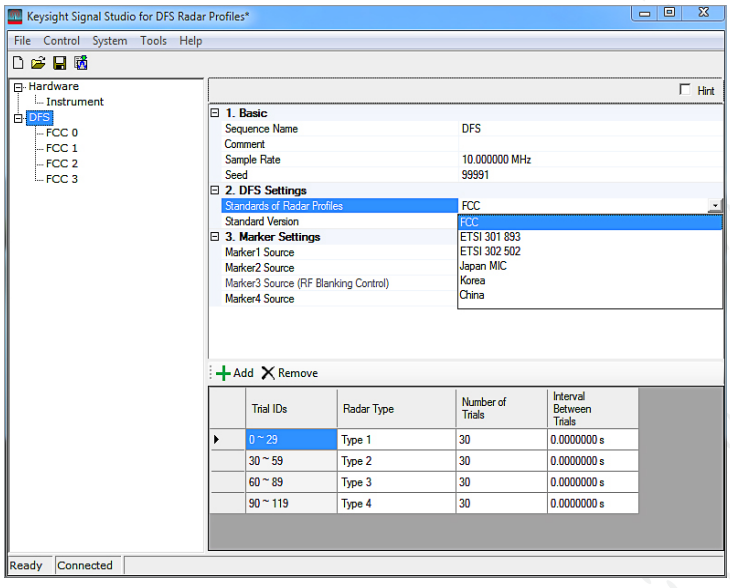
TECHNICAL OVERVIEW

Signal Studio for DFS Radar Profiles
N7607C

2020 update 1.0

- Create Keysight validated and performance optimized dynamic frequency selection radar profiles
- Enable creation of FCC, ETSI Japan MIC, Korea or China compliant radar 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 Dynamic Frequency Selection (DFS) Radar Profile 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. For DFS radar profiles, Signal Studio's performance-optimized 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 radar signals for DFS tests.

Dynamic frequency selection (DFS) test

Signal Studio's capabilities use waveform playback mode to create and customize the waveform files needed to test DFS. 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:

- Select (DFS) reference test signals, compliant with radar signals defined by FCC, ETSI Japan MIC, Korea and China standard
- Create short (Type 0-4), long (Type 5) and frequency hopping (Type 6) radar profiles defined in FCC 06-96 and FCC-13-22
- Create reference and Type 1-6 radar profiles defined in ETSI 301 893 Version 2.1.1
- Create fixed or variable Type 1-6 radar profiles and hopping radar Type 1-2 profilesdefined in ETSI 302 502 Version 1.2.1
- Create fixed or variable Type 1-3 radar profiles and hopping radar Type 4 profile defined in Korea DFS standard.
- Create constant PRF based Type 1-4 radar signals and single pulse based or packet based staggered PRF radar Type 5 and 6 test signals defined in China DFS standard.
- Create W53 (Fixed and Variable) and W56 (Fixed and Variable) radar profiles defined in Japan MIC standard
- Randomize the radar parameter sets of each trial with the Seed setting
- Adjust pulse width, pulse repetition interval, number of bursts, number of pulses, etc. within the range defined in the standard
- Save and recall the settings of the generated Trial List table with all parameters for repeatability testing

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. 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, EXG and CXG
- PSG[1]
- ESG
- First-generation MXG

PXIe Vector Transceiver

- M9420A/M9421A VXT

1. When N7607C runs with the PSG for DFS testing, it requires the option E8267D-UNW of narrow pulse modulation.

Typical measurements

Test transmitters with DFS capability:

- Detection threshold
- Channel availability check
- Off-channel CAC (channel availability check)
- In-service monitoring
- Channel shutdown
- Non-occupancy period

Dynamic Frequency Selection (DFS) Overview

Unlicensed devices, typically WLAN/WiMax™, are being allowed to operate in the same frequency spectrum that is currently allocated to licensed devices, typically radar systems (mainly for military & weather). Radar systems are guaranteed to have spectrum protection. Therefore, unlicensed devices must not transmit on the same frequency upon which a nearby radar system is operating. They must instead choose an operating channel that covers a frequency range not currently utilized by a nearby operational radar. This choice is made dynamically during operation, and is called Dynamic Frequency Selection (DFS). Currently DFS is mainly defined in U-NII band, which is used primarily for WLAN systems, including three frequency bands: 5.150 to 5.350 GHz, 5.470 to 5.725 GHz, and 5.735 to 5.915 GHz.

DFS tests typically define the radar profiles which describe the RF and time domain characteristics of a given radar signal type. The radar profiles are defined by various government communication agencies including FCC, ETSI Japan MIC, Korea and China DFS standard.

Radar signal time domain characteristics include:

- Radar pulse width (sec), pulse repetition frequency (Hz) or pulse repetition interval (sec)
- Number of pulses per radar burst
- Number of radar bursts

Frequency domain characteristics include:

- Burst center frequency (Hz) for a signal-burst profile which is fixed. For multi-burst frequency hopping profiles, this value changes from burst to burst.
- Chirp bandwidth (Hz)--each pulse has a linear frequency modulated chirp between each bandwidth

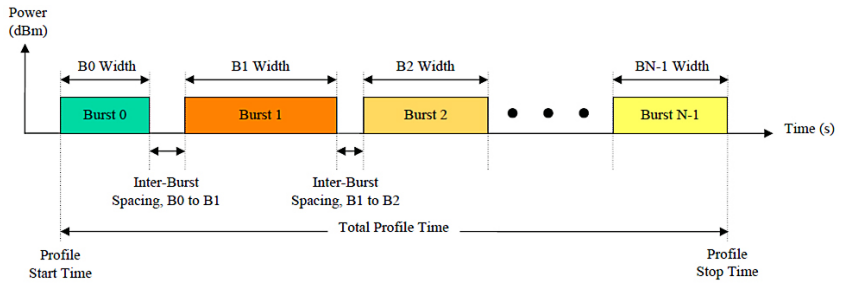


Figure 1. Time domain view of a radar profile.

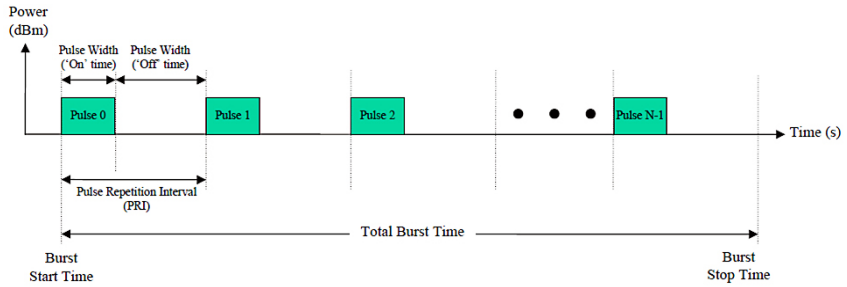


Figure 2. Burst level of a radar profile.

Dynamic Frequency Selection (DFS) Test

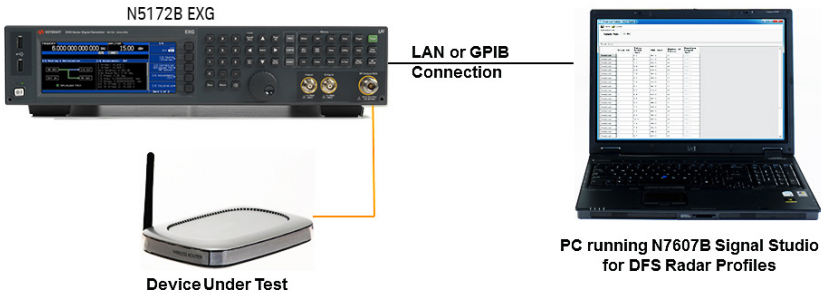
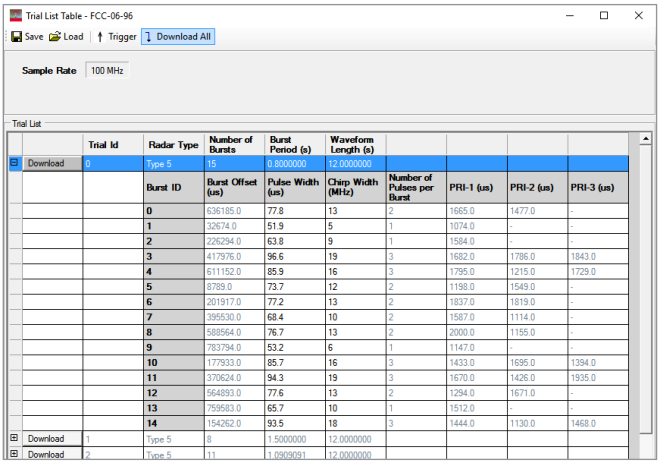


Figure 3. DFS test setup.

N7607C Signal Studio for DFS radar profiles can help you create FCC Part 15 Sub part E (FCC 06-96 and FCC 13-22), ETSI EN 303 893 V2.1.1, ETSI EN 302 502 V1.2.1, Japan MIC, Korea and China standard-compliant radar signals for DFS test, which can be used for R&D or performance test. N7607C provides a user-friendly interface to let you easily generate radar test signals with the following steps:

1. Select DFS in the tree view. Next, select Radar Profiles, and use the drop-down arrow to display a menu from which you can select the desired radar profile from FCC, ETSI Japan MIC, Korea or China standard.
2. Select FCC in the tree view. Next, select Radar Type, and use the drop-down arrow to display a menu from which you can select the desired type, for example, Type 5.
3. Select Create Trial List. A new window named “Radar Profile Display” will be displayed as the bottom graph.
4. Select Download for each trial to generate and download the waveform to the signal generator for playback. The signal for each trial is unique as required by the standards.

Typical DFS measurements include the following tests:
DFS detection threshold
Channel available check (CAC) time
Off-channel CAC time
Channel move time
Channel closing transmission time
Non-occupancy period



	Trial Id	Radar Type	Number of Bursts	Burst Period (s)	Waveform Length (s)				
Download	0	Type 5	15	0.8000000	12.0000000				
		Burst ID	Burst Offset (us)	Pulse Width (us)	Chirp Width (MHz)	Number of Pulses per Burst	PRI-1 (us)	PRI-2 (us)	PRI-3 (us)
		0	636185.0	77.8	13	2	1665.0	1477.0	-
		1	32674.0	51.9	5	1	1074.0	-	-
		2	226294.0	63.8	9	1	1584.0	-	-
		3	417976.0	96.6	19	3	1682.0	1786.0	1843.0
		4	611152.0	85.9	16	3	1795.0	1215.0	1729.0
		5	8789.0	73.7	12	2	1198.0	1549.0	-
		6	201917.0	77.2	13	2	1837.0	1819.0	-
		7	395530.0	68.4	10	2	1587.0	1114.0	-
		8	588564.0	76.7	13	2	2000.0	1155.0	-
		9	783794.0	53.2	6	1	1147.0	-	-
		10	177933.0	85.7	16	3	1433.0	1695.0	1394.0
		11	370624.0	94.3	19	3	1670.0	1426.0	1935.0
		12	564893.0	77.6	13	2	1294.0	1671.0	-
		13	759583.0	65.7	10	1	1512.0	-	-
		14	154262.0	93.5	18	3	1444.0	1130.0	1468.0
Download	1	Type 5	8	1.5000000	12.0000000				
Download	2	Type 5	11	1.0909091	12.0000000				

Figure 4. FCC Type 5 test waveform settings with trial list table using N7607C.

WLAN Performance Test Solution Including DFS Function Testing

N7607C Signal Studio for DFS radar profiles can be paired with N7617C Signal Studio for WLAN 802.11a/b/g/j/p/n/ac/ah/ax, and integrated with a signal generator, signal analyzer and other general-purpose hardware to set up a total solution for WLAN performance testing, including DFS functional testing. This solution can provide a dramatic cost savings for customers who already own a signal generator or signal analyzer.

For more information, please visit
www.keysight.com/find/n7617c
www.keysight.com/find/wlan

Features Summary

N7607C standard-based tests	Features
Common	– Provide a Seed parameter to randomize the parameter sets of each trial – Number of trials (1-200) can be adjusted and waveforms generated for each trial are unique – Save and load the Trial List of radar signals for repeatability testing – All advanced trigger functions defined by the hardware instrument – Trigger type can be single, continuous, gated or segment advanced – Trigger source can be external, bus or trigger key – External source can be pattern trigger In 1 or 2 – Real-time AWGN (Opt. required) – I/Q adjustment – Sample rate adjustment – Radar profiles standards for FCC, ETSI and Japan MIC
FCC	– FCC version 06-96 and version 13-22 – Type 0-4 short pulse radar test waveforms (New Type 1 is defined in FCC 13-22) – Type 5 long pulse radar test waveforms – Type 6 frequency hopping radar test waveforms – For detailed parameters of the radar test signals defined in the FCC standard for each type, please see Tables 1-3
ETSI	– ETSI 301 893 V2.1.1 and ETSI 302 502 v1.2.1 – For detailed parameters of the radar test signals defined in the ETSI standard for each type, please see Table 4-6
Japan MIC	– Japan MIC W53 and W56 radar test signals – For detailed parameters of the radar test signals defined in the Japan MIC standard for each type, see Table 7 and 8
Korea standard	– Type 1-3 fixed or variable radar profiles – Type 4 hopping radar profiles – For detailed parameters of the radar test signals defined in the Korea standard for each type, see Table 8.
China standard	– Radar Type 1-4 are constant PRF based signals. – Radar Type 5 and 6 are single pulse based or packet based staggered PRF radar test signals using 2 or 3 different PRF values.

Table 1. Short pulse radar test waveform (Type 1-4) defined in FCC (13-22)

Radar type	Pulse width[1] (µs)	PRI (us)[1]	Number of pulses[1]	Number of bursts	Number of trials (default = 30)
0	1	1428	18	1	1 to 200
1	1	See footnote 3	Roundup $\{\left(\frac{1}{360}\right)*\left(\frac{19*10^6}{PRI_{usec}}\right)\}$	1	1 to 30
2	1 to 5	150 to 230	23 to 29	1	1 to 200
3	6 to 10	200 to 500	16 to 18	1	1 to 200
4	11 to 20	1000 to 2000	12 to 16	1	1 to 200

Table 2. Long pulse radar test waveform (Type 5) defined in the FCC standard (FCC 06-96 and FCC 13-22)

Radar type	Pulse width[1] (µs)	PRI (us)[1]	Chirp width[1] (MHz)	Number of bursts	Number of trials[1]
5	50-100	1000-2000	5-20 MHz	8-20	1-200

Table 3. Frequency hopping radar test waveform defined in the FCC standard (FCC 06-96 and FCC 13-22)

Radar type	Pulse width1 (us)	PRI (us)[1]	Pulse per hop[1]	Hopping rate[1] (kHz)	Number of bursts	Number of trials (default = 30)
62	1	333.3	9	0.333	100	1-200

1. This parameter can be adjusted within the range as defined in the table.
2. The frequency hopping range is 5250 to 5724 MHz with 1 MHz step and the channel bandwidth is dependent upon the instrument analysis bandwidth. The N5182B MXG X-Series signal generator with Option 657 can support up to 160 MHz BW.
3. Test A: 15 unique PRI values randomly selected from the list of 23 pre-defined PRI values. Test B: 15 unique PRI values randomly selected within the range of 518 to 3066 µs, with a minimum increment of 1usec, excluding PRI values selected in Test A.

Table 4. Radar test signal parameters as defined in ETSI 301 893 V2.1.1

Radar type	Pulse width[1] (us)	PRI (us)[1]	Number of pulses[1]	Number of different PRFs	Number of bursts (default = 1)	Number of trials (default = 30)
Reference	1	700	18	1	1-100	1-200
1	0.5-5	200-1000	10	1	1-100	1-200
2	0.5-5	200-1600	15	1	1-100	1-200
3	0.5-5	2300-4000	25	1	1-100	1-200
4	20-30	2000-4000	20	1	1-100	1-200
52	0.5-2	300-400	10	2-3	1-100	1-200
62	0.5-2	400-1200	15	2-3	1-100	1-200

1. The internal between bursts is fixed in V1.7.1 or earlier which is changed to variable in V2.1.1

Table 5. Parameters of radar test signals defined in ETSI 302 502 V1.2.1

Radar type	Pulse width[3] (us)	PRI (us)[3]	Number of pulses[3]	Number of trials (default = 30)
1	1	750	15	1 to 200
2	1, 2, 5	200, 300, 500, 800 , 1000	10	1 to 200
3	10, 15	200, 300, 500, 800 , 1000	15	1 to 200
4	1, 2, 5, 10, 15	1200, 1500, 1600	15	1 to 200
5	1, 2, 5, 10, 15	2300, 3000, 3500, 4000	25	1 to 200
6	20, 30	2000, 3000, 4000	20	1 to 200

Table 6. Parameters of hopping radar test signals defined in ETSI 302 502 V1.2.1

Radar type	Pulse width (us)	Pulse repetition frequency PRF (pps)	Pulse per burst	Burst length (ms)	Burst per trials[3]	Pulse modulation	Number of trials (default = 30)
1	1	3000	9	3	8	None	1 to 200
2	20	4500	9	2	2	Chirp	1 to 200

Table 7. Radar test signal parameters as defined by the Japan MIC standard

Radar type	Pulse width[1] (us)	PRF (Hz)[1]	Number of pulses[1]	Number of bursts	Repetition cycle(s)	Number of trials (default = 30)
W53 Fixed Pulse 1	1.0	700	18	1	15	1-200
W53 Fixed Pulse 2	2.5	260	18	1	15	1-200
W56 Fixed Pulse 1	0.5	720	18	1	15	1-200
W56 Fixed Pulse 2	1.0	700	18	1	15	1-200
W56 Fixed Pulse 3	2.0	250	18	1	15	1-200
W56 Variable Pulse 4	1-5	4347-6667	23-29	1	15	1-200
W56 Variable Pulse 5	6-10	2000-5000	16-18	1	15	1-200
W56 Variable Pulse 6	11-20	2000-5000	12-16	1	15	1-200
W56 Chirp (5-10 MHz width, 1MHz step)	50-100	500-1000	1-3	8-20	12	1-200
W56[4] hopping	1	3000	9	100	10	1-200

1. This parameter can be adjusted within the range as defined in the table.
2. When the radar profile is Type 5 or Type 6, another parameter, Single Pulse Based Staggered PRF and Packet Based Staggered PRF can be chosen.
3. For each of the trials, the burst interval will increase from 1.25 ms to 37.5 ms in steps of 1.25 ms for radar signal 1 and from 5 ms to 150 ms in steps of 5 ms for radar signal 2
4. The frequency hopping range is 5250-5724 MHz with 1 MHz step and the channel bandwidth is dependent upon the instrument analysis bandwidth. The N5182B MXG X-Series signal generator with Option 657 can support up to 160 MHz BW.

Note: N7607C uses the RF blanking method to generate pulses. The pulse rise/fall time accuracy is dependent upon the sampling rate setting and RF on/off speed.

Table 8. Radar test signal parameters as defined by the Japan MIC standard (July 2019)

Radar Type	Pulse Width (us)		Pulse Repetition Frequency PRF (PPS)		Number of Different PRFs	Pulse Per Burst for Each PRF (PPB)
	Min	Max				
W53 Variable Pulse 3[1]	0.5	5	200	1000	1	10
W53 Variable Pulse 4[2]	0.5	15	200	1600	1	15
W53 Chirp 5	0.5	5	200	1000	1	min{max{22,[0.026xPRF]},30}
W53 Chirp 6	0.5	5	200	1600	1	min{max{22,[0.026xPRF]},30}
W53 Chirp 7	0.5	1.5	1114	1118	1	10
W53 Chirp 8	0.5	1.5	928	932	1	10
W53 Chirp 9	0.5	1.5	886	890	1	10
W53 Chirp 10	0.5	1.5	738	742	1	10

1. Chirp modulation (frequency deviation: ± 0.5 to 1.0 MHz), T1, T2≧70µs, 20µs≦W2≦110µs, |W1-W2|≧15µs, Duty cycle ratio: less than 10%.
2. 2. Chirp modulation (frequency deviation: ± 0.5 to 1.0 MHz), T1, T2≧50µs, 30µs≦W2≦32µs(deviation: ± 5%).

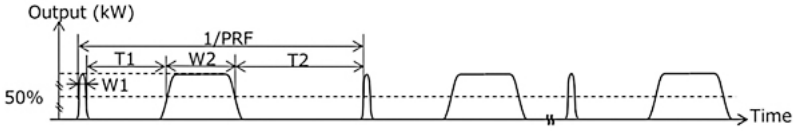


Table 9. Parameters of radar test signals defined in Korean DFS standard

Radar type	Pulse width[1] (µs)	Pulse repetition frequency (pps)[1]	Number of pulses[1]	Number of bursts	Number of trials (default = 30)
Type 1	1.0	700	18	1	1 to 200
Type 2	1.0	1800	10	1	1 to 200
Type 3	2.0	330	70	1	1 to 200
Type 4[1]	1.0	3000	3	100	1 to 200

1. Frequency hopping between bursts range is 5250 to 5724 MHz.

Table 10. Parameters of radar test signals defined in China DFS standard

Radar type	Pulse width (µs)	Pulse repetition frequency PRF (Hz)	Number of different PRFs	Number of pulses per burst[2]
Reference	1	1000	NA	20
1	0.5~5	200~1000	1	12
2	0.5~15	200~1600	1	16
3	0.5~30	2300~4000	1	24
4[1]	20~30	2000~4000	1	20
5	0.5~2	300~400	2 or 3	12
6	0.5~2	400~1200	2 or 3	16

1. Radar test signal 4 is a modulated radar test signal. The modulation to be used is a chirp modulation with a ± 2.5 MHz frequency deviation.
2. The total number of pulses in a burst is equal to the number of pulses for a signal PRF multiplied by the number of different PRFs used.

Supported Standards

DFS standard	Specification	Version	Release date
FCC	DFS standard MO&O Federal Communication Commission	06-96 13-22	2006 2012
ETSI	ETSI EN 301 893 V2.1.1, Harmonized European Standard, “Broadband Radio Access Networks (BRN), 5 GHz high performance RLAN, Harmonized EN Covering the essential requirements of article 3.2 of the R&TTE Directive”	V2.1.1	2017
ETSI	ETSI EN 302 502 V1.2.1 Broadband Radio Access Networks (BRAN); 5.8 GHz fixed broadband data transmitting systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	V1.2.1	2008
Japan MIC	Testing procedures for implementation of Dynamic Frequency Selection (DFS) in the 5 GHz band	W53 & W56	2010
Korea	Korean standard for DFS test	Type 1-4	2014
China	Chinese standard for DFS test	Type 1-6	2019

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.

N7607C Signal Studio for DFS Radar Profiles

Waveform playback licenses (N7607EMBC)

Software License Type	Support Contract	Description
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 Contract	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.

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

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 & 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
www.keysight.com/find/N7607C

Comprehensive Online Documentation

www.keysight.com/find/signalstudio_support

Signal Studio and Signal Creation Software

www.keysight.com/find/signalstudio_software

Keysight's WLAN design and test solutions

www.keysight.com/find/n7617c
www.keysight.com/find/wlan
www.keysight.com/find/802.11ac

Literature

Signal Studio Software, Brochure, literature number 5989-6448EN

Testing New-generation Wireless LAN, Application Note, 5990-8856EN

Creating and Optimizing 802.11ac Signals and Measurements, Application Note, 5991-0574EN

Testing Very High Throughput 802.11ac Signals, Application Note, 5990-9987EN

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES