

P8820S RU Testing Toolset

Solutions for Radio Unit Testing



Role of Radio Units in Open RAN Networks

Open RAN (Open Radio Access Network / O-RAN) is an approach to building RANs using open and interoperable interfaces, allowing components from different vendors to work together providing following flexibility for the network providers and operators.

Open Radio Unit (O-RU) plays a critical role as one of the main building blocks of O-RAN network. The O-RU handles Radio Frequency (RF) processing and Digital Front-End (DFE) functions performing tasks like transmitting and receiving radio signals between User Equipment's (UEs), digital beamforming, and converting signals between analog and digital formats.

O-RUs are connected to the Open Distributed Unit (O-DU) via open Fronthaul Interface over eCPRI (enhanced CPRI). This interface enables vendor interoperability, a cornerstone of Open RAN.

Open RAN RUs are **scalable** based on network load and coverage needs, optionally supporting **massive MIMO** and **beamforming** to improve spectral efficiency and user experience.

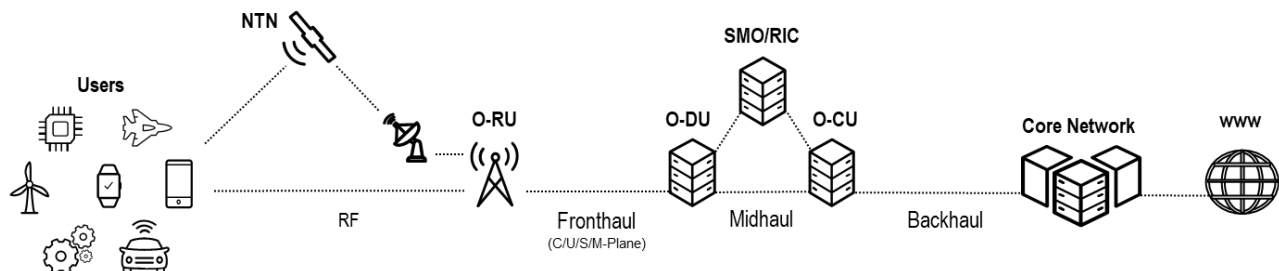


Figure 1. O-RAN architecture for Terrestrial and Non-Terrestrial networks

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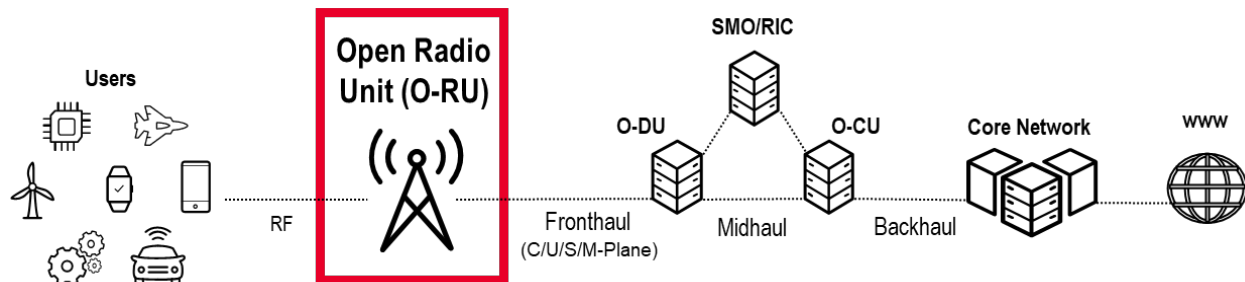
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Challenges in Radio Unit Testing Workflow



Testing an Open RAN Radio Unit (O-RU) presents several unique challenges due to the disaggregated and multi-vendor nature of the Open RAN architecture.

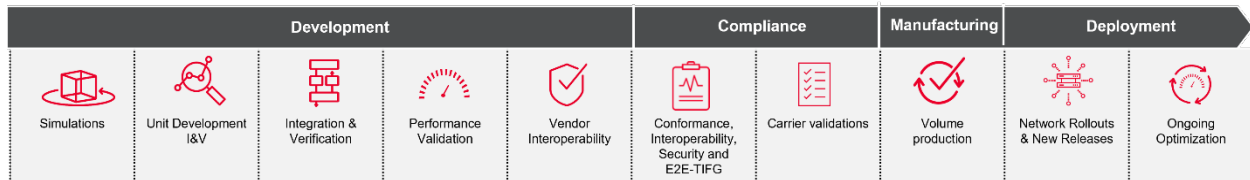


Figure 2. Example of Radio Unit development workflow

Development phase



Development phase includes various steps where each of them introduces their own challenges. Some of the key challenges which are shared across the steps:

RF testing and calibration

- Includes antenna calibration, transmit power accuracy, EVM (Error Vector Magnitude), ACL (Adjacent Channel Leakage), etc.
- Testing RUs with **massive MIMO** arrays is particularly challenging due to the complexity of beam patterns and spatial diversity.

Feature verification

- Test radio unit with different combinations of section types and section extensions to validate the implementation of O-RAN features.
- Critical relationship between RF, timing and fronthaul protocol.
- Visibility into the fronthaul protocol exchange as well as RF signal is required for accelerating the feature development and validation.

Performance validation

- Ensure Latency, Throughput, mMIMO and Beamforming accuracy and efficiency expectations are met.

Timing and synchronization

- TDD and beamforming RUs need **precise synchronization** using protocols like **IEEE 1588v2 (PTP)** or **SyncE**.
 - Testing tools must simulate timing inaccuracies, jitter, and delay to evaluate RU stability.

Compliance phase



In compliance phase components need to be validated to meet the industry standards. For this type of testing, automation is crucial to be able to run the tests according to test specifications published by standard organizations such as 3GPP, ETSI and O-RAN Alliance.

- How to ensure O-RU fulfills O-RAN conformance specifications.
- How to ensure O-RU fulfills 3GPP RF conformance specifications.
- How to ensure O-RU meets carrier expectations.
- How to characterize and optimize energy efficiency of O-RU.
- How to assess and improve O-RU response to security threats like DoS.

Manufacturing



For the manufacturing testing phase capability for volume testing is the key, not to forget accuracy and reliability where calibration plays the key role. Optimization of test time is crucial as slower test cycles reduce overall production throughput, hence increasing overall costs.

Therefore, manufacturing testing facing these challenges.

- How to reuse the test vectors and test configurations in R&D test to reduce the complexity.
- How to test multiple radio units in parallel to increase test efficiency.
- How to use automation to increase test efficiency and accuracy.
- Use low-cost hardware to reduce the TCO of test line.

P8820S Radio Unit Testing Toolset

Leader in
development
and compliance
testing.

Solution for
manufacturing
solution, see
P8821S.



Figure 3. P8820S Radio Unit testing toolset

P8820S RU Testing Toolset is a scalable solution designed to meet evolving O-RU testing needs, supporting C/U/S/M-planes and ensuring comprehensive mMIMO testing capabilities.

P8820S Radio Unit testing toolset (RU toolset) solutions for O-RU testing enable Network Equipment Manufacturers (NEMs) and OTIC labs to validate the functionality, protocol conformance, performance, energy efficiency and security of radio units by emulating and measuring network traffic over both radio and O-RAN fronthaul interfaces. Solution is designed to meet the range of requirements

Key features

- Support and follow the latest O-RAN Alliance WG4 CUS plane and M Plane specifications.
- Support for O-RAN fronthaul Control, User, Sync and Management (CUSM) Plane Testing towards O-RU under test.
- Massive MIMO (mMIMO) testing up to 64TRx, including O-RAN ALLIANCE WG4 uplink performance improvement (ULPI)
- Comprehensive support for different types of O-RU.
 - FR1 & FR2
 - TDD & FDD
 - 5GNR & LTE & DSS
 - Cat-A & Cat-B (including ULPI)
- Support various fronthaul e-CPRI link speeds: 10GE/25GE/50GE/100GE.
- Decodes and visualizes the O-RAN protocol information and enables measurement in both protocol and RF domains.
- O-RAN compliance test case batches running on Atlas test management center provide standard O-RU standalone test cases according to O-RAN, 3GPP and ETSI specifications. Pre-canned test cases will be executed in an accurate and consistent way by controlling and orchestrating all test equipment with test automation. Test reports can be generated automatically according to test specifications.

Leader in
Massive MIMO
Testing.

Who benefits from this solution?

- O-RU equipment and chipset vendors
- Mobile network operators
- System integrators
- Open Test and Integration Centres (OTIC)

Solution components

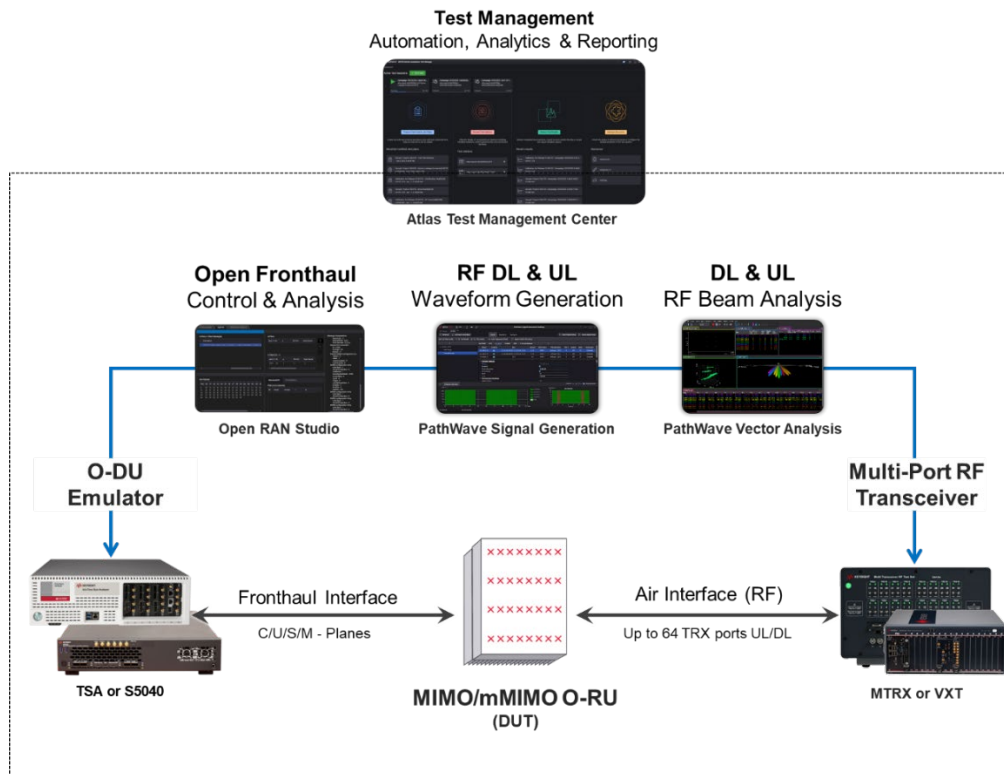
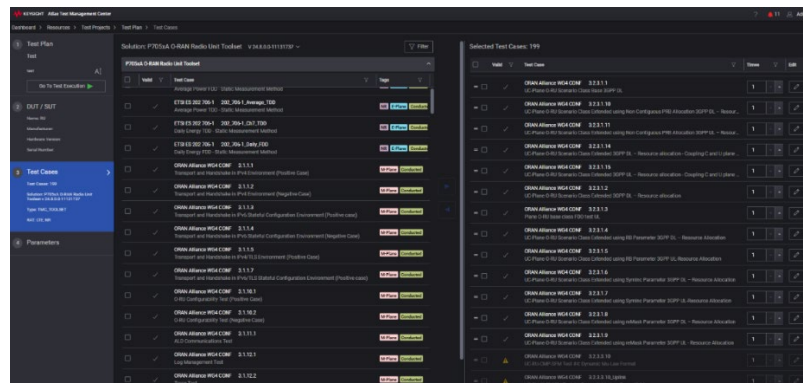


Figure 4. P8820S RU Testing Toolset Overview

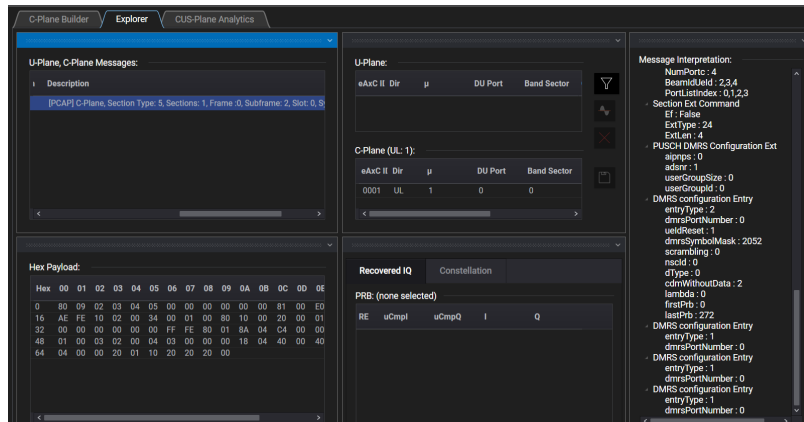
Software components

- **Atlas Test Management Center (Atlas-TMC)**
 - Web-based user interface for test automation, analytics and reporting.
 - O-RAN WG4 compliance O-RU test batch enable users to perform test cases according to O-RAN Alliance and 3GPP specifications.
 - O-RU Energy Efficiency test batch provides O-RU Energy efficiency measurement according ETSI specification.
 - O-RAN security test batch containing O-RU centric test cases provide an automated approach to validate O-RU security capability according to O-RAN and 3GPP test specifications.



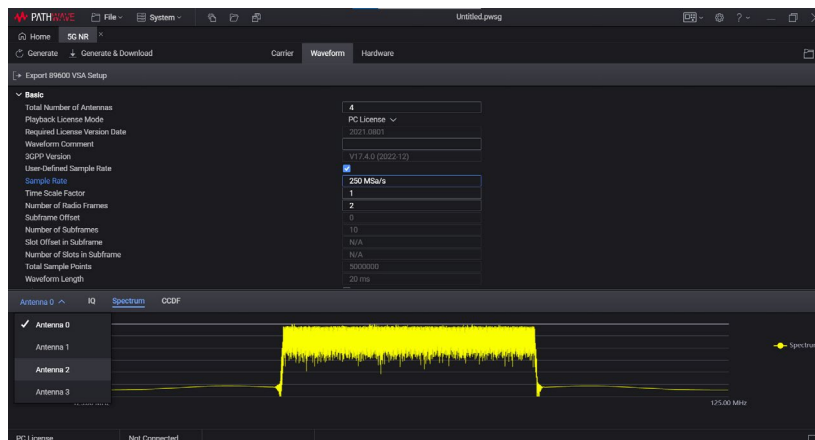
- **Open RAN Studio software**

- Keysight Open RAN Studio tests O-RAN Radio Units (O-RU) and chipsets with O-RAN option 7.2 split compliant CUSM_plane stimulus generation and analysis. Open RAN Studio emulates a Distributed Unit (O-DU), enabling users to generate test vectors against a DUT, captures O-RAN uplink communications and perform the measurements necessary to validate an O-RU's functional operation and performance.
- Open RAN Studio is a flexible and easy-to-use tool which enables users to run tests against O-RU in a manual way.



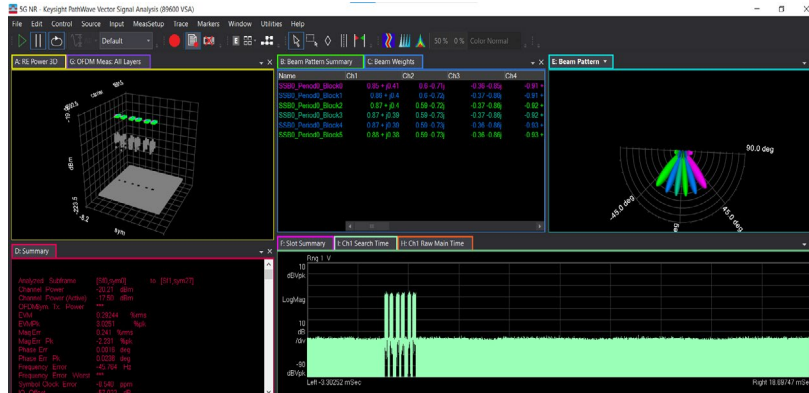
- **Pathwave Signal Generation software**

- The software is a flexible signal creation tool that helps significantly reduce the time spent on signal simulation. Quickly and easily generate 5G NR or LTE signals for component, transmitter and receiver test.



- **Pathwave Vector Analysis software**

- The software provides frequency-, time-, and modulation-domain analysis results in a single measurement. By configuring result traces of spectrum, acquisition time, and NR specific modulation quality traces and tables, engineers can identify overall signal & beam characteristics and troubleshoot intermittent error peaks or repeated synchronization failures.



Hardware components

• O-DU Emulator options

- S5040A Open RAN Studio Player and Capture Appliance
 - Designed for LTE and 5G O-RAN Radio Unit (O-RU) testing, Keysight S5040A Open RAN Studio Player and Capture Appliance is a Windows® 10/11 Pro Workstation based operating system 1RU server and FPGA hardware accelerated Ethernet acquisition, timing, and triggering hardware.



Optimized for MIMO radio development and manufacturing testing.

- 941-0120 Time Sync Analyzer Appliance
 - The Keysight Time Sync Analyzer (TSA) is a high-performance O-RAN DU emulator and a Time Sync Tester. Time Sync Analyzer is available as a factory-assembled modular appliance with flexible configuration options. It includes one timing card, providing reference clock input/output, and up to three ethernet line cards offering 50 Gbps to 600 Gbps CU traffic throughput for O-RU testing, and multiple clock quality measurement lines for clock quality testing.



For Massive MIMO and C/U/M/S -plane testing.

• RF Instrument options

- E6416A/E6464A Multi Transceiver RF test set – For MIMO/mMIMO
 - MTRX is a scalable RF test platform hardware that provides 4 or up to 64 Vector Signal Analyzer (VSA) and 4 or up to 64 Vector Signal Generators (VSG) in one instrument with an advanced digital MIMO and massive MIMO signal weighting matrix. Its capability of Phase and time coherent multi-channel RF measurements enables fast and accurate MIMO and massive MIMO RF beamforming measurement and analysis



**From SISO to Massive
MIMO testing up to 64TRx.**

- VXT RF Vector Transceiver Platforms
 - PXI bases chassis with integrated vector signal generator and vector signal analyzer per module.
 - Support multi-channel measurement
 - Extensive support for FR2 bands



For SISO and MIMO testing.

Key Use Case Examples

- Manual R&D development for C/U/S/M -plane
- mMIMO beamforming validation
- Automated O-RAN WG4 conformance testing
- Automated 3GPP 38.141 RF pre-conformance testing
- Automated O-RU energy efficiency testing
- Automated O-RAN WG11 and 3GPP 33.117 security testing

Manual R&D development for C/U/S/M -plane

Open RAN Studio provides a test environment that integrates with the tools, in both RF and Protocol Domains, to help you completely exercise an O-RAN CUSM compliant Radio Unit (O-RU).

To ensure measurement consistency between both RF and Baseband sides of the O-RU, Open RAN Studio software leverages the same industry leading 5G & LTE signal generation and measurement science used in Keysight spectrum analyzers and signal sources. This tight coupling ensures CU_plane messages and baseband information match exactly with the signals captured on the RF side of the Radio Unit.

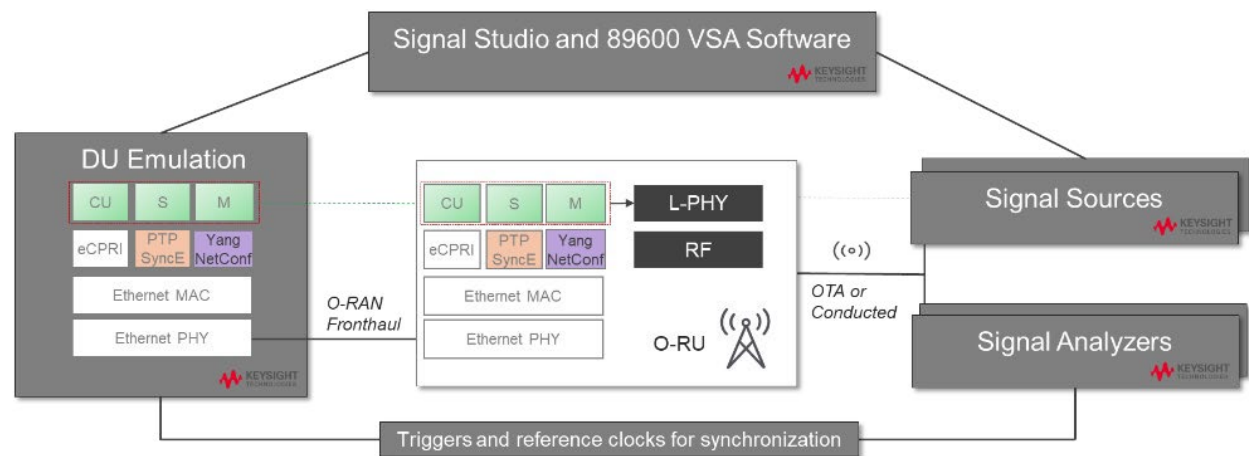


Figure 5. Manual R&D development and verification

Massive MIMO (mMIMO) beamforming validation

As shown in Figure 7, on the left side, Open RAN Studio software, running in O-DU emulator (Time Sync Analyzer or S5040A), includes powerful O-RAN focused tools to construct, play, capture, and measure O-RAN traffic over 10 Gbps/25 Gbps (fronthaul) Ethernet interfaces. Out of the box integration with Keysight's industry PathWave Signal Generation and 89600 VSA software enables sophisticated 5G NR and LTE signal creation and easy capture, extraction, and export of IQ vectors – for advanced modulation analysis of received RF and radio performance.

Combined with Keysight Vector Signal Analyzer (VSA) and PathWave Signal Generation Software (PWSG) running inside the Multi Transceiver RF Test Set (MTRX) on the right side, the integrated Open RAN Studio solution delivers the most comprehensive cross domain, multi-channel RF and O-RAN protocol measurements available in the industry, for both Downlink (DL) and Uplink (UL) paths. P8820S RU Toolset provides the solution to cover the needs for mMIMO testing, in different phases of the product development workflow. Solution supports massive MIMO beamforming including also ULPI with O-RU up to 64T64R, with the possibility to aggregate more units to test wider O-RU panels and multiple MU-MIMO carriers.

P8820S RU toolset can support all beamforming methods defined in O-RAN.WG4.CUS specification for both Uplink and Downlink test:

- Predefined-Beam Beamforming (PDBF)
- Weight-based Dynamic Beamforming (WDBF)
- Attribute-based Dynamic Beamforming (ABBF)
- Channel-Information-based Beamforming (CIBF)
- DMRS based beamforming (ULPI)

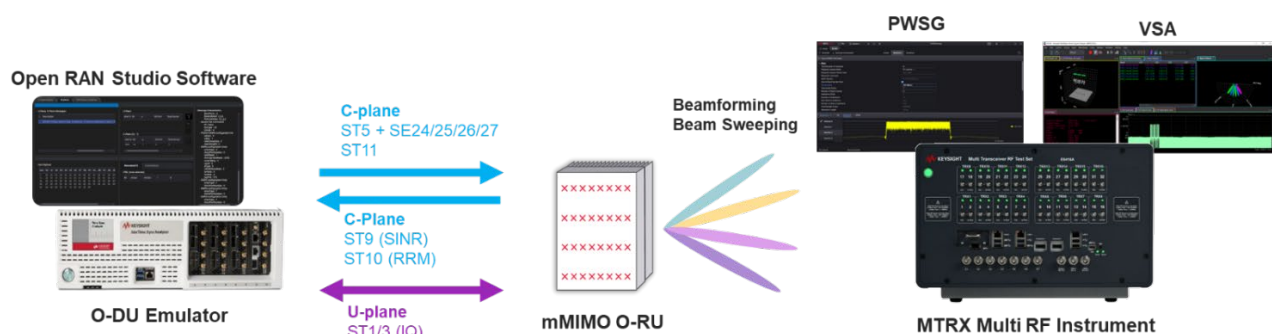


Figure 6. Test Setup for ULPI capable mMIMO O-RU

Read more about this topic from [Keysight Open RAN mMIMO ULPI Capable RU Testing](#).

Automated O-RAN WG4 conformance testing

Keysight O-RAN Compliance Test Cases Portfolio offers comprehensive test coverage for scenarios defined by the O-RAN Alliance.

The Keysight P705xA O-RAN Radio Unit Test Automation Solution is an integrated software package for automated conformance testing of an O-RAN Radio Unit (O-RU) according to O-RAN. WG4. Conformance test specification.

This solution operates in combination with the Atlas Test Management Center software environment, a test sequencer software with timing analyzer, result viewer, and other useful tools for test automation development.

The P705xA O-RAN Radio Unit Test Automation Solution integrates measurements within a range of technical disciplines, including network protocols, baseband and RF measurements, along with instruments and device control, system design and calibration, and technical standards expertise, to help exercise and validate an O-RAN CUSM compliant Radio Unit (O-RU).

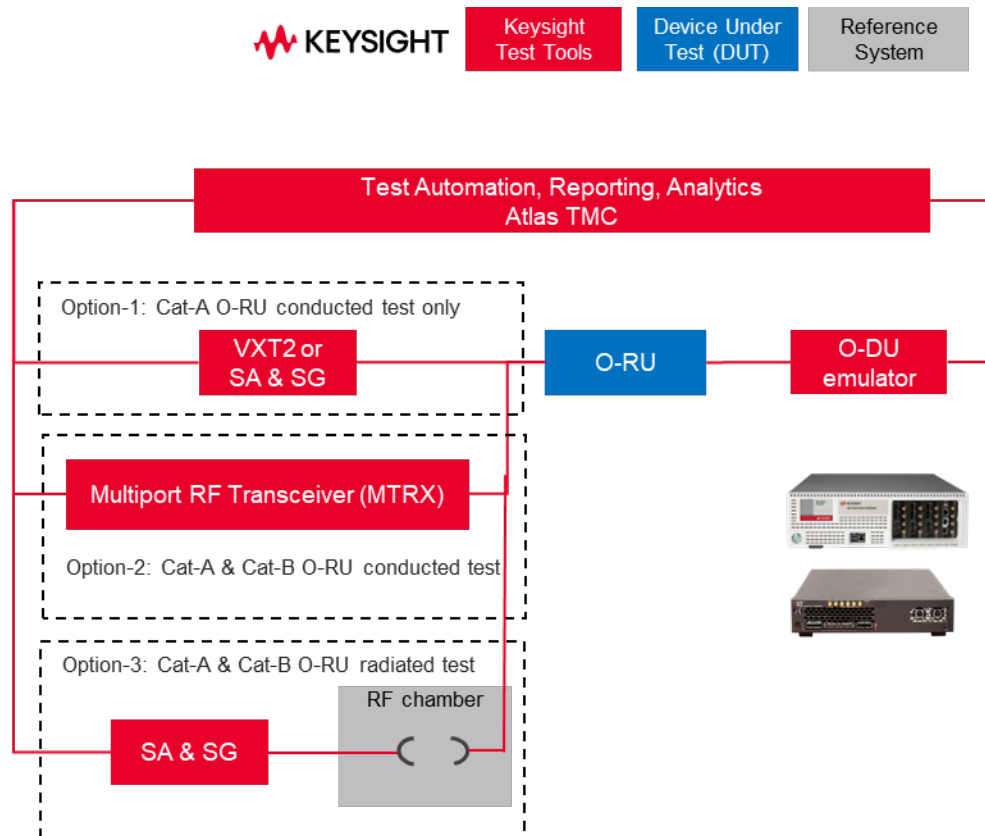


Figure 7. Keysight Atlas Test Management Center (Atlas-TMC) orchestrates the O-RU Conformance test setup

Read more about this topic from [Keysight Open RAN compliance test cases](#).

Automated 3GPP 38.141 RF pre-conformance testing

With similar hardware setup as O-RAN Radio Unit Conformance test, O-RU can also be tested to validate its compliance to 3GPP 38.141 RF Conformance test specification.

Orchestrated by PathWave KS8400 Test Automation, Open RAN Studio software running in S5040A or Time Sync Analyzer can act as O-DU and transmit stimulus to O-RU and put it in certain 3GPP test mode. Thousands of measurements as needed for each test case, (eg: TRP, ALCR, Intermodulation, Frequency, Beam Declarations, Polarization, etc...) can be measured by the RF Instruments used in the test, test automation will collect all these measurements and verdict the pass/fail of each test case while test report can be automatically generated.

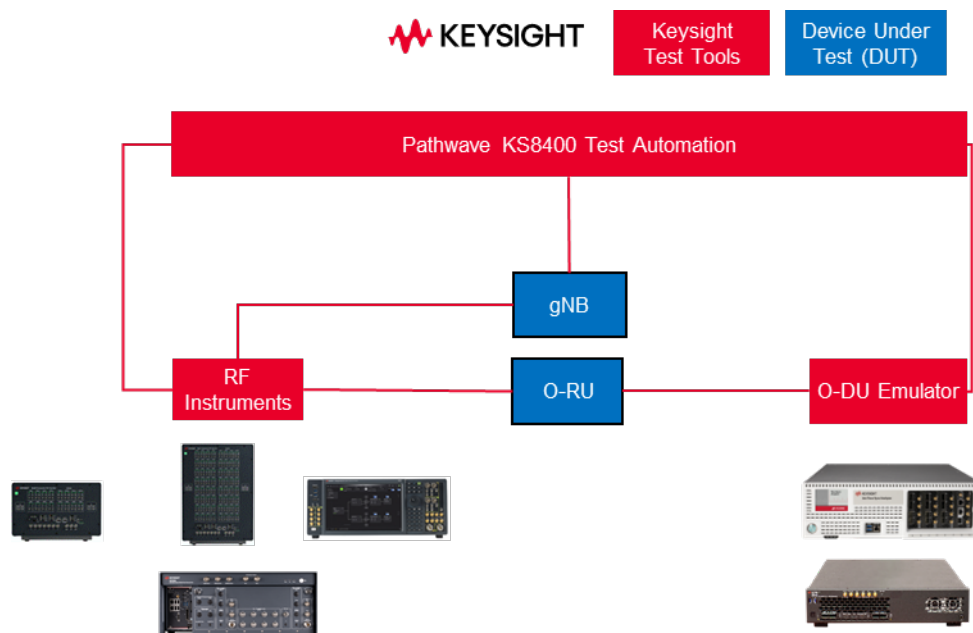


Figure 8. 3GPP 38.141 RF pre-conformance test setup for O-RU & gNB

Read more about this topic from [Keysight Open RAN compliance test cases](#).

Automated O-RU energy efficiency testing

The O-RU E-Plane ETSI Test Suites measure Energy Consumption (EC) and Energy Efficiency (EE) in O-RU based on ETSI standards. Energy efficiency testing combines power measurement with protocol and RF domains, requiring a cross-domain measurement system and cross-correlation of the data to gain meaningful insights into the overall energy performance of the RAN components.

Orchestrated by Atlas Test Management Center, Open RAN Studio software running in S5040A or Time Sync Analyzer can act as O-DU and transmit stimulus to O-RU and put it into different load levels defined by ETSI 202 706 specification. Meanwhile, power consumption of the O-RU can be characterized as well as the RF performance, so that it can be validated the energy efficiency is not achieved in the sacrifice of

RF performance. It is also possible to test O-RU using this test suite while different energy saving techniques are turned on vs. off, so that we can benchmark and quantify the gain in energy efficiency brought by energy saving techniques.

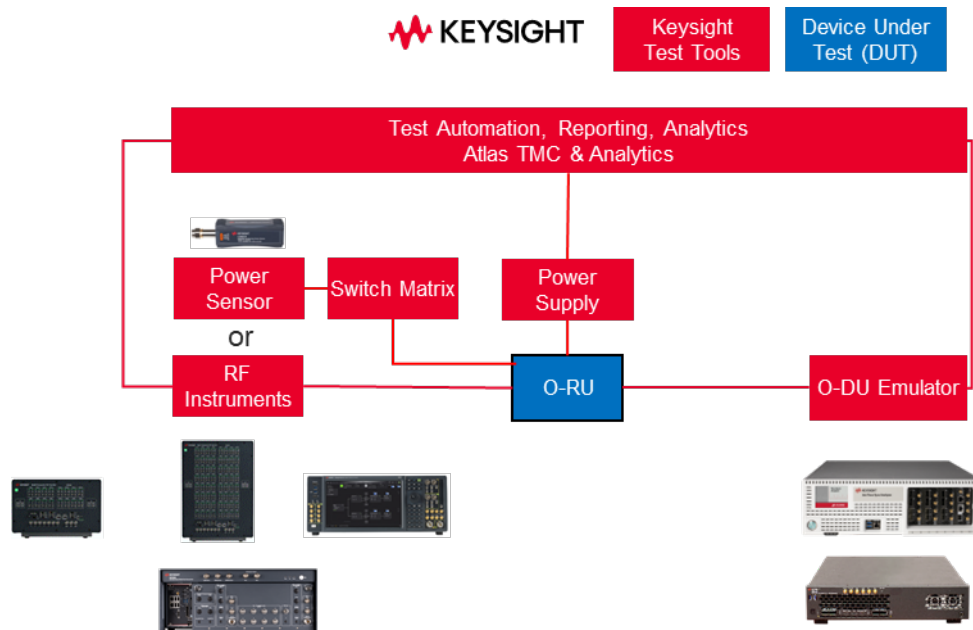


Figure 11. O-RU energy efficiency test setup

Read more about this topic from [Energy Plane \(E-Plane\) Test Suites for RAN/vRAN/O-RAN – Technical Overview](#).

Automated O-RAN WG11 and 3GPP 33.117 security testing

Keysight 5G and O-RAN security test suite consists of Keysight's state-of-the-art test solutions widely adopted by leading operators, vendors, and system integrators supporting functional, performance and deployment readiness with real world test scenarios. It includes O-RAN WG11 and 3GPP 33.117 security test cases against O-RU. It supports simulating real world threat attacks scenarios and performing extensive scan and audit functions required for commercial networks deployment readiness testing from the functional, performance and DevSecOps perspectives.

With Atlas test management center, minimum learning curve and no extensive security/security test knowledge is required to run these test cases.

Read more about this topic from [Keysight Open RAN compliance test cases](#).

Flexible Licensing Options

Keysight offers a wide range of license types and terms for meeting your testing needs, allowing cost effective use of assets.

License type	Description
Node locked	Allows you to use the license on one specified instrument/computer.
Transportable	Allows you to use the license on one instrument or computer at a time. This license may be transferred to another instrument or computer using Keysight's online tool.
USB portable	Allows you to move the license from one instrument/computer to another by end-user only with certified USB dongle, which is purchased separately.
Network floating (multiple PCs)	Allows you to access the license on networked instruments/computers from a server, one at a time. For concurrent access, multiple licenses may be purchased. Three types of floating licenses are available: Single Site: 1-mile radius from the server; Single Region: Americas; Europe; Asia, Worldwide: export restriction identified in End User License Agreement (EULA)

License type	Description
Perpetual	Software license can be used in perpetuity.
Subscription based	Software license is available for the length of the subscription.

Further Resources

- [P8820S RU Testing Toolset](#)
- [U5040BSCB Open RAN Studio for O-RU Testing and Validation](#)
- [Keysight Open RAN compliance test cases brochure](#)
- [Vector RF Transceivers](#)
- [E6414A/E6464A Multiport RF Transceivers](#)
- [S5040A Open RAN Studio Player and Capture Appliance](#)
- [921-0120 Time Sync Analyzer Appliance](#)
- [P7000A Base Station Measurement Automation Solution](#)
- [Radio Access and Core Network Test](#)

Related Solutions

- [P8800S UeSIM RAN Testing Toolset](#)
- [P8822S RuSIM – UE / O-RU Emulation Over the O-RAN Fronthaul](#)
- [P8827S CuSIM – O-DU Midhaul Solutions](#)
- [P8826S DuSIM – O-CU Midhaul Solutions](#)
- [P8828S RICtest — RAN Intelligent Controller Test Solutions](#)
- [P8900S LoadCore – Core Network Solutions](#)
- [SJ001A WaveJudge Wireless Analyzer Toolset](#)
- [PROPSIM Channel Emulator Platforms](#)
- [S9160A Massive MIMO and MIMO RF Beamforming Test Accelerator for 5G](#)

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