U5040BSCB Open RAN Studio Software

Open RAN studio for 5G & LTE O-RAN
Radio Unit (O-RU) testing and validation

KEYSIGHT

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Introduction

O-RAN is an effort to transform the cellular Radio Access Network (RAN) towards open, intelligent, virtualized, and fully interoperable RAN.

The RAN is disaggregated into:

- The Radio Unit (O-RU)
- The Distributed Unit (O-DU)
- The Centralized Unit (O-CU)

The interface between the O-RU and the O-DU is called the 'Fronthaul' and the interface between O-DU and O-CU is called the 'Midhaul.' Open RAN Studio is designed to test and validate the 'O-RAN Fronthaul' interface and the O-RU.

Open RAN Studio runs on a PC or a specialized hardware platform and tests O-RAN Radio Units (O-RU) and chipsets with O-RAN (ORAN-WG4.CUS.0-v0x.00) 7.2 split (categories A and B) compliant CU-Plane. It generates stimulus in the form of O-CU messages and performs analysis of the response and RF output of the O-RU. Open RAN Studio, along with a specialized hardware platform, emulates a Distributed Unit (O-DU), enabling users to generate test vectors for a DUT, capture O-RAN uplink communications, and perform the measurements necessary to validate an O-RU's functional operation and performance.

Open RAN Studio runs on two specialized hardware platforms that can support different fronthaul data rates.

- **S5040A:** Open RAN Studio Player and Capture Appliance
- **941-0120:** Open RAN Studio Time Sync Analyzer (On a connected Windows machine)
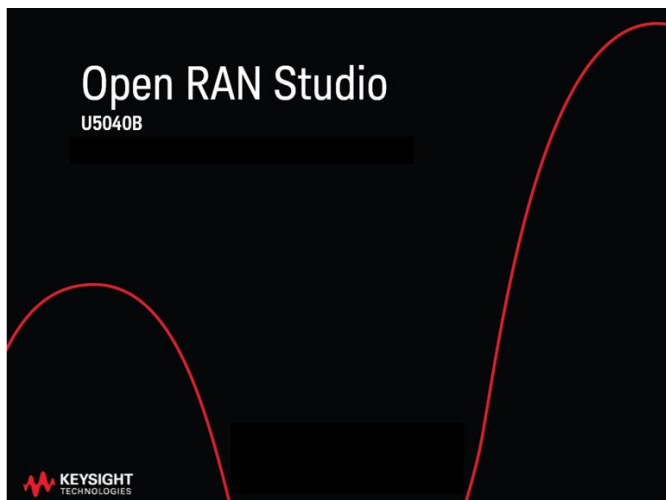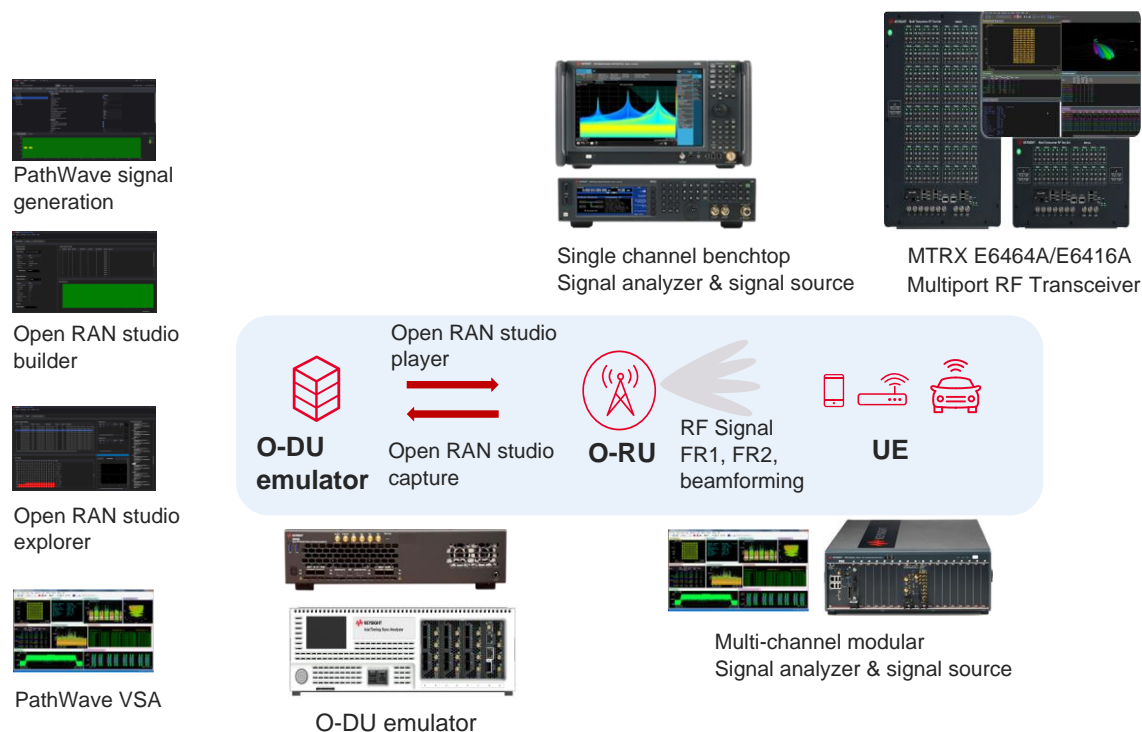
Open RAN Studio — Solution Overview

Designed for 5G O-RAN Radio Unit (O-RU) testing, Open RAN Studio provides powerful, yet easy to use, capabilities to build O-RAN compliant CUSM-Plane test vectors. It runs on specialized hardware platforms, generates the test vectors for an O-RU as the Device Under Test (DUT), captures the O-RU's responses, and performs measurements that are needed to validate that the O-RU meets standards compliant operation.

Open RAN Studio includes powerful tools to construct, play, capture, and measure O-RAN traffic over the eCPRI Fronthaul Ethernet interface. The two hardware platforms support different fronthaul interface speeds and count. Detailed comparison of the two hardware platforms follows later in this solution brief.

Out of the box integration with Keysight's PathWave Signal Generation software and PathWave Vector Signal Analysis (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 / mmWave signals. The integrated Open RAN Studio solution delivers the most comprehensive cross domain, multi-channel RF / mmWave, and O-RAN protocol measurements available in the industry. It covers testing of both FR1 and FR2 radios with base or beamforming, downlink (DL), and uplink (UL) paths.

PathWave signal generation

Open RAN studio builder

Open RAN studio explorer

PathWave VSA

Single channel benchtop
Signal analyzer & signal source

MTRX E6464A/E6416A
Multiport RF Transceiver

Open RAN studio player

O-DU emulator

Open RAN studio capture

O-RU

RF Signal FR1, FR2, beamforming

UE

O-DU emulator

Multi-channel modular
Signal analyzer & signal source

Open RAN Studio Solution Components

The Open RAN Studio based O-RU test solution consists of the following main parts:

- Open RAN Studio Hardware platform
- Software components: Open RAN Studio, PathWave Signal Generation for 5GNR, Signal Studio software for LTE, PathWave Vector Signal Analysis (89600 VSA)
- Signal Generator to act as the uplink source
- Signal Analyzer to analyze the signals transmitted by the O-RU

Open RAN Studio hardware platforms

	S5040A appliance	Time Sync analyzer
General		
Input power	AC 110/230	AC 110/230
Operating system	Windows	Linux
Single / Multi-user	Single user	Multi-user
Power consumption	450 W	1-line card system – Max 380 W, typical 268 W
		2-line card system – Max 540 W, typical 328 W
		3-line card system – Max 700 W, typical 388 W
Rack space	2U	3U
Ethernet		
Management Ethernet	2 x 1 GbE	1 x 1 GbE
Fronthaul Ethernet speeds supported	10 / 25 / 50 GbE	10 / 25 / 100 GbE
Number Ethernet ports	up to 2 ports 10/25 GbE 1 port 50 GbE	up to 6 ports of 25 GbE
Sync-E	Yes	Yes

|	S5040A appliance	Time Sync analyzer
Open RAN Fronthaul Elements		
CU Plane	Yes	Yes
S-Plane	Yes	Yes
M-Plane	Yes	Yes
Clock and synchronization		
Clock	-	Option for Rubidium
Clock reference	-	GNSS, ToD
10MHz & 1PPS input	10 MHz only	10 MHz & 1PPS
8275.1 Master	Yes	Yes
8275.1 Slave	Yes	No

Software components

Open RAN Studio integrates five powerful O-RAN development tools to construct, play, capture, analyze and extract IQ vectors for 7.2 split O-RAN traffic over 10GE or 25 GbE fronthaul Interfaces.

- **Open RAN Studio Builder** helps you easily construct diverse O-RAN test vectors. The PCAP formatted output file includes the complete Ethernet / VLAN / eCPRI / O-RAN stack.
- **Open RAN Studio Player** is a hardware-based exerciser that emulates a DU and generates test vectors to an O-RU / DUT through the O-RAN interface — honoring O-RAN timing windows.
- **Open RAN Studio Capture** is a hardware-based analyzer that captures the bidirectional Tx and Rx information flows between the O-DU and O-RU over the O-RAN interface.
- **Open RAN Studio Explorer** decodes and visualizes the O-RAN protocol information and enables measurement in both protocol and RF / mmWave domains.
- **Open RAN Studio IQ Extractor** is an optional application that reconstructs a time domain IQ file from an O-RAN trace capture for further modulation measurements with PathWave VSA software.
- **Open RAN Studio Fronthaul Analytics** for protocol analysis of captured .PCAP files.
- **PathWave Signal Generation** software is used to create 3GPP compliant 5G NR signals and **Signal Studio software** is used to create LTE signals for emulation through Open RAN Studio to an O-RU / DUT and subsequent transmission to a downstream analyzer, DUT, or compliant UE.
- **PathWave Vector Signal Analysis (89600 VSA)** software for 5G NR may optionally receive captured IQ vectors from Open RAN Studio IQ Extractor to demodulate the 5G NR signal and measure the radio performance.
- **P705xA** O-RAN Radio Unit Test Automation Solution software.

Open RAN Studio

Open RAN Studio provides a test environment that includes tools, in both RF and protocol domains, to completely exercise an O-RAN CUSM-Plane compliant Radio Unit (O-RU).

Open RAN Studio software leverages the same industry leading 5G signal generation and measurement science used in Keysight spectrum analyzers and signal sources. This ensures measurement consistency between both RF and Baseband sides of the O-RU. This tight coupling ensures CU-Plane messages and baseband information match exactly with the signals captured on the RF side of the radio unit.
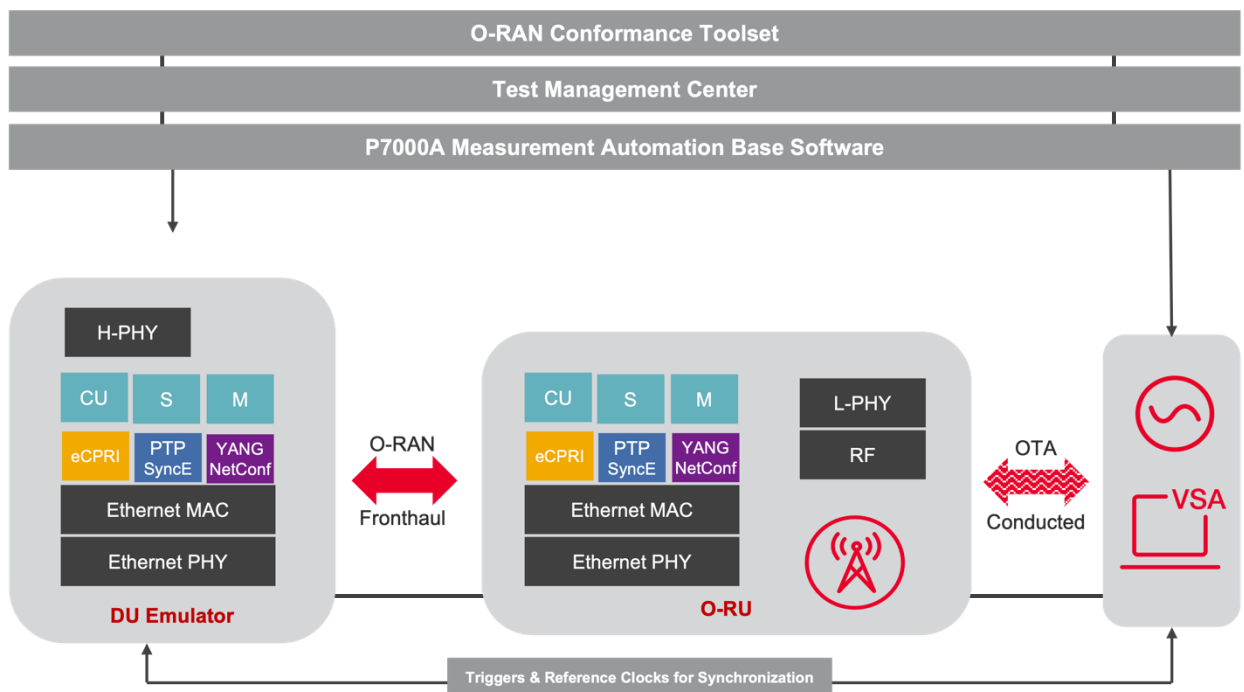
Open RAN Studio Builder

Keysight Open RAN Studio Builder generates quickly and easily, O-RAN test vectors, compliant with the ORAN-WG4 specification. The generated test vectors represent Ethernet based O-RAN messages from an O-DU (Distributed Unit) to the device being tested – the O-RU (Radio Unit).

Open RAN Studio Builder is integrated with Keysight PathWave Signal Generation for 5G NR (N7631ORNC/EMBC) and LTE (N7624ORNC/N7625ORNC) to create 3GPP NR standard-compliant signals and construct the corresponding Ethernet based O-RAN protocol test vectors, including complete and consistent C-Plane and U-Plane messages, ready for playout.
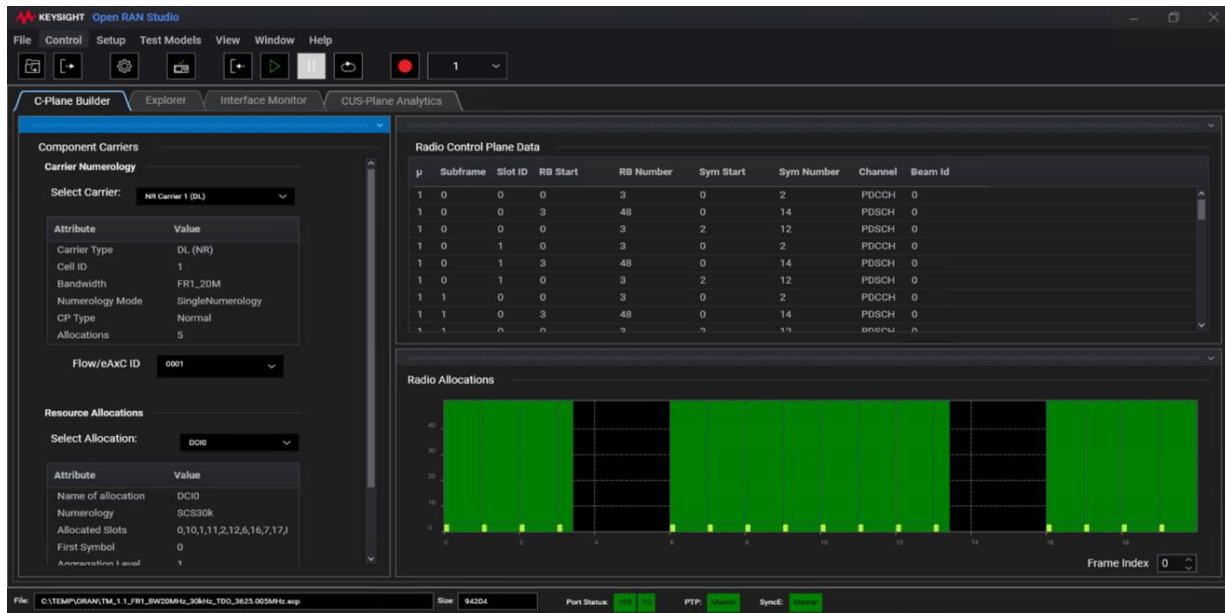
Key features

- Fully automated generation of Ethernet based O-RAN CU-Plane messages with eCPRI transport encapsulation types. (ORAN-WG4.CUS Specification)
- Predefined 3GPP test Patterns
- Downlink stimulus test generation
- Uplink stimulus test generation
- Multi-carrier support (up to 8 carriers)
- Generates a .PCAP based stimulus file for use with Open RAN Studio Player or Explorer

Downlink test vectors include both, O-RAN C-Plane and U-Plane messages. C-Plane messages are constructed to fully represent the allocations defined in the 5G NR signal definition, and the U-Plane include frequency domain IQ for each resource block.

Uplink test vectors only include C-Plane messages, as U-Plane messages will be generated by the DUT. To ensure consistency, the C-Plane messages match with the uplink test signal generated by Keysight Signal Sources.
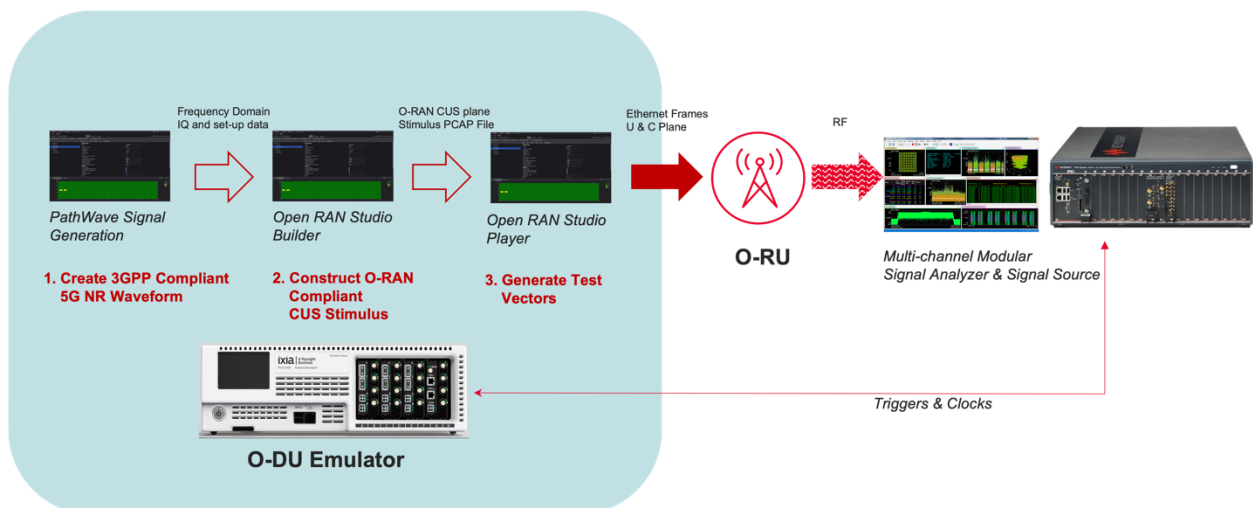
Open RAN Studio Player

The Open RAN Studio Player appliance will playback Open RAN Studio Builder generated stimulus files to an O-RU over an Ethernet based O-RAN interface. The Open RAN Studio Player acts as CUSM emulator (O-DU emulator). The Keysight Open RAN Studio Player application runs on the Keysight S5040A Stimulus Player and Capture Appliance or on Windows 10 PC in case of TSA being the O-DU emulator.

Key features

- Stimulus file player, once or repetitively
- Dynamic Frame Numbering during playout
- Reconfigurable DUT Destination MAC Address
- 10/25/50 Gbps Ethernet interfaces
- SFP or QSFP support (quad QSFP cage)
- 10 frame stimulus memory depth

To ensure Radio configuration and frame synchronization, the Open RAN Studio Player supports M-Plane configuration and S-Plane (acting as a PTP primary or secondary) and ensures that O-RAN messages are played honoring required timing windows.

Downlink Test flow

Open RAN Studio Explorer

Radio Units combine O-RAN protocol operation with RF transmit and receive performance — creating new test challenges. Analysis and validation of O-RU performance requires cross-domain measurements in both RF and Protocol domains.

Open RAN Studio Explorer helps to visualize and fully decode the captured trace and enables IQ extraction, with the optional Open RAN Studio IQ extractor, which enables RF measurements and vector analysis using Keysight 89600 Vector Signal Analyzer (VSA).
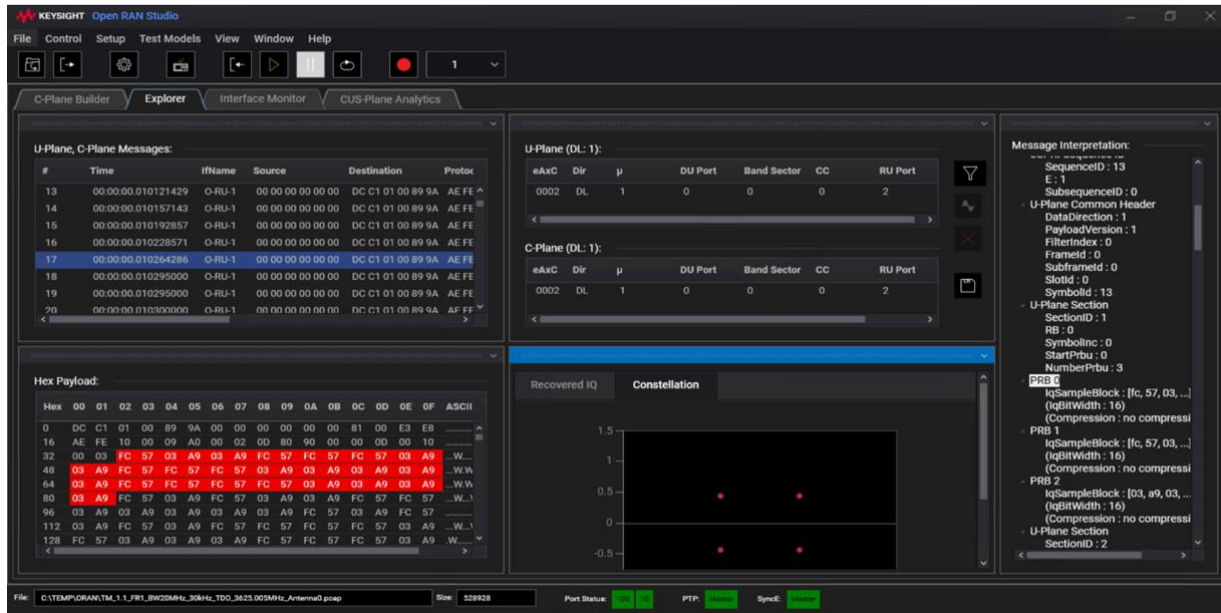
Key features

- Bidirectional display of Tx and Rx messages
- Accurate timestamped traces
- U-Plane and C-Plane message summary
- O-RAN CU-Plane Decoding
- O-RAN Multiple Abstraction level
- Cross referencing between displays
- Flow based Filtering
- Filter traces on a single carrier
- IQ extraction (with optional U5040IQEB)
- IQ information embedded in PRBs can be extracted for RF modulation measurements using the PathWave VSA

IQ features
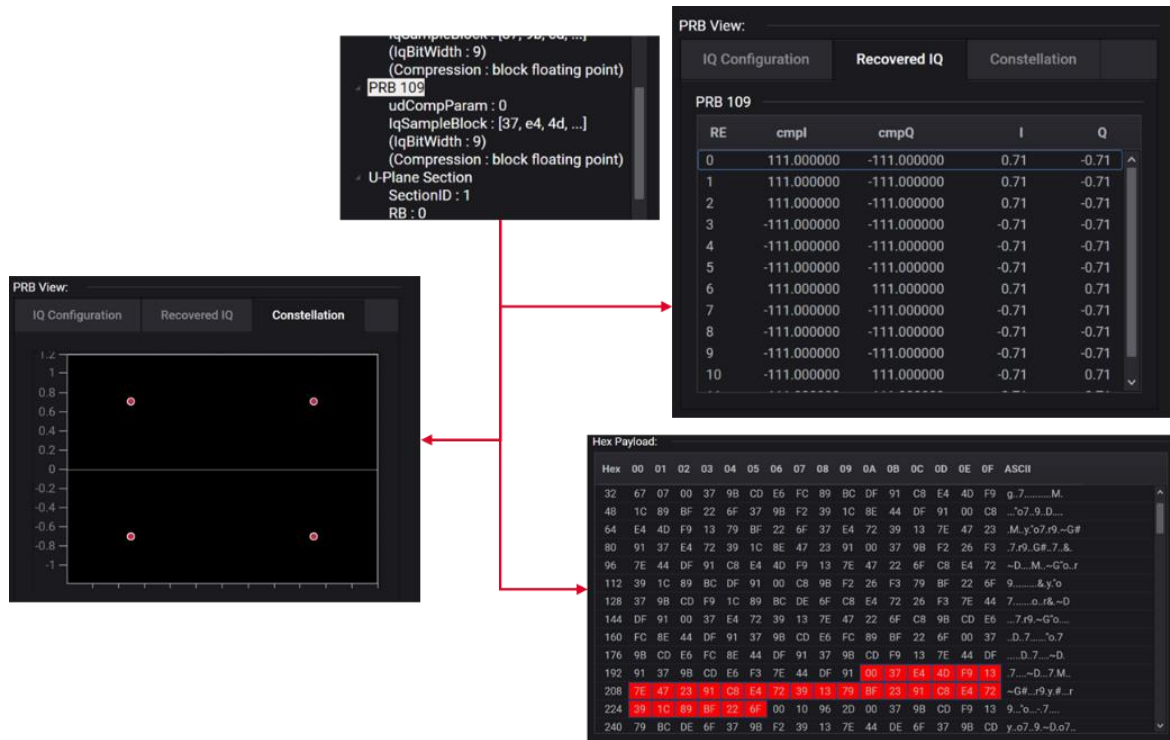
Key features

- Configurable IQ bit width
- Extraction of uncompressed IQ from captures
- Decompression of block floating point compressed IQ
- Decompression of IQ from captures using single dynamic compression methods (udCompHdr)
- PRB view
- Recovered IQ
- Constellation view

Open RAN Studio Capture

The Open RAN Studio Capture application is integrated with the S5040A (Open RAN Studio Player and Capture Appliance) and also the 941-0120 (Time Sync Analyzer). It captures both Tx and Rx information flows between the DUT and O-DU — acting as an embedded protocol analyzer by passively extracting the information flows traveling over the Ethernet based O-RAN interface. Open RAN Studio Capture is transparent to the network. Captured flows are stored in a capture buffer and can be saved as .PCAP compliant files for analysis in Open RAN Explorer or Wireshark.

Key features

- Start/stop capture
- Continuous capture mode until stop (last N frames)
- Full duplex capture capability
- Configurable capture depth in # frames
- Captured data saved in PCAP file format
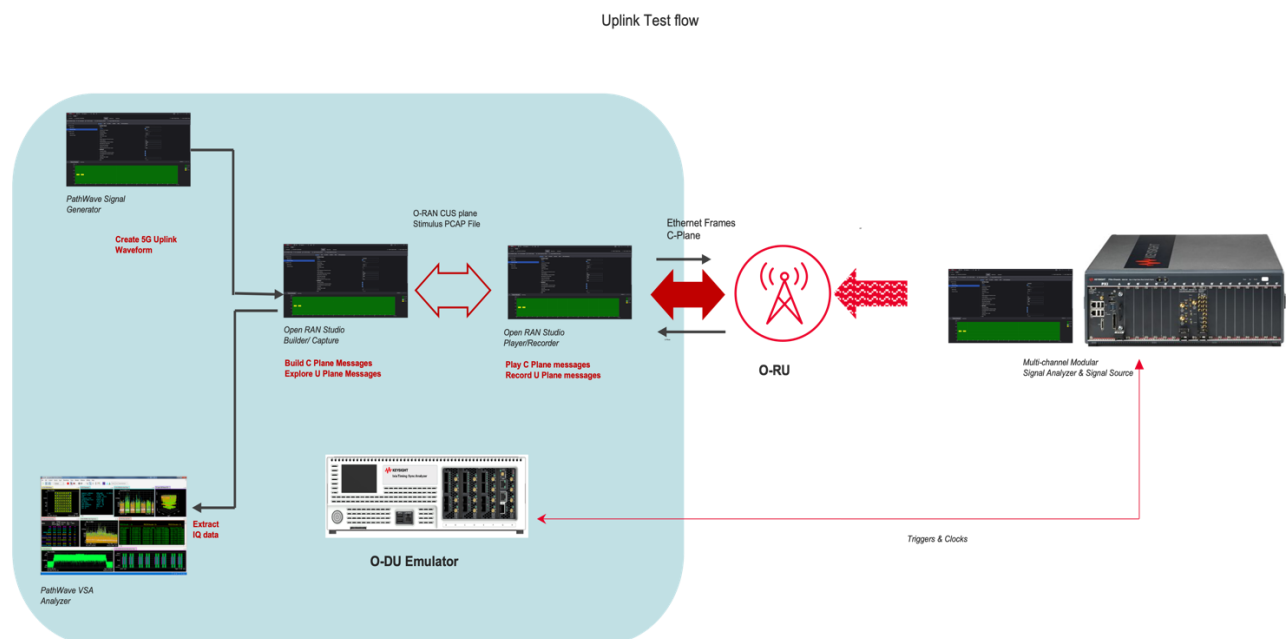
PathWave signal generator

PathWave signal generation for 5G NR and Signal Studio for LTE software are flexible signal creation tools that helps significantly reduce the time spent on signal simulation. The software generates 5G NR or LTE signals. The user-friendly interface lets you configure signal parameters, calculate the resulting waveforms, and download .SCP files — for generation with Open RAN Studio Builder or for analysis using PathWave VSA software.

The licenses required for signal generation are as follows:

| Hardware used	5GNR signal generation	LTE signal generation
S5040A or Time sync analyzer	N7631ORNC	N7624ORNC (FDD) N7625ORNC (TDD)
Signal generator	N7631EMBC	N7624EMBC (FDD) N7625EMBC (TDD)
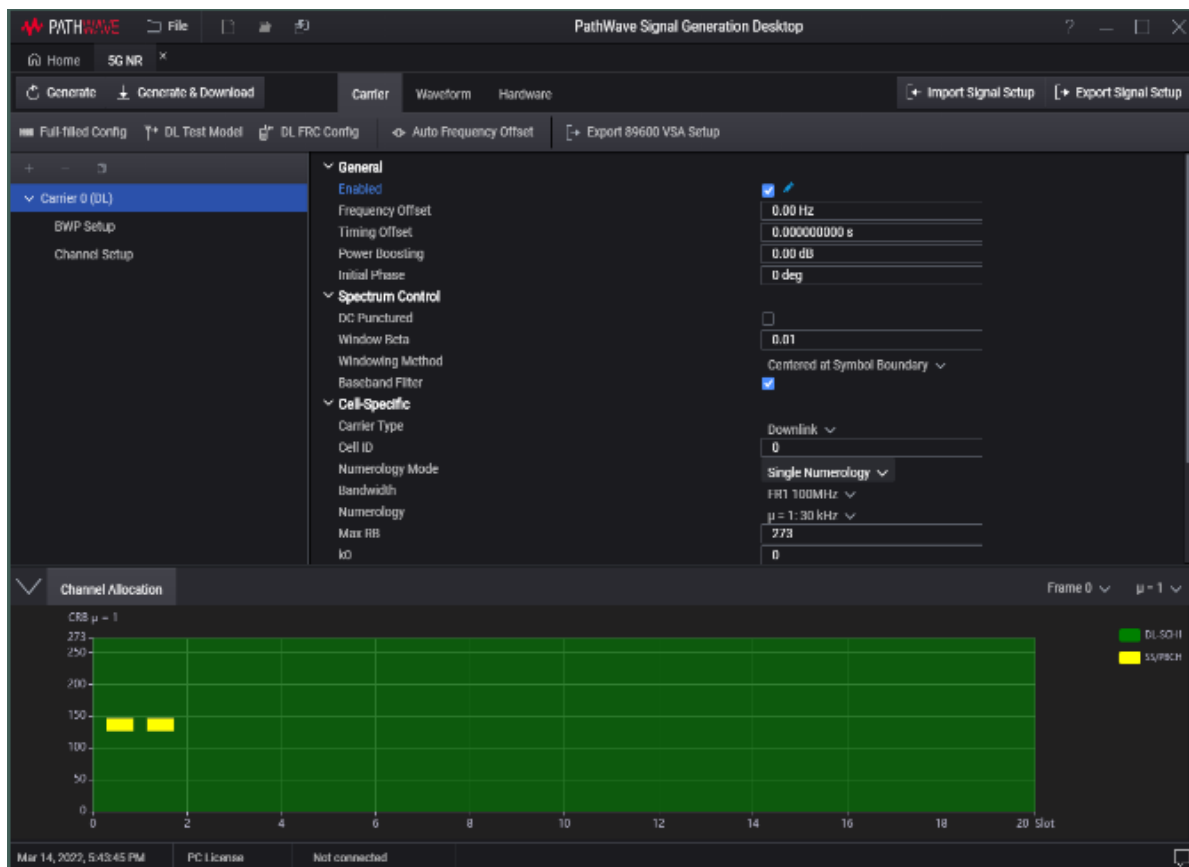
Key features

- Creation of 3GPP 5G NR compliant signal for BTS and UE testing with LDPC and Polar channel coding and multi-antenna port
- Downlink channels for PBCH, PDSCH and PDCCH and uplink channels for PUSCH, PUCCH and PRACH
- Downlink signals for PSS/SSS, CSI-RS, PBCH-DMRS, PDSCH-DMRS, PDSCH-PTRS, PDCCH-DMRS and uplink signals for SRS, PUSCH-DMRS, PUCCH-DMRS and PUCCH-PTRS
- Test model presets for FR1 and FR2
- UL FRC configurations and UL/DL full-filled configurations
- Multiple BWP and mixed numerology in a single carrier
- Multi-user channel generation with PUSCH and PDSCH
- Downlink and uplink configuration with flexible sub-frame allocations
- Flexible signal configuration with both single-carrier and multi-carrier support

PathWave VSA

The PathWave Vector Signal Analysis (89600 VSA) software option BHN provides comprehensive analysis capabilities in the frequency, time, and modulation domains for signals based on both 3GPP's 5G NR specification (www.3gpp.org).
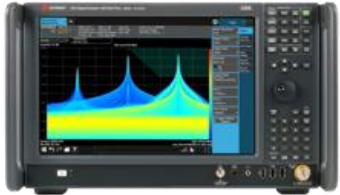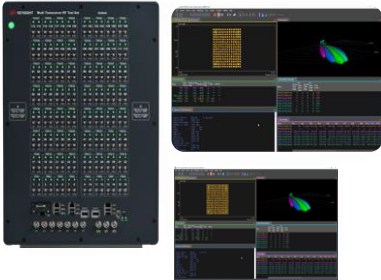
The software provides frequency-, time-, and modulation-domain analysis results in a single measurement. By configuring result traces of spectrum, acquisition time, and NR specific modulation quality traces and tables, engineers can identify overall signal characteristics and troubleshoot intermittent error peaks or repeated synchronization failures.
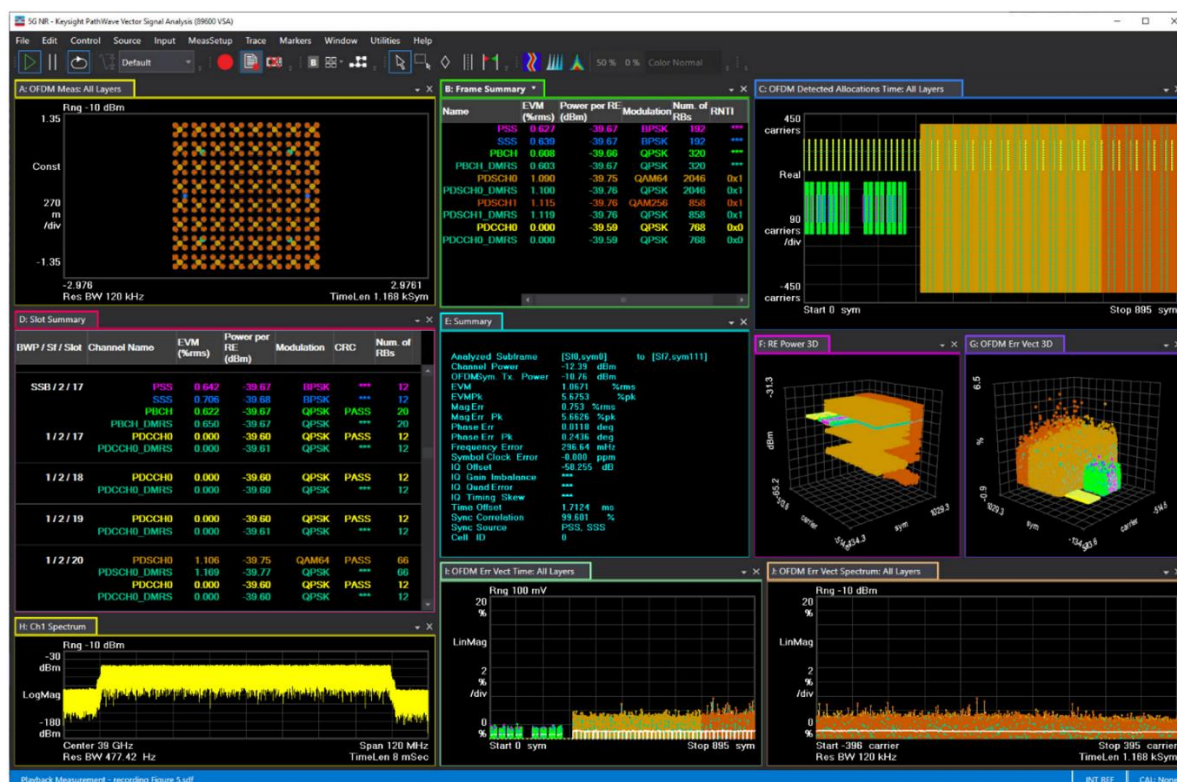
Key features

- Measurements in line with the 3GPP Release 15, Release 16 and Release 17 specifications
- 5G uplink and downlink measurements for FR1 and FR2
- Transport layer decoding with CRC pass/fail results
- Up to 8x8 MIMO for the downlink and 4x4 MIMO for the uplink
- Dynamic Spectrum Sharing (DSS) with simultaneous demodulation of LTE and 5G NR signals
- In-depth analysis and troubleshooting traces, with color coding and marker coupling, and 3D traces for visualization

Signal generator and signal analyzer

Model name		Description
Bench top single channel		X Series signal generators
		X Series signal analyzers
Modular single or multi-channel		PXI RF transceivers 5G NR multi-channel transceivers
Up to 64 x channel		Keysight E6464A Keysight E6416A

Note: For generation of 5G NR Uplink signal, the signal generator requires PathWave Signal Generation software, which can be either N7631EMBC or N7631APPC.

Configure Open RAN Studio

Open RAN Studio is the most comprehensive solution for O-RU Testing.

Software selection (R&D or DVT set-up)

Model number		Description
U5040BSCB	Required	Open RAN Studio Application Suite, includes
		Open RAN Studio Builder
		Open RAN Studio Player
		Open RAN Studio Capture
		Open RAN Studio Explorer
N7046A-001	Optional	Upgrade from single link to dual-link (*Applicable only for S5040A*)
N7631ORNC	Required	PathWave Signal Generation software for 5G NR signal creation (Signal generation for U5040BSCB)
N7624ORNC	Optional	LTE FDD & TDD Signal Generation (Signal generation for O-DU emulator)
N7625ORNC	Optional	LTE FDD & TDD Signal Generation (Signal generation for O-DU emulator)
U5040IQEB	Optional	IQ Extraction Option for Open RAN Studio requires at least one of Pathwave Signal Analyzer options 89601BHNC (5G NR) or 89601BHHC (LTE-TDD) or 89601BHGC (LTE-FDD) for analysis of extracted IQ files
U5040ORAB	Optional	Fronthaul protocol analysis software
U5040SC1B	Optional	This feature enables basic 802.1x authenticator support on the O-DU emulator.
89601200C	Optional	PathWave 89600 VSA Software (Basic vector signal analysis and hardware connectivity)
89601BHNC	Optional	5G New Radio Modulation Analysis for 89600 VSA Software • Requires 89601200C base VSA software • Requires U5040IQEB for IQ extraction from O-RAN packets)
89601BHHC	Optional	LTE Modulation Analysis for 89600 VSA Software • Requires 89601200C base VSA software • Requires U5040IQEB for IQ extraction from O-RAN packets
P705XA	Optional	O-RAN radio unit (O-RU) test automation software (**Needs KS8400A PathWave Test Automation**)
C8700A000	Optional	Test Management Center (Automation platform)

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Software selection (Manufacturing set-up)

Model number		Description
U5040MDLB	Mandatory	Support for Downlink Manufacturing Test
U5040BLRB	Optional	Support for BLER measurement for manufacturing
89601OR1C	Optional	Measurement Option for 5G NR EVM Metric
89601OR2C	Optional	Measurement Option for 5G NR BLER Metric
N7046A-001	Optional	Upgrade from single link to dual-link (*Applicable only for S5040A*)
N7046A-003	Optional	Upgrade from single O-RU to dual O-RU support on fronthaul (*Applicable only for S5040A*)

Hardware selection

S5040A

Model number	Description
S5040A	Open RAN Studio Player and Capture Appliance
941-0120	Open RAN Studio Time Sync Analyzer. For details of hardware configuration, please refer to this

Software licensing

Keysight offers a variety of flexible licensing options to fit your needs and budget. Choose your license term, license type, and KeysightCare software support subscription.

License terms

Perpetual: Perpetual licenses can be used indefinitely.

Time-based: Time-based licenses can only be used through the term of the license (6, 12, 24, or 36 months license options available).

License types

Node-locked: License can be used on one specified instrument/computer.

Transportable: License can be used on one instrument/computer at a time but may be transferred to another using Keysight Software Manager (Internet connection required).

USB Portable: License can be used on one instrument/computer at a time but may be transferred to another using a certified USB dongle (available for additional purchase with Keysight part number E8900-D10).

Floating (single site): Networked instruments/computers can access a license from a server one at a time. Multiple licenses can be purchased for concurrent usage.

KeysightCare software support subscriptions

Perpetual licenses are sold with a 12 (default), 24, 36, or 60-month software support subscription. Support subscriptions can be renewed for a fee after that.

Time-based licenses include a software support subscription through the term of the license.

Selecting your license

1. Choose your software product (for example, U5040BSCB).

2. Choose your license term: perpetual or time-based.

3. Choose your license type: node-locked, transportable, USB portable, or floating.

4. Depending on the license term, choose your support subscription duration.

Open RAN Studio Specifications and Performance Characteristics [1]

Open RAN Builder	Supported standards and performance characteristics
O-RAN specifications version supported	ORAN-WG4.CUS.0-v13.00
Radio type	Categories A and B
Waveform input type	Supports Keysight Signal Studio for LTE and PathWave Signal Generation for 5G NR
Waveform generation	Fully automated generation of Ethernet based O-RAN CU-plane messages with eCPRI transport encapsulation types
	Predefined 3GPP test Patterns
	Downlink stimulus test generation
	Uplink stimulus test generation
Carrier support	Multi-carrier support (up to 8 carriers)
	5G NR + LTE carrier support
Numerology	Single numerology
Bandwidth	Support all 3GPP bandwidth schemes
Sub Carrier Spacing (SCS)	Support all 3GPP Sub Carrier Spacing (SCS) schemes
Configurable eAxC	Parametric bit allocation according to supported specification version
Allocation	Support DL-SCH PRB allocations following Signal Studio configurations and assign section ID for each allocation
	Support DCI Channel PRB allocations following Signal Studio configurations and assign section ID for each allocation
	Support SS/PBCH Channel PRB allocations following Signal Studio configurations and assign section ID for each allocation
	Support UL-SCH PRB allocations following Signal Studio configurations and assign section ID for each allocation
	Configurable eAxC (manual configuration of eAxC bits)
IQ Bit width, Compression, and Scaling	IQ Compression Support: • Uncompressed IQ • Block Floating Point • Block Scaling • μ law • Modulation Compression
	Configurable IQ bit width per eAxC-id
	Single Static compression method per eAxC-id
	Single Dynamic compression methods (udCompHdr) eAxC-id

1. There are no warranted specifications for the Open RAN Studio software applications or third-party hardware appliance.

Open RAN Builder	Supported standards and performance characteristics
Section type	Section type #0 support
	Section type #1 support
	Section type #1 support – numPrBc support for > 255 blocks
	Section type #3 support – PRACH
	Section type #5 support – UE scheduling information
	Section type #6 support – sending channel information for a specific UE ID
Beamforming	Index based beamforming (Pre-defined beam beamforming)
	Weight-based dynamic beamforming
	Attribute-based dynamic beamforming
	Channel-information-based beamforming
	Flexible weight-based dynamic beamforming
O-DU Transmission Window	Configurable downlink Timing Advance
Transport	Application layer fragmentation support
	VLAN support
	Configurable MAC address
	MTU size control
	Jumbo packet support

Open RAN Explorer	Supported standards and performance characteristics
Explorer features	Tx, Rx bidirectional display
	Timestamped trace
	O-RAN U-plane and C-plane message summary
	Cross referencing between displays
Filters	Flow based filtering
	Filter trace on single carrier
Protocol support	Ethernet, VLAN, eCPRI and O-RAN
IQ level measurements	Configurable IQ bit width
	Extract uncompressed IQ from capture
PRB details	Hex byte view
	Recovered IQ
	Constellation view
IQ extraction (Requires U5040IQEB)	IQ information embedded in PRB can be extracted for RF modulation measurement using PathWave VSA
	Output in. orb format

Keysight O-RAN Test Solutions

Keysight's industry-first O-RAN end-to-end design and test solutions enable the mobile industry to accelerate O-RAN product design development from the physical layer to the application layer and across the entire workflow from simulation, design, and verification to manufacturing, deployment, and optimization.
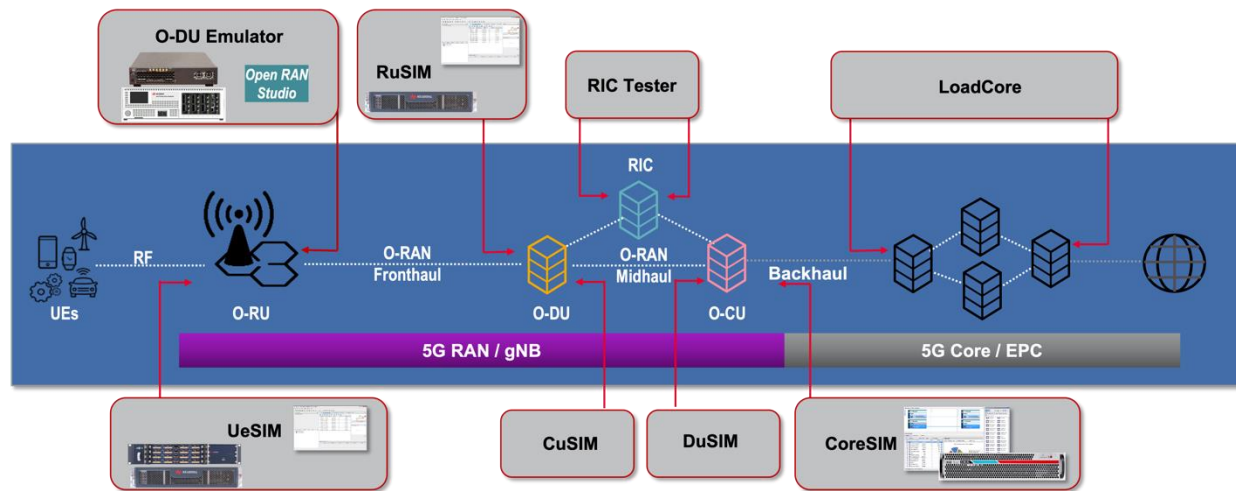
Keysight offers common software and hardware platforms compliant to the latest 3GPP standards, enabling the ecosystem to quickly and accurately validate O-RAN chipsets, devices, and networks, as well as emulate subscriber behavior scenarios. Additional information about Keysight's O-RAN solutions is available here.