N7660C Signal Studio for Multi-Emitter Scenario Generation

Simplify Electronic Warfare (EW) Test Signal Creation

During the electronic warfare (EW) test and evaluation process, threat simulation with enhanced realism will ensure greater confidence in the system under test's (SUT) ability to detect the most complex threats. Keysight Technologies Inc. N7660C Signal Studio for Multi-Emitter Scenario Generation (MESG) provides an intuitive software interface to create realistic multi-threat environments from 0 to 40 GHz. EW scenarios can be downloaded to the N5193A UXG agile signal generator and N5194A UXG Vector Adapter to play out the scenario for either direct inject or over the air testing. With the scalable and flexible architecture of the UXG family, additional signal generators can be included in the simulation to increase pulse density and simulate Angle of Arrival (AoA) for multi-port receivers, providing a cost-effective solution to take your lab to the next level[1].
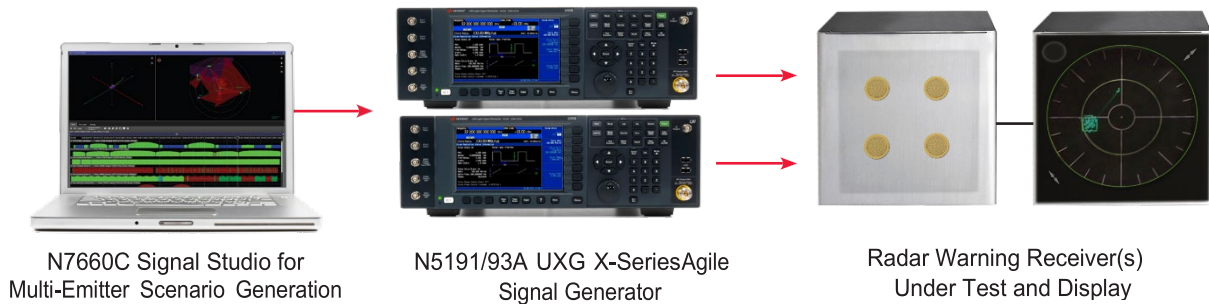
EW system under test

Development and validation of EW SUT's require simulation of a complex RF environment. With N7660C's suite of signal creation tools you can create EW scenarios to test the following SUT applications:

- Threat identification, prioritization and classification
- Threat de-interleaving and sorting
- Subsystem interface management
- Subsystem threat correlation
- Electronic countermeasures.

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[1] N7660C is subject to US Government export regulations. For more information contact your Keysight sales representative.

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N7660C Signal Studio for
Multi-Emitter Scenario Generation

N5191/93A UXG X-SeriesAgile
Signal Generator

Radar Warning Receiver(s)
Under Test and Display

Figure 1. EW receiver test setup with one or multiple UXGs for high pulse density or AoA simulations.

EW threat environment

When creating a threat in the EW environment, define the emitter characteristics by controlling radar parameters such as amplitude, frequency, pulse width, modulation-on-pulse, pulse repetition interval (PRI), coherent processing intervals (CPI) and antenna scan modulation. Then increase the complexity of the environment by adding additional emitters.
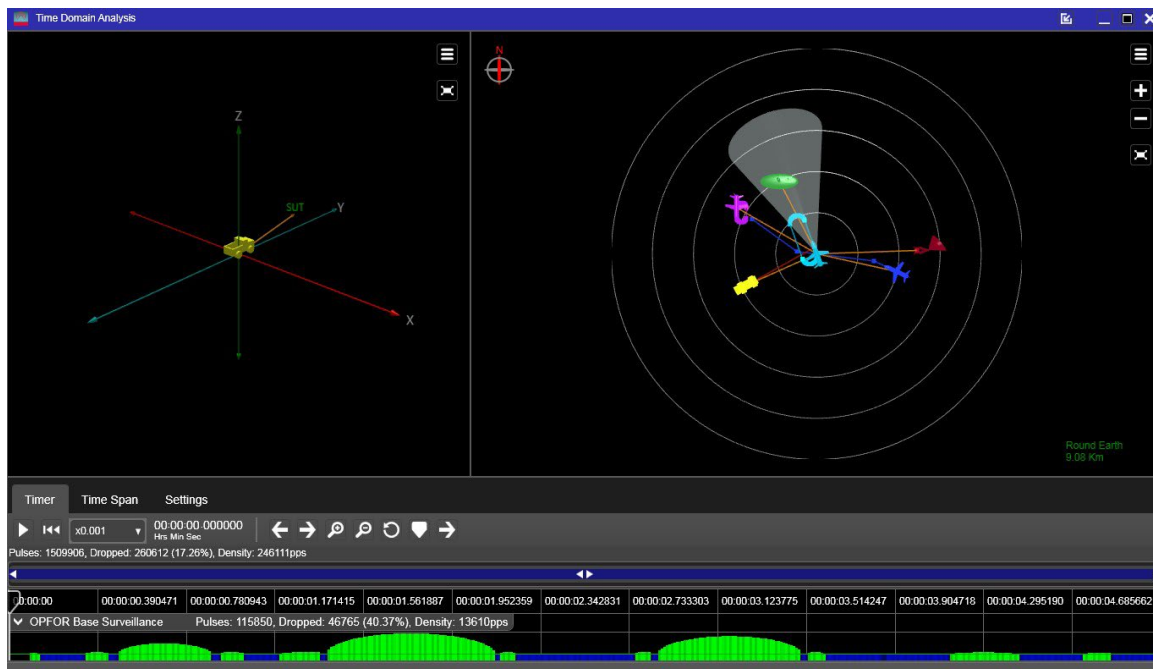

Figure 2. Add multiple emitters to simulate the most complex threat environment.
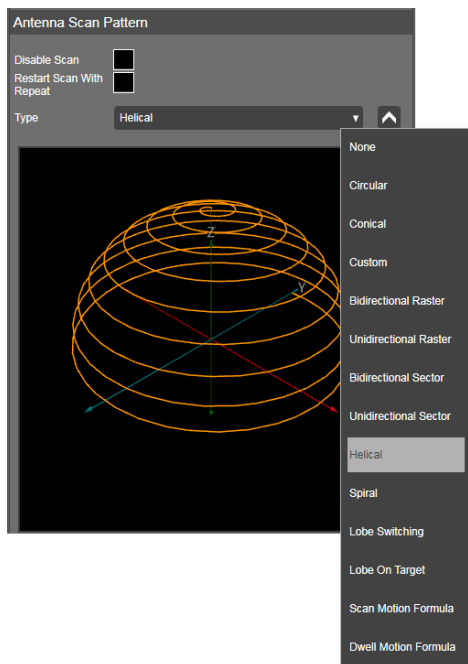
Figure 3. Specify antenna scan patterns for SUT and threats.

With the constant evolvement of the EW threat environment, MESG is now compatible with the N5194A UXG Vector Adapter to create even more advanced threats by importing custom files and applying IQ modulation to the pulses. The digital IQ baseband system in the UXG Vector Adapter enables you to create more complex pulses with variable rise/fall times and arbitrary modulation within the pulse, including non-linear chirps.
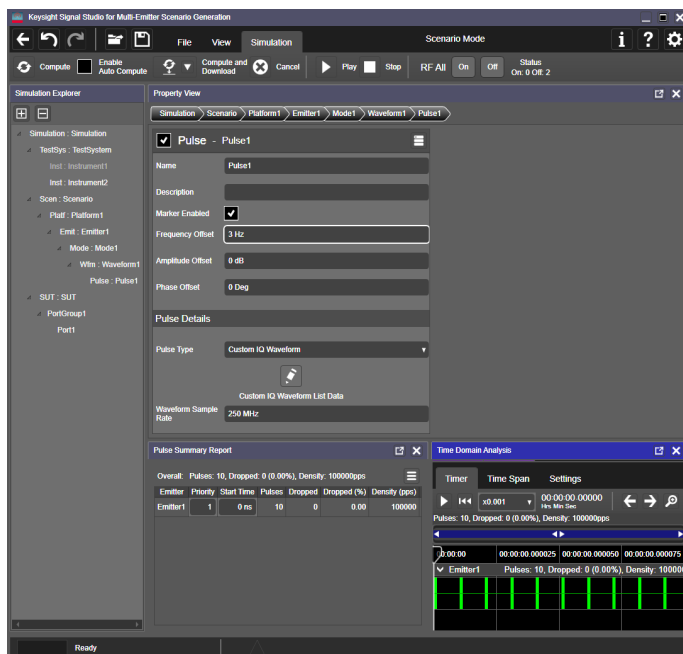
Figure 4. Import custom IQ waveforms with N5194A.

Kinematics and angle of arrival

With the use of multiple coherent UXG's, MESG supports Angle of Arrival (AoA) simulations for multi-port SUTs. The MESG option supporting AoA and kinematics provides dynamic environments by simulating the SUT or threat's route based on waypoints, which can be imported or set in the software.
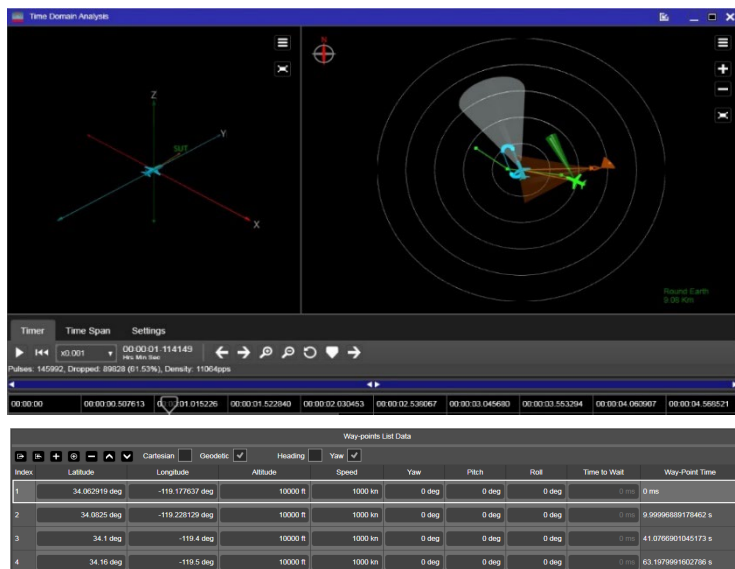

Figure 5. Import waypoints to define flight path for SUT or environment threats.

The route is simulated by changing power levels, Doppler frequencies, and signal phases between ports, which are based on geometric physics-based models. Keysight's multi-source calibration software automates calibration and correction of the UXG's relative phase, amplitude, and timing for highly accurate AoA simulations[2].
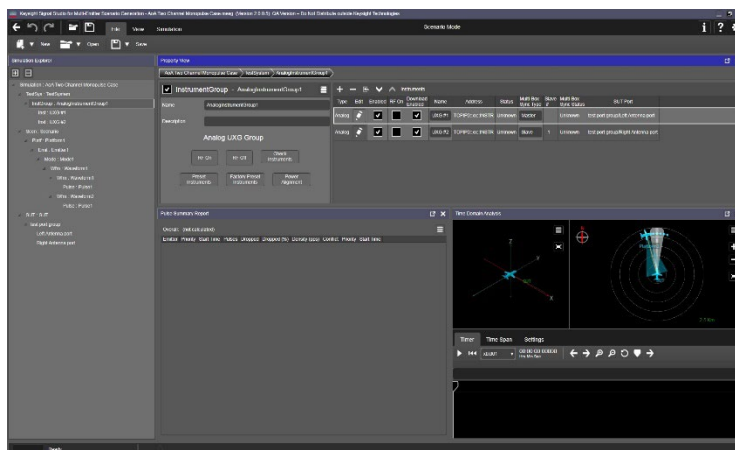

Figure 6. Set the desired number of ports in MESG for AoA simulation.

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[2] Multi-source calibration (MSC) software is available as part of Keysight's custom threat simulation solutions. For more information, please contact your Keysight sales representative.

Get Closer to Reality

The Keysight N5193/94A UXG agile signal generator features up to 180 ns transition times, 2 ns timing resolution, and –70 dBc SFDR to simulate multiple radar emitters out of one or more UXGs. Add complexity and custom IQ modulation on pulse with the UXG Vector Adapter.

To learn more, download the UXG data sheet at:

www.keysight.com/find/N5193A

www.keysight.com/find/N5194A

Legacy compatibility

EW labs often have extensive threat simulation libraries that have been developed over the years and still serve as important benchmarks for EW SUT performance. However, some of these libraries were developed for threat simulation systems that may have been discontinued or are no longer supported. MESG software's translation capability allows Pulse Builder files to be imported into MESG for use with UXGs. MESG software also offers an optional threat simulation import (TSIm) capability that converts AMES DIF files into the closest equivalent signals using PDWs for the N5194A UXG signal generator. This TSIm technology makes it possible to:

- Playback an instantaneous static scenario using low-level parameters
- Create a PDW representation of the transmit signal with the ability to:
  - Turn beams on and off
  - Change start times and mode period
  - Change power level
  - Make signal amplitude constant
  - Show low-level parameters
  - Synchronize all beams

Pulse Density Optimization

Based on the simulations you create, MESG will automatically interleave multiple threats and generate dropped pulse reports to optimize pulse density. Control pulse density and dropped pulses by changing threat start times and priority, pulse width and repetition frequency and coherent processing intervals, or by adjusting on and off settings of emitters. To reduce dropped pulses and increase density, scale your test system by adding additional UXG channels.
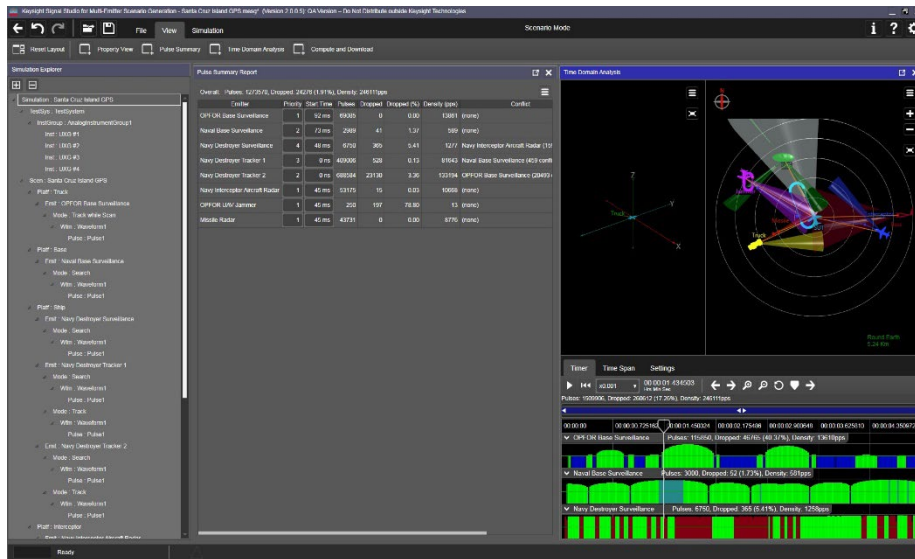
Figure 7. MESG automatically interleaves multiple threats.

Scenario Visualization

After creating the EW threat environment, including kinematics, pulse parameters, priorities, antenna scan and modulation patterns, use the simulation view to visualize the scenario. This view will also show the pulse density in the time domain. Then the simulation can be downloaded to the UXG system as a pulse descriptor word (PDW) list.
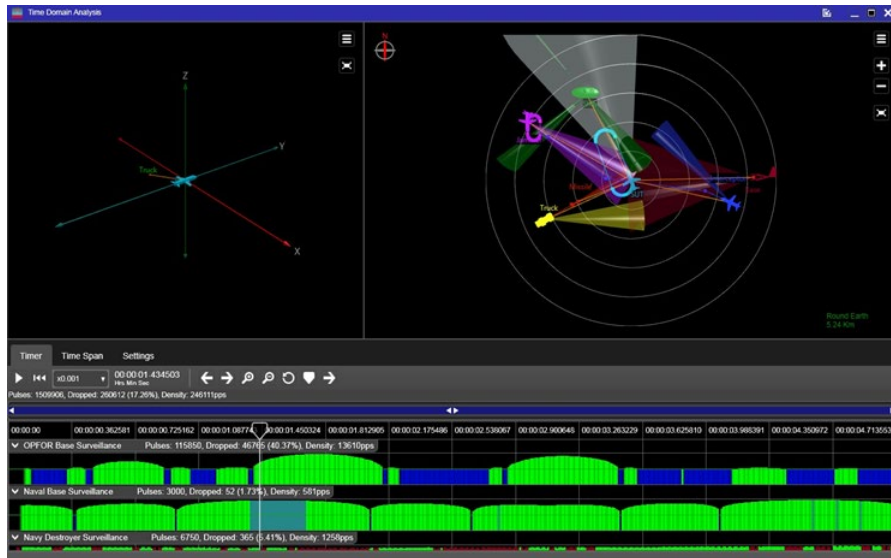
Figure 8. Visualize simulation and pulses in the time domain before downloading to UXG system.

Features Summary

Pulse parameters	
Pulse width stagger	Linear ramp, stepped, or staggered specified by timing parameters and number of pulses

Modulation on pulse parameters	
Barker	Nested Barker and Barker codes (2, 3, 4, 5, 7, 11, 13) with user control over Barker direction and polarity
Formats	Custom BPSK, IQ waveforms[3] and FM chirp (sawtooth or triangle FM chirp deviation of 10-25% of center frequency)

Pulse repetition interval parameters	
PRI stagger	Bursted, linear ramp, list, stepped, sinusoidal
Frequency agility	Offset, linear ramp, list, stepped

Antenna scan parameters	
Radiation pattern type	Isotropic, Blackman, Cosine1, Cosine2, Cosine3, Cosine4, Cosine5, Exact Blackman, Hamming, Programmable, Rectangular, Three Term, Three Term Minimum, Gaussian, Omni, Pyramidal Horn, Sinc, and Table Lookup
Antenna scan type	Circular, conical, custom, bidirectional raster, unidirectional raster, bidirectional sector, unidirectional sector, helical, spiral, lobe switching, lobe on target
Antenna properties	Az/El 3 dB beam width

Simulation parameters	
Multi-emitter simulation	Multiple emitters are played from a PDW list according to the capability of the UXG to transition frequency and amplitude according to the number of emitters and their duty cycles
Multi-UXG	Connect to multiple UXGs to increase pulse density and simulate AoA; no angle-of-arrival or multi-channel optimization is provided in this configuration
Emitter interleaving	Emitters are interleaved to optimize pulse density and minimize dropped pulses while maintaining accurate pulse width and PRI
Dropped pulse reporting and pulse collision reporting	Pulse collision percentages and conflicting emitters are reported; modifications to emitter start time and priority can be made in the report to resolve conflicts; report is recalculated when emitter parameters are changed
Scenarios	Create a hierarchy of platforms, emitters, modes, and waveforms; user can build up a library of emitters or modes and reuse them in different simulations
Test system definition	Add one or more UXG agile signal generators with different options to the simulation
System under test definition	Set the minimum simulation power level according to the sensitivity of the receiver under test

Kinematics	
Angle of arrival (AoA)	Provides a dynamic environment with changing power levels, changing Doppler frequency, and changing signal phases between ports, throughout the scenario
User-defined ports	SUT can have multiple ports identified by the user for AoA; each port is user-assigned to a different UXG

Streaming mode	
LAN streaming	Allows the user to save extremely long scenarios to their PC storage and stream the PDWs to the UXG
SSD Playback	Allows the user to store extremely long scenarios (streaming PDW format) on the UXG's internal SSD drive instead of to the more limited list point memory

Time domain analysis	
Antenna scan display	Click and drag the changeable 3-dimensional axis of the view to visualize the antenna scan pattern of any emitters (and associated platforms) in the scenario
Trajectory display	The motion of the platforms/SUT and their associated emitters (kinematics) is displayed; this view provides basic visual feedback to help confirm that the configured paths are correct
Timeline/pulse report	Visualize the relative amplitude of pulses and sections of the scenario which have dropped pulses

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[3] Only applicable with UXG Vector Adapter.

Software and Licensing Configuration

Signal Studio offers flexible licensing options with different terms, support subscriptions and types of licensing:

License term		
Perpetual	License is perpetual however a support subscription includes software updates and support for a chosen duration (ie: 12 months up to 60 months). Can be renewed annually.	
Subscription	Support subscription includes software updates and support through the license duration	
License term	License term	License term
Node Locked	License may be used on one specified instrument	Locked to one instrument
Transportable	License may be used on one instrument at a time but may be transferred to another	Flexibility to move from instrument to instrument

Instrument support

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

How to configure:

1. Choose Product Model Number N7660EMxC

2. For each model number choose License Type

3. For each license type choose License Term

   ○ For perpetual licenses: Choose support subscription duration
   ○ For subscription licenses: Choose license duration (support is included through license time-period)

4. To utilize firmware Ver 2.3, your support license must be within its support period.

N7660EMBC Create Multiple Emitters from One UXG Agile Signal Generator

License term

License type		Perpetual		Subscription	
Node-locked	R-Y5B-001-A Plus support duration	12-month	R-Y6B-001-L	6-month	R-Y4B-001-F
		24-months	R-Y6B-001-X	12-month	R-Y4B-001-L
		36-months	R-Y6B-001-Y	24-month	R-Y4B-001-X
		60-months	R-Y6B-001-Z	36-month	R-Y4B-001-Y
Transportable	R-Y5B-004-D Plus support duration	12-month	R-Y6B-004-L	6-month	R-Y4B-004-F
		24-months	R-Y6B-004-X	12-month	R-Y4B-004-L
		36-months	R-Y6B-004-Y	24-month	R-Y4B-004-X
		60-months	R-Y6B-004-Z	36-month	R-Y4B-004-Y

N7660EM1C Multi-Channel for AoA, Kinematics, and Polarization[4]

License term

License type		Perpetual		Subscription	
Node-locked	R-Y5B-001-A Plus support duration	12-month	R-Y6B-001-L	6-month	R-Y4B-001-F
		24-months	R-Y6B-001-X	12-month	R-Y4B-001-L
		36-months	R-Y6B-001-Y	24-month	R-Y4B-001-X
		60-months	R-Y6B-001-Z	36-month	R-Y4B-001-Y
Transportable	R-Y5B-004-D Plus support duration	12-month	R-Y6B-004-L	6-month	R-Y4B-004-F
		24-months	R-Y6B-004-X	12-month	R-Y4B-004-L
		36-months	R-Y6B-004-Y	24-month	R-Y4B-004-X
		60-months	R-Y6B-004-Z	36-month	R-Y4B-004-Y

N7660EM2C Threat Simulation Import[5]

License term

License type		Perpetual		Subscription	
Node-locked	R-Y5B-001-A Plus support duration	12-month	R-Y6B-001-L	6-month	R-Y4B-001-F
		24-months	R-Y6B-001-X	12-month	R-Y4B-001-L
		36-months	R-Y6B-001-Y	24-month	R-Y4B-001-X
		60-months	R-Y6B-001-Z	36-month	R-Y4B-001-Y
Transportable	R-Y5B-004-D Plus support duration	12-month	R-Y6B-004-L	6-month	R-Y4B-004-F
		24-months	R-Y6B-004-X	12-month	R-Y4B-004-L
		36-months	R-Y6B-004-Y	24-month	R-Y4B-004-X
		60-months	R-Y6B-004-Z	36-month	R-Y4B-004-Y

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[4] N7660EMBC is a prerequisite for the EM1C License.
[5] N7660EMBC is a prerequisite for the EM2C License.

Extension to Support Contracts for Perpetual Licenses

Support subscription	Description
R-Y6B-501	12-months of support for node-locked licenses
R-Y6B-504	12-months of support for transportable licenses
R-Y6B-600	Reinstatement charge to bring back support after expiration

Firmware Revision and Options Needed to Use N7660C Signal Studio for Multi-Emitter Scenario Generation with N5193A UXG X-Series Agile Signal Generator

Firmware:

Firmware revision A.01.86 or later (Required)

Options:

One option from each category is required:

Categories	Option	Option details
Frequency range		
	N5193A-520	10 MHz to 21.5 GHz
	N5193A-540	10 MHz to 40 GHz
Switching speed		
	Standard	100 µs
	N5193A-SS1	1 µs
	N5193A-SS2	250 ns (switching time to or from regions 6-9 is 30 µs, has been discontinued and N5193A-SS4 has replaced it)
	N5193A-SS4	180 ns (Recommended, supersedes SS2, reduced switching time of 2.7 µs @ 20-40 GHz when switching to or from Regions 6-9)
Frequency resolution		
	Standard	10 kHz resolution BDC mode, 8.192 kHz in LVDS/binary mode
	N5193A-FR1	1 Hz resolution (Recommended)
Power		
	Standard	10 to +10 dBm
	N5193A-AT1	Mechanical + solid state attenuator assembly (120 dB overall range, 80 dB agile range to 26 GHz, has been discontinued and N5193A-AT2 has replaced it)
	N5193A-AT2	Mechanical + solid state attenuator assembly (Recommended, supersedes AT1, 120 dB overall range, 85 dB agile range to 40 GHz)
Spectral purity		
	Standard	Standard phase noise
	N5193A-EP1	Enhance phase noise (Recommended)

Analog modulation		
	N5193A-UNT	AM, FM, phase modulation, LF output, and narrowband chirp (Required for intra-pulse modulation including chirps and Barker Codes)
	N5193A-WC1	Wideband chirp (requires opt UNT) (Recommended)
	N5193-U04	Enhanced frequency and phase modulation allow MESG to provide Non-Linear Chirps, FM Step, PM Step, Frank Code and polyphase codes P1-P4. (Option U04 or higher is required for enhanced modulations)
Pulse modulation		
	N5193A-PM1	Pulse (Required. Without this option, no pulses are created)
Multi-box synchronization (MBS)		
	N5191A-CC1	LVDS I/O interface, 14 triggers (Required for use as a primary. Can also be used as a secondary. Needed to use as Fast LO for Vector UXG.)
	N5191A-CC2	50-Pin Interface, BCD Data interface (Secondary only, rarely used)
	N5191A-CC3	10 Gigabit Ethernet I/O interface (Secondary only)
	N5191A-CC4	10 Gigabit Ethernet LAN, 14 triggers (Recommended, supersedes CC3)

Firmware Revision and Options Needed to Use N7660C Signal Studio for Multi-Emitter Scenario Generation with N5194A UXG Agile Vector Adapter

Firmware:

Firmware revision A.01.32 or later (Required)

Options:

Must use a N5193A UXG X-Series Agile Signal Generator with the following options:

Required Options:

- N5193A-520
- N5193A-FR1
- N5193A-SS4
- N5193A-EP1
- N5193A-CC1

Must have one option in each of the following categories:

Categories	Option	Option details
Frequency range		
	N5194A-520	10 MHz to 21.5 GHz
	N5194A-540	10 MHz to 40 GHz
Baseband generator bandwidth/sample rate		
	Standard	200 MHz modulation bandwidth, 250 MSa/s sample rate
	N5194A-BB1	1.6 GHz modulation bandwidth, 2 GSa/s sample rate (Recommended)
	N5194A-BB2	400 MHz modulation bandwidth, 2 GSa/s sample rate
Baseband generator memory size		
	Standard	512 MSa memory
	N5194A-BBM	4-6 GSa memory (Recommended)

Additional Information

Websites

Access the comprehensive online documentation, which includes the complete software HELP, download the software, and request a trial license.

www.keysight.com/find/N7660C

www.keysight.com/find/SignalStudio

Literature

Signal Studio Software, Brochure, 5989-6448EN

UXG Agile Signal Generator Data Sheet, 5992-0091EN

Electronic Warfare Signal Generation: Technologies and Methods, Application Note, 5992-0094EN

N5194A UXG Agile Vector Adapter, Data Sheet, 5992-2228EN

N5194A UXG Agile Vector Adapter, Configuration Guide, 5992-2332EN

N5194A UXG Agile Signal Generator, Data Sheet, 5992-0092EN

N5194A and N5191A Agile Signal Generator, Configuration Guide, 5992-1116EN

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