FALSE	The UE supports APN rate control	36.523-2	A.4.4-2/27
★ TTCN3	pc_A_BDS	Boolean	FALSE	Support for A-BDS	37.571-3	A.4.3-2/18
★ TTCN3	pc_A_GLONASS	Boolean	FALSE	Support for A-GLONASS	37.571-3	A.4.3-2/7
☆ TTCN3	pc_A_GPS_ADR	Boolean	FALSE	Support of ADR measurement reporting for Gps	37.571-3	A.4.3-6/1
★ TTCN3	pc_A_GPS_ADR_ENH	Boolean	FALSE	Support of ADR enhancements for Gps	37.571-3	A.4.3-6/13
☆ TTCN3	pc_A_GPS_HA	Boolean	FALSE	Support of High accuracy GNSS modes for Gps	37.571-3	A.4.3-6/19
☆ TTCN3	pc_A_GPS_L1C_A	Boolean	FALSE	Support for A-GPS L1C/A	37.571-3	A.4.3-2/6
☆ TTCN3	pc_A_GPS_L1C_A_MGPS	Boolean	FALSE	Support for A-GPS L1C/A and Modernized GPS	37.571-3	A.4.3-2/8
☆ TTCN3	pc_A_GPS_L5	Boolean	FALSE	Support of A-GPS L5 signal	37.571-3	A.4.3-5/3
☆ TTCN3	pc_A_GPS_VelocityMeas	Boolean	FALSE	Support of Velocity measurement reporting for Gps	37.571-3	A.4.3-6/6
☆ TTCN3	pc_A_Galileo	Boolean	TRUE	Support for A-Galileo	37.571-3	A.4.3-2/9
☆ TTCN3	pc_A_QZSS	Boolean	FALSE	Support of A-QZSS	37.571-3	A.4.3-2/14
☆ TTCN3	pc_A_SBAS	Boolean	TRUE	Support of A-SBAS	37.571-3	A.4.3-2/13
☆ TTCN3	pc_Additional_PDU_establishment	Boolean	FALSE	ExpectedNoOfPDUSessionsAtRegistration + 1	38.508-2	A.4.3.7-1/9
☆ TTCN3	pc_Allowed_CSG_list	Boolean	FALSE	Support of Allowed CSG list	36.523-2	A.4.4-1/2
★ TTCN3	pc_Attach	Boolean	TRUE	Support EPS attach (with or without pre-configuration)	36.523-2	A.4.4-2/1
★ TTCN3	pc_AttachWithPDN	Boolean	TRUE	Support of EMM-REGISTERED with PDN	36.523-2	A.4.4.1-1/134
☆ TTCN3	pc_AttachWithoutPDN	Boolean	TRUE	Support of EMM-REGISTERED without PDN	36.523-2	A.4.4.1-1/133
☆ TTCN3	pc_Auto_PDN_Connectivity	Boolean	TRUE	Support of automatic PDN Connectivity in EUTRAN	36.523-2	A.4.4-1/68
☆ TTCN3	pc_AutomaticHRPD_PDN_Connection	Boolean	TRUE	Support of automatic PDN connection trigger on HRPD cell	36.523-2	A.4.4-1-146
☆ TTCN3	pc_Automatic_EPS_Re_Attach	Boolean	TRUE	Support of automatic re-activation of the EPS bearer(s)	36.523-2	A.4.4-1/64
★ TTCN3	pc_Automatic_Re_Attach	Boolean	TRUE	Support of automatic re-activation of the EPS bearer(s) during Network Initiated Detach with detach type set to re-attach required	36.523-2	A.4.4-1/27
☆ TTCN3	pc_Available_PLMNs_AcT_Ind	Boolean	TRUE	Support of AccessTechnology indication in available PLMNs list	36.523-2	A.4.4-1/78

Figure 4: PICS/PIXIT parameter editor

Test Case Execution

Once a test project and one or more test plans have been created you can run the test cases in the test plan. This is done from the Test Run tab in S8704A Protocol Conformance Toolset. Users can choose to run all the test cases or a few of the test cases in the test plan by ticking the boxes for each test that the user wants to run, please see Figure 5. During test case execution, information on the verdict of the test cases, number of remaining tests, estimated times is updated on the right-hand side of the window. This includes information on the current test being updated.
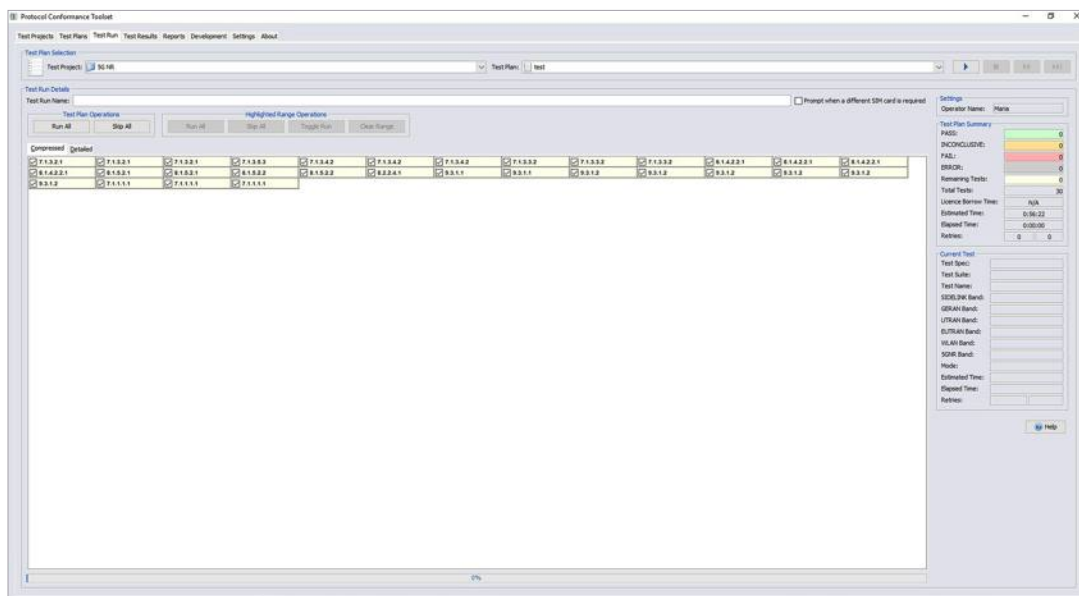

Figure 5: Run test cases and check status

Test Results

In the following section the Test Results tab will be explained as well as the logs used to view and debug results.

Test Results window to manage test results

Test Results are displayed in the Test Results tab of S8704A Protocol Conformance Toolset. It shows all test plans that have been run as well as the verdicts of each test case in the test plan. The Test Results window allows the user to do the following:

- Run test plans which have previously been run and select which verdicts to repeat, for example, only failed test cases.
- Run previously aborted test plans and resume the execution at which it was previously stopped.
- Open a log file for a specific test case in the log viewer application.
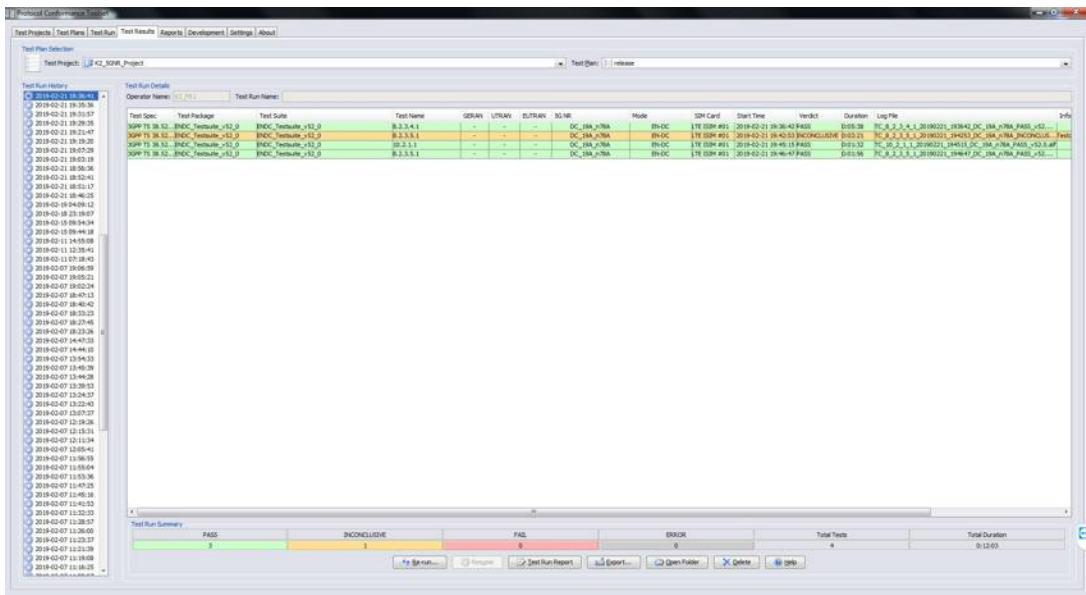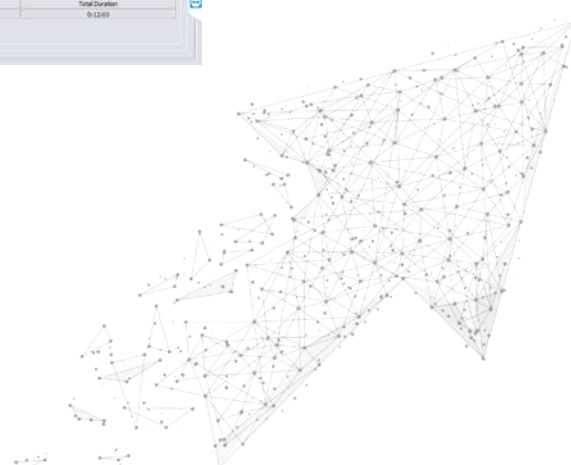- Generate a report showing details of a specific test run.

Figure 6: Test results viewer

Real Time Trace to view logging during test case execution

The Real Time Trace displays test activity whilst a test is running. This is useful to immediately observe if there are any issues during test execution instead of waiting for the test to end.

Log Viewer to facilitate troubleshooting

The Log Viewer enables the user to view all protocol layers (i.e. PHY, MAC, RLC, PDCP and RRC) in one log. The log viewer has a user-friendly graphical user interface where several windows are displayed in one view (see Figure 8). The filtering functionality allows the user to view the protocol layers and test information of interest. It is possible to use any of the default filters or create customised ones. Bookmarks enable the user to go back to any record in the log thereby facilitating troubleshooting. The Bookmarks tab displays all bookmarks that have been created.

The following records can be logged in log viewer:

- LTE and NR protocol messages for all protocol layers (PHY, MAC, RLC, PDCP and RRC)
- All information transmitted and received at the air interface, recorded at the MAC/PHY boundary
- Control information, such as the activation/deactivation of physical and transport channels
- Test System Diagnostic Data

The log viewer allows you to analyze the results of tests on the test system PC or a separate PC, thereby freeing the test system PC so that it can be used solely for running tests.

Log viewer offers access the TTCN code in a TTCN-3 editor by clicking on the TTCN icon in log viewer.

The log viewer is a common logging tool also used for all Keysight 5G Network Emulation solutions.
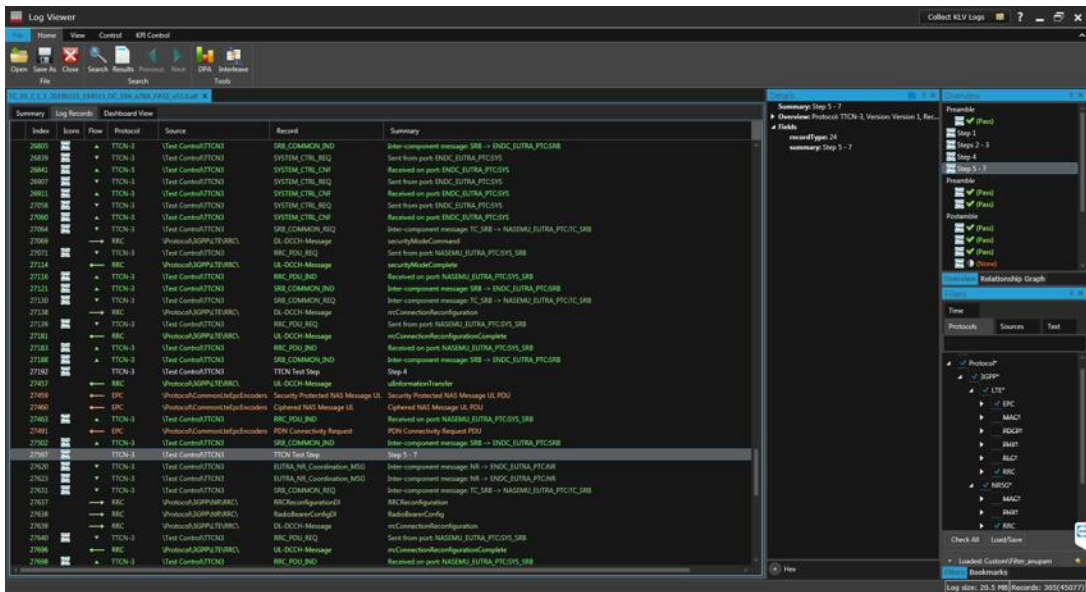
Figure 7: The log viewer is useful for debugging

Test suite development tools

The S8704A Protocol Conformance Toolset's test suite development tools provide capabilities including viewing, editing, and building development test suites as well as defining new ICS and IXIT parameters. The new test suites can be copies of Keysight test suites or entirely new ones. For test suite development users need PSPad and a Danet TTCN-3 compiler. These are used for editing test cases and building the test suite respectively. This is useful for modifying a 3GPP test case and creating a test case with a slightly different requirement.

Remote management of test cases

S8704A Protocol Conformance Toolset has an integrated remote control feature which uses a software component, Remote Control Management Interface (RCMI), for running protocol conformance test cases under the control of a remote TCP/IP client. The client could be a simple command line interface or a rich-featured program. Keysight provides a sample client source code for integrating RCMI into proprietary applications to develop specific clients.

Test Case Automation Tools

S8704A Protocol Conformance Toolset has an in-built automation feature, which removes the need for a human operator to respond to test case-initiated requests thereby simplifying and speeding up test case execution. Requests are instead sent to Keysight's automation application, Terminal Automation Gateway (TAG). Alternatively, users are able to use a customised automation application.

Test case automation can be enabled by configuring some options in the Settings tab, see Figure 8.
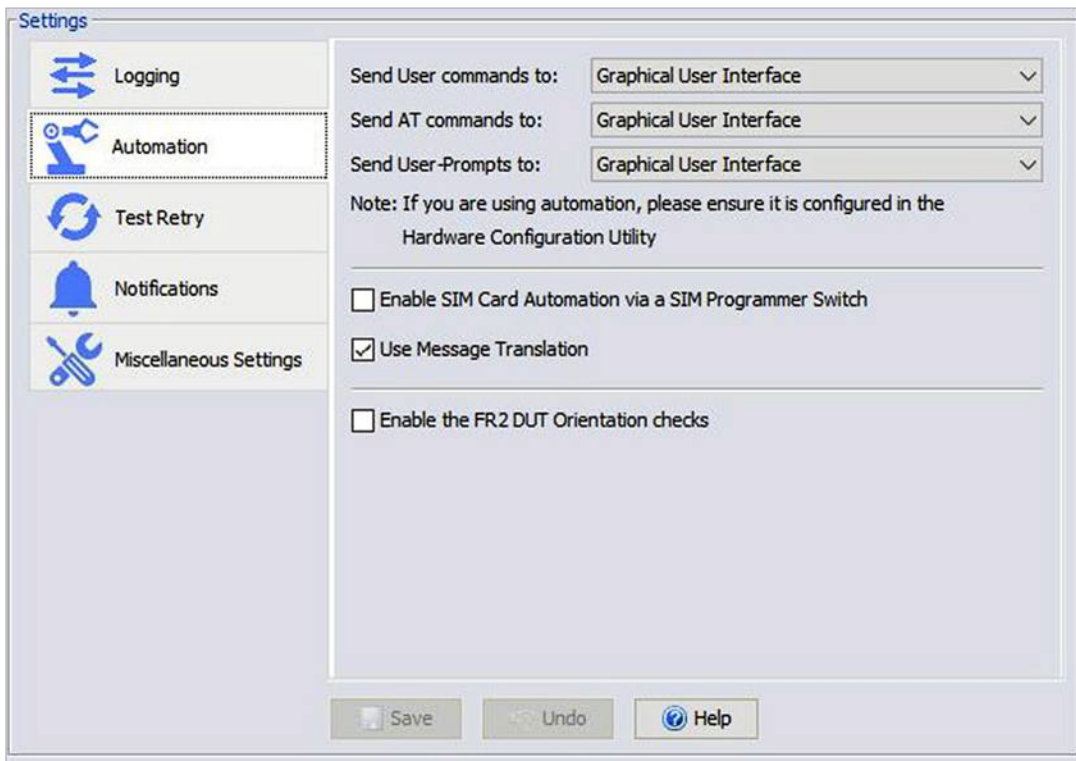

Figure 8: Automation settings

SIM Programmer Switch

Keysight's SIM Programmer Switch enables users to automate the programming of SIM cards for running test cases with different SIM card requirements in the same campaign.

Flexible Licensing Options

Keysight offers a wide range of license types and terms to fit into your testing needs, allowing cost-effective use of assets:

License type	Description
Node locked	License may be used on one specified PC/instrument
Transportable	License may be used on one PC/instrument at a time but may be manually transferred to another via the Keysight Software Manager website
Floating	Networked instruments/computers can access a license from a server one at a time
• Floating single site	License server is based within 1 mile radius from the instrument/computer
• Floating single region	License server is based in the same region as the instrument/computer eg. Americas, Europe and Asia
• Floating worldwide	License server can be based anywhere in the world -export restrictions identified in End User License Agreement (EULA)

License terms	Description
Perpetual	Perpetual licenses can be used indefinitely
Subscription based	Temporary licenses can be used for a limited duration of 6, 12, 24, or 36 months

Hardware Platform

The S8704A Protocol Conformance Toolset uses the Keysight E7515B UXM 5G Wireless Test Platform to flexibly address a wide range of requirements and support a comprehensive set of 5G protocol conformance test cases in FR1 and FR2 for both 5G non-standalone (NSA) and standalone (SA) modes. It also supports a comprehensive set of 5G USIM/USAT, IMS, LBS, LTE and C-V2X protocol test cases.

The UXM 5G integrates seamlessly with a Keysight E7770A Common Interface Unit and Keysight M1740A mmWave dual-band (28/39 GHz) Transceivers, and an Over-the-Air (OTA) test chamber to support an extended range of FR2 test cases.

In order to perform C-V2X testing an MXG N5181B must be added to the hardware configuration. This will simulate the GNSS signal.

**Test System PC
(C8801A)**

**1Gb Switch
(C8803A)**

**UXM 5G
(E7515B)**

For FR1 (sub6GHz) Testing

+

**Common Interface Unit
(E7770A)**

**Remote Radio Heads
(M1740A)**

**2D MPAC
(Z2160A-1A5)**

For FR2 (mmWave) Testing

+

**MXG
(N5182B)**

For C-V2X Testing

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