Maintain consistent test results while choosing the best signal generator or signal analyzer for each phase of your electronic product development lifecycle. Proven Keysight RF/μW measurement software enables measurement consistency when used with Keysight's benchtop and modular signal generators and signal analyzers.
Introduction

Fundamentally, RF/μW test is growing in complexity. Modern radio systems implement sophisticated multiplexing and transmission schemes - with increased modulation complexity, number of channels, wider bandwidth and more. All of these systems require high performance, complex signal testing throughout their development cycle, from basic signal quality, such as power and distortion, to advanced modulation analysis and verification.

Test strategies influence success in the design and manufacture of electronic devices, not to mention product quality and time to market. However, even with the most well thought out test strategy, getting consistent measurement results can be a challenge. Some engineering teams may elect to use the same type of test instruments from R&D through manufacturing in order to maintain measurement consistency. Others select the best equipment for a specific test need and then spend time reconciling differences in test results generated by equipment from different vendors and/or different instrument form factors. The challenge is to achieve reliably consistent measurement results while using the best instrument for a specific purpose.

This application note provides a no-sacrifice-required solution for achieving consistent measurement results that correlate across instrument types, throughout the product development cycle.
Problem: RF/μW Measurement Inconsistencies from R&D to Manufacturing

As a new electronic device moves through the development cycle, various instrument form factors from different vendors may be used to design and validate its performance based on the needs of a particular engineering group or stage of product development. While using different instruments to meet different needs brings obvious advantages, this could lead to measurement inconsistencies across the development cycle which need to be reconciled, slowing down time to market, decreasing throughput, and increasing design and production costs.

R&D, validation, and manufacturing teams may use different instruments and employ different test strategies. These differences along the product development lifecycle can result in different levels of accuracy and inconsistent measurement results as the product moves from one stage to the next. Measurements, based on the processing of samples, give meaningful information to the test engineer. If the samples and the algorithms used to process this data are not consistent throughout the product development cycle, the resulting measurements may be inconsistent. It may be difficult to identify the root cause of the inconsistency and lead to finger pointing between engineering teams. This results in wasted time and money spent reconciling discrepancies and/or tracking down the source of the inconsistency; not knowing whether it’s caused by the process, test operator, instrument, software, or the product itself.

Choosing the Best Instrument Through the Product Development Cycle

To accelerate the design process, it is critical to select the right instrument to address specific test needs throughout the product development cycle. Selection criteria include: performance specifications and characteristics, cost, size, speed, scalability, etc.

In general, purpose-built benchtop instruments are ideal when the test engineer needs to get the best performance out of a single instrument. Benchtop instruments are often used in the design phase because they typically include a front panel for analysis and debugging.

Modular instruments are ideal for multi-instrument and multi-channel applications where multiple instruments are combined into a single chassis to deliver a compact solution that takes up less floor space. While benchtop instruments are generally less expensive as a stand-alone item, modular solutions are less expensive when multiple instruments are combined into a single chassis since overhead costs can be spread across several instruments. Modular instruments are typically used in design validation or manufacturing due to their smaller footprint, high speed, and lower cost; but can also be used in R&D in the design of multichannel or MIMO (multiple input, multiple output) devices.
Application-specific requirements

A “one size fits all” approach to test instrument selection is a limiting value proposition. Test requirements not only differ based on the phase of product development (i.e., research, validation or manufacturing), they also differ by product type, as discussed below.

In manufacturing, for example, military radar equipment requires completely different test solutions than consumer products like smartphones and tablets. The quantity of units to be produced and the performance requirements the product must meet also influence the choice of test solution. A satellite payload, which costs several million dollars to manufacture and cannot be repaired in orbit, requires a higher quality measurement than a smartphone or tablet. The specifications regarding temperature, stability, repeatability, and accuracy will also be much more demanding for the payload than for the smartphone.

Because of this variation in performance and test requirements, selecting either a bench-top only solution or modular-only solution is not always the best answer. Instead, it may be optimal to select a hybrid of bench-top and modular instruments to meet specific test needs. In other words, use a benchtop solution for one phase of development (i.e., testing prototypes), and modular solutions for other phases (i.e., system verification), or in some cases, a combination of benchtop and modular in the same phase will be the best solution.

As an example, consider a scenario in which multi-channel requirements are important, but performance is also critical, as is the case with radar testing. Here, the best solution would be to test the microwave section of the radar using bench-top instruments and the baseband section using modular instruments.

Solution: Measurement Consistency Across RF/μW Instrument Form Factors

The RF/μW measurement inconsistencies resulting from using different instruments at different points of the product development cycle can be addressed by using the same measurement software applications in all phases of product development and manufacturing. This consistent measurement approach is enabled with Keysight’s broad modular and benchtop instrument portfolio based on common measurement science and algorithms.

By using RF/μW hardware and software based on the same measurement algorithms, engineers benefit from the ability to generate consistent measurement results with a familiar user interface and shared programming commands. Keysight’s portfolio of solutions that are based on the same measurement algorithms includes:

- Thoroughly specified RF and microwave signal analyzers and generators in benchtop and modular formats that enable engineers to implement test solutions with the optimal form factor for their specific application.
- A common suite of core measurement software with proven measurement algorithms that enable engineers to easily correlate test results between development, design validation and manufacturing phases, regardless of instrument.
- Measurement software solutions reduce the need for re-training or familiarization and also simplify measurement setup.

Realizing the value of consistent measurement algorithms

Measurement algorithms that are consistent across software applications and provide reliable, comparable measurements from the earliest stages of electronic device hardware and firmware design to volume manufacturing (Figure 1) aid the product development cycle in a number of ways.

Test solutions based on benchtop and modular (PXI and AXIe) hardware and compatible software that share the same measurement algorithms enable engineers to create best-in-class measurement solutions—whether benchtop-only, modular-only or a hybrid of the two, depending on the optimal approach for their specific application.

Figure 1. Proven Keysight measurement algorithms, shared across multiple hardware and software platforms, ensure reliable and comparable measurement results over the complete product development cycle.
Software solutions

Here are some examples of software solutions that ensure consistency when making complex measurements, regardless of instrument form factor or the product development lifecycle phase in which they are employed:

89600 VSA software

Keysight’s industry standard 89600 VSA software provides a comprehensive set of tools for RF/μW single or multi-channel demodulation and signal analysis. The 89600 VSA software can be used with a wide range of Keysight hardware platforms, including benchtop and modular signal analyzers, oscilloscopes, digitizers, and logic analyzers. It is possible to take advantage of the reliability of the algorithms at different stages of the signal path (e.g., digital and analog baseband signals, and IF and RF sections). Engineers can test signals wherever they are found and confidently compare their characteristics to signals at any other point, in whatever form -- baseband, RF, analog or digital -- that they appear.

Modular signal analyzers are easily scalable in situations where multi-channel testing is required. Benchtop analyzers running the 89600 VSA software can be linked together and coordinated to perform two-channel measurements, while modular analyzers can be used for even more channels. Because the 89600 VSA is hardware agnostic, it doesn’t matter if the signal analyzers are being used for single-channel or multi-channel measurements. This means that if test engineers are performing single-channel measurements and they want to migrate to multi-channel measurements, they can do so while continuing to use the same software.

X-Series measurement applications

The X-Series measurement applications focus on common and essential measurements for wireless communications standards such as LTE, LTE-Advanced, WLAN, and WCDMA. Measurement and display configuration is streamlined, leading to easier setup of measurements that are then straightforward to interpret. They are well suited to design verification and manufacturing applications where the RF tests are well defined and where speed and simplicity are paramount, as well as incorporation into automated test programs. The X-Series measurement applications have straightforward SCPI programming that is compatible across benchtop and modular platforms and provide standard setups, a range of graphic and tabular measurement results, and customized pass/fail testing.

Signal Studio software

To guarantee consistent signal measurements it is crucial to ensure consistency in the stimulus signals used in the device under test. Using Signal Studio software, Keysight-validated reference signals can be generated for both benchtop X-Series signal generators and modular RF sources. The same software can be used with similar SCPI commands to control both benchtop and modular signal generators. Signal Studio can be used to build waveforms and generate signals for a wide range of communications standards.

In R&D, best-in-class RF and microwave performance lets designers establish benchmarks for accuracy and precision. When transitioning to Design Validation (DV), they can leverage common and proven measurement science built into software applications, such as Electronic Design Automation (EDA) software often used in R&D, to define meaningful margins in DV test systems using Signal Studio software.

In the transition to manufacturing, system creators can accelerate test-plan development by leveraging test code developed in DV and using Signal Studio waveform packs to maintain measurement consistency. Common hardware architectures and measurement methodologies help them optimize the tradeoffs between size, performance, throughput, and more, on the production line.

Figure 2. 89600 VSA software, X-series measurement application and Signal Studio software for LTE/LTE-Advanced test.
Programming consistency

Along with measurement consistency, programming compatibility is essential for efficient testing of electronic devices using benchtop and modular solutions at multiple points in the product development cycle. Common Application Programming Interfaces (API) across multiple instruments not only facilitates the reuse of existing test code - saving test development time - but also contributes to measurement consistency, as the same set of test commands are executed on various instruments. Moreover, a common programming environment, such as Keysight’s free Command Expert software application, enables programming across different platforms. It provides fast and easy instrument control in many different PC application environments and combines instrument commands, documentation, syntax checking, and command execution all in one simple interface.

To illustrate the compatibility of command sets used in Keysight’s measurement applications across its benchtop and modular instruments, consider a set of SCPI programming commands used with a MXA benchtop signal analyzer, which are also executed with the modular M9391A PXIe VSA, as shown in Figure 3. When first run, the Command Expert software automatically recognizes the use of the modular instrument and flags a minor hardware change indicating that an attenuation setting should be changed to a range setting (Figure 4). All subsequent commands are executed without requiring a change. This cross-platform programming strategy speeds software development, while maintaining measurement consistency and also increases leverage and re-use.

Figure 3. The SCPI commands needed to perform a WCDMA EVM measurement with an MXA X-Series signal analyzer are shown in this screen from Keysight’s Command Expert software.

Figure 4. Initial execution of the same SCPI commands using the M9391A VSA.

Figure 5. Keysight’s driver and interface architecture for the M9391A PXIe VSA is compatible with multiple approaches to test executive programming.
Single and multi-channel solutions

RF testing of complex multi-channel systems can often be performed with 1 or 2 analysis channels using benchtop instruments. However, some specific tests require simultaneous measurements over a larger number of channels. A prime example is when working with LTE-Advanced MIMO and carrier aggregation configurations. Here, two-, four-, or even eight-channel solutions are needed to generate complex LTE-A multi-channel/MIMO waveforms and analyze multiple channels in the frequency and modulation domains simultaneously.

Modular solutions are a natural fit for the requirements of multi-channel system analysis, primarily because their structure enables channel coordination and transfer of multi-channel data. In addition, they provide easy timing analysis between channels and a re-configurable compact package, which is beneficial in parallel testing.

To guarantee measurement consistency from multiple channels, the 89600 VSA software can perform single and multi-channel measurements with both benchtop or modular PXI instrumentation.

To demonstrate measurement consistency using Keysight’s 89600 VSA and X-Series measurement application software, consider the complex digital modulation analysis of an LTE-FDD signal. The measurement results in Figure 6 were achieved using the LTE-FDD X-Series measurement application software and two different Keysight instruments—the M9391A PXIe VSA on the left and the N9020A MXA signal analyzer on the right. Note the consistency of the EVM measurements between the two. To demonstrate the consistency between the 89600 VSA software and the X-Series measurement applications, the same LTE FDD measurement performed using the 89600 VSA software is presented in Figure 7.

**LTE-FDD signal with PXI VSA**

![Figure 6](image_url)

**LTE-FDD signal with MXA**

![Figure 7](image_url)
The consistency of Keysight modulation analysis solutions applies equally to other signals as well. An example of a WLAN 802.11g signal is shown in Figure 8. The measurement on the left was made with the M9391A PXIe VSA, while the measurement on the right was made with the N9020A MXA signal analyzer. In both cases, the measurements of average RMS EVM are comparable.

WLAN signal with PXI VSA

WLAN signal with MXA

Summary

As an electronic product moves from early R&D through volume manufacturing, a number of different tests are required. Depending on the product and measurement application in question, a variety of instruments will offer the most appropriate test solution. Using different types of instruments may lead to inconsistent measurement results that cannot be easily compared across the product development cycle.

A common set of application software that can run on a wide portfolio of instruments, and which are based on a shared set of measurement algorithms, allow engineers to choose the best instrument for their application, while ensuring measurement consistency across the product development cycle. For test engineers and development teams alike, the benefits of measurement consistency are clear: reliable measurement results throughout the product development lifecycle. Measurement consistency means greater confidence in test results, more efficient product development, and greater confidence that when errors do arise, they are likely caused by the product under test, rather than inconsistent measurement results.
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