DATASHEET

GSS7000

GNSS Constellation Simulator for Civil and Commercial Applications

spirent™
Federal Systems

Spirent GSS7000 Series GNSS Constellation Simulator

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About this Document

This datasheet describes the functionality of the Spirent GSS7000 series multi-frequency, multi-GNSS RF constellation simulators. This datasheet also provides technical product specification data and configuration information and is used as the basis of a formal quotation or acceptance of a purchase order. **Spirent Federal reserves the right to change this specification at any time**.

Please speak to your Spirent Federal sales representative to discuss your requirements.

Introduction

The **Spirent GSS7000 series multi-frequency, multi-GNSS RF constellation simulator** sets a new standard of excellence in GNSS RF simulation for performance testing and evaluation of GNSS systems and devices for civil and consumer applications. The GSS7000 produces a comprehensive range of emulated multi-GNSS, multi-frequency RF signals with class-leading flexibility, coherence, fidelity, performance, accuracy, and reliability.

The GSS7000 provides numerous benefits to all those working in GNSS/system technology and application development, including accurate and properly-defined signals, comprehensive and feature-rich simulation and full control of all aspects of the GNSS operating environment, inherent repeatability, and the ability to apply systematic errors and incidents that are impossible to realize using real satellite signals.

Application of Spirent's expertise in producing GNSS test solutions acquired over the past five decades, plus advancements in the performance and efficiency of the state-of-the-art core technology on which the GSS7000 is built, means that properly-defined GNSS testing is now more accessible than ever, at the entry-level for fundamental testing, and right through the series to the most capable configuration for advanced testing. These benefits, together with Spirent's proven global expertise and support, make the Spirent GSS7000 multi-frequency, multi-GNSS RF constellation simulator the essential choice for all civil and consumer device application test needs.

GNSS Testing Using the Right Methods

Regardless of the application for GNSS devices, testing using proper methods is essential. The GSS7000 supports an extensive range of constellation configurations that enable authentic testing of devices using any of the existing and planned open-service/civil-use satellite navigation signals.

GSS7000 key attributes include:

- The use of correct and accurate techniques/models to derive satellite constellation and navigation data parameters commensurate with the applicable ICDs
- Dual-RF option (available with Spirent's SimGEN® and SimREPLAYplus™ software, the world's leading GNSS simulation software for test scenario definition, execution, data management, and GNSS RF constellation simulator command and control)
- Single Channel Utility for single channel multi-frequency simulation

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- True[1] performance in several key areas such as:
  - 1000Hz[2] system iteration rate (SIR) and hardware update rate (HUR)
  - 0.3mm pseudorange accuracy
  - Zero pseudorange bias
  - <0.02 rad RMS phase noise
- Up to 256 channels in one chassis
- Highly flexible configurations selectable via feature license keys
- Three operating software options to cover all levels of test
- Complete portability of Spirent SimGEN scenarios from other Spirent systems
- In-field upgradeability of principal GNSS functionality and capability
- On-the-fly, run-to-run re-configuration of constellation and signal configurations
- All GNSS constellation types and all frequencies within a single chassis
- Fully future proofed for all advances in GNSS systems, signals, modulations, codes, and data
- Integrated interference generation and spoofing test solution
- Dedicated APIs for integration with external vehicle models/driving simulation (HIL)

In view of the wide range of possible permutations, Spirent Federal recommends that you discuss your current and future needs with your Spirent Federal sales representative. Spirent Federal will provide specific configuration and pricing information to meet your needs.

[1] "True" performance means the simulator specification is met for ALL dynamic conditions as specified. Many 'GNSS simulators' stop working properly when (even relatively benign) receiver motion is applied because they employ generic hardware.
[2] 100Hz by default. 1000Hz licensable.

SimGEN, SimREPLAYplus, and SimTEST™ Operating Software

The GSS7000 can be operated using any of the three software options from the Spirent “Sim” family, allowing ultimate choice in the capability and complexity of testing.

SimGEN Software

SimGEN is the world’s leading GNSS simulation software for test scenario definition, execution, data management, and GNSS RF constellation simulator command and control. With the fullest capability, features, and performance continuously developed in close consultation with GNSS system authorities over the last 30 years, SimGEN supports all the GNSS test parameters and control capabilities needed for comprehensive GNSS testing for research, development, and design of GNSS systems, services, and devices across any application.

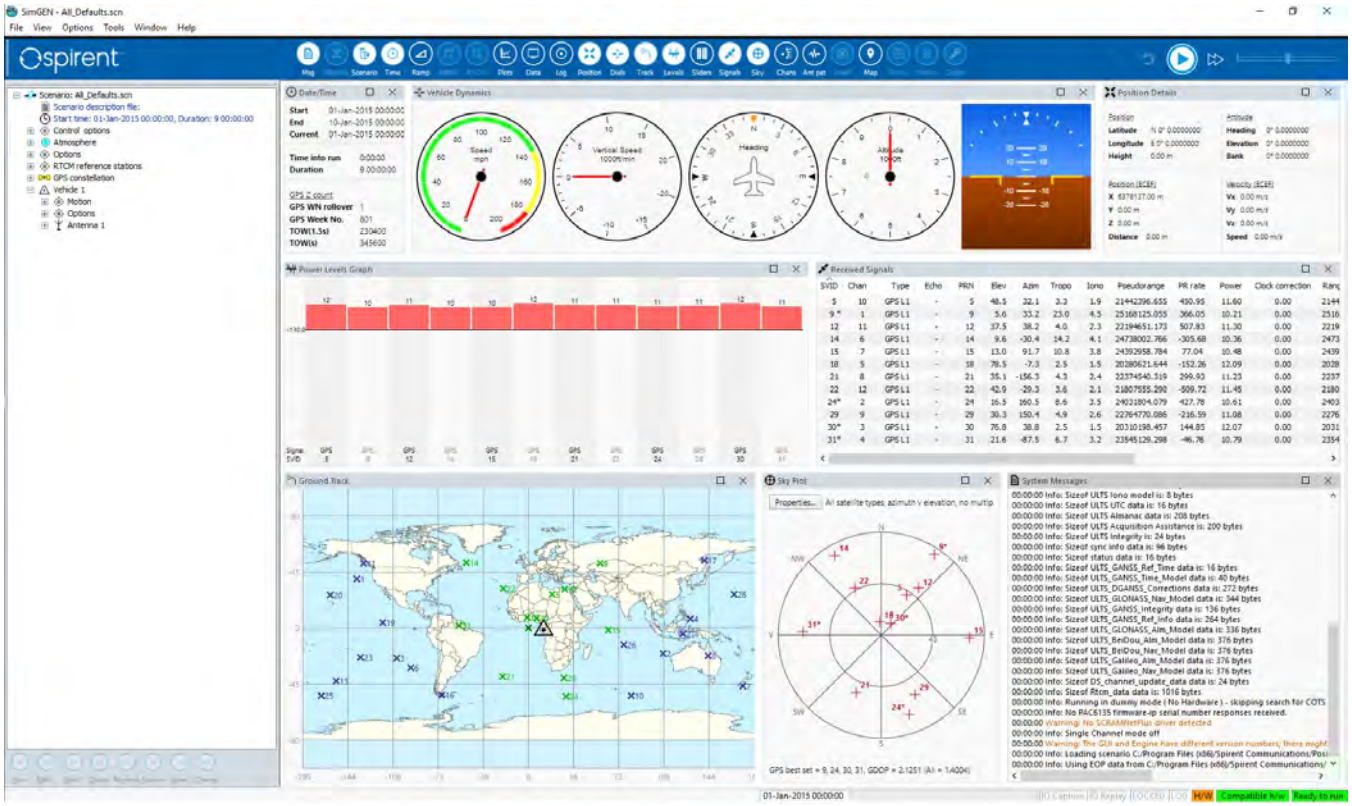

Figure 1. Spirent SimGEN scenario definition and simulation control software

Key SimGEN fundamental performance and modeling capabilities include:

- Fully automatic and propagated generation of precise satellite orbital data, ephemerides, and almanac
- Multiplicity of mechanisms for applying declared and undeclared errors and modifications to navigation data, satellite clocks, and orbits
- SimREMOTE™, a comprehensive remote simulation control and 6-DOF trajectory delivery capability
- Generation of trajectories based on extensive Google® mapping data

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- Data logging and streaming of signal, time, control, vehicle, and trajectory data over a variety of interfaces in real time and to file
- Range of models for multipath reflections
- Terrain obscuration models
- Independent satellite/channel signal power control
- Signal modulation and code control
- Vehicle personalities and motion modeling for aircraft, spacecraft, LEO satellites[3], marine vessels, and land vehicles
- Vehicle antenna reception gain and phase patterns
- Satellite transmit antenna pattern control
- Clock G-sensitivity
- INS aiding data
- Ionosphere and troposphere effects including ionospheric scintillation
- DGPS corrections
- Pseudorange ramps (for RAIM testing)
- Coherent and non-coherent interference and noise modeling (optional Spirent GSS7765 interference generator)
- Leap-second and week roll-over event testing
- Multiple RTCM reference stations, RTCM data streaming, and built-in NTRIP server interface
- Spoofing testing with embedded Spoofing option, which enables spoofers to be placed within the scenario and the effects modeled commensurately

For more information, please refer to the *SimGEN User Manual*, Reference a).

[3] An extension to SimGEN native spacecraft model, feature key required.

SimREPLAYplus

SimREPLAYplus is designed to allow the replay of pre-defined test scenarios while providing a range of tools and capabilities to enhance usability before, during, and after testing. A powerful feature of SimREPLAYplus is the ability to replay complex scenarios that have been created on other Spirent SimGEN-controlled systems. Depending on the hardware and constellation licenses installed, the full complexity of the SimGEN scenario is faithfully replayed in SimREPLAYplus but without the detailed scenario editing and modification capability. This is ideal for controlled test planning where a central R&D lab can issue version-controlled test scenarios out to other teams, knowing the detailed test parameters cannot be altered by mistake.

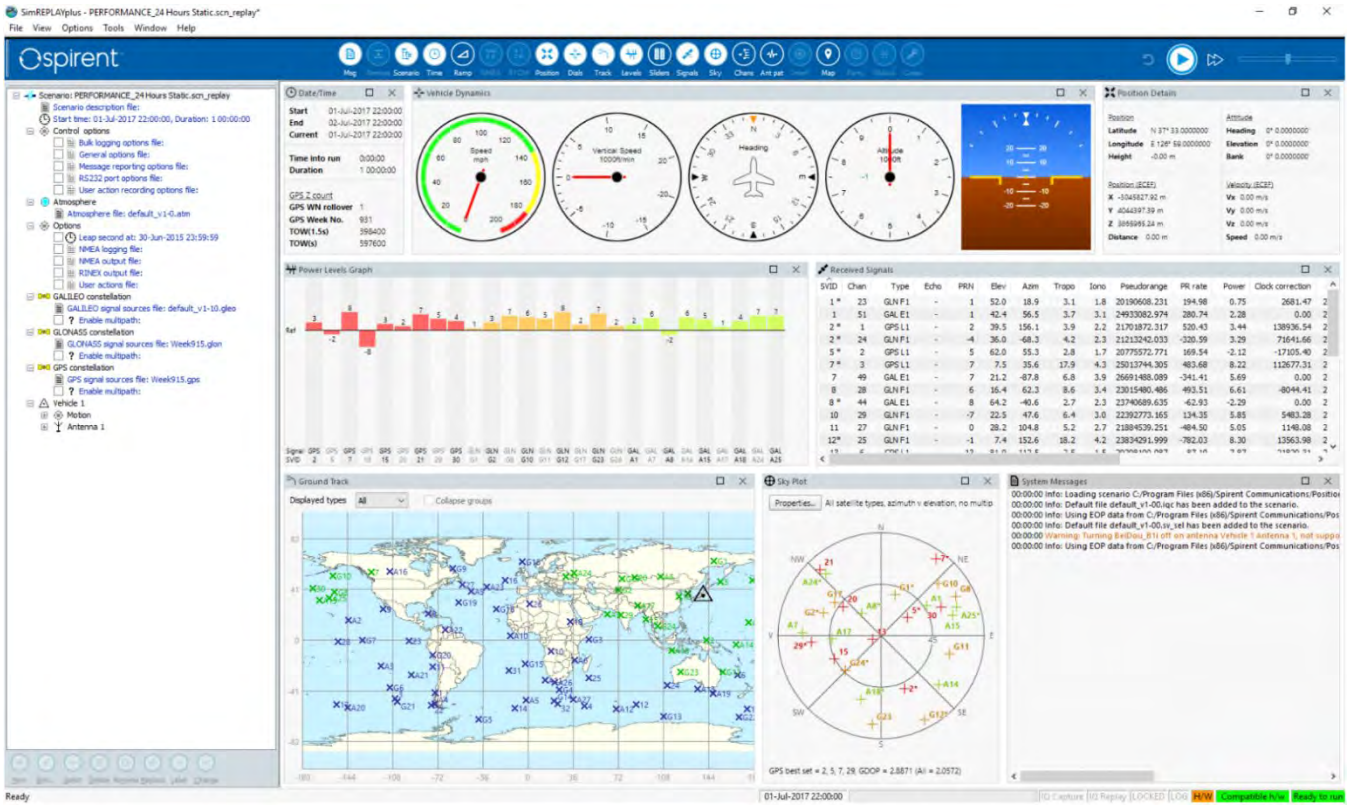

Figure 2. SimREPLAYplus main screen

Key SimREPLAYplus features include:

- Interactive run-time control
- Share scenarios between systems to facilitate collaboration
- Save and compare device under test (DUT) data with logged simulation data
- Receiver antenna pattern modeling
- Environment terrain modeling
- Edit and save time, date, and location
- Use motion from logged NMEA and Google Maps® matched trajectories via the SimROUTE™ tool
- Flexibly allocate available hardware channels across licensed constellations

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- Display simulation parameters
- Display sky plot
- Selected remote control capability via Ethernet connection
- Bulk logging of scenario data
- NMEA input and output
- Licensable RTCM and NTRIP capability
- Spoofing testing with embedded Spoofing option

For more information, please refer to the *SimREPLAYplus for GSS6700 and GSS7000 User Manual*, Reference b).

SimTEST

SimTEST is for essential testing. It provides the capability needed to perform fundamental verification tests. Spirent's complex and precise modeling of constellations and navigation data is built-in, providing maximum ease of use to the user. Simply set up a few key parameters and press 'run.'

Figure 3. SimTEST main screen

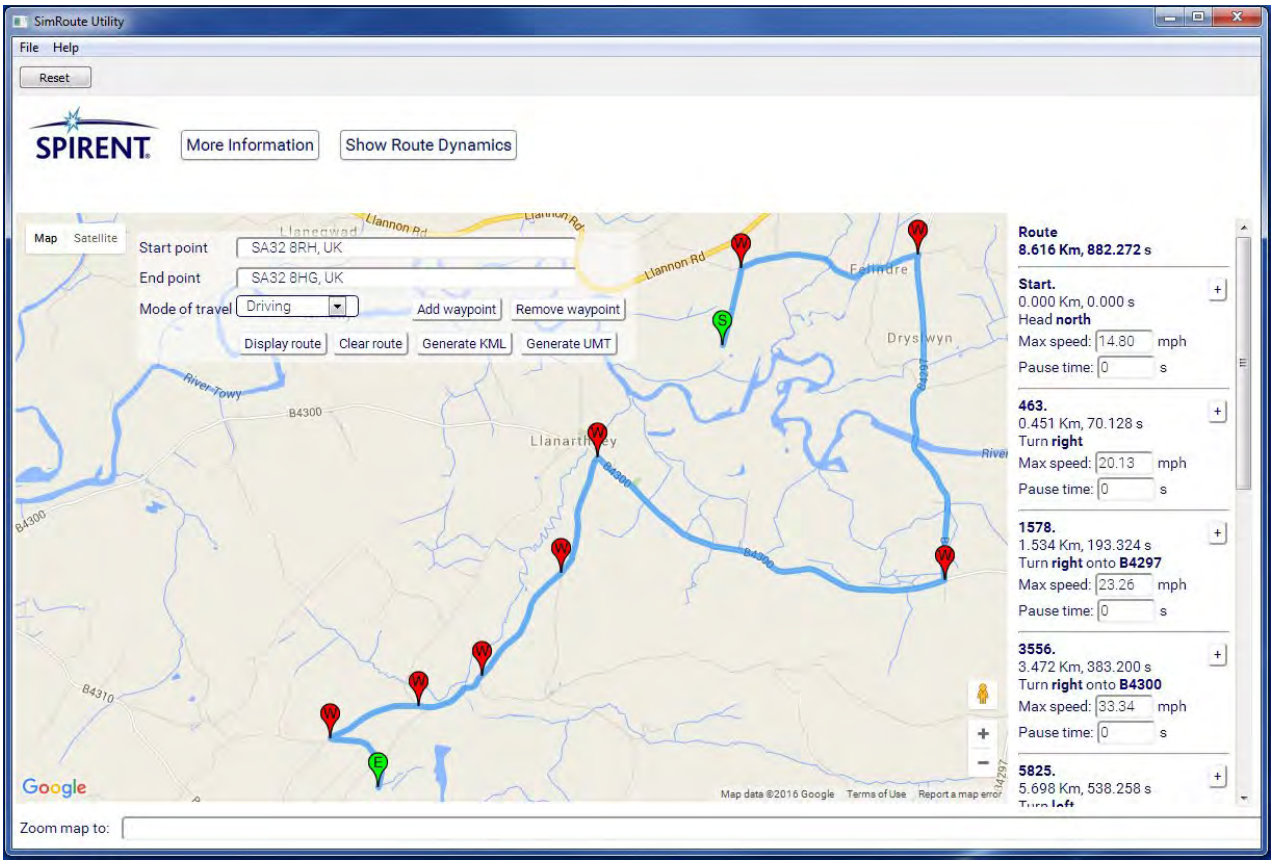

Figure 4. SimROUTE Google Maps user motion trajectory generation tool linked to SimTEST

Key SimTEST features include:

- Edit and save time and date
- Enable/disable atmospheric modeling
- Enable/disable multipath
- Interactive power control of each individual constellation
- Load real constellation almanacs
- Choose static position, simple motion, “racetrack” motion, or Google Maps matched trajectories via the SimROUTE tool
- RX antenna level patterns editing
- Simulate leap second events
- Flexibly allocate available hardware channels across licensed constellations
- Display simulation parameters
- Display sky plot
- Selected remote control capability via Ethernet connection

For more information, please refer to the *SimTEST Software User Manual*, Reference c).

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Single Channel Utility (SCU)

The GSS7000 supports the generation of a single channel satellite signal for each licensed constellation. This allows individual control of several parameters via remote commands including: a satellite's carrier frequency, power level, velocity profile and PRN, secondary code, and navigation data. Under Single Channel mode, GSS7000 can be controlled via the graphical user interface (GUI) or remote commands. Commands are formatted according to Spirent's SimREMOTE ICD and are sent via TCP/IP.

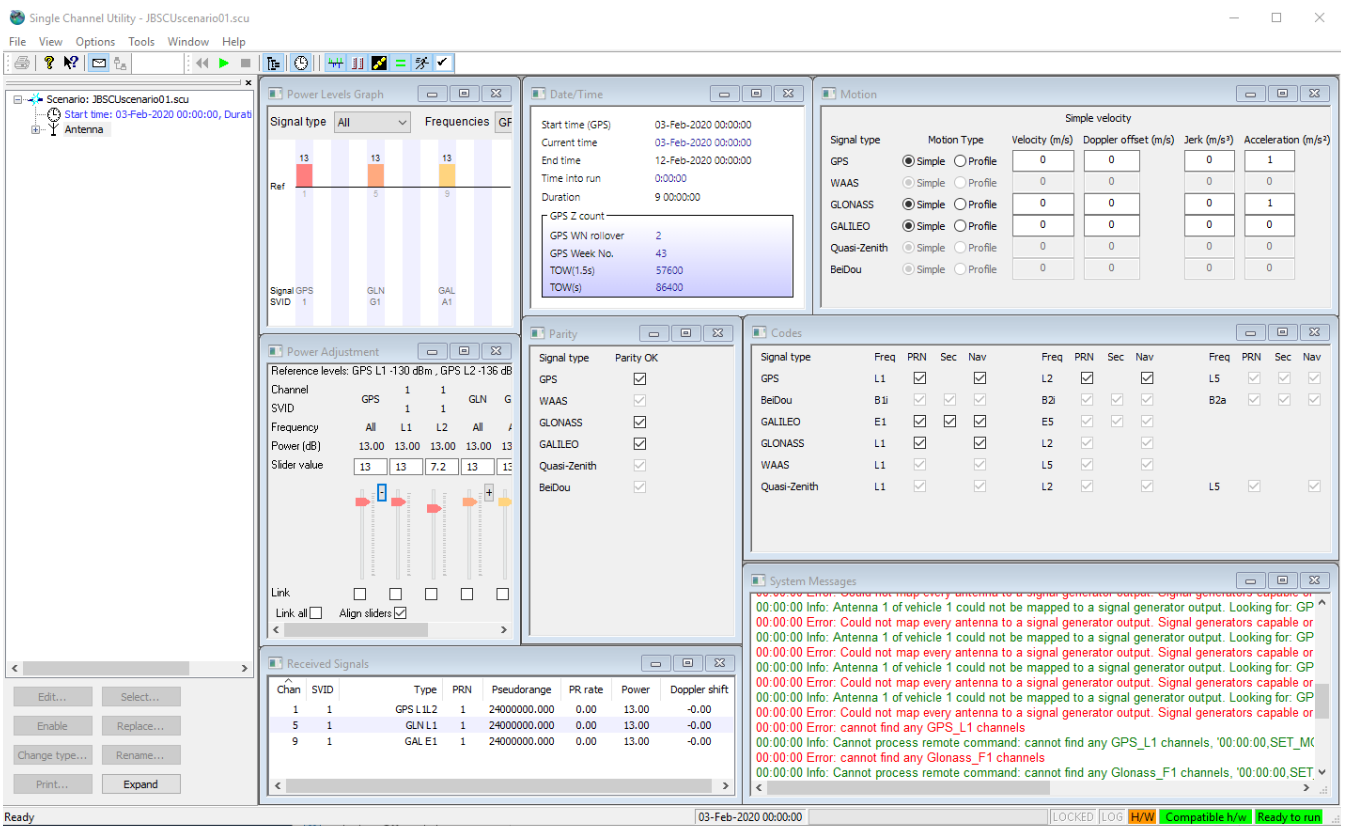

Figure 5. Single Channel Utility main screen

Commands can be grouped into the following 5 sets:

- Before a run
- Starting a run
- During a run
- After a run
- Miscellaneous

Before a Run

Command	Description
SET_ANT_FREQS	Enable constellation frequencies
SET_DIR_INIT_PR	Set the initial pseudorange
SET_DIR_SV	Set the signal SVID and PRN
SET_EXT_REF	Set the external reference frequency
START_TIME	Set the simulation start time and duration
TR	Set the trigger mode

Starting a Run

Command	Description
AR	Arm the simulation
AR_NOWAIT	Arm the simulation, response returned immediately
GET_EXT_REF	Return the status of any time reference signal
RU	Run the simulation
RU_NOWAIT	Run the simulation, response returned immediately

During a Run

Command	Description
EN	End a running scenario
POW_LEV_SCU	Set the power level of a satellite signal
SET_DIR_PROFILE	Set signal velocity profile
SET_DIR_VEL	Set signal velocity and doppler
SET_MODS	Set PRN, BeiDou secondary code and navigation data on/off
SET_PARITY_ERR	Turn navigation data parity errors on and off
TIME	Get the time into run

After a Run

Command	Description
RW	Rewind a simulation that has ended

Miscellaneous Commands

Command	Description
EXIT_SIMGEN	Terminate the PosApp Engine
GET_ANT_FREQS	Return the enabled constellation frequencies
*IDN?	Return the software version
LOG_DIR	Return the log file folder
MSG_REPORTING_FILE_NAME	Return the message log file name
NULL	Return the status information
STTIME	Return the simulation start time

For more information, refer to the *Single Channel Utility User Manual*, reference (d).

Extensions and Options

With the appropriate licenses, extensions and options are available with the GSS7000 to facilitate development and testing of systems and applications that use other signals for navigation, including:

- MEMS IMU sensor output data modeling with SimSENSOR™
- Embedded in-band interference signal generation (see Tables 10 and 11)
- Embedded Spoofing simulation with dedicated spoofing channels which are available only for spoofing (see Table 12. Embedded Spoofing feature specifications)
- Automation capabilities with PNT Automation
- Integration with third-party vehicle models/driving simulation for Hardware-in-the-Loop use cases (See Table 13. SimHIL options)

Table 1 shows the support for extension and optional products with GSS7000.

Table 1. Support of extension and optional products

Product	Supported on SimTEST	Supported on SimREPLAYplus	Supported on SimGEN
SimINERTIAL	NO	NO	NO
SimSENSOR	NO	YES	YES
SimSAFE	NO	NO	YES
Sim3D	YES	YES	YES
SimHIL	YES	YES	YES
SimIQ Capture	YES	YES	YES
SimIQ Replay	NO	NO	YES
GSS7765	NO	YES	YES
Embedded interference generation	YES	YES	YES
Embedded Spoofing simulation	NO	YES	YES
Classified options	NO	NO	NO
GBAS Simulation (via the GSS4150)	NO	NO	YES
ScramNET I/O	NO	NO	NO
PNT Automation	YES	YES	YES
Embedded LEO dynamic models	NO	YES	YES

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Automation Capabilities

GSS7000 supports automation in all PosApp SW levels via PNT Automation, a comprehensive test authoring and execution tool built for testers, developers, and automation teams. It addresses the needs of manual testers, automation specialists, and managers alike to improve the productivity of the entire test workflow.

PNT Automation enables multiple tests to be run without any external intervention while providing analysis and test report capabilities.

It is specifically designed for PNT testing and includes the control software (based on SimREMOTE) to accurately achieve the interoperability between Spirent GSS7000 and the DUT(s). The DUTs are configured and controlled with PNT Automation using a dedicated user interface.

For additional information, please see MS3119.

Table 2 shows a summary of default and licensed options across the three software levels for the GSS7000.

Table 2. Summary of supported, default, and licensable options

Product	Supported on SimTEST	Supported on SimREPLAYplus	Supported on SimGEN
Fixed Offset Multipath	By default	By default	By default
Standalone SBAS and all QZSS	Licensed	Licensed	Licensed
Land Mobile Multipath	X	X	By default
GPS P Code (inc Pseudo Y)	Licensed	Licensed	By default
GLONASS P Code	Licensed	Licensed	By default
GPS L1C	By default	By default	By default
GPS L2C	By default	By default	By default
BeiDou B1I, B1C, B2I, B2a, B2b, B3I	Licensed	Licensed	Licensed
NavIC (IRNSS) L1, L5	Licensed	Licensed	Licensed
GSS7000 Channel Usage	By default	By default	By default
SimROUTE	By default	By default	By default
REPLAY of SimGEN scenarios	X	By default	By default

Compatibility with Other Spirent Simulator Hardware

Note the GSS7000 is a standalone system. It is not possible to connect the GSS7000 to other GNSS simulator hardware platforms in a system controlled by a common test scenario. Note this does not apply to ancillary options such as GSS4150 GBAS simulator.

GSS7000 System Overview

The GSS7000 consists of a single bench-top unit with internal controller running the appropriate operating software. Peripherals (monitor, keyboard, and mouse) are optional and can be supplied.

Figure 6. GSS7000 system (single and dual RF)

GSS7000 Signal Generation Flexibility and Capability Overview

- A single GSS7000 chassis can support a maximum of 4 generic channel banks. (A channel bank consists of a digital signal generator and RF upconverter.) The signals from all banks are combined and fed simultaneously to the front-panel primary RF output and rear-panel high-level output.
- Each channel bank can be configured to generate up to 64 channels of any signal type within one of four frequency bands. Multiple constellations can be generated from a single channel bank simultaneously, providing they are all from the same frequency band. Refer to Table 4 for details of signal type groupings.
- The total number of channels in any one chassis is 256.
- The configuration of constellation/frequency is fixed for the duration of the simulation run.
- The constellations/frequencies available to the user are dependent upon the licenses that are installed.
- The GSS7000 supports the opportunity for in-field RF channel bank hardware upgrade.
- The GSS7000 supports a 100Hz SIR.
- The GSS7000 supports backwards compatibility with Spirent SimREPLAYplus and SimGEN scenarios.
- The GSS7000 is available as a single or dual-RF chassis. Table 3 provides details of software support.

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Table 3. Single and dual-RF GSS7000 software compatibility

Product variant	Supported on SimTEST	Supported on SimREPLAYplus	Supported on SimGEN
GSS7000 Single-RF	YES	YES	YES
GSS7000 Dual-RF	NO	YES	YES

Table 4. Channel band allocations

Carrier Frequency (MHz)	Band
1176.45	1
1191.795	1
1202.025	2
1207.14	2
1227.6	2
1245.781	2
1248.06	2
1268.52	3
1278.75	3
1561.098	4
1575.42	4
1575.42	4
1601.719	4

GNSS Constellations

The GSS7000 architecture supports GNSS signal generation capability in a very flexible way. With the appropriate constellation feature license keys, each generic RF Channel Bank can support **– at any one time –** any number of constellation types within the same band - as shown in Table 5. (Note: For current ICD compliance, see Table 20).

Table 5. Supported constellations for each channel bank

Constellation	Frequency
GPS/SBAS	L1
GPS	L2
GPS/SBAS	L5
Galileo	E1
Galileo	E5
Galileo	E6
GLONASS	L1
GLONASS	L2
GLONASS	L1OC (CDMA)
GLONASS	L2OC (CDMA)
GLONASS	L3OC (CDMA)
BeiDou-2	B1I
BeiDou-2	B2I
BeiDou B1C	B1C
BeiDou B2a	B2a
BeiDou B2b	B2b
Beidou B3I	B3I
SBAS (note 1)	L1
SBAS (note 1)	L5
QZSS	L1
QZSS	L2
QZSS	L5
QZSS	L6
NavIC/(IRNSS)	L1
NavIC/(IRNSS)	L5

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The combinations of constellations generated can vary from scenario to scenario and even between successive runs of the same scenario, depending on the settings in the control software. The principle is that at a particular instant in time, signals from any constellation can be generated provided there is a valid feature license key and an available RF channel bank with the requisite number of licensed channels in the system.

Notes for Table 5:

- SBAS will be provided with any purchase of GPS L1 or L5, respectively. GPS satellite signals are substituted for SBAS ones as required. For non-GPS systems, it is possible to order SBAS as a separate signal.
- The GSS7000 is technology-ready for support of other future GNSS systems/signals, some of which can be supported today through Spirent's Tailored Solutions. Others are planned on the product roadmap.

Flexible Channel Allocation

A useful feature of the GSS7000 is the flexible way licensed satellite channels can be assigned to constellations.

For example: Consider a L1 system with GPS, GLONASS, GALILEO, BEIDOU, and QZSS licenses and 64 channels.

- User can allocate the 64 channels in any ratio between constellations using a slider control.
- Note for different signals on the same constellation (that is, GPS L1 and GPS L5), it is not possible to have an unequal ratio, as in practice the GPS constellation would transmit L1 and L5 signals equally on all satellites. Figure 7 illustrates the concept of the user slider control.

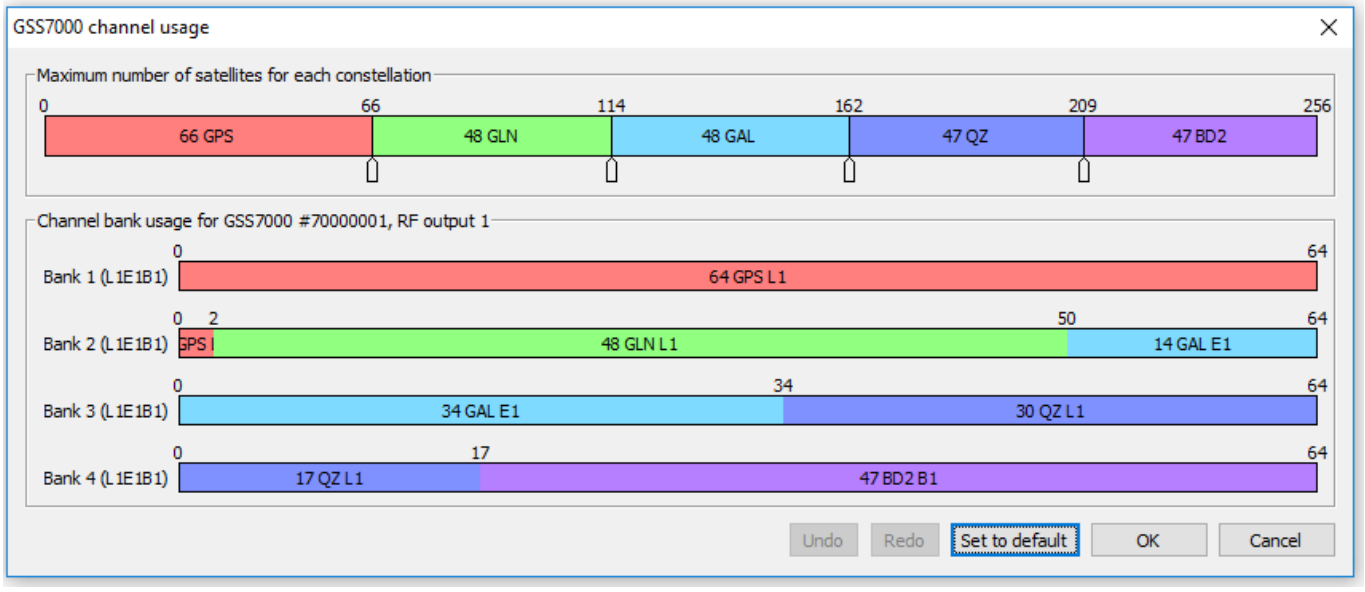

Figure 7. Dynamic channel allocation control concept

Example GSS7000 Systems

The highly-flexible architecture of the GSS7000 allows many different system configurations. Some may have the required number of RF channel banks to support simultaneous generation of all licensed signals. Some systems may have more licensed signals than RF channel banks, allowing support for different combinations of signals.

Figures 8 to 13 show just a few examples of the extensive number of possible combinations and modes of operation. Your Spirent Federal sales representative will be pleased to guide you through the process of selecting the best configuration for your current and future test requirements.

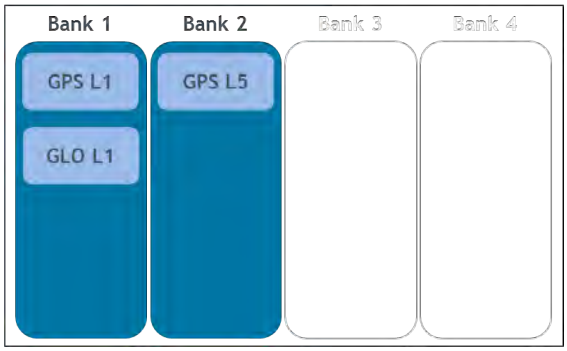

Figure 8. Dual-frequency, 2-constellation system

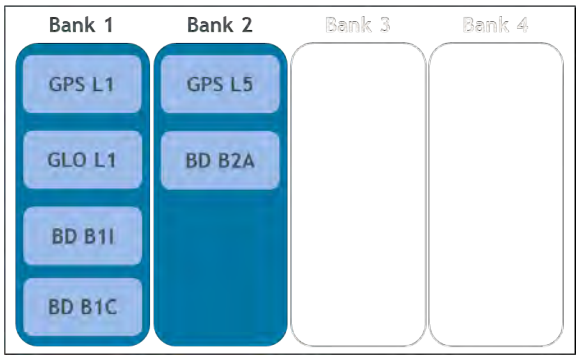

Figure 9. Dual-frequency, 3-constellation system

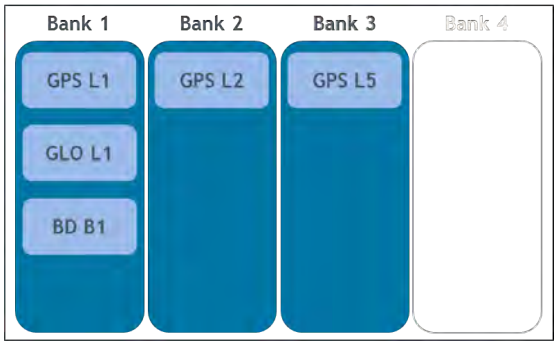

Figure 10. Triple-frequency, 3-constellation system

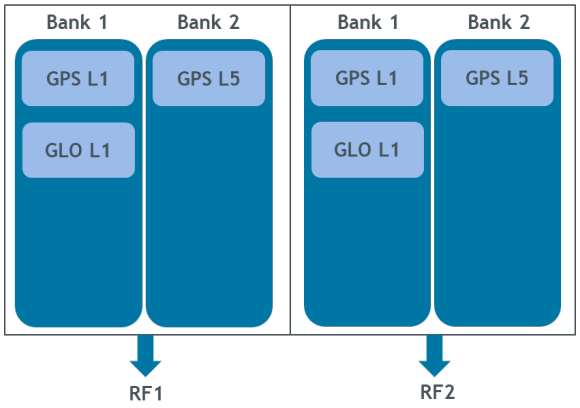

Figure 11. Dual-frequency, 2-constellation 2RF system

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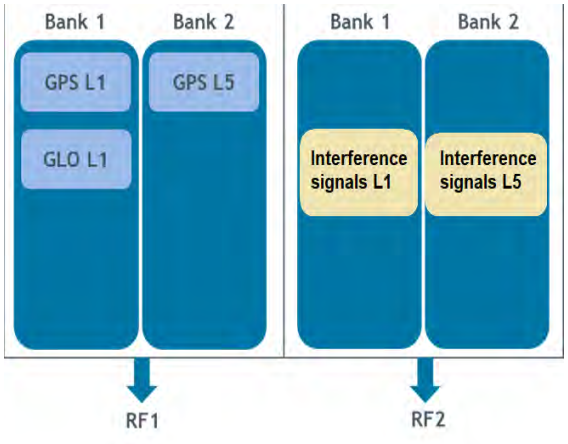

Figure 12. Dual-frequency, GNSS + interference 2RF system

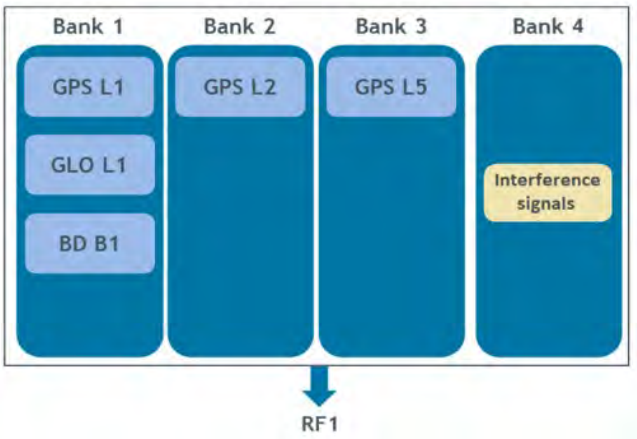

Figure 13. Triple-frequency, GNSS + interference 1RF system

Upgrades

The extensibility of the GSS7000 means that **in-field upgrading** of the system can be achieved easily, flexibly, and in a way that matches the developing needs of your testing requirements as closely as possible.

- Existing RF channel banks can be issued with new license keys, allowing extra channels to be added.
- Additional constellation licenses can be added, allowing other signal types to be enabled.
- New RF channel banks can be added to enable signal types using existing feature keys.
- Both RF channel banks and new feature keys can be added in the field. It is not necessary for the system to be returned to Spirent, but a one-off purchase is required for a Channel Bank Upgrade Tool Kit that has specific tools to assist with the upgrade.
- Simulation software can be upgraded by license key.

This extensibility makes the GSS7000 very flexible in terms of future-upgradeability.

Additional upgrade options are listed in the Related Product References. (See Table 19.)
Please contact Spirent Federal to discuss your requirements.

Performance Specifications

GNSS Constellations and Supported Ranging Signals

The GSS7000 supports the GNSS constellations and ranging signals as shown in Table 6.

Table 6. GNSS constellations and ranging signals

Constellation	Carrier	Standard Signal Types	Licensed Signal Types	Notes
GPS	L1	C/A, L1C	P (including Pseudo Y)	[4]
	L2[5]	C/A, L2C	P (including Pseudo Y)	[1]
	L5	I, Q		
Galileo[6,7]	E1	OS Data/Pilot		
	E5ab	E5a Data/Pilot, E5b Data/Pilot		[8]
	E6	E6-B, E6-C		
GLONASS	L1	C/A	P (Chan No. -7 thru +6)	
	L2	C/A	P (Chan No. -7 thru +6)	
SBAS[9]	L1	C/A		
	L5	I		
BeiDou	B1	B1I, B1C		
	B2	B2I, B2a, B2b		
	B3	B3I		
QZSS	L1	L1S, C/A, C/B, L1C		
	L2	L2c		
	L5	I, Q, L5S		
	L6	L61 or L62		
NavIC (IRNSS)	L1	SPS-L1		
	L5	SPS-L5		

[1,4] "Pseudo-Y" code is provided using public-domain encryption of P-code to fully support L1/L2 squaring or 'Z-tracking', with data message.
[5] C/A code also supported on this carrier as an alternative to L2c.
[6] Open Service ICD support supplied as standard.
[7] Galileo PRN data available from user definable file. Open Service users are supplied PRN data for E1B/C and E5a signal components, PRN data for other signal types is 'dummy data'.
[8] E5ab signaling employs 8-PSK modulation of E5a and E5b onto a single carrier. Appropriate carrier dispersion is applied from E5a to E5b. Channel count per RF Channel Bank is limited to 16 for E5ab.
[9] SBAS includes WAAS, EGNOS, MSAS, GAGAN, SDCM, KASS, A-SBAS, SouthPAN, and UKSBAS.

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Multipath is supported through additional channels, where an individual channel is used for every discrete echo.

The GSS7000 supports valid combinations of signals during simulations, per the relevant signal specification documents.

Nominal Signal Levels

Table 7. Nominal signal levels[10]

System	Carrier	Signal	Level
GPS	L1	C/A	-130.0 dBm
		L1c Pilot code	-128.25 dBm
		L1c Data code	-133.0 dBm
		P	-133.0 dBm
	L2	L2c or C/A	-136.0 dBm
		P	-136.0 dBm
	L5	I,Q	-127.9 dBm
Galileo	E1	E1-B, E1-C	-127.0 dBm
	E5ab	E5a-I + E5a-Q + E5b-I + E5b-Q	-122.0 dBm
	E6	E6-B, E6-C	-128.0 dBm
GLONASS	L1	C/A	-131 dBm
		P	-131 dBm
	L2	C/A	-137 dBm
		P	-137 dBm
BeiDou	B1 (1.561098 GHz)	B1I	-133 dBm
	B1 (1.57542 GHz)	B1C	-130 dBm
	B2 (1.20714 GHz)	B2I	-133 dBm
	B2 (1.17645 GHz)	B2a	-127 dBm
	B2 (1.20714 GHz)	B2b	-131 dBm
	B3 (1.26852 GHz)	B3I	-133 dBm

[10] Nominal signal power levels as defined by Spirent. Using the simulator software, the user has extensive facilities to adjust these nominal power levels to meet individual GNSS ICD conditions and or specific test needs.

System	Carrier	Signal	Level
QZSS	L1	C/A code	-128.5 dBm
		L1S	-131 dBm
		L1c Data + Pilot	-127 dBm
	L2	L2c	-130 dBm
	L5	I + Q	-124.9 dBm
		L5S	-124.0 dBm
	L6	L61/L62	-126.82 dBm[11]
NavIC (IRNSS)	L1	SPS-L1	-125.8dBm
	L5	SPS-L5	-130 dBm

[11] Default power level setting is for Block II satellites.

Table 8. Navigation messages types per constellation (standard and optional signals)

Constellation	Message Type	Applicable Signal	Requirements	Notes
GPS	Legacy	C/A, P		
	CNAV	L2C, L5-I		
	CNAV-2	L1C		
Galileo	I/NAV	E1-B, E5b-I	OS Galileo Excludes SOL support	
	F/NAV	E5a-I	OS Galileo supported	
	C/NAV(HAS)	E6-B		
GLONASS	Public[12]	L1-C/A		
BeiDou	D1 and D2[13]	B1I, B2I, B3I		
	B-CNAV1	B1C		
	B-CNAV2	B2a		
	B-CNAV3	B2b		
	PPP-B2b_I	PPP-B2b		
SBAS	Data	L1, L5-I		[14]
IRNSS	CNAV	L1		
	Legacy	L5		
QZSS	QZ-Legacy	L1 C/A		
	QZ-L1S	L1S		
	QZ-CNAV	L2C, L5-I		
	QZ-CNAV-2	L1C		
	L6D	L61/L62		
	L6E	L62		

[12] There is no data message on the GLONASS P-code.
[13] D2 does not include differential corrections or Iono grid.
[14] The same message is broadcast at L1 and L5 for any satellite.

Table 9. Performance levels for GSS7000 series

Parameter	Description	Units		Notes
RF Signal Level	Carrier Level Control Maximum	+15 dB		
	Minimum	-40 dB		[15]
	Resolution	0.1 dB		
	Linearity +15 dB to -30 dB	<0.10 dB		
	-30.1 dB to -40 dB	<0.20 dB		
	Absolute Accuracy	±0.5 dB		[16]
	Run to Run Repeatability	±0.1 dB		
Iteration Rates	Supported SimGEN Simulation Iteration Rates (SIR)[17]	10, 100, 250, 500,1000 Hz,		
	Hardware update rate[18]	1000Hz		
	Bulk logging update rate	1000Hz		[19]
	Latency (remote data to RF)	4 x SIR		
Limit of Signal Dynamics [20]		Units @ 100Hz	Units @ 1000 Hz[21]	
	Relative Velocity	±30,000 m/s	±120,000 m/s	[22]
	Relative Acceleration	±2000 m/s^2	±192,600 m/s^2	
	Relative Jerk	±22000 m/s^3	±890,400 m/s^3	
	Angular Rates (at 1.5m lever arm) (indicative) (at 0.05m lever arm)	>2π rad/s >10π rad/s	>15πrad/s >60π rad/s	
Signal Accuracy	Pseudorange Accuracy	3 mm RMS	0.3mm RMS	[23]
	Pseudorange Bias	0 mm RMS	0 mm RMS	[24]
	1PPS to RF Alignment	< ±2ns		[25]
	Inter Frequency Alignment	< ±250ps (±75mm)		[26]

[15] The control range extends to -50dB, but performance is unspecified below -40dB. Operation below -20dB is primarily to support antenna pattern and multipath functionality.
[16] At 21oC ±5oC, +15 to -30dB. ±1.5dB 3-sigma all conditions.
[17] For single box configuration. 250, 500 and 1000Hz SIR can be activated through a license.
[18] For the GSS7000 system, the maximum rate at which any value can change is limited by SIR. For example, with a 1000Hz SIR, the values applied at the HUR change at 1000Hz. In this case, the HUR is applying the same value many times over.
[19] Bulk logging at the fastest rate, with many parameters, will result in a reduced scenario duration.
[20] Note that the signal dynamic limits are dependent on the SIR and HUR.
[21] 1kHz is activated through a license.
[22] For 6DOF data externally supplied via SimREMOTE or from data file.
[23] Digitization-induced error for signal acceleration < 45m/s2, jerk < 50m/s3, 100Hz SIR.
[24] Per carrier operating on a single channel bank. When the same signal is generated across channel banks, the inter channel bank bias uncertainty is ±250ps (±75mm).
[25] Between any RF carrier.

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Parameter	Description	Units	Notes
Spectral Purity	Harmonics	< -40dBc	
	In-band Spurious (highest limit applies)	< -182dBW	[27]
	Phase Noise (single sideband)	<0.02 Rad RMS	[28]
Signal Stability	Internal 10.00MHz OCX Oscillator (after warm up)	± 5 x 10-10 per day	
Static Multipath Channels	Fixed path-length delay per path	0 to 1245m	
	Resolution (approx.)	2.4m	
Scenario Duration	The maximum duration of a single scenario	65 days on SimGEN and SimREPLAYplus 24 days on SimTEST	[29]
Latency	For the operating in the HIL environment, the commands will take 4 times the SIR to be effective at RF.	40ms @ 100Hz 4ms[30] @1000Hz	[31]

[26] PRN code alignment between frequency band.
[27] In-Band Spurious Bandwidths (relative to center frequency unless otherwise stated):
GPS: L1 ± 20.5MHz , L2 ± 20.5MHz , L5 ± 20.5MHz
Galileo: E1 ± 20MHz , E5a ± 25.5MHz , E5b ± 25.5MHz
GLONASS: (relative to channel frequency 0) L1 ± 20MHz , L2 ± 20MHz
BeiDou: B1/B2 ± 20.5MHz
[28] Value is typical, integrated over a 1Hz to 10kHz bandwidth.
[29] 13 days duration when operates at 1000Hz update rate.
Bulk logging of many parameters will reduce the effective scenario duration.
[30] 4ms on average but with transient latencies of up to 18ms depending upon scenario complexity and logging type and rate.
[31] Simulation running at 10ms SIR.

Table 10. Embedded interference signal specifications

Parameter	Detail	Value	Notes
Interference Transmitter	Per Frequency Band	8 maximum	
Frequency Bands	L1 band	1539-1615MHz	[32]
	L2 band	1182-1258MHz	
	L5 band	1154-1230MHz	
	L6 band	1237-1313MHz	
	A1 band	1485-1561MHZ	
	A2 band	1588-1664MHZ	
	A3 band	1115-1191MHZ	
	A4 band	1271-1347 MHz	
Carrier frequency offset resolution		0.5kHz	
Signal types	CW, PSK narrowband/ broadband, CW pulse, AWGN, FM, AM, PM, CHIRP		
RF Signal Level	Single signal	-47 dBm (max)	[33]
	Multiple signals	-72 dBm (max)	[34]
	Minimum level per signal	-117 dBm	
	Linearity, per signal, >-97 dBm	<0.1 dB	
	Linearity: per signal, > –107 dBm	<0.2 dB	
	Linearity: per signal, > –117 dBm	<0.5 dB	

[32] ±38MHz allows for 80% sample rate and 20MHz AWGN.
[33] Single signal per channel bank (CW, FM, PM), -49dBm (BPSK, pulsed CW), -53dBm (AM), -60dBm (AWGN).
[34] -72dBm per signal for AWGN signals, other signal types can be up to 3dB higher.

Table 11. Embedded interference signal modulation types and performance

Signal type	Detail	Value
BPSK	Main lobe width: Wide Band	20.46 MHz
	Narrow Band	0.1023 MHz
CW Pulse	Pulse width	1 to 10000 µs
	Pulse repetition interval range	50 to 10000 µs
	Pulse repetition interval resolution	50 µs
	Rise time (10% to 90%)	100 ns (max)
	On/Off ratio min	30 dB
AWGN	3 dB Bandwidth	0.1 to 20 MHz
	Bandwidth resolution	10 kHz
AWGN Pulse	3 dB Bandwidth	0.1 to 20 MHz
	Bandwidth resolution	10 kHz
	Duty cycle	1 to 50 %
	Pulse rate	0.001 to 20 kHz
FM CW	FM deviation	±0.01 to ±15 MHz
	FM rate	0.005 to 10 kHz
	FM rate step size	0.005 kHz
	Modulating Waveform	Triangular
AM	Modulation depth	10 to 90%
	Modulation depth step size	10%
	AM rate	0.5 to 10 kHz
	Modulating Waveform	Sinusoidal
PM	Modulation deviation	±0 to ±5 rad
	PM rate	0.5 to 10 kHz
	Modulating Waveform	Sinusoidal
Chirp	CHIRP deviation	±0.01 to ±15 MHz
	Sweep rate	±50 kHz
	Modulating Waveform	Sawtooth

Table 12. Embedded Spoofing feature specifications

Parameter	SimREPLAY+	SimGEN
Supported GNSS signals	GPS, GLONASS, Galileo, BeiDou, QZSS, IRNSS (provided individual signals are licensed)	
Spoofer vehicles	1	Up to 2
Spoofer transmitters (per spoofer)	2	Up to 8
Spoofer transmitters' location	Absolute or relative to vehicle	Absolute or relative to vehicle
Spoofer power level selection	Fixed or modelled	Fixed or modelled
Trajectory spoofing	Yes	Yes
Navigation data spoofing	Replay only	Yes
Meaconing	Yes	Yes

SimHIL is compatible with the third-party tools listed in Table 13. Third-party tools hardware, firmware, and software compatibility must always be checked with your Spirent Federal representative prior to order. PosApp version compatibility must always be checked too. If the variant you are interested in is not listed, please contact Spirent Federal for more information.

Table 13. SimHIL options

Option	Real-time HW Supported	SW Versions Supported	Supported SIR
SimHIL for dSPACE	dSPACE SCALEXIO 2.0	dSPACE Release 2019-A dSPACE Release 2021-A dSPACE Release 2022-A dSPACE Release 2023-A	Up to 10 ms (100 Hz)
SimHIL for IPG	NI PXIe 8840 13.1	IPG CarMaker 8.1.2 (Windows) IPG CarMaker 9.1.2 (Windows) IPG CarMaker HIL 9.1.2 (NI RT Linux OS) IPG CarMaker 10.1 (NI RT Linux OS)	Up to 10 ms (100 Hz)
SimHIL for SCANeR		SCANeR Studio 1.7 SCANeR Studio 1.8 SCANeR Studio 1.9r65 SCANeR Studio 2021, 2022 and 2023	Up to 10 ms (100 Hz)

Table 14. Signal generator connectivity

Port	Type	Parameter
Main RF Port	Output	N-type coax female, 50 Ohm, VSWR <1.2:1 AC coupled ±50 V DC, maximum reverse RF 30 dBm
High Level RF Port	Output	N-type coax female, 50 Ohm, VSWR <1.2:1 AC coupled ±50 V DC, maximum reverse RF 30 dBm
Auxiliary RF	Input	N-type coax female, 50 Ohm, VSWR <1.4:1 0.5 to 2 GHz, Insertion Loss 14.5 dB typical
External Frequency Standard	Input	BNC coax socket, 50 Ohm -5 to +10 dBm at 1 MHz, 5 MHz, 10 MHz
Internal Frequency Standard	Output	BNC coax socket, 50 Ohm 10.00 MHz at +5 dBm nominal
1PPS IN	Input	BNC coax socket, 50 ohm, TTL level compatible
1PPS OUT	Output	BNC coax socket, 50 Ohm, TTL level compatible
Trigger IN	Input	BNC coax socket, 50 ohm, TTL level compatible

Table 15. Internal controller connectivity

Interface	Type	Parameter
USB (x4)	I/O	Mouse, keyboard, and general file access (2 accessed from front + 2 on rear panel)
Ethernet (x2)	I/O	RJ-45 Ethernet interface standard. Used for general network access and available for remote control.
DVI	I/O	Video monitor port

Table 16. Optional monitor

Type	Type	Manufacturer
P2217H	22-inch	Dell

Table 17. Physical and environmental properties

Part	Parameter	Value
Signal Generator	Approximate Dimensions (H x W x D) (9.25” x 4U chassis)	176.95mm x 235.2mm x 555mm 6.96” x 9.25” x 21.85”
	Typical Weight	<15kg (33lb) (configuration dependent)
	Operating Environment	0 to +50°C (32 to 122°F) (40-90% RH, non-condensing) Altitude restriction of 2000m
	Storage Environment	-40 to +60°C (-40 to 140°F) (20-90% RH, non-condensing)
	Electrical Power	100-240V 5A Max 50 to 60Hz

Note(s): Physical and environmental properties such as the operating and storage environments apply to the GSS7000 signal generator only. Associated equipment such as the monitor, keyboard, and mouse or other Spirent supplied equipment may not extend to these environmental limits. Optionally, the chassis can be mounted in an equipment rack, details available upon request.

Table 18. Safety and EMC compliance

Compliance	Applicable Standard
Safety	Low Voltage Directive (LVD) 2014/35/EU IEC 62368-1:2014 (Second Edition) Audio/video, Information and communication technology equipment. Safety requirements
EMC	EMC Directive 2014/30/EU EN 61326-1:2021 Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements
NRTL Certification	MET Certification. Listing number E113897; MET Project Number 111632 UL 62368-1/CAN C22.2 CSA 62368-1, Second Edition: Audio/video, information and communication technology equipment. Safety requirements

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Calibration Requirements

The digital architecture of the signal generator requires only limited annual calibration, for which a detailed procedure is provided.

The GSS7000 GNSS Constellation Simulator is calibrated to the ISO/IEC 17025 standard at the time of purchase. We have determined that the calibration of this product is not affected by storage of up to 180 days prior to its initial receipt by the customer. The recalibration of this unit should be based on when the product is put into service and first used. The recommended calibration interval is 12 months. Annual re-calibration must be carried out at a Spirent facility or accredited laboratory to maintain this accreditation.

Installation of additional purchased channel banks or performing calibrations out of a Spirent authorized ISO/IEC17025 accredited laboratory will invalidate your accredited calibration. This includes customer use of the Auto Calibration Utility (where installed) and certain upgrade procedures.

For more information on Spirent's calibration service, customers may refer to MS3089: Spirent Support Service for Positioning Technology Products. Customers who require more information on how to renew the annual accredited calibration may contact their local Spirent Federal representative.

Related Brochures, Data Sheets and Specifications

Table 19. Related product references

Related Product	Description	Datasheet / Specification
SimGEN	GNSS Software Suite	MS3008
SimSAFE	Vulnerability Test Tool	MS3092
SimREMOTE	Simulator Remote Control Additional Options	MS3015
GSS7765	Generic Interference Generator Option	MS3055
SimSENSOR	MEMS Sensor Simulation Option	MS3086
GBAS	GSS4150 VHF Data Broadcast Simulator for GBAS Product Specification	MS3014
SimROUTE	Road-Matched Trajectory Generation Tool	MS3073
Sim3D	Realtime Multipath Simulation Tool	MS3105

ICD Compliance – Applicable Documents

Table 20. ICD compliance[35, 36]

Reference	Title	Notes
IS-GPS-200	Navstar GPS Space Segment / Navigation User Interfaces	
IS-GPS-705	Navstar GPS Space Segment / User Segment L5 Interfaces	
IS-GPS-800	L1C Interface Specification	
OS SIS ICD	Galileo Open Service Signal-in-Space Interface Control Document	
SISICD	GLONASS Interface Control Document	
OS_SISICD	BeiDou Navigation Satellite System (Phase-2) Signal-in-Space Interface Control Document Open Service Signal	ForB2I
OS_SISICD	BeiDou Navigation Satellite System (Phase-2) Signal-in-Space Interface Control Document Open Service Signal	For B1I
Beidou3_ICD_B1C_B2a	BeiDou Navigation Satellite System (Phase-3) Signal-in-Space Interface Control Document Open Service Signals	For B1C, B2a[37]
Beidou3_ICD_B2b	BeiDou Navigation Satellite System (Phase-3) Signal-in-Space Interface Control Document Open Service Signals	For B2b, PPP-B2b
RTCA-DO229	WAAS MOPS	
IS-QZSS-PNT-001	Quasi-Zenith Satellite System Interface Specification Satellite Positioning, Navigation and Timing Service	For L1, L2, L5
IS-QZSS-L6-001	Quasi-Zenith Satellite System Interface Specification Centimeter Level Augmentation Service	For L6
IRNSS_SISICD_SPS	Aug. 2017 IRNSS Signal-in-Space ICD for SPS	
NMEA	0183	
RINEX	-	

Spirent operates a policy of upgrades to meet ICD changes as they are adopted and to implement ICDs for new signals as they are made public. To obtain ongoing upgrades, your system needs to be under warranty or a current support agreement.

Please contact Spirent Federal for current ICD compliance.

[35] For the latest ICD compliance, please refer to the latest issues DGP000686AAA SimGEN software user manual, DGP01449AAA SimREPLAYplus user manual, and DGP01446AAA SimTEST user manual.
[36] Compliance assumes the latest version of control software is installed and the system is fully calibrated.
[37] BeiDou Phase-3 implementation includes BDGIM Ionospheric model.

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Environmental Social & Governance (ESG)

Spirent's Positioning Technology Business Unit has been committed to ESG good practice and improvement since achieving ISO14001:2015 Environmental Managemental System certification in 2004.

We take ESG seriously across all aspects of our business from sustainable buildings, sustainable product design to sustainable supply chain, manufacturing, and shipping/exports.

Many of Spirent's Test Solutions rely on physical test equipment used in situ by our customers. We are working to reduce the lifecycle impacts of our products and the environments they are used in through a range of ways:

- Designing for environment and end of life, including compliance with all legal requirements;
- Reducing the size, weight, noise, and power use of our products;
- Virtualization and the development of Test-as-a-Service via PNT Professional Services;
- Improving utilization and automation
- In-field servicing and upgrades.

We use formal sustainability metrics in the product development process.

For more specific information on how ESG applies to our PNT Test Solutions, please contact your Spirent Federal representative.

For more information visit, https://corporate.spirent.com/sustainability.

Referenced Documents

a) DGP00686AAA SimGEN Software User Manual [latest issue]

b) DGP01449AAA GSS7000, GSS6700 and SimREPLAYplus User Manual [latest issue]

c) DGP01446AAA SimTEST Software User Manual [latest issue]

d) DGP01491AAA Single Channel Utility User Manual [latest issue]

e) MS3119 PNT Automation Datasheet [latest issue]

Glossary of Terms

1PPS	One Pulse-Per-Second
BITE	Built In Test Equipment
BeiDou	Chinese GNSS System
DOP	Dilution Of Precision caused by satellite geometry
EMC	Electromagnetic Compatibility
FPGA	Field-Programmable Gate Array – a reconfigurable electronic device
GALILEO	EU GNSS System
GPS	Global Positioning System US GNSS system
GNSS	Global Navigation Satellite System (Galileo +GPS+SBAS+GLONASS+IRNSS+BeiDou)
GLONASS	GLObal NAvigation Satellite System (Russian Federation)
GUI	Graphical User Interface
HUR	Hardware Update Rate
IRNSS	Indian Regional Navigation Satellite System
ICD	Interface Control Document
IEEE-488	An 8-bit parallel Hardware Interface
OS	Open Service – Galileo
PRS-NOISE	A signal with the same spectral distribution as PRS, but with an arbitrary code structure of the correct chip rate that is phase and frequency correlated with the other Galileo signals
PRN	Pseudo-Random Number, representing the unique transmitted signal code
QZSS	Quasi-Zenith Satellite System
RAIM	Receiver Autonomous Integrity Monitoring
RF	Radio Frequency
SBAS	Space-Based Augmentation System
SOL	Safety Of Life
SIR	Simulation Iteration Rate
ESG	Environmental Social & Governance

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For More Information

For more information on any aspect of GSS7000, please contact Spirent Federal.

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Why Spirent?

Across five decades Spirent has brought unrivaled power, control, and precision to positioning, navigation and timing (PNT) simulation. Spirent partners with the leading developers and integrators to consult and deliver on innovative solutions, using the highest quality hardware and the most flexible and intuitive software on the market.

Spirent delivers

- Simplified testing accelerates the innovation cycle and deployment of robust PNT systems
- Proven track record of being first-to-market with new signals and ICDs
- Unrivaled investment in customer-focused R&D
- World-leading expertise, redefining industry expectations
- Powerful, flexible, and customizable SDR technology for future-proofed test capabilities
- Signals built from first principles — giving reliable and precise truth data

About Spirent Positioning Technology

Spirent enables innovation and development in the GNSS and additional PNT technologies that are increasingly influencing our lives. Our clients promise superior performance to their customers. By providing comprehensive and tailored test and assurance solutions, Spirent assures that our clients fulfill that promise.

About Spirent Federal Systems

Spirent Federal Systems provides the world's leading PNT test solutions to the US Government and contractors to enable resilient PNT under any conditions and outpace evolving navigation warfare threats. As a US proxy company, Spirent Federal enhances Spirent's commercial offerings with classified and other sensitive military signal emulation capabilities.