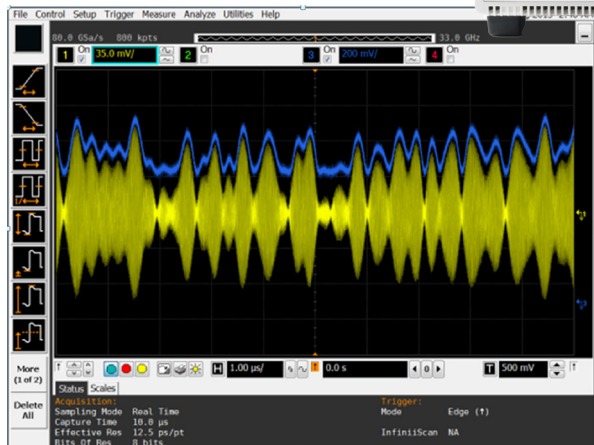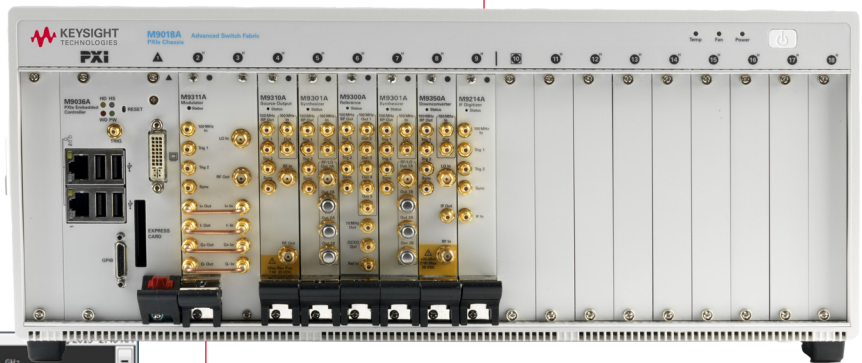# Keysight Technologies
RF Power Amplifier Test, Reference Solution

Solution Brochure

The RF power amplifier test, reference solution provides a unique combination of test speed and throughput with trusted and consistent measurements for cellular and wireless connectivity formats.

KEYSIGHT
TECHNOLOGIES

Introduction

RF power amplifier (PA) test challenges

Wireless mobile device manufacturers continue to face pressures to simultaneously reduce cost and increase data throughput without sacrificing battery life. These requirements create conflicting challenges for test engineers because they must reduce overall test system cost and test times despite adding complex test techniques such as envelope tracking (ET). These techniques are required to optimize RF PA power efficiency which add to test system cost.

Testing RF PAs with ET brings new challenges:
– Test environment must include additional envelope generation capabilities to test under realistic conditions
– Tight alignment between signal and envelope has a significant effect on the quality of measurement
– Precision power sourcing and measurements are required during test since power consumption is a critical factor

RF power amplifier test, Reference Solution

The RF PA Test, Reference Solution is a combination of hardware, software, and measurement expertise providing the essential components of a PA test system. This enables engineers to use, enhance, or modify the test system as required to meet specific test application needs including envelope tracking and RF Front End (RFFE) control.

Control software enables tight synchronization between the signal source and the arbitrary waveform generator (AWG), resulting in optimal alignment between input signal and envelope. A stepped FFT technique provides high speed, wide dynamic range harmonics measurements up to 27 GHz. Precision power sourcing and measurement is also included in this solution. To facilitate evaluation and integration in your test environment, you can use supplied test code examples that have been designed to optimize test throughput without compromising performance.

Reference Solution architecture
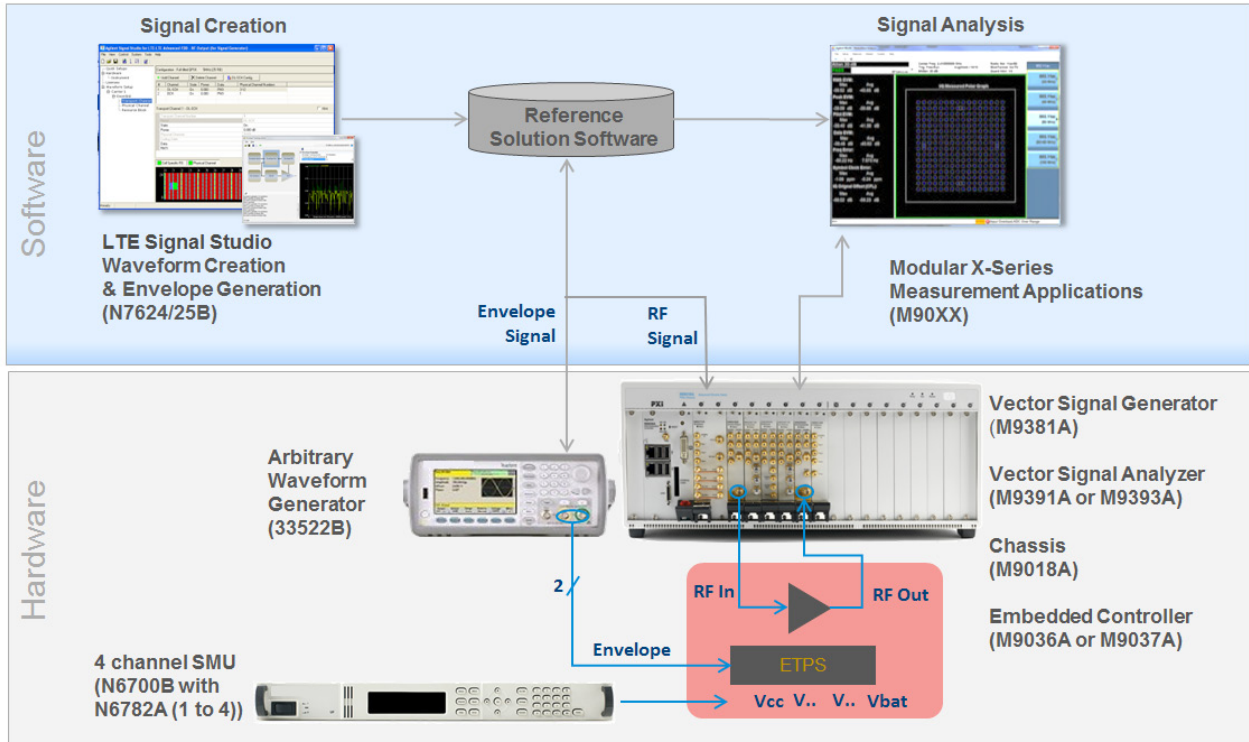
Hardware

Solution features & benefits	
Feature	**Benefit**
Real-time signal processing	Fast measurements
Adjustable RF signal/envelope skew to ± 1 ps resolution over ± 250 ns range	Tight synchronization between RF signal and envelope
X-series measurement applications for modular instruments	Measurement correlation to bench top instruments
Solution measurement speed	
EVM measurement speed	< 50 ms, nominal [1]
ACPR measurement speed	0 ms [2]
Servo loop time	< 5 ms, nominal [3]
Tuning speed [4]	150 µs, nominal

1. LTE 5 MHz
2. Use last FFT from power servo to calculate all channels for ACPR measurement.
3. Average of 2.5 iterations.
4. With M9393A, option UNZ

Product specifications & characteristics	
M9391A PXIe Vector Signal Analyzer	
Frequency range	1 MHz to 3 or 6 GHz
Analysis bandwidth	160 MHz
Absolute amplitude accuracy	±0.45 dB, typical
M9393A PXIe Performance Vector Signal Analyzer	
Frequency range	9 kHz to 27 GHz
Analysis bandwidth	160 MHz
Absolute amplitude accuracy	±0.15 dB, nominal
M9381A PXIe Vector Signal Generator	
Frequency range	1 MHz to 3 or 6 GHz
RF modulation bandwidth	160 MHz
Absolute level accuracy	±0.4 dB
33522B Waveform Generator	
Bandwidth	30 MHz
Sub ns real timeime alignment w/VSG	
Differential output for better noise rejection	
Very low broadband noise	
N6700B Mainframe & N6782A SMU	
Measurement accuracy:	
Current, 100 mA range	0.025% + 10 µA
Current, 10 µA range	0.025% + 8 nA
Voltage, 20 V range	0.025% + 1.2 mV

Hardware configuration

M9381A PXIe Vector Signal Generator

www.keysight.com/find/m9381a

Generate tightly synchronized RF signals and envelope using the 6 GHz, 160 MHz bandwidth M9381A PXIe VSG, together with the 33522B arbitrary waveform generator. Adjust synchronization at 1 ps resolution. A typical M9381A configuration includes 4 individual PXIe modules - M9311A digital vector modulator, M9310A source output, M9301A synthesizer and the M9300A frequency reference - designed for fast data interfaces and high-speed automated test systems.

M9391A PXIe Vector Signal Analyzer

www.keysight.com/find/m9391a

Analyze signals using the 6 GHz, 160 MHz bandwidth M9391A PXIe VSA. A typical M9391A configuration includes 4 individual PXIe modules – M9301A synthesizer, M9214A digitizer, M9350A downconverter and the M9300A frequency reference.

M9393A PXIe Performance Vector Signal Analyzer

www.keysight.com/find/m9393a

Analyze signals, including harmonic distortion, using the 27 GHz, 160 MHz bandwidth M9393A PXIe Performance VSA. A typical M9393A configuration includes 4 individual PXIe modules – M9308A synthesizer, M9214A digitizer, M9365A downconverter and the M9300A frequency reference.

33522B Waveform Generator

www.keysight.com/find/33522b

When used with the M9381A PXIe VSG, generate tightly synchronized RF signals and envelope. The Keysight Technologies Inc. 33522B is a 2-channel, 30 MHz function/arbitrary waveform generator. The 33522B offers the highest signal fidelity and implements a breakthrough technology providing you with the ability to generate more accurate arbitrary waveforms.

N6700B Mainframe and N6784A SMU

www.keysight.com/find/n6700b

The Keysight N6700B is a 1U high modular power mainframe that accepts the N6784A module, a source/measure unit (SMU) designed for precision sourcing and measurement. Its glitch-free operation ensures safe usage with the DUT during output and measurement range changes, even with capacitances of up to 150 µF.

Software - Signal creation

This Reference Solution enables multiple ways to create the RF signal along with the envelope of the RF signal to enhance the characterization and validation of your device. Create standard based waveforms and envelope signal with Keysight Signal Studio

Create Keysight validated and performance optimized reference signals in cellular and wireless connectivity formats. In Signal Studio for LTE/LTE-Advanced (FDD or TDD), developers can define and optimize test stimuli for power amplifiers using envelope waveforms based on the LTE in-phase/quadrature (I/Q) signal.

Signal Studio for LTE can also generate envelope information for waveforms created with other Signal Studio applications. Signal Studio waveforms in other formats can be imported, including W-CDMA/HSPA+, cdma2000/1xEV-DO, GSM/EDGE/Evo, TD-SCDMA/HSDPA.

Additional features include:
– Export external unencrypted envelope waveforms
– IQ over-sampling ratio (x1 – x32)
– Bandwidth control
– ETPS gain & offset value control
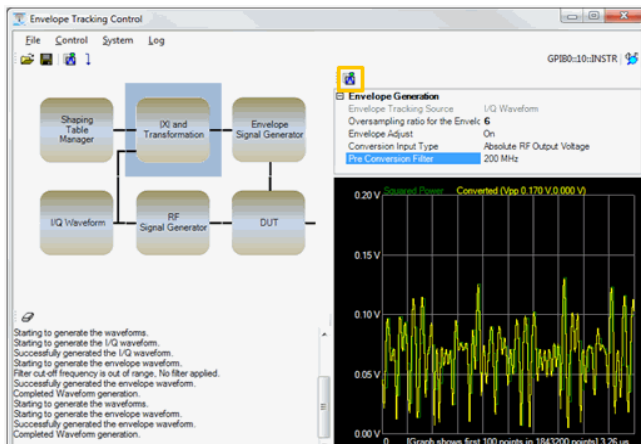– Set voltage limits to protect ETPS inputs

Figure 1. Signal Studio envelope tracking control window.

A shaping table, derived from the PA characteristics and system design goals / trade-offs, can be built or imported and then applied to the signal. The shaping table will tailor the envelope for better efficiency.

Custom waveforms

Custom waveforms and envelopes can also be imported into this reference solution.

Software - Signal analysis

X-Series measurements applications for modular instruments

The X-Series measurement applications for modular instruments transform PXI vector signal analyzers into standards-based RF transmitter testers. Fast RF conformance measurements help you evaluate and manufacture your devices and equipment.
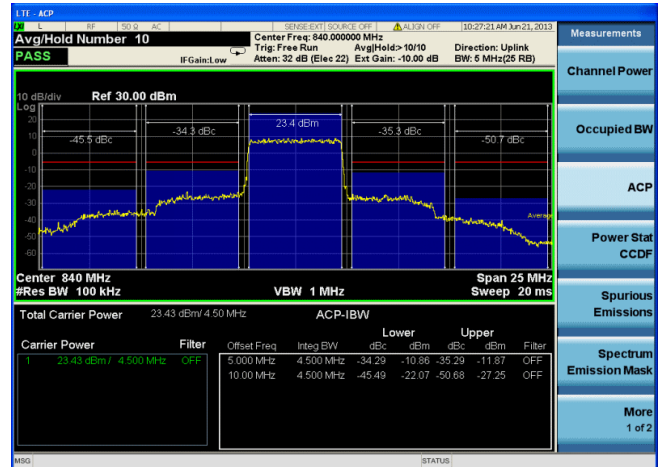

Figure 2. X-Series measurement application for modular instruments.

Software - Test automation

This Reference Solution includes a C# test code example that optimizes speed without compromising performance and repeatability. To accelerate test development and facilitate the integration in your test environment, the source code of the test automation software is also provided.

Power amplifier test library

This library includes PA test functions that leverage from the PXI VSA's high speed embedded measurement capabilities. For example, the same embedded FFT measurements can be used for both servo loops and ACPR, reducing test times. Test functions include: Init instruments, Load Waveforms, PowerServoLoops, Pout, harmonics and ACPR measurements.

Test program examples

Included in this Reference Solution are test program examples for standards, including WCDMA, LTE (5, 10 and 20 MHz), GSM, 1xEV-DO, WLAN. These examples leverage from the PA test library as well as X-Series applications measurements.
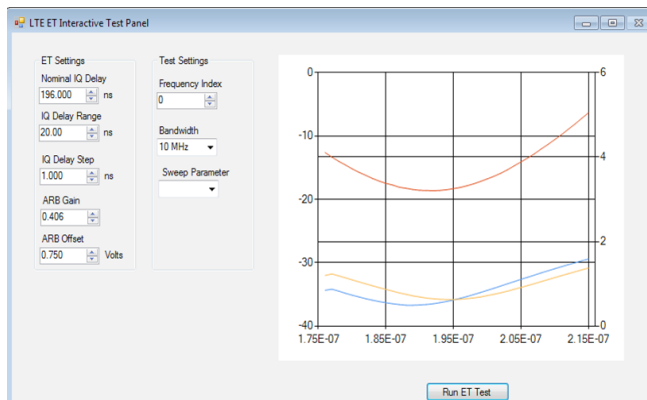

Figure 3. ACPR versus timing in test application example.

Measurements include EVM, ACPR, SEM, power and harmonics, as well as data logging and test times, as shown in figure 4. It also includes dynamic EVM measurements for WLAN applications.
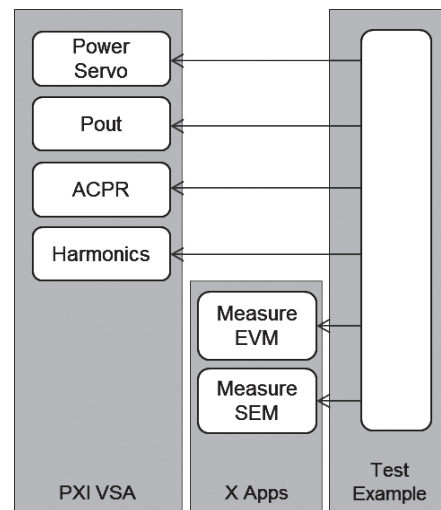

Figure 4. Measurement capabilities portfolio

Instrument control library

The instrument control library includes the main functions to interface with the main test instruments including PXI VSA & VSG, SMU, AWG for envelope generation, power sensor and the PA control through the MIPI RFFE interface. Hardware controls are provided to optimize test time and synchronization.

Demonstration and evaluation GUI

To help you quickly and easily evaluate this Reference Solution, a demo program integrates all the features described above. Configure the GUI to test your own devices without writing software.
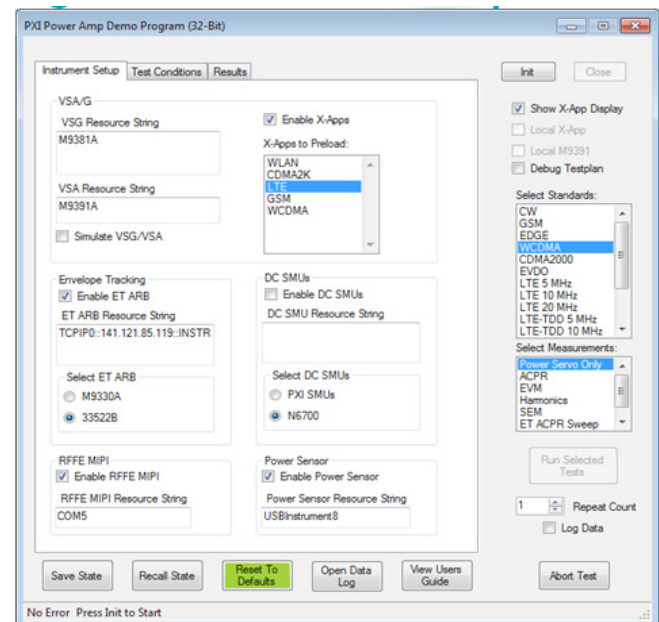

Figure 5. Demonstration and evaluation GUI.

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Recommended Reference Solution configuration [1]

Model	Description
M9381A	**PXIe Vector Signal Generator**
M9381A-F06 M9381A-B10 M9381A-M01 M9381A-UNZ	1 MHz – 6 GHz frequency range 100 MHz modulation bandwidth 32 MSa memory Fast switching
M9391A	**PXIe Vector Signal Analyzer 2**
M9391A-F06 M9391A-B10 M9391A-M01 M9391A-UNZ	1 MHz – 6 GHz frequency range 100 MHz analysis bandwidth 128 MSa memory Fast switching
M9300A	**PXI Frequency Reference**
33522B	**Waveform Generator, 30 MHz, 2-channel**
33522B-OCX 33522B-MEM	Adds high stability OCXO timebase Adds 16 MB memory
N6700	**Modular Power System & SMUs**
N6700B	Low-Profile Modular Power System Mainframe, 400W, 4 slots
N6782A	2-Quadrant Source/Measure Unit for Functional Test
U2004A	USB Power Sensor
PXIe chassis and controllers	
M9018A	PXIe 18-slot chassis
M9037A	PXIe embedded controller
Application software (more options available)	
M9080B-1TP	LTE-FDD X-Series measurement application for modular instruments, transportable perpetual license
N7624B	Signal Studio for LTE/LTE-Advanced FDD

1. For a more complete set of configutation options, please refer to the
   RF Power Amplifier Test, Reference Solution configuration guide, literature number **5991-4105EN**.
2. If harmonics measurements > 6 GHz are required, the M9393A PXIe Performance VSA - 9 kHz to 27 GHz is recommended.
   See the *RF Power Amplifier Test, Reference Solution configuration guide,*
   literature number **5991-4105EN**, for more information.

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