# SPG9000

## Professional Synchronization, Timing, and Reference Test Signal Generation

## Executive Summary

**SPG9000 Timing and Reference System**

- Four independent ports for PTP, supporting multiple leader, dual follower, and follower + leader configurations for redundant amber/blue networks.
- Integrated multi-system (GPS, GLONASS, BeiDou, Galileo, NavIC, QZSS) dual-band GNSS receiver for a highly accurate and reliable timing source
- Analog genlock input and multiple sync outputs for legacy and hybrid SDI/IP facilities
- Multiple video/audio/data test signal generators for formats from SD to HD/2K to UHD/4K
- 4 multi-rate (SD-SDI to 12G-SDI) SDI test signal outputs
- 2 10G/25G Ethernet ports for ST 2110 test signal streams with ST 2022-7 redundancy
- NMOS management of IP sender configuration
- Secure web interface for remote operation and REST- style HTTP API for easy integration with third-party management software

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## Advantages of SPG9000

- Ideal for use in broadcast, sports, mobile live production, and post-production
- Provides a variety of timing references: GNSS, PTP, black burst, and 10MHz
- Highly versatile with reference distribution options such as PTP, NTP, black burst, and DARS
- Sets up fast as a Grandmaster or Follower using PTP
- Ensures precise timing and seamless connectivity by producing known-good references for SDI and IP
- Offers a user-friendly web interface
- Supports a multitude of broadcast and post-production signal formats including SD, HD/2K and UHD/4K

## Unmatched IP Synchronization & Redundancy

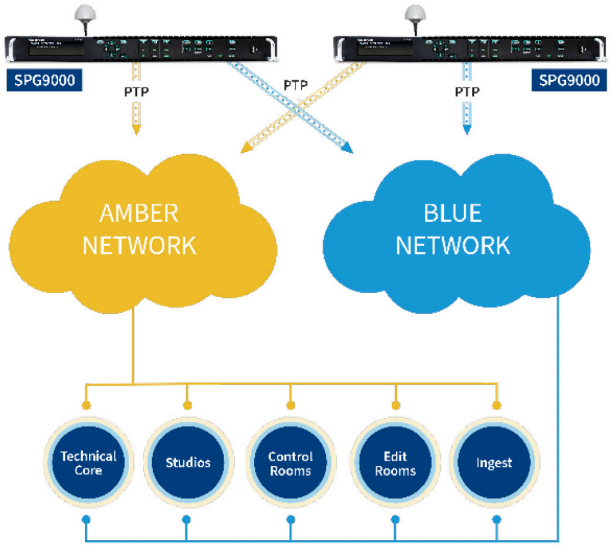
In modern IP-based facilities, PTP is distributed for timing and synchronization to a common source. The SPG9000 can use a GNSS signal as the time source and serve as a PTP grandmaster for the video network. With four independent ports and PTP engines, each SPG9000 can provide PTP for multiple domains and profiles (e.g. ST 2059 and AES67) or can connect to both sides of redundant networks.

For easy connectivity to spine or backbone switches, two PTP ports of the SPG9000 can connect at either 10 Gbps or 1 Gbps line rate, using SFP+ transceiver modules and two ports can connect at either 10 Gbps or 25 Gbps using SFP28 transceiver modules.

Each PTP instance of the SPG9000 can operate as a leader only, a follower only, or use “Ordinary Clock” mode which can adapt between leader and follower as required.

For example, if GNSS-based time synchronization is not available (perhaps because there is no clear view of the sky for the antenna), a pair of SPG9000 systems can still function as a primary + backup pair for redundancy. The backup will use PTP to sync to the primary, and takeover with no time disturbance when it switches from follower to leader.

The SPG9000 can also function as an NMOS-controlled media sender, generating video, audio and data reference test signals over ST 2110 IP streams. The two 25 Gbps ports for IP traffic can operate independently or as redundant links per ST 2022-7. PTP can operate in-band with ST 2110 test signal streams using these two ports.



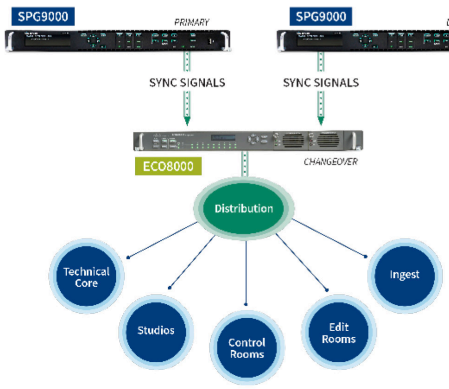
# Optimal Synchronization Made Easy for SDI & Hybrid Workflows

## SDI/Analog Video Facilities

The SPG9000 is a full-featured sync pulse generator, providing all the necessary reference signals for an SDI-based video facility. The SPG9000 can lock to a GNSS signal or genlock to another SPG. It has six analog outputs for NTSC/PAL black burst, HD tri-level sync, 10 MHz continuous wave, or 1 pulse-per-second signals, each with independent timing offsets. Time code can be distributed from four LTC outputs and from VITC on any NTSC/PAL black outputs. Word Clock and Digital Audio Reference Signal (DARS) outputs are available for audio reference.

The SPG9000 also includes four multi-rate SDI test signal outputs that can operate independently for SD, HD-SDI (1.5G and 3G), and UHD (6G and 12G-SDI) formats.

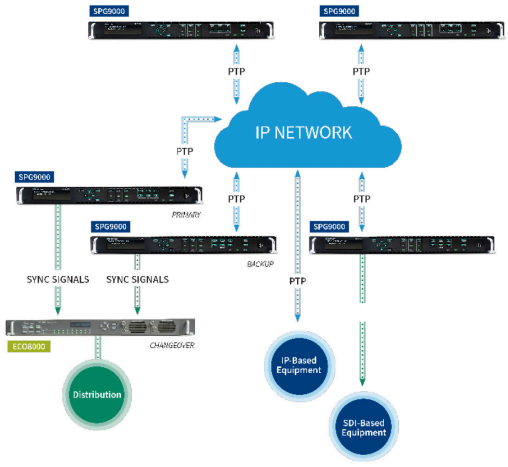
Along with the companion ECO8000 changeover unit, a pair of SPG9000 units (primary and backup) comprise a highly available synchronization solution.




## Hybrid SDI/IP Video Facilities

The SPG9000 is ideal for facilities that have a hybrid mix of IP-based equipment and SDI/analog equipment. SPG9000s can serve as PTP grandmasters for the facility's time and synchronization source. PTP is distributed through the facility, and directly to IP-based devices. At the network edge, additional SPG9000 units (either standalone or paired in a primary/backup configuration with an ECO8000) can operate as PTP followers and lock to the active grandmaster. This reference is then used to generate analog sync and time code signals for SDI/analog equipment that uses a traditional genlock input. This system architecture ensures that all equipment in the facility is synchronized to the same time source.

Test signal outputs of each SPG9000 can be configured to duplicate the same video test patterns to both IP and SDI outputs, or they can be configured to use separate test patterns.



## Flexible Configuration Options for Any System Architecture

The SPG9000 offers a complete set of reference inputs and outputs, supporting a wide variety of system designs. The base configuration includes all the features of a complete sync pulse generator, and all options are licensed so that they can be purchased with the base unit or any time later to upgrade the system.

The SPG9000 has multiple options for setting the internal clock reference (frequency and time-of-day). It can lock to a received GNSS signal, to another PTP grandmaster, or to another sync generator or an external atomic clock using the analog genlock input. A Secondary Reference mode can be enabled to provide a backup reference source when the primary source signal is lost.

The loop-through genlock input can lock to many different types of analog synchronization signals, including NTSC and PAL black burst, HD tri-level sync signals for all common 1080-line and 720-line frame rates and formats, and continuous wave (CW) signals at 10 MHz.

## Resilient to Interruption and Reliable for Continuous Operation

Resiliency and reliability are essential attributes for a timing reference generator since it is a mission-critical component for the video facility. The SPG9000 has a high-quality oven-controlled micro-electromechanical system (MEMS) oscillator for its internal clock. If the received GNSS signal or genlock input signal is temporarily lost, the SPG9000 will switch to holdover mode in which this clock maintains its time and phase from the previous lock. When the reference input signal is restored, the holdover recovery process adjusts the clock slowly to eliminate any accumulated phase difference. Avoiding an abrupt “jam” when the SPG9000 is re-locked ensures that no “synchronization shock” will be observed by follower devices.

Most facilities require the timing reference to be available continuously and the SPG9000 has an innovative dual power supply system to assist high availability. Unlike simpler devices, the SPG9000 has a designated active power supply and an idle backup supply. This ensures that they are not used at the same rate and will not potentially fail at about the same time. The SPG9000 will monitor the temperature-weighted hours of the active supply and alert the user when it approaches the rated limit. The backup supply undergoes a brief load test automatically each day and the user can be notified if this test fails.

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## Integrated Dual-Band GNSS Receiver

In addition to their main purpose of providing position information, Global Navigation Satellite Systems also provide highly accurate time-of-day information. Video systems can use this time to compute the precise number of video and audio frames since the “epoch” date and time, thereby synchronizing signals even from disconnected systems.

The SPG9000 has an integrated multi-GNSS, dual-band receiver, supporting GPS, GLONASS, Galileo, BeiDou, NavIC, and QZSS satellite constellations at L1 and L5 frequencies as applicable. Unlike “smart” antennas that include an internal receiver, the SPG9000’s antenna produces a simple RF signal that can be brought to the SPG9000 by plain coaxial cable, greatly simplifying installation and maintenance.

The SPG9000 constantly monitors the received GNSS signal, showing the ID, status, and signal strength of each satellite currently in view. This information can be viewed on the web interface and retrieved via the HTTP API, providing valuable diagnostic information when investigating signal reception issues.

## Complete PTP Solution for Today’s IP Video Networks

The SPG9000 includes an advanced implementation of the Precision Time Protocol, making it the ideal choice for a facility’s timing and synchronization reference.

Both Leader and Follower modes are supported, and the SPG9000 can also operate as an “Ordinary Clock” that adapts between the two modes depending on dynamic network conditions. With four independent PTP instances, the SPG9000 can operate as a multiple Leaders serving different domains and/or profiles, as a dual Follower connected to the two sides of a redundant network, or simultaneously as a dual Follower synchronized to an upstream grandmaster and as a dual Leader to a separate downstream redundant network. The two PTP ports operate over 1G/10G-capable interfaces (using SFP+ modules) and two PTP ports operate over 10G/25G-capable interfaces (using SFP28 modules) for easy connection to commonly used switch ports.

The SPG9000 supports the three profile types required for media networks: SMPTE ST 2059-2, AES67 Media Profile, and IEEE 1588 Default. Both multicast and unicast communication models are supported, including mixed multicast/unicast mode.

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PTP performance monitoring per IEEE 1588-2019 Annex J is supported, with real-time display of delay and offset measurements and message rates. The data is also available via the HTTP API, for easy integration with management dashboards.

The SPG9000 has a unique Dynamic Priority algorithm that minimizes unnecessary grandmaster changes. For example, it is normal and expected behavior for the Best Master Clock Algorithm (BMCA) to cause a switch from a primary (active) leader to a backup (passive) leader when the GNSS signal degrades. But if that signal is restored, the current active leader is equally capable of serving PTP to the network, so there is no need to switch back to the original leader. Dynamic Priority ensures that the unnecessary GM change does not happen, improving stability for ST 2110 and PTP networks.

For best performance, the SPG9000 is typically used in local networks with Boundary Clock switches, but the SPG9000 can also work well with networks that have high packet delay variation (PDV). The PTP Follower can be configured to filter PTP packets and use only those with the lowest delay, and then automatically adjust its internal servo loop parameters to accommodate high-PDV network conditions so that it can lock to the grandmaster.

## Powerful Test Signal Generator

Test signals are useful video and audio references that can be used to troubleshoot or verify performance of equipment and network links within the facility. The SPG9000 includes video, audio, and ancillary data generators for four multi-rate (up to 12G) SDI outputs and two 10/25 Gbps IP outputs.

A wide variety of standard video test patterns are available, such as color bars, monitor calibration patterns, ramps and staircases, and multiburst patterns. Formats and image sizes from standard definition to UHD/4K are supported simultaneously on the independent outputs. User-supplied image files can be loaded onto the instrument and output from the test signal outputs.

A set of overlays can be superimposed above the video test signal background. The text ID overlay supports multiple lines of text at a configurable text size, and uses Unicode characters for localized text in many languages. The logo overlay adds an uploaded image file for network or channel graphics, for example. The burnt-in time code overlay adds the frame-accurate time code to the test pattern, creating a dynamic test signal.

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The SPG9000 has multiple independent audio tone generators that can be embedded into the SDI signals and output as ST 2110-30 IP streams. A special synchronized audio and video sequence can be used to measure AV delay on a companion PRISM monitor.

Ancillary data can be included in the SDI signals and output as ST 2110-40 IP streams. Four different ancillary data types can be generated simultaneously for each output: ancillary time code (ATC), video payload identifier (VPID), userdefined static packet (such as Active Format Description) and user-defined dynamic packet (such as captions/subtitles).

## NMOS-Enabled Media Sender

Using the Networked Media Open Specifications (NMOS) developed by the Advanced Media Workflow Association (AMWA), the SPG9000 can function as a media device in an IP network.

Using the Discovery & Registration API (IS-04), the SPG9000 can register as a node with sender capabilities. Using the Device Connection Management API (IS-05), receivers can automatically configure IP connections to receive IP streams for test signal content (video, audio, and data).

## Remote System Management and Monitoring

The SPG9000 includes several tools to facilitate easy integration with modern management systems and monitoring dashboards.

In addition to the front panel display and keypad for local operation, the SPG9000 has a full-featured easy-to-use web-based interface for remote operation. Access is controlled via user login and password authentication, with both administrator and operator access levels. HTTPS can be used for secure network access per EBU R 143 cybersecurity requirements.

A complete HTTP-based Application Programming Interface (API) is available for client-side software to query the instrument status and to configure its run-time options. Integrated web-based API documentation makes it easy for developers to understand message structures, and to interactively send requests to the instrument and view the responses.

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The SPG9000 also utilizes syslog for sending log messages to a remote server. The minimum reported severity level is configurable, to only report error and warning messages or to also report informational system messages, for example.

PTP status and performance monitoring and GNSS receiver status are well supported by both the HTTP API and syslog. The API conforms with the proposed SMPTE RP 2059-15 data model, providing a vendor-neutral interface for client-side developers.

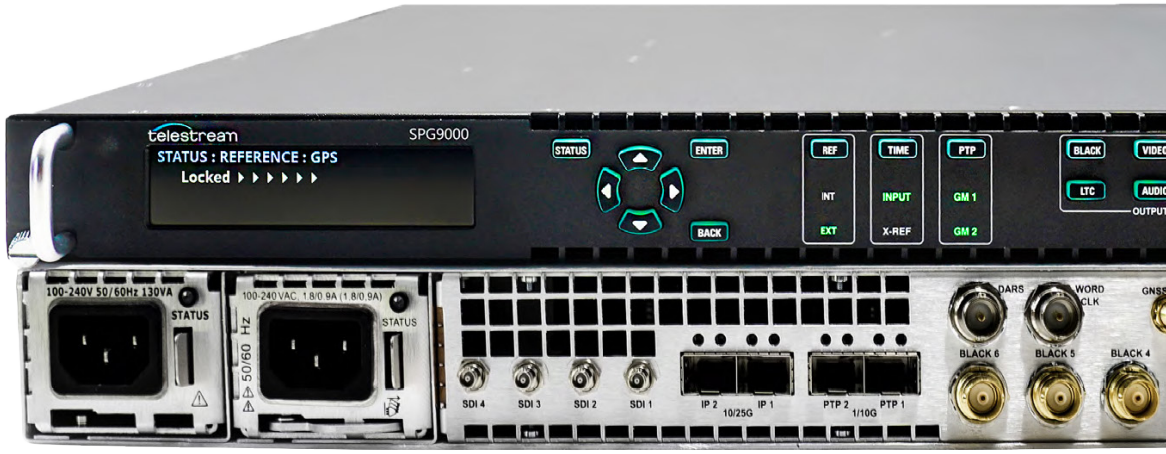
The SPG9000 has an SNMP agent for system monitoring with traditional management systems. SNMPv3 can be used for secure networks or SNMPv2c can be used for trusted networks, and the agent supports objects for system and reference status and Trap messages for event notifications.

## Companion Changeover Unit

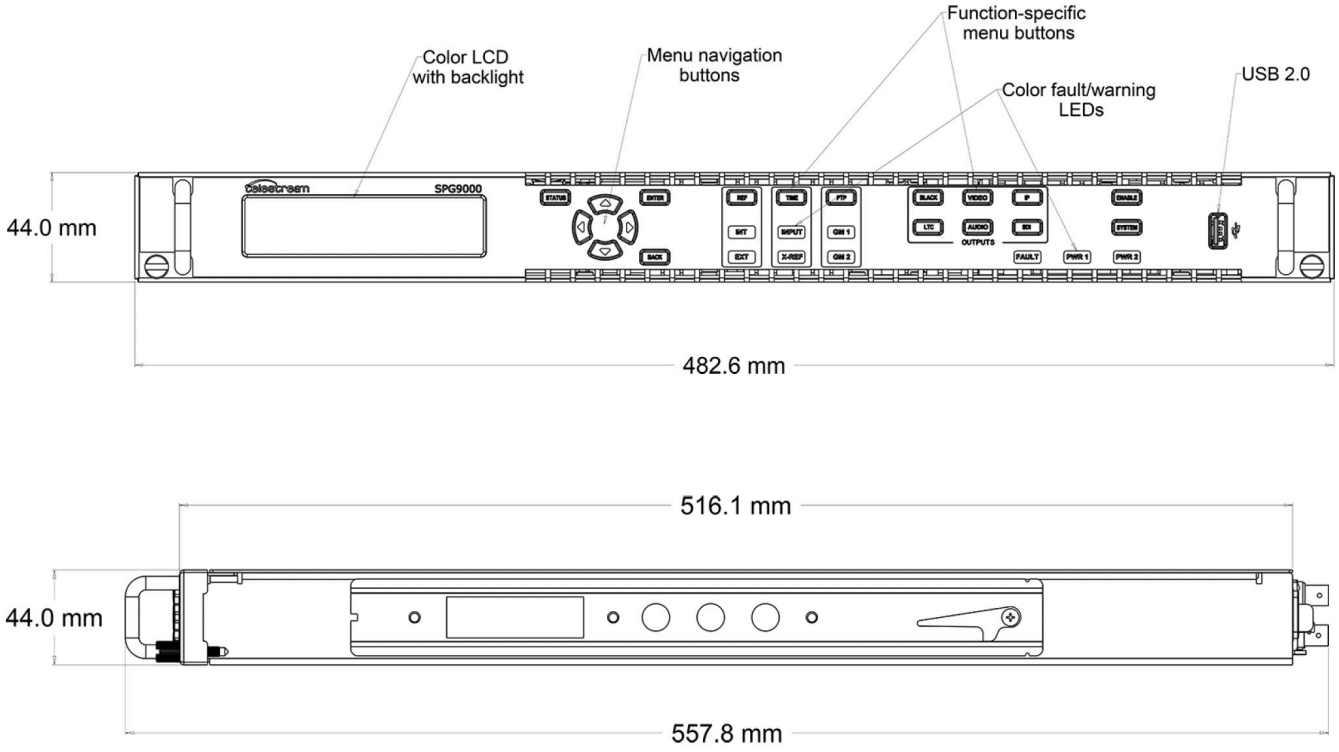
The ECO8000 electronic changeover unit works with a primary + backup pair of SPG9000 units to serve as a highly-reliable redundant system. It utilizes electronic fast switches for near glitch-less sync source switching, minimizing disruption in operation. Dual hot-swappable power supplies ensure continuous availability of reference signals, and signals are passed even when the unit is powered off.

The ECO8000 provides six or nine user-configurable BNC channels and four LTC channels. Each channel consists of primary and backup inputs and an output. Two BNC channel types are available: 50 MHz electronic fast switch channels support black burst, HD tri-level sync, AES/DARS, and word clock signals, and 3 GHz relay switch channels support SD/HD/3G-SDI signals as well as most analog reference signals. The base configuration of the ECO8000 includes six 50 MHz electronic switch channels and four LTC channels. A hardware option can add three more 50 MHz electronic switch channels or three 3 GHz relay switch channels.

# Technical Specifications

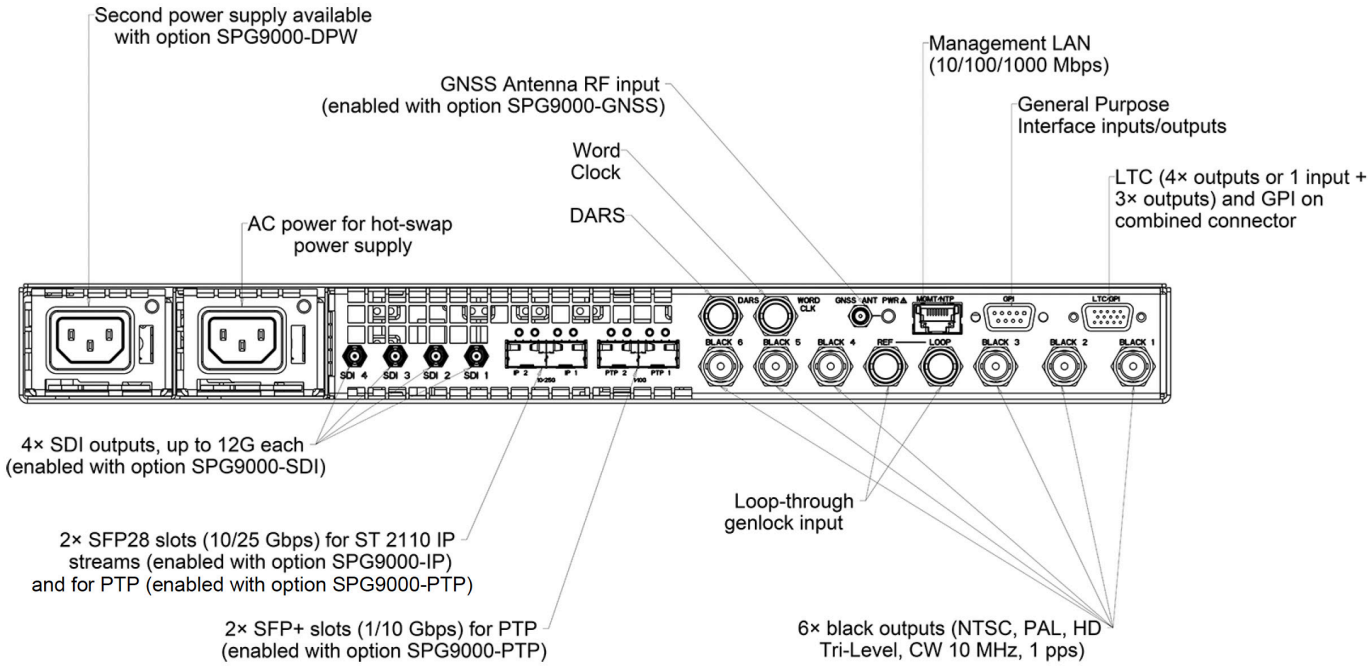



## Form Factor & Dimensions




| Dimensions | |
|---|---|
| Height | 44.0 mm (1.73 in.) |
| Width | 482.6 mm (19 in.) |
| Depth | 516.11 mm (20.32 in.) |
| Weight | 4.85 kg (10.7 lbs) |

# Connectivity




# Baseband Synchronization

## Internal Oscillator

| | |
|---|---|
| Frequency accuracy in internal/holdover modes | ±35 × $10^{-9}$ over 1-year calibration interval; (after the first 30 days of continuous operation) typically ±10 × $10^{-9}$ just after adjustment |
| Frequency drift | <±30 × $10^{-9}$ per year for internal and holdover modes at constant temperature (after the first 30 days of continuous operation) |

## Genlock Input

| | |
|---|---|
| Connector | BNC ×2, passive loop-through |
| Formats | • NTSC/PAL black burst<br>• HD tri-level sync<br>  • 1080 60/59.94/50i<br>  • 1080 30/29.97/25/24/23.98p<br>  • 1080 24/23.98sF<br>  • 720 60/59.94/50p<br>• CW 10 MHz |
| Amplitude Range | −8 dB to +6 dB |
| Lock Stability<br>±3 dB amplitude change<br>Jitter with burst lock<br>Jitter with tri-level sync lock<br>Jitter with CW lock | <br><1 ns<br><0.5°<br><1 ns<br><1 ns (typ. 1°) |
| Timing Adjustment<br>Range<br>Resolution | <br>± ½ color frame<br><0.5° of NTSC/PAL subcarrier, 1 ns for tri-level sync |

## Black Outputs

| | |
|---|---|
| Number of Outputs | 6 |
| Formats | • Black burst<br>  • NTSC-M (7.5 IRE black)<br>  • NTSC-J (0 IRE black)<br>  • PAL-B<br>• HD tri-level sync<br>  • 1080 60/59.94/50i<br>  • 1080 60/59.94/50/48/47.95/30/29.97/25/24/23.98p<br>  • 1080 24/23.98sF<br>  • 720 60/59.94/50p<br>• CW 10 MHz<br>• 1 PPS |
| Amplitude Accuracy | ± 2% |
| Timing Adjustment<br>Range<br>Resolution | <br>± ½ color frame<br>Clock resolution: 18.5 ns for black burst, 13.5 ns for HD tri-level<br>Fine resolution: 0.1 ns for black burst, 0.2 ns for HD tri-level |
| Time Code (VITC)<br>Line Numbers<br>Date and Time Zone<br>Source | <br>User-selectable 1 or 2 lines, default 14/16 for NTSC, 19/21 for PAL<br>SMPTE ST 309, YYMMDD format<br>Time-of-day with adjustable offset, or program (elapsed) time counter |
| Ten-Field Sequence | For NTSC formats per SMPTE ST 318 (Black 4-6 outputs only) |

## LTC Inputs/Outputs

| | |
|---|---|
| Number of Outputs | 4 outputs or 3 outputs and 1 input |
| Connector | Available through D-sub 15-pin connector; Optional break-out cable to XLR connectors |
| Formats | 24 fps (24 Hz or 23.98 Hz), 25 fps (25 Hz), 30 fps (30 Hz or 29.97 Hz), 30 fps drop-frame (29.97 Hz) per SMPTE ST 12-1 |
| Date and Time Zone | User selectable SMPTE ST 309 (YYMMDD format), or pre-standard legacy date format |
| Source | Time-of-day with adjustable offset, or program (elapsed) time counter |
| Output Amplitude | 5V ±10%, adjustable from 0.5 V to 5 V in 0.5 V steps |

## Word Clock

| | |
|---|---|
| Connector | BNC ×1 |
| Frequency | 48 kHz |
| Output Level | 0-5 V DC (CMOS compatible) or ±1 V into 75 Ω (AES level) |

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## DARS

| | |
|---|---|
| Outputs | 2 channels (1 AES/EBU pair) |
| Connector | BNC ×1 |
| Amplitude | 1 V ± 0.2 V |
| Sampling Frequency | 48 kHz (lock on video signal) |
| Quantization | Linear PCM, 20 or 24 bits |

## Network Time Protocol (NTP)

| | |
|---|---|
| Network Interface | Combined MGMT/NTP interface for management functions and NTP server/client<br>RJ45 connector, 10/ 100/ 1000 Mbps line speed |
| Server | |
| Stratum Level | Stratum 1 when the reference time source is GNSS or PTP Follower<br>Optional Stratum 12 operation for internal time or LTC/VITC time source |
| Client Query Rate | Maximum 1 query per 8 seconds for each individual client<br>Rate limiting is enabled to prevent DoS attacks |
| Number of Clients | 5000 or more at maximum query rate |
| Client | |
| Operation | Available when using internal time source<br>Update internal time from NTP manually, upon system startup, from API, or from GPI |
| Remote Time Servers | One or two remote servers from local network or Internet |

# Precision Time Protocol (PTP)

| | |
|---|---|
| Port Connectors | 2× SFP+ sockets. Available transceiver modules for 1G or 10G line speeds.<br>2× SFP28 sockets. Available transceiver modules for 10G or 25G line speeds. |
| Operating Modes | Leader only, Follower only, Ordinary Clock (adaptive). |
| PTP Instances | 4 independent, as multiple Leader, dual Follower or Follower + Leader combinations |
| Profiles | SMPTE ST 2059-2, AES67 Media Profile, IEEE 1588-2019 Default |
| Communication Model | Multicast, Unicast, Mixed Multicast/Unicast |
| Follower Lock Time | Typically 30 seconds for initial lock for networks with low packet delay variation (PDV) |
| Follower Lock Range | ± 7.5 ppm |
| Measurements | For follower, shown on user interface or available via API<br>• Offset from Master<br>• Path Delay<br>• Leader-Follower Delay<br>• Follower-Leader Delay |
| Status Reporting | Current GM Clock Identity, Clock Class, Clock Accuracy, Time Source , Steps Removed<br>Message rates for Announce, Sync, Delay_Req, and Delay_Resp messages |
| SMPTE Synchronization Metadata | For ST 2059-2 profile, automatically inserted in TLV data of Management messages for leader instances, and automatically decoded for follower instances |

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# Global Navigation Satellite System (GNSS)

## GNSS Receiver

| | |
|---|---|
| Constellations | GPS, GLONASS , Galileo, BeiDou, NavIC, QZSS |
| Frequency Bands | L1 1575.42 MHz and 1602 MHz (GPS, GLONASS, Galileo, NavIC)<br>L1 1561.098 MHz (Beidou)<br>L5 1176.45 MHz (GPS , QZSS, Galileo, BeiDou, NavIC) |
| Time Accuracy | Within 150 ns to UTC |
| Acquisition Time | 2 minutes on boot up with warm oven, good satellite signal, and known position |
| Status Reporting | Available via user interface and API<br>• Satellites in view and in fix<br>• Per-satellite signal information<br>• Position |

## GNSS Antenna Input

| | |
|---|---|
| Connector | SMA female |
| Input Impedance | 50 Ω, internally terminated |
| DC antenna power output voltage | 3.3 V or 5 V at 55 mA |
| Fault Protection | Shor t-circuit/open detection and protection |
| Return loss | 15 dB for L1 band at 1575 MHz<br>7 dB for L5 band at 1176 MHz |
| Signal Strength | Recommended 18 dB above ambient level after cable loss and signal amplifiers |

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# Test Signal Generation

## Video Formats

All listed formats are available for SDI outputs. ST 2110-20 video streams support 10-bit 4:2:2 progressive and interlaced formats for all listed image sizes and frame rates.

| Image Size | Scan Type | Frame Rate | Sampling | Color Space | Bit Depth |
|---|---|---|---|---|---|
| 720×486 | Interlaced | 29.97 | 4:2:2 | YCbCr | 10 |
| 720×576 | Interlaced | 25 | 4:2:2 | YCbCr | 10 |
| 1280×720 | Progressive | 60/59.94/50<br>30/29.97/25/24/23.98 | 4:2:2<br>4:4:4 4:4:4 | YCbCr<br>YCbCr<br>RGB | 10<br>10<br>10 |
| 1920×1080 | Progressive | 60/59.94/50 | 4:2:2 | YCbCr | 10 |
| | | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr | 10<br>10<br>10<br>12<br>12<br>12 |
| | Interlaced | 30/29.97/25 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr | 10<br>10<br>10<br>12<br>12<br>12 |
| | Segmented | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:2:2 | YCbCr<br>YCbCr<br>RGB<br>YCbCr | 10<br>10<br>10<br>12 |
| 2048×1080 | Progressive | 60/59.94/50/48/47.95 | 4:2:2 | YCbCr | 10 |
| | | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2<br>4:4:4 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr<br>XYZ | 10<br>10<br>10<br>12<br>12<br>12<br>12 |
| | Segmented | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2<br>4:4:4 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr<br>XYZ | 10<br>10<br>10<br>12<br>12<br>12<br>12 |
| 3840×2160 | Progressive | 60/59/94/50 | 4:2:2 | YCbCr | 10 |
| | | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr | 10<br>10<br>10<br>12<br>12<br>12 |
| 4096×2160 | Progressive | 60/59/94/50/48/47.95 | 4:2:2 | YCbCr | 10 |
| | | 30/29.97/25/24/23.98 | 4:2:2<br>4:4:4<br>4:4:4<br>4:4:4<br>4:4:4<br>4:2:2 | YCbCr<br>YCbCr<br>RGB<br>YCbCr<br>RGB<br>YCbCr | 10<br>10<br>10<br>12<br>12<br>12 |

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## Video Encoding

| | |
|---|---|
| Colorimetry | BT.601, BT.709, or BT.2020 per source format |
| Transfer Characteristics | SDR, HDR HLG, HDR PQ |
| Range | Narrow or Full, as permitted by source format |

## Video Test Patterns

| | |
|---|---|
| Color Bars | 100%, 75%, Bars Over Red, SMPTE EG1, SMPTE RP219-1 and RP219-2, BT.2111 (HLG Narrow, PQ Narrow, PQ Full), EBU 3373, NBCU HLG, Sony S-Log3, ARIB B28, ARIB B66 |
| Monitor | BT. 814 SD/SDR/HDR Pluge, Pluge and Luma Reference, Convergence, Production Aperture, Clean Aperture, Checkerboard, Window, EBU 3374 EOTF Validation, Black-White Step Scale, Black-Dark Gray Step Scale, SMPTE 303M Color Reference, SMPTE EG432-1 Color Accuracy, ChromaDuMonde |
| Linearity | Valid Ramps (Y, B-Y, R-Y), Limit Ramp, 3 Channel Ramp, Shallow Ramp Matrix, Color Ramp Matrix, 5/10 Step Staircases |
| Flat Field | 0% Black, 50% Gray, 100% White, 100% Red/Green/Blue/Cyan/Magenta/Yellow, Interlaced Field Test |
| SDI Pathological | Equalizer Test, PLL Test, Checkfield per SMPTE RP198, Full-Length and Half-Length variants, Bandwidth Test, Matrix, Matrix with Color Bars |
| Frequency Response | Multiburst, various packet frequencies |
| Pulses | 2T Pulse and Bar, Color Pulses, Co-siting Pulse |
| Image File | Any user-supplied image file, TIFF 16-bit or 8-bit RGB format.<br>Automatic colorimetry conversion if necessary for YCbCr output. |

## Video Overlays

### ID Text

| | |
|---|---|
| Text Length | Multiple lines, up to 1000 characters total |
| Available Scripts | Latin, Cyrillic, Chinese (both Simplified and Traditional), Japanese, Korean, Devanagari, Arabic |
| Appearance | Near-white (90%) with or without near-black (10%) border rectangle or the inverse of these colors |
| Text Size | Adjustable from 1% to 25% of active picture height |
| Position | Adjustable anywhere within the active picture |

### Burnt-In Time Code

| | |
|---|---|
| Value | Same format and source as ancillary time code, updated every frame |
| Displayed Digits | HH:MM:SS:FF (hours, minutes, seconds, frames)<br>“.0” or “.1” suffix for frame-pair when the video frame rate is greater than 30 fps<br>Optional Y YYY-MM-DD (year, month, day) on second line of text |
| Text Size | 10% or 20% of active picture height, including black border rectangle |
| Position | Adjustable anywhere within the active picture |

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### Logo

| | |
|---|---|
| File Format | PNG, 8-bit RGBA, full color with transparency |
| Maximum size | 1920×1080 pixels |
| Position | Adjustable anywhere within the active picture |

## Audio Tones

| | |
|---|---|
| Number of Tones | 32 independent tone generators. Each tone generator can be used for any individual SDI embedded audio channel and any individual ST 2110-30 audio channel. |
| Sampling | 48 kHz |
| Resolution | 24 bits (HD and UHD), 20 bits (SD) |
| Frequency | 10.0 Hz to 20000.0 Hz, 0.5 Hz resolution |
| Amplitude | −60 to 0 dBFS, 1dB steps or mute |
| Channel Identification | Audible click, AES channel origin |

# Serial Digital Interface (SDI)

## SDI Outputs

| | |
|---|---|
| Number of Outputs | 4 |
| Connector | HD-BNC |
| Output Impedance | 75 Ω |
| Output Amplitude | 800 $mV_{p-p}$ ±3% |
| Rise/Fall Time<br>SD<br>1.5G/3G<br>6G/12G | <br>≤ 700 ps (20-80%), 550 ps typ.<br>≤ 100 ps (20-80%), 60 ps typ.<br>≤ 42 ps (20-80%), 30 ps typ. |
| Jitter<br>SD<br>1.5G<br>3G<br>6G/12G | <br>210 ps typ. (alignment), 300 ps typ. (timing)<br>40 ps typ. (alignment), 70 ps typ. (timing)<br>30 ps typ. (alignment), 60 ps typ. (timing)<br>15 ps typ. (alignment), 45 ps typ. (timing) |
| Return Loss | ≥ 25 dB typ. from 5 MHz to 2 GHz<br>≥ 15 dB typ. from 2 GHz to 3 GHz<br>≥ 10 dB typ. from 3 GHz to 6 GHz<br>≥ 10 dB typ. from 6 GHz to 12 GHz |

## SDI Formats

| | |
|---|---|
| **Standard Definition (SD-SDI)** | |
| Interface Bit Rate | 270 Mbps |
| Standards | SMPTE ST 259 Level C, ST 272 |
| Formats | 720×486 (525-line) and 720×576 (625-line) |
| **High Definition (HD-SDI)** | |
| Interface Bit Rate | 1.485 Gbps and 1.485/ 1.001 Gbps |
| Standards | SMPTE ST 274, ST 292-1, ST 296 |
| Formats | 1920×1080, 2048×1080, 1280×720 4:2:2 10-bit |
| **3G-SDI** | |
| Interface Bit Rate | 2.97 Gbps and 2.97/ 1.001 Gbps |
| Standards | SMPTE ST 424, ST 425-1 |
| Formats | 1920×1080, 2048×1080, 1280×720<br>Level A, Mapping Structures 1, 2, 3, and 4<br>Level B, per ST 372 Mapping Structures I, II, III, and IV |
| **6G-SDI** | |
| Interface Bit Rate | 5.94 Gbps and 5.94/1.001 Gbps |
| Standards | SMPTE ST 2081-10, ST 425-3 |
| Formats | 3840×2160, 4096×2160<br>ST 2081-10 Mode 1 |
| **12G-SDI** | |
| Interface Bit Rate | 11.88 Gbps and 11.88/ 1.001 Gbps |
| Standards | SMPTE ST 2082-10, ST 425-5 |
| Formats | 3840×2160, 4096×2160<br>ST 2082-10 Mode 1 |

## Embedded Audio

| | |
|---|---|
| Number of Channels | 16 (4 groups of 4 channels each) |
| Channel Control | Enable/Disable per group<br>Active/Inactive per channel |
| Standard | SMPTE ST 299-1 |

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## Ancillary Data

| | |
|---|---|
| Ancillary Time Code<br>Source<br>Format | ATC_LTC and/or ATC_VITC per SMPTE ST 12-2<br>Local time-of-day with adjustable offset, UTC, or program (elapsed) time counter<br>24 fps, 25 fps, 30 fps drop-frame, 30 fps non-drop per video format |
| Payload Identifier | Per SMPTE ST 352, automatic or manual override |
| Static User-Defined Packet<br>Insertion Mode<br>Packet Contents<br>Location | <br>Continuous, single packet (manual), or time trigger<br>DID, SDID, DC, UDW (255), CS; Automatically calculate checksum and/or parity, or manual override<br>Line number, sample offset, luma/chroma channel, field, data stream |
| Dynamic User-Defined Packet<br>Packet Contents<br><br><br>Location | <br>Text file (.MCC format) of pre-encoded ST 291 ancillary data packets, inserted once per frame<br>Maximum loop duration 8400 frames (SDI 1) or 1800 frames (SDI 2-4)<br>Sample files provided for CTA 608/708 captions encoded in ST 334 CDP and for WST encoded in RDD 8/OP-47 SDP<br>Line number, sample offset, luma/chroma channel, field, data stream |
| Error Detection and Handling | EDH packet inserted in SD-SDI per SMPTE RP 165 |

# Internet Protocol (IP)

## IP Ports

| | |
|---|---|
| Port Connectors | 2 SFP28 sockets |
| Line Speed | 10 Gbps or 25 Gbps per installed SFP type |
| Error Correction | RS-FEC per Clause 108 of IEEE 802.3by-2016<br>Enable/disable for 25G SFPs, not applicable for 10G SFPs |

## ST 2110 Generation

| | |
|---|---|
| Operating Modes | Stream generation on both ports per SMPTE ST 2022-7 or on either individual port |
| Number of Streams | 6× ST 2110-20 video streams<br>6× ST 2110-30 audio streams<br>6× ST 2110-40 data streams |
| Sender Type | Type N (Gapped) or Type NL (Linear) PRS |
| RTP Payload Type | Independent value (96–127) per stream |
| UDP Size Limit (MAXUDP) | 1460 octets |
| UDP Port Numbers | Independent source and destination port numbers for both paths of each stream |
| Destination Address | Multicast, 224.0.2.0 to 239.255.255.255<br>Independently configured for both paths of each stream |
| Session Description Protocol (SDP) | Available via web interface and API for each enabled stream |
| ST 2110-20 Video<br>Packing Mode<br>$TR_{OFFSET}$ | <br>General Packing Mode (GPM) or Block Packing Mode (BPM)<br>Automatically calculated or Manual override |

| | |
|---|---|
| ST 2110-30 Audio | |
| Number of Channels | Each stream is independently configured for 1, 2, 4, 6, 8, or 16 channels |
| Channel Order | Manual configuration, signaled via SDP |
| Packet Time | 1 ms or 125 µs |
| ST 2110-40 Data | |
| Ancillary Time Code | ATC_LTC or ATC_VITC per SMPTE ST 12-2<br>Time code format of 24 fps, 25 fps, 30 fps, or 30 fps drop-frame<br>Local time-of-day with adjustable offset, UTC, or program (elapsed) time counter |
| Payload Identifier | Per SMPTE ST 352, automatic or manual override |
| Static User-Defined Packet | Continuous, single packet (manual), or time trigger insertion<br>DID, SD DID, SDID, DC, UDW (255), CS; Auto calculate checksum and/or parity, or manual override<br>Line number, sample offset, and Y/C channel specified per RFC 8331 |
| Dynamic User-Defined Packet | Text file (.MCC format) of pre-encoded ST 291 ancillary data packets, inserted once per frame<br>Maximum loop duration 8400 frames (stream 1) or 1800 frames (streams 2-6)<br>Sample files provided for CTA 608/708 captions encoded in ST 334 CDP and for World System Teletext (WST) encoded in RDD 8/OP-47 SDP<br>Line number, sample offset, and Y/C channel specified per RFC 8331 |

## Networked Media Open Specifications (NMOS)

| | |
|---|---|
| Specifications | IS-04 NMOS Discovery and Registration<br>IS-05 NMOS Device Connection Management<br>BCP-003-01 Secure Communication in NMOS Systems |
| Registry Discovery | Automatic using DNS-SD (unicast or multicast) or Manual |
| API Versions | |
| Node | v1.0, v1.1, v1.2, v1.3 |
| Connection | v1.0, v1.1 |
| Registration | v1.0, v1.1, v1.2, v1.3 |

# Power Consumption

| | |
|---|---|
| Typical | 130 VA |
| Maximum | 180 VA |
| Voltage Range | 100 to 240 VAC ±10%, 50/60 Hz |

# Packaging Dimensions

| | |
|---|---|
| Height | 29.2 cm (11.5 in.) |
| Width | 64.1 cm (25.2 in.) |
| Depth | 73.7 cm (29.0 in.) |
| Weight | 9.6 kg (21.2 lbs.) with no options<br>12.0 kg (28.7 lbs.) with all options |

# Ordering Information

## Base Model

| Product Code | Description |
|---|---|
| SPG9000 | SPG9000 timing and reference generator; includes loop-through genlock input, 6 analog black/tri-level outputs, 4 LTC outputs, word clock output, DARS output, general-purpose interface, and management LAN interface |

## Licensed Feature Options

| Option Code | Description |
|---|---|
| SPG9000-GNSS | License; SPG9000, Enable internal GNSS receiver and time synchronization features |
| SPG9000-PTP | License; SPG9000, Enable PTP (IEEE 1588) support on four ports |
| SPG9000-SDI | License; SPG9000, Enable SD/HD/UHD test signal generation on four SDI outputs |
| SPG9000-IP | License; SPG9000, Enable ST 2110 test signal generation on two IP ports |
| SPG9000-TSG | License; SPG9000, Includes both SDI and IP licenses for test signal generation |

## Accessory Options

| Option Code | Description |
|---|---|
| SPG9000-RACK | Rackmount slides and rails kit for SPG9000 (1 RU height, standard full depth) |
| SPG9000-XLR | Adapter cable (6 feet long) from 15-pin D-sub GPI/LTC connector on the SPG9000 to 4 XLR male connectors (for LTC input/outputs) and 3 BNC male connectors (for General Purpose Interface input/outputs) |

## SFP Modules

| Option Code | Description |
|---|---|
| SPG9000-SFP-1GESR | Gigabit Ethernet short reach 850 nm SFP transceiver module |
| SPG9000-SFP-10GESR | 10G Ethernet short reach 850 nm SFP+ transceiver module |
| SPG9000-SFP-10GELR | 10G Ethernet long reach 1310 nm SFP+ transceiver module |
| SPG9000-SFP-25GESR | 25G Ethernet short reach 850 nm SFP28 transceiver module |
| SPG9000-SFP-25GELR | 25G Ethernet long reach 1310 nm SFP28 transceiver module |

## Power Options

| Option Code | Description |
|---|---|
| SPG9000-SPW | Includes a single hot-swappable power supply |
| SPG9000-DPW | Includes two hot-swappable power supply modules for a redundant (primary + backup) pair |

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## Power Cords

| Option Code | Description |
|---|---|
| PWR-CORD-NA-S15 | North America Power Cord, Straight 15A |
| PWR-CORD-EURO | Universal EURO Power Cord |
| PWR-CORD-CHN | China Power Cord |
| PWR-CORD-IND | India Power Cord |
| PWR-CORD-AUS | Australia Power Cord |
| PWR-CORD-UK | United Kingdom Power Cord |
| PWR-CORD-BRZ | Brazil Power Cord |
| PWR-CORD-CHE | Switzerland Power Cord |
| PWR-CORD-JPN | Japan Power Cord |
| PWR-CORD-NONE | No Power Cord or AC Adapter |

## Service Options

| Option Code | Description |
|---|---|
| SPG9000 R3 | Standard Warranty Extended to 3 Years. Covers parts, labor and 2-day shipping within country. Guarantees faster repair time than without coverage. All repairs include performance verification and updates. Hassle free - a single call starts the process |
| SPG9000 R5 | Standard Warranty Extended to 5 Years. Covers parts, labor and 2-day shipping within country. Guarantees faster repair time than without coverage. All repairs include performance verification and updates. Hassle free - a single call starts the process |

## Standalone Accessories

The DPW, RACK and XLR accessories can be ordered at the same time as the base SPG9000 product (see “Accessory Options” above) and shipped together in the same packaging, or they can be ordered separately and shipped in individual packaging. The ANT accessory is only shipped in separate packaging.

| Product Code | Description |
|---|---|
| SPG9000-ACC-ANT | Multi-GNSS (GPS, GLONASS, Galileo, BeiDou) dual-band (L1 & L5) rooftop antenna that works with the integrated GNSS receiver of the SPG9000 with option SPG9000-GNSS. Includes mounting bracket. Coaxial cable with TNC connector required. |
| SPG9000-ACC-DPW | Hot-swappable, redundant (backup) power supply for the SPG9000 |
| SPG9000-ACC-RACK | Rackmount slides and rails kit for SPG9000 (1 RU height, standard full depth) |
| SPG9000-ACC-XLR | Adapter cable (6 feet long) from 15-pin D-sub GPI/LTC connector on the SPG9000 to 4 XLR male connectors (for LTC input/outputs) and 3 BNC male connectors (for General Purpose Interface input/outputs) |

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## Post-Purchase License Upgrades

The licensed feature options for the SPG9000 can be ordered at any time after the initial base unit purchase. No hardware upgrades are necessary to enable these features.

| Product Code | Description |
|---|---|
| SPG9000-LICENSE | Upgrade license(s) to enable features for the SPG9000 |

| Option Code | Description |
|---|---|
| SPG9000-LIC-GNSS | License; SPG9000, Enable internal GNSS receiver and time synchronization features |
| SPG9000-LIC-PTP | License; SPG9000, Enable PTP (IEEE 1588) support on four ports |
| SPG9000-LIC-SDI | License; SPG9000, Enable SD/HD/UHD test signal generation on four SDI outputs |
| SPG9000-LIC-IP | License; SPG9000, Enable ST 2110 test signal generation on two IP ports |
| SPG9000-LIC-TSG | License; SPG9000, Includes both SDI and IP licenses for test signal generation |

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