GSS9000 Series

The very best in performance, flexibility and capability for GNSS developers and testers

Datasheet with Product Specification

Spirent **GSS9000 Series GNSS Simulation System**

Purpose of this Document

This datasheet describes the functionality of the Spirent GSS9000 Multi-Frequency, Multi-GNSS RF Constellation Simulator, which sets a new standard of excellence in GNSS RF Simulation for R&D and performance test.

This datasheet also provides technical data and configuration information.

The GSS9000 offers a very wide range of capabilities and options. Please speak to your Spirent sales representative before ordering to ensure your specific needs are met.

PROPRIETARY INFORMATION

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Introduction

To develop positioning, navigation and timing systems for military, space, and other high precision applications you require comprehensive, highly sophisticated testing. The updated GSS9000 Series multi-frequency, multi-GNSS RF constellation simulator sets a new standard of excellence in future-proofed simulation for R&D and performance testing.

Powered by SimGEN®, and using the latest state-of-the-art technology designed specifically for GNSS signal simulation, the GSS9000 Series produces a comprehensive range of emulated RF signals with industry-leading flexibility, fidelity, performance and reliability.

Ultimate Flexibility, Supreme Performance, Comprehensive Capability

The GSS9000 supports an extensive range of constellation configurations, from GPS L1 C/A through to multi-GNSS, multi-frequency systems including authorised signals. Configurations are available that support multi-antennas and multi-vehicles, for example differential-GNSS, attitude determination, interference/jamming and spoofing and Controlled Reception Pattern Antenna (CRPA) testing.

Some of the GSS9000's key attributes are:

- World-leading performance in several key areas such as:
  - 1000 Hz System Iteration Rate (SIR) and Hardware Update Rate (HUR)
  - 0.3 mm RMS Pseudorange Accuracy
  - 0 mm uncertainty due to inter-channel bias
  - <0.005 Rad RMS Phase Noise

- Highly flexible configurations selectable via a 'cabinet' of feature licence keys
- Complete portability of Spirent SimGEN™ scenarios
- In-field upgradeability of principal GNSS functionality and capability
- On-the-fly re-configuration of constellation and signal configurations
- All GNSS constellation types and all frequencies brought into a single chassis
- Multi-RF output options available
- Embedded Interference Sources option (GTx) available
- Backward compatibility with legacy scenarios enabling seamless transition from existing Spirent platforms
- Fully future-proofed for all advances in GNSS systems, signals, modulations, codes and data

A key benefit of the GSS9000 is that the signal performance specification is met under ALL operating conditions, including the full range of ultra-high dynamics.

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

Spirent **GSS9000 Series GNSS Simulation System**

SimGEN™ Scenario Definition and Simulation Control Software

SimGEN™ is Spirent's software application suite that supports the GSS9000.

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 more than 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.

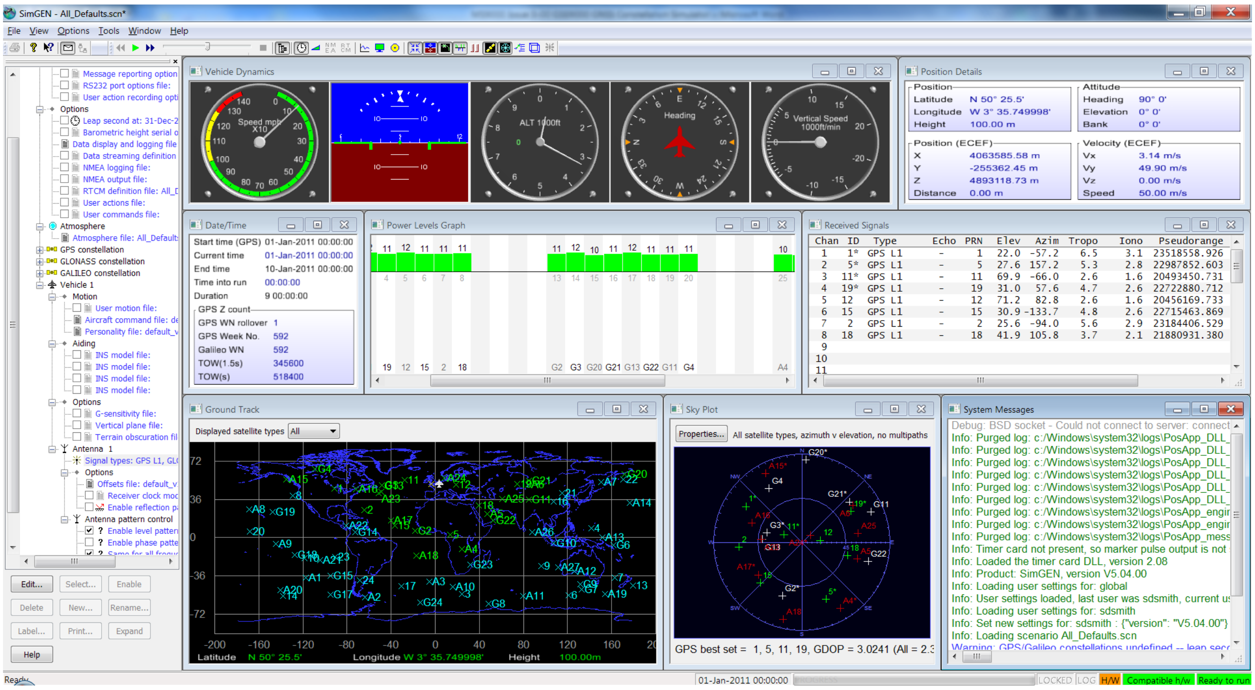

Figure 1 SimGEN scenario definition and simulation control software

Some of SimGEN's fundamental performance and modelling 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: Comprehensive simulation control and 6-DOF trajectory delivery capability
- 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
- Multi-copy constellations for spoofing testing
- 2-vehicles to 1RF for trajectory spoofing
- Vehicle personalities and motion modelling for aircraft, spacecraft, marine vessels and land vehicles
- Antenna reception gain and phase patterns

- Satellite transmit antenna pattern control
- Clock g-sensitivity
- Antenna lever arm effects
- INS aiding data
- Ionosphere and Troposphere effects including ionospheric scintillation
- DGPS corrections
- Pseudorange ramps (for RAIM testing)
- Coherent and non-coherent Interference and noise modelling (with optional GSS7765 Interference Simulation System)
- Leap-second and week roll-over event testing

More information about the capabilities of SimGEN™ can be found in the separate specification document, see Table 18.

Extensions and Options

Extensions and options are available with the GSS9000 to facilitate development and testing of systems and applications which use other GNSS codes/signals and alternative technology for position, navigation and time determination alongside GNSS. These include:

- Authorised GPS and Galileo signal generation for authorised users (see 'Authorised Testing' section)
- GBAS VHF Data Broadcast Simulation available with the GSS4150 solution.
- Inertial Test input simulation of several types of Integrated GPS/Inertial (IGI) navigation sensors (also known as EGIs) and emulation of the presence of Inertial Measurement Units (IMU) with SimINERTIAL™ and SimAUTO™
- Interference signal generation, using the GSS7765™ Interference Simulation System, where the interference sources are positioned and dynamically modelled by the GSS9000 system
- Embedded in-band interference (Ground Transmitters – GTx) With a variety of modulations and signal controls (See Table 13)
- Sophisticated jamming laboratory testing using the GSS7765 Interference Simulation System and spoofing laboratory testing using Spirent's SimSAFE™ solution alongside in-built capabilities

GSS9000 Feature / Capability Temporary Licensing

The flexibility of the GSS9000 allows constellations and channels to be temporarily enabled on a time-limited rental basis. This is particularly useful if the system is to be used for short to medium-term projects requiring an additional constellations and/or additional satellite channels for a defined period. An existing GSS9000 system can have additional feature(s) enabled by providing the user with a suitably revised soft licence key, the intention is that a system is returned to a default condition upon expiry of the temporary licence. If licences are consecutively renewed for the requisite number of times, the feature becomes permanent and the licence runs in perpetuity.

Spirent **GSS9000 Series GNSS Simulation System**

GSS9000 System Overview

The GSS9000 system consists of a Signal Generator Chassis and dedicated C50r Host Unit running Spirent's SimGEN™ scenario definition and simulation control software, as shown in Figure 2.

Figure 2 GSS9000 system

GSS9000 Signal Generator Chassis

The GSS9000 Signal Generator Chassis consists of one or more **RF Channel Banks**. An RF Channel Bank consists of 2 cards - a digital signal generator card and an RF up-converter card. Each RF Channel Bank is licenced to support; **4, 8, 12, 16 or 32 separate channels**. Each RF Channel Bank is capable – at any one time – of supporting any number of licenced GNSS constellations in the same frequency band.

The Signal Generator Chassis is available in 2 main variants:

- Single RF Output - behind which up to 10 RF Channel Banks can be installed
- Dual RF Output - with up to 5 RF Channel Banks installed behind RF Output 1 and up to 5 RF Channel Banks installed behind RF Output 2.
    - Optionally, the Dual RF Signal Generator Chassis can be provided with the capability for the RF Channel Banks behind RF Output 2 to be configured to operate as interference sources (GTx – Ground Transmitters), using a dedicated rear panel link cable.
    - There are also multi-output versions of the 1-RF and 2-RF chassis (supported as Tailored Solutions), allowing highly flexible configurations to be tailored to specific needs, such as the GSS9790 CRPA/Wavefront system.

This extensive capacity enables a single Signal Generator Chassis to support up to **320 independent channels**. In addition to this, each primary channel also supports an additional **4 embedded multipath channels** that are delayed and attenuated copies of the primary channel and are applied to the first 16 channels of the bank, giving up to **640 embedded multipath channels** in a single chassis..

GSS9000 C50r SimGEN Host

The Signal Generator Chassis is controlled by a dedicated, rack-mountable **C50r SimGEN Host**, which is a Spirent proprietary design, multi-processor/core system, configured with a mixed Operating System (OS) environment (Linux and Windows® 10 Professional for Embedded Systems ESD [Virtualisation Only]) This combination of processing power and dual OS provides the perfect platform to enable the GSS9000's new bench-mark performance levels, and to support Spirent's SimGEN™ scenario definition and simulation control software application. The C50r SimGEN Host is supplied with a free-standing monitor, desktop keyboard and mouse.

GNSS Constellations

The GSS9000 architecture supports GNSS signal generation capability in a very flexible way. With the appropriate constellation feature licence keys, each generic RF Channel Bank can support **– at any one time –** any one of the constellation/frequency variations as shown in Table 1 (for current ICD compliance, see Table 19).

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 SimGEN. The principle is that at an instant in time, signals from any constellation can be generated provided there is a valid feature licence key and an available RF Channel Bank in the system.

Table 1 Supported variations for each channel bank

Variation	Constellation	Frequency
1	GPS/SBAS	L1
2	GPS	L2
3	GPS/SBAS	L5
4	Galileo	E1
5	Galileo	E5
6	Galileo	E6
7	GLONASS	L1
8	GLONASS	L2
9	BeiDou	B1I
10	BeiDou	B2I
11	BeiDou	B1C
12	BeiDou	B2A
13	BeiDou	B3I
14	SBAS (note 1)	L1
15	SBAS (note 1)	L5
16	QZSS	L1
17	QZSS	L2
18	QZSS	L5
19	QZSS	L6
20	NavIC (IRNSS)	L5
21	Others (note 2)	-

Notes for Table 1

1. In addition to the support of GPS-based SBAS augmentations (WAAS, EGNOS, MSAS, GAGAN) and SDCM on any dedicated GPS channel bank, it is possible to have a channel bank solely generating SBAS augmentations

2. The GSS9000 is technology-ready for support of other future GNSS systems/signals, some of which can be supported today as Tailored Solutions, and some of which are planned on the current product roadmap. Please contact Spirent for further information if you have a requirement for capability not explicitly detailed in this specification.

Spirent **GSS9000 Series GNSS Simulation System**

Figure 3 illustrates the feature licence key/generic RF Channel Bank architecture of the GSS9000:

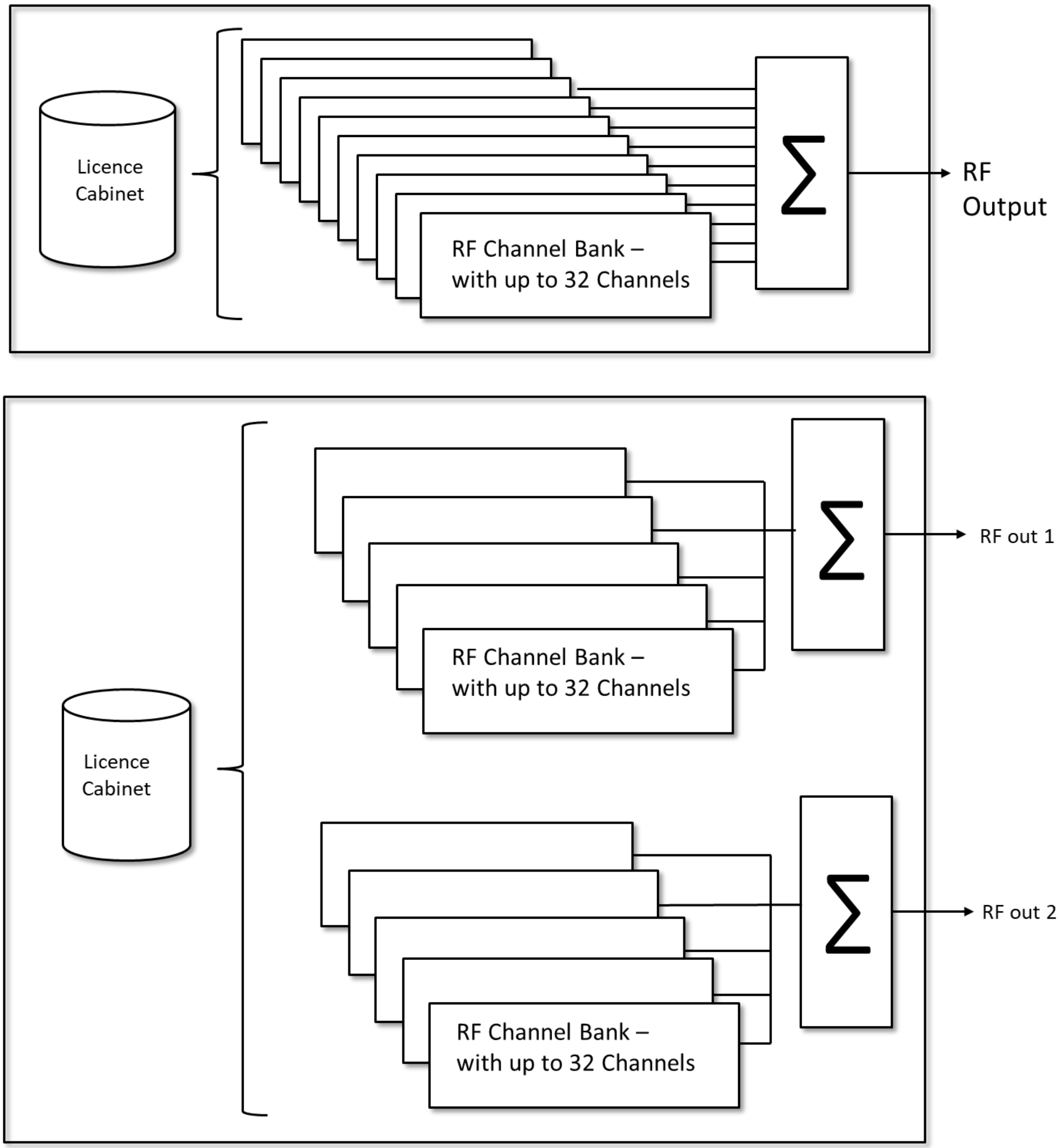

Figure 3 GSS9000 Signal Generator Chassis RF Channel Bank configuration (Single and dual composite output variants shown)

GPS Simulation

The supported ranging signal types of the GPS constellation are shown in Table 2

Table 2 GPS Signals

Carrier	Standard Signal Types	Optional Signal Types	Notes
L1	C/A, L1c Data/Pilot, P, M Noise, Pseudo Y	Y, MNSA-M, AES-M and SDS-M-Code via data server, GTx	"Pseudo-Y" code is generated through public-domain encryption of P-code to fully support L1/L2 squaring or 'Z-tracking', with data message. "M Noise" is a spectrally representative M-Code signal from each satellite when enabled, with no data message. See 'Authorised Testing' section for information on optionally available GPS authorised signals.
L2	L2c, P, Pseudo Y, M Noise	Y, MNSA-M, AES-M and SDS-M-Code via data server, GTx	C/A code is also supported as on this carrier as an alternative to L2c. See 'Authorised Testing' section for information on optionally available GPS authorised signals.
L5	I, Q	N/A	N/A

SBAS Simulation

SBAS (defined as WAAS, EGNOS, MSAS, SDCM and GAGAN) simulation capability is included with GPS configurations at L1 and/or L5. Note that SBAS uses available GPS channels when choosing channel count for GPS L1 and L5.
In addition, a separate SBAS licence key can be purchased which allows SBAS to be run on a separate RF Channel Bank, without the need to 'use up' GPS L1 or L5 channels.

The supported ranging signal types of the SBAS constellation are shown in Table 3

Table 3 SBAS Signals

Carrier	Standard Signal Types
L1	C/A
L5	I

Spirent **GSS9000 Series GNSS Simulation System**

Galileo Simulation

The supported ranging signal types of the Galileo constellation are shown in Table 4.

Table 4 Galileo Signals

Carrier	Standard Signal Types	Optional Signal Types	Notes
E1	PRS Noise, OS Data/Pilot	PRS via 'PRS[WARE]'	See Authorised Testing for information on Galileo authorised signals
E6	PRS Noise, CS Data/Pilot (without encryption)	PRS via 'PRS[WARE], CS Data/Pilot (with encryption)	See Authorised Testing for information on Galileo authorised signals
E5ab	E5a Data/Pilot, E5b Data/Pilot	N/A	E5ab signalling employs 8-PSK modulation of E5a and E5b onto a single carrier. Appropriate carrier dispersion is applied from E5a to E5b

Galileo Open Service (OS) ICD support is supplied as standard. Optional support for Galileo Full Operational Capability (FOC) signalling is available with Spirent's **SimCS™** option, subject to user status.

Galileo PRN data is available form a user definable file. Open Service users are supplied with PRN data for the E1B/C and E5a signal components, PRN data for other signal types is 'dummy data'.

FOC authorised users are supplied with PRN data signal for all signal types, except for PRS.

PRS requires the third-party extension **PRS[WARE]** upgrade, see Authorised Testing..

GLONASS simulation

The supported ranging signal types of the GLONASS constellation are shown in Table 5

Table 5 GLONASS Signals

Carrier	Signal types
L1	C/A, P (Chan Number -7 to +6)
L2	C/A, P (Chan Number -7 to +6)

GLONASS is supported in accordance with the SISICD GLONASS Interface Control Document, see Table 19.

BeiDou simulation

The supported ranging signal types of the BeiDou constellation are shown in Table 6

Table 6 BeiDou Signals

Carrier	Signal types
B1 (1.561098 GHz)	B1I
B1 (1.57542 GHz)	B1C
B2 (1.20714 GHz)	B2I
B2 (1.17645 GHz)	B2A
B3 (1.26852 GHz)	B3I

BeiDou Phase-2 is supported in accordance with the BeiDou-2 Open Service SIS ICD, see Table 19. Spirent's implementation includes the B1I signal described in the SIS ICD and offers the same signalling on the B2I frequency. D1 and D2 navigation data supports the provision of full Ephemerides and Almanacs as well as system time offsets. As an interim solution,

As at this issue, BeiDou Phase-3 is supported in accordance with Beidou3_ICD_B1C_B2a Beta version, 2017-08. Customers purchasing BeiDou Phase-3 licence keys for B1C and/or B2A will receive a FOC software upgrade when the implementation to BDS-SIS-ICD-B1C/B2A-1.0 2017-12 is completed. Spirent plans to complete this implementation by end Q3-2018

Quasi-Zenith (QZSS) Simulation

The supported ranging signal types of the Quasi-Zenith constellation are shown in Table 7

Table 7 QZSS Signals

Carrier	Signal types
L1	SAIF, C/A, L1c
L2	L2c
L5	I, Q
L6	L61/L62 (Available Q4 2018)

QZSS is supported in accordance with the QZSS Interface Specifications in Table 19.

NavIC (IRNSS) Simulation

The supported ranging signal types of the Quasi-Zenith constellation are shown in

Carrier	Signal types
L5	C/A
S	Available as a Tailored Solution only – please contact Spirent

NavIC is supported in accordance with the IRNSS_SPS_ICD see Table 19

FLEX Simulation

FLEX simulation comprises built-in and user-configurable control and set-up of non-current SIS ICD PRN codes, nav data content, nav data rate, chipping rate, edge shaping, and modulation types.

Table 8 FLEX Simulation

Carrier	Signal types
L1,L2,L5,E1,E5,E6, B1,B2,QZL1	User-definable codes – See Table 11

Three user-definable codes are supported per FLEX channel which corresponds to a single simulated SV. The Galileo E5 AltBOC signal structure is not supported on FLEX channels.

Spirent **GSS9000 Series GNSS Simulation System**

Authorised Testing

GPS authorised testing

GPS authorised testing is supported via a range of additional options (see Related Brochures, Data Sheets and Specifications referenced within this datasheet specification). **In all cases, the options are available for authorised users only.**

Selective Availability/Anti-Spoofing (SA/A-S) simulation is available for GSS9000 as an option. The applicable package is **SimSAAS** (for customers in USA) or **SimCLASS** (non-US). These options add additional capabilities - that includes SA/A-S simulation - to standard GSS9000 systems.

Standard product broadcasts a spectrally representative “M-Noise” signal from each satellite when enabled, with no data message.

MNSA M-Code requires the **SimMNSA** option which is available for US authorised users only

AES M-Code requires the **SimMCODE** option – available subject to end-user approval by US authorities.

SDS-M-Code requires the **SimMCODE and SDS-M-Code via data server** option – available subject to end-user approval. Note: SDS-M-Code via data server option is not a customer in-field upgrade.

Further detail is given in Detailed Performance Specifications.

Galileo authorised testing

Galileo FOC authorised testing can be supported with the Public Regulated Signal (PRS) at E1 and E6 and the encrypted part of the Commercial Service (CS) at E6. Full PRS requires the **PRS[WARE] upgrade** option. Full CS requires the **SimCS upgrade** option, (which also enables Safety-of-Life at E5) Both PRS[WARE] and SimCS provide the required full PRN data for the respective signals they support (non-authorised users are only supplied with ‘dummy’ data for these signals).

In all cases, the options are available for authorised users only.

The way PRS is supplied for the GSS9000 has changed. Order processing for the new “PRS[WARE]” solution is entirely managed by LZE GmbH of Erlangen, Germany, with Munich-based Fraunhofer IIS having complete responsibility for the current and future development, fulfilment and support of PRS[WARE] operating on the Spirent GSS9000 and future Spirent GNSS test solutions.

Fraunhofer IIS is the sole owner of PRS[WARE] software/firmware, therefore, all issues and questions relating to PRS and PRS[WARE] must be directed to Fraunhofer IIS

Spirent cannot provide any support relating to PRS, please contact LZE and Fraunhofer IIS directly for all questions relating to the PRS capability and ordering

LZE can be contacted as follows:

LZE GmbH, Tel: +49 9131 92894-85, contact@prs-ware.de

FPGA Module daughter card

A dedicated FPGA Module daughter card has been developed to work in unison with each signal generator RF Channel Bank and associated software modules to support authorised testing. The FPGA Modules are designed to enable:

- **GPS**: - Y code SA/A-S* with SimCLASS* or SimSAAS (US–only) software, MNSA M-code with SimMNSA, AES-M-code with SimMCODE software and SDS M-Code via data server with an extension to SimMCODE
- **Galileo**: - PRS with PRS[WARE] software, and/or Galileo FOC with SimCS for approved users.

*The procurement and supply of FPGA Modules specifically for GPS SA/A-S (for **Non-US** customers) involves a customer’s government to US government Foreign Military Sales (FMS) procurement process.

This process can be lengthy, so customers are strongly advised to discuss their requirements with Spirent and contact the appropriate department within their government at the earliest opportunity.

Supply of FPGA Modules for AES-M-code with SimMCODE are not subject to an FMS process.

Embedded Multipath Simulation

The GSS9000 can generate up to 4 multipath channels per satellite signal source. These multipath channels are delayed and attenuated copies of the primary channel and are applied to the first 16 channels in each channel bank. The delay and attenuation of each path is user-specified and fixed for the simulation duration of that satellite. This gives up to **640 Multipath** channels in one GSS9000 Signal Generator Chassis (i.e. 10 channel banks x 16 channels per channel bank x 4 embedded multipath channels).

The embedded multipath simulation capability is in addition to the comprehensive multipath modelling supported by SimGEN™ that uses spare generator channels, see Table 18. The comprehensive multipath modelling provides full control of multipath signals, including nav data, e.g. for advanced spoofing attack vectors simulation, using independent hardware channels, up to the licensed allowance.

Multi-Chassis capability

The GSS9000 system can be configured to include up to 4 Signal Generator Chassis' controlled as a coherent system via a single C50r and one SimGEN scenario. Applications for this configuration include multiple GNSS antenna simulation where composite, multi-GNSS signals are required on each antenna, and/or an increase in the number of simulated satellites beyond the 320 supported in a single chassis. For GSS9000 systems consisting of greater than two chassis, a GSS9367 Distribution Unit is required for management and distribution of various signals.

Spirent can provide equipment rack solutions to house GSS9000 systems consisting of multiple components.

Please note that the performance of GSS9000 in multi-chassis configurations can vary depending on several factors. Please refer to the Detailed Performance Specifications section for more information

Tailored Multi-output capability

The GSS9000 architecture supports the provision of a multiple-RF output capability where the signal on each channel bank can be output via a dedicated 'N-type- RF connector on the front panel. This provides significant flexibility in support of various multi-antenna and/or multi-vehicle test configurations.

Also available is a variant called GSS9790 which has been specifically developed to provide the core element in GNSS test applications that require independent access to each simulated satellite signal at RF. Up to 10 independent signal output ports, each with its own dedicated baseband signal generator channel and RF up-converter are provided.

These multi-output RF options are supplied as Tailored Solutions only. Applications include:

- **CRPA - Control unit testing**. The system can be integrated with a user-supplied multi-element RF phase shift or delay matrix to produce an RF wave-front at multiple simulated antenna elements.
- **CRPA - System Testing**. The system can be used as the signal generator attached to multiple transmission antennas installed in an anechoic chamber. The antennas are spatially distributed to present the appropriate arrival vectors of the simulated satellite signals at the antenna site. Interference sources can then be located anywhere in the chamber to represent different test cases. This is the only possible alternative to live testing of a complete CRPA system, including the actual antenna. By mounting the antenna on a rate table that replicates the attitude changes of the simulated vehicle platform comprehensive evaluation of all aspects of the CRPA system can be achieved in a secure environment, free from unintentional interference, both incoming and outgoing, and free from external observation.
- **Radiated Testing**. Again, using an anechoic chamber with radiating antennas, the system can provide spatial signal diversity for testing items such as GPS-equipped mobile telephones

and PDAs through the actual antenna. Items such as reflectors, signal attenuators (a dummy human head for example) can be physically placed adjacent to the unit under test to emulate environments.

- **Indoor GPS**. With appropriate real-world time synchronisation and transmission antennas, the system can form the basis of an experimental indoor GPS implementation.

If you are interested in GSS9000 multi-output capabilities, please contact Spirent to discuss your requirements.

Ancillary Components

Depending on the system configuration, ancillary components may be required to distribute, synchronise and combine signals from more than one chassis. These include a Signal Distribution Unit (for systems with more than two chassis) and a Multi-chassis Combiner Unit. If these elements are required for your system configuration these will be detailed on the quotation.

Upgrades

The extensibility of the GSS9000 means that **in-field upgrading** of the system can be achieved easily, flexibly and in a way which matches the developing needs of your testing requirements as closely as possible.

- Existing RF Channel Banks can be issued with new licence keys, allowing extra channels to be added
- Additional constellation licences 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

This extensibility makes the GSS9000 very flexible in terms of future-upgradeability.

Additional upgrade options are listed in the Related Product References, see Table 18. Please contact Spirent to discuss your requirements.

Calibration status

Spirent Positioning Technology calibrate the GSS9000 simulator to the ISO/IEC 17025 standard. This Accredited Calibration comes with a default 12-month calibration period.

Annual re-calibration must be carried out at a Spirent facility or accredited laboratory to maintain this accreditation.

Please note that installation of additional purchased channel banks or performing calibrations outside of a Spirent authorized ISO/IEC17025 accredited laboratory will invalidate this accredited calibration.

This includes customer use of the Auto Calibration Utility (where installed) and certain upgrade procedures. Customers are advised to refer to procedural documentation for further details.

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 representative.

Example composite output GSS9000 systems

Given the highly flexible architecture of the GSS9000, many different system configurations are possible. Some systems may have the required number of RF Channel Banks to support simultaneous generation of all licenced signals, some systems may have more licenced signals than RF Channel Banks to support them, and so different combinations of signals are possible.

This section shows just a few examples of the extensive number of possible combinations and modes of operation. Your Spirent representative will be pleased to guide you through the process of selecting the best configuration for you current and future test requirements.

In the configuration shown in Figure 4, there is a single-RF output chassis with two RF Channel Banks, 64 channels, a feature licence key for GPS/SBAS L1, plus a feature licence key for GPS L2. The system can therefore generate all the licenced signals simultaneously.

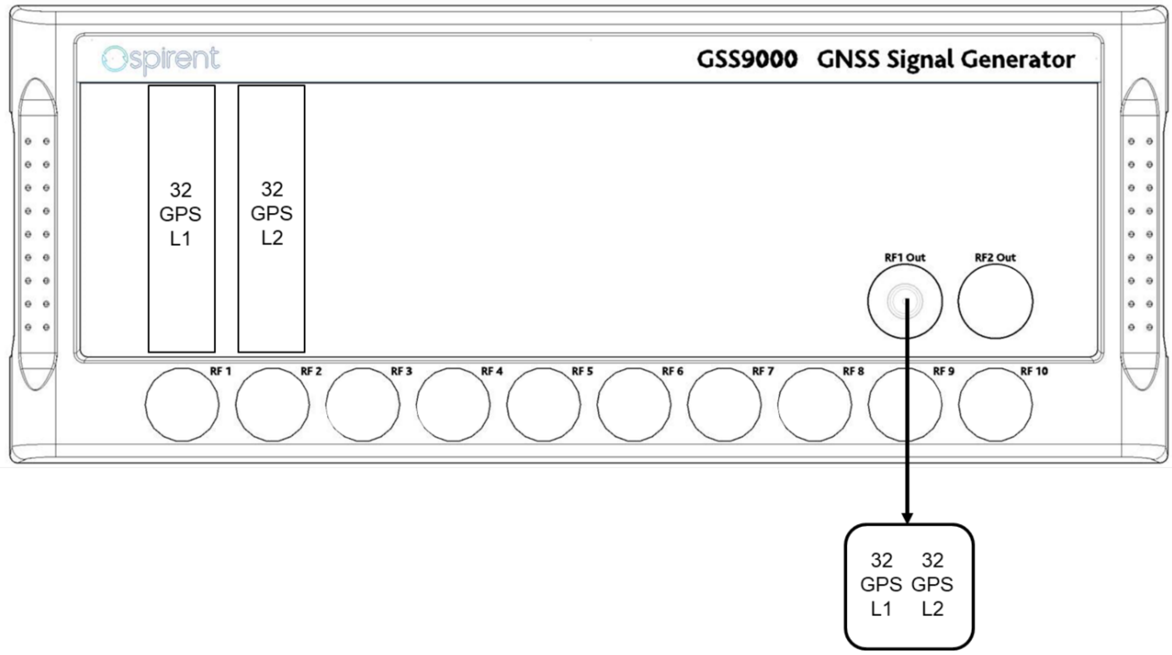

Figure 4 Example of a single output, 2-bank system GPS L1 L2

In the configuration shown in Figure 5, there are three RF Channel Banks and 6 feature licence keys.

There is a single-RF output chassis with three RF Channel Banks, 96 channels, a feature licence key for GPS/SBAS L1, GLONASS L1, Galileo E1, BeiDou B1, GPS L5 an Galileo E5 plus a feature licence key for GPS L2. The system can therefore generate signals for all the licenced constellations simultaneously.

Spirent **GSS9000 Series GNSS Simulation System**

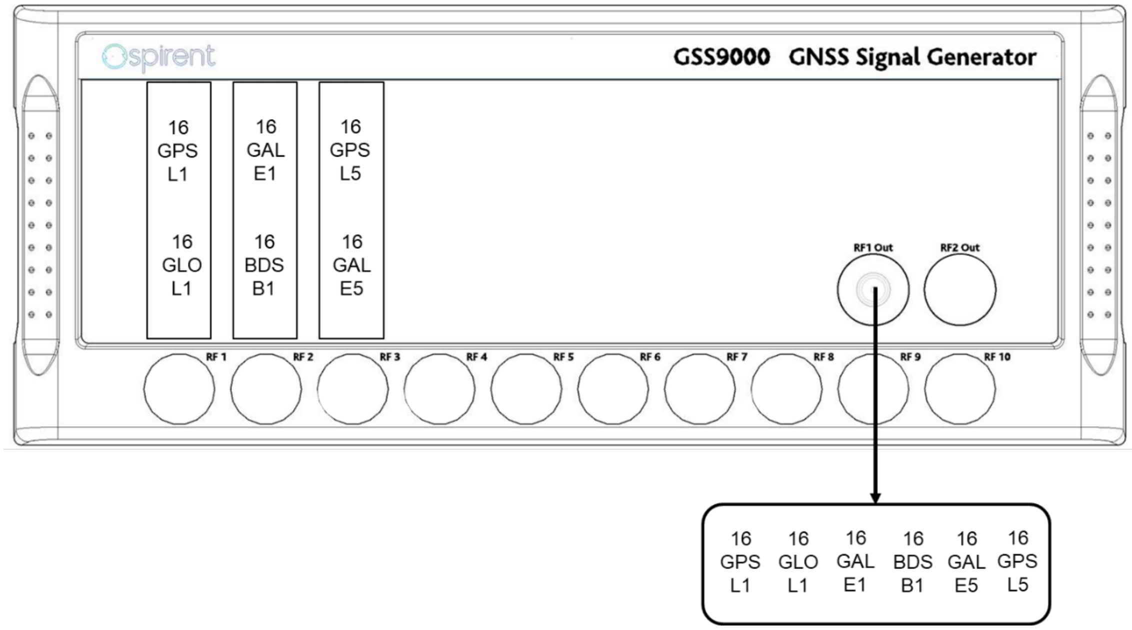

Figure 5 Example of a single output, 3-bank system

In the configuration shown in Figure 6, there are 2 RF outputs, allowing signals for either one vehicle with two independent antennas or, two independent vehicles with one antenna each, to be simulated.

The configuration has three RF Channel Banks per RF output (so 6 in total) and two feature keys for each of the desired constellations (GPS and GLONASS). Therefore, the system can generate the licenced signals simultaneously on both outputs.

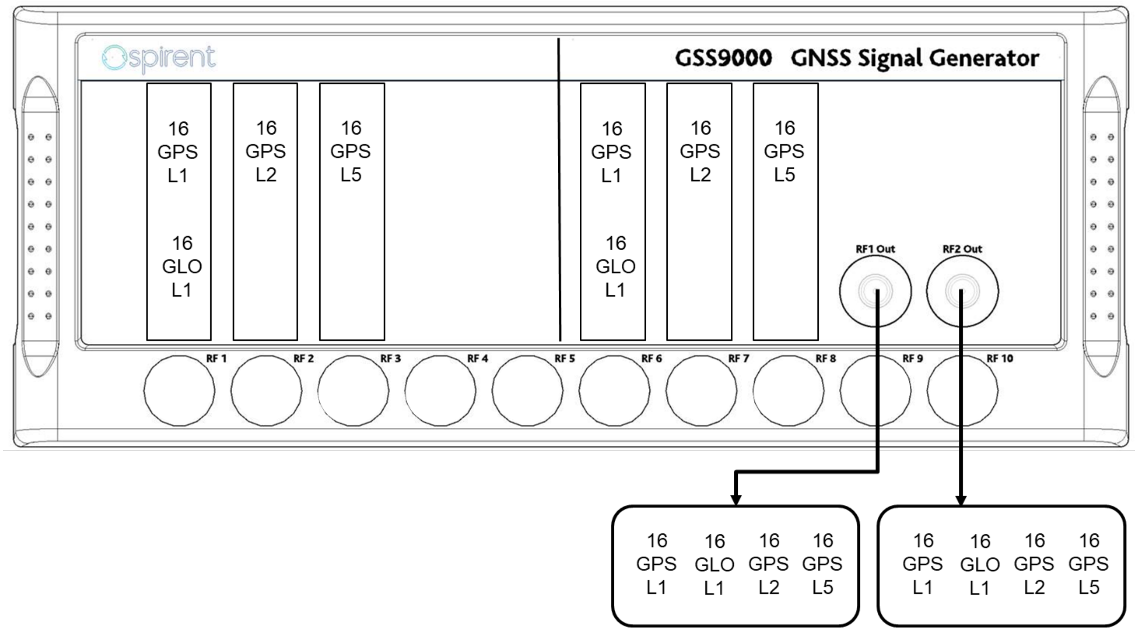

Figure 6 Example of a dual-RF Output, 6-bank system

In the configuration shown in Figure 7, there are two RF outputs, allowing signals for either one vehicle with two independent antennas or, two independent vehicles with one antenna each, to be simulated.

The configuration has five RF Channel Banks per RF output (so 10 in total), 320 channels and two feature keys for each of the desired constellations (GPS, GLONASS, Galileo, Beidou and NavIC). Therefore, the system can generate the licenced signals simultaneously on both outputs.

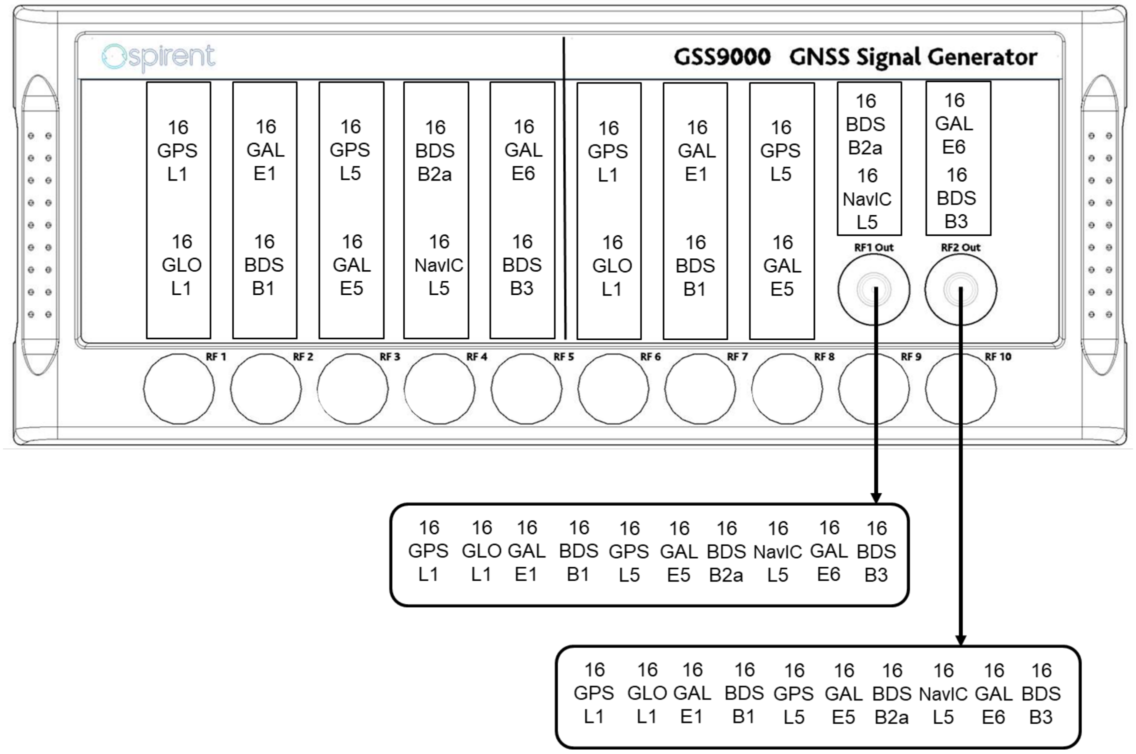

Figure 7 Example of a dual-RF output, 10-bank, 320-channel system

Optional single-RF combination in a dual-RF system

With a dual-RF GSS9000 system it is possible to generate Differential-GNSS signals for GNSS signal types simultaneously, as each RF Output can have up to five RF Channel Banks behind it. However, for some tests, the user may wish to have all GNSS signal types from just one RF output.

To support this, an RF Link Cable is provided free-of-charge, for use with dual-RF Signal Generator Chassis.

When required, the RF Link cable is fitted to the rear of the Signal Generator Chassis and it combines all the signals associated with RF#2 with those of RF#1 and outputs them all at RF 1. The RF Link Cable can only be used on signal generator chassis without the front-panel high-level ports option fitted, and the use of the cable prevents access to the high-level port for RF#1 on the rear panel. .

SimGEN allows the user to select an operating mode which compensates for power level and group delay of the re-routed signal path.

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Detailed Performance Specifications

Table 9 Nominal Signal Levels[1]

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
		M Noise	-128.5 dBm
	L2	L2c or C/A	-136.0 dBm
		P	-136.0 dBm
		M Noise	-132.5 dBm
	L5	I, Q	-127.9 dBm
Galileo	E1	E1-A	-125.5 dBm
		E1-A PRS Noise	-125.5 dBm
		E1-B, E1-C	-128.0 dBm
	E6	E6-A	-125.5 dBm
		E6-A PRS Noise	-125.5 dBm
		E6-B, E6C	-128.0 dBm
	E5ab	E5a-I + E5a-Q + E5b-I + E5b-Q	-122.0 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
	B3 (1.26852 GHz)	B3I	-133 dBm
QZSS	L1	C/A code	-128.5 dBm
		S	-131 dBm
		L1c Data + Pilot	-127 dBm
	L2	L2c	-130 dBm
	L5	I + Q	-124.9 dBm
	L6	L61/L62	-126.82 dBm[2]
NavIC (IRNSS)	L5	C/A	-130 dBm

1 Nominal signal power levels as defined by Spirent. Through SimGEN, the user has extensive facilities to adjust these nominal power levels to meet individual GNSS ICD conditions.
2 Default power level setting is for Block II satellites

Table 10 Navigation Messages Types per Constellation

Constellation	Message Type	Applicable Signal	Requirements	Notes
GPS	Legacy	C/A, P, Y	Support for Y code requires SimCLASS/SimSAAS Option	
	CNAV	L2c, L5-I		
	CNAV-2	L1c		
	MNAV	AES-M, M. MNSA	MNSA-M requires SimMNSA option. AES-M requires SimMCODE option. M requires SimMCODE and SDS-M-Code via data server options	
Galileo	I/NAV	E1-B, E5b-I	OS Galileo - Excludes SOL support FOC Galileo – Includes SOL support	
	F/NAV	E5a-I	OS Galileo - Supported FOC Galileo - Supported	
	C/NAV	E6-B	Requires 3rd party PRS[WARE] product	
	G/NAV	E1-A, E6-A	Requires 3rd party PRS[WARE] product	
GLONASS	Public	L1-C/A		There is no data message on the GLONASS P-Code
BeiDou	D1 and D2	B1I, B2I		D2 does not include differential corrections or Iono grid.
		B1C, B2A		
	Legacy	B3I		
SBAS	Data	L1, L5-I		The same message is broadcast at L1 and L5 for any satellite.
QZSS	QZ-Legacy	L1 C/A, L1 SAIF		
	QZ-CNAV	L2c, L5-I		
	QZ-CNAV-2	L1c		
NavIC	IRNSS legacy	C/A		
FLEX	Standard	All		See Table 11

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Table 11 FLEX Option Signal Definitions

Parameter	Value	Units
Codes	Three user-definable codes per SV	
Code Assignment	+I, -I, +Q, -Q	
Code Definition	User-definable memory codes (primary and secondary)	
Base Chip Rate	1.023	Mcps
Chip Rate Multiplier	1, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10	
BOC Rates Multiplier	Integer multiple of Base Chip Rate	
Nominal Signal Level	-123 to -133	dBm
Nav Message	Standard for constellation	

Table 12 Performance Levels for GSS9000 Series

Parameter	Detail		Value	Foot note
RF Signal Level	Carrier Level Control	Maximum	+20 dB	3
		Minimum	-40 dB	4
		Resolution	0.1 dB	
		Linearity +20 dB to -30 dB -30.1 dB to -40 dB	<0.10 dB <0.20 dB	
	Absolute Accuracy Run to Run Repeatability		±0.5 dB ±0.1 dB	5
Iteration Rates	Supported SimGEN Simulation Iteration Rates (SIR)		10, 100, 250, 500,1000 Hz	
	Hardware update rate		1000 Hz	
Limit of Signal Dynamics	Relative Velocity		120,000 m/s	6
	Relative Acceleration		192,600 m/s2	7
	Relative Jerk		890,400 m/s3	
	Angular Rates (indicative)	(at 1.5 m lever arm) (at 0.05 m lever arm)	>15π rad/s >60π rad/s	
Signal Accuracy	Pseudorange Accuracy		0.3 mm RMS	8

3 Maximum signal level of +20 dB is available for up to 16 channels per channel bank. A maximum of +17 dB is supported for up to 32 channels per channel bank

4 The control range extends to -50 dB, but performance is unspecified below -40 dB. Operation below -20 dB is primarily to support antenna pattern and multipath functionality.

5 RSS at 21±5°C, +20 to -30 dB. ±1.5 dB 3-sigma, all conditions.

6 For 6-DOF data externally supplied via SimREMOTE or from data file

7 When operating at >=250 Hz SIR

8 For signal acceleration < 450 m/s^2, jerk < 500 m/s^3, 1000 Hz SIR

Parameter	Detail	Value	Foot note
	Pseudorange Bias	0 mm RMS	9
	Delta-range Accuracy	Better than ±1.0 mm RMS	
	Inter-carrier Bias	Better than ±2 ns	10
	1PPS to RF Alignment	Better than ±2 ns	11
Spectral Purity	Harmonics	< -40 dBc	
	In-band Spurious	< -182 dBW	12, 13
	Phase Noise (single sideband)	< 0.005 Rad RMS	14
Signal Stability	Internal 10.00 MHz OCX Oscillator (after warm up)	± 5 x 10-10 per day	
Static Multipath Channels	Fixed path-length delay per path	0 to 1245 m	
	Resolution (approximately)	2.4 m	

Table 13 GTx Performance

Parameter	Detail	Value	Foot Note
Signal sources	Per Frequency Band	32	15
Frequency Bands		Centre frequency	16
	GPS L1	1.57542 GHz	
	GPS L2	1.2276 GHz	
	GPS L5	1.17645 GHz	
	Galileo E1	1.57542 GHz	
	Galileo E5	1.191795 GHz	
	Galileo E6	1.27875 GHz	
	GLONASS L1	1.602 GHz (F0)	
	GLONASS L2	1.246 GHz (F0)	
	BeiDou B1i	1.561098 GHz	
	BeiDou B2i	1.20714 GHz	
	BeiDou B2a	1.17645 GHz	
	BeiDou B1c	1.57542 GHz	
	BeiDou B3i	1.26852 GHz	

9 Single Channel Bank – supporting up to 32 channels. When the same signal is generated across multiple Channel Banks the inter channel bank bias uncertainty is +/-230ps (+/-69mm)
10 Between any RF carrier.
11 Between any RF carrier at the output port(s). Applicable for both single and multi-output systems.
12 For relative velocities <50,000 m/s
13 In-Band Spurious Bandwidths (relative to centre frequency unless otherwise stated):
GPS: L1 ± 20.5 MHz, L2 ± 20.5 MHz, L5 ± 20.5 MHz
Galileo: E1 ± 20 MHz, E6 ± 20 MHz, E5a ± 25.5 MHz, E5b ± 25.5 MHz
GLONASS: (relative to channel frequency 0) L1 ± 20 MHz, L2 ± 20 MHz
BeiDou: B1/B2 ± 20.5 MHz
14 Value is typical, integrated over a 1 Hz to 10 kHz bandwidth. Worst case < 0.01 rad RMS.

[15] For civilian GNSS signals
[16] Subject to licence

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Parameter	Detail	Value	Foot Note
Carrier frequency offset	Independent for each source	± 5 MHz	17
	Resolution	1 kHz	
CW	Power	See ‘RF Signal Level’	
BPSK	Power	See ‘RF Signal Level’	
	Main lobe width: Wide Band	20.46 MHz	
	Narrow Band	0.1023 MHz	
CW Pulse	Power	See ‘RF Signal Level’	18
	Pulse width	1 to 10000 µs	
	Pulse repetition interval range	100 to 10000 µs	
	Pulse repetition interval resolution	100 µs	
	Rise time (10% to 90%)	100 ns (max)	
	On/Off ratio min	30 dB	
AWGN	Power	See ‘RF Signal Level’	
	3 dB Bandwidth	0.1, 0.5, 1, 2 10, 20 MHz	
	Bandwidth accuracy	±5%	
FM CW	Power	See ‘RF Signal Level’	
	FM deviation	±0.01 to ±5 MHz	
	FM rate	0.5 to 10 kHz	
	FM rate step size	0.5 kHz	
	Modulating Waveform	Triangular	
AM	Power	See ‘RF Signal Level’	
	Modulation depth	10 to 90%	
	Modulation depth step size	10%	
	AM rate	0.5 to 10 kHz	
	Modulating Waveform	Sinusoidal	
PM	Power	See ‘RF Signal Level’	
	Modulation deviation	±0 to ±5 rad	
	PM rate	0.5 to 10 kHz	
	Modulating Waveform	Sinusoidal	
RF Signal Level	Single signal	-47 dBm (max)	19
	Multiple signals	-72 dBm (max)	20
	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	

[17] In addition to Doppler caused by vehicle motion. Applies to all signal types
[18] At 100% duty cycle. Average power reduces in proportion to duty cycle.
[19] Single signal per channel bank (CW, FM, PM), -49dBm (BPSK, pulsed CW), -53dBm (AM), -60dBm (AWGN).
[20] Per signal, up to 16 signals of AWGN on the same channel bank – other signal types can be up to 3dB higher

Parameter	Detail	Value	Foot Note

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Performance in multi-chassis configurations

There is a practical limit to how much data can be reliably processed by the simulation engine at the designated simulation iteration rate. There are many factors that can influence the processing capacity of the simulation system, but in practical terms the main sources are:

- The total number of active channel banks (influenced by the number of antenna outputs in the configuration and the selected signal types)
- The total number of satellite signals (channel density)
- The volume of data logging enabled and the logging rate

The variety of permutations from these contributing factors is extremely difficult to fully characterise. Instead Spirent provides guidance based on previously explored cases in order to set a reasonable expectation of the performance that can be achieved.

For a system with a capability of 256 channels or greater:

- The simulation iteration rate shall be 100Hz
- SimGEN 'truth' data logging capability, during real-time scenario playback, must be limited to bulk logging in binary format OR data-streaming UDP output OR nav data binary dump.
- To access scenario 'truth' data from any other source, or to employ two or more sources concurrently, SimGEN should be run in 'no hardware mode'.

For a system with more than 256 channels, up to and including 512 channels:

- It will be necessary to strike a balance between the increasing channel density and truth data output by:
    - Decreasing the real-time data logging rate; or
    - Needing to rely solely on UDP data-streaming; or
    - Having to disable real-time logging and rely solely on 'no hardware mode' pre/post-processing data capture.

If these operating criteria present a challenge to the intended test application, and for systems of more than 512 channels, Spirent is pleased to discuss the challenges of each user case and to determine whether an alternative system architecture might be suitable in those circumstances, via a Tailored Solution.

Table 14 Signal Generator Connectivity

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

Table 15 C50r SimGEN Host Connectivity

Interface	Type	Parameter
PCI Express	Private Bus	Cabled PCIe
USB	I/O	Maximum of 4 spare ports for general file access
Ethernet	I/O	RJ-45 Ethernet interface standard. Used for general network access and available for remote control
Optional GPIB	I/O	Available for remote control and GSS7765 control
Optional ScramNET	I/O	Available for remote control

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Table 16 Physical and Environmental Properties

Part	Parameter	Value	
Signal Generator	Approximate Dimensions (H x W x D) (19” 4U chassis)	175 mm x 445 mm x 620 mm 6.9” x 17.75” x 24”	
	Typical Weight	<30 kg (66 lb) (configuration dependent)	
	Operating Environment	+10 to +40°C (50 to 104°F) (40-90% RH, non-condensing)	
	Storage Environment	-40 to +60°C (-90 to 140°F) (20-90% RH, non-condensing)	
	Electrical Power	100-120 V 4.0 A 48 to 66 Hz	220-240 V 2.0 A 48 to 66 Hz
Standard C50r SimGEN Host	Approximate Dimensions (H x W x D) (19” 4U chassis)	177.8 mm x 426.0 mm (482.0 mm with Rack Mount installed) x 600.6 mm (Not including front handles and front bezel door closed) 7.00” x 16.77” (18.98”) x 23.65”	
	Weight (excl. peripherals)	<20 kg (44 lb)	
System Mean Time Between (component) Failure (MTBF)	2,562,327	Hours (per Bellcore 6)	

Table 17 Safety and EMC Compliance

Compliance	Applicable Standard
Safety	Low Voltage Directive (LVD) 2006/95/EC BS EN 60950-1:2006 Information technology equipment. Safety. General requirements
EMC	EMC Directive 2004/108/EC EN 61326-1:2006 Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements

Related Brochures, Data Sheets and Specifications

Table 18 Related Product References

Related Product	Description	Data Sheet / Specification
SimGEN	GNSS Software Suite	MS3008
SimINERTIAL	Inertial Sensor Emulation Option	MS3030
SimBARO	Barometric Pressure Emulation Option	MS3056
SimAUTO	Automotive Sensor Emulation Option Single Axis Rate Table Option	MS3023 MS3049
SimCS	Galileo FOC Upgrade Option	MS9043
SimCLASS	GPS SA/A-S Upgrade Option (Non-USA)	MS9020
SimSAAS	GPS SA/A-S Upgrade Option (USA only)	SF1001
SimMNSA SimMCODE SDS-M-Code	MNSA M-code Upgrade Option AES M-Code Upgrade Option SDS-M-Code via server Upgrade to SimMCODE	MS9018 MS9048
SimSAFE	Vulnerability Test Tool	MS3092
SimREMOTE	Simulator Remote Control Additional Options	MS3015
GBAS	GSS4150 VHF Data Broadcast Simulator for GBAS Product Specification	MS3014
GSS7765	Generic Interference Generator Option	MS3055
SimSENSOR	MEMS Sensor Simulation Option	MS3086
SimROUTE	Road-Matched Trajectory generation Tool	MS3073

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ICD Compliance – Applicable Documents

Table 19 ICD compliance[21] (WORK IN PROGRESS)

Reference		Title	Issue	Notes
GPS	IS-GPS-200	NAVSTAR GPS Space Segment/Navigation User Segment Interfaces	K	
	IS-GPS-705	NAVSTAR GPS Space Segment/User Segment L5 Interfaces	F	
	IS-GPS-800	NAVSTAR GPS Space Segment/User Segment L1C Interfaces	F	
GLONASS	ICD L1, L2 GLONASS	GLONASS Interface Control Document, Navigational radiosignal in bands L1, L2	5.1(2)	
Galileo	OS SIS ICD	European GNSS (Galileo) Open Service, Signal-in-Space Interface Control Document	1.3	
	FOC SIS ICD	FOC Galileo Signal-in-Space Interface Control Document GAL-ICD-ESA-SYST-X/0027	1.2	
QZSS	IS-QZSS-PNT-001	Quasi-Zenith Satellite System Interface Specification Satellite Positioning, Navigation and Timing Service	003	L1, L2, L5
	IS-QZSS-L6-001	Quasi-Zenith Satellite System Interface Specification Centimetre Level Augmentation Service	Draft Edition, Apr 2018	L6
	IS-QZSS-L1S-003	Quasi-Zenith Satellite System Interface Specification Sub-meter Level Augmentation Service	003	
	IS-QZSS-TV	-	002	L5S
Beidou	BDS-SIS-ICD (B2I)	BeiDou Navigation Satellite System (Phase-2) Signal-in-Space Interface Control Document Open Service Signal	2.1	B2I
	BDS-SIS-ICD (B1C, B2a)	BeiDou Navigation Satellite System (Phase-3) Signal-in-Space Interface Control Document Open Service Signals	1.0	B1C, B2a
	BDS_SIS-ICD-B3I	BeiDou Navigation Satellite System Signal-in-Space Interface Control Document Open Service Signals B3I	1.0	
SBAS	RTCA DO-229	SBAS MOPS	D	
LAAS	RTCA DO-246		C	Partial support for Rev. D
	NMEA	0183	4.10	
IRNSS	IRNSS_SISICD_SPS	ISRO-ISAC-IRNSS-PR July 2011 IRNSS Signal-in-Space ICD for SPS	1.1	
	RINEX	-	3.00	

Spirent operates a policy of upgrades to meet ICD changes as they are adopted. To obtain ongoing upgrades your system needs to be under warranty or a current support agreement.

Please contact Spirent for current ICD compliance, including for information relating to export-controlled options and those for authorised users that are not shown here.

[21] Compliance assumes the latest version of SimGEN™ is installed and is being used on the C50r

Glossary of terms

1PPS	One Pulse-Per-Second
BITE	Built In Test Equipment
AOC	Auxiliary Output Chip
BOC	Binary Offset Carrier
BeiDou	Chinese GNSS System
CS	Commercial Service - Galileo
DOP	Dilution Of Precision caused by satellite geometry
EMC	Electromagnetic Compatibility
FLEX	Flexible constellation with user defined code and BOC rates
FPGA	Field-Programmable Gate Array – a reconfigurable electronic device
FOC	Full Operational Capability – available to authorised Galileo customers via SimCS
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)
GTx	Ground Transmitters – Embedded interference generation
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
MTBF	Mean Time Between Failure
NavIC	Navigation with Indian Constellation
OS	Open Service – Galileo
PRS	Public Regulated 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 (such as WAAS, EGNOS, MSAS)
SDS	SDS-M-Code via data server
SOL	Safety Of Life
SIR	Simulation Iteration Rate

Spirent **GSS9000 Series GNSS Simulation System**

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