IQFR1-RU

5G FR1 O-RAN Radio Unit Test System

LITEPOINT

Overview

The IQFR1-RU is the industry's first fully integrated 5G FR1 O-RAN Radio Unit (O-RU) tester supporting the 3GPP 5G NR RF downlink/uplink measurement, as well as the O-RAN C/U/M/S-plane functionality necessary to configure the interface with the O-RU under test.
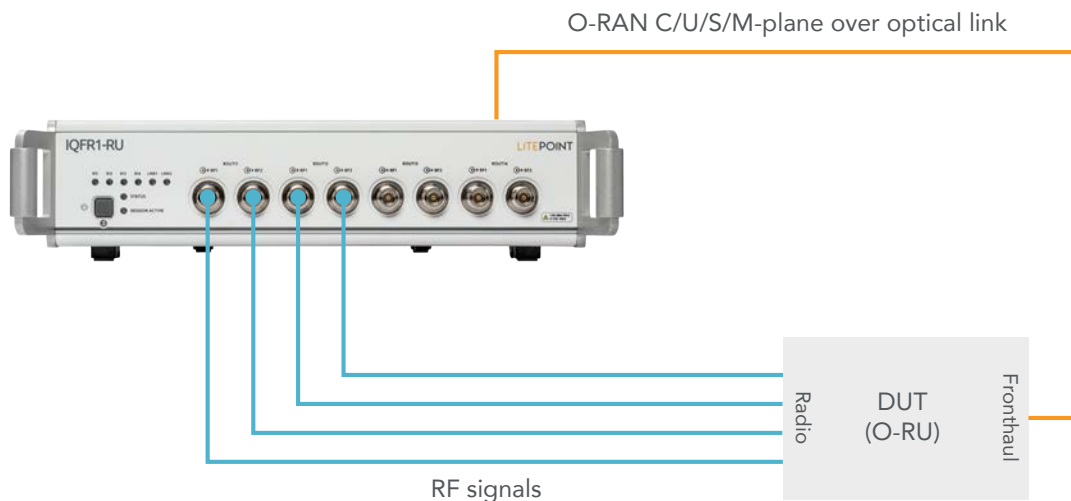
The IQFR1-RU contains multiple independent Vector Signal Generators (VSG) and Vector Signal Analyzers (VSA). All RF signal generation, analysis, and RF front-end routing hardware are self-contained inside a single chassis. The IQFR1-RU supports up to eight bi-directional RF ports. All eight ports are factory calibrated which enables a very fast set up in terms of minutes, rather than in hours, as no external switches or combiners are required.

The IQFR1-RU implements required portions of the O-RAN Distributed Unit (O-DU) functions as defined by split option 7-2x. For downlink test, the engine generates eCPRI packets from downlink signal generated by VSG. eCPRI packets are transported to O-RU under test over Ethernet fronthaul interface. VSA captures and analyzes downlink signal from the O-RU Tx port. For uplink test, O-RU under test receives uplink signal from VSG via O-RU Rx port. eCRPI packets are transported to IQFR1-RU over Ethernet fronthaul interface, the uplink signal is analyzed by VSA.

Solution Highlights

- **Eliminates requirement for external DU emulator**
- **Enables simplified waveform based O-RU testing**
- **Optical link for C/U/S/M-plane messaging**
- **Enables DL and UL RF parametric measurements**
- **Software regression of RU O-RAN interface**
- **Single-box simplicity allows easy scalability from R&D to production**

Connection Diagram

Port Descriptions

Front Panel

I/O	Function	Type
Power Button	Power On/Off	Pushbutton Switch
Power Indicator	LED solid red – test system is in standby mode LED blinking red – test system is powering off LED blinking green – test system is booting up LED solid green – test system is powered on	LED indicator
Session Active Indicator	LED Green – remote session active LED Red – remote session lock	LED indicator
Status Indicator	LED Green – no faults/errors detected LED Orange – Software error detected LED Red – Hardware fault detected	LED indicator
RF11 Indicator	LED green – port is a VSA input LED red – port is a VSG output LED orange- port is in duplex mode	LED indicator
RF12 Indicator	LED green – port is a VSA input LED red – port is a VSG output LED orange- port is in duplex mode	LED indicator
RF13 Indicator	LED green – port is a VSA input LED red – port is a VSG output LED orange- port is in duplex mode	LED indicator
RF14 Indicator	LED green – port is a VSA input LED red – port is a VSG output LED orange- port is in duplex mode	LED indicator
Link1 Indicator	LED green – LINK1 connected	LED indicator
Link2 Indicator	LED green – LINK2 connected	LED indicator
ROUT11: RF1/ RF2	VSA input VSG output VSA input and VSG output	N Female
ROUT12: RF1/ RF2	VSA input VSG output VSA input and VSG output	N Female

I/O	Function	Type
ROUT13: RF1/ RF2	VSA input VSG output VSA input and VSG output	N Female
ROUT14: RF1/ RF2	VSA input VSG output VSA input and VSG output	N Female

Rear Panel

I/O	Function	Type
AUX 1	General Purpose I/O	iPass
AUX 2	General Purpose I/O	iPass
AUX 3	General Purpose I/O	iPass
TRIG I/O	Not Used	
DATA 1	DATA 1 Connection	iPass PCIe x4
DATA 2	DATA 2 Connection	iPass PCIe x4
HDMI	Video Output	HDMI
USB (4 ports)	USB 3.0 compatible connection to external controller	USB Type A
LAN	1000 Base-T LAN	RJ-45
TRIG/MKR 1	TTL Trigger Input / Output	BNC female
TRIG/MKR 2	TTL Trigger Input / Output	BNC female
10 MHz REF IN	10 MHz reference input	BNC female
10 MHz REF OUT	10 MHz reference output	BNC female
QSFP28 4x25GbE	High bandwidth data connector	QSFP connector
AC in	AC power input	100 to 240V AC (automatically switched) 50 to 60 Hz, Includes hard power switch

General Hardware Specifications

Vector Signal Analyzer (VSA)

Parameter	Value
Frequency Range	600 – 6000 MHz
RF Bandwidth	200 MHz
Maximum Input Power	+34 dBm (avg) +36 dBm (peak)
Input Power Accuracy	For input > -40 dBm: <±0.4 dB 600 to 3800 MHz <±0.5 dB > 3800 MHz
Input Return Loss	>12 dB 600 to 3800 MHz >10 dB 3800 to 5300 MHz >8 dB >5300 MHz
Noise Figure	< 20 dB 600 to 4500 MHz < 25 dB >4500 MHz
Power measurement repeatability	< 0.1 dB (within 30 seconds of initial value), input power > -40 dBm
Frequency Resolution	1 Hz
Frequency Level Settling Time	< 900 ms to within 1 kHz
Port Switching Time	< 50 usec (to within 0.1 dB)
Sampling Rate	30.72, 61.44, 122.88, 245.76 MHz
Signal to Noise Ratio	> 95 dB @ RBW = 1 kHz, input power > -10 dBm
Spurious (signal applied)	< -50 dBc, (±100 MHz, 1 MHz RBW, input power > -10 dBm) Excludes image rejection
Spurious Signals Floor (no input signal applied)	< -75 dBm (± 100 MHz, RLEV = -10 dBm)
Image Rejection	< -30 dBc (±50 MHz, input power > -10 dBm), < 5000 MHz < -25 dBc (±50 MHz, input power > -10 dBm), > 5000 MHz
Spectral Flatness	< 1 dB (±100 MHz, input power > -10 dBm) max-min
Integrated Phase Noise	≤ 0.5 degrees (1 kHz to 10 MHz), 600MHz – 2100 MHz ≤ 0.8 degrees (1 kHz to 10 MHz), 2100 MHz – 4300 MHz ≤ 0.9 degrees (1 kHz to 10 MHz), > 4300 MHz

Vector Signal Generator (VSG)

Parameter	Value
Frequency Range	600 – 6000 MHz
RF Bandwidth	200 MHz
Output Power Range	0 dBm to -120 dBm (<5000 MHz) -5 dBm to -120 dBm (>5000 MHz)
Output Power Accuracy	< ±0.5 dB @ levels ≥ -50 dBm < ±1dB @ levels <-50 dBm
Output return loss	> 12dB 600 to 3800 MHz > 10dB 3800 to 5300 MHz > 8dB > 5300 MHz
Output Power level repeatability	< 0.1 dB (within 30 seconds of initial value), power > -40 dBm
Power Level Resolution	0.01dB
Frequency Resolution	1 Hz
Frequency Level Settling Time	< 900 ms to within 1 kHz
Sampling Rate	30.72, 61.44, 122.88, 245.76 MHz
Signal to noise ratio	≥ 60 dB power level > -30 dBm (CW)
Spurious (in channel)	≤ -40 dBc (measured at -10 dBm, 200 MHz bandwidth) (CW) Excludes carrier leakage and image rejection
Spurious (out of channel) (excluding harmonics)	< -40 dBc (power > -40 dBm, < 6 GHz)
Harmonic Attenuation	> -25 dBc (power level < -10 dBm)
Carrier Leakage	< -50 dBc, 600 – 3000 MHz (measured at -10 dBm) < -35 dBc, > 3000 MHz (measured at -10 dBm)
Image Rejection	< -30 dBc (±50 MHz, input power > -10 dBm), < 5000 MHz < -25 dBc (±50 MHz, input power > -10 dBm), > 5000 MHz
Spectral Flatness	< 1 dB (±50 MHz, measured at -10 dBm) max-min < 1 dB (±100 MHz, measured at -10 dBm, < 5 GHz) max-min
Integrated Phase Noise	≤ 0.5 degrees (1 kHz to 10 MHz), 600MHz – 2100 MHz ≤ 0.8 degrees (1 kHz to 10 MHz), 2100 MHz – 4300 MHz ≤ 0.9 degrees (1 kHz to 10 MHz), > 4300 MHz

Port to Port Isolation

Parameter	Value
VSA to VSA	> 100 dB 600 MHz to 5000 MHz > 95 dB > 5000 MHz
VSG to VSG	> 115 dB 600 MHz to 5000 MHz > 105 dB 5000 MHz to 5500 MHz > 95 dB > 5500 MHz
VSG to VSA	> 100 dB 600 MHz to 4000 MHz > 95 dB 4000 MHz to 5000 MHz > 90 dB 5000 MHz to 5500 MHz > 80 dB > 5500 MHz

Timebase

Parameter	Value
Oscillator type	OCXO
Frequency	10 MHz
Initial accuracy (25°C, after 60min warm-up)	< ±0.05 ppm
Maximum aging	< ±0.1 ppm per year
Temperature stability	< ±0.05 ppm over 0°C to 50°C range, referenced to 25°C
Warm-up time	5 Minutes to < ±0.1ppm

Frequency Reference Input

Parameter	Value
Frequency	10 MHz
Max Frequency Variation	0.5 ppm
Input Voltage Range	0.3 Vpp to 4.0 Vpp
Impedance	50 Ω

Frequency Reference Ouput

Parameter	Value
Frequency	10 MHz
Output Voltage	> 0.8 Vpp
Impedance	50 Ω

TTL Trigger Input/Output

Parameter	Value
Impedance	5 kΩ nominal
Trigger/Marker 1 & 2 Input Level	3.5 V – V(IH) 1.5 V – V(IL)
Trigger/Marker 1 & 2 Output Level	3.8V to 4.9V – V(OH), 32mA max 0.1V to 0.55V – V(OL), 32mA max

General Hardware Specifications

Parameter	Value
Dimensions	15" W x 3.6" H x 21.3" D (381 mm x 91.5 mm x 541 mm)
Weight	26.4 lb. (12 kg)
Power consumption (maximum)	550 W
Power requirements	100 - 240 VAC, 50-60 Hz
Operating temperature	20°C to 35°C (valid range for specifications)
Storage temperature	-20°C to +70°C (IEC EN60068-2-1, 2, 14)
Operating humidity	15% to 95% relative humidity, non-condensing (IEC EN60068-2-30)
EMC/EMI	61326-1: 2013 Industrial Environment, CISPR11 Class A per EN61326-1:2013, FCC Part 15 Class A, VCCI V-3 Class A, BSMI CNS-13438 Class A, ACMA AS/NZS CISPR11: 2011, ICES-003 Class A
Safety	IEC 61010-1, EN61010-1, UL61010-1:2012 and Canada: CSA C22.2 No. 61010-1, GI1, GI2
Mechanical vibration	MIL-STD 810G for Random Vibration
Mechanical shock	ASTM D3332-99
Recommended connector torque	12 lbs-in (135 N-cm) Recommended
Recommended calibration cycle	12 months
Warranty	12 months hardware, 12 months software updates

5G NR Radio Unit (RU) Downlink Tests

Parameter	Paragraph Reference	Notes
Base Station Output Power	6.2	
Output Power Dynamics	6.3.3	Total Power Dynamic Range (TPDR)
Transmit ON/OFF Power	6.4.1 6.4.2	Transmitter OFF Power Transmitter Transient Period
Transmitted Signal Quality	6.5.2 6.5.3 6.5.4	Frequency Error Modulation Quality (EVM) Time Alignment Error (TAE)
Unwanted Emissions	6.6.2 6.6.3 6.6.4	Occupied Bandwidth (OBW) Adjacent Channel Leakage Power Ratio (ACLR) Operating band unwanted emissions (OBUE) System loopback ACLR: 100 MHz BW, 256QAM, input -10 dBm NR ACLR -50 dBc, 600 to 5000 MHz, typical NR ACLR -48 dBc, 5000 to 6000 MHz, typical E-UTRA ACLR -53 dBc, 600 to 6000 MHz, typical
Reference Sensitivity Level	7.2	DUT support required
Dynamic Range	7.3	Characterization only, not recommended for manufacturing. Requires additional signal generator
In-Band Selectivity and Blocking	7.4.1 7.4.2	Adjacent Channel Selectivity (ACS) In-Band Blocking (IBB) & Narrowband Blocking (NBB) (Characterization only, not recommended for manufacturing. Requires additional signal generator)
Receiver Intermodulation	7.7	Characterization only, not recommended for manufacturing. Requires additional signal generator
In-Channel Selectivity	7.8	Characterization only, not recommended for manufacturing. Requires additional signal generator

5G NR Radio Unit (RU) Uplink Tests

Parameter	Paragraph Reference	Notes
Transmit Power	6.2	Maximum Output Power
Output Power Dynamics	6.3	Minimum Output Power Transmit OFF Power Transmit ON/OFF time mask Power control
Transmit Signal Quality	6.4	Frequency Error Error Vector Magnitude (EVM) Carrier Leakage In-Band Emissions (IBE) Spectrum Flatness System loopback EVM: 1x100 MHz CC, @-10 dBm <1.1% (-39 dB): 600 MHz - 2700MHz, 3000 - 4500 MHz <1.4% (-37 dB): 4500 MHz - 5875 MHz
Output RF Spectrum Emissions	6.5	Occupied Bandwidth (OBW) Spectrum Emission Mask (SEM) Adjacent Channel Leakage Ratio (ACLR)

O-RAN Specifications

Parameter	Value
Bandwidth	10, 15, 20, 25, 30, 40, 50, 60, 80, 90 ,100 MHz
FFT Size	512, 1024, 2048, 4096
Subcarrier Spacing (SCS)	15, 30, 60 kHz
RU Category	Category A
Duplexing Mode	FDD & TDD
C-plane Session Messages	Section Type 1 & Section Type 3
Synchronization	IEEE 1588 PTP Master Sync using G.8275.1, G.8275.2 SyncE ITU G.8262
Transport	L2 Ethernet Qos over Fronthaul Jumbo Ethernet Frames eCPRI Application Fragmentation
Physical Interface	One QSFP28 / QSFP+ Port (SFP RUs are supported by adapter cable)
Speeds	QSFP28: 25G (Supported), 50G, 100G (Future) QSFP+: 10G (Supported), 20G, 40G (Future)
Lane Configurations	Statically configurable C, U, S, M - lanes E.g. C/U/S/M-plane = fiber0
Trace / Debug Tool	Supported

Order Codes

Code	Product
0100-5GSG-100	IQFR1-RU (8 Port) Radio Unit Test System
0100-5GSG-101	IQFR1-RU (4 Port) Radio Unit Test System
0300-5GSG-102	5G MIMO Measurement Suite Software License
0300-5GSG-104	5G O-RAN Fronthaul Conformance Test Software License for U/C-Plane FDD & TDD Signal
0300-5GSG-106	5G O-RAN Fronthaul Conformance Test Software License for S-Plane & M-Plane

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