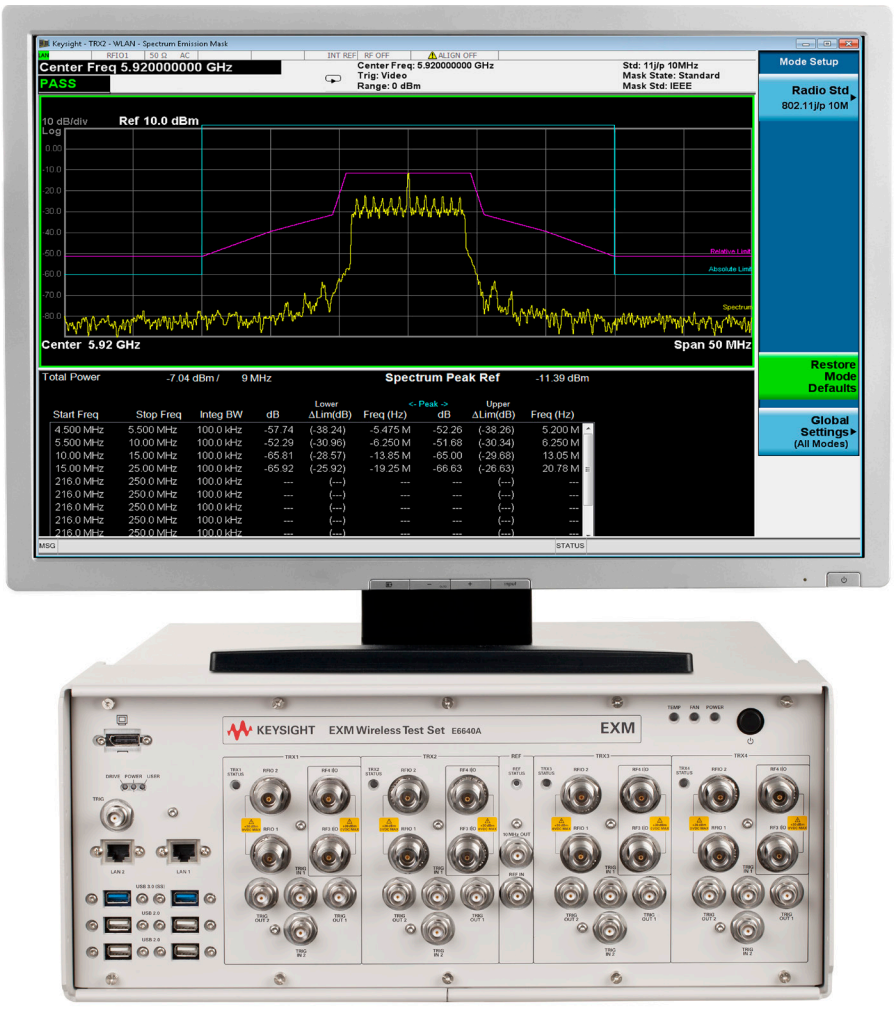
Keysight Technologies
Measurement Applications
For the E6640A EXM Wireless Test Set

Solution Brochure



KEYSIGHT TECHNOLOGIES

EXM Overview

The Keysight Technologies, Inc. EXM wireless test set provides ultimate scalability and port density to help device manufacturers keep pace with production capacity needs and preserve their investment in the future. The test set enables full parallel testing of multiple, multi-format devices simultaneously within a compact design. With the flexibility to start with one TRX and add up to three additional TRXs, or upgrade the TRXs' frequency coverage or analysis bandwidth, you can cost-effectively meet today's production requirements and enjoy up to 16 connections without any external switching.

In addition to its flexible architecture, chipset support and test techniques and methodology play a key role in giving you the freedom to optimize manufacturing test performance and support new cellular and wireless communication technologies as needed.

Key Features

- Up to four TRXs per EXM
- Each TRX is a complete vector signal analyzer/vector signal generator with integrated RFIO
- Up to 6 GHz with 160 MHz bandwidth on each TRX
- Two full-duplex and two half-duplex ports, or four-full duplex ports with rugged type-N connectors
- Software applications licensed to the platform; buy one copy of software and use it on up to four TRXs
- Smart scheduling, advanced sequence analyzer to optimize time efficiency of cellular and wireless connectivity test plans
- Independent source and analyzer on each TRX for parallel transmitter and receiver testing



Figure 1. EXM's system hardware architecture consists of a controller, reference, and up to four TRXs

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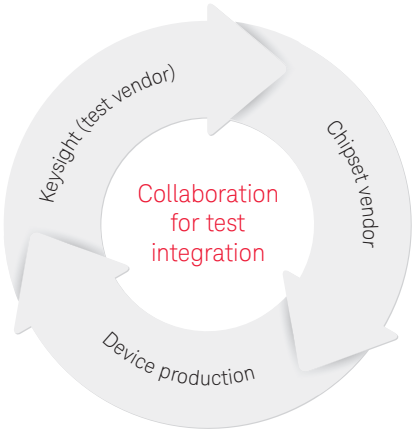
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Accelerate Time to Volume Manufacturing

Manufacturing test integration

Keysight's Manufacturing Test Integration program, an ongoing collaboration with chipset vendors, provides you with chipset vendor-approved tools to test your wireless devices now and in the future. To make your production line run as fast as possible, EXM supports the latest generation of fast-sequenced calibration and verification techniques. In addition, wireless chipset vendors can benefit by working with Keysight's industry-proven measurement experts to achieve the highest test speed possible for specific chipsets as they are brought to market.



Chipset vendor or UE manufacturer's tools

Figure 2. Test integration collaboration

Test automation platform

If you are doing your own chipset software development, Keysight has created a reference solution called the Keysight Test Automation Platform (TAP). This tool supplies you with the framework for optimizing calibration and verification procedures of the leading wireless chipsets. TAP software also serves as a development guide or blueprint for instrument and chipset automation, and explains how to integrate automation instructions together for test steps. In addition to serving as a test development guide for development of your own test executive or shop floor tools, the TAP tool can be run on the lab bench by new product introduction (NPI) engineers using a graphical user interface (GUI).

Whether using chipset vendors' test tools or the Keysight TAP reference solution, you will save engineering test time and cost, allowing you to focus on your core business of device design, development, and manufacturing. Plus, if you are developing your own test tools, Keysight's technical experts are available to provide instrument control expertise to speed up and optimize your test plan.

Accelerate Test Execution

Advanced sequencing

EXM is part of Keysight's comprehensive Power of X Suite of test products, and comes standard with a source list and sequence analyzer. The powerful sequence analyzer function, which includes a set of full-featured analysis tools, synchronizes EXM's source and signal analyzer, facilitates measurement of the device under test (DUT), and provides a host of other capabilities to increase speed and throughput in non-signaling manufacturing test.

WLAN manufacturing test has been predominantly non-signaling test for many years. The nature of non-signaling test eliminates the protocol-based interaction between the tester and DUT, which makes the manufacturing test much faster than signaling mode. Now chipset vendors are improving the non-signaling test modes to achieve even higher test throughput.

One important new test methodology is sequencer-based Tx measurement. With this methodology, the DUT transmits a pre-defined signal sequence that includes various power level, modulation, or even frequency changes, without the time penalty for adjusting the DUT for each of the changes individually.

EXM's flexible sequencer uses this same technique to facilitate faster testing with current chipsets and their test modes, and allow for future advances in the chipset test modes.

Execute test plans at the chipset's highest achievable speed using the powerful and flexible EXM sequencer:

- Designed for non-signaling, ultra-fast device calibration and verification
- Works in synch with chipset test modes to eliminate signaling overhead
- Enables single acquisition with multiple measurements
- Allows precise control of test intervals, test levels, and measurement timing
- Performs multi-technology sweeps

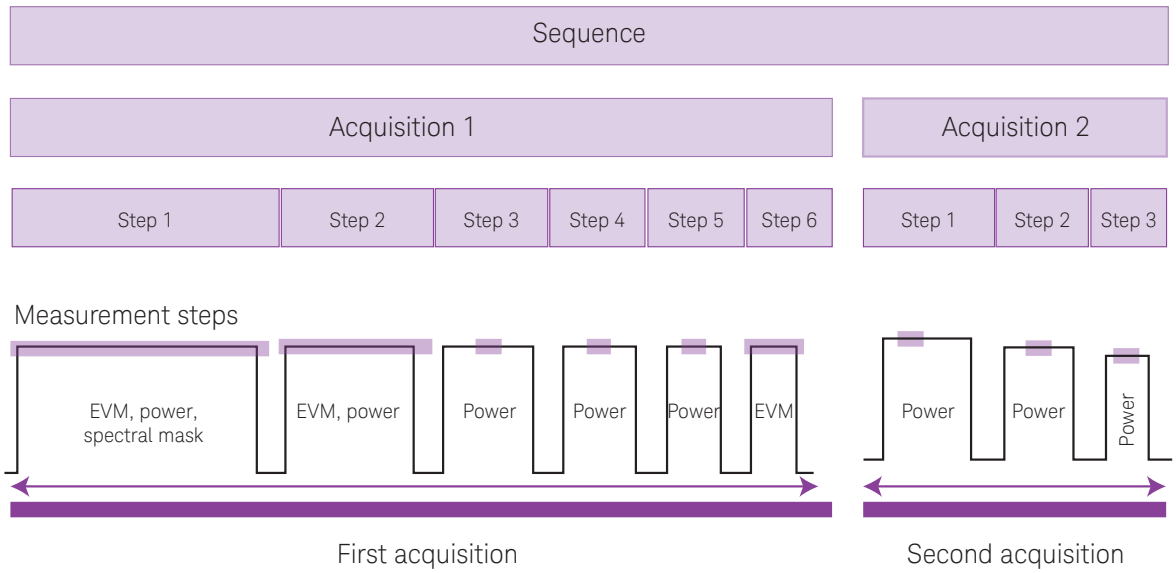


Figure 3. An example of the EXM's WLAN sequencer

An EXM sequence can be comprised of up to hundreds of separate acquisitions and in each case the frequency, expected signal level, and trigger conditions can be programmed. Figure 3 shows two such acquisitions. Within each acquisition, a number of measurement steps can be defined that will normally be programmed to match the programmed output from the DUT using its sequence mode. Each measurement step can be set up to process and return one or more measurement results from the data acquired in that time period. In the figure, there are six measurements made on the data from the first acquisition. The EXM sequence is constructed to match the sequence programmed in the DUT, and when initiated, both are executed together.

Smart Scheduling Instrument

Another test technique supported by EXM is the use of an intermediate test scheduling executive to manage the TRX to ensure maximum use of the test resources and ensure maximum production throughput.

Keysight's name for this is Smart Scheduling Instrument (SSI) and it allows an intermediate test scheduling program to manage instrument control and test execution in a way that allows each DUT to see a "virtual VSA/VSG" independent of the number of physical TRXs populated in the EXM.

This approach to dynamic resource allocation can improve test efficiency significantly.

Broadest Multi-Format Coverage

EXM delivers fast and accurate measurements using high-throughput manufacturing applications for cellular and wireless connectivity devices. These feature-rich applications allow you to choose the capabilities you need and help ensure you achieve your manufacturing test goals for today's multi-format devices.

X-Series measurement applications

Based on the library of industry-proven X-Series measurement applications for benchtop signal analyzers the X-Series cellular and wireless connectivity applications are tailored for the EXM. True to the traditions of X-Series products, each application allows you to characterize, troubleshoot, and rapidly create test code for the manufacture of your design.

For cellular communications measurement, these applications cover a full range of technologies – from existing 2G/3G systems to evolving 3.5G and 4G communication systems. These measurement applications are based on the 3GPP and 3GPP2 standards, and closely follow standards as they change, allowing you to stay on the leading edge of your design and manufacturing challenges.

The wireless connectivity measurement applications cover a full range of technologies, including 802.11a/b/g/n/j/p/ac, WLAN MIMO, *Bluetooth* 1.0 to 4.2, ZigBee, WiSUN (MR-FSK), and Mobile WiMAX.

Giving you added flexibility, you can choose from two product categories of EXM X-Series applications for cellular and wireless communication technologies:

V90xxB

These applications cover transmit measurements only. They allow you to use the 150 waveform slots included with each EXM for output of specific test waveforms. If additional waveforms are needed, additional slots can be purchased in 5-pack or 50-pack quantities.

Y90xxB

These applications provide the transmit measurements as well as the ability to play unlimited waveforms for the technology purchased, eliminating any maximum waveform restriction for those test cases that require a large number of waveforms[1].

Signal Studio applications

Keysight Signal Studio helps you simplify signal creation for receiver measurement and it is the benchmark for test stimuli in the cellular industry. Signal Studio is a comprehensive suite of 2G, 3G, and 4G-compliant solutions. These applications address current and emerging standards with tools that reduce the time you spend on signal creation and simulation while providing a high degree of flexibility in waveform creation.

EXM measurement applications available by cellular and wireless technology are summarized in Tables 1 thru 4.

1. Receiver test waveforms may be played through EXM's source ARB function to make the receiver measurements that are available in the chipset being tested. Waveforms may be provided by the chipset provider, generated by the user through Keysight Signal Studio software, or using any of several third-party software programs.

Table 1. Available cellular communication applications by technology
Cellular communications[1]

Application	X-Series measurement application (transmit measurements)	Signal Studio application (signal generation)	Combined measurement and waveform application
LTE/LTE-Advanced FDD	V9080B	N7624B	Y9080B
LTE/LTE-Advanced TDD	V9082B	N7625B	Y9082B
W-CDMA/HSPA/HSPA+	V9073B	N7600B	Y9073B
TD-SCDMA/TD-HSPA	V9079B	N7612B	Y9079B
GSM/EDGE/EDGE Evo	V9071B	N7602B	Y9071B
cdma2000	V9072B	N7601B	Y9072B
1xEV-DO	V9076B	N7601B	Y9076B
PHS	V9064B	User waveforms	n/a
DECT	V9064B	User waveforms	n/a

Table 2. Available wireless connectivity applications by technology
Wireless connectivity[1]

Application	X-Series measurement application (transmit measurements)	Signal Studio application (signal generation)	Combined measurement and waveform application
802.11a/b/g/n/j/p/ac	V9077B	N7617B	Y9077B
Bluetooth	V9081B	N7606B	Y9081B
Mobile WiMAX	V9075B	N7615B	Y9075B
FM	V9063B	N7611B	n/a
ZigBee	V9064B	User waveforms	n/a
WiSUN (MR-FSK)	V9064B	N7610B	n/a
GNSS	n/a	N7609B	n/a
Digital video	n/a	N7623B	n/a

1. Information referencing “V90xxB” applications also apply to “Y90xxB” applications (where both applications exist). See the EXM Configuration Guide for specific ordering information.

Table 3. Available WLAN MIMO applications by capability
WLAN MIMO[1]

WLAN MIMO	X-Series measurement application	Signal Studio application (signal generation)
Up to 2x2/3x3/4x4 True MIMO	E6640A-M22/M33/44	N7617B
Combined stream MIMO	V9077B-KFP	N7617B
Switched MIMO	V9065B-SFP	N7617B

Table 4. Available General purpose applications
General purpose[1]

Application	X-Series measurement application (transmit measurements)
Analog demodulation	V9063B
Digital demodulation	V9064B

Extensive test coverage

For cellular and wireless connectivity testing, EXM measurement applications provide you with extensive measurement test capabilities.

1. Information referencing “V90xxB” applications also apply to “Y90xxB” applications (where both applications exist). See the EXM Configuration Guide for specific ordering information.

Cellular Communications

LTE/LTE-Advanced FDD

Transmitter test

Keysight V9080B X-Series measurement application for LTE/LTE-Advanced FDD supports all LTE FDD bandwidths: 1.4 to 20 MHz. The V/Y9080B applications support 3GPP LTE FDD transmitter characterization measurements including:

- Channel power
- Occupied bandwidth
- Frequency error
- ACP
- Spectrum emission mask
- EVM
- Transmit On/Off power
- Modulation analysis
- Conformance EVM

Receiver test

Typical measurements for manufacturing or design validation include:

- Reference level sensitivity
- Maximum input level
- Adjacent channel selectivity
- Intermodulation

Keysight N7624B Signal Studio software for LTE/LTE-Advanced FDD provides a high degree of flexibility in waveform creation, including:

- Single- and multi-carrier LTE/LTE-Advanced FDD signal generation
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding

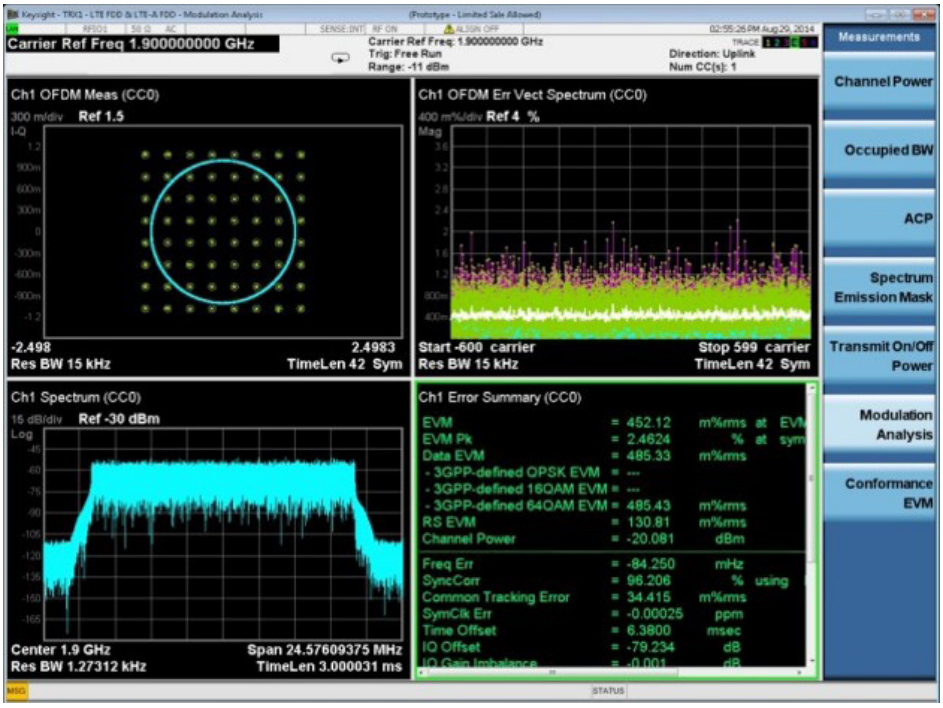


Figure 4. V9080B LTE/LTE-Advanced FDD modulation analysis

LTE/LTE-Advanced TDD

Transmitter test

Keysight V9082B X-Series measurement application for LTE/LTE-Advanced TDD supports all LTE TDD bandwidths: 1.4 to 20 MHz. The V/Y9082B application supports 3GPP LTE TDD transmitter characterization measurements including:

- Channel power
- Occupied bandwidth
- Frequency error
- ACP/ACLR/CACLR
- Spectrum emission mask
- EVM
- Transmit On/Off power
- Modulation analysis
- Conformance EVM
- I/Q offset
- In-band emissions

Receiver test

Typical measurements for manufacturing or design validation include items such as:

- Reference level sensitivity
- Maximum input level
- Adjacent channel selectivity
- Intermodulation

Keysight N7625B Signal Studio Software for LTE/LTE-Advanced FDD provides a high degree of flexibility in waveform creation, including:

- Single- and multi-carrier LTE/LTE-Advanced TDD signal generation
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding

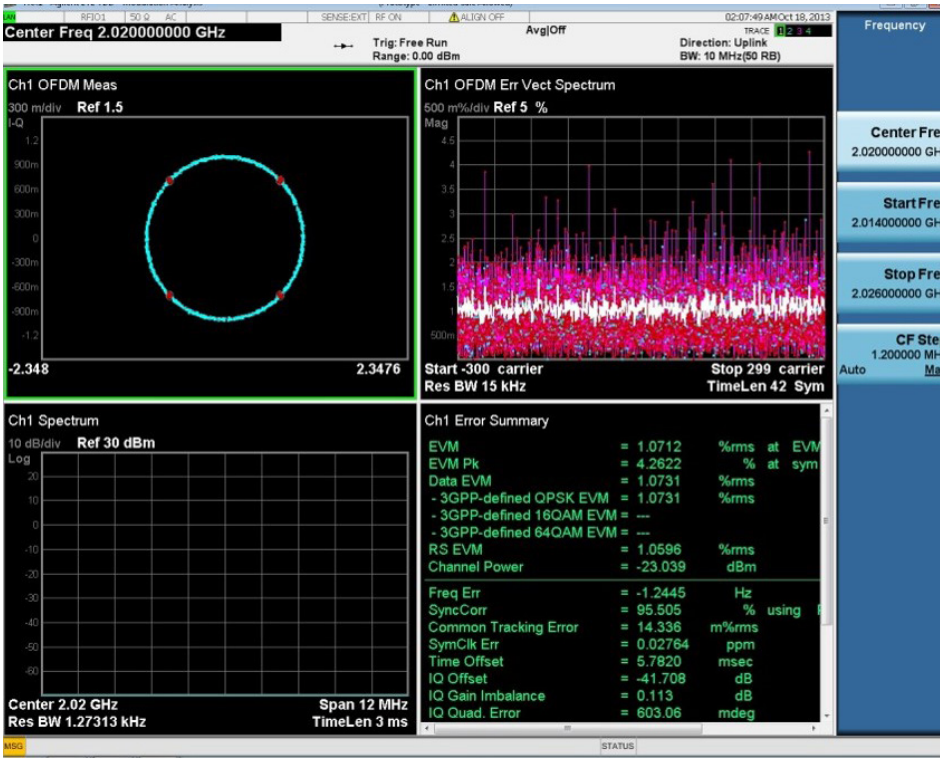


Figure 5. V9082B LTE/LTE-Advanced TDD modulation analysis

GSM/EDGE/EDGE Evo

Transmitter test

Keysight V9071B X-Series measurement application for GSM/EDGE/EDGE Evo supports standard-based measurements per the 3GPP GERAN standard. Transmitter characterization measurements include:

GSM/EDGE measurements
- Transmit power and power vs time (PvT) with multi-slot capability
- Error vector magnitude (EDGE only), and phase and frequency error (GSM only) through polar vector and constellation displays

EDGE Evo measurements
- Normal burst (NB) support: GMSK, 8PSK, 16QAM, and 32QAM
- High symbol rate (HSR) burst support: QPSK, 8PSK, 16QAM, and 32QAM including spectrally-narrow and wide-pulse shaping Tx filter
- Auto-detection and synchronization for all modulation formats including mixed slots containing NB and HSR bursts, plus enhanced trigger hold-off setting for stable burst detection

Receiver test

Typical measurements for manufacturing or design validation include:
- Reference level sensitivity
- Maximum input level
- Adjacent channel selectivity
- Intermodulation

Keysight N7602B Signal Studio Software for GSM/EDGE/EDGE Evo provides a high degree of flexibility in waveform creation, including:
- Single- and multi-carrier GSM, EDGE, and EDGE Evo signals
- Advanced mode for Rx test with transport-channel coding
- Mixed GSM, EDGE, and EDGE Evo carriers and timeslots

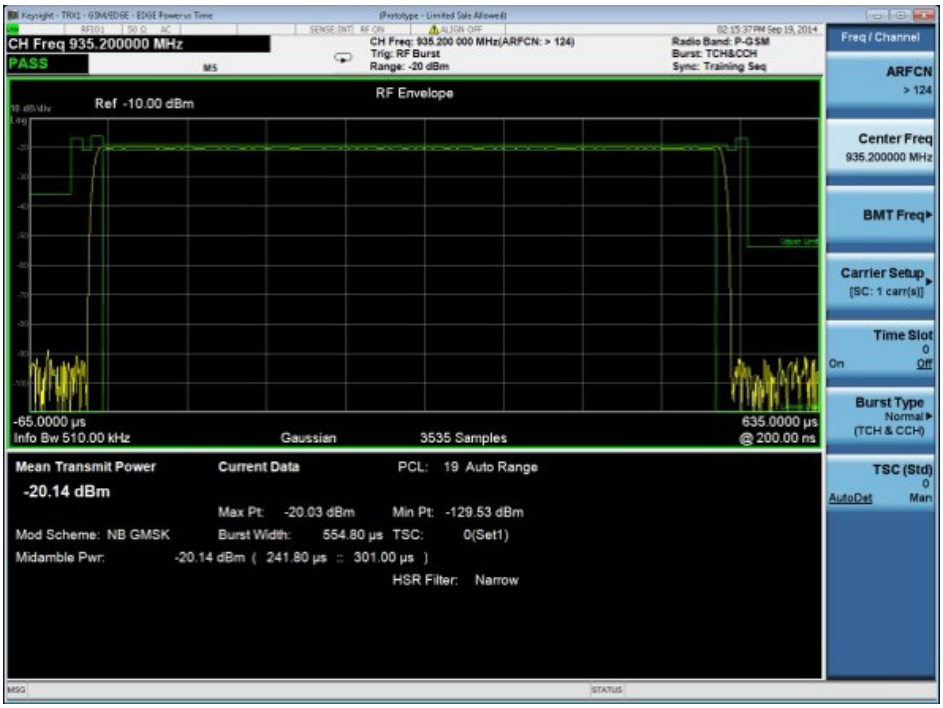


Figure 6. V9071B GSM/EDGE/EDGE Evo channel power

W-CDMA/HSPA/HSPA+

Transmitter test

Keysight V9073B X-Series measurement application for W-CDMA/HSPA/HSPA+ provides transmitter characterization measurements including:

- Channel power
- Occupied bandwidth
- ACP
- Spectrum emission mask
- Frequency error
- Modulation accuracy
- Code domain error
- Code domain power
- Power control
- QPSK EVM

Receiver test

Typical measurements for manufacturing or design validation include:

- Reference level sensitivity
- Maximum input level
- Adjacent channel selectivity
- Intermodulation

Keysight N7600B Signal Studio software for W-CDMA/HSPA/HSPA+ provides a high degree of flexibility in waveform creation, including such capabilities as:

- Single- and multi-carrier W-CDMA, HSPA, and HSPA+ signals
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding
- Complete UE receiver evaluation with DC, MIMO, DC+MIMO, CPC, compressed mode, and more

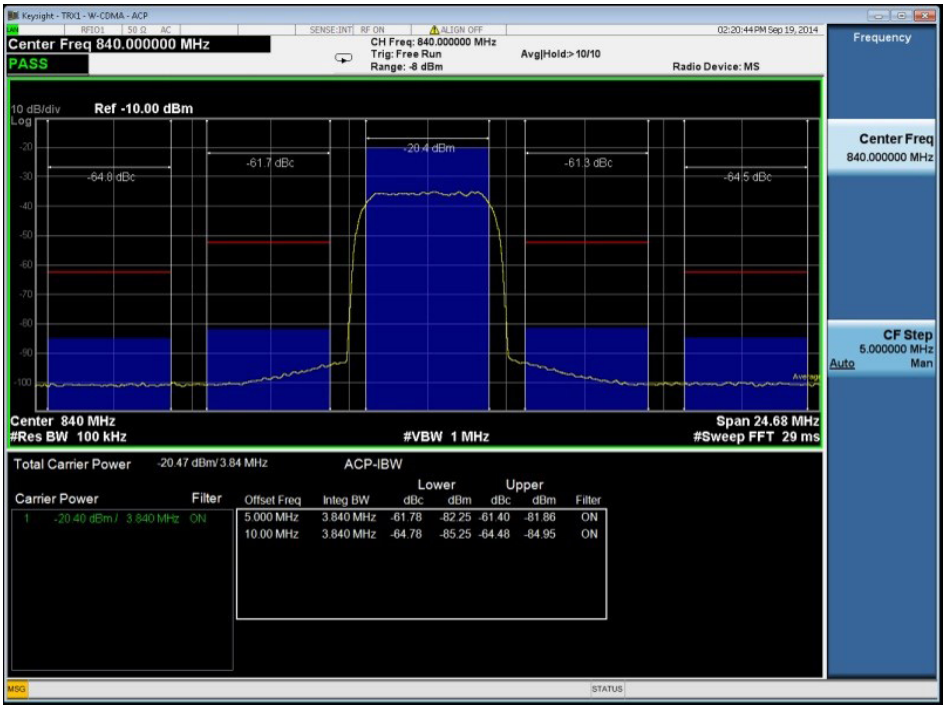


Figure 7. V9073B W-CDMA/HSPA/HSPA+ adjacent channel power

TD-SCDMA/HSPA

Transmitter test

Keysight V9079B X-Series measurement application for TD-SCDMA/HSPA supports TD-SCDMA, TD-HSDPA, TD-HSUPA, and 8PSK per the 3GPP TS 25 standard and provides transmitter characterization measurements including:

- Transmit power
- ACP
- Power vs. time
- Spectrum emission mask
- Occupied bandwidth
- Modulation accuracy (composite EVM)
- Frequency stability
- Transmit On/Off power
- Code domain error
- Code domain power

Receiver test

Typical measurements for manufacturing or design validation include:

- Reference level sensitivity
- Maximum input level
- Adjacent channel selectivity
- Intermodulation

Keysight N7612B Signal Studio software for TD-SCDMA/HSPA provides a high degree of flexibility in waveform creation, including:

- Single- and multi-carrier 3GPP TD-SCDMA LCR with HSDPA signals
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding

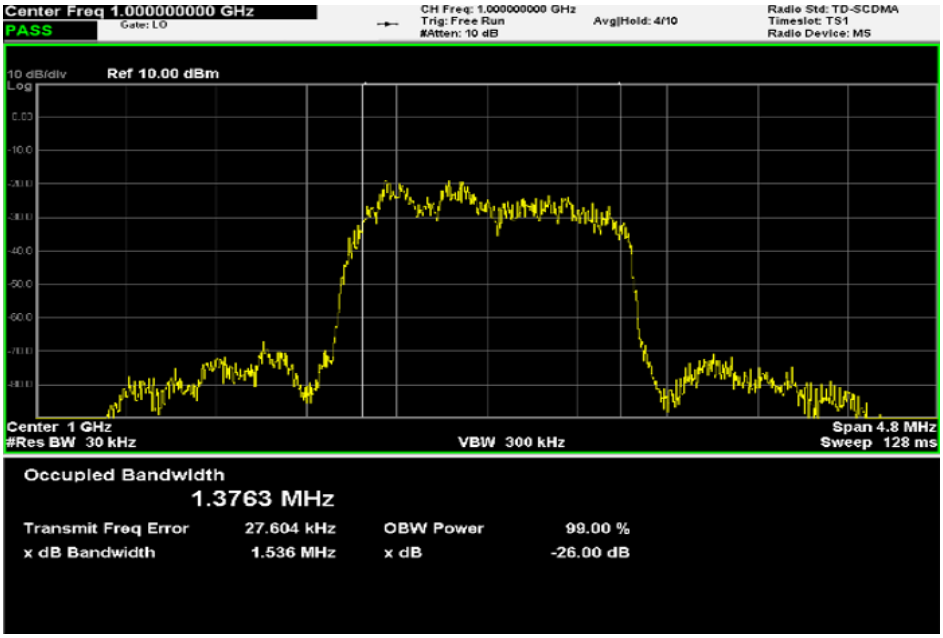


Figure 8. V9079B TD-SCDMA/HSPA occupied bandwidth measurement

cdma2000/cdmaOne

Transmitter test

Keysight V9072B cdma2000/cdmaOne measurement application supports 3GPP2 Release A and provides characterization measurements including:

- Modulation accuracy
  - Composite rho and EVM
  - Frequency error
  - I/Q offset
- Code domain power displayed in Hadamard code or bit reverse order
- Power and spectrum measurements
  - Channel power
  - ACP
  - SEM
  - Occupied bandwidth

Receiver test

Typical measurements include:

- Sensitivity
- Dynamic range

Keysight N6701B Signal Studio software for 1xEV-DO/cdma2000 provides a high degree of flexibility in waveform creation, including:

- Single- and multi-carrier 3GPP2 cdma2000 and 1xEV-DO (Rev. 0 and Rel. A) signals
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding

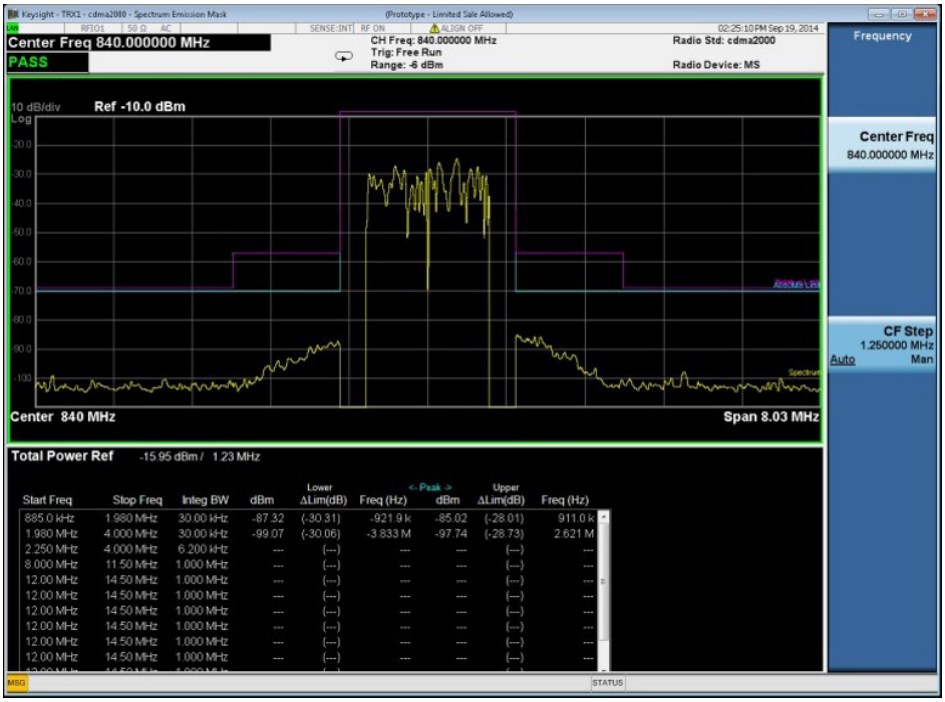


Figure 9. V9072B cdma2000/cdmaOne SEM measurement

1xEV-DO

Transmitter test

Keysight V9076B 1xEV-DO measurement application supports Rev. 0, Rev. A, and Rev. B of 3GPP2 and provides transmitter characterization measurements including:

- Modulation accuracy
- Composite EVM and rho
- CDP
- CDE
- I/Q chip error
- Power and spectrum measurements
- Channel power
- Power vs. time
- ACP
- SEM

Receiver test

Typical measurements include:

- Sensitivity
- Dynamic range

Keysight N7601B Signal Studio software for 1xEV-DO/cdma2000 provides a high degree of flexibility in waveform creation, including such capabilities as:

- Single- and multi-carrier 3GPP2 cdma2000 and 1xEV-DO (Rev. 0 and Rel. A) signals
- Basic mode for Tx design and verification
- Advanced mode for Rx test with transport-channel coding

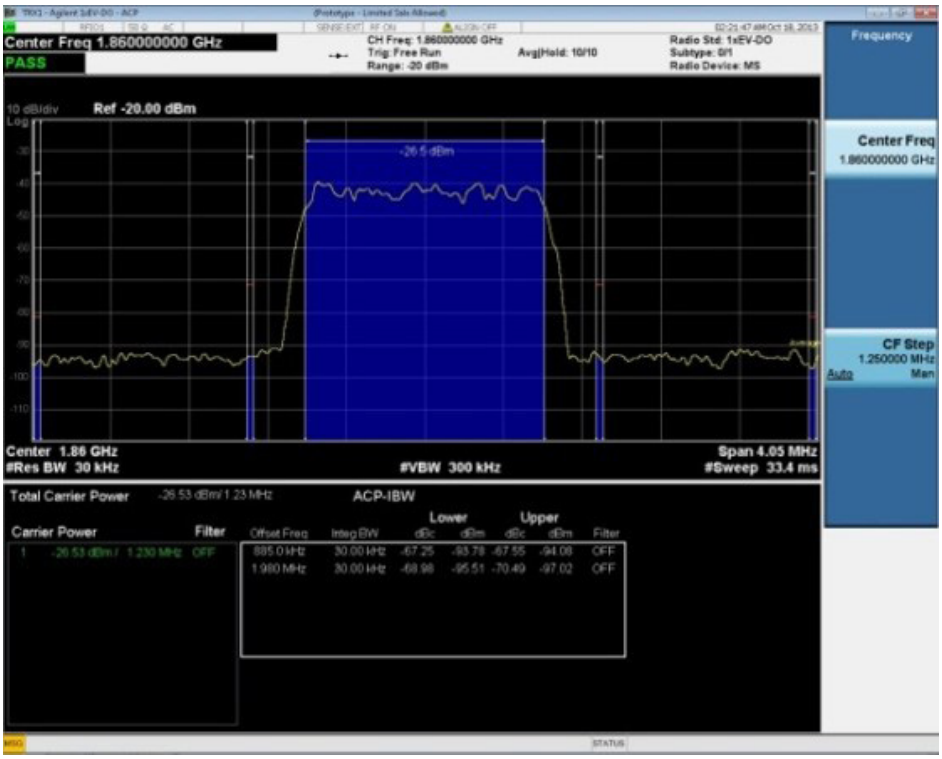


Figure 10. V9076B 1xEV-DO adjacent channel power measurement

Wireless Connectivity

WLAN 802.11a/b/g/n/j/p/ac

- IEEE 802.11a/b/g/n/j/p/ac standard
- One-button measurements with pass/fail per the standard
- Superior measurement speed for manufacturing with multiple measurements from a single acquisition using the EXM sequencer
- Comprehensive MIMO solution from R&D, integration and verification to manufacturing

Transmitter test

By using the EXM WLAN measurement application you can perform WLAN transmitter measurements in the time, frequency, and modulation domains for IEEE 802.11a/b/g/n 20 MHz and 40 MHz signals, 802.11j/p 5/10/20 MHz signals, and 802.11ac 20/40/80/160/80+80 MHz signals. RF transmitter test requirements for WLAN are defined in the IEEE 802.11 series standard. Tables 5 thru 8 show the required transmitter tests along with the corresponding measurement applications. 802.11a/b/g/n/j/p is based on the 802.11-2012 standards, and 802.11ac is based on the 802.11ac-2013 standard.

Table 5. 802.11a/b/g/j/p transmitter tests supported by V9077B-2FP

IEEE802.11a	IEEE802.11b	IEEE802.11g	IEEE 802.11p	Transmitter test	V9077B-2FP
18.3.9.2	17.4.7.2	19.4.8.2	Annex D2.2	Transmit power	Channel power
18.3.9.3	17.4.7.4	19.5.5	Annex D2.3	Spectrum mask	Spectrum emission mask
18.3.9.5	17.4.7.5	19.4.8.3	18.3.9.5	Center frequency tolerance	Frequency error
18.3.9.6	17.4.7.6	19.4.8.4	18.3.9.6	Symbol (chip) clock frequency tolerance	Symbol (chip) clock error
18.3.9.7.2		18.3.9.7.2	18.3.9.7.2	Center frequency leakage	IQ origin offset
	17.4.7.7			Power on/down ramp	Power vs. time
	17.4.7.8			RF carrier suppression	Carrier suppression
18.3.9.7.3		18.3.9.7.3	18.3.9.7.3	Spectral flatness	Spectral flatness
18.3.9.7.4		18.3.9.7.4	18.3.9.7.4	Constellation error (EVM rms)	Constellation error (EVM rms)
18.3.9.8	17.4.7.9	18.3.9.8	18.3.9.8	Modulation accuracy test	Modulation analysis

Table 6. 802.11n transmitter tests supported by V9077B-3FP

IEEE802.11n	Transmitter test	V9077B-3FP
20.3.20.1	Transmit spectrum mask	Spectrum emission mask
20.3.20.2	Spectral flatness	Spectral flatness
20.3.20.3	Transmit power	Channel power
20.3.20.4	Transmit center frequency tolerance	Frequency error
20.3.20.6	Symbol clock frequency tolerance	Symbol (chip) clock error
20.3.20.7.2	Center frequency leakage	IQ origin offset-
20.3.20.7.3	Constellation error (EVM rms)	RMS EVM
20.3.20.7	Modulation accuracy test	Modulation analysis
20.3.20.7	Modulation accuracy test	Modulation analysis

Table 7. 802.11ac transmitter tests supported by V9077B-4FP

IEEE	Transmitter test	V9077B-3FP
22.3.18.1	Transmit spectrum mask	Spectrum emission mask
22.3.18.2	Spectral flatness	Spectral flatness
22.3.18.3	Transmit center frequency tolerance	Frequency error
22.3.18.3	Symbol clock frequency tolerance	Symbol (chip) clock error
22.3.18.4.2	Transmit center frequency leakage	IQ origin offset
22.3.18.4.3	Transmit constellation error (EVM rms)	RMS EVM
22.3.18.4.4	Modulation accuracy test	Modulation analysis

Table 8. Detailed measurements supported by V9077B

Modulation analysis measurement	Technology			
	IEEE 802.11b/g (DSSS/CCK/ PBCC)	IEEE 802.11a/g (ERP-OFDM, DSSS-OFDM), 11p, 11j	IEEE 802.11n (20 MHz and 40 MHz)	IEEE 802.11ac (20/40/80/160 MHz)
RMS EVM	●	●	●	●
Peak EVM	●	●	●	●
Pilot EVM		●	●	●
Data EVM		●	●	●
1K chips EVM 802.11-2007	●			
RMS magnitude error	●			
Peak magnitude error	●			
RMS phase error	●			
Peak phase error	●			
Frequency error	●	●	●	●
Chip clock error	●			
Symbol clock error		●	●	●
I/Q origin offset (CFL)	●	●	●	●
Quadrature skew	●	●	●	●
I/Q gain imbalance	●	●	●	●
Carrier suppression	●			
Average burst power	●	●	●	●
Peak burst power	●	●	●	●
Peakk-to-avg power ratio	●	●	●	●
Modulation format	●	●	●	●
Bit rate	●	●	●	●
Preamble frequency error		●	●	●
OFDM data burst info			●	●
OFDM HT-sig info			●	●
Channel power	●	●	●	●
Occupied bandwidth	●	●	●	●
Spectrum emission mask (SEM)	●	●	●	●
Power vs. time	●	●	●	●
Spectral flatness	●	●	●	●
I/Q waveform	●	●	●	●

Receiver test

Keysight N7617B Signal Studio helps you simplify WLAN signal creation for receiver measurement and the EXM TRX provides support for the transmission of WLAN RF signals from the vector signal generator to the DUT. The number of received packets can be read with the chipset vendor's control software.

Table 9. Receiver measurements supported by EXM

IEEE802.11a	IEEE802.11b	IEEE802.11g	IEEE 802.11p	IEEE802.11n	IEEE802.11ac	Receiver test items
18.3.10.2	17.4.8.2	19.5.2	18.3.10.2	20.3.21.1	22.3.19.1	Receiver minimum input level sensitivity
18.3.10.3	17.4.8.4	19.5.3	18.3.10.3	20.3.21.2	22.3.19.2	Receiver adjacent channel rejection1
18.3.10.4			18.3.10.4	20.3.21.3	22.3.19.3	Nonadjacent channel rejection1
18.3.10.5	17.4.8.3	19.5.4	18.3.10.5	20.3.22.4	22.3.19.4	Receiver maximum input level

802.11ac 80+80 MHz test solution

The 802.11ac standard specifies two ways to achieve the highest data rate: a single 160-MHz contiguous channel (in many geographies, only two or three such channels are available), or two non-contiguous 80-MHz channels (i.e. a 160-MHz non-contiguous channel). In the latter mode of operation, a special spectral mask is defined. Also note that the two 80-MHz channels used may have a number of different channel spacing between them.

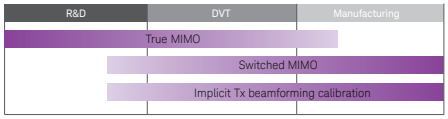


Figure 12. EXM provides comprehensive MIMO solutions across lifecycle

In addition, EXM can support measurements on 2x2 MIMO, non-contiguous 80+80 MHz signals. This feature of 802.11ac WAVE 2 increases data rate with spatial multiplexing and spectrum efficient usage. Figure 11 shows the constellation and EVM numerical results for two streams on two different frequency segments. EXM can also help you verify devices for SISO implementations of 80+80 MHz. Contact Keysight for more information on how to configure these measurements.

WLAN MIMO test solutions

EXM provides comprehensive MIMO measurement solutions for WLAN MIMO devices across the lifecycle from research, development, and verification to manufacturing. Test solutions include:

- Switched MIMO measurements for cost effective manufacturing testing of WLAN MIMO devices
- True MIMO measurements with multiple TRX channels for design and validation of WLAN MIMO devices
- Detailed MIMO measurement results per stream and per channel: Modulation analysis, IQ offset, frequency error, cross talk, and more
- Support Implicit transmitter beamforming calibration test

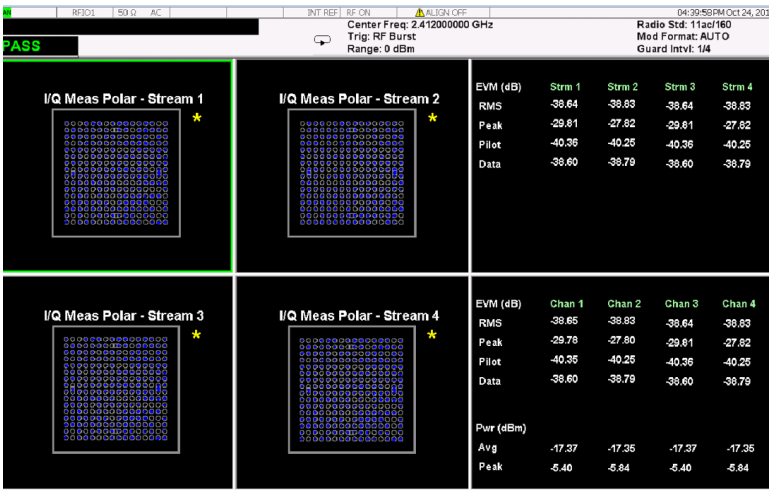


Figure 11. Constellation and EVM numerical results for frequency segment 1, stream1, frequency segment 1, stream2, frequency segment 2, stream1, and frequency segment 2, stream2

True MIMO

EXM offers True MIMO measurements for design and validation of multiple antenna performance. EXM's four independent TRXs make it easy to set up and quickly obtain MIMO measurement results using trusted X-Series measurement science. EXM's precise time alignment across each TRX channel and high port-to-port isolation ensures accurate MIMO measurement results. Each antenna in the DUT is connected to a separate analyzer/source in the tester. EXM provides:

- Multiple TRX for simultaneous test of all MIMO channels
- Provides full set of MIMO metrics quickly; each channel is captured in parallel
- Design and validate 802.11n and 802.11ac up to 4x4 MIMO devices
- Multiple TRXs enable simultaneous test for up to 4x4 MIMO channels
- Supports 802.11ac 20/40/80/160/80+80 MHz
- Supports both Tx and Rx test for MIMO devices
- Detailed measurement results per channel: EVM, power, SEM, cross talk, frequency response, etc.

Switched MIMO

In contrast to True MIMO, Switched MIMO provides a much lower cost method for obtaining a full set of MIMO performance metrics using just a single EXM TRX channel. With any space time block code (STBC) and scrambling turned off, the EXM's built-in fast switching RFIO switches the DUT antennas in turn to the analyzer and captures data sequentially from successive signal bursts. Keysight measurements reconstruct the multiple MIMO streams and perform measurements. EXM's quad-core processor maximizes production throughput by bringing the speed penalty associated with sequentially capturing data from the MIMO streams down to a barely perceptible level. EXM provides:

- Cost-effective solution to test MIMO performance
- Built-in fast switching RFIO switches the DUT antennae in turn to the analyzer
- Sequential capture from successive bursts
- Detailed measurement results per stream and channel: RMS EVM, peak EVM, pilot EVM, data EVM, IQ offset, frequency error, etc.
- 802.11ac 20/40/80/160 MHz support

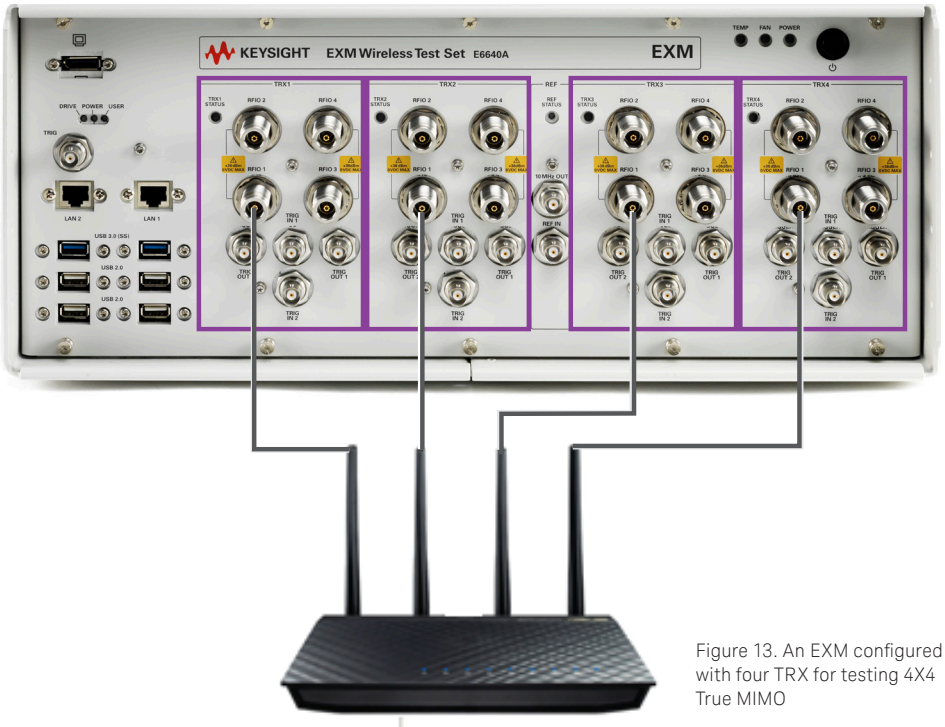


Figure 13. An EXM configured with four TRX for testing 4X4 True MIMO

Implicit transmit beamforming calibration

Beamforming is a technique in which the beamformer (the transmitter in beamforming) uses the knowledge of the MIMO channel to generate a steering matrix that improves reception in the beamformee (the receiver in beamforming). (See Figure 14.) It enables a dramatic improvement in WLAN 802.11n and 802.11ac performance in terms of reliability, range, and coverage. There are two categories of beamforming based on the methods of getting channel knowledge:

Category 1: Explicit feedback
Here, the beamformee makes a direct estimate of the channel from training symbols sent from the beamformer to the beamformee.

Category 2: Implicit feedback
Here, the beamformer receives long training symbols transmitted by the beamformee. Implicit transmit beamforming is based on the assumption that the channel between the beamformer and beamformee is reciprocal. The beamformer obtains a reverse link channel estimate from a long training sequence in acknowledgements (ACKs). This method also:

- Calculates forward link HAB channel information, as shown in Figure 14
- Applies channel compensation (and radio calibration) to a transmitted signal

For this to work, the transmit chain radio performance needs to be calibrated to compensate for the transmit phase response. Implicit transit beamforming calibration testing can be easily performed using EXM Option V9077B-KFP or V9077B-KTP.

EXM WLAN MIMO Test Solutions Summary

Small form factor	Up to 4 TRXs to support 4X4 True MIMO in one 4U box
Easy set up	Easy to set up, no need complex connection for synchronization
High performance	Fast, accurate and reliable MIMO measurement and detailed measurement results

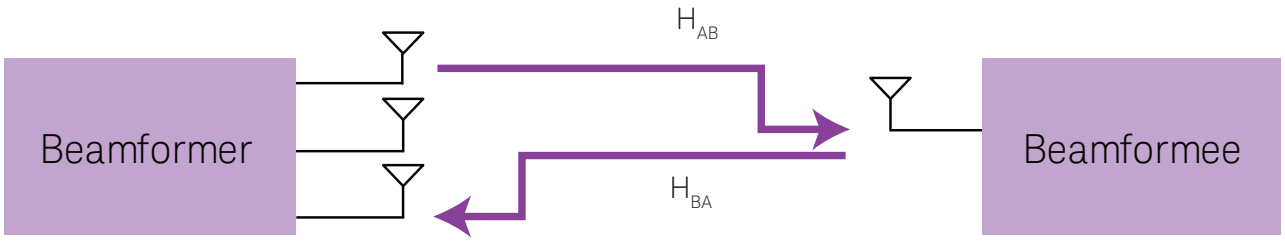


Figure 14. The implicit feedback method assumes that the channel between the beamformer and beamformee is identical in the uplink and downlink directions. Computation of correction matrices is required to eliminate any mismatch between the uplink and the downlink channels.

Table 10. E6640A MIMO test solutions summary and comparison

	True MIMO	Switched MIMO	Combined Stream MIMO
Use case	WLAN MIMO R&D and design and validation	Cost-sensitive manufacturing	Implicit Tx beamforming calibration test
Test methods	Multiple analyzer/source pairs for simultaneous test of all MIMO channels	Sharing analyzer/source pair to measure each MIMO channel in turn	Calibrate transmit chain radio performance
EXM capability	Up to 4X4 MIMO	Up to 3x3 MIMO	Up to 8 streams
Hardware	EXM with multiple TRXs (N TRXs for NxN MIMO)	EXM with 1 TRX	EXM with 1 TRX
Product option	E6640A-M22/M33/M44 for up to 2x2/3x3/4x4 MIMO	V9065B-SFP/TP for up to 3x3 Switched MIMO	V9077B-KFP/TP for up to 8 streams

Bluetooth

Compliant with *Bluetooth* Core Specifications of *Bluetooth* 1.0 to 4.2. Capabilities include:

- One-button measurements with pass/fail per the standard
- Superior measurement speed for manufacturing with multiple measurements from a single acquisition using EXM sequencer
- Modulation: Deviation, initial carrier frequency tolerance (ICFT), carrier frequency drift, EDR frequency stability, and EDR modulation accuracy
- Multiple result views: RF envelope, demodulation waveform, and numeric display

Transmitter test

The *Bluetooth* specifications are developed and licensed by the *Bluetooth* Special Interest Group (SIG). The *Bluetooth* Test Specification document contains the test suite structure (TSS) and test purpose (TP). *Bluetooth* 4.2 updated the *Bluetooth* core specifications including new features for *Bluetooth* Smart. Low energy data packet extension is one new feature in *Bluetooth* 4.2, and EXM supports the required *Bluetooth* 4.2 measurements. Table 11 provides a list of tests with their test purpose identifiers and corresponding measurement applications for transmitter tests.

Table 11. Summary of measurement applications for Bluetooth transmitter tests

***Bluetooth* transmitter test identifiers**	**Test items**	**V9081B-2FP measurement**
Basic Rate (BR)		
TRM/CA/01/C	Output power	Transmit analysis
TRM/CA/05/C	Tx output spectrum – 20 dB bandwidth	Output spectrum bandwidth
TRM/CA/06/C	Tx output spectrum – adjacent channel power	Adjacent channel power
TRM/CA/07/C	Modulation characteristics	Transmit analysis
TRM/CA/08/C	Initial carrier frequency tolerance	Transmit analysis
TRM/CA/09/C	Carrier frequency drift	Transmit analysis
Enhanced data rate (EDR)		
TRM/CA/10/C	EDR relative transmit power	Transmit analysis
TRM/CA/11/C	EDR carrier frequency stability and modulation accuracy	Transmit analysis
TRM/CA/12/C	EDR differential phase encoding	Transmit analysis
TRM/CA/13/C	EDR in-band spurious emissions	EDR in-band spurious emissions
***Bluetooth* 4.0 low energy (LE)**		
TRM-LE/CA/01/C and TRM-LE/CA/02/C	Output power	Transmit analysis
TRM-LE/CA/03/C and TRM-LE/CA/04/C	In-band spurious emission	LE in-band emission
TRM-LE/CA/05/C	Modulation characteristics	Transmit analysis
TRM-LE/CA/06/C and TRM-LE/CA/07/C	Carrier frequency offset and drift	Transmit analysis

KEY

Identifier format is: (Test)/CA/NN/C, in which

TRM = Transmitter test

CA = Capability test (defines the type of testing)

NN = Test purpose number

C = Conformance test performed on dedicated *Bluetooth* test system

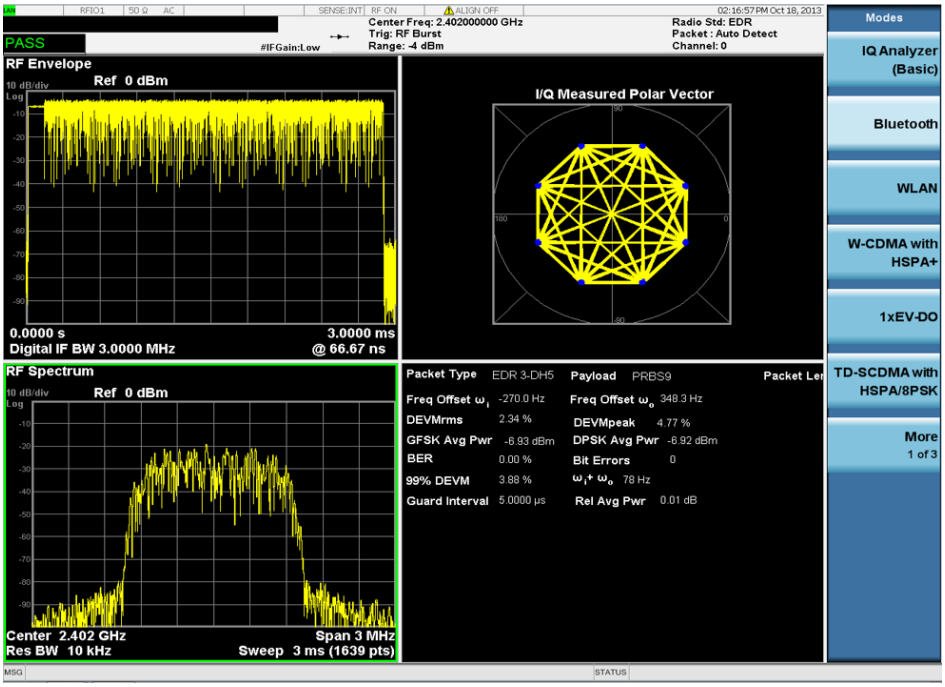


Figure 15. V9081B *Bluetooth* EDR measurements

Receiver test

Keysight N7606B Signal Studio helps you simplify *Bluetooth* signal creation for receiver measurements and EXM TRX provides support for the transmission of *Bluetooth* RF signals from the vector signal generator to the DUT.

Table 12. *Bluetooth* receiver tests

***Bluetooth* receiver test**	**Test items**
RCV/CA/01/C	Output power
RCV/CA/02/C	Sensitivity/single-slot packets
RCV/CA/03/C	Sensitivity/multi-slot packets
RCV/CA/04/C	C/I performance[1]
RCV/CA/05/C	Blocking performance[1]
RCV/CA/06/C	Intermodulation performance[1]
RCV/CA/07/C	Maximum input level
RCV/CA/08/C	EDR sensitivity
RCV/CA/09/C	EDR BER floor performance
RCV/CA/010/C	EDR C/I performance[1]
RCV-LE/CA/01/C and 02/C	EDR maximum input level
RCV-LE/CA/03/C	Sensitivity test
RCV-LE/CA/04/C	C/I and receiver selectivity performance[1]
RCV-LE/CA/05/C	Blocking performance[1]
RCV-LE/CA/06/C	Intermodulation performance[1]
RCV/CA/07/C	Maximum input signal level PER report integrity

KEY

Identifier format is: (Test)/CA/NN/C, in which

TRM = Transmitter test

CA = Capability test (defines the type of testing)

NN = Test purpose number

C = Conformance test performed on dedicated *Bluetooth* test system

1. Requires an additional signal source with Bluetooth capability for the interfering signal.

802.16e OFDMA (Mobile WiMAX)

Transmitter and receiver test

- 802.16 OFDMA measurements per IEEE 802.16 2005 standard
- RCE (EVM), RSSI, preamble PCINR, subcarrier flatness, and IQ metrics
- Time-gated power measurements: ACP and channel power
- Center frequency tolerance, symbol clock frequency tolerance, and power rise/fall
- Delivers relative constellation error (RCE) in multiple levels (composite, pilot, data burst, un-modulated, and preamble)

Mobile WiMAX transmitter tests supported by V9075B:

- Output power
- Power rise/fall
- Spectrum mask
- Spectral flatness
- Center frequency tolerance
- Symbol clock frequency tolerance
- Relative constellation error (EVM)

Receiver test

Keysight N7615B Signal Studio helps you simplify Mobile WiMAX signal creation for receiver measurement and EXM TRX provides support for transmission of Mobile WiMAX signals from the vector signal generator to the DUT. The number of received packets can be read with the chipset vendor's control software. Mobile WiMAX receiver tests supported by EXM include:

- Sensitivity
- Maximum input level
- Adjacent and alternate channel rejection[1]
- Receiver linearity
- Frequency and timing requirements

1. Requires an additional signal source with Mobile WiMAX capability for the interfering signal.

GNSS

Receiver test

Keysight N7609B Signal Studio helps you simplify GNSS signal creation for receiver measurements. The software generates multi-satellite waveforms including: GPS, GLONASS, Galileo, BeiDou, SBAS, QZSS, GPS+SBAS+QZSS, GPS+BeiDou, and GPS+Galileo. GNSS waveform file simulations are useful for testing satellite acquisition and tracking sensitivity on receivers. EXM's TRX provides support for transmission of GNSS signals from the vector signal generator to the DUT.

Table 13. Multi satellite GNSS support by EXM

	Global Navigation Satellite Systems (GNSS)
Test objective GNSS system supported	– Generate multi-satellite waveform files for GPS, GLONASS, Galileo, BeiDou, SBAS, QZSS, GPS+SBAS+QZSS, GPS+BeiDou, GPS+Galileo for manufacturing test – U.S. Global Positioning System (GPS) – Russian Global Navigation Satellite System (GLONASS) – European Galileo system – Chinese Compass/BeiDou system – Satellite-based Augmentation Systems (SBAS) – Japanese Quazi-Zenith Satellite System (QZSS)
Tests covered	– Satellite acquisition and tracking – Receiver sensitivity
Licensing	The satellite waveform files can be used with waveform 5-pack or 50-pack licenses

Digital video

Receiver test

Keysight N7624B Signal Studio helps you simplify digital video signal creation for receiver measurement and the EXM TRX transmits the digital video signals from the vector signal generator to the DUT. EXM provides receiver testing solutions for various digital video, e.g. ISDB-T, DTMB, DVB-S/S2/T2, and CMMB. N7624B supports up to the frequency range of the ordered TRX.

Table 14. Digital video support by EXM

	GDigital video receiver test
Test objective	Generate digital video waveform files for – Advanced ATSC-M/H – Advanced BER tools – Advanced DVB-T/H/C/J.83 Annex A/C – Advanced ISDB-T – Advanced DTMB – Advanced ATSC – Advanced DVB-S – Advanced DVB-S2 – Advanced CMMB – Advanced DVB-T2
Tests covered	Receiver test
Licensing	The satellite waveform files can be used with waveform 5-pack or 50-pack licenses

General Purpose

Analog demodulation is one of the general purpose X-Series measurement applications leveraged to enable EXM to expedite the development and manufacturing of various transmitting devices. Supported one-button measurements include all of the modulation quality plus I/Q waveform measurements.

Analog demodulation

- Modulation analysis for AM, FM, and PM signals
- Analyze analog modulation signals with a selection of detectors: Peak+, Peak-, (Pk-Pk)/2, and RMS
- View RF spectrum, demodulated waveform, AF (modulating signal) spectrum, and demodulation metrics table at the same time with quad view

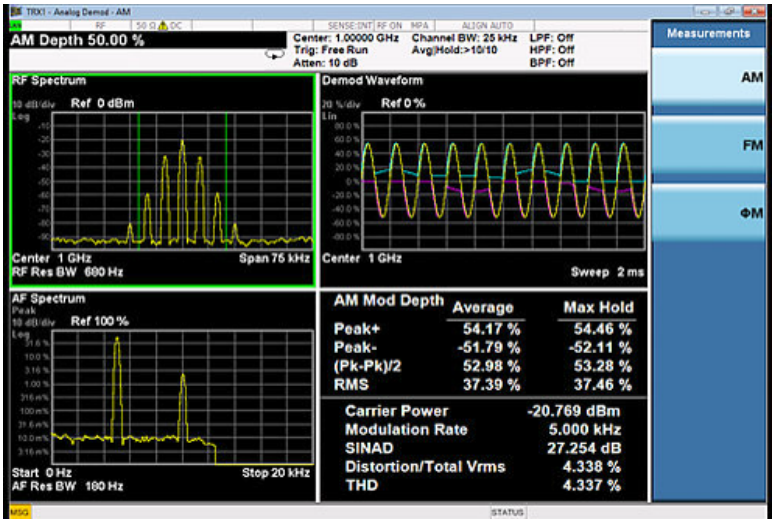


Figure 16. V9063B analog demodulation measurements, quad view

Vector signal analysis

Keyisght V9064B VXA vector signal analysis application provides a wide range of measurements, demodulation types, and filters to perform comprehensive signal analysis. This capability helps you thoroughly test your designs, ensure product quality, and optimize without compromise. The application also provides convenient presets for many popular formats including: ZigBee, PHS, DECT, TETRA, cdma2000, GSM/EDGE, *Bluetooth*, APCO25, and WiSUN (MR-FSK PHY).

V9064A features include:

- FFT-based spectrum analysis and time-domain analysis tools for burst analysis
- General-purpose analog and digital modulation analysis
- Spectrum: center frequency, span, OBW, band power, markers
- Time domain: amplitude, markers, CCDF
- Digital modulation analysis including: 2-16FSK, BPSK, QPSK, 16-1024QAM
- Presets for ZigBee, PHS, DECT, TETRA, cdma2000, GSM/EDGE, *Bluetooth*, APCO25, and WiSUN (MR-FSK PHY)



Figure 17. ZigBee demodulation with V9064B VXA vector signal analysis

Performance You Can Depend On

Keysight measurement applications are based on industry standards, and provide fast, one-button measurements, and sequence analysis capability to speed calibration and verification for your wireless devices for next-generation manufacturing test.

Maximize production yield with industry-proven measurement science. Your team can leverage the test system software through all phases of product development, allowing them to move at a faster pace. You'll get the unified measurement experience and correlated results from R&D to NPI to manufacturing. A common, familiar user interface helps you increase efficiency and productivity – when you learn how to use one X-Series product, you know how to use them all. The consistent programming commands used across the X-Series help you minimize the automation effort and cost of creating automated test systems.

More Information

Title	Literature number
E6640A EXM Wireless Test Set, Flyer	5991-3532EN
E6640A EXM Wireless Test Set, Configuration Guide	5991-3533EN
E6640A EXM Wireless Test Set, Data Sheet	5991-4287EN
Solutions for LTE-Advanced Manufacturing Test, Application Note	5991-3762EN
Solutions for WLAN 802.11ac Manufacturing Test, Application Note	5991-4113EN

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