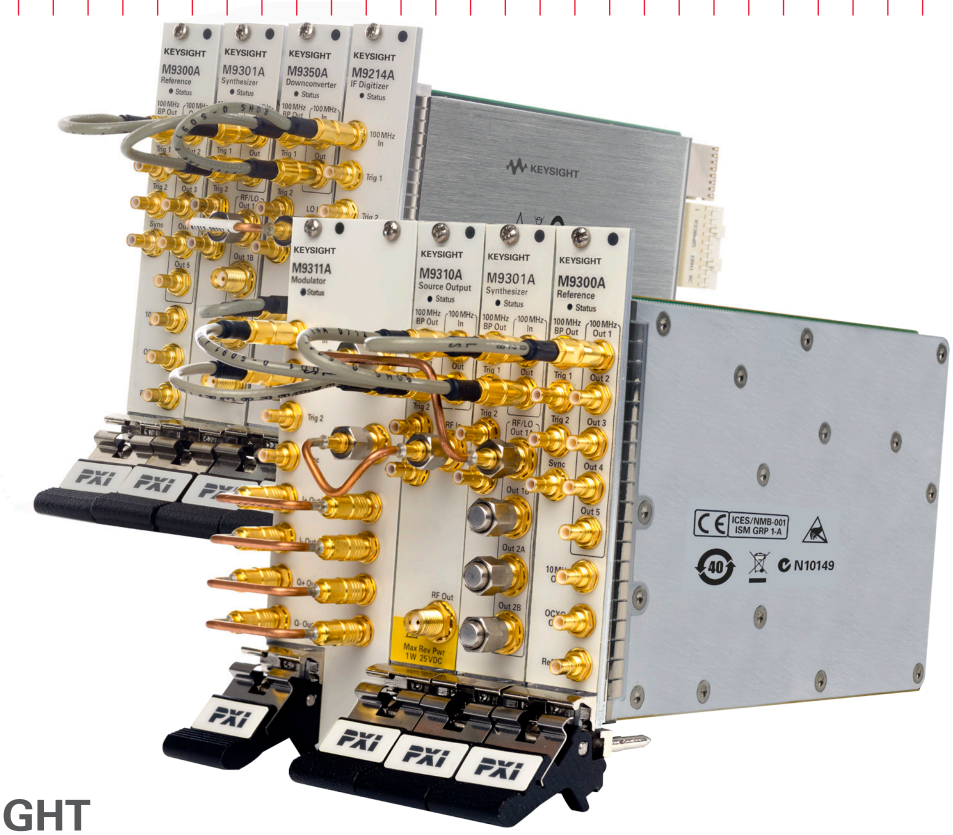
Keysight Technologies
Increase Power Amplifier Test Throughput with the Keysight M9381A PXIe Vector Signal Generator

Application Note

Challenge the Boundaries of Test
Keysight Modular Products



KEYSIGHT
TECHNOLOGIES

Introduction

Abstract

Power amplifier designs for mobile handsets are becoming more complex, which directly impacts test demands and the cost of test. Complexity increases with the introduction of new, wider bandwidth standards and the addition of the number of radios to each device. At the same time, demand for improved battery life is driving efficiency improvements, such as digital pre-distortion and envelope tracking. Business issues, such as pressure on prices of these devices places greater demands on engineering teams producing power amplifiers.

Engineers who test mobile power amplifiers and front end modules on the production line are looking for solutions to reduce test cost through maximizing throughput while ensuring that the devices meet required performance levels.

This application note provides an overview of the key issues in a power amplifier and front end module test system related to the RF signal analyzer and generator.

Key issues faced by power amplifier test engineers

This application note addresses test challenges faced by power amplifier engineers including:

- The need to reduce test times by providing fast input power adjustment and fast power measurements.
- The need to assess modulation performance quickly with high quality and trusted measurements.

Figure 1 shows a simplified block diagram for the RF vector signal analyzer and signal generator in a typical power amplifier/front end module test system. Typical power amplifier modules require an input power level of 0 to + 5 dBm, digitally modulated according to communication standards such as WCDMA or LTE. The specified performance of the power amplifier or front end module is normally set at a specific output level of the DUT. If the devices have small variations in gain, it may be necessary to adjust the power level from the PXI VSG to get the correct output level of the DUT. Only after the DUT output level is set at the correct value, can the specified parameters be tested. The time spent adjusting the PXI VSG to get the correct DUT output power can be a major contributor to the test time and the overall cost of test.

The PXI VSG is connected to the DUT using a cable and switches. The switching may be used to support testing of multi-band modules or multi-site testing. The combination of the RF cables and the switching network can add several dB of loss between the output of the PXI VSG and the input of the DUT, which requires higher output levels from the PXI VSG. Since the tests are performed with a modulated signal, the PXI VSG must also have adequate modulation performance at the higher power levels.

The PXI VSA is also connected to the DUT using switches and cables. If the PXI VSA is not able to make fast and accurate power measurements, a power meter may also be required on the DUT output. The signal analyzer needs to perform measurements of power, ACPR, EVM, harmonics and other parameters. It needs to measure all of these parameters quickly and accurately and be able to switch between measurement modes in minimal time.

Using the M9391A VSA and M9381A VSG to increase test throughput and quality

The Keysight Technologies, Inc. M9391A and M9381A PXI VSA/G offer unique features that:

- Increase test throughput with fast amplitude and frequency switching as well as hardware accelerated power measurements.
- Enable synchronization with an arbitrary waveform

  generatorfor envelope generation to support test of envelope tracking devices.
- Provide good modulation performance, particularly at highpower levels and very linear power level changes.
- Achieve continuity of measurement results from R&D to manufacturing, as well as from previous generation test systems by using X-Series measurement applications
- Further reduces test development time through code reuse.

The M9381A PXI VSG reduces the overall switching time through a powerful, innovative tuning methodology. It further increases throughput by providing good linearity and repeatability which reduces the number of iterations required to get the DUT to the correct power output level. The PXI VSG also offers high modulation quality so you can drive amplifiers directly without having to add external amplification.

Several other vector signal generations offer amplitude and frequency switching times of less than 1 ms when used in list modes. However, since the output level of the signal generator cannot be predetermined for each test, list modes cannot be used for power amplifier testing. Other signal generators require significantly longer switching time when controlled through anormal programming interface. The PXI VSG offers the fastest switching time on the market of 250 μs from its programming interface and 10 μs in list mode, with fastune, an exclusive baseband tuning technology innovation.

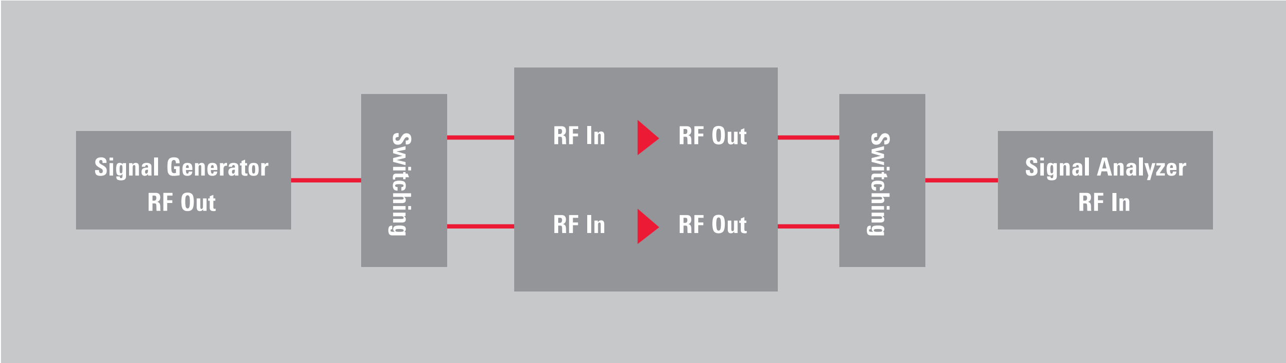


Figure 1. Typical Power Amplifier/Front End Module Test Setup

The PXI VSG comes with 40 MHz bandwidth, but can be upgraded to 100 MHz or 160 MHz. The baseband frequency offset can be programmed to any offset within the purchased modulation bandwidth. For example, the 160 MHz bandwidth option allows the baseband frequency offset to be set to ±80 MHz. The baseband power offset can be set to 20 dB below the programmed RF power level and still achieves high quality modulation performance. To take advantage of this feature for power amplifier testing, engineers can set the RF frequency to the center of the band being tested and the RF power level to the maximum required for all tests. From there, baseband frequency adjustments are made to test at multiple frequencies across the band and the baseband power level is adjusted to servo the DUT output level to the correct value.

Better linearity, repeatability and resolution offered by the PXI VSG further reduces the test time by enabling the servo loop to converge in fewer steps. After the DUT output level is measured by the signal analyzer, the new value of the PXI VSG output power is calculated based on the difference between the measured power and the desired power. Then, the PXI VSG is adjusted by the amount necessary to achieve the correct DUT output power.

The PXI VSG provides high modulation quality, particularly at high output power levels. In many cases, signal levels as high as + 15 dBm may be needed to overcome the loss between the PXI VSG and the DUT input. As shown in Figure 2, the PXI VSG has excellent adjacent channel power (ACPR) at high output power levels. At + 10 dBm, there is little or no degrading of the ACPR and at + 15 dBm, the ACPR level is still near 60 dBc.

The M9391A PXI VSA reduces the overall test time through a hardware accelerated power measurement methodology. Power measurements are accumulated in real time in the digitizer, requiring only a single value to be returned to the application program and no computation of power from the IQ data in the controlling PC. In addition, the PXI VSA provides very repeatable power measurements, with acquisition times as low as 10 µs. Figure 3 shows the repeatability of the PXI VSA's power measurements with acquisition times from 10 µs to 1 ms at power levels from the expected input level to 75 dB below the expected input level. For power levels as low as 25 dB below expected input level, the PXI VSA can provide a power measurement with 0.005 dB standard deviation in a total execution time of less than 400 µs. When combined with the power level switching speed of the PXI VSG, the step time for a power servo loop can be less than 1 ms.

Power servo and ACPR measurements can be made using the hardware accelerated power measurement technique mentioned in the preceding paragraph or by using hardware accelerated FFT acquisition mode. The FFT acquisition mode offers similar accuracy and repeatability, but enables ACPR to be calculated from a single acquisition that spans all of the desired adjacent channels. By re-using the last acquisition from the power servo loop, the ACPR values can be calculated with no additional measurement time.

Emerging power efficiency technologies, such as envelope tracking, can be supported by synchronizing the PXI VSG with an arbitrary waveform generator. The PXI VSG enables fast time alignment with the envelope signal through an automated, real-time hardware adjustment of the IQ waveform delay. Resolution of ± 1 picosecond is achievable in hundreds of microseconds, without stopping the waveform playback.

The PXI VSA and PXI VSG can be used with the same measurement applications that run on corresponding Keysight bench top instruments. Using a combination of Keysight bench top and modular equipment with Keysight measurment applications can result in excellent correlation of measurement results at multiple points in your product design cycle. Additionally, it offers a common programming interface, enabling code reuse and reduced test development time.

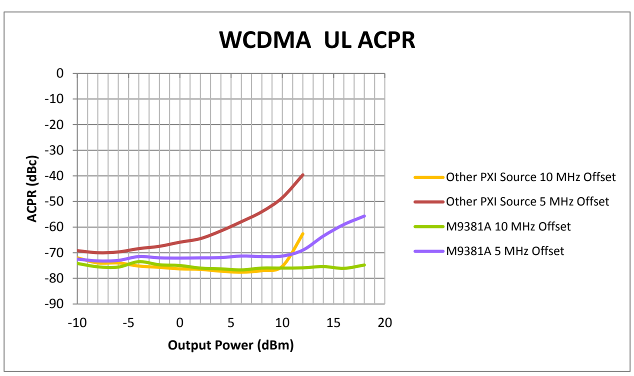


Figure 2. Note the M9381A shows little ACPR degradation below 10 dBm and is better than 60 dBc at 15 dBm.

Repeatability vs. acquisition time vs. power level

Acquisition Time		Power Level Relative to the Expected Input Level 0 dB	-25 dB	-75 dB	Test Time
10 µs	Avg	1.767	-23.244	-65.047	0.0003
	Std Dev	0.033	0.032	0.550	
100 µs	Avg	1.895	-23.113	-65.073	0.0004
	Std Dev	0.007	0.005	0.168	
1 ms	Avg	1.758	-23.246	-65.059	0.0024
	Std Dev	0.003	0.001	0.0588	

Figure 3. Repeatability of power measurements using the M9391A.

Ordering information

Model	Description
M9381A	PXIe Vector Signal Generator 1 MHz to 6 GHz Includes: M9301A PXIe Synthesizer M9310A PXIe Source Output M9311A PXIe Digital Vector Modulator
M9391A	PXIe Vector Signal Analyzer 1 MHz to 6 GHz Includes: M9301A PXIe Synthesizer M9350A PXIe Downconverter M9214A PXIe IF Digitizer
M9381A-300	PXIe Frequency Reference 10 MHz to 100 MHz Adds M9300A PXIe Frequency Reference which supports multiple M9391A or M9381A instruments
Base Configuration Included	
M9381A-F03	Frequency range: 1 MHz to 3 GHz
M9381A-B04	RF modulation bandwidth, 40 MHz
M9381A-M01	Memory, 32 MSa
M9391A-F03	Frequency range: 1 MHz to 3 GHz
M9391A-B04	Analysis bandwidth: 40 MHz
M9391A-M01	Memory: 128 MSa
Recommended configuration includes	
M9381A-F06	Frequency range: 1 MHz to 6 MHz
M9381A-B10	RF modulation bandwidth: 100 MHz
M9381A-M01	Memory: 32 MSa
M9381A-UNZ	Fast switching
M9391A-F06	Frequency range: 1 MHz to 6 GHz
M9391A-B10	Analysis bandwidth: 100 MHz
M9391A-M01	Memory 128 MSa
M9391A-UNZ	Fast switching
M9300A	PXIe Frequency Reference

Software Information

Supported operating systems	Microsoft Windows XP (32-bit) Microsoft Windows 7 (32/64-bit) Microsoft Windows Vista (32/64-bit)
Standard compliant drivers	IVI-COM, IVI-C, LabVIEW, MATLAB
Supported application development environments (ADE)	VisualStudio (VB.NET, C#, C/C++), VEE, LabVIEW, LabWindows/CVI, MATLAB
Keysight IO Libraries (version 16.2 or newer)	Includes: VISA Libraries, Keysight Connection Expert, IO Monitor

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