

## CASE STUDY

# Winning in 5G with Rapid Characterization of Evolving Antenna Designs

## Keysight Success Stories: 5G mmWave Phased-Array Antenna Testing

In multiple product categories, the race is on to be first to market with 5G devices. Ultimately, the 5G future will include new experiences enabled by ultra-high data rates and reliability, and ultra-low latency and energy requirements. These goals depend on advanced phased-array antennas capable of implementing innovative technologies such as massive multiple-input/multiple-output (MIMO) and beamforming. To compound the challenge, the antenna arrays will handle digitally modulated signals operating at millimeter-wave (mmWave) frequencies. Collectively, these changes have major implications for the process of designing and testing antenna arrays.

Developers at a U.S. manufacturer of components for aerospace and defense applications faced this situation. The company aimed to be first to market with a 5G antenna providing 1 GHz of bandwidth in specific mmWave bands of the 5G frequency allocations. Achieving this goal required a major change in the manufacturer's antenna testing process, including a shift to over-the-air (OTA) characterization using signal generation and signal analysis at mmWave frequencies. Keysight provided the tools the design engineers needed to characterize the digitally modulated signals that mmWave phased arrays generate over the air.



### Organization

- Component manufacturer, A&D

### Challenges

- To be first to market with a 5G antenna that provides 1 GHz bandwidth at mmWave frequencies
- Characterizing phased-array antennas using complex 5G signals

### Solution

- Keysight 5G waveform generation and analysis testbed with benchtop signal analysis

### Results

- Proving design performance with accurate, repeatable OTA measurements (achieved 1% EVM performance)
- Rapidly revising antenna designs to meet the specific needs of individual customers



## The Challenge: Characterizing Array Performance

The engineering team of a U.S. manufacturer of components for the aerospace and defense industry leveraged its expertise to begin developing a 5G antenna with 1 GHz bandwidth in the mmWave bands. One crucial goal was to enable fine-tuning of antenna performance through rapid design changes to address the specific needs of customers developing 5G devices. Device makers need new antennas designs that provide reliable and high-speed connections. The team needed a way to fully characterize the transmit and receive paths to understand and prove the performance of each design variation. OTA testing techniques were necessary because the antennas operate at mmWave frequencies.

Prior to the 5G program, the development team validated antennas in a test chamber using a vector network analyzer (VNA). However, the signal generator in the VNA was not capable of producing 5G New Radio (NR) waveforms carrying digital modulation. Applying realistic 5G NR signals is essential to fully characterizing antenna and array performance.

## The Solution: Adapting and Applying a 5G Testbed

The local Keysight team introduced the company's developers to the Keysight 5G waveform generation and analysis testbed (Figure 1). This is a reference solution that can meet a wide range of test requirements, including 5G NR (3GPP), pre-5G (5G Technical Form), and custom orthogonal frequency-division multiple access (OFDMA) waveforms.



**Figure 1.** This configuration of the 5G testbed supports 3GPP NR signal creation up to 44 GHz (lower left) and includes benchtop spectrum analysis up to 50 GHz (right), both with integrated 1 GHz bandwidth

Simulation and verification through real-time beamforming and beam tracking were essential capabilities for this use case to simulate real-world environments. RF channel in-phase/quadrature (I/Q) constellation, error vector magnitude (EVM), antenna pattern, and beam width were crucial measurements. EVM is an industry standard for signal quality used to measure the performance of an RF signal. More stringent specifications for RF performance increase the importance of EVM measurements, particularly in R&D and design validation.

The solution includes Keysight hardware and software elements for signal generation and signal analysis. The system uses a Keysight M9383A PXIe microwave signal generator and Keysight Signal Studio signal-creation software to produce 5G NR signals. The M9383A provides 1 GHz bandwidth across a frequency range of 1 MHz to 44 GHz. Developers download 5G NR signals created in Signal Studio to the M9383A. During testing, the M9383A connects directly to the antenna array under test, and the resulting signal is beamed at the signal analyzer.

For signal analysis, the solution includes a Keysight N9040B UXA signal analyzer and Keysight 89600 VSA software. An antenna connected to the UXA provides the input signal. The 89600 VSA software enables demodulation and detailed analysis of 5G NR signals, including EVM, which is the key figure of merit for measurement quality. Different views make debugging easier accelerating development time to be first to market.

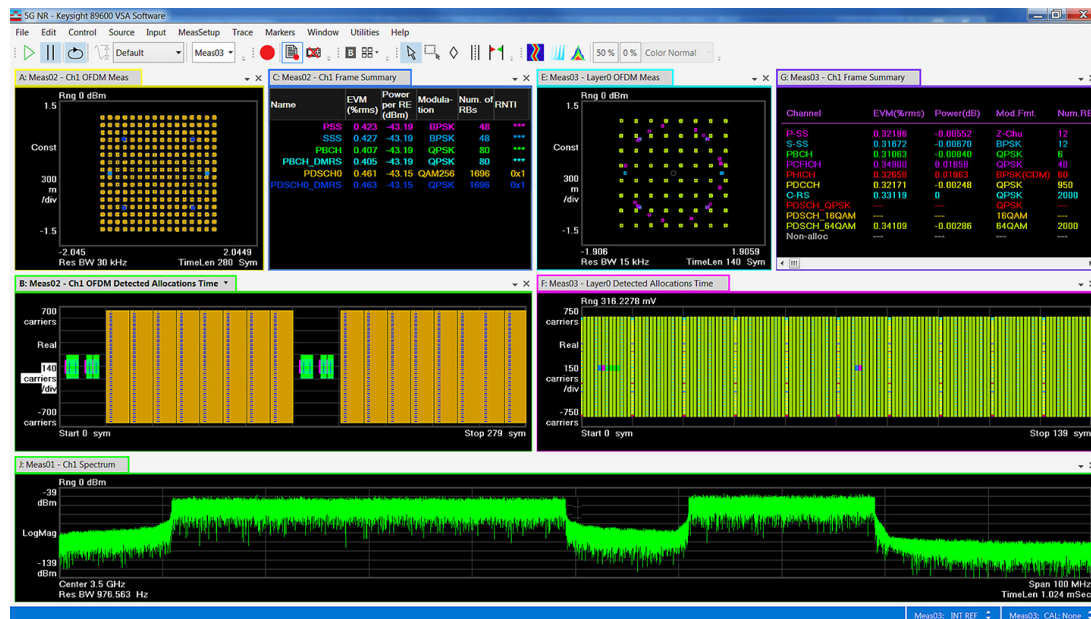


Figure 2. In this side-by-side multi-measurement display, the Keysight 89600 VSA software shows demodulation of 5G NR and LTE carriers

## The Results: Rapidly Characterizing Revised Designs

Using the Keysight 5G testbed, the component manufacturer's engineers were able to perform accurate and repeatable OTA testing using 5G NR signals. One exceptional result: the testbed can measure 1 percent EVM in the OTA configuration. This enables the company to show its customers the true performance of each 5G phased-array design.

Additionally, the testbed enables the creation of real-time 5G signals and instantaneous measurements of the transmit/receive channel. With these capabilities, the component manufacturer achieves complete test coverage, meet 5G device makers' need for more performance, and can make rapid design changes in response to evolving requirements.

## Going Forward

The future success of 5G depends on speed, whether it is in the creation of devices, the deployment of networks, or the performance of those devices and networks. In the run-up to 5G, the faster component manufacturers respond to multiple unique requirements, the faster their customers launch devices. Keysight's solutions equipped this component manufacturer to achieve this goal. For example, the company introduced a development tool to help its customers accelerate their own projects.

## Related Information

- **Brochure:** [5G Waveform Generation & Analysis Testbed, Reference Solution](#), publication 5992-1030EN
- **Data Sheet:** [M9383A PXIe Microwave Signal Generator](#), publication 5992-1928EN
- **Brochure:** [Simplify Signal Creation with Signal Studio Software](#), publication 5989-6448EN
- **Data Sheet:** [UXA X-Series Signal Analyzer, Multi-touch N9041B](#), publication 5992-1822EN
- **Brochure:** [89600 VSA Software — See Through the Complexity](#), publication 5990-6553EN

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