

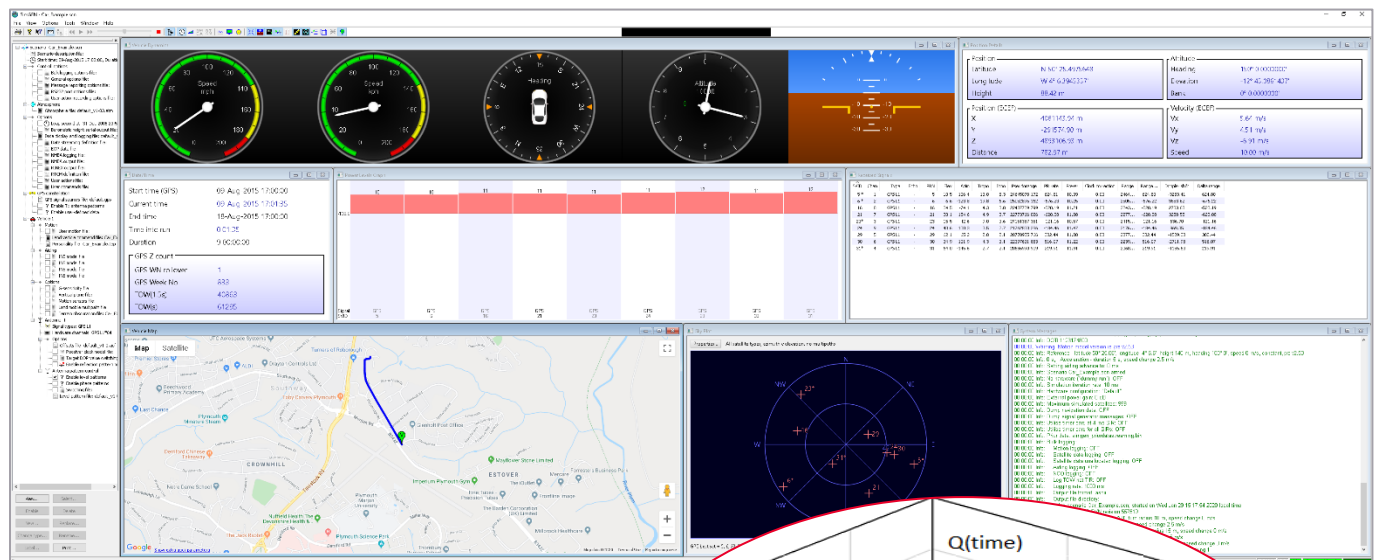
SimIQ

Software-In-the-Loop and I/Q File Replay Solution

Purpose of This Document

This data sheet describes the functionality of Keysight SimIQ, a software solution that captures and/or replays in-phase and quadrature (I/Q) data files using Keysight PNT X, GSS7000, Keysight and GSS9000 PNT simulators.

This data sheet also provides technical product specification data and configuration information. Please speak to your Keysight sales representative to discuss your requirements.



Glossary of Terms

AGC	Automatic Gain Control
ASIC	Application-Specific Integrated Circuit
COTS	Commercial Off-The-Self
DMA	Direct Memory Access
DUT	Device Under Test
FPGA	Field Programmable Gate Arrays
GA	General Availability
GNSS	Global Navigation Satellite Systems
HW	Hardware
Hz	Hertz
IF	Intermediate Frequency
ION	Institute Of Navigation
I/Q	In-phase and Quadrature
MB	MegaByte
MHz	MegaHertz
MIL	Model-In-the-Loop
OS	Operating System
PCIe	Peripheral Component Interconnect express
PosApp	Positioning Application
RAID	Redundant Array of Independent Disks
RF	Radio-Frequency
SIL	Software-In-the-Loop
SIR	Simulation Iteration Rate
SSD	Solid-State Drive
TB	TeraByte
USB	Universal Serial Bus

Definitions

Capture

Licensable SimIQ mode of operation in which I/Q data is generated by a designated radio card and stored in a user-specified file (DMA'ed over PCIe), at a given bit-depth and sample rate on the host PC. In this mode of operation, no RF is generated.

Replay

Licensable SimIQ mode of operation in which an I/Q data file generated by the user (external to our system), with a user-specified bit-depth and sample rate residing on the host PC is streamed to a designated radio card (DMA's over PCIe). The I/Q data from the file can also be mixed with I/Q data generated natively by Keysight's simulator hardware for upconversion to RF.

Overview

SimIQ is a software feature available on Keysight PNT X , GSS7000, and GSS9000 PNT simulators, that enables the capture and replay of I/Q data files. SimIQ has three variants: **SimIQ Capture**, **SimIQ Replay**, and **SimIQ Replay Interference**. Each SimIQ variant is enabled by its respective license key.

SimIQ Capture allows the recording of I/Q data into a file stored in the host PC. RF is disabled during the simulation and, instead, the generated I/Q data by the signal generators is saved as a binary file into an internal or external solid-state drive (SSD). (See Figure 1.) In this mode of operation, the user can create and run scenarios with the different constellations and frequencies specified in the SimIQ license feature, regardless of the RF licensing.

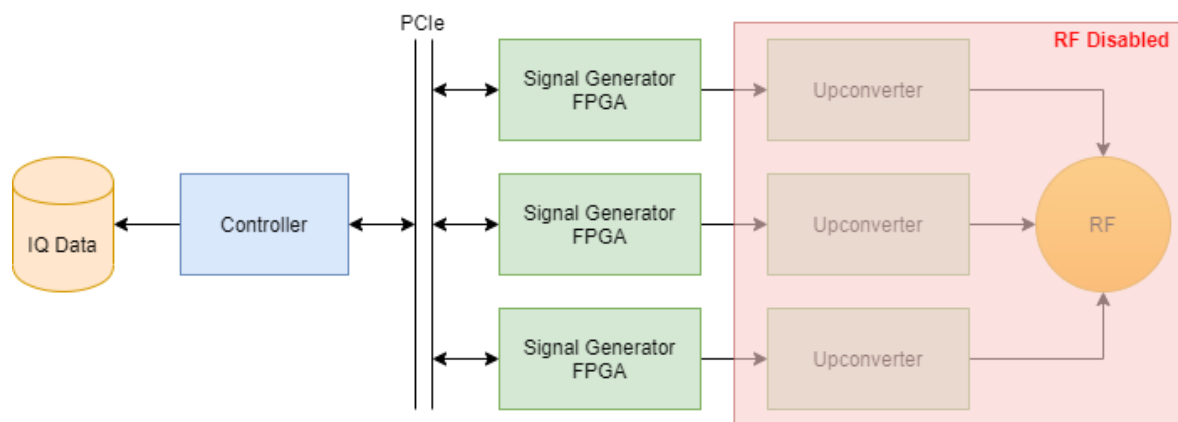


Figure 1. SimIQ Capture overview

SimIQ Replay allows users to read I/Q data from a file stored in the host PC and generate the corresponding RF at GNSS nominal power levels. In this mode of operation, **SimGEN** streams I/Q data from the SSD controllers to the signal generators over the PCIe bus. The streamed I/Q data is mixed with all the other standard **PosApp** scenario signals generated by the field-programmable gate arrays (FPGAs). (See Figure 2.)

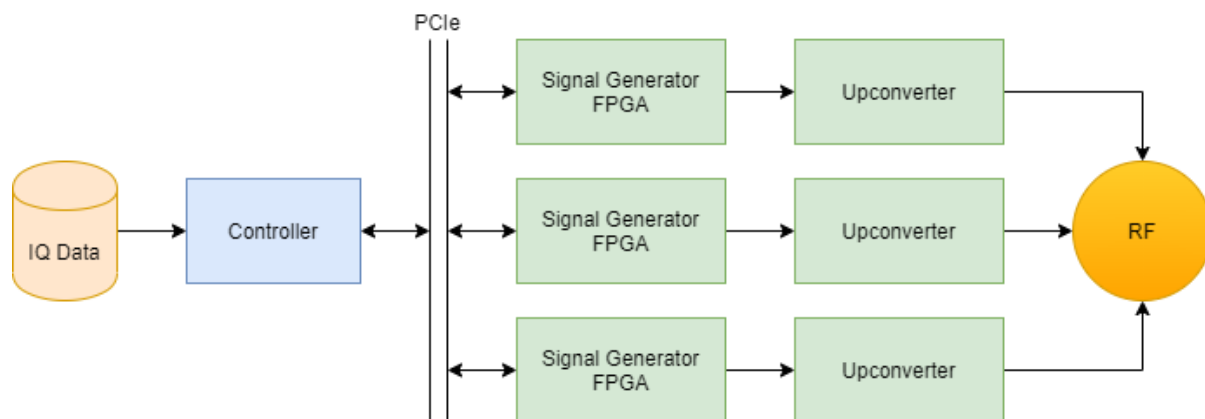


Figure 2. SimIQ Replay overview

SimIQ Replay Interference makes use of the chassis with interference capabilities (available on the PNT X, GSS7000, and GSS9000 platforms) to generate high power interference signals from I/Q data files alongside other standard **PosApp** scenario signals generated by the FPGAs. (See Figure 3.)

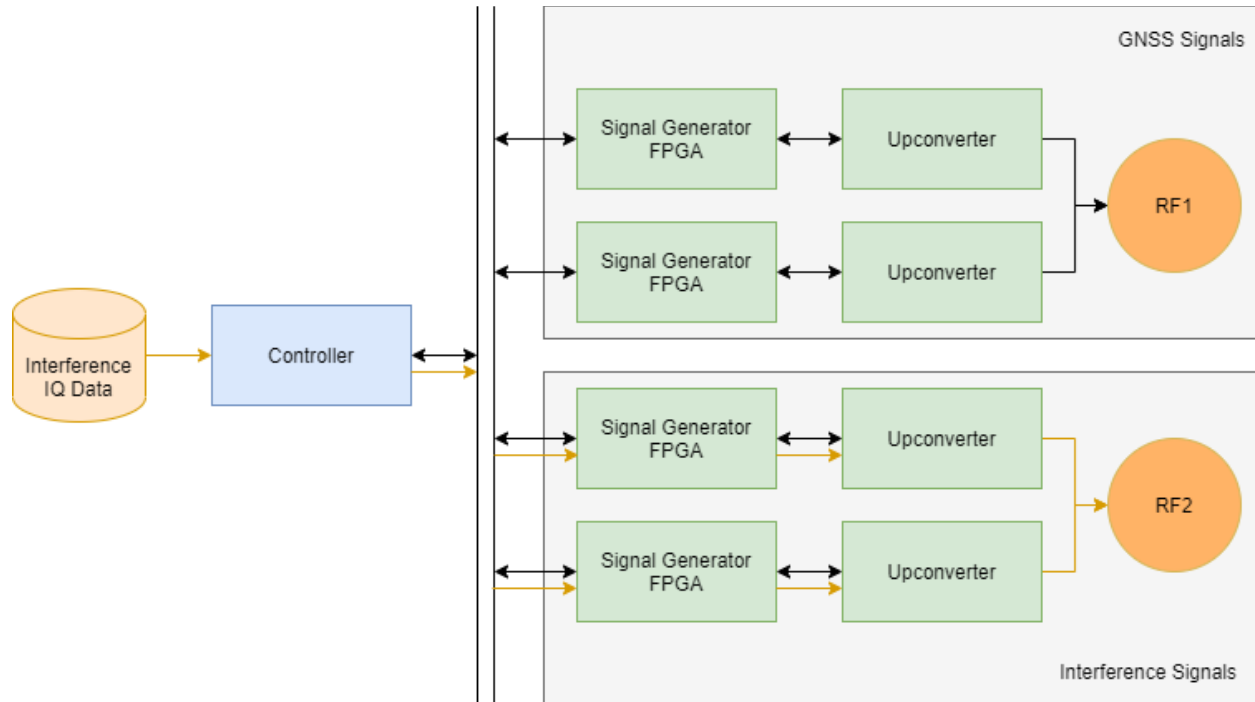


Figure 3. SimIQ Replay Interference overview

As **SimIQ Capture** does not generate RF, these modes of operation are mutually exclusive. (See Table 1.) However, all features (i.e., **SimIQ Capture**, **SimIQ Replay**, and **SimIQ Replay Interference**) can be licensed together under the same **SimGEN** or **SimREPLAY+** license.

Table 1. SimIQ Runtime Compatibility

SimIQ Runtime Compatibility	SimIQ Capture (e.g. GPS L1)	SimIQ Replay (e.g. GPS L1)	SimIQ Replay Interference (e.g. GPS L1)	Standard GNSS RF Generation
SimIQ Capture (e.g. GPS L2)	✓	✗	✗	✗
SimIQ Replay (e.g. GPS L2)	✗	✓	✓	✓
SimIQ Replay Interference (e.g. GPS L2)	✗	✓	✓	✓
Standard GNSS RF Generation	✗	✓	✓	✓

Features and Benefits

SimIQ Capture

Keysight PNT simulators can now generate I/Q files with **SimIQ Capture** containing all the GNSS signal data required to test the algorithms, conformance, and performance of software receivers. This allows Keysight to support its customers with their testing needs across the whole product development cycle, including MIL, SIL, HIL, and VIL testing.

Validation of Receiver Algorithms (MIL)

As GNSS receivers become more complex, early testing is essential to avoid expensive errors and delays. Being able to identify inaccuracies or issues in their receiver models prior to ASIC design and hardware implementation may help reduce development cost and potential delays. **SimIQ Capture** helps developers and testers validate their models and software before hardware is involved, with the same realistic scenarios that they use to validate their hardware receivers in a later stage of their design cycle.

Testing GNSS Software Receivers (SIL)

Certain applications, such as autonomous vehicles, require an extensive amount of testing to ensure the robustness and reliability of the proposed solution. To optimize their time for testing and ensure a timely release in the market, developers are including virtual testing in their product roadmap. Some of them are keen to reduce the amount of hardware required for their virtual tests using software models instead. **SimIQ Capture** enables the possibility to test GNSS software receivers by injecting the generated I/Q data, removing RF real-time constraints while allowing massive parallel simulation.

SimIQ Replay

Keysight PNT simulators can now generate RF from I/Q files using **SimIQ Replay**. The hardware's flexibility and reliability enables the generation of RF signals from I/Q files while maintaining the fidelity and quality of the solution, thanks to Keysight's unrivaled signal generation architecture.

Injection of External Signals

SimIQ Replay can generate any RF signals given a center-frequency (L1, L2, L5, or L6) and bandwidth within spec. This enables our customers to not only generate the well-known GNSS signals, but also custom waveforms, custom noise, or even interference and jamming events. In addition to the replay of the I/Q files, users can still generate, simultaneously, GNSS signals as usual with Keysight PNT X, GSS7000, and GSS9000.

SimIQ Replay Interference

SimIQ Replay Interference has been specifically designed to offer interference testing capabilities on Keysight's PNT X, GSS7000, and GSS9000 using I/Q files. This solution allows the generation of high-power interference alongside standard **PosApp** GNSS signals using the 2RF interference-capable chassis architecture of Keysight's signal generators.

High Power, High Realism

SimIQ Replay Interference allows the definition of transmitter objects within **PosApp** that can generate interference signals from I/Q files. Transmitters can have an absolute or relative position to the vehicle under test, applying in both cases the corresponding attenuation power levels to the signals contained in the I/Q file based on the distance traveled from the transmitter to the antenna. Moreover, a I/Q file can be looped to fit scenario duration, or a list of I/Q files can be used — either in a predefined order or randomized.

SimIQ Contents

Table 2. SimIQ Capture: License Contents

Description	Content	PosApp Version Supported
SimIQ Capture	Software license that enables the capture of I/Q files that contain all GNSS signal data required.	SimGEN, SimREPLAY+

Table 3. SimIQ Replay: License Contents

Description	Content	PosApp Version Supported
SimIQ Replay	Software license that enables the generation of RF from I/Q files that contain L-band custom waveforms that meet users' sample rate and bit-depth requirements.	SimGEN, SimREPLAY+

Table 4. SimIQ Replay Interference: Licensable Contents

Description	Content	PosApp Version Supported
SimIQ Replay Interference	Software license that enables the generation of RF from I/Q files that contain L-band custom interference waveforms that meet users' sample rate and bit-depth requirements.	SimGEN, SimREPLAY+

Operation

SimIQ Capture, **SimIQ Replay**, and **SimIQ Replay Interference** features are editable from PosApp's scenario tree. (See Figure 4.) From the scenario tree, the user can enable the modes by selecting an I/Q file and ticking the corresponding box.

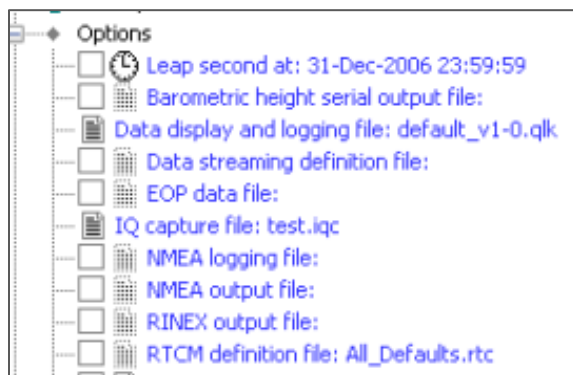


Figure 4. SimIQ scenario tree

SimIQ Capture

SimIQ Capture is supported by SimREPLAY+ and SimGEN PosApp levels. When a user selects this mode, a compatible hardware configuration will be automatically selected by PosApp. (See Figure 5.) The compatible hardware configuration automatically enables the appropriate constellations and frequencies, which are dependent upon the user's licensed constellations and frequencies.

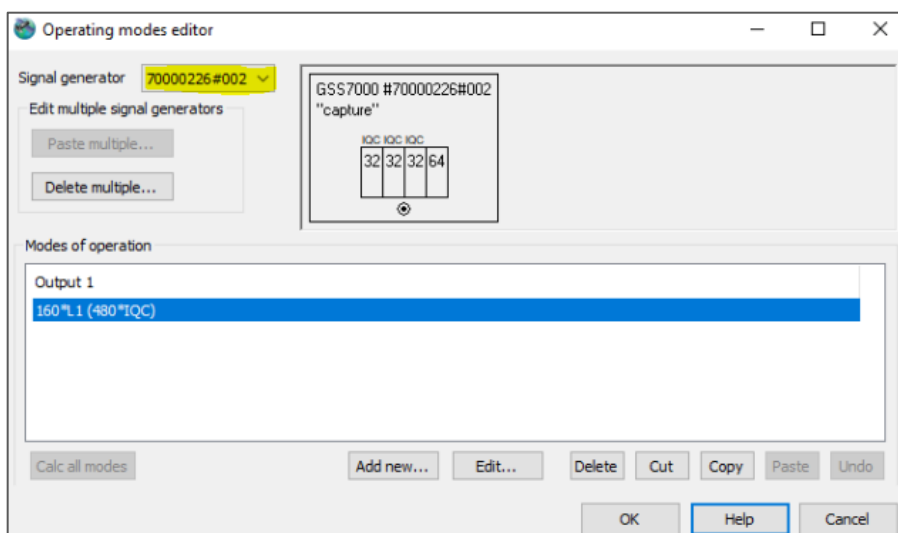


Figure 5. SimIQ Capture hardware configuration

SimIQ Replay

SimIQ Replay is supported by SimGEN and SimREPLAY+ software levels. When a user selects this mode, PosApp can read I/Q files and generate the corresponding RF. PosApp has no knowledge of the signals, modulation, channels, or waveforms that are defined within the I/Q file. The only knowledge PosApp has is the information contained in the associated metadata file. This file contains information regarding the center frequency of the I/Q data, which is used by the system to automatically select the right radio card to output the I/Q file. **SimIQ Replay** can be thought of as an extra channel that can replay I/Q data within spec.

User definable settings can be set per radio card and include the following:

- IQ file selection: either single file or a sequence of them.
- Loop option: allows IQ file or IQ file sequence to loop when playback has completed.
- Randomize option: allows IQ file sequence order to be randomized rather than in the defined sequence order.
- Frequency offset: $\pm 40\text{MHz}$ for SimIQ Replay and SimIQ Replay Interference.¹
- Gain (-99 to 0 dB)²: overall power offset applied in addition to any modelled power.
- Swap IQ (reverse order of I & Q samples).

SimIQ Replay Interference

SimIQ Replay Interference is supported by SimGEN and SimREPLAY+ software levels. This feature requires a PNT X, GSS7000, or GSS9000 chassis with interference capabilities and the corresponding interference feature keys to generate RF for a particular center frequency. Both **SimIQ Replay** and **SimIQ Replay Interference** share a common dialog within **PosApp** for the configuration of playback parameters.

Signals generated from I/Q files can be associated with an I/Q transmitter object that can be displayed on the Ground Track view in **PosApp** and supports modeled power levels. The user can freely define the transmitter location (either absolute or relative to the vehicle in the **PosApp** scenario). The scenario-based transmitter position is then used to calculate the range between transmitter and the vehicle antenna and the appropriate power level attenuation is applied during the scenario run.³

¹ Careful consideration is required on the frequency offset selected to ensure that all signal bandwidth is replayed.

² Keysight recommends overall power offsets within the range of 0 to -70 dB .

³ Limited to power level attenuation only. Other effects such as phase modelling, angle of arrival, and doppler effects are not modified when generating RF from an I/Q file.

Performance Specifications

Common Features

Table 5. SimIQ Performance Specifications

Parameter	Value	Note
Supported constellations	GPS L1, L2, L5. GAL E1, E5, E6. GLO L1, L2, CDMA L1, CDMA L2, CDMA L3 BD B1, B2, B3. SBAS L1, L5. QZSS L1, L2, L5, L6. IRNSS L5.	Constellations are available via purchase of appropriate Keysight licensing.
Supported codes	GPS L1: C/A, L1c Pilot, L1c Data, P. GPS L2: L2c or C/A, P. GPS L5: I, Q. GAL E1: E1-A, E1-B, E1-C. GAL E5ab: E5aI + E5aQ + E5bI + E5bQ. GAL E6-A, E6-B, E6-C GLO L1: C/A, P. GLO L2: C/A, P. GLO CDMA L1 GLO CDMA L2 GLO CDMA L3 BD B1: B1I, B1C. BD B2: B2I, B2a, B2b. BD B3: B3I. QZSS L1: C/A, L1S, L1c Data + Pilot. QZSS L2: L2c. QZSS L5: I + Q. QZSS L6: L6I/L62. IRNSS L5: C/A	
Supported simulator	PNT X ⁴ GSS9000 ⁵ GSS7000 ⁵	<u>PNTX</u> : Supported SIR with SimIQ: Up to 2 kHz <u>GSS9000</u> : Supported SIR with SimIQ: Up to 1 kHz <u>GSS7000</u> : Supported SIR with SimIQ: Up to 100 Hz

⁴ SimIQ Replay Interference is only supported by 2RF chassis with interference capabilities.

⁵ SimIQ Replay Interference is only supported by 2RF chassis with interference capabilities.

Table 6. SimIQ System Iteration Rate

Parameter	Value	Note
Supported PosApp Iteration Rate	100 ms – 10 Hz 10 ms – 100 Hz 1 ms – 1 kHz* 0.5 ms – 2 kHz*	The rate at which PosApp computes the required data and updates the hardware. *GSS7000: Up to 10 ms (100 Hz) *GSS9000: Up to 1 ms (1 kHz) *PNT X: Up to 0.5 ms (2 kHz)
Supported PosApp Logging Rate	100 ms – 10 Hz 10 ms – 100 Hz 1 ms – 1 kHz	The rate at which PosApp logs the data.
Supported Third-Party Application Iteration Rate	Up to 1 ms – 1 kHz	The rate at which the third-party application computes the vehicles dynamics and sends a vehicle motion message to PosApp.

SimIQ Capture

Table 7. SimIQ Capture Performance Specifications

Parameter	Value	Note
Software Level	SimREPLAY+ SimGEN	
Bit-Depth	4, 8, 16 bits	Please, contact Keysight for other bit-depths.
Sample Rate	30, 60 Msps	Additional sample rates (up to 120 Msps) available as a Tailored Solution.
Optional Noise Generation	Gaussian-like	
No. I/Q radio cards supported	Up to 3 ⁶	SimIQ Capture is not supported on radio cards with FPGA security modules installed.

SimIQ Replay and SimIQ Replay Interference

Table 8. SimIQ Replay and SimIQ Replay Interference Performance Specifications

Parameter	Value	Note
Software Level	SimGEN SimREPLAY+	
Carrier Offset	±40 MHz	Increments of 100 Hz.
Bit-Depth	4, 8, 16 bits	
Sample Rate	30, 60 Msps ⁷	Additional sample rates (up to 120 Msps) available as a Tailored Solution.
No. I/Q files per radio card	1	Each licensed I/Q radio card is able to run an I/Q file and 32 additional channels (if licensed) for a given frequency.
No. I/Q radio cards supported	Up to 3	Depending on the customer's hardware. ⁸

⁶ Maximum number of radio cards supported depends on the hardware owned. Please contact Keysight for the most demanding applications (e.g., three radio cards, 16 bits, 60 Msps).

⁷ 30.69 and 51.15 Msps also supported for GSS6450 compatibility.

⁸ Radio cards licensed with the SimIQ Replay feature must be different from those with security modules installed.

Deliverables

With the purchase of any **SimIQ Capture** part number, the following items are delivered (see Table 9).

Table 9. Delivery Items for SimIQ Capture

Item No.	Quantity	Description	Notes
1	1	Base Image Patch	Upgrade required to use any SimIQ feature.
2	1	I/Q FPGA Image	Upgrade required to use any SimIQ feature.
3	1	SimIQ Capture License	

With the purchase of any **SimIQ Replay** part number, the following items are delivered (see Table 10).

Table 10. Delivery Items for SimIQ Replay

Item No.	Quantity	Description	Notes
1	1	Base Image Patch	Upgrade required to use any SimIQ feature.
2	1	I/Q FPGA Image	Upgrade required to use any SimIQ feature.
3	1	SimIQ Replay License	SimIQ Replay: up to 3 licenses/radio cards per system.

With the purchase of any **SimIQ Replay Interference** part number, the following items are delivered (see Table 11).

Table 11. Delivery Items for SimIQ Replay Interference

Item No.	Quantity	Description	Notes
1	1	Base Image Patch	Upgrade required to use any SimIQ feature.
2	1	I/Q FPGA Image	Upgrade required to use any SimIQ feature.
3	1	SimIQ Replay Interference License	SimIQ Replay Interference: up to 3 licenses/radio cards per system.

A second SSD, with up to 4TB of storage capacity, can be fitted into the system to save the files used by SimIQ Capture and SimIQ Replay. With the purchase of the SimIQ SSD part number, the following items are delivered (Table 12).

Table 12. Delivery Items for SimIQ Hardware

Item No.	Quantity	Description	Notes
1	1	Second Internal SSD ⁹	Return to factory required to perform the internal installation with the purchase of this part number. External support does not require a return to factory.

⁹ Storage capacity dependent on the hardware platform.

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