S8714A UXM 5G RF Application

Designed for RF testing

Simplify RF Verification of 5G NR Devices

Fifth-generation new radio (5G NR) is a complex technology. Performing radio frequency (RF) measurements requires deep knowledge of 5G NR protocol and the complexity continues to increase. The third-generation partnership project (3GPP) adds more tests and test configurations with each release increasing the difficulty of performing measurements correctly according to specified procedures. Time to market pressure requires fast test development and performance verification, but devices still must meet specifications.

Keysight's S8714A UXM 5G RF Application (RA) is a solution to these challenges. Designed for RF testing, its intelligent signaling reduces the need for protocol expertise and its efficient usability makes test development and execution quick and easy.

KEYSIGHT

Focus on RF Performance

Verifying the RF performance of device designs is essential. Developers reading standards and learning protocol spend less time analyzing and optimizing the RF behavior of their designs. Detailed knowledge of standards and protocol is not required for measuring RF performance with the S8714A. RF testing is quick and easy with built-in 3GPP tests and intelligent signaling.

Reduce time learning standards with built-in 3GPP tests

Easily verify RF performance of 5G NR non-standalone (NSA) and standalone (SA) devices with built-in 3GPP tests. Simply select the test from the drop-down menu (Figure 1) and the RF application automatically configures parameters according to 3GPP TS 38.521 and starts the measurement. Save test development time since understanding the 3GPP specification in detail is not necessary.

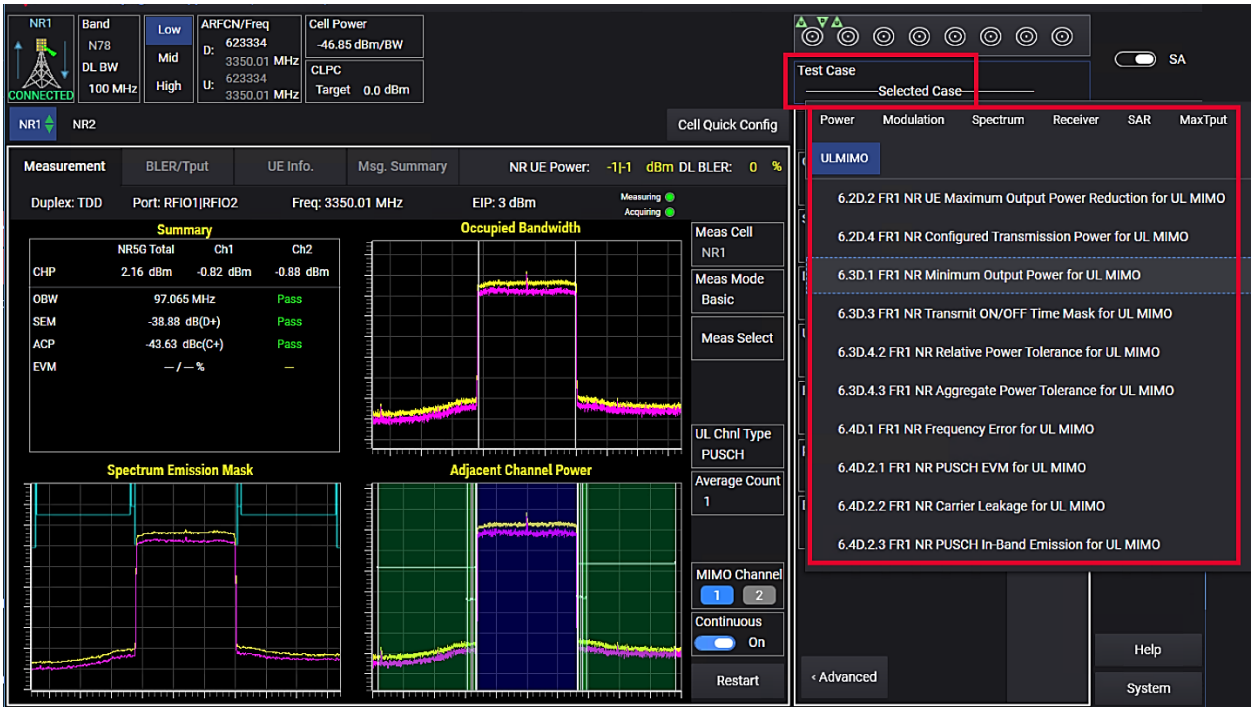

Figure 1. Test selection menu

Find specific tests quickly using selection groups: power, modulation, spectrum, receiver, specific absorption rate (SAR), maximum throughput, and uplink (UL) multiple input multiple output (MIMO).

Select in-band transmit and receive tests for frequency range 1 (FR1) NSA, SA, and UL MIMO. Tables 1, 2, and 3 list supported tests based on 3GPP TS 38.521-1 (SA) and 38.521-3 (NSA).

Table 1. Supported 3GPP SA tests

TS 38.521-1	5G NR SA tests supported with S8714A RA
6.2.1	User equipment (UE) maximum output power
6.2.2	UE maximum output power reduction
6.2.3	UE additional maximum output power reduction
6.2.4	Configured transmitted power
6.3.1	Minimum output power
6.3.2	Transmit (Tx) OFF power
6.3.3.2	General ON/OFF time mask
6.3.4.3	Power control relative power tolerance
6.3.4.4	Aggregate power tolerance
6.4.1	Frequency error
6.4.2.1	Error vector magnitude (EVM) (PUSCH, PUCCH, PRACH)
6.4.2.2	Carrier leakage
6.4.2.3	In-band emissions (PUSCH, PUCCH)
6.4.2.4	EVM equalizer spectrum flatness
6.5.1	Occupied bandwidth (OBW)
6.5.2.2	Spectrum emission mask (SEM)
6.5.2.3	Additional spectrum emission mask
6.5.2.4	Adjacent channel leakage ratio (ACLR)
7.3.2	Reference sensitivity power level
7.4	Maximum input level

Table 2. Supported 3GPP SA UL MIMO tests

TS 38.521-1	5G NR SA UL MIMO tests supported with S8714A RA
6.2D.2	UE maximum output power reduction for UL MIMO
6.2D.4	Configured output power for UL MIMO
6.3D.1	Minimum output power for UL MIMO
6.3D.2	Transmit OFF power for UL MIMO
6.3D.3	Tx ON/OFF time mask for UL MIMO
6.3D.4.2	Relative power tolerance for UL MIMO
6.3D.4.3	Aggregate power tolerance for UL MIMO
6.4D.1	Frequency error for UL MIMO
6.4D.2.1	Error vector magnitude for UL MIMO
6.4D.2.2	Carrier leakage for UL MIMO
6.4D.2.3	In-band emissions for UL MIMO
6.4D.2.4	EVM equalizer flatness for UL MIMO
6.5D.1	Occupied bandwidth for UL MIMO
6.5D.2.2	Spectrum emissions mask for UL MIMO
6.5D.2.4	Adjacent channel leakage ratio for UL MIMO
7.3D.2	Reference sensitivity power level for UL MIMO
7.4D	Maximum input level for UL MIMO

Table 3. Supported 3GPP NSA tests

TS 38.521-3	5G NR NSA tests supported with S8714A RA
6.2B.1.3	UE maximum output power for inter-band E-UTRA-NR dual connectivity (EN-DC) within FR1
6.2B.2.3	UE maximum output power reduction for inter-band EN-DC within FR1
6.2B.3.3	UE additional maximum output power reduction for inter-band EN-DC within FR1
6.2B.4.1.3	Configured output power for inter-band EN-DC within FR1
6.3B.1.3	Minimum output power for inter-band EN-DC within FR1
6.3B.2.3	Transmit OFF power for inter-band EN-DC within FR1
6.3B.3.3	Tx ON/OFF time mask for inter-band EN-DC within FR1
6.3B.8.2.3	Relative power tolerance for inter-band EN-DC within FR1
6.3B.8.3.3	Aggregate power tolerance for inter-band EN-DC within FR1
6.4B.1.3	Frequency error for inter-band EN-DC within FR1
6.4B.2.3.1	Error vector magnitude for inter-band EN-DC within FR1 (PUSCH, PUCCH, PRACH)
6.4B.2.3.2	Carrier leakage for inter-band EN-DC within FR1
6.4B.2.3.3	In-band emissions for inter-band EN-DC within FR1 (PUSCH, PUCCH)
6.4B.2.3.4	EVM equalizer flatness for inter-band EN-DC within FR1
6.5B.1.3	Occupied bandwidth for inter-band EN-DC within FR1
6.5B.2.3.1	Spectrum emissions mask for inter-band EN-DC within FR1
6.5B.2.3.2	Additional spectrum emissions mask for inter-band EN-DC within FR1
6.5B.2.3.3	Adjacent channel leakage ratio for inter-band EN-DC within FR1
7.3B.2.0.3	Reference sensitivity for inter-band EN-DC within FR1
7.4B.3	Maximum input level for inter-band EN-DC within FR1

Modify parameters essential for RF testing

The multitude of test conditions required to verify RF performance seems endless. Save time with the S8714A RA by modifying parameters essential for RF testing such as channel, band, and bandwidth while on a live connection. Change multiple parameters simultaneously by configuring and executing a blind handover. Necessary procedures such as paging, expected input power (EIP) and subscriber identity module (SIM) authentication, and cell state are handled automatically in the background with no user intervention.

Specify the desired channel as low, medium, or high for automatic selection of the absolute RF channel number (ARFCN) according to the 3GPP specifications. Optionally, enter the frequency or ARFCN for the channel to be tested (Figure 2).

Figure 2. Accessible cell parameters

Test RF Performance Efficiently

Time to market pressure is inevitable in device design. Develop designs efficiently using the S8714A RA with its intuitive graphical user interface (GUI), parameter changes on a live connection, simultaneous results from multiple measurements, and easy automation.

Vary parameters without interrupting RF measurements

Quickly configure and modify parameters essential for RF testing. Access frequently used parameters while establishing a connection with a device or making measurements.

Reduce time to re-configure for additional test conditions by modifying parameters on a live connection. Procedures such as paging and authentication are done automatically, resulting in fewer manual re-connections and cell power state changes.

View results of multiple measurements

Speed up RF verification of 5G NR devices by viewing results of multiple measurements simultaneously (Figures 3 and 4). Configure desired measurements for viewing on the main screen.

Figure 3. LTE measurement results

Figure 4. 5G NR measurement results

Develop automated tests quickly

Automation is a requirement for several phases of development such as regression and design verification testing. Develop tests quickly with the simple standard commands for programmable instruments (SCPI) of the S8714A RA (Figure 5).

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BSE:MEASure:TX:BASic:CONTinuous 0
BSE:MEASure:TX:NR5G:CASE:CONFig FR1NRACLR
BSE:MEASure:TX:NR5G:BASic:INIT
BSE:CONFig:NR5G:CELL1:SCHeduling:UL:QCONfig PITBpsk
BSE:CONFig:NR5G:CELL1:DL:POWer:CHANnel -47
BSE:CONFig:NR5G:CELL1:SCHeduling:UL:PRB:CALLocation  IFUL
BSE:MEASure:TX:ENGine:NR5G:AVERage:COUNt 1
BSE:FUNCtion:TXMeas:NR5G:CHANnel:TYPE PUSCh
BSE:FUNCtion:TXMeas:NR5G:INIT:ACP
BSE:FUNC:TXM:NR5G:FETC:STAT?
BSE:FUNCtion:TXMeas:NR5G:FETCh:ACP?
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Figure 5. SCPI example for 5G NR ACLR measurement

Alternatively, use Keysight's S8702A RF Automation Toolset (RFA) to automate 3GPP tests quickly. Supported tests are listed in Tables 4, 5, and 6.

Table 4. Supported 3GPP SA tests with S8702A RFA and S8714A RA

TS 38.521-1	5G NR SA tests supported with the S8702A RFA and the S8714A RA
6.2.1	UE maximum output power
6.2.2	UE maximum output power reduction
6.2.3	UE additional maximum output power reduction
6.2.4	Configured transmitted power
6.3.1	Minimum output power
6.3.2	Transmit OFF power
6.3.3.2	General ON/OFF time mask
6.3.3.4	PRACH time mask
6.3.4.2	Absolute power tolerance
6.3.4.3	Power control relative power tolerance
6.3.4.4	Aggregate power tolerance
6.4.1	Frequency error
6.4.2.1	Error vector magnitude (PUSCH, PUCCH, PRACH)
6.4.2.2	Carrier leakage
6.4.2.3	In-band emissions (PUSCH, PUCCH)
6.4.2.4	EVM equalizer spectrum flatness
6.4.2.5	EVM equalizer spectrum flatness for pi/2 BPSK
6.5.1	Occupied bandwidth
6.5.2.2	Spectrum emission mask
6.5.2.3	Additional spectrum emission mask
6.5.2.4	Adjacent channel leakage ratio (NR)
7.3.2	Reference sensitivity power level
7.4	Maximum input level

Table 5. Supported 3GPP UL MIMO SA tests with S8702A RFA and S8714A RA

TS 38.521-1	5G NR UL MIMO SA tests supported with the S8702A RFA and the S8714A RA
6.2D.2	UE maximum output power reduction for UL MIMO
6.2D.3	UE additional maximum output power reduction for UL MIMO
6.2D.4	Configured transmitted power for UL MIMO
6.3D.1	Minimum output power for UL MIMO
6.3D.2	Transmit OFF power for UL MIMO
6.3D.3	Transmit ON/OFF time mask for UL MIMO
6.3D.4.1	Absolute power tolerance for UL MIMO
6.3D.4.2	Relative power tolerance for UL MIMO
6.3D.4.3	Aggregate power tolerance for UL MIMO
6.4D.1	Frequency error for UL MIMO
6.4D.2.1	Error vector magnitude for UL MIMO
6.4D.2.2	Carrier leakage for UL MIMO
6.4D.2.3	In-band emissions for UL MIMO
6.4D.2.4	EVM equalizer spectrum flatness for UL MIMO
6.5D.1	Occupied bandwidth for UL MIMO
6.5D.2.2	Spectrum emission mask for UL MIMO
6.5D.2.3	Additional spectrum emission mask for UL MIMO
6.5D.2.4	Adjacent channel leakage ratio for UL MIMO
7.3D.2	Reference sensitivity power level for UL MIMO
7.4D	Maximum input level for UL MIMO

Table 6. Supported 3GPP NSA tests with S8702A RFA and S8714A RA

TS 38.521-3	5G NR NSA tests supported with the S8702A RFA and the S8714A RA
6.2B.1.3	UE maximum output power for inter-band EN-DC within FR1
6.2B.2.3	UE maximum output power reduction for inter-band EN-DC within FR1
6.2B.3.3	UE additional maximum output power reduction for inter-band EN-DC within FR1
6.2B.4.1.3	Configured output power for inter-band EN-DC within FR1
6.3B.1.3	Minimum output power for inter-band EN-DC within FR1
6.3B.2.3	Transmit OFF power for inter-band EN-DC within FR1
6.3B.3.3	Tx ON/OFF time mask for inter-band EN-DC within FR1
6.3B.4.3	PRACH time mask for inter-band EN-DC within FR1
6.3B.8.1.3	Absolute power tolerance for inter-band EN-DC within FR1
6.3B.8.2.3	Relative power tolerance for inter-band EN-DC within FR1
6.3B.8.3.3	Aggregate power tolerance for inter-band EN-DC within FR1
6.4B.1.3	Frequency error for inter-band EN-DC within FR1
6.4B.2.3.1	Error vector magnitude for inter-band EN-DC within FR1 (PUSCH, PUCCH, PRACH)
6.4B.2.3.2	Carrier leakage for inter-band EN-DC within FR1
6.4B.2.3.3	In-band emissions for inter-band EN-DC within FR1 (PUSCH, PUCCH)
6.4B.2.3.4	EVM equalizer flatness for inter-band EN-DC within FR1
6.5B.1.3	Occupied bandwidth for inter-band EN-DC within FR1
6.5B.2.3.1	Spectrum emissions mask for inter-band EN-DC within FR1
6.5B.2.3.2	Additional spectrum emissions mask for inter-band EN-DC within FR1

TS 38.521-3	5G NR NSA tests supported with the S8702A RFA and the S8714A RA
6.5B.2.3.3	Adjacent channel leakage ratio for inter-band EN-DC within FR1
7.3B.2.0.3	Reference sensitivity for inter-band EN-DC within FR1
7.4B.3	Maximum input level for inter-band EN-DC within FR1

Measure RF Performance Rapidly

Time is money especially when it comes to testing device designs. The S8714A RA reduces measurement time with parallel measurements, an embedded measurement engine, and quick configuration of test parameters.

Speed up measurements

Parallel test is a method of decreasing overall test time (Figure 6). Test time is significantly reduced when data is analyzed while configuring the device for the next tests and acquiring the next sets of data.

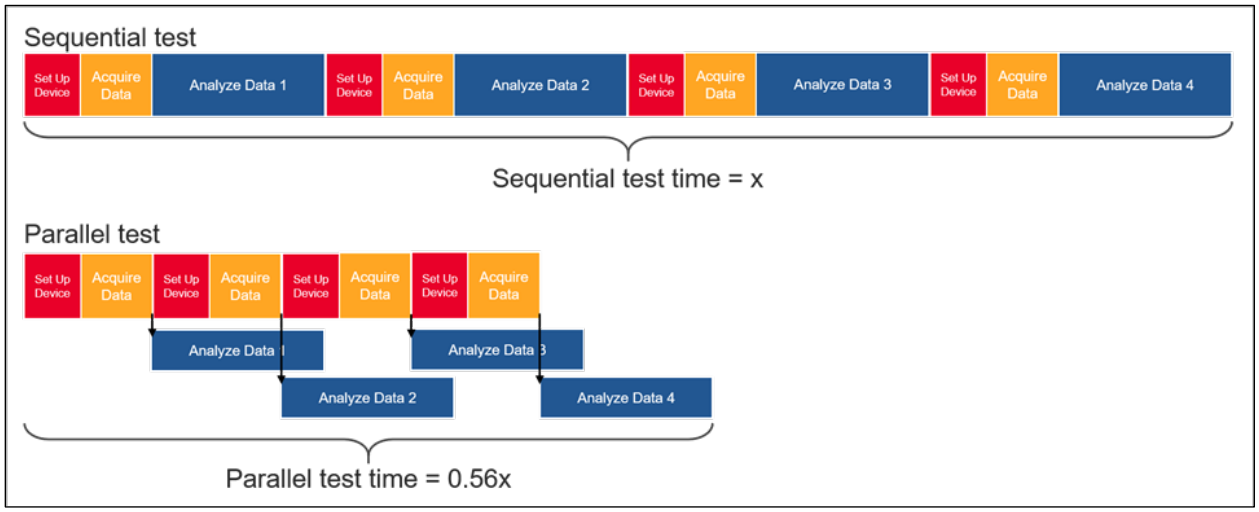

Figure 6. Parallel test example

Test speed is optimized further with the S8714A RA since the measurement engine is embedded within the application, analyzing results locally without sending data to an external processor.

Reduce time when repeating the same test by quickly recalling configurations saved previously.

Verify Device Performance Across the Workflow

Test equipment is expensive, so solutions that can be used in multiple parts of the workflow are in demand. Manual and automated testing is quick and easy during hardware integration, performance optimization, regression and design verification testing, and device repair using the RF-focused user interface of the S8714A RA.

Test devices after hardware and software integration

Device hardware design requires extensive RF testing. An especially important phase occurs after the hardware turn-on is complete and integration with software begins. For mobile devices, integration with a protocol stack is a key milestone.

The S8714A RA helps with frequently used parameters and functions on the main screen (Figure 7):

- Make changes to band, channel, UE power, and modulation without dropping the connection
- Verify performance using RF measurements such as channel power, ACLR, SEM, EVM
- Establish and maintain connections easily without detailed protocol knowledge

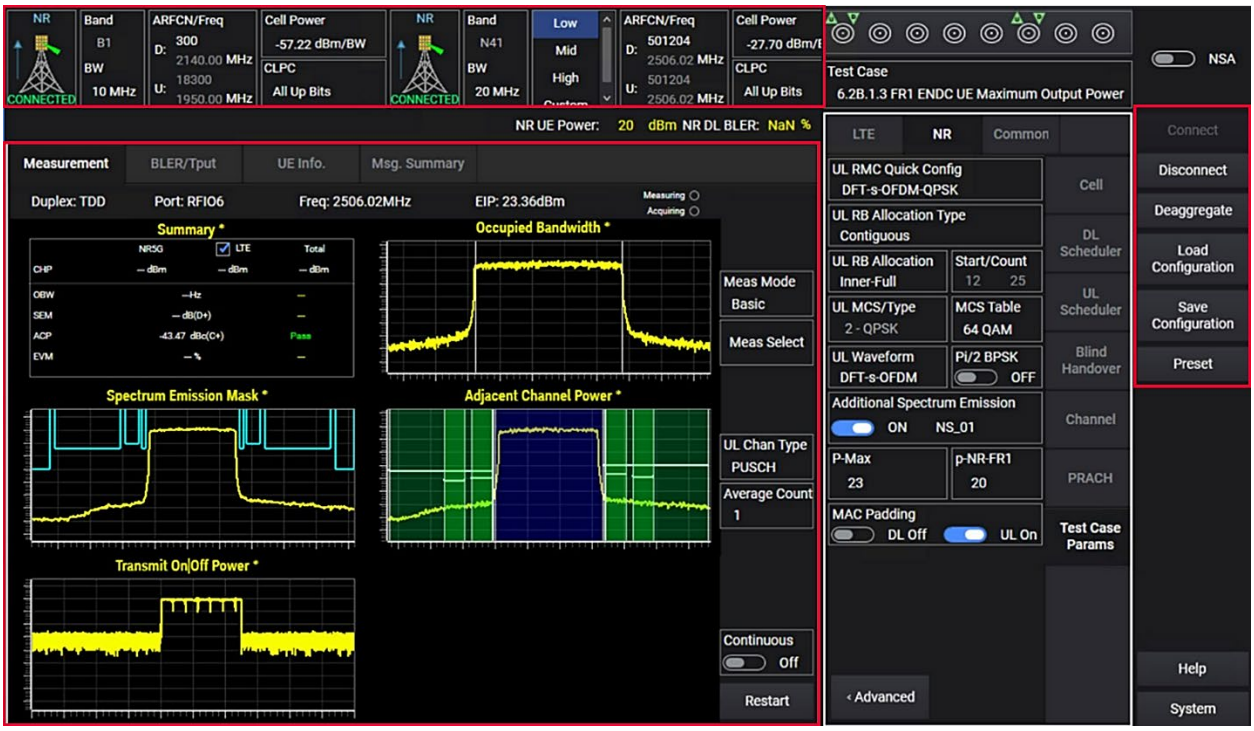

Figure 7. Frequently used parameters and functions on the main screen

Optimize device throughput

Once the protocol stack and hardware are integrated with firmware and software, analysis of additional device behavior such as throughput begins. Internet protocol (IP) data throughput is a measure of a device's real-time performance when downloading videos or uploading photos. Measuring and comparing a device's throughput to the theoretical maximum under different conditions and over time provides data to optimize performance during real-world scenarios.

Use the S8714A RA to select NR Maximum Throughput and automatically configure 5G NR parameters for maximum throughput. Then, measure downlink (DL) and UL IP throughput (Figure 8) to compare with theoretical performance.

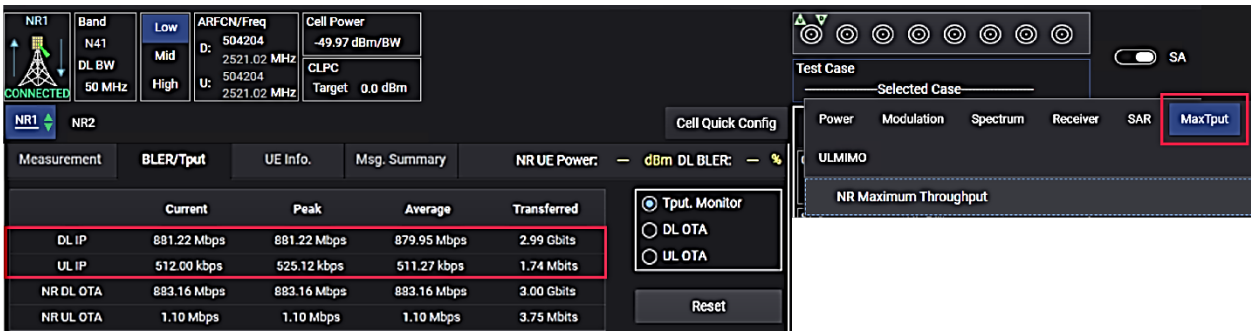

Figure 8. Measuring IP data throughput

Verify device performance over frequency and bandwidth

Design verification starts after a design's hardware, protocol, and software are integrated. This phase tests RF and functional performance while parameters such as frequency, power, and bandwidth are varied over their full ranges. Devices support many combinations of frequency and bandwidth so they can be used on networks worldwide. Testing RF performance with asymmetrical bandwidths as defined by 3GPP is an essential part of design verification. Monitoring and analyzing device performance during a live connection with asymmetrical bandwidths is easy with the S8714A RA.

Test using multiple carriers and device antennas

Carrier aggregation (CA) and MIMO also require extensive testing during design verification. 3GPP defines many combinations of LTE and 5G NR component carriers (CC). Verifying these combinations with the S8714A RA is easy. Use one screen to configure aggregated cell parameters for both LTE and 5G NR (Figure 9). Parameters from other cells can be copied simplifying re-test of previous conditions.

Also use the S8714A RA to analyze LTE and 5G NR performance with MIMO, up to 4x4.

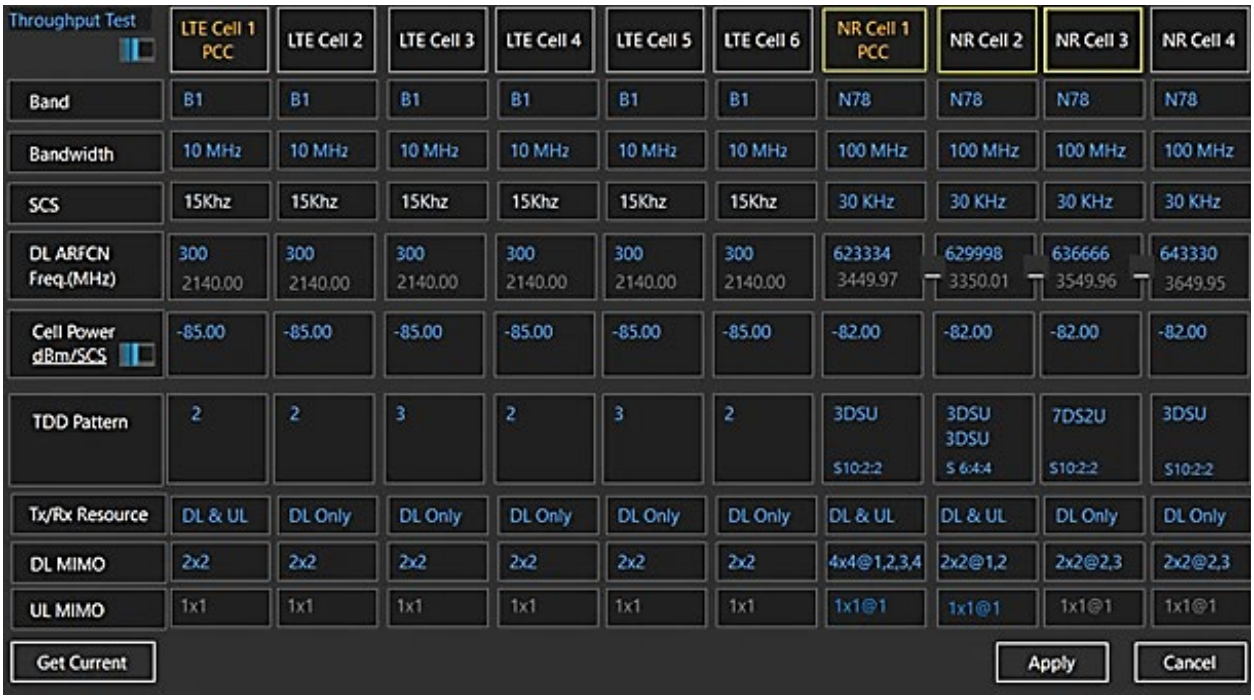

Figure 9. Configure multiple aggregated cell parameters

Establish voice connections

Making voice calls with a mobile device is one of the most common use cases. Many algorithms are used to code and decode (codec) voice into data for transmission and reception. The S8714A RA uses its built-in IMS server and client with selectable codecs to emulate a voice call with a device.

Develop tests to verify new and modified designs

Design verification test is another area where RF test is important. The design is verified against internal and external specifications. Regression testing, where an existing design's RF performance is verified after new enhancements or modifications, requires automation because tests are typically performed over many hours or days.

The S8714A RA is a fast and stable solution for manual and automated RF testing. Use the built-in, pre-configured 3GPP tests or verify more general RF performance using configurable measurements such as channel power, ACLR, SEM, and EVM. Quickly develop automation within the S8714A RA with simple SCPI or verify design performance using specific 3GPP tests with the S8702A RFA.

Configure parameters for SAR testing

Another phase in device development is acceptance testing. Verifying a device's SAR performance is one part of device acceptance. SAR test conditions are defined by regulatory groups in each country or region. The S8714A RA makes SAR configuration easy with selections for specific conditions defined by region (Table 7). Testing SAR performance under maximum throughput conditions is another pre-configured selection.

Table 7. S8714A RA SAR test selections

SAR Test Selection	Country and Duty Cycle
KRDC23MS2P5	Korea 23%
USDC25MS5	USA 25%
CNDC33MS5	China 33%
CNDC63MS2P5	China 63%
EUD30MS2P5	EU 30%
JPDC50MS2P5	Japan 50%
DC23MS5	23%
CMCCN79V1	CMCC
CMCCN79V2	CMCC
CMCCN41	CMCC
CTCUN78	CT & CU
RMCMU0	RMC SCS 15 kHz
RMCMU1	RMC SCS 30 kHz
TPUT8D1UV1	Maximum DL throughput

Keysight Solutions Test the Device Workflow

Optimized for speed, Keysight's S8714A UXM 5G RF Application is designed for RF testing with intelligent signaling and efficient usability. Reduce time to market with this essential solution for RF verification of 5G NR devices.

Running on the first-to-market UXM 5G platform, the S8714A RA is an important solution in Keysight's device test portfolio (Figure 10).

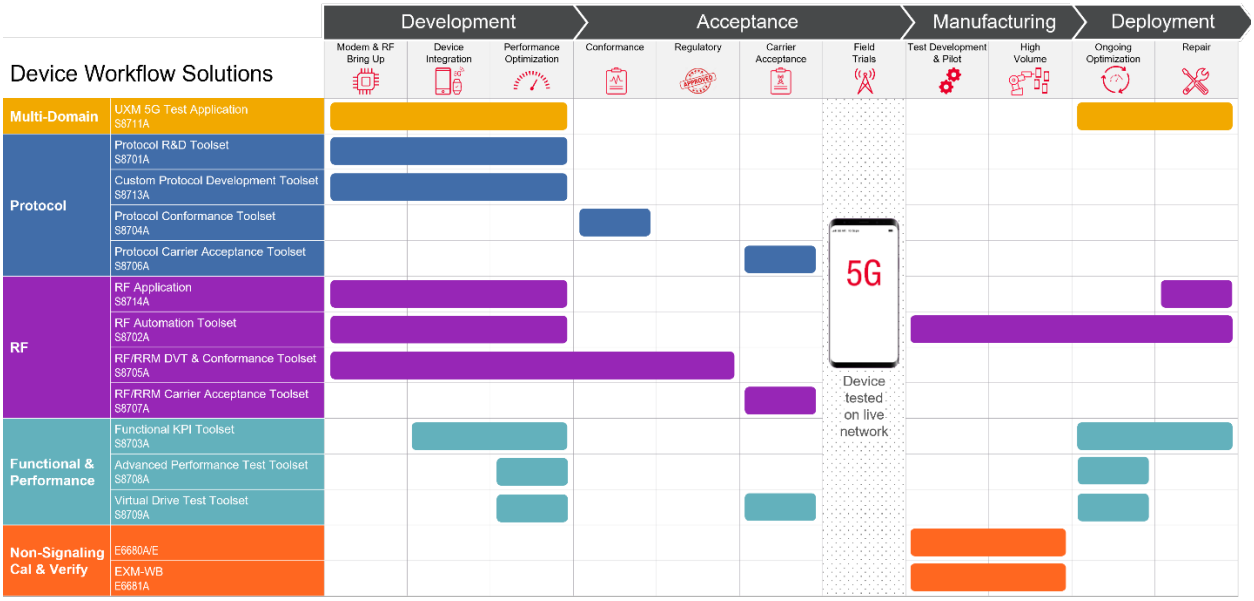

Figure 10. 5G network emulation solutions

For more information about

- the S8714A RF Application, visit www.keysight.com/find/uxm5gra.
- the S8702A RF Automation Toolset, visit www.keysight.com/find/rfa.
- the S8711A Test Application, visit www.keysight.com/find/uxm5gta.
- 5G device test solutions, visit www.keysight.com/find/5gnes.
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