Time Sync Analyzer — O-RAN

High-performance O-DU emulator for 5G O-RAN Radio Unit (O-RU) testing and validation

Introduction

The mobile network industry is moving towards an open, intelligent, virtualized, and fully interoperable Radio Access Network (RAN). Open fronthaul architectures and gNB disaggregation requires comprehensive analysis of RAN elements of O-RU, O-DU, and O-CU. The Radio Unit (O-RU) needs to support RF and digital signal conversion, split 7.2x Low-PHY processing, and stringent time synchronization. Massive Multiple Input and Multiple Output (MIMO) and beamforming technologies for increasing spectral efficiency and energy saving for power and cost reduction add further challenges. As chipset vendors and NEMs roll out massive MIMO O-RAN Radio Unit (O-RU), they need to test O-RAN compliance, beamforming, and massive MIMO performance to guarantee the coverage, capacity, and user experience that is promised with 5G.

The Keysight Time Sync Analyzer (TSA), expanding Open RAN Studio solution portfolio, is a high-performance O-DU emulator that targets CUSM Plane test and validation for MIMO and massive MIMO O-RAN Radio Units. Driven by the Keysight Open RAN Studio application, it tests O-RU and chipsets with O-RAN 7.2x split compliant CU Plane stimulus generation and analysis, enables users to generate test vectors against a DUT, captures O-RAN uplink communications, and performs the measurements necessary to validate O-RU's functional operation and performance with up to 600 Gbps fronthaul throughput.

Figure 1. Time sync analyzer O-RAN player and sync tester

KEYSIGHT

Keysight 5G Open RAN Studio — Solution Overview

Designed for 5G O-RAN Radio Unit (O-RU) testing, Keysight Open RAN Studio provides powerful, yet easy to use capabilities to emulate an O-RAN Distributed Unit (O-DU) — generate O-RAN compliant CUSM Plane test vectors, capture the DUT's responses, and perform measurements that are needed to validate if the O-RU meets standard compliant operation and radio performance.

Open RAN Studio includes powerful O-RAN focused tools to construct, play, capture, and measure O-RAN traffic over specialized hardware platform. Out of the box integration with Keysight's PathWave Signal Generation and 89600 VSA software enables sophisticated 5G NR and LTE signal creation and analysis, extraction, and export of IQ vectors — for advanced modulation analysis of received RF / mmWave and radio performance. Additionally, when combined with Keysight Spectrum Analyzers and Signal Sources, the integrated Open RAN Studio solution delivers the most comprehensive cross domain, multi-channel RF / mmWave, and O-RAN protocol measurements that are available in the industry, for both FR1 and FR2 radios, Downlink (DL), and Uplink (UL) paths.

See the Open RAN Studio solution brief for further details.

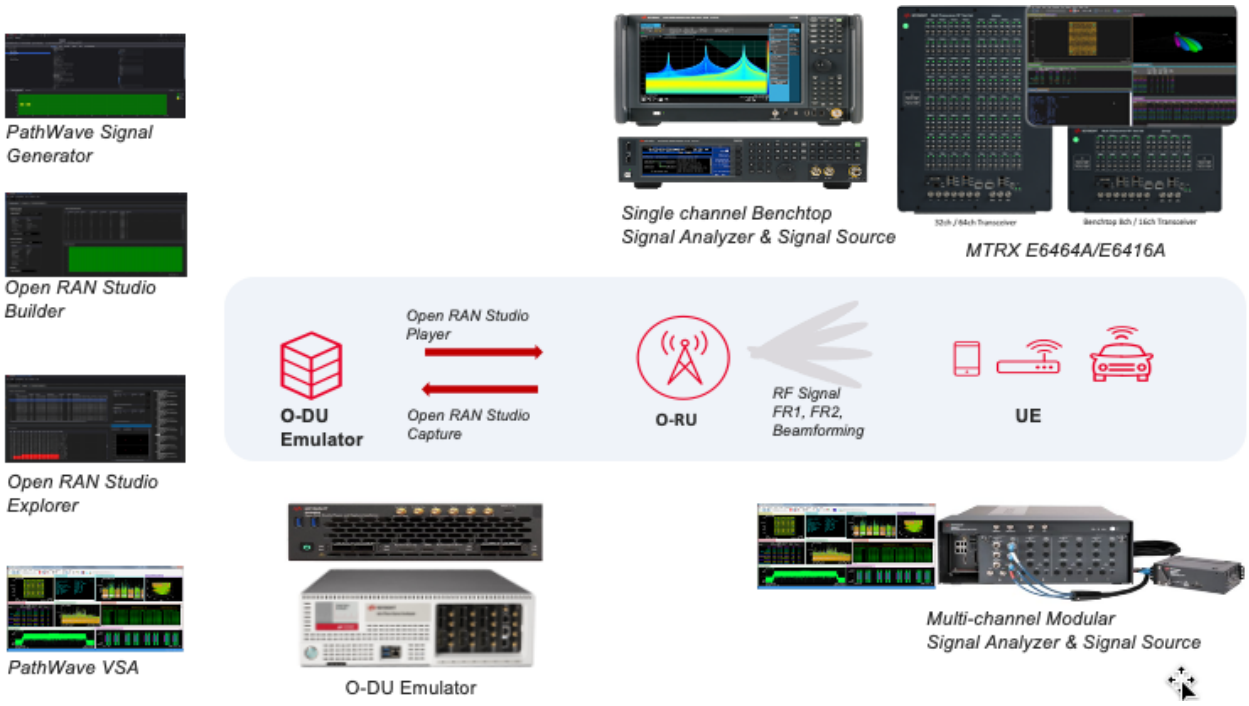


Figure 2. Integrated Open RAN Studio solution for comprehensive O-RU testing

Open RAN Studio for 5G O-RAN Radio Unit (O-RU) Testing

Open RAN Studio provides a test environment that includes and 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 NR and LTE signal generation and measurement science that is used in Keysight spectrum analyzers and signal sources. This tight coupling ensures that CU Plane messages and baseband information match exactly with the signals that are captured on the RF side of the Radio Unit.

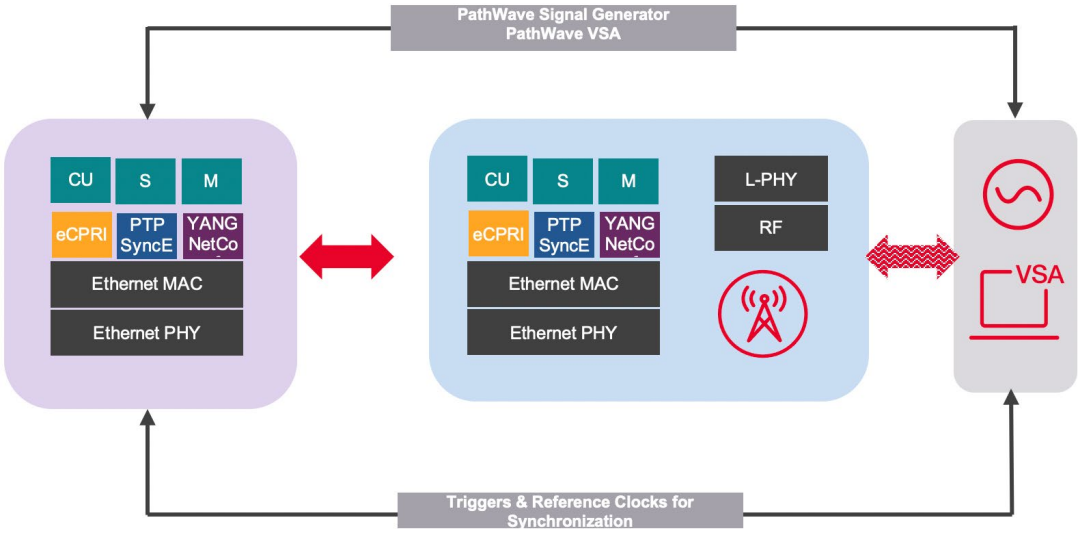


Figure 3. Open RAN Studio Software Architecture

Time Sync Analyzer for O-RU CUSM Plane Validation

Time Sync Analyzer is a high-performance Open RAN Studio Player and Capture appliance. It expands the Open RAN Studio solution portfolio and offers up to 150 Gbps at 25GE and up to 600 Gbps at 100GE fronthaul throughput for massive MIMO and beamforming test. The system is designed to provide highly accurate and stable timing source to O-RU and advanced S-Plane validation and characterization. With proven Open RAN Studio application and powerful Time Sync Analyzer platform, it targets CUSM Plane test coverage for O-RU fronthaul validation in a single system, combined with Signal Analyzer/Signal Generator for O-RAN and 3GPP conformance. With TSA high fronthaul throughput support and MTRX for massive MIMO beamforming analysis, Keysight provides the industry first O-RAN wraparound test solution to address Massive MIMO test challenges.

Highlights

- High-performance O-DU emulator for MIMO and massive MIMO O-RU test and validation
- Integrates with Open RAN Studio to play, capture, and analyze O-RAN traffic over fronthaul interface
- Future proof CUSM Plane fronthaul validation in a single system
- Optimized for testing massive MIMO beamforming, data throughput, and capacity
- O-RU S-Plane conformance test with deterministic and easy to manage test environment
- Scalable multi-user architecture for sharing and parallel test execution
- Flexible reference clock input/output fits various lab timing infrastructure and fronthaul timing topologies
- Multiple factory configurations to address the testing requirements and lab budgets
- Intuitive web-based user interface for system operation
- Comprehensive Python/REST test automation and easy-to-use

Key features

- Open RAN Studio integration for CUSM Plane operations
  - Sends CU Plane messages by playing Stimulus
  - Capture/Decode/Analyze fronthaul eCPRI messages
  - M-Plane support to configure O-RU and retrieve status
  - S-Plane emulation as PTP and SyncE clock source
- Time sync analyzer S-Plane feature set
  - Emulates PTP TimeTransmitter or TimeReciever supporting ITU-T G.8275.1/G.8275.2 and IEEE 1588v2-2008
  - Emulates SyncE and ESMC with QL TLV and enhanced QL TLV per ITU-T G.8264
  - Dynamic update of PTP clock class and ESMC quality level
  - Generates PTP impairment, SyncE wander, and digital clock wander
  - Analyzes clock quality for PTP, SyncE, 1PPS, 10MHz per ITU-T Recommendations and O-RAN specification
  - Frequency stability test with controlled frequency drift and adjustable FFO reference frequency
  - Event Markers for correlating TE/TIE change to an event for analyzing potential impact
- 2 Ethernet interfaces per Line Card supporting 10/25/100GE
- Support up to 600 Gbps fronthaul throughput to test massive MIMO beamforming
- Line rate bi-directional capture on each port
- 10 MHz and 1 PPS Phase reference input and output
- Integrated GNSS receiver, ITU-T G.8271/G.703 ToD+ input port, and Rubidium option

- Pulse per Radio Frame (PPRF) and start of CU Plane stimulus output triggers
- Convenient Web based user interface for S-Plane test and system timing source configuration
- Multiple user support (up to three test sessions, one per card)
- Python/REST API support for automation and scripting

See the Open RAN Studio data sheet for detailed feature support of OpenRAN Studio Builder/Player/Capture/Explorer/IQ Extractor and PathWave VSA.

Comprehensive O-RU CUSM plane validation

The Time Sync Analyzer driven by the Open RAN Studio application exercises C-Plane, U-Plane, S-Plane, and M- Plane for O-RU testing. It configures the radio through M-Plane, plays back the stimulus files generated by the Open RAN Studio Builder over an Ethernet based O-RAN interface, and acts as PTP (and SyncE) TimeTransmitter to synchronize the radio. With the rich test options, and highly accurate timing source, the Time Sync Analyzer covers comprehensive O-RU validation conforming to O-RAN specifications.

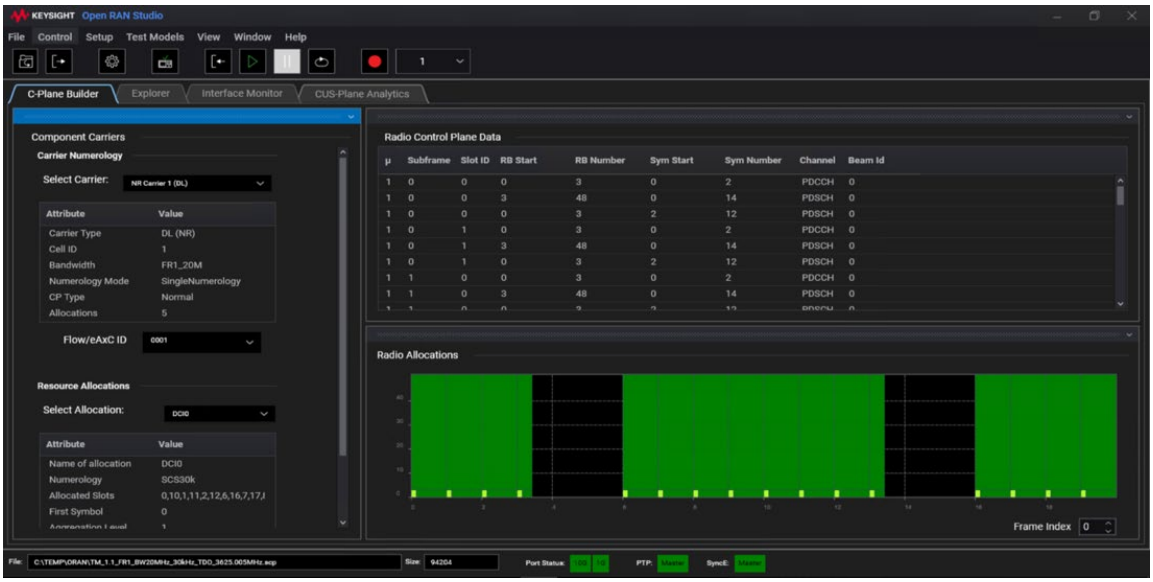


Figure 4. Open RAN Studio Builder C Plane setup

Massive MIMO throughput and capacity

The time sync analyzer is optimized for testing massive MIMO beamforming, data throughput, and capacity needs. It offers CU Plane data throughput up to 150 Gbps at 25GE and up to 600 Gbps at 100GE, addresses fronthaul demands for Massive MIMO radio with and beyond 16 layers and with a wide range of bandwidth support.

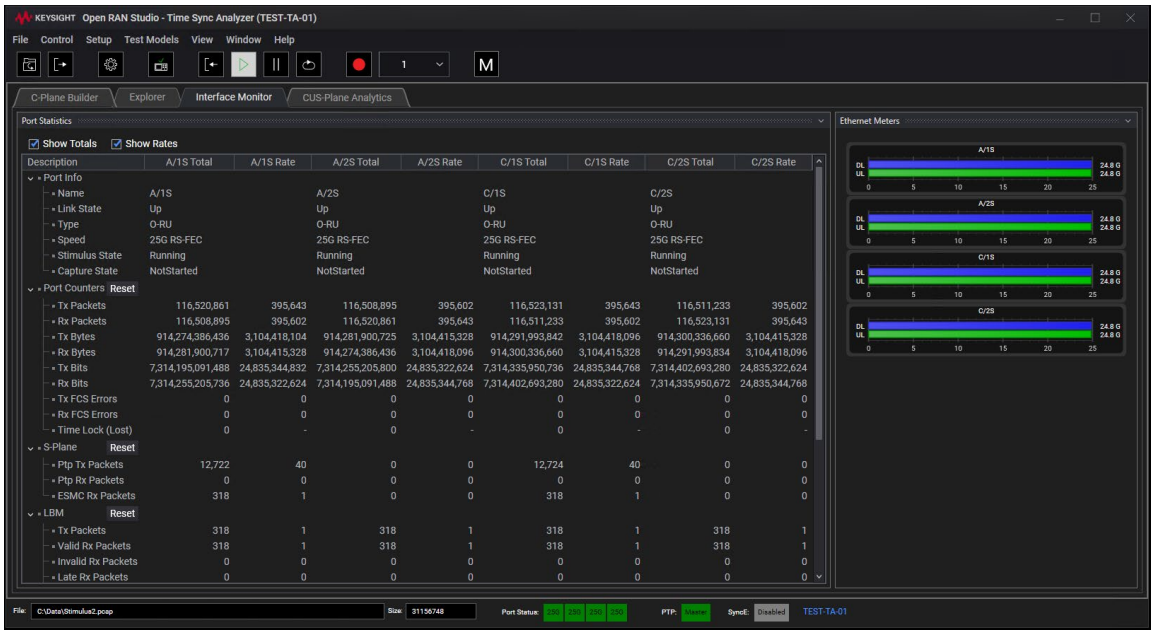


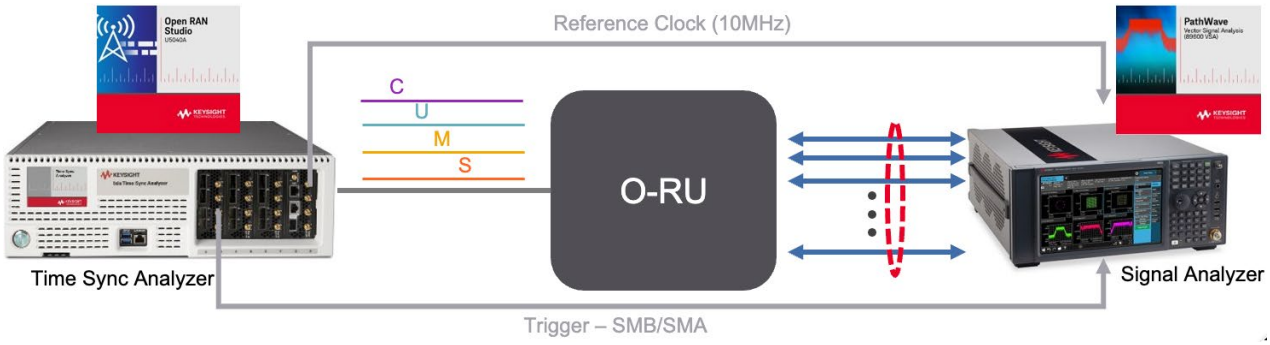
Figure 5. Open RAN Studio port cumulated and rate statistics for 4 x 25GE

O-RU S-Plane conformance test

O-RAN Working Group 4 defines O-RU conformance test for CUSM Plane.

Time sync analyzer is specialized for O-RU S-Plane conformance test with integrated CUSM Plane support in a single fronthaul system, provides a controlled and deterministic test environment fully compliant with WG4 Conformance test specification. It also provides advanced S-Plane test capabilities to help characterize synchronization performance of radio unit component blocks and end-to-end.

Note: A range of Signal Analyzer hardware can be used with VSA to measure frequency error and time error at radio interface such as VXT, MXA, PXA, and UXA.



The following two test cases defined for O-RU S-Plane conformance test are supported:

Test cases	Description
3.3.2	• Functional test of O-RU using ITU-T G.8275.1 profile (LLS-C1/C2/C3)
3.3.3	• Performance test of O-RU using ITU-T G.8275.1 Profile (LLS-C1/C2/C3)

Time sync analyzer performs the following for 3.3.2 functional test:

- Simulates PTP clock degradation with clock class change and check O-RU PTP state through M-Plane
- Simulates SyncE clock degradation with ESMC QL level change and check O-RU SyncE state through M-Plane

Time sync analyzer performs the following for 3.3.3 performance test:

- Sends CU Plane stimulus to O-RU to send radio frame over the air interface
- Adds constant time error (cTE) and dynamic time error per WG4 CONF spec
- Measures frequency error and timer error by using VSA/Signal Analyzer at radio interface per pass/fail criteria

In addition, Time sync analyzer provides advanced S-Plane test capabilities to test synchronization function and characterize performance of radio unit component blocks and end-to-end.

Flexible architecture for increased productivity

Time sync analyzer is designed with flexible factory configuration and multi-user architecture. It supports one test user per line card and up to three test users per system, allows sharing of the system for parallel test execution, and saves rack space and power. Customer has the flexibility to use the system to its full capacity for massive MIMO radio performance test or share among multiple users to test multiple O-RUs independently at same time.

Time Sync Analyzer Specifications

Key specifications	Details
Appliance	• Time sync analyzer appliance • 1 Timing card with Rubidium option • Up to 3 Ethernet line cards, factory configured
Timing card	• Internal Reference Clock (with Rubidium): ◦ Frequency stability over temperature < 1 x 10^{-10} ◦ Short term stability (10s Tau, TDEV): 30ps or better (typical) ◦ Long term stability (1000s Tau, ADEV): < 1 x 10^{-12} • FlexREF 1 & 2 SMB ports ◦ Frequency and Phase reference input: 10MHz and 1 PPS • FlexIO 1 ~ 4 SMB ports ◦ Frequency reference output: 2.2 Hz to 10MHz ◦ Phase (1PPS) reference output ◦ Test input: 1 PPS or 0.9 Hz to 10MHz • FlexIO inputs: +0.1 V to +3.3 V; 50 Ohm input impedance • FlexIO outputs: +1.65 V square into 50 Ohms • Embedded multi-constellation capable GNSS receiver (GPS, GALILEO, QZSS) • ToD+ interface with RJ48 connector, supports ITU-T G.8271 format data
Ethernet line card	• 2 x Ethernet ports per line card with SFP28 and QSFP28 • Supporting 10/25/100GE speeds, speed option licensed per card • Independent speed and operation across line cards • Capture buffer per port: Tx 512 MB, Rx 512MB • 4 x PortIO SMB connector for trigger output: ◦ 1 PPS ◦ Pulse per radio frame ◦ Stimulus start trigger out • PortIO outputs: +1.65 V square into 50 Ohms
Control and user plane	• Ethernet, VLAN, eCPRI and O-RAN
M-Plane	• Embedded M-Plane support • M-Plane on any or all Ethernet ports • DHCPv4/v6, LBM, Netconf, eCPRI One-Way Delay Measurement, SFTP
Synchronization	• Emulate PTP TimeTransmitter or TimeReceiver supporting G.8275.1/G.8275.2/1588v2-2008 • Dynamic update of PTP clock class • Generates constant time error (cTE) and dynamic time error (dTE) for PTP clock • SyncE and ESMC Message generation • Dynamic update of ESMC quality level • Generate and measure wander per ITU-T G.8262/G.8262.1 • PTP TE Generation and Measurement Accuracy: 1ns or better typical
Stimulus memory depth	• 10 frames (512 MB)
Playout features	• Configurable DUT destination MAC address • Dynamic System Frame Number (SFN) during playout

Key specifications	Details
	• Play stimulus file once or repetitively • Configurable to start playing frames on next 10 ms boundary
Throughput	• 50Gbps per line card and 150 Gbps per system at 25GE link speed • 200Gbps per line card and 600 Gbps per system at 100GE link speed
General	• Web-based user interface • Separate Windows system to host Open RAN Studio applications • Automation API: Python, RestAPI
Chassis	• Rack mount and desktop mounting hardware included • Dimensions: 3RU 17.27 in (438 mm) x 14.61 in (371 mm) x 5.21 in (132 mm) • Weight: 29.9 lbs / 13.6 kg (with a maximum load of 3 line cards) • Noise Level: 60 dBA normal operation, 70 dBA max • Thermal ◦ Operating temperature: 5° C to 40° C (41° F to 104° F) ◦ Operating humidity: 10 % to 85 % (RH), non-condensing ◦ Storage temperature: -40° C to 70° C (-40° F to 158° F) ◦ Storage humidity: 5 % to 95 % (RH), non-condensing • Input power ◦ 100–127 Vac / 200–240 Vac, 10 / 5A, 50/60 Hz (x2) or ◦ 100–127 Vac / 200–240 Vac, 10 / 5A, 50/60 Hz (x1) • Power consumption: ◦ 1-line card system – Max 380W, typical 268W ◦ 2-line card system - Max 540W, typical 328W ◦ 3-line card system - Max 700W, typical 388W
Safety	• UL 62368-1 / CSA C22.2 No. 62368-1 • EN 62368-1 / IEC 62368-1
Emissions and immunity	• FCC Part 15B, Class A • CAN ICES-003(A)/NMB-003(A) • EN 55032 Class A / EN 55035 / EN 61000-3-2 / EN 61000-3-3 • AS/NZS CISPR 32 Class A • KS C 9832 Class A / KS C 9835 / KS C 9610-3-2 / KS C 9610-3-3 • VCCI – CISPR 32 Class A
Regulatory approvals	• CSA (USA, Canada) • CE (Europe) • UKCA (United Kingdom) • RCM (Australia) • KCC (Korea) • VCCI (Japan)
Environmental	• RoHS Directive 2011/65/EU; Annex II, Directive (EU) 2015/863 • WEEE Directive 2012/19/EU • China RoHS

Product ordering information

Open RAN solution software

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
N7631ORNC (Required)	PathWave Signal Studio Pro software for 5G NR signal creation (Signal generation for U5040BSCA)
U5040IQEB (Optional)	IQ Extraction Option for Open RAN Studio (Requires 89601BHNC for analysis of extracted IQ files)
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 U5040IQEA for IQ extraction from O-RAN packets)

Time sync analyzer hardware appliance

Part number	Description
941-0120	Keysight Time Sync Analyzer Appliance and Base Software Rack mountable 3U unit, INCLUDES: Keysight Timing Sync Analyzer Appliance, Keysight Time Sync Analyzer Base Software which enable timing reference input/output of 10MHz and 1PPS, and timing reference input of GPS and TOD, 2 power supply modules, 1 Rackmount kit, and 1 Ship kit; REQUIRED: 1 Timing card and minimum 1 Ethernet line cards; NOTE: Additional hardware accessories can be purchased separately for increased system availability or for backup
944-1801	Keysight Time Sync Analyzer TIMING Card (944-1801); Enable system timing control and distribution with internal and external time source, output timing source to external system, support test input/output and trigger input/output
944-1802	Keysight Time Sync Analyzer TIMING Card with Rubidium (944-1802); Enable system timing control and distribution with internal and external time source, output timing source to external system, support test input/output and trigger input/output
944-1811	Keysight Time Sync Analyzer 2-port Ethernet Line Card (944-1811); Support 2 Ethernet ports with SFP28 and/or QSFP28 physical interface; REQUIRES: Minimum one Speed option to be purchased

Time sync analyzer software options

Part number	Description
930-7200	Keysight Time Sync Analyzer Ethernet Line Card 100G Speed Enablement (930-7200); Enable QSFP28 100G speed for exact one Ethernet Line Card
930-7201	Keysight Time Sync Analyzer Ethernet Line Card 25GE Speed Enablement (930-7201); Enable 25GE speed for exact one Ethernet Line Card
930-7202	Keysight Time Sync Analyzer Ethernet Line Card 10GE Speed Enablement (930-7202); Enable 10GE speed for exact one Ethernet Line Card
930-7301	Keysight Time Sync Analyzer Advanced Software (930-7301); Enable digital clock impairment and measurement, and Clock Quality Analysis; REQUIRES: 930-7300 Keysight Time Sync Analyzer Base Software Package
930-7302	Keysight Time Sync Analyzer IEEE 1588v2 (PTP) Generation and Measurement (930-7302); Enable PTP TimeTransmitter and TimeReceiver emulation for testing G.8273.x Boundary Clock, Transparent Clock, and Ordinary Clock; Enable TIE collection and clock quality analysis of derivative metrics; REQUIRES: 930-7301 Keysight Time Sync Analyzer Advanced Software
930-7303	Keysight Time Sync Analyzer SyncE Clock Generation and Measurement (930-7303); Enable ESMC generation and analysis for EEC and enhanced EEC clock per ITU-T G.8264, Enable TIE collection and clock quality analysis of all derivative metrics ; REQUIRES: 930-7301 Keysight Time Sync Analyzer Advanced Software
930-7305	Keysight Time Sync Analyzer O-RU S-Plane Conformance Test for O-RU (930-7305); Enable O-RU S-Plane Conformance test for functional and performance test cases per O-RAN WG4 S-Plane Conformance specification; REQUIRE: 930-7300 Keysight Time Sync Analyzer Base Software
930-7306	Keysight Time Sync Analyzer Custom Traffic Generation (930-7306); Enable Custom Traffic Generation to assess synchronization performance; REQUIRE: 930-7301 Keysight Time Sync Analyzer Advanced Software

Note: 930-7305 enables feature set for O-RU S-Plane conformance test, which is a subset of 930-7302 + 930-7303.

Optics and cables

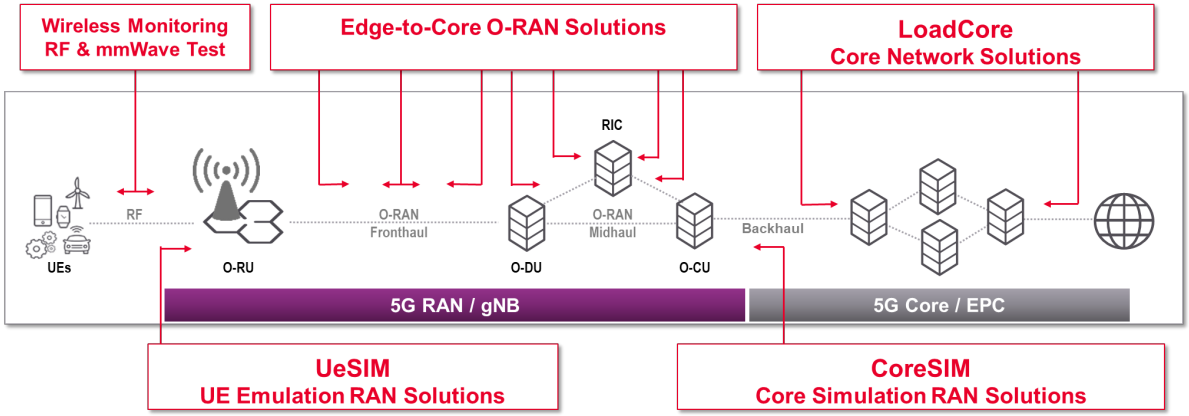
Part number	Description
SFP28-SR-XCVR	SFP28 Dual-Rate 25GBASE-SR 25GE and 10GBASE-SR 10GE pluggable optical transceiver
SFP28-LR-XCVR	SFP28 Dual-Rate 25GBASE-LR 25GE and 10GBASE-LR 10GE pluggable optical transceiver
QSFP28-SR4-XCVR	QSFP28 100GBASE-SR4 100GE pluggable optical transceiver, MMF (multimode), 850nm, 100m reach (948-0036)
QSFP28-LR4-XCVR	Ixia, QSFP28 100GBASE-LR4 100GE pluggable optical transceiver, SMF (single mode fiber), 1310nm, 10km reach (948-0038)
SFP-PLUS-SR-XCVR-D-T	SFP+ 10/1GBASE Dual Rate SR pluggable optical transceiver, MMF (multimode fiber), 850nm, 300m reach, LC
SFP-PLUS-LR-XCVR-D-T	SFP+ 10/1GBASE Dual Rate LR pluggable optical transceiver, 1310nm, MMF (single mode fiber), 10km reach, LC
0950-6311	USB 3.0 to Gigabit Ethernet Adapter Eaton / Tripp-Lite U336-000-R

Keysight 5G Solutions

Keysight's industry-first 5G end-to-end design and test solutions enable the mobile industry to accelerate 5G 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 5G Radio Access and Core Network Test Portfolio

Keysight Open RAN Architect (KORA) Solutions



Keysight offers common software and hardware platforms compliant to the latest 3GPP standards, enabling the ecosystem to quickly and accurately validate 5G chipsets, devices, base stations, and networks, as well as emulate subscriber behavior scenarios. Additional information about Keysight's 5G solutions is available at www.keysight.com/find/5G

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.