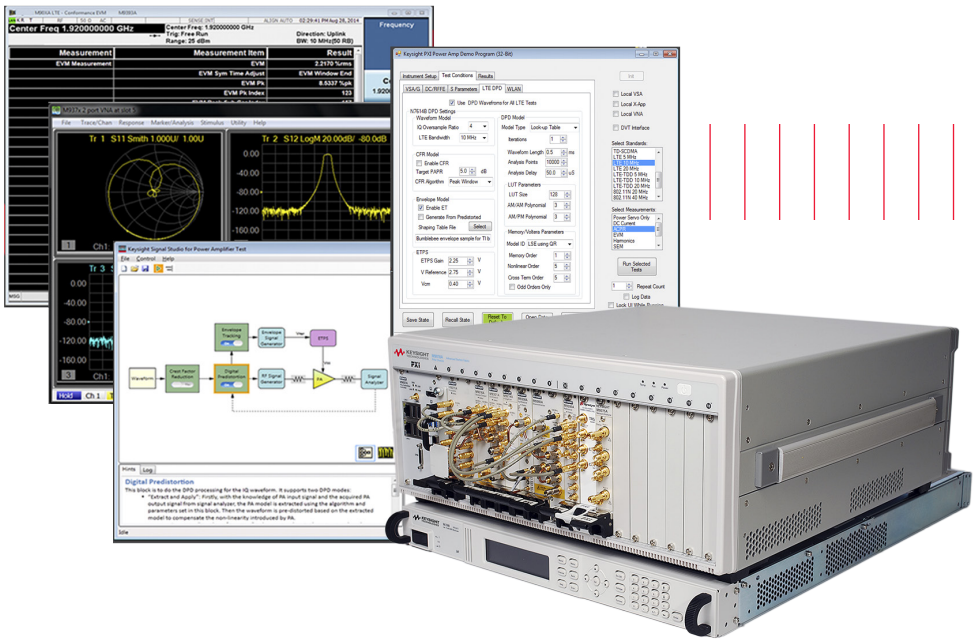
Keysight Technologies
RF PA/FEM Characterization & Test, Reference Solution

Solution Brochure



KEYSIGHT TECHNOLOGIES

The RF power amplifier characterization and test, Reference Solution provides high throughput, measurement quality, and performance for design validation and production test of next generation power amplifiers/front end modules supporting cellular and wireless connectivity format.

Next generation RF power amplifier (PA) characterization and test challenges

Wireless mobile device manufacturers continue to look for ways to drive down cost while improving performance of their devices. To support this trend, power amplifier duplex (PAD) devices are an increasingly popular alternative to the more traditional PA architecture. These smaller, highly integrated devices allow designers to optimize space by replacing multiple, discrete components with a single, compact module while lowering power consumption and increasing performance.

With device complexity and performance requirements increasing, the amount and type of testing continues to grow while price pressures simultaneously drive the need for higher throughput.

Testing next generation RF PAs brings new challenges:

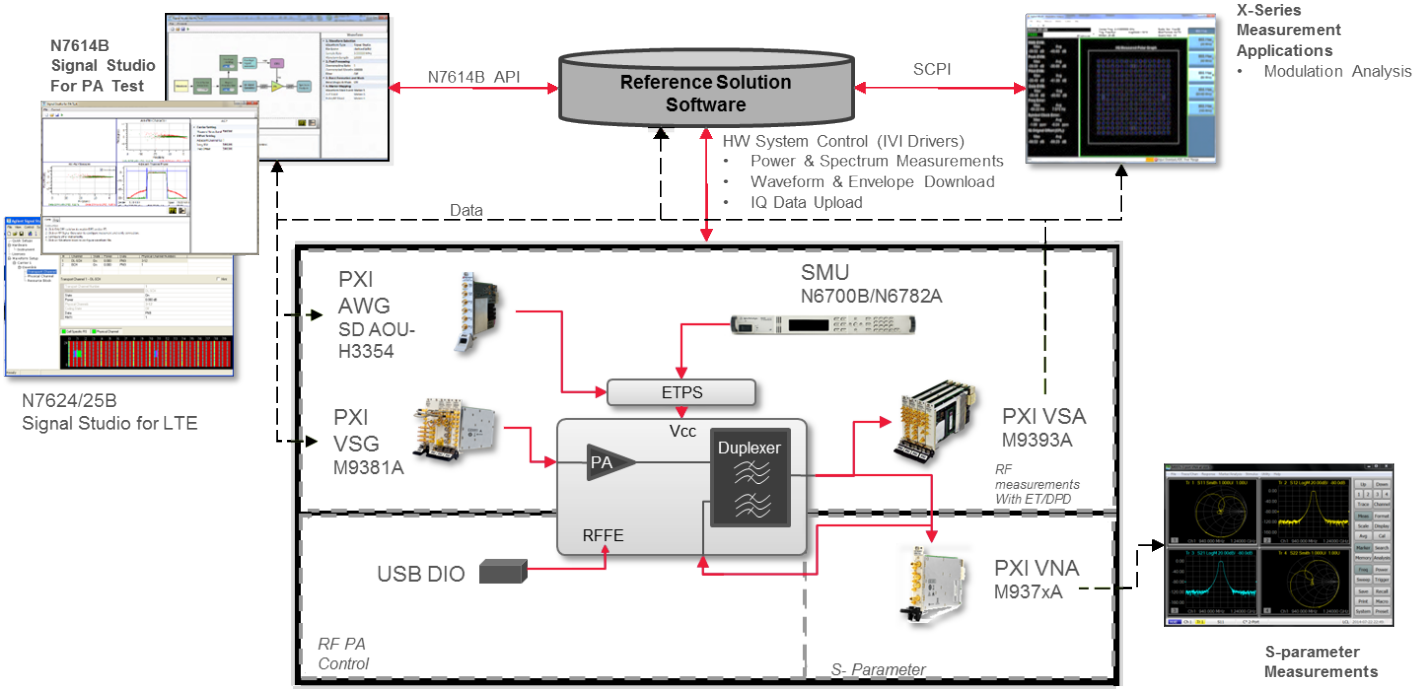
- Passive components integrated onto PAD-type devices must be tested in addition to the PA
- Envelope tracking and digital pre-distortion to overcome efficiency issues caused by high peak-to-average ratio modulation formats
- Higher number of bands and modulation formats requiring additional test conditions

RF power amplifier/FEM characterization and test, Reference Solution

RF PA/FEM characterization and test, Reference Solution enables rapid, full characterization of next-generation power amplifier modules such as PAD devices, including S-parameter, demodulation, power, adjacent channel power and harmonic distortion measurements. Digital pre-distortion and envelope tracking signal generation and analysis are enabled by Keysight's N7614B Signal Studio for Power Amplifier Test software. The Reference Solution control software enables tight synchronization between the signal source and the arbitrary waveform generator (AWG), resulting in optimal alignment between input signal and envelope. This multi-vendor solution also includes a Signadyne single slot, high speed PXI AWG, which supports fast envelope tracking capability, while maintaining a small test footprint.

To facilitate evaluation and integration into 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

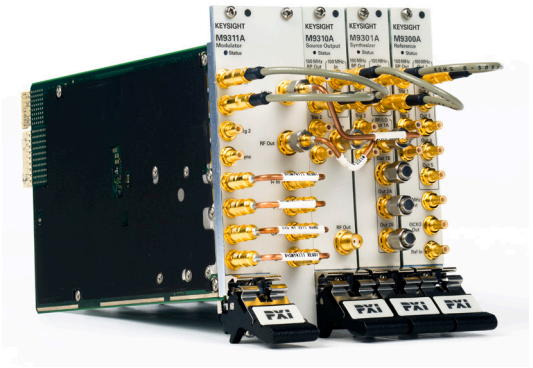
Solution Features & Benefits	
Feature	**Benefit**
Integration with N7614B Signal Studio for PA Test	Automated DPD & ET for fast design and characterization
High performance VSA	Wide dynamic range and frequency coverage for harmonic distortion
Real-time signal processing	Fast measurements
Adjustable RF signal/ envelope skew to ± 1 ps resolution over 250 ns range	Tight synchronization between RF signal and envelope
X-series measurement applications for modular instrument	Measurement correlation to bench top instruments
Add multiple independent full 2-port VNAs	Reduces COT by simultaneously characterizing many devices
True multiport VNA with N-port correction capability	No degradation in performance (i.e. dynamic range, trace noise, directivity, stability)
Solution measurement speed	
EVM measurement speed	< 50 ms, nominal for LTE 10 MHz BW
ACPR measurement speed	0 ms, after a power servo loop
Servo loop time	< 3 ms, nominal
Tuning speed	150 us, nominal
Full 2-port S-parameter measurement speed	28-33 msec across 401 points
Complete DPD loop	< 1 second

Product Specifications & Characteristics	
M9381A PXIe Vector Signal Generator	
Frequency range	1 MHz to 3, 6 GHz
Analysis bandwidth	160 MHz
Absolute amplitude accuracy	± 0.4 dB
M9391A PXIe Vector Signal Analyzer	
Frequency range	1 MHz to 3, 6 GHz
Analysis bandwidth	160 MHz
Absolute amplitude accuracy	± 0.45 dB, typical
M9393A PXIe Performance Vector Signal Analyzer	
Frequency range	9 kHz to 8.4, 14, 18, 27 GHz
Analysis bandwidth	160 MHz
Absolute amplitude accuracy	± 0.15 dB, nominal
SD AOU-H3353 PXIe Arbitrary Waveform Generator	
Real-time bandwidth	200 MHz
Maximum sample rate	500 MSPS per channel
M937xA PXIe Vector Network Analyzer	
Frequency range	300 kHz to 4, 6.5, 9, 14, 20, 26.5 GHz
Dynamic range	≥ 116 dB (9 GHz), > 98 dB (20 GHz)
Trace noise	< 0.001 dB
N6700B Mainframe & N6782A SMU	
Measurement accuracy:	
Current, 100 mA range	0.025% + 10 uA
Current, 10 uA range	0.025% + 8 nA
Voltage, 20 V range	0.025% + 1.2 mV

Hardware – Instruments

M9381A PXIe Vector Signal Generator

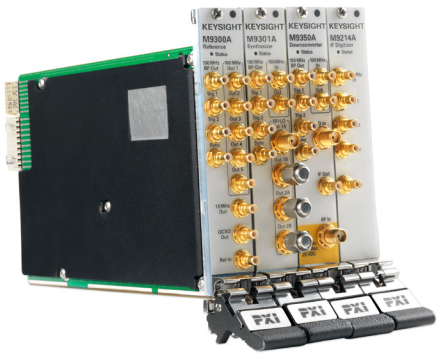
www.keysight.com/find/m9381a



Designed for fast data interfaces and high-speed automated test systems, the M9381A generates RF signals up to 6 GHz with 160 MHz bandwidth. The M9381A is compatible with the full range of Signal Studio communications applications. A typical M9381A configuration includes 4 individual PXIe modules – M9311A digital vector modulator, M9310A source output, M9301A synthesizer and M9300A frequency reference (may be shared with other signal generators and analyzers in the same chassis).

M9391A PXIe Vector Signal Analyzer

www.keysight.com/find/m9391a



Designed for fast power and demodulation measurements in high-speed automated test systems, the M9391A analyzes signals up to 6 GHz with 160 MHz bandwidth. Perform power measurements quickly with real-time signal processing and analyze harmonic distortion up to 6 GHz. The M9391A is compatible with the full range of X-Series Measurement Applications for signal analysis. A typical M9391A configuration includes 4 individual PXIe modules – M9301A synthesizer, M9214A digitizer, M9350A downconverter and the M9300A frequency reference (may be shared with other signal generators and analyzers in the same chassis).

M9393A PXIe Performance Vector Signal Analyzer

www.keysight.com/find/m9393a

Designed for fast power and demodulation measurements in high-speed automated test systems, the M9393A analyzes signals up to 27 GHz with 160 MHz bandwidth. Perform power measurements quickly with real-time signal processing and analyze harmonic distortion up to 27 GHz. The M9393A is compatible with the full range of X-Series Measurement Applications for signal analysis. A typical M9393A configuration includes 4 individual PXIe modules – M9308A synthesizer, M9214A digitizer, M9365A downconverter and the M9300A frequency reference (may be shared with other signal generators and analyzers in the same chassis).

N6700B Mainframe and N6782A SMU

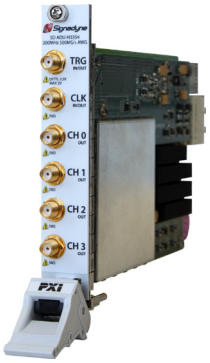
www.keysight.com/find/m6700b

Designed for glitch-free operation the N6700B with N6782A ensures safe usage with the DUT during output and measurement range changes, even with capacitances of up to 150 uF. The N6700B is a 1U high modular power mainframe that accepts the N6782A module, a source/measure unit (SMU) designed for precision sourcing and measurement.

Signadyne SD AOU-H3353 PXIe Arbitrary Waveform Generator

www.signadyne.com/en/products/hardware/high-speed/analog-out--awgs--signal-generators/sd-aou-h3353--analog-out--awg--signal-generator

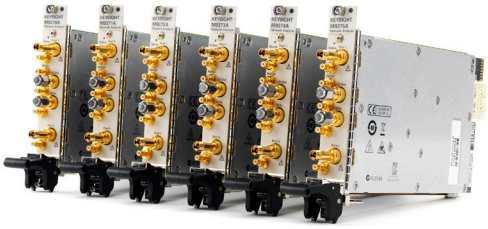
Designed for high-speed waveform generation, the single-slot SD AOU-H3353 enables fast envelope generation for use in high-speed automated test applications. Combine with the M9381A PXIe Vector Signal Generator for synchronized RF and envelope signals. Adjust synchronization at 1 ps resolution.



M937XA PXIe Vector Network Analyzer

www.keysight.com/find/pxivna

Designed for fast S-parameter measurements in high-speed automated test systems, the M937XA series analyzes signals up to 26.5 GHz. This single-slot, full 2-port VNA enables multiport/multi-site capability in a very small package. Easily add or subtract VNA modules based on the needs of your test station. The full N-port correction capability allows for complete and accurate characterization of multiport devices.



Software

Common application software, usable with both modular and benchtop instruments, provides users with the same measurement routines, user interfaces and programming models on both benchtop and modular solutions. The RF PA/FEM Characterization & Test, Reference Solution includes measurement applications that can be used with benchtop and modular instruments: Signal Studio for signal creation, X-Series measurement applications for demodulation and PNA-X-based software for S-parameter measurements

Software – Signal creation

The RF PA/FEM characterization and test, Reference Solution enables multiple ways to create the RF signal. A range of standard waveforms generated with the Keysight Signal Studio software applications are included for demonstration. The Reference Solution software and the M9381A PXIe VSG programming interface support importing customer supplied waveforms, as well.

Signal Studio

Keysight Signal Studio software is a flexible test suite of signal-creation and measurement tools that will reduce the time you spend on signal simulation.

Signal Studio's basic capabilities use waveform playback mode to create and customize waveform files needed to test components and transmitters.

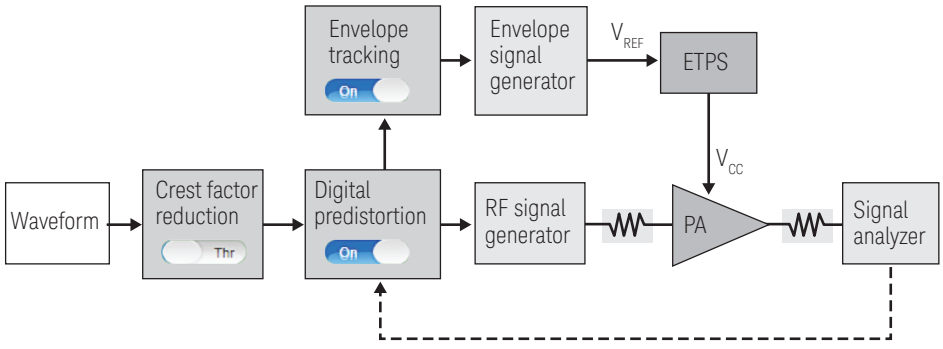
With the N7614B power amplifier test software, Signal Studio's performance-optimized test flow – validated by Keysight – enhances the characterization and verification of your devices.

Modern mobile communications, such as LTE and 802.11ac demand higher data throughput, up to Gb/s, and use wider bandwidth, multi-input multi-output (MIMO) space-time coding, and higher order orthogonal frequency division multiplexing (OFDM) modulation formats. These requirements place new demands on linearity, bandwidth and power consumption in wireless components and place unprecedented battery requirements on mobile terminals or base stations.

Crest factor reduction, envelope tracking and digital pre-distortion, the three main PA test methods that have been introduced, are undergoing research aimed at achieving these goals. All of these methods are supported by the N7614B Signal Studio for power amplifier test software.

Custom waveforms

Custom waveforms and envelopes can also be imported into this Reference Solution.

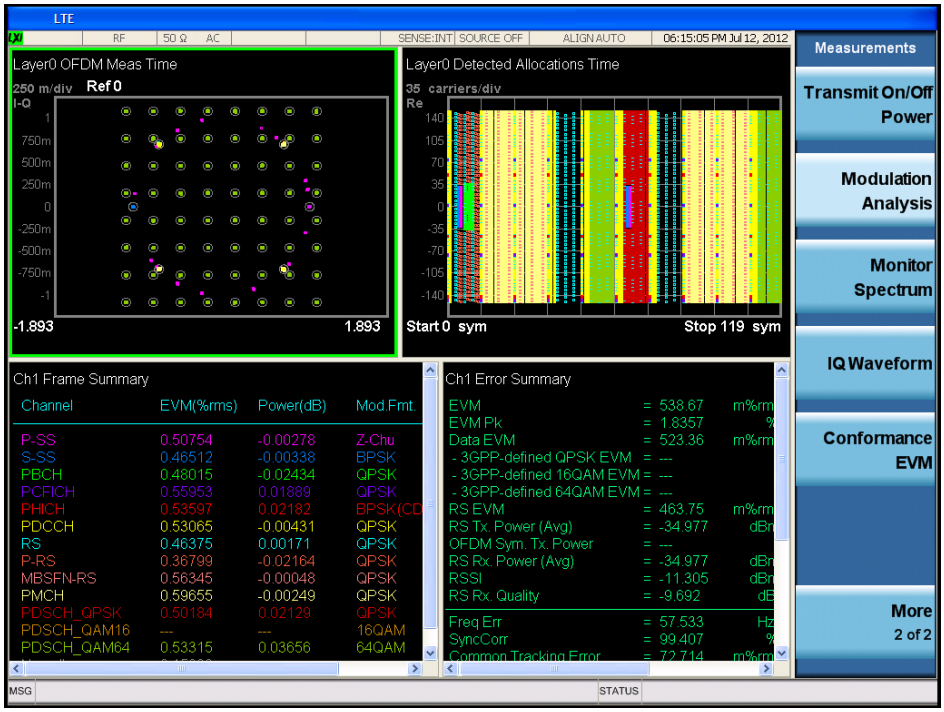


Signal Studio's ET and DPD test flow allows the envelope calculation to be performed using a non-pre-distorted signal, a pre-distorted DPD signal, or an user-specified envelope waveform

Software – Signal analysis

X-Series measurements applications for modular instruments

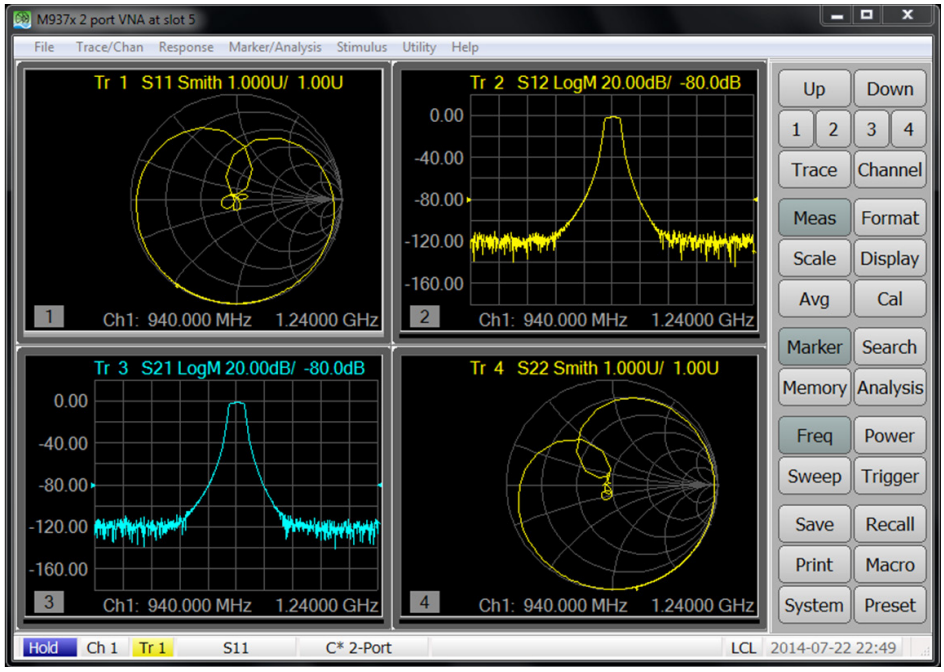
The X-Series measurement applications for modular instruments transform PXI vector signal analyzers into standards-based RF transmitter testers. Fast RF conformance measurements help you evaluate and manufacture your devices and equipment.



X-Series measurement applications for modular instruments

S-parameter measurements

The PXI VNA extends Keysight's expertise in measurement and metrology into the modular PXI form factor. It provides the same quality results you have come to expect in our benchtop VNAs. The graphical user interface guides test engineers using a similar look and feel as Keysight's popular PNA family of network analyzers.



S-parameter measurements using PXI VNA

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.

Instrument control

Power amplifier measurement libraries

The power amplifier measurement libraries include the main functions to interface with the test instruments including PXI VSA, VSG, VNA & AWG, power sensor, SMU and the PA control through the MIPI RFFE interface. Hardware controls are provided to optimize test time and synchronization.

The primary function of the power amplifier measurement library is to use the IVI drivers for the PXI instruments and VNA measurement application; and the SCPI interface for the X-Series measurement applications to setup and make the required measurements for testing of power amplifiers (PA) and front end modules (FEM). 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: Load waveforms, power servo loops, Pout, harmonics and ACPR measurements, modulation analysis and S-parameters.

Digital pre-distortion and envelope tracking

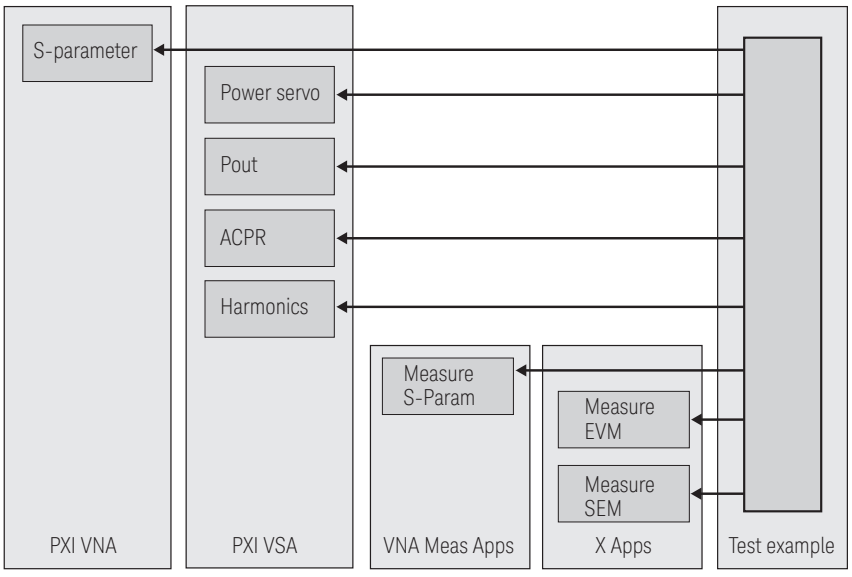
Examples are provided that use the programming API to the N7614B Signal Studio for PA Test application as a signal generation and analysis library while using the IVI drivers to control the PXI VSG, VSA and AWG. These examples include:

- Generating and loading IQ and envelope waveforms generated from N7614B into the PXI VSG and AWG
- Capturing IQ data from the PA output with the VSA and then using this IQ data to perform the digital pre-distortion model extraction with N7614B
- Performing AM/AM and AM/PM analysis from N7614B using the IQ data captured from the PA output, as well as ACPR, efficiency and modulation analysis measurements with the pre-distorted waveforms applied to the PA input

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 measurement library as well as X-Series measurement applications.

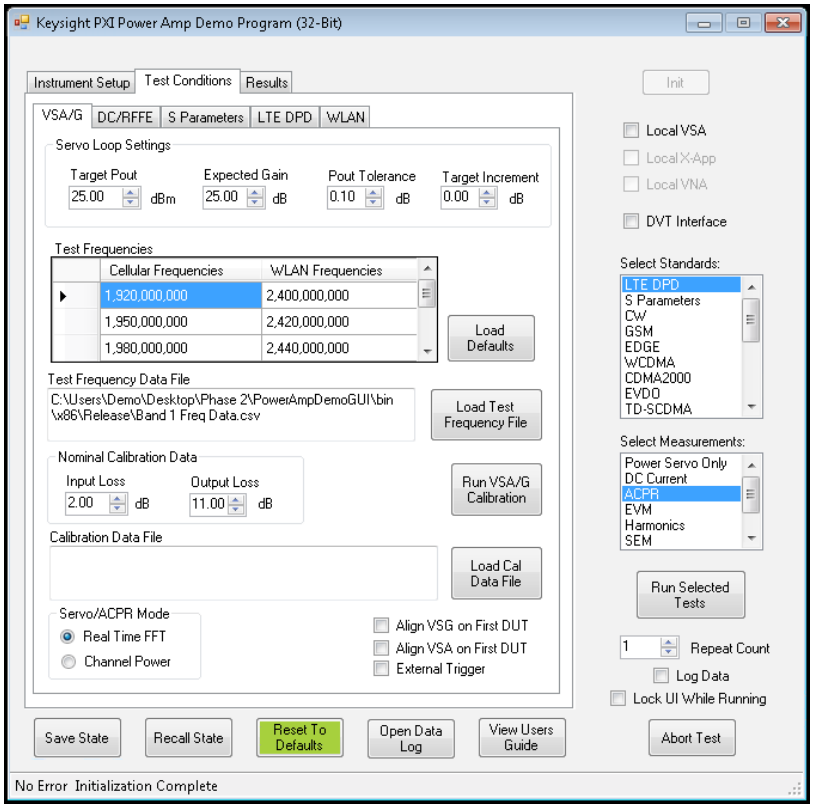
Measurements include EVM, ACPR, SEM, power, harmonics, and S-parameters, as well as data logging and test times as shown in the figure x. It also includes dynamic EVM measurements for WLAN applications.



Measurement capabilities portfolio

Demonstration and evaluation GUI

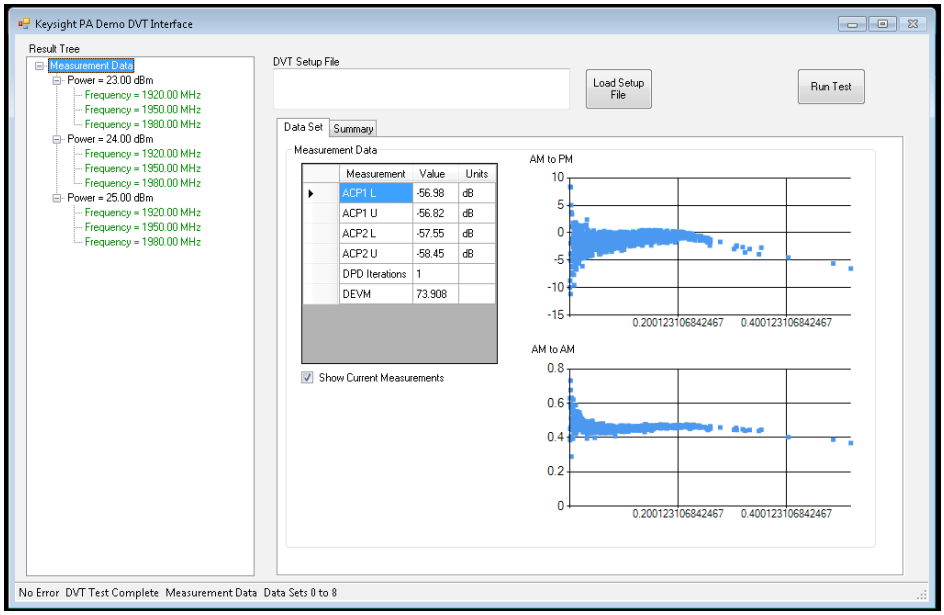
To help you quickly and easily evaluate this Reference Solution, a demo program integrates all the features described in this brochure. Configure the GUI to test your own devices without writing software.



Demonstration and evaluation GUI

Design validation test interface

The design validation test (DVT) interface allows any of the above measurements to be performed across a wide range of user configurable test conditions, with three levels of nested loops. The loops can be configured to cover RF frequency, RF power level and DC voltages, in any order. The measurement data collected in the DVT interface can be displayed for each test point or as a summary for any collection of the measurements.



Design validation interface

Recommended reference solution configuration [1]

Model	Description
M9381A	PXIe Vector Signal Generator
M9381A-F06	1 MHz – 6 GHz frequency range
M9381A-B10	100 MHz modulation bandwidth
M9381A-M01	32 MSa memory
M9381A-UNZ	Fast switching
M9393A	PXIe Vector Signal Analyzer
M9393A-F08	9 kHz – 8.4 GHz
M9393A-B10	100 MHz analysis bandwidth
M9393A-M01	128 MSa memory
M9393A-UNZ	Fast tuning
M9300A	PXIe Frequency Reference
N6700	Modular Power System & SMU
N6700B	Low-Profile Modular Power System Mainframe, 400 W, 4 slots
N6782A	2-Quadrant Source/Measure Unit for Functional Test
U2004A	USB Power Sensor
PXI Arbitrary Waveform Generator	
SD AOU-H3353	Order from Signadyne http://www.signadyne.com/en/products/hardware/high-speed/analog-out--awgs--signal-generators/sd-aou-h3353--analog-out--awg--signal-generator
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
N7624B-9FP	Connect to M9381A/M9252A fixed perpetual license
N7624B-HFP	Basis LTE FDD Rel 9 fixed perpetual license
N7614B	Signal Studio for Power Amplifier Test
N7614B-9FP	Connect to M9381A fixed perpetual license
N7614B-EFP	Envelope tracking
N7614B-FFP	Digital pre-distortion

1. For a more complete set of configuration options, please refer to the *RF PA/FEM Characterization and Test, Reference Solution* configuration guide, literature number 5992-0072EN

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A personalized view into the information most relevant to you.

www.lxistandard.org
LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Keysight is a founding member of the LXI consortium.

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

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Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

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