Multiple-input/multiple-output (MIMO) technology can provide communications networks with increased data throughput and high data integrity through path diversity, spatial multiplexing and beamsteering/beamforming techniques. The improved antenna gain overcomes path loss, enabling higher data rates per hertz compared with an isotropic signal at the same power.

Full Dimension MIMO (FD-MIMO) is already under development, progressing toward standardization by the 3rd Generation Partnership Project (3GPP) for LTE-Advanced Pro. The application of beamforming in both azimuth and elevation enables a base station to steer its signal to a specific user.

The use of antenna arrays for beamforming is well established in radar and communications applications. The relative amplitude and phase of the multiple transmit signals are dynamically adjusted at each antenna element to create the desired beam pattern. Different base station architectures apply the beamforming algorithm in different ways. For example, relative phase and amplitude differential could be applied at different stages of the transmit chain, either at the RF, at baseband, or a combination of both. The signal conditioning can be accomplished in different domains – analog, digital or a hybrid of the two.

Operational performance and end user experience will be dependent on the system working to design limits. This requires characterization of signal quality in 3D space. As a starting position, it will be necessary to characterize relative amplitude, phase and delay variations across all transmit elements.

Keysight Technologies can help you take the lead - from evolution to revolution to reality. Gain the advantage from Keysight’s ongoing collaboration in wireless research and standards setting. This expertise is swiftly embodied into Keysight test solutions, tuned for next-generation technologies.
MIMO Beamforming Design and Verification Challenges

As MIMO extends to full-dimension azimuth and elevation beam steering with 64, 128 and more antenna elements, both practical and comprehensive measurement techniques are needed to verify designs and qualify products.

**NEED**
Exploration of beamforming performance and signal quality in 3D space.

**CHALLENGE**
Complexity of combining multiple measurements through hardware and software.

**SOLUTION**
Keysight signal analysis software continues to keep pace with the communication standards – from single channel to MIMO to FD-MIMO measurements, including 3D visualization and parametric analysis in azimuth and elevation.

**NEED**
Tight amplitude, phase and timing requirements for signals at every element of the active antenna system.

**CHALLENGE**
Difficult to achieve by design, to satisfy all operating conditions, therefore requires determination and application of correction factors.

**SOLUTION**
Keysight enables you to measure actual performance, accurately set the correction factors and verify design goals are met.

**NEED**
Calculate correction factors by reliably characterizing physical layer performance of signals driving each antenna element.

**CHALLENGE**
Accurately probing multiple ports requires metrology expertise to deliver cross-channel calibration at the measurement plane.

**SOLUTION**
Keysight provides embedded calibration expertise, providing known measurement tolerances right at the point you connect your device.

**NEED**
Efficiently capture physical-layer performance of signals driving each antenna element.

**CHALLENGE**
Probing an RF signal at every element of an antenna array simultaneously can quickly result in an expensive and bulky test solution. Sequential probing keeps down capital cost, but drives up test time.

**SOLUTION**
Keysight solutions scale easily to multi-channel measurements while minimizing the total cost of test. Choose from our extensive portfolio to optimize for throughput and size, while maintaining a path to new radio technologies.
Solutions for MIMO Characterization and Verification

Keysight Technologies is uniquely positioned to help you improve your time-to-insight while keeping your total cost of test under control. Our MIMO test solutions are highly scalable with comprehensive measurement capability based on 3GPP specifications.

With the introduction of beamforming, and as the number of antenna elements increases, verification of base-station performance becomes increasingly complex. Multi-channel measurement solutions based on traditional bench-top instrumentation are no longer practical or efficient, and new methods are required to ensure reliable and repeatable characterization right to the measurement plane. Keysight solutions scale to the large port-count required for MIMO antenna arrays, incorporating novel techniques to improve measurement accuracy and repeatability.

Keysight multi-channel, phase coherent test solutions can be customized to quickly and precisely align antenna elements in an active array, both in phase and amplitude. A range of modular components make it easy to scale to the number of elements being tested in the array. Further, it provides parallelism to the test process that increases test throughput.

In addition to capturing raw measurements, you can use Keysight’s industry-leading analysis software to turn data into meaningful visualizations and parametric measurements, in 3D space. With this independent verification solution, you can be confident that your system performance is meeting or exceeding design goals.

Improve your efficiency, confidence and time to market

Move quickly through verification – let Keysight take care of test development and test optimization:

- Significantly drive down your total cost of test for multi-channel measurement.
- Rapidly verify your beamforming algorithms and hardware performance.
- Build confidence through use of an independent measurement-grade verification toolset.
- Purchase only the functionality you need now.
- Expand or upgrade later, as cellular technology evolves through 5G.

Validate your MIMO system performance

A comprehensive measurement suite enables you to quickly verify base-station design goals are being met or exceeded:

- Evaluate true DUT performance, corrected for fixturing offsets.
- Reduce time to insight with ready-to-use LTE performance tests and 3D beamforming visualization.
- Measurement science based on industry-leading VSA software.
- Fast and repeatable capture with parallel signal acquisition.
- Adaptable to meet the demands of new radio access technologies, ahead of standardization.

Tailor to your unique requirements

Test capability can be configured and customized for your application. The following indicates a range of available options:

- MIMO and beamforming analysis from 8/16/32/64 (and more) antenna elements.
- Physical layer capture from 6 GHz, 160 MHz bandwidth to 40 GHz, 1 GHz bandwidth phase-coherent channels.
- Configure for different antenna array topologies and element spacing.
- 3D beam pattern visualization with marker-based measurement on and around the peak beam.
- Per-layer modulation quality plus amplitude, phase, and time offset.

Example Configurations

LTE FD-MIMO Downlink Measurement Suite, to 6 GHz

- Vector Signal Analysis (VSA) software
- Multi-element antenna configuration and visualization
- Narrowband system calibrator/optimizer
- PXIe Measurement Receivers, 6 GHz, 160 MHz bandwidth

5G/LTE FD-MIMO Downlink Measurement Suite, to 40 GHz

- Vector Signal Analysis (VSA) software
- Multi-element antenna configuration and visualization
- Wideband system calibrator/optimizer
- AXIe Measurement Receivers, 40 GHz, 1 GHz BW

At Keysight we continuously develop our test methods to offer solutions that carefully balance cost, coverage and measurement times. In design and test, our solutions help you innovate across new and existing technologies as you transform ideas into reality. Keysight’s industry-leading solutions provide meaningful results, fast. Contact us to learn how we can help you take the lead toward next generation wireless.

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