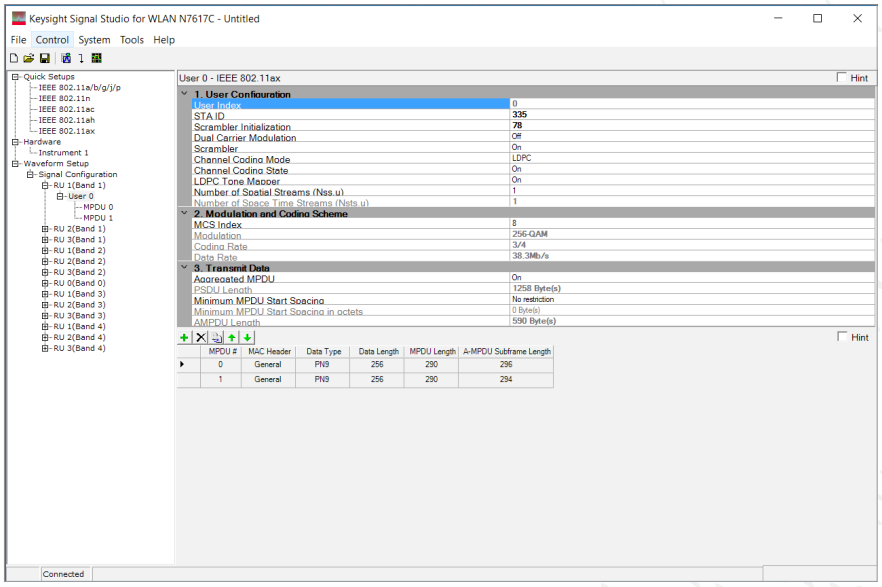
TECHNICAL OVERVIEW

Signal Studio for WLAN

802.11a/b/g/j/p/n/ac/ah/ax N7617C

- Create Keysight validated and performance optimized reference signals compliant with the IEEE 802.11a/b/g/j/p/n/ac/ah/ax standards
- Use basic options to provide partially-coded signals for testing components such as power amplifiers
- Use advanced options to provide signals with full channel coding, flexible configuration of MAC headers, spatial stream mapping, and application of channel models for testing receivers
- Support MIMO testing with up to 8 streams/antennas
- N7607C Signal Studio for DFS Radar Profiles enables creation of FCC, ETSI, Japan MIC, Korean or Chinese radar test signals for DFS test
- Accelerate the signal creation process with a user interface based on parameterized and graphical signal configuration and tree-style navigation



KEYSIGHT TECHNOLOGIES

Simplify WLAN Signal Creation

Keysight Technologies, Inc. Signal Studio software is a flexible suite of signal-creation tools that will reduce the time you spend on signal simulation. Signal Studio's performance-optimized WLAN reference signals—validated by Keysight—enhance the characterization and verification of your devices. Through its application-specific user-interface you'll create standards-based and custom test signals for component, transmitter, and receiver test.

Component and transmitter test

Signal Studio's basic capabilities use waveform playback mode to create and customize waveform files needed to test components and transmitters. Its user-friendly interface lets you configure signal parameters, calculate the resulting waveforms and download files for playback.

The applications for these partially-coded, statistically correct signals include:

- Parametric test of components, such as amplifiers and filters
- Performance characterization and verification of RF sub-systems

Receiver test

Signal Studio's advanced capabilities enable you to create fully channel-coded signals for receiver packet-error-rate (PER) analysis. Applications include:

- Performance verification and functional test of receivers, during RF/baseband integration and system verification
- Coding verification of baseband subsystems, including FPGAs, ASICs, and DSPs

Performance test

N7617C Signal Studio for WLAN 802.11 and N7607C Signal Studio for DFS Radar Profiles can be integrated to set up a test system for WLAN performance tests including DFS test.

Typical measurements

Test components with basic capabilities:

- IMD/NPR
- ACLR
- CCDF
- EVM
- Modulation accuracy
- Channel power
- Occupied bandwidth

Verify receivers with advanced capabilities:

- Sensitivity
- Maximum input level
- Adjacent and nonadjacent channel rejection
- Clear channel assessment

Component and Transmitter Test

Figure 1. Typical component test configuration using Signal Studio's basic capabilities with a Keysight X-Series signal generator and an X-Series signal analyzer.

Signal Studio's basic capabilities enable you to create and customize a variety of WLAN 802.11 waveforms including 802.11a/b/g/j/p/n/ac/ah/ax to characterize the power and modulation performance of your transmitter or receiver components, such as amplifiers and IQ modulators. Easy manipulation of a variety of signal parameters, including standard format, transmission bandwidth, guard interval, data rate, and modulation type, simplifies signal creation.

- Create spectrally-correct signals for channel power, ACP, spectral mask, and spurious testing
- Set parameters such as channel bandwidth and modulation and coding scheme (MCS) for modulation verification and analysis, such as EVM tests
- Configure up to three 802.11a/b/g/j/p carriers with individual channel parameters such as data rate, modulation type, payload data, PN data seed value, and frequency offset
- The 802.11ac option provides a downclocking ratio parameter to allow creation of signals proposed by IEEE 802.11af
- View CCDF, spectrum and time domain graphs to investigate the effects of modulation formats, power changes, filtering, and other effects on the test signal

Apply your signals in real-world testing

Once you have set up your signals in Signal Studio, you can download them to a variety of Keysight instruments and software platforms. Signal Studio software complements these platforms by providing a cost-effective way to tailor them to your test needs in design, development and production test.

- Vector signal generators
  - X-Series: MXG and EXG
  - PSG
  - ESG
  - First-generation MXG
  - M9381A PXIe VSG
  - M9383A PXIe MicroWave VSG
- M9420A/M9421A PXIe vector transceiver
- M9410A/M9411A PXIe vector transceiver
- E6640A EXM wireless test set
- M8190A arbitrary waveform generator

Receiver Test

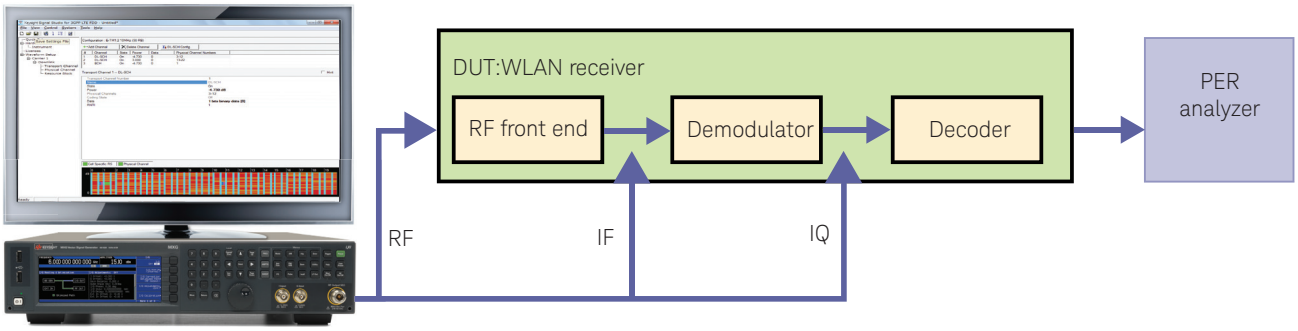


Figure 2. Generate fully channel-coded signals to evaluate the PER of your receiver with Keysight X-Series signal generators and Signal Studio's advanced capabilities.

Signal Studio's advanced mode capabilities provide additional features to help you create IEEE 802.11 WLAN standard-compliant signals for testing receiver designs in all stages of development. Use the baseband signal to perform demodulation and decoding verification on ASIC and DSP chips. To thoroughly test the demodulation capabilities of a receiver, a fully-coded test signal is necessary. This level of coding enables you to determine if each functional stage of a receiver is operating correctly and enables you to use this test signal to perform PER measurements.

- Enable or disable channel coding, scrambling and interleaving
- Configure MAC header settings, MAC FCS, sequence control, data type, and data length
- A multi-frame waveform with an incrementing Sequence Control field can be created for PER testing
- For the 802.11n, 802.11ac, 802.11ah and 802.11ax standards, the software also supports Aggregation MPDU mode and LDPC encoding
- Test MIMO receivers with up to 4 antennas for 802.11n and 802.11ah or up to 8 antennas for 802.11ac and 802.11ax (hardware dependent). Choose the number of transmit chains and space-time streams, and select direct mapping or configure a spatial expansion matrix. The effects of fading can also be incorporated into a longer waveform file with MIMO channel modeling. Users can choose one of the 802.11n or 802.11ac channel models (A through F), or select a user-defined channel model. A beamforming matrix can be added for 802.11ac
- Support 802.11ax OFMDA testing with configuration of different number and location of allocated Resource Units (RU) in the 20/40/80/80+80/160 MHz signal bandwidths. For each RU, the user can further configure Single-User or Multi-User MIMO and the spatial mapping will be applied at the RU level instead of the entire signal bandwidth

Features Summary

802.11 WLAN	Component and transmitter testing	Receiver testing
802.11a/b/g/j/p	**Basic waveform playback mode**	**Advanced waveform playback mode**
Modulation types		
– OFDM	❑	❑
– DSS-OFDM	❑	❑
– DSSS/PBCC/CCK	❑	❑
– ERP-PBCC	❑	❑
Data source types: all 0s, PN9, PN15, user-defined file	❑	❑
PN9 and PN15 seed value	❑	❑
Preamble type: long DSSS, short DSSS, OFDM	❑	❑
Multi-carrier support (up to 3)	❑	❑
Baseband I/Q impairments	❑	❑
OFDM subcarrier mask	❑	❑
Windowing and filtering for spectrum control	❑	❑
Multipath, up to 20 paths	❑	❑
Multi-frame control	❑	❑
Channel encoder		
Scrambler ON/OFF		❑
Convolutional encoder ON/OFF		❑
OFDM scrambler and reserved service bits		❑
PBCC encoder ON/OFF		❑
DSSS scrambler		❑
MAC parameter configuration		
Header		❑
FCS		❑
Sequence number		❑
802.11n		
20 or 40 MHz bandwidth	❑	❑
MCS index from 0 to 32	❑	❑
MCS index from 33 to 76	❑	❑
Data source types: all 0s, PN9, PN15, user-defined file	❑	❑
PN9 and PN15 seed value	❑	❑
Operating mode: legacy, mixed, green field	❑	❑
Beacon frame		❑
Windowing and filtering for spectrum control	❑	❑
MIMO configurations for up to 4 transmitter signals	❑	❑
Direct mapping or spatial expansion	❑	❑
Space-time block coding	❑	❑
MIMO channel models A through F or user-defined	❑	❑
Channel encoder		
Scrambler ON/OFF		❑
Channel coding ON/OFF		❑
BCC encoding		❑
LDPC encoding		❑
Interleaver On/Off		❑
MAC parameter configuration		
Header (general, RTS, CTS)		❑
FCS		❑
Sequence number		❑
Aggregation MPDU		❑
– Minimum MPDU start spacing		❑
Frequency selective I/Q impairment (VHT-PPDU)	❑	❑

802.11 WLAN	Component and transmitter testing	Receiver testing
802.11ac	**Basic waveform playback mode**	**Advanced waveform playback mode**
20, 40, 80, 80+80, or 160 MHz bandwidth	❑	❑
Non-HT and VHT NDP format generation	❑	❑
Beacon frame		❑
MCS index from 0 to 9	❑	❑
1024QAM	❑	❑
Data source types: all 0s, PN9, PN15, user-defined file	❑	❑
PN9 and PN15 seed value	❑	❑
Windowing and filtering for spectrum control	❑	❑
Downclocking ratio	❑	❑
MIMO configurations for up to 8 transmitter signals	❑	❑
Direct mapping or spatial expansion	❑	❑
Space-time block coding	❑	❑
Beamforming	❑	❑
802.11ac MIMO channel models A through F or user-defined	❑	❑
Channel encoder ON/OFF		❑
Scrambler ON/OFF		❑
BCC or LDPC channel coding		❑
Interleaver On/Off		❑
MAC parameter configuration		
Header (general, RTS, CTS)		❑
FCS		❑
Sequence number		❑
Aggregation MPDU		❑
– Minimum MPDU start spacing		❑
Single or multi-user MIMO (up to 8 streams)		❑
Frequency selective I/Q impairment (VHT-PPDU)	❑	❑
802.11ah	**Basic waveform playback mode**	**Advanced waveform playback mode**
1, 2, 4, 8, 16 MHz bandwidth	❑	❑
PPDU Format, NDP for sounding or NDP MAC	❑	❑
Format of S1G, 1 MHz duplicate, 2 MHz duplicate	❑	❑
Preamble of S1G Short and S1G Long	❑	❑
MCS0-10	❑	❑
Data Source types: all 0s, PN9, PN15, user-defined file	❑	❑
Windowing and filtering for spectrum control	❑	❑
Oversampling ratio	❑	❑
MIMO configuration for up to 4 transmitter signals	❑	❑
Direct mapping or spatial expansion	❑	❑
Space-time block coding	❑	❑
Beamforming	❑	❑
Channel encoder ON/OFF		❑
Scrambler ON/OFF		❑
BCC or LDPC channel coding		❑
Interleaver ON/OFF		❑
MAC parameter configuration		
Header (general, RTS, CTS, or short frame)		❑
MAC FCS		❑
Sequencer number		❑
Aggregated MPDU		❑
– Minimum MPDU start spacing		❑
Frequency selective I/Q impairment	❑	❑

802.11 WLAN	Component and transmitter testing	Receiver testing
802.11ax	**Basic waveform playback mode**	**Advanced waveform playback mode**
20, 40, 80, 80+80, or 160 MHz bandwidth	❑	❑
OFDMA Resource Units configuration	❑	❑
Dual-Carrier Modulation	❑	❑
Non-HT (Data and Control, or Trigger), HE NDP, HE SU/Extended Range SU, HE MU PPDU formats generation	❑	❑
HE trigger based PPDU generation (20/40/80/160 and 80+80 MHz)		❑
HE Extended-Range SU PPDU with single 106-tone RU		❑
LTF Symbol Interval Mode	❑	❑
MCS index from 0 to 11	❑	❑
1024QAM	❑	❑
Data source types: All 0s, PN9, PN15, user-defined file	❑	❑
PN9 and PN15 seed value	❑	❑
Windowing and filtering for spectrum control	❑	❑
MIMO configurations for up to 8 transmitter signals	❑	❑
Spatial Mapping Matrix	❑	❑
Space-time block coding	❑	❑
Channel encoder ON/OFF		❑
Scrambler ON/OFF		❑
BCC or LDPC channel coding		❑
BCC Interleaver On/Off		❑
Trigger frame		❑
MAC parameter configuration		
Header (General, RTS, CTS, or short frame)		❑
FCS		❑
Sequencer number		❑
Aggregated MPDU		❑
– Minimum MPDU start spacing		❑
Single or multi-user MIMO (up to 8 streams)		❑

Supported Standards

WLAN format	Approval date	IEEE technical specification
802.11a	1999	802.11-2007 802.11-2010 802.11-2012 802.11ac/D7.0 802.11-03/940r41 802.11-09/0308r122
802.11b	1999	
802.11g	2003	
802.11j	2004	
802.11p	2010	
802.11n	2009	
802.11ac	2013	
802.11ah	2016	802.11ah/D1.1
802.11ax	2019 (planned)	802.11ax/D3.2

1. 802.11n channel models.
2. 802.11ac channel models.

Performance Characteristics

Definitions

Typical (typ):

Represents characteristic performance, which 80% of the instruments manufactured will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 25 °C).

Characteristic:

Non-warranted value based on testing during development phase of this product.

In the following table, characteristics for the N5162A/N5182A apply to all instruments with serial number 4742xxxx or greater, and to instruments with lower serial numbers that have Option 1EA (high power output).

		EVM (typical), valid power range					
Standard	**Frequency**	**N5172B/N5182B**	**N5182A**	**E4438C**	**E8267D**	**M9381A**	**M9420/21A**
802.11a/g/j/p OFDM	2.412 GHz	< 0.28%, ≤ +10 dBm	< 0.28%, ≤ +10 dBm	< 1%, ≤ –1 dBm	< 0.8%, ≤ –1 dBm	< 0.27%, ≤ +6 dBm	–
	5.805 GHz	< 0.35%, ≤ +4 dBm	< 0.45%, ≤ +4 dBm	< 1%, ≤ –1 dBm	< 0.6%, ≤ +6 dBm	< 0.47%, ≤ 0 dBm	0.6%, –5 dBm
802.11b/g DSSS	2.412 GHz	< 0.34%, ≤ +10 dBm	< 0.34%, ≤ +10 dBm	< 1%, ≤ –1 dBm	< 0.7%, ≤ +8 dBm	< 0.24%, ≤ +10 dBm	4%, 0 dBm
802.11n OFDM 20 MHz BW	2.412 GHz	< 0.35%, ≤ +10 dBm	< 0.3%, ≤ +10 dBm	< 0.5%, ≤ +4 dBm	< 0.8%, ≤ –2 dBm	< 0.27%, ≤ +4 dBm	–
	5.805 GHz	< 0.5%, ≤ +6 dBm	< 0.4%, ≤ +6 dBm	< 0.5%, ≤ 0 dBm	< 0.5%, ≤ +6 dBm	< 0.49%, ≤ 0 dBm	0.7%, –5 dBm
802.11n OFDM 40 MHz BW	2.422 GHz	< 0.35%, ≤ +10 dBm	< 0.35%, ≤ +10 dBm	< 0.5%, ≤ +4 dBm	< 0.8%, ≤ –2 dBm	< 0.24%, ≤ +4 dBm	–
	5.795 GHz	< 0.4%, ≤ +6 dBm	< 0.4%, ≤ +6 dBm	< 0.5%, ≤ 0 dBm	< 0.5%, ≤ +6 dBm	< 0.49%, ≤ 0 dBm	0.6%, –5 dBm
802.11ac OFDM 40 MHz BW	5.795 GHz	< 0.5%, ≤ +4 dBm	< 0.5%, ≤ +4 dBm	< 0.5%, ≤ 0 dBm	< 0.5%, ≤ +6 dBm	< 0.45%, ≤ 0 dBm	–
802.11ac OFDM 80 MHz BW	5.775 GHz	< 0.5%, ≤ +4 dBm	< 0.5%, ≤ +4 dBm	< 1%, ≤ 0 dBm	< 0.6%, ≤ +6 dBm	< 0.49%, ≤ 0 dBm	–
802.11ac OFDM 160 MHz BW	5.25 GHz	< 0.5%, ≤ +4 dBm	Not supported	Not supported	Not supported	< 0.64%, ≤ +2 dBm	–
802.11ah 1 MHz BW	850 MHz	< 0.34%, ≤ +10 dBm	< 0.40%, ≤ +10 dBm	< 0.60%, ≤ +10 dBm	< 0.72%, ≤ +10 dBm	–	–
802.11ah 2 MHz BW	920 MHz	< 0.20%, ≤ +10 dBm	< 0.28%, ≤ +10 dBm	< 0.36%, ≤ +10 dBm	< 0.40%, ≤ +10 dBm	–	–
802.11ax OFDM 80 MHz BW	5.775 GHz	< 0.5%, ≤ +5 dBm	–	–	–	–	–
802.11ax OFDM 160 MHz BW	5.25 GHz	< 0.5%, ≤ +5 dBm	–	–	–	–	–

All EVM measurements were made with an N9030A PXA signal analyzer with Option B1X (160 MHz bandwidth), using the 89601B vector signal analyzer software with Options B7R, B7Z, BHJ, BHF and BHX for 802.11a/b/g/j/p, 802.11n, 802.11ac, 802.11ah, and 802.11ax modulation analysis.

	802.11a/g/ j/p OFDM	**802.11b/g DSSS**	**802.11n OFDM 20 MHz BW**	**802.11n OFDM 40 MHz BW**	**802.11ac OFDM 80 MHz BW**	**802.11ah 2 MHz BW**	**802.11ax OFDM 80 MHz BW**	**802.11ax OFDM 160 MHz BW**
Sofware settings								
Data rate	54 Mbps	11 Mbps	–	–	–	–	–	–
MCS index	–	–	15	15	6	8	11	11
Modulation	64QAM	–	64QAM	64QAM	64QAM	256QAM	1024QAM	1024QAM
Coding rate	3/4	–	5/6	5/6	3/4	3/4	5/6	5/6
Encoder	On	CCK	On	On	On (BCC)	On (BCC)	–	–
Scrambler	On	DSSS On	On	On	On	On	On	On
Interleaver	On	On	On	On	On	On	–	–
Scrambler initialization	93	–	93	93	93	93	93	93
Support carrier setup	All channels active	–	–	–	–	–	–	–
Idle interval	100 µs	100 µs	20 µs	20 µs	20 µs	20 µs	20 µs	20 µs
Oversampling ratio	≥ 2	≥ 2	≥ 2	2	1.25	2	2	1.25
Data type	PN15	PN15	PN15	PN15	PN15	PN15	PN15	PN15
Data length	1024	1024	1024	1024	1024	1024	16384	16384
Window length	≥ 8	–	≥ 16	≥ 16	2	2	2	4
Spectrum control filter type	–	Gaussian	–	–	Root raised cosine	–	Root raised cosine	Root raised cosine
– Length (symbols)	–	6	–	–	100	–	17	9
– Filter parameter	–	BT = 0.7	–	–	Alpha = 0.05		Alpha = 0.05	Alpha = 0.05
Bandwidth	–	–	20 MHz	40 MHz	80 MHz	2 MHz	80 MHz	160 MHz
Aggregation MPDU	–	–	Off	Off	On	On	On	On
Signal generation settings								
Reconstruction filter	Thru	Thru	Thru	Thru	Thru	Thru	Thru	Thru
ALC	On	On	On	On	On	On	On	On
RF blanking	Off	Off	Off	Off	Off	Off	Off	Off
Modulation attenuation	8 to 10 dBm	8 to 10 dBm	Auto	Auto	Auto	Auto	Auto	Auto
Waveform runtime scaling	70%	70%	70%	70%	70%	70%	70%	70%
89601B settings								
Range			Optimal	Optimal	Optimal	Optimal	Optimal	Optimal
Equalizer training			Preamble, pilots and data	Preamble, pilots and data	Preamble, pilots and data	Preamble and data	Preamble, pilots and data	Preamble, pilots and data

Ordering Information

Software licensing and configuration

Signal Studio offers flexible licensing options, including:

- **Node-locked:** Allows you to use the license on one specified instrument/computer.
- **Transportable:** Allows you to use the license on one instrument/computer at a time. This license may be transferred to another instrument/computer using Keysight's online tool.
- **Floating:** Allows you to access the license on networked instruments/computers from a server, one at a time. For concurrent access, multiple licenses may be purchased.
- **Time-based:** License is time limited to a defined period, such as 12-months.

Try before you buy!

Free 30-day trials of Signal Studio software provide unrestricted use of the features and functions, including signal generation, with your compatible platform. Redeem a trial license online at www.keysight.com/find/SignalStudio_trial

N7617C Signal Studio for WLAN 802.11a/b/g/j/p/n/ac/ah/ax

Waveform playback licenses (N7617EMBC)

Software license type	Software license	Support subscription (12-month)[2, 3]
Node-locked perpetual	R-Y5B-001-A	R-Y6B-001-Z[2]
Node-locked time-based	R-Y4B-001-Z[1]	Included
Transportable perpetual	R-Y5B-004-D	R-Y6B-004-Z[2]
Transportable time-based	R-Y4B-004-Z[1]	Included

One-month KeysightCare software support subscription extension[3]

Support subscription	Description
R-Y6B-501	1-month of support subscription for node-locked perpetual licenses
R-Y6B-504	1-month of support subscription for transportable perpetual licenses

1. Z means different time-based license duration. F for 6 months, L for 12 months, X for 24 months, and Y for 36 months. All time-based licenses have included the support subscription same as the time-base duration.
2. Z means different support subscription duration. L for 12 months (as default), X for 24 months, Y for 36 months, and Z for 60-months. Support subscription must be purchased for all perpetual licenses with 12-months as the default. All software upgrades and KeysightCare support are provided for software licenses with valid support subscription.
3. Support subscription for all perpetual licenses can be extended with monthly extensions.

Hardware configurations

To learn more about compatible hardware and required configurations, please visit: www.keysight.com/find/SignalStudio_platforms

PC requirements

A PC is required to run Signal Studio. www.keysight.com/find/SignalStudio_pc

Model numbers and options

To learn more about Signal Studio licensing, model numbers and options, please visit: www.keysight.com/find/signalstudio_model

Websites

- www.keysight.com/find/SignalStudio

Comprehensive Online Documentation

- www.keysight.com/find/signalstudio_support

Signal Studio for WLAN:

- www.keysight.com/find/n7617c

Signal Studio for DFS Radar Profiles:

- www.keysight.com/find/n7607c

Keysight's WLAN design and test solutions

- www.keysight.com/find/wlan

Signal Studio and Signal Creation Software

- www.keysight.com/find/signalstudio_software

Literature

- *History of 802.11 - White Paper,* 5992-1581EN
- *Testing New-Generation WLAN 802.11ac - Application Note,* 5990-8856EN
- *Creating and Optimizing 802.11ac Signals and Measurements - Application Note,* 5991-0574EN
- *Solutions for Testing Very High Throughput 802.11ac Signals - Application Note,* 5990-9987EN
- *Simplify Signal Creation with Signal Studio Software - Brochure,* 5989-6448EN

Learn more at: www.keysight.com

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