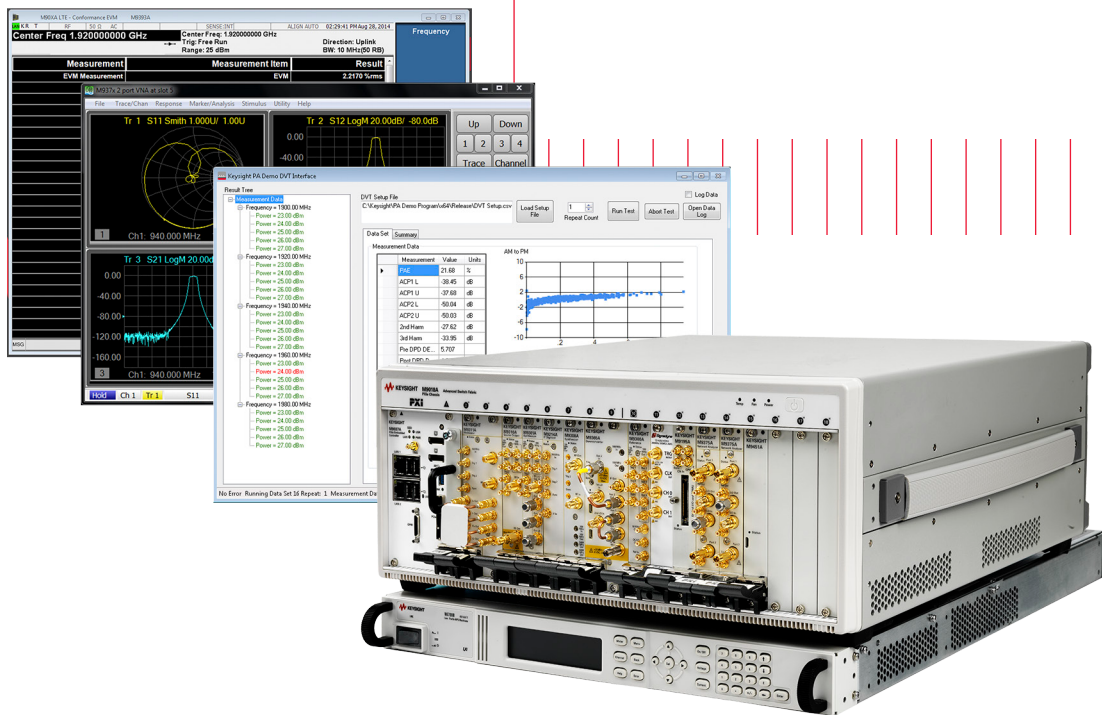


Keysight Technologies

Minimize Risk When Deploying or Updating RF Power Amplifier Test Systems

Reference Solution Case Study



Market Trends

Component and semiconductor manufacturing companies who build RF power amplifiers (PAs) and front-end modules (FEMs) for smart mobile devices are challenged to produce these complex products, often in large volumes, for a highly competitive market. These manufacturers are always looking for ways to drive down costs while improving the performance of their devices.

Because the PAs and FEMs must meet tight tolerances and specifications, testing plays a critical role in the manufacturing process. However, testing can become a production bottleneck as PA and FEM designs become more complicated and require an increasing number of tests.

Testing the latest generation of RF PAs and FEMs brings a host of new test requirements:

- Modern designs such as power amplifier duplex (PAD) modules integrate other components such as filters and duplexers, which must be tested along with the PA
- Techniques such as digital pre-distortion (DPD) and envelope tracking (ET) are used to overcome efficiency issues caused by high peak-to-average ratio modulation formats, and these techniques must be verified
- Higher numbers of frequency bands and modulation formats require additional test conditions.

To achieve greater measurement speed and throughput, many power amplifier manufacturers are evaluating modular test systems, which offer huge speed improvements in an automated test environment. Modular systems not only are fast, but they have the benefit of a small, more flexible instrument form factor that is adaptable to changing technology and provides relief on a crowded production test floor.

The Challenge

Moving to a new test platform involves a certain amount of effort and risk. The new system needs to be more than fast; it needs to deliver accurate, repeatable results and the advanced measurements, test capability, and performance that will meet the needs of a global manufacturer in a fast-paced market.

Evaluating a traditional test system built around benchtop instruments is relatively straightforward—typically the instrument front panels are used to set up the required measurements or some basic command software is generated using a common high level programming tool.

Evaluating a system based on modular instruments is not quite as simple. Developing test code requires low level programming expertise and a deeper understanding of the measurement science than a manufacturer may have in-house. Modular instruments do not have front panels for quick setup and troubleshooting, which can add time to the test development process. The manufacturer faces a sizeable software effort and could spend months or even years evaluating a system configuration that in the end is not suitable for the application.

Power amplifier manufacturers face some additional hurdles to incorporate specialized hardware and measurement techniques such as digital predistortion and envelope tracking into their systems. And once a system configuration has been evaluated and approved, it must then be seamlessly integrated into the overall production test environment, requiring further investment in programming and test application expertise.

The Solution

Keysight Technologies, Inc. has developed the RF PA/FEM Characterization and Test Reference Solution to help PA and FEM manufacturers quickly and cost-effectively evaluate and deploy design validation and production test systems. This market-validated solution for power amplifier testing combines Keysight benchtop, Keysight and non-Keysight PXI hardware, Keysight measurement software, and Keysight test expertise—in the form of optimized configuration, documentation, and programming examples. This helps manufacturers more rapidly configure and evaluate a test system to meet their specific requirements.

Keysight's application engineers, solution partners, or the manufacturer's own internal test groups then integrate the new hardware and software configuration into their larger production test system, incorporating additional hardware, test fixtures, and software as needed.

Reference Solution Features

The RF PA/FEM Reference Solution enables rapid, full characterization of power amplifiers and modules such as PAD devices with S-parameter, demodulation, power, adjacent channel power, and harmonic distortion measurements. DPD and envelope-tracking signal generation and analysis are enabled by Keysight's N7614B Signal Studio for Power Amplifier Test software.

Closed and open loop DPD and envelope tracking measurements can be made in tens of milliseconds with the M9451A PXIe measurement accelerator. The Reference Solution control software enables tight synchronization between the signal source and the arbitrary waveform generator (AWG), resulting in optimal alignment of the input signal and envelope. The RF PA/FEM Reference Solution also includes a Signadyne single-slot, high speed PXI AWG, which supports fast envelope tracking capability while maintaining a small test footprint. See solution architecture diagram in Figure 1.

To facilitate evaluation and integration into a production test environment, manufacturers can use the supplied test code examples, shown in Figures 2 and 3, which are designed to optimize test throughput without compromising performance.

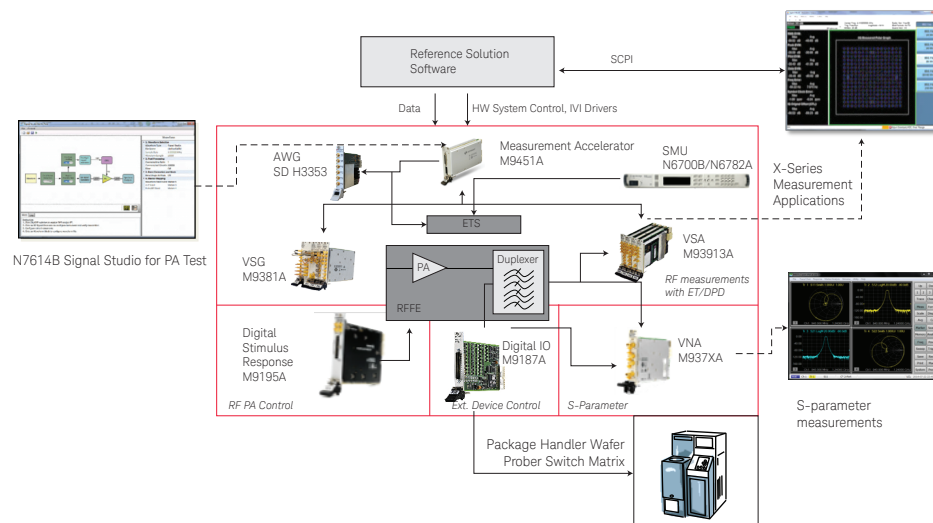


Figure 1: Keysight's RF PA/FEM characterization and test, Reference Solution.

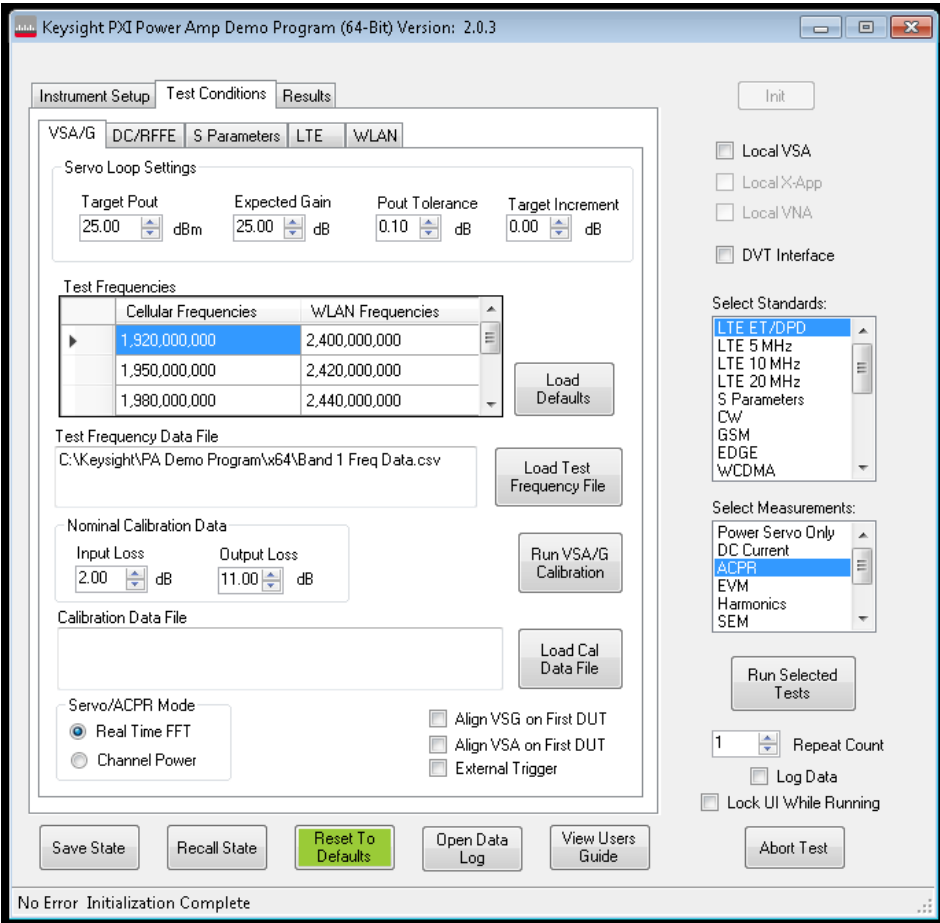


Figure 2: Keysight's RF PA/FEM characterization and test, Reference Solution demo program API programmatically controls instruments and runs Signal Studio for waveform creation and analysis.

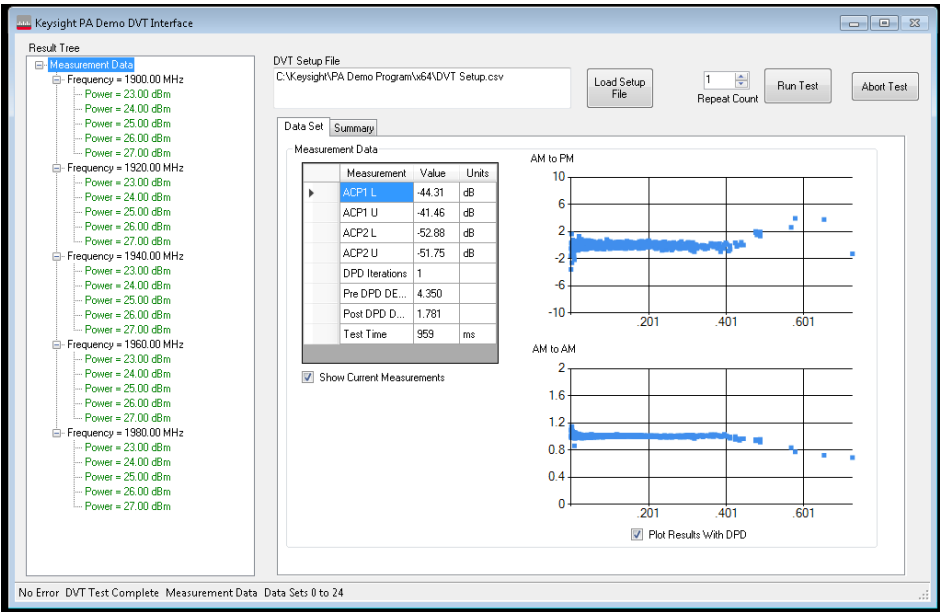


Figure 3: Keysight's RF PA/FEM characterization and test, Reference Solution design validation test interface quickly makes measurements over a wide variety of test conditions.

The Customer Experience

The Keysight PA/FEM Reference Solution is being used successfully today by manufacturers to meet their design validation and production test goals. The experiences of three selected customers are presented here.

Customer A:

Market-leading manufacturer of RF semiconductors for mobile communications

A high volume manufacturer of PAs, this customer required a test system with fast throughput and repeatable, reliable measurements. The system also had to be scalable, providing the ability to ramp up quickly and flexible, so that it could be modified easily as volume and product mixes change or as new capabilities are added to devices.

The integrated, modular Keysight Reference Solution provided the right form factor and met the manufacturer's speed requirements. Moreover, the Reference Solution's building blocks, algorithms, and test methodologies provided everything needed to prove the system's functionality and throughput capabilities within the Keysight software environment. The manufacturer did not have to design and configure sets of instruments and software in house, which saved setup time and costs throughout the system evaluation phase.

Keysight application engineers worked side-by-side with the manufacturer to successfully implement a number of power amplifier test systems into production—an effort that neither party could have done alone. Since the manufacturer already used Keysight's measurement software for benchtop instruments, integrating the system into the broader production test environment was more efficient as large amounts of known working code and known working algorithms could be reused. Using the test program GUI, optimized for test speed and additional conveniences, the new modular systems have met all of the manufacturer's requirements and are currently about 40% faster than the systems they replaced.

Ongoing enhancements are being made as the manufacturer's test requirements change and new test cases are added to production. Keysight's commitment to future product enhancements, along with methods provided for the customer to programmatically extend the solution capability on their own, enables this manufacturer to keep up with product changes and evolving cellular standards. When Keysight introduces new functionality to the Reference Solution product, the manufacturer is able to quickly validate the new code and integrate the functionality back into its systems.

Manufacturer's requirements:

A test system with fast and reliable throughput, able to scale and ramp up quickly, easy to modify as volume and product mixes change

Manufacturer's feedback on the Reference Solution:

- Test system is fast, reliable, scalable, flexible
- Saved set up time and cost
- Eliminated the need to design and configure sets of instruments and software
- Keysight application engineering support quickly deployed a complete solution
- Keysight's commitment to ongoing enhancements will help them keep up with changing standards and additional complexity

Bottom line:

Increased throughput by about 40%

Customer B:

Top-tier global manufacturer of electronic components, modules, and systems

This manufacturer wanted to produce higher performance components by integrating envelope tracking and digital pre-distortion (DPD) into power amplifier design validation and production test. The manufacturer was particularly interested in deploying a modular system, which they believed would provide the fastest and most efficient test solution, and they evaluated offerings from several test vendors including the PA/FEM Reference Solution.

Keysight managers and engineers engaged with the customer from the outset, demonstrating an in-depth understanding of the power amplifier application and technical expertise that impressed the manufacturer. Keysight also made a commitment to deliver a complete solution that would fit the manufacturer's needs for measurement speed and performance. This combination technical expertise and willingness to work for the manufacturer's success led to the selection of the PA/FEM Reference Solution.

The PA/FEM Reference Solution provided all of the measurement functionality required by the manufacturer, including s-parameters, AM/AM, AM/PM conversion, delta EVM, envelope tracking and DPD along with many standard signal generation and analysis measurements. This accounted for about 80% of the complete test system; the remaining 20% represented integration of the system into the manufacturer's overall test environment.

A new measurement accelerator being introduced for the Reference Solution added the speed enhancements required for the manufacturer's complex test scenario, and the DPD application—leveraging the Reference Solution's built-in, multi-instrument synchronization capability—helped ensure that the accelerator module was making the measurements correctly. With the measurement accelerator module, the manufacturer has the ability make a full DPD loop measurement in < 70 ms, for a 20 times speed improvement, as shown in the table below.

	Without M9451A		With M9451A	
	Extract	Apply	Extract	Apply
LTE Signals				
5 MHz	415.4 ms	48.7 ms	4.9 ms	21.8 ms
20 MHz	1676.1 ms	172.5 ms	6 ms	63 ms

Keysight application engineering services were used to develop the remaining 20% customer-proprietary waveforms and measurements, and the engineering team integrated and verified all the system's test functionality. Keysight startup assistance for the Reference Solution helped with everything from unpacking and installing the system hardware to getting the system ramped up and operational in a minimal amount of time.

The customer reported that Keysight had exceeded expectations for meeting technical and support commitments, delivering and implementing a complete power amplifier test solution within an aggressive time schedule and achieving a high level of customer satisfaction.

Manufacturer's requirements:

A modular platform for power amplifier DVT and production test

Manufacturer's feedback on the Reference Solution:

- Impressed by Keysight's in-depth technical understanding of the customer's application
- Reference Solution provided nearly all of the measurement functionality, including envelope tracking and DPD, with
- Keysight application engineering support developed the remaining proprietary waveforms and measurements needed for integration into the production test environment
- Appreciated Keysight's commitment to deliver a total solution that would fit the customer's needs for measurement speed and performance

Bottom line:

Keysight exceeded customer expectations for meeting technical and support commitments

Customer C:

Leading provider of high performance RFICs

This manufacturer used Keysight benchtop instruments for power amplifier characterization tests but wanted to move to a modular system. Because the manufacturer's device had thousands of different states to test, critical requirements for the system included tight integration of the instrumentation and increased measurement speed.

The manufacturer evaluated PXI-based systems from several test companies, but recognized the benefits of the PA/FEM Reference Solution almost immediately when, within an hour of inserting the device to be tested, the Reference Solution was operational and making measurements. Using the Reference Solution's comprehensive demonstration software, the manufacturer was able to make the desired measurements, meeting test time and repeatability requirements, right from the start.

Collaboration with Keysight was an important factor in getting the Reference Solution fully integrated into the manufacturer's existing code and the system up and running quickly. Because the manufacturer was already using Keysight's benchtop signal generator and signal analyzer products, it was a relatively straightforward task to port the existing X-Series measurements to the PXI-based solution, where it is being used for characterization testing and application development.

Tools built into the Reference Solution—including data logs and statistics—allowed the application engineering team to understand the tradeoffs between measurement time and repeatability and to apply that insight to optimize the system for best performance. The customer appreciated the flexibility of the software interface for optimizing fast measurements and was particularly impressed with the power servo loop time measurement of < 3 ms. Plus, by re-using the last acquisition from the power servo loop, the ACPR values can be calculated with no additional measurement time.

Several other features of the PA/FEM Reference Solution provide ongoing value to this manufacturer:

- Frequency range to 26.5 GHz, typically used for higher order harmonic measurements, provides them the option to use the same modular test system for those measurements with the same level of performance and throughput for DPD
- Fast solution implementation via direct code reuse
- Drivers to implement a robust GUI similar to an X-Series front panel for easier troubleshooting
- Fast measurements that are compatible with the manufacturer's production-test environment
- Worldwide support from Keysight, including calibration services.

One of the manufacturer's key goals was to have a system that would satisfy future test needs, and with the cutting-edge capabilities and modular flexibility of the PA/FEM Reference Solution, that goal is being met.

Manufacturer's requirements:

Move power amplifier characterization testing from benchtop instruments to a modular system; speed of measurement was critical

Manufacturer's feedback on the Reference Solution:

- Quickly integrated into existing system with collaboration with Keysight to customize
- Ongoing perceived value in ET and DPD measurements, the flexible software interface for troubleshooting, and compatibility with their production environment

Bottom line:

Immediately realized benefits at the demo stage after inserting their DUT and making measurements within an hour

Conclusions

Leading power amplifier manufacturers want to migrate to fast, flexible, modular test systems not only to meet today's challenges, but also tomorrow's. Measurement speed and reliability are core requirements for any new test system, and manufacturers generally want a solution as complete and flexible as possible, sourced from a knowledgeable, reliable test vendor.

Manufacturers quickly “get” the potential benefits of Keysight's proven, measurement-validated PA/FEM Reference Solution designed specifically for their power amplifier test applications—a solution that immediately eliminates the pressure to develop and evaluate a test system in-house, that saves considerable time and effort, and that reduces the risk of implementation error.

Other factors that are important, and which the Keysight PA/FEM Reference Solution addresses, are the time to first measurement when a proposed system configuration is evaluated; the application engineering expertise of the test partner; and the commitment of the test partner to the manufacturer's success from solution development through operation.

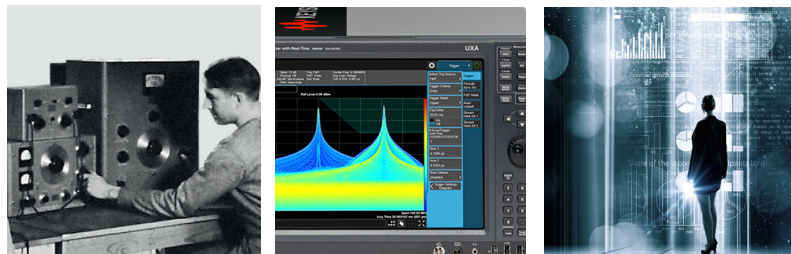
More Information

- Reference Solutions Webpage: www.keysight.com/find/solution-modular
- RF PA/FEM Reference Solution Webpage: www.keysight.com/find/solution-padvf
- Speed power amplifier DPD/ET testing with PXI Reference Solution:
<http://literature.cdn.keysight.com/litweb/pdf/5992-0883EN.pdf>

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