TECHNICAL OVERVIEW

S8803A Massive MIMO Base Station Fading Performance Toolset

Introduction

5G base station products are flexible to deploy and reconfigure, and most importantly, can deliver a huge capacity to end users. Massive multiple-input, multiple-output (MIMO) is the key technology in delivering the promises of 5G because of the drastic improvements it offers in throughput and efficiency.

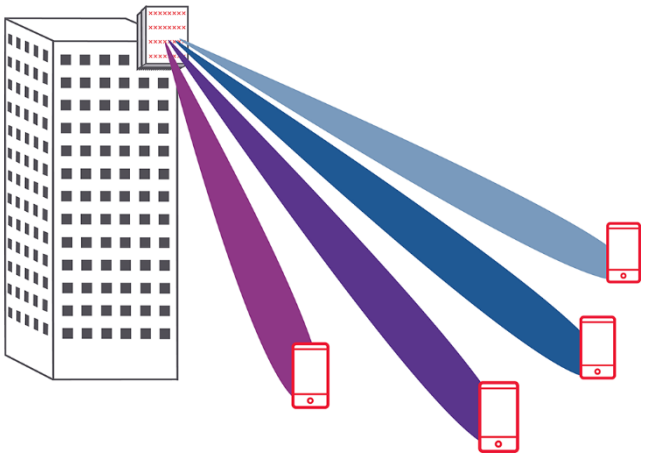

Figure 1. Multi-user massive MIMO scenario, multiple users in different beams

The actual gain provided by massive MIMO is affected by many factors, such as the capability to perform successful beam precoding for multiple users in different directions (see Figure 1), and the way that the user equipment's (UE) movement and interference is managed. Any issues in these factors can be observed as degraded and unstable data performance, which is why profound testing is essential.

Validate and optimize your base station designs prior to market launch with the S8803A Toolset:

- Emulate up- and downlink massive MIMO channels in real time

The toolset is extendable to:

- Measure SU/MU-MIMO downlink RF beams with an embedded multi-port signal analyzer
- Test SU/MU-MIMO uplink RF beams with an embedded multi-port signal generator
- Analyze and debug up- and downlink SU/MU-MIMO L1/L3 signaling with an integrated RF sniffer
- Test key performance indicators, such as multi-user data throughput in an instant

KEYSIGHT TECHNOLOGIES

What is the S8803A Massive MIMO Base Station Fading Performance Toolset?

The testing of massive MIMO base stations requires an advanced laboratory test setup that is capable of measuring and processing phase and time coherent RF signals across all transmit and receive antenna ports of the massive MIMO radio unit simultaneously and in real time. Keysight's S8803A Massive MIMO Base Station Fading Performance Toolset fulfills these testing requirements, providing a fully integrated and automated turn-key testing solution for 5G base station and Open RAN (O-RAN) massive MIMO interoperability and performance verification and optimization. It integrates the base station, several real UEs, and channel emulation together with full test automation.

The toolset supports single- and multi-user uplink/downlink (UL/DL) data performance testing and MIMO technologies, such as PMI feedback, uplink sounding reference signal (SRS), and open loop testing. It also enables network equipment manufacturers and mobile network operators to test and optimize the functionality of network equipment against ready- and custom-made test cases as well as field measurement -based scenarios in a lab environment.

For R&D and pre-conformance testing, the toolset optionally supports:

- Downlink (TX) and uplink (RX) in-band RF measurements with an embedded multi-channel signal analyzer and signal generators.
- Uplink (RX) fading demodulation tests with an integrated multichannel signal generator.
- Massive MIMO uplink and downlink 2D and 3D beam measurements (from 8TR up to 64TR).
- L1/L2 test implementation with an embedded multi-channel signal analyzer & signal generation.
- Embedded RF sniffing and analysis tools for full-stack testing

Testing can be replayed in an automated 24/7 controlled laboratory environment with all testing tools. Both basic and advanced debugging is therefore possible, including channel parametrization.

The S8803A Massive MIMO Base Station Fading Performance Toolset is a part of Keysight's comprehensive portfolio of base station testing solutions.

Who benefits from using the S8803A toolset?

- Network equipment manufacturers including O-RAN radio unit manufacturers to
  - test and verify RF characteristics of RF beams in uplink and downlink (RF, L1/L2)
  - test and validate new 5G features and bug fixes
  - test, validate, and optimize base station performance in fading RF channel conditions
- Mobile network operators to
  - validate and optimize network equipment manufacturers' base station functionality and performance parameters in fading RF channel conditions
  - benchmark base station manufacturers' product performance
  - verify new network radio units prior to market launch and assure radio units' interoperability with the local network configuration
- Related ecosystems (test houses and system integrators) to
  - test, optimize and benchmark base station manufacturers' product performance and interoperability
  - verify new network radio units prior to market launch and assure the interoperability of radio units with the local network configuration

What does the S8803A toolset offer?

- A fully automated end-to-end toolset for base station massive MIMO testing, verification, and optimization
- An integrated framework comprising a massive MIMO base station, a channel emulation solution, real UEs, and automated 24/7 testing
- Test scenario and test case packages covering peak and average data throughput and link performance testing for both uplink and downlink directions for single and multi-user testing. Separate UL, DL, and combined UL/DL testing is supported under clean channel and 3GPP (TR38.901) specified fading conditions.
- GCM Channel Studio tool for custom test case creation
- RF Field-To-Lab tool bringing real-world RF conditions to the testing workflow in a laboratory
- Real 5G reference devices and test equipment for single- and multi-UE testing
- The possibility to replay testing in an automated 24/7 controlled laboratory environment with all advanced testing, KPI reporting, and debugging tools
- For multiport RF measurements: embedded PathWave Signal Analyser 89600 and PathWave Signal Studio for up to 64 ports simultaneously
- For downlink and uplink protocol analysis: embedded WaveJudge Wireless Analyzer Toolset
- UE trace log analysis with the 5G Device Analytics toolset

5G O-RAN Network Elements - End-to-End Performance Verification

The S8803A Massive MIMO Base Station Fading Performance Toolset is a part of Keysight's end-to-end O-RAN architect wireless network testing portfolio (see Figure 2), providing fading performance testing tools for massive MIMO base stations.

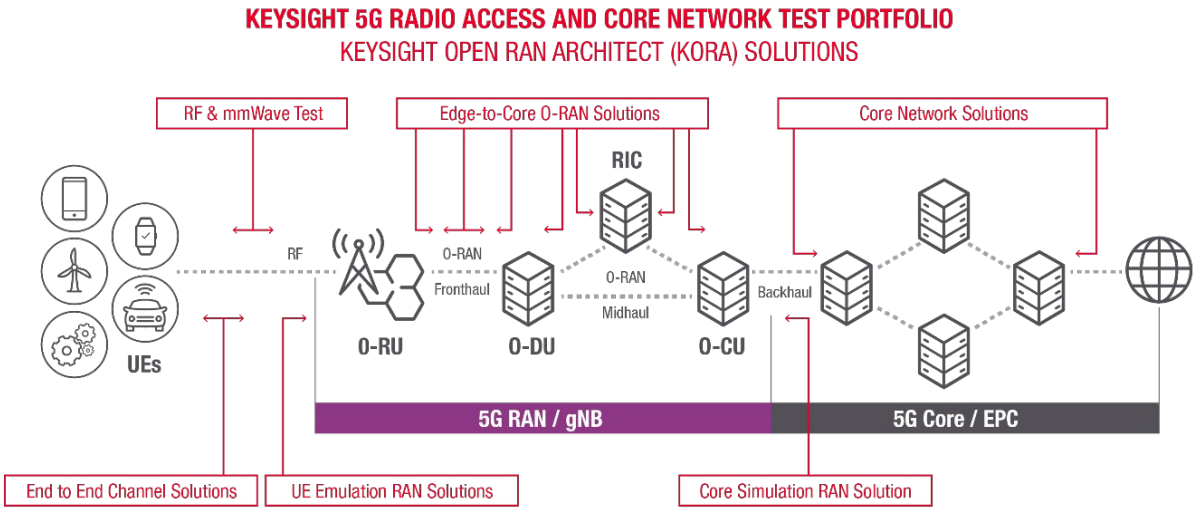

Figure 2. Keysight's 5G radio access and core network test portfolio

Keysight's O-RAN Architect offers integrated solutions that accelerate the development, integration, and deployment of O-RAN compliant equipment. The suites are tailored for the supply chain workflow. You can uniquely access a common set of solutions to simplify the sharing of results across the workflow from pre-silicon to cloud deployments.

The S8803A toolset is a part of network equipment manufacturers', mobile network operators' and Open Test and Integration Centers' (OTIC) testing suites that validate real-world data throughput, mobility performance, and interoperability.

Hardware Components

Advanced massive MIMO testing

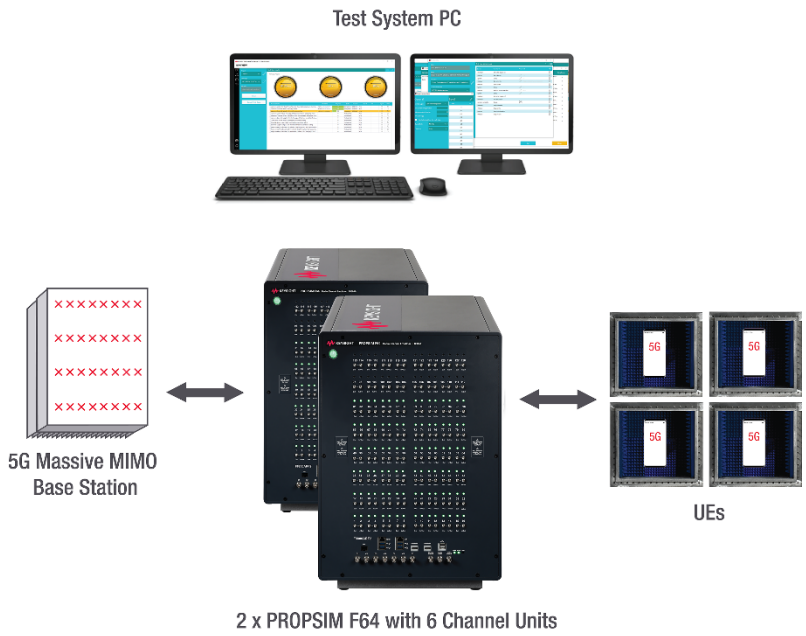

Figure 3. Advanced 64T64R Massive MIMO base station testing setup with four 4x4 MIMO UEs

Keysights' S8803A Massive MIMO Base Station Fading Performance Toolset supports different types of massive MIMO base station configurations. The S8803A toolset supports massive MIMO base station testing with:

- 16, 32, and 64 antenna ports
- 4, 8, and 16 spatial layers with a single PROPSIM F64 unit

Figure 3 illustrates a 64T64R antenna port massive MIMO base station testing configuration with 16 spatial layers and Figure 4 illustrates a 32T32R antenna port Massive MIMO base station testing configuration with 8 spatial layers.

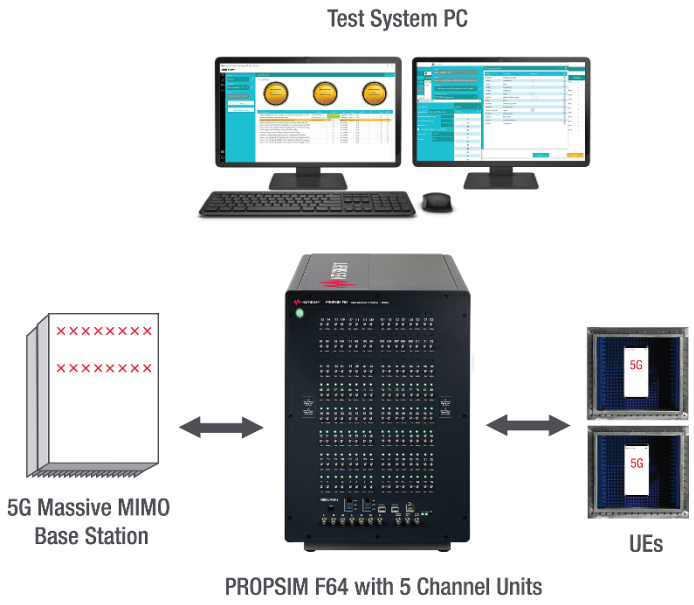

Figure 4. Advanced 32T32R Massive MIMO base station testing setup with two 4x4 MIMO UEs

Massive MIMO testing with antenna interface units

Massive MIMO testing demands a high number of RF ports, resulting as an increased complexity of the lab test setup. Keysight's Antenna Interface Unit (AIU) can be used to reduce the amount of required fader RF ports by combining an elevation or azimuth co-polarized antenna elements in one RF port. Figure 5 illustrates how the S8803A Massive MIMO Base Station Fading Performance Toolset with an AIU solution can meet the market requirements with a single PROPSIM F64 unit and enable testing a full 64T64R massive MIMO base station.

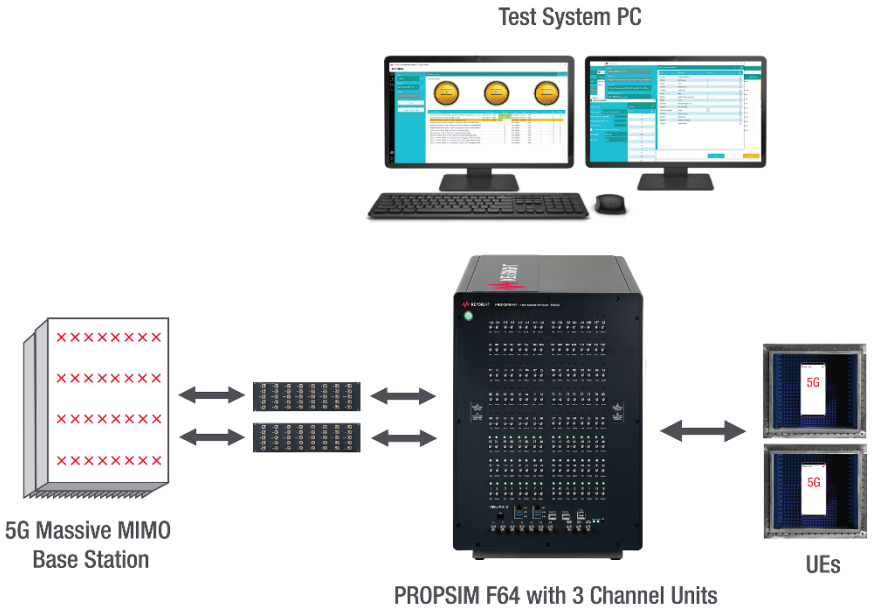

Figure 5. 64T64R Massive MIMO base station testing setup with two 4x4 MIMO UEs using antenna interface units

Key Software Components

Performance Test Manager

The optional F9340A Performance Test Manager (PTM) enables fully automated end-to-end laboratory testing with real applications. PTM controls UEs and channel conditions created by PROPSIM during test runs and collects KPI data from UEs. With ready-made or user-defined test scripts, you can create a variety of test cases. PTM also generates test cases based on the information measured in the field with the Field-to-Lab feature. Moreover, PTM generates a textual report of each test case from the selected KPIs.

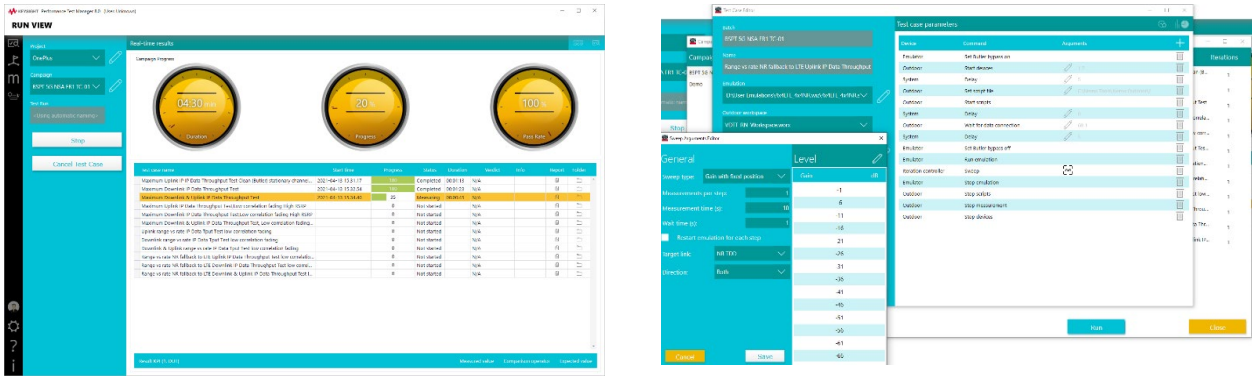

Figure 6. The user interface of F9340A Performance Test Manager

Ready-made verified massive MIMO test cases and test scenarios

The optional ready-made and verified massive MIMO test case packages support 64T64R, 32T32R, and 16T16R massive MIMO base station testing for single and multiple users and with 4, 8, or 16 spatial MIMO layers. The test cases cover peak and average data throughput testing and link performance testing for both uplink and downlink directions. Separate UL, DL, and combined UL/DL testing is supported under clean channel and 3GPP (TR38.901) specified fading conditions. The test cases include both static and dynamic scenarios as listed below:

- Stationary and dynamic/moving Urban Micro (UMi) and Urban Macro (UMa) outdoor street canyon performance test cases
- Single- and multi-UE maximum data throughput test cases with clean channel conditions
- Sector angular coverage test cases
- Near-Far / link range performance test cases

The 5G NR FR1 Massive MIMO test scenario packages offer pre-defined test scenario models for your own test case creation.

GCM Channel Studio

The optional F9860A GCM Channel Studio tool for custom-made channel model creation with the Antenna Array Tool options, enables creating customer-specific channel models. Dynamic modelling capabilities include mobile speed, multipath profile, range delay, and base station antenna correlation. The other parameters include interference and distant propagation path reflections to the device.

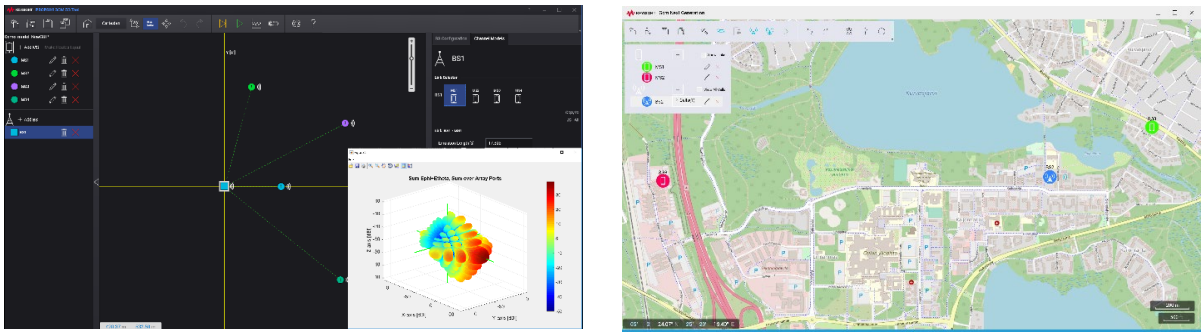

Figure 7. The user interface of F9860A GCM Channel Studio

RF Field-to-Lab Channel Studio

The optional RF Field-to-Lab Channel Studio tool brings field-measured RF conditions to the lab testing environment. With the RF Field-to-Lab tool, you can easily bridge the gap between lab and field testing under realistic air-interface conditions through seamless real-world representation of the environment. The RF Field-to-Lab tool offers a repeatable and realistic lab-based test method that enables you to cost-effectively and quickly verify multiple designs or multiple revisions of a single design. You can also build a library of RF Field-to-Lab test cases containing data measured in various locations around the world.

The RF Field-to-Lab tool imports radio channel parameters (e.g., Cell ID, RSRP, SNR, and MIMO correlation) from the measurement files to create a channel model for the channel emulator. It delivers a reliable replication of recorded field conditions without the need for additional modeling or user input.

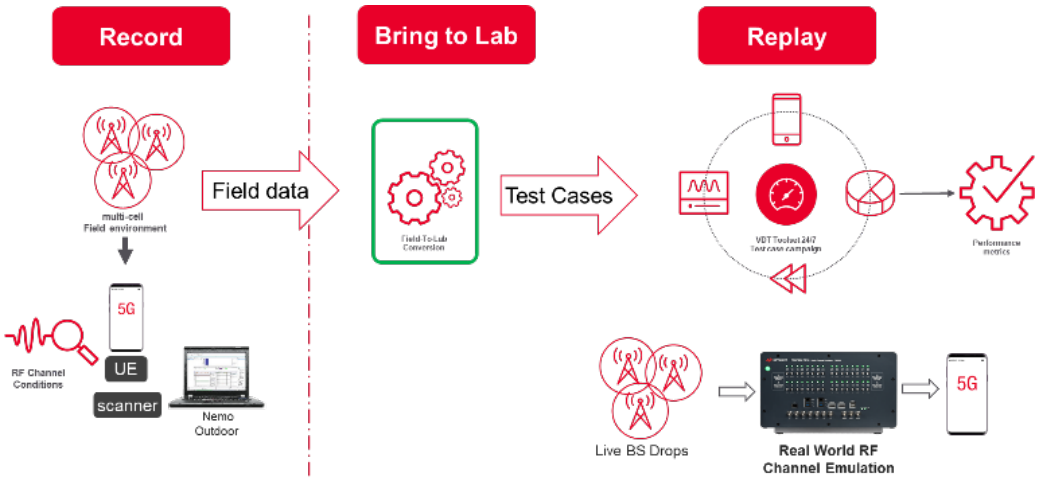

Figure 8. The F9340A100 RF Field-to-Lab tool brings field-measured RF conditions to the lab testing environment

Optional Keysight tools for deeper analysis and issue solving

When integrated with the S8803A toolset, the following optional tools provide you with more data for deeper analysis and issue solving.

The NTL50000A 5G Device Analytics tool is an in-depth troubleshooting, benchmarking, and analytics software for analyzing 5G chipset and device trace logs in lab.

With the PROPSIM signal capture feature, you can capture raw IQ data from PROPSIM inputs and save it into the desired location in a text or binary format. 16TR, 32TR and up to 64TR port massive MIMO measurements are supported.

With the PROPSIM signal streaming feature, you can stream IQ data created with additional signal studio software. This way PROPSIM can playback 3GPP 5G NR and self-designed waveforms.

The 89600 PathWave VSA software solution performs a vector signal analysis to visualize signal quality with multiple domain traces in time, spectrum, and modulation based on PROPSIM-captured uplink and downlink IQ data files.

The N7631 PathWave Signal Studio solution enables you to generate, export, download, and playback 3GPP 5G NR (New Radio) waveforms with the PROPSIM platform. PathWave Signal Studio enables flexible signal configuration with both single-carrier and multi-carrier support.

The SJ001A WaveJudge Wireless Analyzer Toolset allows design and verification engineers to gain visibility into protocol and physical layer interaction in wireless transmissions. The toolset also combines a powerful over-the-air communications analysis, real-time protocol decoding and a PHY analysis. It is an essential tool for troubleshooting 5G network performance issues between devices and base stations in development and deployment using PROPSIM-captured uplink & downlink IQ data files.

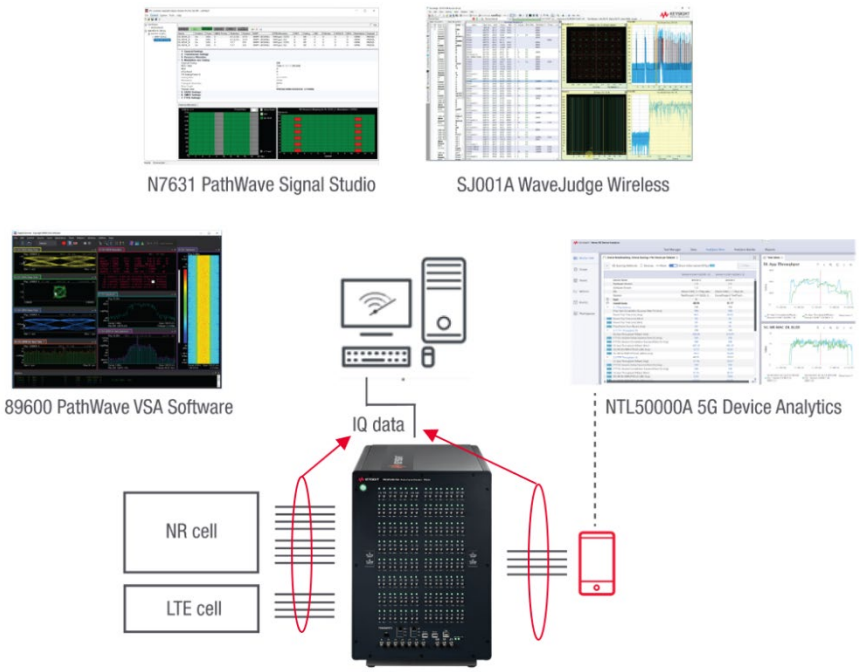

Figure 9. Optional Keysight tools for Massive MIMO issue solving

Custom test case creation

With the S8803A Massive MIMO Base Station Fading Performance Toolset, you can verify base station data performance under static and mobile test conditions, as well as validate device maximum data throughput performance under TDL-x and CDL-x channel models defined in the 3GPP 38.901 standard. The toolset supports a predefined set of data throughput test cases supporting NR FR1 together with LTE for NR standalone and non-standalone testing in sub-7 GHz frequency ranges. Base station performance can be verified across different massive MIMO configurations. Keysight's GCM Channel Studio tool enables you to create custom scenarios on top of the verified performance test cases. With the GCM Channel Studio tool, you can create different massive MIMO antenna arrays and device antenna beam patterns.

Validated 5G reference UEs for testing

Keysight provides a wide variety of 5G reference devices for base station performance testing. The list of support devices is growing rapidly as new user devices are launched. The supported devices are equipped with latest chipsets, such as the Qualcomm X50/X55/X60 and Samsung Exynos 5100/5123. The 5G reference devices for sub-7GHz testing are delivered with the RF cabled option.

Keysight 5G Solutions

Keysight's 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 offers common software and hardware platforms compliant to the latest 3GPP standards enabling the ecosystem to quickly and accurately validate 5G. You can test 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.

- For more information about PROPSIM Base Station Fading Performance Testing, visit keysight.com/find/propsim/basestationtesting
- For more information about Keysight KORA solutions, visit keysight.com/products/network-test/radio-access-core-network-test
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KEYSIGHT TECHNOLOGIES

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