The ALERT submenu provides additional details if there are any signal warnings, such as a loss of lock on the reference source. The menu will update in real-time, so if the condition clears, the menu will change to display "No alerts".

Reference Status

The Reference section on the Status tab contains information about the current reference source, the genlock input signal, and the received GNSS signal.

Note: Option SPG9000-GNSS must be licensed to view GNSS signal status. Without the option, these items are not shown on the web page.

Primary Source

Displays the primary reference source, one of:

- Internal
- Genlock Input
- GNSS Signal
- PTP Follower

The colored indicator shows the health of the primary source. Green indicates that the SPG9000 is able to lock to the source, and red indicates that the SPG9000 is not able to lock to the source.

If the primary source is GNSS Signal, a secondary source can be configured. In this mode, if the primary source is active, "(Active)" or "(Auto)" will be displayed after the source type. See *Secondary Reference*.

Secondary Source

Displays the secondary reference source, if available. If the secondary source is active, "(Active)" or "(Auto)" will be displayed after the source type.

The colored indicator shows the health of the secondary source. Green indicates that the SPG9000 is able to lock to the source, and red indicates that the SPG9000 is not able to lock to the source.

If the secondary source is set to CW 10 MHz and the primary source is active, the SPG9000 can only detect signal presence on the genlock input but not its format. Therefore, the indicator would be blank if the signal is present and red if the signal is missing.

Reference Status

Displays the status of the current reference source. The status text is colored green, yellow, or red indicating good, warning, or error status respectively.

Reference Source	Status Value	Status Color	Description
Internal	Off	Green	The internal oven-controlled MEMS oscillator is used as the frequency reference.
Genlock Input	Locked	Green	Locked to the genlock input signal
	Near Loss of Lock	Yellow	The system is locked but within 1×10^{-6} of the limits of the tune range.
	Unlocked	Red	The system is unable to lock to the genlock input signal.
	Unlocked - Waiting for Manual Lock	Red	The system is waiting for user input to manually relock. This happens when the Lock Action Mode is set to Manual. See *Lock Action Mode*.
	No Signal	Red	There is no detectable signal at the genlock input.

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Reference Source	Status Value	Status Color	Description
GNSS Signal[1]	Locked Strong	Green	Locked to the GNSS signal with 8 or more satellites reporting a carrier-to-noise ratio (C/N) of 40 dB or better
	Locked Nominal	Green	Locked to the GNSS signal with 4 or more satellites reporting C/N of 30 dB or better
	Locked Minimum	Green	Locked to the GNSS signal with 4 or more satellites reporting C/N of 10 dB or better
	Locked (possible jamming or spoofing)	Yellow	Locked to the GNSS signal but the receiver is reporting possible jamming (signal interference from external sources) or spoofing (incorrect signals received from external sources).
	Holdover	Yellow	The system has previously locked to the GNSS signal but is now unlocked. The holdover mode continues until the system relocks.
	Adjusting Phase	Yellow	The system has a good GNSS signal and is now adjusting its time base and frame timing to align with the GNSS signal within 150 ns.
	Acquiring Position	Yellow	The system is acquiring multiple satellite fixes to compute a new position that be stored in non-volatile memory.
	Bad Position	Yellow	The system has detected that the stored position is different from the current position. The position will be reacquired.
	Acquiring Satellites	Yellow	The system is receiving satellite data to determine which signals to use.
	Unlocked	Red	The system is unable to lock to the GNSS signal because there is no signal or the signal quality is too low.

Reference Source	Status Value	Status Color	Description
PTP Follower[2]	Locked 50 ns	Green	The system is locked to the PTP leader with an offsetFromMaster value of 50 ns or less, and the system phase is within 50 ns of the PTP-derived timing.
	Locked 100 ns	Green	The system is locked to the PTP leader with an offsetFromMaster value of 100 ns or less, and the system phase is within 100 ns of the PTP-derived timing.
	Locked 250 ns	Green	The system is locked to the PTP leader with an offsetFromMaster value of 250 ns or less, and the system phase is within 250 ns of the PTP-derived timing.
	Locked 1 µs	Green	The system is locked to the PTP leader with an offsetFromMaster value of 1 µs or less, and the system phase is within 500 ns of the PTP-derived timing.
	Holdover	Yellow	The system has a valid PTP time from a previous lock, but the PTP instance is no longer tracking the leader.
	Adjusting Phase	Yellow	The PTP instance is tracking within 1 µs of the PTP leader and the system is now adjusting its time base and frame timing to align with the PTP-derived timing.
	Listening	Yellow	The PTP instance is waiting to receive Announce and Sync messages from a PTP leader in the same domain.
	Unlocked	Red	The PTP instance is disabled, initializing, or faulty (possibly because the link is down).

1. Option SPG9000-GNSS must be licensed to select GNSS Signal as the time and reference source
2. Option SPG9000-PTP must be licensed to select PTP Follower as the time and reference source

Genlock Input

Displays information about the received genlock input signal (from the REF LOOP connectors on the back panel). Detailed information is available when the reference source is Genlock Input. Simple signal detection is the only available status when the reference source is not Genlock Input.

Reference Source	Genlock Input Status	Description
Genlock Input	NTSC Burst	The system is locked to the genlock input signal and the input format is NTSC Burst.
	PAL Burst	The system is locked to the genlock input signal and the input format is PAL Burst.
	Any of the HD tri-level formats, such as 1080 59.94i or 1080 25p	The system is locked to the genlock input signal and the input format is HD Tri-Level. The specific tri-level sync format is displayed. See *Web Interface for Genlock Input*.
	CW 10 MHz	The system is locked to the genlock input signal and the input format is 10 MHz CW (continuous wave).
	Signal Present	There is a detectable signal on the genlock input, but the system cannot lock to it. This usually indicates a mismatch between the expected genlock input format and the format of the received signal.
	No Signal	There is no detectable signal on the genlock input.
Internal or GNSS Signal or PTP Follower	Signal Present	There is a detectable signal on the genlock input, but the system cannot identify the specific format when the reference source is not Genlock Input.
	No Signal	There is no detectable signal on the genlock input.

Signal Amplitude

Displays the peak-to-peak signal level (in volts) measured at the genlock input. The instrument can lock to signals within −8 to +6 dB of the nominal signal level for NTSC, PAL, and HD tri-level formats and 0.5 to 2V for the CW 10 MHz signal.

If the displayed signal amplitude is greater than expected, the loop-through input on the back panel might be unterminated. Connect the second connector to the genlock reference input of another device or add a 75 Ω terminator.

GNSS Status

Displays the status of the received GNSS signal. The possible values and what they mean are listed in the table.

Note: Option SPG9000-GNSS must be licensed for the GNSS status items to appear on the web interface.

GNSS Status Value	Description
Locked Strong	The GNSS signal has data from 8 or more satellites with a carrier-to-noise ratio (C/N) of 40 dB or better.
Locked Nominal	The GNSS signal has data from 4 or more satellites with C/N of 30 dB or better.
Locked Minimum	The GNSS signal has data from 4 or more satellites with C/N of 10 dB or better.
Locked (possible jamming or spoofing)	The GNSS receiver is reporting possible jamming (signal interference from external sources) or spoofing (incorrect signals received from external sources) of the received signal.
Acquiring Position	The system is acquiring multiple satellite fixes to compute a new position that will be stored in non-volatile memory.
Unusable Signal	The pulse-per-second (PPS) signal from the GNSS receiver is questionable.
Acquiring Satellites	The system is receiving satellite data to determine which signals to use.
Low Signal	Some satellites are in view, but none are in fix.
No Signal	No satellites are in view. This is normal for a short time after the signal is applied but if this status persists it usually means one of three problems: there is a problem in the antenna or cable; the antenna is blocked from direct line of sight to the satellites; the power is not getting to the antenna.

Signal Quality

Displays the sum of C/N from all satellites currently in fix. A value of about 200 or higher is usually sufficient for Locked Strong status.

Satellites

Displays the number of satellites in-fix and in-view for each satellite constellation. For example, "GPS 16/17" means 17 GPS satellites are in-view, and 16 of those are in-fix. A satellite whose signal is received by the internal GNSS receiver is counted in-view, but it must be used in the time and position calculation to be counted in-fix. A satellite with a low C/N value or that is low in the sky (close to the horizon) is not used.

Antenna

Displays the status of the external GNSS antenna; the table explains what each value means:

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Antenna status value	Description
Normal Operation	The external GNSS antenna is operating normally.
Power Off	The antenna is not powered from the instrument. This is a normal condition if the antenna is powered from an external source. See *GNSS Receiver Settings* to change the antenna power settings.
Short Circuit	The antenna is shorted. A shorted antenna does not damage the internal GNSS receiver. If a splitter is used on the antenna, it might appear as a short at DC but still pass through the RF signal, which would allow the internal GNSS system to function.
Open Circuit	An open circuit condition occurs if no antenna is connected or if the current load is less than expected because a splitter or DC block is being used.

Show Details

Click to open a panel on the web interface that provides details information about the received GNSS data. The position data of the GNSS antenna is shown along with a table with data of every satellite that is currently in view.

Latitude 45.457788
Longitude -122.790513
Altitude 45.213

View in Google Maps

GNSS ID	Satellite	Signal	C/N (dB)	Health	Used
Galileo	7	L1-A	32	ok	no
Galileo	7	E5a	30	ok	no
Galileo	1	L1-A	39	ok	yes
Galileo	1	E5a	40	ok	yes
GPS	14	L1 C/A	46	ok	yes
GPS	14	L5-I	44	ok	yes
GPS	7	L1 C/A	48	ok	yes
Galileo	27	L1-A	48	ok	yes
Galileo	27	E5a	47	ok	yes
GPS	13	L1 C/A	42	ok	no
BDS	45	B1C	45	ok	yes
BDS	45	B2-a	36	ok	yes
Galileo	19	L1-A	41	ok	yes
Galileo	19	E5a	35	ok	yes
GLONASS	12	L1 C/A	43	ok	yes
GLONASS	23	L1 C/A	29	ok	no

Latitude and Longitude

Displays the position in degrees of the GNSS antenna, which might be located at a distance from the GNSS receiver inside the SPG9000. The latitude value is a positive number (0 to 90) for the northern hemisphere and a negative number (−90 to 0) for the southern hemisphere. The longitude value is a positive number (0 to 180) for the eastern hemisphere and a negative value (−180 to 0) for the western hemisphere.

Altitude

Displays the altitude of the GNSS antenna location in meters relative to sea level.

View in Google Maps

Click to open a new browser tab with the location of the GNSS antenna shown at https://google.com/maps. This can be used as a diagnostic aid to confirm that the GNSS signal is showing the correction position if there are concerns that the signal is being spoofed.

GNSS ID

Indicates the Global Navigation Satellite System for this satellite.

GNSS ID	System Name	Operator	Coverage
GPS	Global Positioning System	United States	Global
GLONASS	Global Navigation Satellite System	Russia	Global
Galileo	Galileo	European Union	Global
BDS	BeiDou Navigation Satellite System	China	Global
QZSS	Quasi-Zenith Satellite System	Japan	Regional (Asia-Oceania, centered around 135° E longitude)

Satellite

Displays the space vehicle identifier for this satellite. Each GNSS constellation has its own numbering system for its set of satellites.

Signal

Displays the signal identifier. The GNSS receiver of the SPG9000 can receive signals from both the L1 and L5 bands, but this also requires an external antenna that also

supports L1 and L5 frequency bands. If only the L1 signals are visible in this table, it usually means the antenna does not support L5 bands.

Bands	Frequencies	Constellations
L1	1575.42 MHz	GPS, Galileo, QZSS
	1561.098 MHz	BeiDou
	1602 MHz	GLONASS
L5	1176.45 MHz	GPS, Galileo, BeiDou, QZSS

C/N (dB)

Displays the carrier-to-noise ratio in decibels of the satellite signal. Values above 10 are usable for a nominal fix and values above 40 are used for a strong fix.

Health

Reports the satellite's health status. If the status is not OK, the satellite is reporting an issue and the receiver would not use its data for a timing and position solution.

Used

Indicates if this satellite signal is used by the receiver for the timing and position solution. Satellite data is usually used unless the vehicle is low in the sky (close to the horizon) or its C/N value is low.

Time Status

The Time section on the Status tab contains information about the current time-of-day source, local offsets, time code inputs, and the program time counter.

Primary Source

Displays the current main time-of-day (MTOD) source, one of:

- Internal
- VITC Input
- LTC Input
- GNSS Signal
- PTP Follower

Primary Time

Displays the current main time-of-day value (date and time) including offsets for the local time zone and daylight saving time if applicable.

Time Zone Offset

Displays the current time zone offset relative to UTC. For example, Central European Time (CET) is shown as +01:00 and Pacific Time for North America is shown as -08:00.

DST Offset

Displays the current daylight saving time offset. For standard time, this is 00:00. For daylight saving time (in regions that observe it), the offset is almost always 01:00.

VITC Status

Indicates the presence or absence of the Vertical Interval Time Code (VITC) data on the genlock input signal. When VITC is present, its detected line number in the NTSC or PAL input signal is displayed. The status shows "Discontinuous" for a few seconds if there is an unexpected change in the received time code counter sequence.

VITC Input

Displays the received time code value. If the date and time zone information is encoded (described in SMPTE ST 309), the displayed format is YYYY-MM-DD HH:MM:SS. If the ST 309 data is missing, only the HH:MM:SS digits are displayed.

LTC Input

Displays the received Linear Time Code (LTC) value. LTC 1 must be set to Input mode for the time code to be available. If the date and time zone information is encoded

(described in ST 309), the displayed format is YYYY-MM-DD HH:MM:SS. If the ST 309 data is missing, only the HH:MM:SS digits are displayed.

Note: If the reference source is Genlock Input and the time-of-day source is either VITC Input or Internal, the VITC status is displayed instead of the LTC status.

LTC Format

Displays the detected format of the LTC input signal, such as "30 fps drop-frame".

LTC Amplitude

Displays the detected signal level in volts of the LTC input signal

LTC Timing

Displays the timing offset in milliseconds between the LTC input signal and the genlock input signal. The offset should be within −32 µs to +160 µs, according to SMPTE ST 12-1. If the measured value is within these limits, a status of ST 12 OK is displayed. If the measured value is outside these limits a status of ST 12 Warning is displayed.

Program Time

Displays the current value of the program time counter. See *Program Time Counter*.

PTP Status

The PTP 1 and PTP 2 sections on the Status tab contain information about the PTP instances corresponding to the two networks ports labeled PTP 1 and PTP 2 respectively.

Note: Option SPG9000-PTP must be licensed for the PTP status items to appear on the web interface.

Main PTP Status

The PTP status sections include some common items that are always visible as in the example, and a details section that depends on the mode and state of the PTP instance.

Mode

Displays the mode of the PTP instance: Lead, Follow, or Ordinary Clock.

State

Displays the state of the PTP instance according to Table 27 of IEEE 1588-2019.

State Name	IEEE 1588 State	Description
Initializing	INITIALIZING	Temporary state when the PTP instance is re-started after some configuration changes
Faulty	FAULTY	Fault state for the instance, usually because the Ethernet link is down or the IP address is mis-configured. Check the rear panel port indicators (see *PTP 1-2 Ports*) for link status. See *Configuration Settings for PTP Network Interfaces* for the IP address settings.
Disabled	DISABLED	PTP instance is currently disabled.
Listening	LISTENING	PTP instance is waiting to receive Announce messages from any PTP leaders on this domain.
Pre-master	PRE_MASTER	Temporary state before the instance becomes a lead clock for the domain
Active or Active Leader	MASTER	Normal state for a leader that is the grandmaster (GM) for the domain. The reference and time-of-day source of this instrument is used for followers in this domain to lock to the GM. If the PTP Mode is set to Ordinary Clock, the state name is shown as Active Leader.
Passive	PASSIVE	Normal state for a leader that is not the GM for the domain. Another PTP leader is functioning as the GM, but this instance can assume the GM role if the Best Master Clock Algorithm (BMCA) decides so. At that point, the instance transitions from Passive to Active.
Uncalibrated	UNCALIBRATED	Temporary state while the PTP instance is making clock adjustments so it can lock to the GM. The instance should transition to the Tracking state when calibration is complete.

State Name	IEEE 1588 State	Description
Adjusting	SLAVE	The follower is locked to the GM for this domain, but the current Offset From Master value is greater than 1 μs.
Tracking or Follower Tracking	SLAVE	Normal state for a follower that is locked to the GM for this domain and the current Offset From Master value is less than 1 μs. If the PTP Mode is set to Ordinary Clock, the state name is shown as Follower Tracking.

Time (TAI)

Displays the current time value that is being used by the PTP instance in its messages. PTP uses International Atomic Time (TAI, Temps Atomique International), which is different from Coordinated Universal Time (UTC) by exactly 37 seconds (as of 2025). TAI is continuous and does not use leap seconds. See *Leap Second Management*.

The Primary Time value displayed at the top right of the Status tab is based on UTC, with adjustments for time zone and DST offsets. Therefore, it differs from PTP TAI time by at least 37 seconds. See *Primary Time*.

IPv4 Address

Displays the link status and IP address for the PTP 1 or PTP 2 port. See *Configuration Settings for PTP Network Interfaces* to configure the IP address parameters.

A colored indicator is used for the link status:

Red: the SFP module is uninstalled, the fiber is not connected, or the link is down for any other reason.

Yellow: the link is active but the interface is waiting for a DHCP server to assign its address.

Green: the link is up. The IPv4 address is displayed next to the indicator.

White: the port is disabled and not in use.

Domain

Displays the domain number for the PTP instance.

Details of Leader PTP Status

The PTP status sections display some information only when the PTP Mode is set to Leader.

Click **Show Details** to see the information. The button changes to Hide Details.

Profile

Displays the PTP profile in use for this instance:

- SMPTE ST 2059-2, typically used for video broadcast applications.

Note: Grandmasters send PTP Management messages once per second with a Synchronization Metadata (SM) TLV. Followers using this profile decode the received SM values.

- AES67, typically used for professional audio applications
- IEEE 1588-2019 Default

Communication Model

Displays the communication model in use by the profile:

- Both Multicast and Mixed: Leader can use either multicast or mixed models, depending on the communication models used by its followers.
- Unicast: All PTP messages are sent to specific IPv4 destination addresses.

Priority 1 and Priority 2

Displays the priority 1 and priority 2 values used by this leader in Best Master Clock Algorithm (BMCA) calculations. A lower number indicates a higher priority.

If the dynamic priority feature is active, the current priority, base priority and offset will be displayed as "98 (100-2)," for example. See *Dynamic Priority* for details.

Clock Identity

Displays the clock identity of this leader instance. The clock identity is an 8-byte value that is constructed from the first 3 bytes of the MAC address of the Ethernet port, followed by 0xFF FE, followed by the last 3 bytes of the MAC address. For example, a MAC address of 00-90-56-01-10-01 (as viewed in the Network Settings section of the System tab, see *MAC Address*) corresponds to a clock identity of 00:90:56:FF:FE:01:10:01.

Note: The first 3 bytes (00:90:56) of the clock identity values used by the SPG9000 correspond to the Organizationally Unique Identifier (OUI) of Telestream, LLC.

Clock Class

Displays the clock class attribute of this leader instance, according to Table 4 of IEEE 1588-2019. Some common values:

- 6: Instance is directly synchronized to a primary reference time source (such as GNSS).
- 7: Instance was previously using clock class 6 but is now in holdover mode.
- 13: Reference source is Genlock Input and the time-of-day source is a time code input (LTC or VITC) or internal time.
- 14: Instance was previously using clock class 13 but is now in Stay Genlock mode.
- 187: Instance is in Ordinary Clock mode and can be a follower in this domain.
- 248: Default value, used if the instrument is using an internal reference.

Clock Accuracy

Displays the clock accuracy attribute of this leader instance, according to table 5 of IEEE 1588-2019. Both the description and the numeric value (in hexadecimal) of the clock accuracy are displayed.

Time Source

Displays the time source attribute of this leader instance, according to table 6 of IEEE 1588-2019. The SPG9000 can use any of these values:

- GNSS
- PTP
- Hand Set (Internal time-of-day)
- Serial Time Code (LTC or VITC)

Details of Follower PTP Status

The PTP status sections display some information only when the PTP Mode is set to Follower.

Click **Show Details** to see the information. The button changes to Hide Details.

Profile

Displays the PTP profile in use for this instance: SMPTE ST 2059-2, AES67, or IEEE 1588-2019 Default

Communication Model

Displays the communication model in use by the profile:

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- Multicast: All PTP messages are sent using the assigned multicast IPv4 destination address for PTP (224.0.1.129).

- Unicast: A ll PTP messages are sent to specific IPv4 destination addresses.

- Mixed Multicast/Unicast: Leaders use multicast for Announce, Sync, Follow_Up, and Management messages. Followers use unicast for Delay_Req messages and the leader also sends the Delay_Resp message as unicast.

GM Clock Identity

Displays the clock identity information that was sent in the Announce message from the leader. See *Clock Identity*.

GM Clock Class

Displays the clock class information that was sent in the Announce message from the leader. See *Clock Class*.

GM Clock Accuracy

Displays the clock accuracy information that was sent in the Announce message from the leader. See *Clock Accuracy*.

GM Time Source

Displays the time source information that was sent in the Announce message from the leader. See *Time Source*.

Offset From Master

Displays the current Offset From Master measurement, defined as the time error between the lead clock and the follower clock as calculated from the PTP message timestamps. This can be a positive or negative offset, ideally close to zero. A stable PTP lock typically has an Offset From Master value of 100 nanoseconds or less.
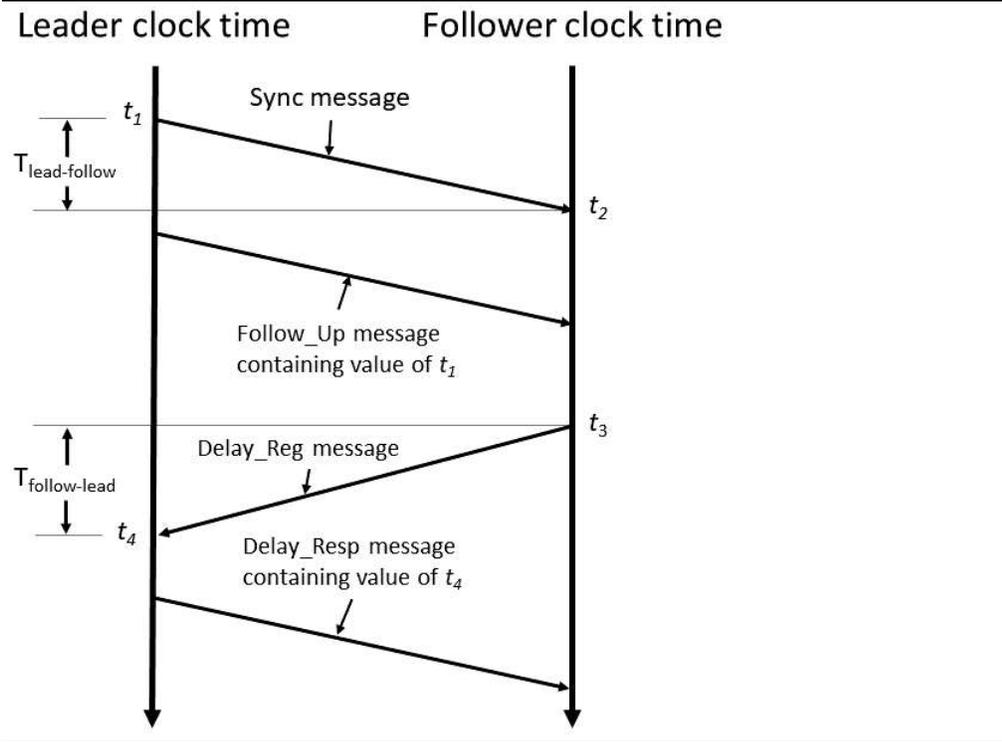
Path Delay

Displays the current Path Delay measurement, defined as the mean of the Leader-Follower Delay and Follower-Leader Delay measurements. Typically, these delay values are a few microseconds or less.

Leader-Follower Delay

Displays the current Leader-Follower Delay measurement, computed from the timestamps used with Sync and Follow_Up messages. The leader-follower delay is $t_2 - t_1$. See the messages example illustration.

Follower-Leader Delay

Displays the current Follower-Leader Delay measurement, computed from the timestamps used with Delay_Req and Delay_Resp messages. The follower-leader delay is $t_4 - t_3$. See the messages example illustration.

Leader clock time   Follower clock time

t_1

$T_{lead\text{-}follow}$

Sync message

t_2

Follow_Up message containing value of t_1

t_3

Delay_Reg message

$T_{follow\text{-}lead}$

t_4

Delay_Resp message containing value of t_4

Announce Rate

Displays the instantaneous and average message rates for Announce messages received from all leaders. This rate can be used to verify that messages are being received from at least one leader and at the expected rate.

Sync Rate

Displays the instantaneous and average message rates for Sync messages received from all active leaders.

Delay_Req Rate

Displays the instantaneous and average message rates for Delay_Req messages received from visible followers.

Delay_Resp Rate

Displays the instantaneous and average message rates for Delay_Resp messages received from all leaders.

Note: All messages received on the Ethernet port are counted, including those from other domains.

SMPTE Synchronization Metadata

This table displays the values decoded from the most recent Management message received with the SMPTE ST 2059-2 Synchronization Metadata (SM) TLV. The PTP profile must be set to ST 2059-2 for this data to be sent from the leader and received by the follower.

System Status

The System section at the bottom of the Status tab displays diagnostic information for the instrument hardware.

Hardware Status

Indicates if the system is operating normally, or if there are any hardware faults or warnings. Select **Show Details** to open a panel with detailed diagnostic information, including:

- Power-On Self Test (POST) results
- Voltage measurements
- Fan speed measurements
- Temperature sensor measurements
- Oven-controlled MEMS oscillator diagnostic values
- Phase-locked loop (PLL) diagnostic values
- Real-time clock (RTC) battery status
- Other internal diagnostic values

If any values are displayed with a Warning or Error indicator, as in the example, the user might need to contact Telestream Technical Support.

Note: The error indicator is displayed when operating with two power supplies but only one supply is connected to the power source. Connect the second supply to the power source to clear the error condition. If the error indicator is still displayed after the power source is connected to both supplies, replace the faulty supply.

Power Supplies

Shows the state of the power supply modules in the instrument. See *Power Supply Monitoring and Replacement* for information on power supply operation.

Select **Show Details** to open a panel with power supply information:

- Measured DC voltage from the power supply
- Number of hours in which the power supply was active or on standby
- Load test history

Reference and Time Sources

This section describes the frequency and time-of-day references for the SPG9000 and how they are used to provide synchronization of its various outputs.

Theory of Operation

The SPG9000 functions by synchronizing its internal clock to a stable frequency source and an accurate time-of-day source. Its outputs are in turn synchronized to that internal clock, ensuring that all devices locked to the SPG9000 are all synchronized with each other.

Epoch-Based Synchronization

The SPG9000 uses epoch-based synchronization. An epoch is a fixed moment in time that is an absolute reference for subsequent events. The SMPTE epoch (defined in ST 2059-1) and the PTP epoch (defined in IEEE 1588-2019) are both 00:00:00 on January 1, 1970 TAI (*Temps Atomique International*). At this time, we can consider video and audio signals of various formats and frame rates to all be aligned with each other.

A video signal with a frame rate of 29.97 (30/1.001) frames per second has a frame duration of about 33.367 ms, but video of 25 fps has a frame duration of 40 ms. At the epoch, and exactly every 1001 seconds afterwards, the two frame sequences are aligned. At any arbitrary time relative to the epoch, we can precisely compute the expected phase of these (or any other) frame rates.
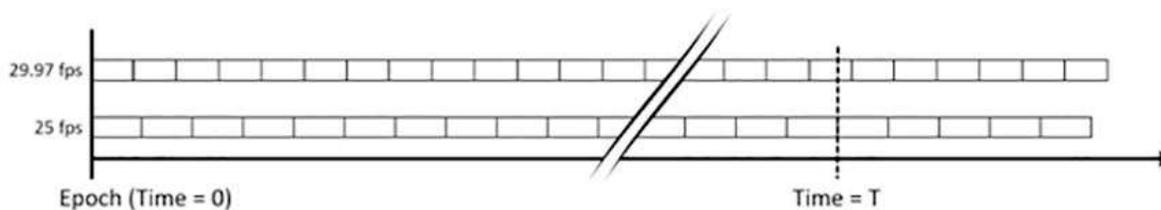
The SPG9000 uses a main time-of-day (MTOD) value that represents the integer and fractional number of seconds since the epoch. For example, a time value of 1677608972.00000000 corresponds to February 28, 2023 at 18:29:32 TAI. TAI time does not include leap seconds, and as of 2025, UTC time is behind TAI by exactly 37 seconds.

When the SPG9000 is synchronized to a GNSS signal it receives a pulse-per-second (1 PPS) signal and a time-of-day value in a data message from its internal GNSS receiver. When synchronized to another PTP grandmaster, it computes the time-of-day value from the exchange of PTP messages. In either case, the SPG9000 adjusts its own MTOD to align with the externally received time so the seconds of the MTOD increment at the same time as the 1 PPS signal.

The SPG9000 also uses three frame-reset signals to synchronize its outputs (Black, LTC, SDI) that can be set to different frame rates:

| Frame Reset	Clock Rate	Video Format or Frame Rate (fps)
1	2.997 Hz	NTSC, 29.97, 59.94, 23.98, 47.95
2	6.250 Hz	PAL, 25, 50
3	3.000 Hz	24, 30, 48, 60

When locked to an absolute time source or when in internal mode, the three frames are all aligned as if they started at the epoch. This enables the frames to have predictable and consistent timing relationships and line up every 4004 seconds.

Phase Adjustment

When the SPG9000 is initially powered up and locks to the external reference, there is a phase difference between the external and internal clocks. The SPG9000 forces the internal clock to match the external reference for the initial lock and a quick startup.

When the instrument is locked to an external reference source, its internal clock is continually and slowly adjusted to align with the external reference clock. These adjustments are small so the SPG9000 remains locked without any sudden synchronization or abrupt phase changes.

Afterward, in normal operation, there could be a disruption to the external reference, such as GNSS signal loss. In this case the SPG9000 goes into holdover mode and uses its internal clock to maintain the timing based on the signal history just before signal loss. If the instrument remains in holdover mode for an extended period, a timing offset from the external reference accumulates.
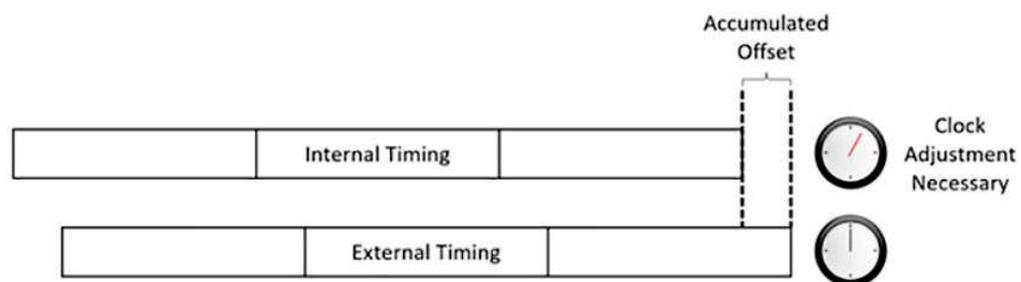
When the external reference is restored, the SPG9000 finds the actual offset between its internal clock to the reference source. The SPG9000 then goes into holdover recovery

mode to re-align the internal clock to the reference clock. The SPG9000 can slowly make this adjustment within clock tolerances that are compliant with SMPTE standards or the SPG9000 can force the adjustment for instant recovery. The stay legal mode (adjustment-within-clock-tolerances method) can take a long time to recover (about 300 seconds for 64 µs line of timing error) but no synchronization shock occurs.

Reference Sources

There are four choices for the Reference source of the instrument.

Internal

The system uses its internal oven-controlled MEMS oscillator as the timing reference for the instrument. External devices can synchronize to this SPG9000 and synchronize relative to each other, but the SPG9000 itself has independent timing relative to any unconnected devices.

Genlock Input

The system uses the video sync signal received at the loop-through connectors labeled REF LOOP, typically a NTSC or PAL black burst analog video signal, an HD tri-level signal, or a 10 MHz continuous wave (CW) signal. See *Genlock Reference*.

GNSS Signal

The system uses the PPS output from an integrated GNSS receiver as the timing reference for the instrument. See *GNSS Receiver Settings* for configuring the GNSS receiver.

Note: The SPG9000-GNSS option must be licensed for this reference source to be available.

PTP Follower

The system uses an internal PPS signal that is synchronized to an external PTP grandmaster. This source is only available if at least one of the PTP instances is configured as a follower. See *Configuration Settings for PTP Instances*.

Note: The SPG9000-PTP option must be licensed for this reference source to be available.

Secondary Reference

When the primary reference source of the SPG9000 is configured for the GNSS signal, a secondary reference source may also be configured. This provides additional resiliency

and stability in situations where the GNSS signal may be unreliable. When the system switches from primary (GNSS) to secondary reference, the time-of-day is maintained and the secondary source is used as a frequency reference only.

Two choices are available for the secondary reference source:

- CW 10 MHz signal on the Genlock Input
- PTP Follower

The CW 10 MHz secondary source would typically be used with an external rubidium or cesium atomic clock, to provide a higher-accuracy frequency reference than the SPG9000's internal oscillator that is normally used in holdover mode.

The PTP Follower secondary source is useful as a backup source from a PTP grandmaster from another network, such as an adjacent building or truck.

The reference can be set to automatically switch from the primary source to the secondary source when the GNSS signal is lost, or you can manually switch between sources. For example, the GNSS signal can be used to obtain the accurate time-of-day value, then manually switch to CW 10 MHz for a more stable frequency reference. As required, you could periodically switch back to GNSS to reacquire the time-of-day and then return to the CW signal.

Time-of-Day Sources

The SPG9000 maintains a main time-of-day (MTOD) value that represents the current TAI time. An accurate time-of-day source is necessary for epoch-based synchronization as described above. The MTOD can be modified by various offsets when creating time code outputs. For example, the leap seconds offset is added to TAI time to create UTC time, then a time-zone offset and a daylight-saving-time offset could be applied to the MTOD to create the local time.

There are five options for the MTOD source. The time-of-day source is constrained by the reference source, with seven combinations possible:

Reference	Time-Of-Day Source	Notes
Internal	Internal	
	LTC Input	Only available when LTC 1 is configured as Input. See *LTC 1 Mode*.
Genlock Input	Internal	
	VITC Input	Only available when Genlock Input format is NTSC or PAL. See *Configuration Settings for Genlock Input*.
	LTC Input	Only available when LTC 1 is configured as Input. See *LTC 1 Mode*.

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Reference	Time-Of-Day Source	Notes
GNSS Signal	GNSS Signal	
PTP Follower	PTP Follower	

Internal

The system uses a user-supplied date and time value that is entered from the front-panel interface, the web interface, or the application programming interface. The system can also be configured to update the internal time from an external Network Time Protocol (NTP) server using the management network interface. When set, the MTOD accurately tracks real time. The internal time is maintained by a battery-backed, real-time clock (RTC) that preserves the time when the system is powered off. The RTC is automatically updated with the time when the system initially locks to a GNSS signal or PTP leader.

VITC Input

The system reads the date and time from the vertical interval time code (VITC) decoded from the received genlock input signal. The genlock input format must be NTSC Burst or PAL Burst because other genlock input formats (HD tri-level or CW 10 MHz) do not carry VITC data. If the time code only includes time information (hours, minutes, seconds, and frames) but not the date information (year, month, and day), according to SMPTE ST 309, the internal date (from the RTC) is used.

LTC Input

The system reads the date and time from the linear time code (LTC) signal received on the LTC 1 pins of the LTC/GPI connector. See *LTC/GPI Connector*. LTC 1 can be configured as input or output (see *LTC 1 Mode*) and therefore must be set to input for this time source to be available. If the time code only includes time information (hours, minutes, seconds, and frames) but not the date information (year, month, and day), according to ST 309, the internal date (from the RTC) is used.

GNSS Signal

The system uses the date and time information decoded from the received GNSS signal. This time-of-day source is automatically selected and is the only option when the reference source is set to GNSS Signal.

Note: The SPG9000-GNSS option must be licensed for this reference source to be available.

PTP Follower

The system uses the date and time data received from the PTP follower instance. This time-of-day source is automatically selected and is the only option when the reference source is set to PTP Follower.

Note: The SPG9000-PTP option must be licensed for this reference source to be available.

Reference and Time Sources

The reference and time-of-day sources are closely related, and should be configured together.

Web Interface for Reference

On the SPG9000 web interface, click the **Reference** tab.

Front-Panel Menu for REFERENCE

To use the front panel of the SPG9000 for this process, press **REF**. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the REFERENCE menu.

REFERENCE :	
PRIMARY SOURCE	
SECONDARY SOURCE	Only available if PRIMARY SOURCE is GNSS Signal
ACTIVE SOURCE	Only available if SECONDARY SOURCE is not None
GENLOCK :	Only available if PRIMARY SOURCE is Genlock Input
PTP FOLLOWER	Only available if PRIMARY SOURCE is PTP Follower
LOSS OF LOCK ACTION :	Not available if PRIMARY SOURCE is Internal
HOLDOVER RECOVERY	Only available if PRIMARY SOURCE is GNSS Signal or PTP Follower
GNSS RCVR :	Requires SPG9000-GNSS license to be enabled

Configuration Overview

Setting the reference and time-of-day sources to the configuration is a multistep process for each of the four reference sources:

Set GNSS Signal Source

1. Configure the GNSS receiver. See *GNSS Receiver Settings*. Wait for a Locked signal. See *GNSS Status Value*.

2. On the **Reference** tab, in Primary Source, select **GNSS Signal**. The time-of-day source automatically changes to GNSS Signal.

3. Set the *Loss of Lock Action* and *Holdover Recovery* behavior.

4. Configure the *Secondary Reference* if desired.

Set PTP Follower Source

1. Configure one or both of the PTP instances as a follower or Ordinary Clock. See *Configuration Settings for PTP Instances*. Wait for the PTP instances to reach the Tracking state. See *PTP Status*.

2. On the **Reference** tab, in Primary Source, select **PTP Follower**. The time-of-day source automatically changes to PTP Follower.

3. If both PTP instances are configured as followers, configure the single or dual follower modes. See *PTP Follower*.

4. Set the *Loss of Lock Action* and *Holdover Recovery* behavior.

Set Genlock Input Source

1. On the **Reference** tab, in Primary Source, select **Genlock Input**.

2. Configure the *Configuration Settings for Genlock Input* including Genlock Timing.

3. Set the *Loss of Lock Action* and *Holdover Recovery* behavior.

4. If LTC Input is the required time-of-day source, configure the LTC 1 connector pins to Input mode. See *LTC 1 Mode*.

5. On the SPG9000 web interface, click the **Time** tab.

6. In Primary Reference, select one of VITC Input, LTC Input, or Internal.

7. Configure the time code input settings if applicable. See *LTC/VITC Mode* and *SMPTE 309 Data*.

8. Set the *Internal Date/Time* if applicable.

Set Internal Source

**1.** On the **Reference** tab, in Primary Source, select **Internal**.

2. If LTC Input is the required time-of-day source, configure the LTC 1 connector pins to Input mode. See *LTC 1 Mode*.

3. On the SPG9000 web interface, click the **Time** tab.

4. In Primary Reference, select either LTC Input or Internal.

5. Configure the time code input settings if applicable. See *LTC/VITC Mode* and *SMPTE 309 Data*.

6. Set the *Internal Date/Time* if applicable or synchronize the internal time from a remote NTP server. See *Network Time Protocol*.

Configuration Settings for Reference

The reference settings are configured from the Reference tab of the web interface.
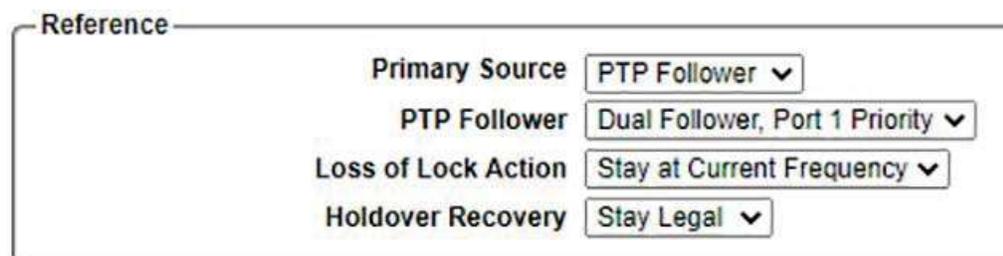
To use the front panel for this process, see *Front-Panel Menu for REFERENCE*.

Primary Source

Selects the current reference source for the instrument, as described in the *Reference Sources*.

Reference	Time-Of-Day Source	Notes
Internal	Internal	
	LTC Input	Only available when LTC 1 is configured as Input. See *LTC 1 Mode*.

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Reference	Time-Of-Day Source	Notes
Genlock Input	Internal	
	VITC Input	Only available when Genlock Input format is NTSC or PAL. See *Format*.
	LTC Input	Only available when LTC 1 is configured as Input. See *LTC 1 Mode*.
GNSS Signal	GNSS Signal	
PTP Follower	PTP Follower	

The GNSS Signal option is only available if the SPG9000-GNSS license is enabled. The PTP Follower option is only available if the SPG9000-PTP license is enabled, and at least one PTP instance is configured as a follower. See *Configuration Settings for PTP Instances*.

Secondary Source

Selects the secondary reference source that is used when the primary reference source is unlocked or manually deselected. The secondary source is only available when the primary source is configured to GNSS Signal.

Genlock Input (10 MHz CW): Selects the Genlock Input source for a 10 MHz CW signal. Other genlock formats, such as NTSC Burst, PAL Burst, or HD Tri-Level sync signals are not available for the secondary reference source.

PTP Follower: Selects a PTP Follower. This option is only available if at least one PTP instance is configured as a follower. See *Configuration Settings for PTP Instances*.

None: Disables the secondary reference source. If the primary source is unlocked, the instrument will directly go to holdover mode.

Active Source

Selects the active source when both primary and secondary reference sources are configured.

Auto: Automatically switches from primary to secondary reference when the primary source is unlocked, and switches back to the primary source when the signal is restored.

Primary: Manually selects the primary reference source, even if the signal is missing or unusable.

Secondary: Manually selects the secondary reference source, even if the signal is missing or unusable.

Note: The reference status on the web interface includes colored indicators for the health of the primary and secondary reference sources, so you can check the signal quality prior to manually switching sources. See *Reference Status*.

PTP Follower

Selects how PTP instances are used for the reference source. This setting is only applicable when the reference source is set to PTP Follower. If only one PTP instance is set to follower mode, that instance is used. If both PTP instances are available as followers, then this setting determines which instance (or both) is used for the reference source.

PTP 1 Only or **PTP 2 Only**: Uses the specified instance as the reference source. The other PTP instance still operates as a follower and takes performance monitoring measurements if it is tracking its leader. This is useful if the user wants the second PTP instance strictly as a monitoring node on the PTP network.

Dual Follower, **Port 1 Priority** or **Dual Follower**, **Port 2 Priority**: Uses either instance as the reference source, with the specified instance as the preferred source. This selection is useful when redundant networks are used, such as with SMPTE ST 2022-7. If the preferred PTP follower loses its lock, the other instance becomes the reference source. The instrument goes into holdover mode briefly during this transition. If both instances lose their PTP lock, the instrument enters holdover mode. If one instance relocks to its PTP grandmaster, it resumes its role as the reference source. If both instances relock, the priority instance is the reference source.

Loss of Lock Action

Selects the instrument's behavior when a loss of lock event occurs. This setting is not applicable when the reference source is set to Internal.

Stay at Current Frequency: Sets the system timing to keep operating at the current frequency from just prior to the loss of lock event. This mode is called Stay Genlock™ when the reference source is Genlock Input, and *holdover* when the reference source is either GNSS Signal or PTP Follower.

Use Internal Frequency: Sets the system timing to use the internal clock at the frequency of the current calibration until the reference source is recovered.

Holdover Recovery

Selects the instrument's behavior when the reference signal is restored after a loss of lock. This setting is only applicable if the reference source is set to GNSS Signal or PTP Follower.

Stay Legal: Adjusts the system clock to match the external reference while staying within the specified frequency offset and frequency rate of change specifications for NTSC and PAL reference signals.

Jam Phase: Adjusts the system clock to match the external reference immediately. This causes a synchronization shock to the system.

Fast Slew: Adjusts the system clock to match the external reference at a rate 25 times faster than the Stay Legal rate, but does not jam and cause synchronization shock.

Web Interface for Time of Day

On the web interface, select the **Time** tab.

Depending on what Primary Source is selected in the Reference tab (Internal, GNSS Signal, PTP Follower, Genlock Input), the Primary Source in Time of Day will have different options with different options following.

Front-Panel Menu for TIME OF DAY

To use the front panel of the SPG9000 for this process, press **TIME** and then select the **TIME OF DAY** option. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for TIME OF DAY.

TIME :	
TIME OF DAY :	
SOURCE :	
INTERNAL	Only available if SOURCE is Internal
TIME CODE MODE :	Only available if SOURCE is LTC Input or VITC Input
ST 309 DATA :	Only available if SOURCE is LTC Input or VITC Input
TIME ZONE OFFSET :	
NTP CLIENT :	
NTP SERVER :	
DST SCHEDULE :	
PROGRAM TIME :	
JAM SYNC :	
LEAP SECOND :	

Configuration Settings for Time of Day

Configuring the time of day provides a point of reference for the SPG9000. There are several potential sources for this and several aspects of the internal time.

Primary Source

Selects the current time source for the instrument, as described in *Time-of-Day Sources*. When the reference source is changed, the time-of-day source can be coerced to a valid combination. For example, if the reference source is changed to GNSS Signal, the time source also changes to GNSS Signal. Choose the required reference source before choosing the time-of-day source.

Internal Date/Time

Sets the main time-of-day (MTOD) and the internal real-time clock (RTC) to the specified date and time. These values can only be set manually if the time source is Internal. Click the Update Now button to change both time and date to the new values.

Time Zone Offset

Sets the offset from UTC (in hours and minutes) for the local time zone. A leading plus or minus sign represents time zones west or east of UTC respectively. For example, an offset of +01:00 would be used for Central European Time (CET) and an offset of -05:00 would be used for Eastern Standard Time (EST).

LTC/VITC Mode

Selects the synchronization mode when time code (either LTC or VITC) is used as the time-of-day source. This setting is only available if the time-of-day source is either LTC Input or VITC Input.

Follow: The time of day follows the time code on the input signal if the signal is stable for at least 100 consecutive frames. If the time code input has any discontinuity, the MTOD also jumps to the new value.

Synchronize Once: The time code on the input signal is continuously monitored until a stable signal is received (at least 100 consecutive frames). At that time, the time of day synchronizes (one time) to this reference. After that, the MTOD counts according to the internal clock.

Synchronize Now: The time of day attempts to synchronize with the time code on the input signal when the user clicks the Synchronize Now button. A total of ten attempts to synchronize are made. After ten attempts, no further attempts are made to synchronize regardless if synchronization occurred or failed. A stable signal of at least 100 consecutive frames is needed.

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SMPTE 309 Data

Sets the mode for handling date and time zone information that can be present in the time code data according to the SMPTE ST 309M. This setting is only available if the time-of-day source is either LTC Input or VITC Input.

Ignore: The hours, minutes, seconds, and frames digits of the time code input are used to set the MTOD, but the date and time zone information from the time code input are ignored. The date from the internal real-time clock and the user-specified time zone offset are used instead. This setting is appropriate if the received time code input lacks the date and time zone information, which is possible because ST 309M is not mandatory for ST 12 time code.

Use as Input: The date, time zone, and daylight saving information from the time code input are used to set the MTOD (along with the hours, minutes, seconds and frames digits). For example, if the received time code value is 2023-01-01 20:00:00 with a signaled time zone offset of UTC–08:00, the MTOD is set to 2023-01-02 04:00:37 (TAI). The extra 37 seconds represents the offset from UTC (time code input) and TAI (uses for MTOD). However, in this mode the time code data on LTC and VITC outputs are recalculated using the user-specified time zone offset and any daylight saving time offset. This mode is useful if the incoming time code data is from a different time zone than the outputs the user intends to create.

Use as Output: The date, time zone, and daylight saving information from the time code input are used to set the MTOD. The information is also used for time code outputs. The user-specified time zone offset is ignored. This mode ensures that time code outputs match the time code input.

Network Time Protocol

The SPG9000 can function as a Network Time Protocol (NTP) server, to distribute time to client devices on the same network as the management interface. The SPG9000 can also function as an NTP client to initialize the internal time and date from a remote NTP server.

Web Interface for NTP

On the web interface, click on the **Time** tab.

Front-Panel Menu for NTP

To use the front panel of the SPG9000 for this process, press TIME and then select the NTP option. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for NTP.

TIME :
TIME OF DAY :
NTP CLIENT :
UPDATE
REMOTE SERVER 1
REMOTE SERVER 2
UPDATE ON RESTART
NTP SERVER :
SERVICE LEVEL
RATE LIMITING
DST SCHEDULE :
PROGRAM TIME :
JAM SYNC :
LEAP SECOND :

Configure Settings for NTP Client

The SPG9000 only functions as an NTP client when the reference source is set to either Genlock Input or Internal and the time-of-day source is set to Internal. When the time-of-day source is set to GNSS Signal or PTP Follower, the MTOD continuously follows the accurate time source. When the time-of-day source is Internal, NTP is not used to continuously update the MTOD; instead, NTP updates the current UTC time one time and the internal clock accurately tracks real time from that starting point.

Remote Servers

Specify one or two remote NTP servers; use an IP address or a host name (fully qualified domain name). If the first server does not respond, the second server is used.

Note: If you use host names for the remote NTP server(s), you will need to configure the DNS server to resolve the name. See *Configuration Settings for NETWORK*.

Update Internal Time Now

Press to manually update the MTOD from the remote NTP server. If the request is successful, the Last Update time is updated with the current local time. This time can be used to determine how long the instrument has been running with the internal clock since it was updated using NTP.

In addition to using the web interface or front-panel interface, the internal time can also be updated from the remote NTP server from a General Purpose Interface input action, or from an API request. See *General Purpose Interface* and *HTTP API*.

Update on Restart

When this option is enabled, the SPG9000 automatically makes a request to the NTP server shortly after the instrument is powered on. This is useful if the power-on default preset includes an Internal time-of-day source and the instrument is frequently powered off and on again, such as in a mobile production truck.

Configure Settings for NTP Server

The SPG9000 can be an NTP server for other clients on the local network. This is useful to distribute accurate time from a GNSS or PTP source to devices that only have a standard network interface.

NTP uses stratum levels to describe the expected accuracy of the system clock. Stratum 0 is defined as the reference clock, such as the internal GNSS receiver or PTP engines within the SPG9000. The stratum level is increased for each "hop" in the network from that reference. Therefore, when the SPG9000 is using the GNSS signal or PTP follower as the time-of-day source, it identifies itself as a stratum 1 server in its NTP messages. A client that receives time from the SPG9000 is a stratum 2 device, and so on.

When the SPG9000 does not have a GNSS or PTP time source, it cannot claim to be a stratum 1 server. When the time-of-day source is Internal, or is a time code input (LTC or VITC), the SPG9000 uses stratum 12 for its NTP messages. This value should be low enough that if a higher stratum server is available, client uses it instead of the SPG9000; but if the SPG9000 is on an isolated network with no other NTP server options, it can still distribute time.

Service Level

Select the operational mode of the NTP server.

Disabled: The SPG9000 does not respond to requests from remote NTP clients.

Stratum 1 only: The NTP server only functions when the time-of-day source is either a GNSS signal or PTP follower.

Stratum 1 or Stratum 12: The NTP server always functions using the stratum level that corresponds to the current time-of-day source.

Note: For a few minutes after the instrument is powered on, responses from the NTP server indicates it is still uninitialized. After the server determines the clock is stable, it responds using stratum 1 or stratum 12, as appropriate.

Rate Limiting

Enable or disable rate limiting for received requests. The NTP server of the SPG9000 has an algorithm to guard against denial-of-service (DoS) attacks. The server will limit the rate at which each individual client may request the time. The long-term average message rate from the client may not exceed one request every 8 seconds. This limit applies to each separate source IP address, so the server can respond to hundreds of messages per second as long as they originate from multiple IP addresses, with each address observing the 1 message per 8 second limit.

Note: It is recommended to only disable the rate limiting function if the SPG9000 is only accessible from a trusted network.

Genlock Reference

When the reference source is set to Genlock Input, additional configuration is necessary. The Genlock Input settings are configured from the Reference tab on the web interface and from the REFERENCE : GENLOCK submenu from the front-panel interface.

Web Interface for Genlock Input

On the web interface, click the **Reference** tab and set the Primary Source to **Genlock Input**. The sample shows a Genlock Input section with additional configuration settings.

Front-Panel Menu for GENLOCK

To use the front panel of the SPG9000 for this process, press **REF** and then select the **GENLOCK** option. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for GENLOCK. The GENLOCK submenu is only available when the SOURCE is Genlock Input.

REFERENCE :	
SOURCE	
GENLOCK :	
INPUT FORMAT	
TIMING :	Not available if INPUT FORMAT is 1 pps
Vertical	
Horizontal Coarse	
Horizontal Fine	
ACTION MODE	
MANUAL LOCK	
LOSS OF LOCK ACTION	
HOLDOVER RECOVERY	
GNSS RCVR :	Requires SPG9000-GNSS license to be enabled

Configuration Settings for Genlock Input

The additional configuration of Genlock Input helps the SPG9000 use the incoming signal.

Format

Selects the expected format for the input signal received at the REF LOOP connector:

NTSC Burst: Sets the expected input format as NTSC black burst (525 lines at 59.94 interlaced fields per second). The signal can have a black level at either 7.5 IRE (NTSC-M) or 0 IRE (NTSC-J, as used in Japan).

PAL Burst: Sets the expected input format as PAL black burst (625 lines at 50 interlaced fields per second).

HD Tri-Level: Sets the expected input format as a tri-level sync signal. The SPG9000 supports genlock using one of several different tri-level formats:

1080 60i	1080 30p	1080 24sF	720 60p
1080 59.94i	1080 29.97p	1080 23.98sF	720 59.94p
1080 50i	1080 25p		720 50p
	1080 24p		
	1080 23.98p		

The instrument automatically detects the specific frame rate, scan type (interlaced, progressive, or segmented frame), and number of lines (1080 or 720) for the input HD tri-level signal.

CW 10 MHz: Sets the expected input format as a continuous wave (CW) signal at 10 MHz frequency.

Lock Action Mode

Selects the behavior after a loss of lock condition and the system is able to relock to the genlock input signal.

Auto: The instrument automatically relocks to the genlock input signal when possible. This could potentially cause a disruption (synchronization shock) to the system timing.

Manual: The instrument waits for the user to manually relock. This mode is useful to avoid synchronization shock at an inconvenient time. While waiting for approval, the EXT indicator (on the front panel and the web interface banner) is red, and the reference status on the web interface shows "Unlocked - Waiting for Manual Lock".

Click **Lock Now** to force the genlock.

Genlock Timing

The Genlock Timing settings adjust the timing offset of the SPG9000 clock relative to the input signal. The selections are only available when the reference source is set to Genlock Input.

The total timing offset is a combination of whole lines (vertical delay) and partial lines (horizontal delay). A negative value means the clock is advanced relative to the genlock input.

Vertical Delay

Enter an integer number of lines in 1-line increments.

Horizontal Delay

The horizontal delay value is the sum of a coarse value (in microseconds) and a fine value (in nanoseconds). Enter the horizontal coarse value in increments of the clock used for the output format. For NTSC and PAL, a 54 MHz clock is used so each coarse step is about 0.0185 µs. For HD tri-level sync formats, a 74.25 MHz clock (integer frame rates) or a 74.1758 MHz clock (non-integer frame rates) is used so each coarse step is about 0.0135 µs. Enter the horizontal fine value in increments of 0.1 ns.

The range of the timing adjustment depends on the selected signal format:

Format	Vertical (lines)	Horizontal Coarse (µs)	Horizontal Fine (ns)
NTSC	± 525	± 63.5556	± 10.00
PAL	± 1250	± 64.0000	± 10.00
1080 60i	± 562	± 29.6296	± 7.00
1080 59.94i	± 562	± 29.6593	± 7.00
1080 50i	± 562	± 35.5556	± 7.00

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Format	Vertical (lines)	Horizontal Coarse (µs)	Horizontal Fine (ns)
1080 30p	± 562	± 29.6296	± 7.00
1080 29.97p	± 562	± 29.6593	± 7.00
1080 25p	± 562	± 35.5556	± 7.00
1080 24p	± 562	± 37.0370	± 7.00
1080 23.98p	± 562	± 37.0741	± 7.00
1080 24sF	± 562	± 37.0370	± 7.00
1080 23.98sF	± 562	± 37.0741	± 7.00
720 60p	± 375	± 22.2222	± 7.00
720 59.94p	± 375	± 22.2444	± 7.00
720 50p	± 375	± 26.6667	± 7.00
CW 10 MHz	± 1125	± 64.0000	n/a

GNSS Receiver Settings

If the reference source is set to GNSS Signal, additional configuration of the internal GNSS receiver might be necessary.

Note: The SPG9000-GNSS license must be enabled for these menus to be available.

Web Interface for GNSS Receiver

On the SPG9000 web interface, click the **Reference** tab.

Front-Panel Menu for GNSS RCVR

To use the front panel of the SPG9000 for this process, press **REFERENCE** and then select the **GNSS RCVR** option. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for GNSS RCVR.

```
REFERENCE :
    SOURCE
    GENLOCK :
    LOSS OF LOCK ACTION :
    HOLDOVER RECOVERY
    PTP FOLLOWER
    GNSS RCVR :                    Requires SPG9000-GNSS license to be enabled
        CONSTELLATION
        ANTENNA POWER
        CABLE DELAY
        POSITION
        ACQUIRE POSN
        SIGNAL WARNING
```

Configuration Settings for GNSS Receiver

The additional configuration of the GNSS receiver helps the SPG9000 find and track the satellite and satellite signal.

GNSS Constellation

Selects the satellite constellation to track. The SPG9000 can receive data from up to four different global navigation satellite systems and one regional system:

GNSS	System Name	Operator	Coverage
GPS	Global Positioning System	United States	Global
GLONASS	Global Navigation Satellite System	Russia	Global
Galileo	Galileo	European Union	Global
BeiDou	BeiDou Navigation Satellite System	China	Global
QZSS	Quasi-Zenith Satellite System	Japan	Regional (Asia-Oceania, centered around 135° E longitude)

Select one of the specific combinations of available systems:

- GPS Only
- BeiDou Only
- Galileo Only
- GPS + GLONASS
- GPS + BeiDou

- GPS + Galileo

- GPS + QZSS

- GPS + BeiDou + Galileo + GLONASS

For most applications, the GPS + BeiDou + Galileo + GLONASS selection is the best choice because more satellites are available to compute the timing solution.

Antenna Power

Selects the power setting for the GNSS Antenna connector on the rear panel:

Off: No power is supplied to the GNSS antenna

3.3 Volt: Supplies 3.3 V DC to power the GNSS antenna

5 Volt: Supplies 5 V DC to power the GNSS antenna

CAUTION: To avoid antenna damage, do not turn on the DC antenna power until you know the antenna is designed to handle the specific voltage. Antenna damage can occur if the antenna is not designed to handle the selected voltage.

When the GNSS ANT connector is configured to provide power to the antenna, the rear panel POWER indicator is on:

- Blinking green means an open circuit. This occurs if no antenna is connected or if the current load is less than expected because a splitter or DC block is being used.

- Solid red means the connected antenna is shorted. A shorted antenna does not damage the GNSS receiver. If a splitter is used on the antenna, it might appear as a short at DC but still pass through the RF signal, which would allow the internal GNSS system to function.

- Solid green means the current load of the antenna is within the nominal range.

Cable Delay

Sets a delay value to compensate for the cable length from the antenna to the instrument. The propagation delay depends on the cable type but is typically 5 nanoseconds per meter. The timing delay can be adjusted to a maximum of 99 microseconds. The delay value is negative to compensate for the positive delay from the physical cable.

Position

Selects the mode in which the GNSS receiver calculates time and position information:

Fixed: An averaged position is stored in flash memory, and only the time is calculated each second. This provides greater stability of the time information and

allows operation with fewer satellites. This mode is well suited to installations such as a broadcast facility, where the antenna and instrument do not move.

Mobile: Recalculates both the position and time each second. This allows for compensation of velocity and acceleration, so the frequency and timing information stay correct while moving, at the expense of some stability. This mode is required if the antenna and instrument are moving, such as an electronic news gathering vehicle.

For applications where the position changes occasionally, but where the antenna and instrument are not moving, then either mode can be applicable. Mobile mode might start up faster since it does not need to average 60 fixes to establish a fixed location. However, fixed mode can operate with fewer satellites when the position is stored.

Signal Warning Threshold

Selects the GNSS status level below which a warning notification would occur.

There are several possible ways a user can be notified:

- If the reference source is set to GNSS Signal, the EXT indicator on the front panel and the web page is yellow. See *Indicators*.

- A message at the warning severity level is sent to the system log. A message at the informational severity level that includes GNSS signal information is also sent to the system log every 32 seconds, even if the signal status has not dropped below the warning threshold. See *Syslog*.

- An SNMP trap message is sent. See *SNMP*.

- If the reference source is set to GNSS Signal, a Lock Warning alarm can be signaled. See *General Purpose Interface*.

Select the signal warning threshold level. See *GNSS Status* for a complete list of status levels.

Locked Warning: The GNSS receiver is reporting possible jamming (signal interference from external sources) or spoofing (incorrect signals received from external sources) of the received signal.

Locked Minimum: The GNSS signal has data from 4 or more satellites with a carrier-to-noise ratio (C/N) of 10 dB or better.

Locked Nominal: The GNSS signal has data from 4 or more satellites with C/N of 30 dB or better.

Locked Strong: The GNSS signal has data from 8 or more satellites with a carrier-to-noise ratio (C/N) of 40 dB or better.

For example, if the threshold is set to Locked Warning, a notification occurs if the GNSS Status is in any of the unlocked states (from No Signal to Acquiring Position). If the threshold is set to Locked Strong, a notification occurs if the GNSS Status is any other state.

Daily Jam Sync

For installations that use drop-frame time code, such as NTSC black outputs with VITC, a daily jam sync event is required.

Drop-frame time code (defined in ST 12-1) is used for non-integer frame rates, specifically 29.97 (30/1.001) and 59.94 (60/1.001) frames per second. In actuality, video frames aren't dropped; instead, the frame counter skips two counts every minute, except for every 10th minute. For example:

HH:MM:SS;FF	Description
12:06:23;29 12:06:24;00 ...	30 fps time code normally counts frames from 00 to 29 each second. When the seconds digits change from 23 to 24, the frame counter rolls over from 29 to 00.
12:07:59;29 12:08:00:02 ...	The 00 and 01 frame counts are skipped when the minutes digits change, in this case from 07 to 08. The frame digits skips from 29 to 02.
12:09:59;29 12:10:00;00	When the minutes digits change to 00, 10, 20, 30, 40, or 50, the frames digits do not skip 00 and 01, but roll over from 29 to 00.

There are 107,892 frames counted in a time code hour, such as from 00:00:00;00 to 01:00:00;00, but the true frame rate of 30/1.001 results in approximately 107,892.108 frames per hour, that is, with 0.108 more fractional frames every hour. The drop-frame algorithm corrects for most of the difference between 30 fps count and 30/1.001 frame rate, but there is a small difference that accumulates approximately 2.6 frames every 24 hours.

To prevent that offset from diverging indefinitely, the solution is to perform a regular (daily) jam sync. At the scheduled time, 2 or 4 additional frame counts are skipped.

Web Interface for Jam Sync

On the SPG9000 web interface, click the **Reference** tab.
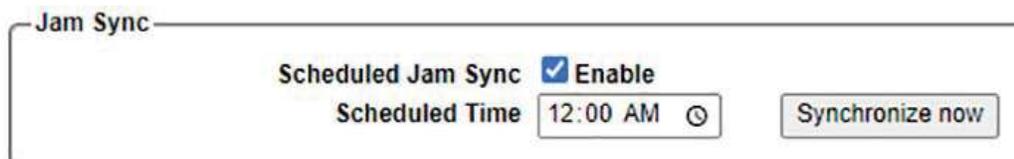
Front-Panel Menu for JAM SYNC

To use the front panel of the SPG9000 for this process, press **TIME** and then select **JAM SYNC**. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for JAM SYNC.

```
TIME :
     TIME OF DAY :
     NTP CLIENT :
     NTP SERVER :
     DST SCHEDULE :
     PROGRAM TIME :
     JAM SYNC :
        MANUAL
        MODE
        SCHEDULED TIME
     LEAP SECOND :
```

Configuration Settings for Jam Sync

The jam sync configuration enables the jam sync and defines when it happens.

Scheduled Jam Sync

Select to enable a daily jam sync. We recommend this when using 30 fps drop-frame time code on any outputs, but is not needed when working exclusively with integer frame rates such as PAL and 25 fps.

Scheduled Time

Enter the local time of day (hours and minutes) for the daily jam sync. Typically, a time such as 02:00 am is used in broadcast applications, when the viewing audience is small. The selected time must have minutes digits of 00, 10, 20, 30, 40, or 50 past the hour.

Daylight Saving Time Management

In several parts of the world, daylight saving time (summer time) is in effect during warmer months so darkness occurs at a later time in the day. Typically, local clocks are advanced one hour in the spring and return to standard time (winter time) in autumn.

On the SPG9000, a daylight saving time offset is used (along with the time zone offset) to compute the local time that can be used in time code outputs.

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Web Interface for Daylight Saving Time

On the SPG9000 web interface, click the **Time** tab.

Front-Panel Menu for DST SCHEDULE

To use the front panel of the SPG9000 for this process, press **TIME** and then select the **DST SCHEDULE** option. See *Menu Operations* for details of using the front-panel menus. The table shows the menus for DST SCHEDULE.

TIME :
TIME OF DAY :
NTP CLIENT :
NTP SERVER :
DST SCHEDULE :
MODE
OFFSET
ONCE DATE/TIME
RECURRING START
RECURRING END
PROGRAM TIME :
JAM SYNC :
LEAP SECOND :

Configuration Settings for Daylight Saving Time
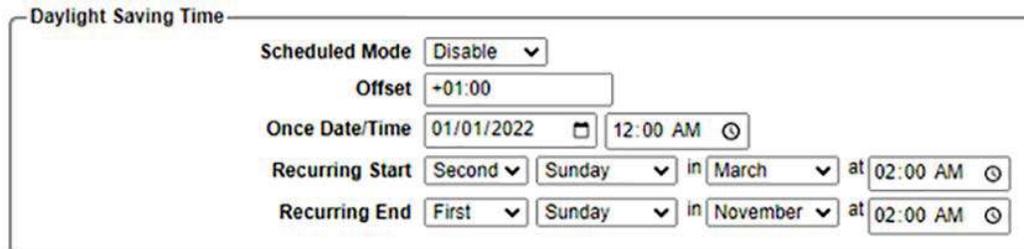
The daylight saving time configuration allows the SPG9000 to change the internal time as needed when DST starts and ends.

Scheduled Mode

Selects the daylight saving schedule mode used by the instrument:

Disable: No daylight saving time offset is used.

Once: At the specified time, the daylight saving offset is applied and the mode resets to Disable. That is, only a single time change is scheduled until the user sets a new schedule.

Recurring: Use the rules defined by the Recurring Start and Recurring End menus to keep an indefinite schedule of DST changes. We recommend this mode for most applications.

Offset

Enter the time offset (hours and minutes) to apply when the daylight saving event occurs. For the Once mode, the offset is applied a single time. Use a positive offset to advance the local clock to daylight saving time or a negative offset to return the local clock to standard time.

Once Date/Time

Enter the date and local time of day (hours and minutes) for the daylight saving time event to occur for Once mode.

Recurring Start

Enter the relative date and local time of day for daylight saving time to begin. The relative date is described using the day of the week and the ordinal number (for example First, Second, Last) of that day within the month. The rules (as of 2025) for daylight saving time in several parts of the world are listed:

Regions	Start	End
Most of United States and Canada	Second Sunday in March at 02:00	First Sunday in November at 02:00
European Union	Last Sunday in March at 01:00 UTC	Last Sunday in October at 01:00 UTC
Parts of Australia	First Sunday in October at 02:00	First Sunday in April at 03:00

Note: In European countries that observe daylight saving time, the local clocks change simultaneously at 01:00 UTC, which can be 01:00, 02:00, or 03:00 local time. Be sure to use local time when setting the DST start and end times on the SPG9000.

Recurring End

Enter the relative date and local time of day for daylight saving time to end.

Leap Second Management

A leap second is a one second adjustment that can be applied to UTC time to accommodate the difference between TAI time and the observed solar time, which varies due to irregularities in the earth's rotation. A leap second can be added at the discretion of the International Earth Rotation and Reference Systems Service (IERS). As of 2025, the most recent leap second was at the end of 2016.

Leap seconds are typically inserted just before 00:00:00 UTC on July 1 or January 1. For example, the positive leap second inserted at the end of 2016 resulted in a time sequence of:

2016-12-31 23:59:59	
2016-12-31 23:59:60	Normally the seconds digits would roll over from 59 to 00.
2017-12-31 00:00:00	

A hypothetical negative leap second would cause the time sequence to roll over from 23:59:58 to 00:00:00 (skipping the 59th second), but a negative leap second has never happened since the introduction of leap seconds in 1972.

If a leap second is scheduled to occur, it is signaled by GNSS data. GPS, Galileo, and BeiDou satellites send the date and time of the next leap second adjustment and the current number of leap seconds in their respective data messages. A "leap second pending" flag is set in the data message several months before the event. When the actual leap second occurs, the UTC offset is updated and the flag is cleared. A PTP grandmaster that is synchronized to GNSS can also signal this information to its followers using the ST 2059 synchronization metadata.

Because leap second adjustments always happen at 00:00:00 UTC, this could be an inconvenient time for some applications. For example, that time would be 19:00 in the Eastern time zone of the United States and Canada, at the start of prime-time television programming. Therefore, the SPG9000 has the ability to postpone the adjustment by up to 24 hours. The user can choose a time such as 04:00 in the local time zone, when there are few viewers.

In some installations the GNSS signal is not available, such as when the SPG9000 is used in a mobile production truck that does not have clear access to the sky. In these situations, the current leap second offset between UTC and TAI time must be configured differently. You can manually enter the offset or you can query a web service for the offset.

Web Interface for Leap Second

On the SPG9000 web interface, click the **Time** tab. The leap second configuration parameters depend on the time-of-day source. For GNSS Signal and PTP Follower time sources, you can configure the time when leap second adjustments are applied.

When the time-of-day source is Internal, LTC Input, or VITC Input, you can configure the offset between UTC and TAI time.

Front-Panel Menu for LEAP SECOND

To use the front panel of the SPG9000 for this process, press **TIME** and then select the **LEAP SECOND** option. See *Menu Operations* for details of using the front-panel menus. The table shows the submenus for the LEAP SECOND menu.

TIME :	
TIME OF DAY :	
NTP CLIENT :	
NTP SERVER :	
DST SCHEDULE :	
PROGRAM TIME :	
JAM SYNC :	
LEAP SECOND :	
MODE :	Only available if primary reference source is GNSS Signal or PTP Follower
OFFSET :	Only available if primary reference source is GNSS Signal or PTP Follower
UTC-TAI OFFSET :	Only available if primary reference source is Internal or Genlock Input
QUERY ON RESTART :	Only available if primary reference source is Internal or Genlock Input
ANNOUNCE VALID :	Only available if primary reference source is Internal or Genlock Input

Configuration Settings for Leap Second

The leap second configuration depends on the time-of-day source.

- For GNSS Signal and PTP Follower time sources, you can configure the time when the leap second adjustments are applied via the following settings:
  - Mode
  - Scheduled Time
- For Internal, LTC Input, and VITC Input time sources, you can configure the offset between UTC and TAI Time via the following settings:
  - UTC to TAI Offset
  - Query Web
  - Update on Restart
  - Announce as Valid

Mode

Select when the leap second adjustment should be made:

Use GNSS Time (00:00 UTC): Use the default behavior of making the adjustment at 00:00 UTC, regardless of the local time zone.

Defer to Schedule Time: Defer the leap second adjustment up to 24 hours, to the specified local time.

Scheduled Time

Enter the local time (hours and minutes) for the leap second adjustment.

UTC to TAI Offset

Enter the integer number of seconds between UTC and TAI. As of 2025, this value is 37 seconds.

Note: The text box on the web interface will be highlighted in red if the offset value is not yet trusted to be correct after the system has powered up. The value is trusted when it is updated or confirmed from this text box, or when the web server is successfully queried for the current value.

Query Web

Press to update the UTC to TAI offset value from a trusted server hosted by the International Earth Rotation and Reference Systems Service (IERS).

Note: You will need to configure the DNS server to resolve the address of the IERS server. See *Configuration Settings for NETWORK*.

Update on Restart

When this option is enabled, the SPG9000 automatically makes a request to the IERS server shortly after the instrument is powered on. This is useful if the power-on default preset includes an Internal time-of-day source and the instrument is frequently powered off and on again, such as in a mobile production truck.

Announce as Valid

When this option is enabled, the SPG9000 assumes the UTC to TAI offset value is trusted to be correct, and will assert the appropriate flag in PTP Announce messages to indicate the validity.

Program Time Counter

As an alternate to the time-of-day, a program time counter can be used as a time code source for any output. This counter can represent elapsed time, such as the time code associated with program content during the editing process.

The program time counter starts counting from the user-specified initial value. Program time can be reset to this value at any time using the user interface, the web services API, or the general purpose interface.

Web Interface for Program Time

On the SPG9000 web interface, click the **Time** tab.

Front-Panel Menu for PROGRAM TIME

To use the front panel of the SPG9000 for this process, press **TIME** and then select the **PROGRAM TIME** option. See *Menu Operations* for details of using the front-panel menus. The table shows the submenus for the PROGRAM TIME menu.

TIME :
   TIME OF DAY :
   NTP CLIENT :
   NTP SERVER :
   DST SCHEDULE :
   PROGRAM TIME :
      RESET
      INITIAL TIME
      ALARM
      ALARM TIME
   JAM SYNC :
   LEAP SECOND :

Configuration Settings for Program Time

The program time configuration includes a reset of the time counter and alarms to note when the selected value is reached.

Initial Time

Set the initial time for the program time counter, in hours, minutes, and seconds (HH:MM:SS).

Apply Initial Time Now

Click to reset the program time counter to the initial value.

Alarm

Check this box to enable the program time alarm. When the program time counter reaches the alarm time, a notification event is generated in the system log, and an output pin of the general purpose interface can be asserted. See *Syslog* and *General Purpose Interface*.

Alarm Time

Enter the required program time counter value (in the format HH:MM:SS) to trigger the alarm.

PTP Operation

Precision Time Protocol (PTP) is defined by IEEE Std 1588™-2019, *IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*. The protocol is used to synchronize clocks using an IP network.

The SPG9000 has two dedicated network interfaces for PTP. The instrument can operate as a leader or grandmaster (GM), providing accurate time-of-day to a set of followers that are synchronized to it, or it can operate as a follower to another GM. Each PTP instance can also be configured as an Ordinary Clock that adapts between leader and follower in response to other PTP devices on the network. As either a leader or a follower, the SPG9000 outputs (black burst, time code, etc.) are synchronized to PTP time.

Note: The SPG9000-PTP license must be enabled for the PTP ports to be operational.

Theory of Operation

PTP operates by exchanges of IP messages between leaders and followers. Through these messages the time of the grandmaster clock is distributed to all other instances so they are all synchronized and share the same time.

A PTP instance is an implementation of the PTP protocol engine that is associated with one or more physical network interfaces. The SPG9000 has two PTP instances; each uses one network port. The two instances are independent of each other, and can operate in different modes and run at different interface speeds.

Messages Types

There are seven different PTP message types used by the PTP implementation in the SPG9000. Four timing messages (Sync, Follow_Up, Delay_Req, and Delay_Resp) are used to exchange time information between leaders and followers:

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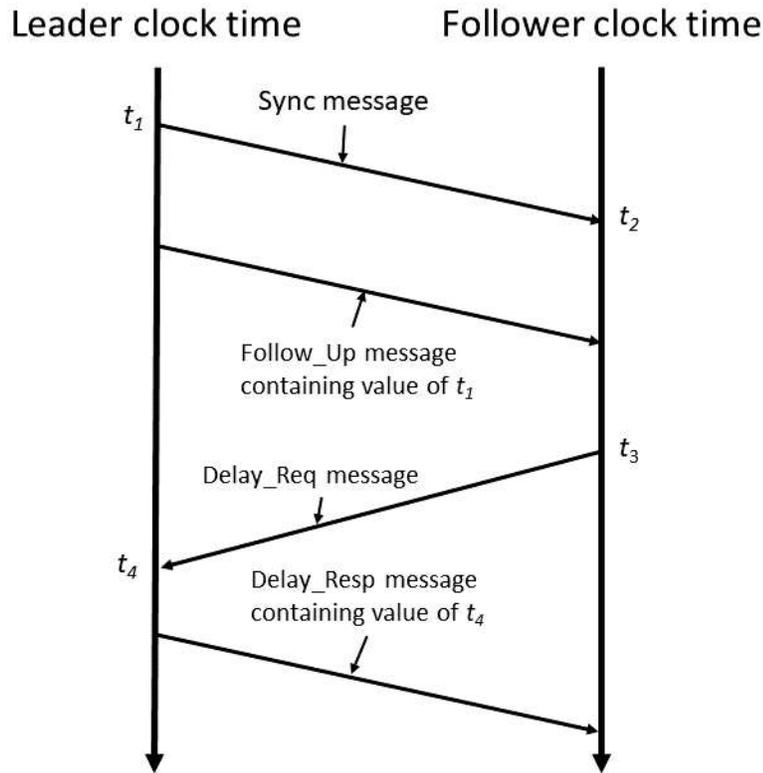
Sync

The Sync message is sent by the leader and is used to measure the propagation delay from the leader to follower. The Sync message might contain the timestamp indicating when it was transmitted, or that timestamp might be in the Follow_Up message. The receiver must timestamp the Sync message upon receipt. These two timestamps are usually called t_1 and t_2 and provide the first delay measurement: leader-to-follower delay or $t_2 - t_1$.

Follow_Up

The Follow_Up message is sent when the PTP network hardware does not insert the t_1 timestamp into the Sync message. Instead, the t_1 timestamp is included in a corresponding Follow_Up message; this is called two-step operation. If the Sync message does include its t_1 timestamp, the Follow_Up message is not required; this is called one-step operation.

A leader instance on the SPG9000 uses two-step operation and sends both Sync and Follow_Up messages. A follower instance on the SPG9000 can operate with either one-step or two-step leaders.

Delay_Req

The Delay_Req message is sent by the follower. The timestamp at which it is transmitted (t_3) is noted by the follower but is not included in the message. When this Delay_Req message is received by the leader, it timestamps the receive time of the message as t_4.

Delay_Resp

The Delay_Resp message is sent from the leader to the follower in response to the associated Delay_Req message. The response contains the t_4 timestamp from when the leader received the Delay_Req message. When the follower receives the Delay_Resp message, it has the second pair of timestamps needed to calculate the second delay measurement: follower-to-leader delay or $t_4 - t_3$.

Announce

The Announce message is sent by the leader to advertise its capabilities. This message contains the clock quality and priority settings needed for the *Best Master Clock Algorithm* to evaluate which instance is the best leader.

Management

Management messages are typically used by external systems to query and update data sets used by the PTP instance through in-band messaging. For the SPG9000, Management messages are used to broadcast synchronization metadata from the leader to its followers when the ST 2059-2 profile is used. See *Synchronization Metadata*.

Signaling

Signaling messages carry information, requests, and commands between PTP instances. For the SPG9000, Signaling messages are used only for unicast negotiation. See *Unicast*.

IEEE 1588-2019 also defines three other PTP message types (Pdelay_Req, Pdelay_Resp, and Pdelay_Resp_Follow_Up) that are used for the peer-to-peer delay mechanism. These are not used by the SPG9000; it only utilizes the end-to-end delay mechanism.

Domains

A PTP domain is a set of PTP instances that are synchronized to the grandmaster of the domain. The domain number is used to identify all the devices within this set.

Multiple domains may coexist on the same physical network. For example, on a given network, one leader and several followers can use domain 100 and a second leader and its followers use domain 101. The two domains are completely independent and can use different communication models and profiles if needed, such as ST 2059-2 for

media devices and AES67 for audio-only devices. With two PTP instances, the SPG9000 can be configured to use two different domains simultaneously.

Clock Types and Modes of Operation

PTP defines three types of clock devices:

Ordinary Clock: This is a PTP instance that has a single port in its domain. Both PTP instances of the SPG9000 are always Ordinary Clocks, as are PTP-capable audio-visual devices such as cameras or microphones.

Boundary Clock: This is a PTP instance that has multiple ports in its domain. This is typically a PTP-capable network switch in which one port is a follower to a leader and the other ports are leaders to followers. Boundary Clocks are frequently used—and strongly recommended—in larger broadcast and media networks.

Transparent Clock: This is a PTP instance (typically a PTP-aware network switch) that does not function as a leader or a follower but instead updates the time information in PTP messages that it forwards.

An Ordinary Clock may be constrained to only function in one of three modes:

Leader Only: The instance either serves as the grandmaster for the domain or it is a passive leader, ready to take over as the active grandmaster if the BMCA determines that it should.

Follower Only: The instance only synchronizes with a separate leader within the domain. If no leader is available, the instance listens for a new leader.

Ordinary Clock: The instance can adapt to network conditions and either follow a higher priority leader or it can become the leader for the domain.

Most media networks utilize a strict hierarchy with Leader Only devices serving as the active grandmaster or as passive backup leaders, and Follower Only devices at the network edge. However, there are situations where the unconstrained Ordinary Clock mode is very useful.

For example, a large live stadium event may require multiple mobile production units, and accurate time from a GNSS signal may not be available in some vehicles. The SPG9000 in one vehicle can be set to Ordinary Clock mode and locked to a grandmaster in another vehicle that does have a GNSS time source. If that GM is dropped from the network, the Ordinary Clock can become the new leader and assume the GM role for the domain. Its time is continuous from the previous GM time source, even without the availability of a direct time source from GNSS.

Best Master Clock Algorithm

The Best Master Clock Algorithm (BMCA) is the mechanism PTP instances use to determine which of the potential leaders should be the active leader. PTP instances do not negotiate which instance should be the active leader; instead, they each independently use the BMCA to arrive at the same result.

The BMCA uses information sent by each leader in Announce messages. These values are compared across all leaders to determine the best leader. The comparisons are made in a specific order:

1. **Priority 1** is a user-configurable number in the range 0-255. Priority values must be in the range 0-128 for the instance to become an active leader. Because this value is considered first by the BMCA, it takes precedence over all other values. This can force a device to be the active leader even if its clock is not the most accurate. Therefore, Priority 1 values are typically set to the same number (for example 128) for all potential leaders in the domain, to let clock quality metrics determine the best leader. More complex networks can use Priority 1 to define a specific fail-over sequence. For example, the SPG9000 grandmasters are configured with Priority 1 of 10, spine switches (Boundary Clocks) are configured with Priority 1 of 20, and leaf switches (also Boundary Clocks) are configured with Priority 1 of 30.

2. **Clock Class** is a number that indicates the current state and performance of the time and frequency source. Specific values are listed in Table 4 of IEEE 1588-2019. For example, the SPG9000 uses class 6 when it is locked to a GNSS signal and class 7 when it is in holdover mode after GNSS signal loss. A lower Clock Class number is better for BMCA purposes, so in this example an SPG9000 that is locked to GNSS is better than an SPG9000 currently in holdover mode.

3. **Clock Accuracy** is a number that represents a conservative estimate of the expected accuracy of the clock. Specific values are listed in Table 5 of IEEE 1588-2019. For example, when the SPG9000 is locked to a GNSS signal, it uses a Clock Accuracy value of 0x21 (hex), which corresponds to an estimate of "within 100 ns". If the SPG9000 is in holdover mode after GNSS signal loss, the Clock Accuracy changes to 0x26, or "within 25 μs".

4. Variance, or **Offset Scaled Log Variance**, is an estimate of the inherent precision of the timestamps generated by the local clock. The SPG9000 uses a conservative value of 14848 for the Offset Scaled Log Variance value that is included in its Announce messages, which corresponds to a variance measurement of about 8.5×10^{-22} s^2.

5. **Priority 2** is the second user-configurable number used by the BMCA. This value is typically used to designate primary, secondary, etc. leaders in a network with multiple leaders. The Priority 2 number is also in the range 0-255 (with a default of 128), with lower numbers representing higher priorities.

6. **Clock Identity** is the final tie-breaker when comparing PTP instances using the BMCA. Because the Clock Identity is created from the MAC address of the instance network interface, and MAC addresses are unique within a network, the Clock Identity of two devices should never be the same.

The Clock Class, Clock Accuracy, and Offset Scaled Log Variance values are collectively called the Clock Quality.

Dynamic Priority

The SPG9000 includes a mechanism to control the behavior of the BMCA by dynamically adjusting the Priority 1 or Priority 2 value during normal operation. Dynamic Priority is useful to avoid grandmaster changes that might not be necessary.

Consider two SPG9000 systems, called "primary" and "backup" for the purpose of this example. Each is configured as a PTP leader with a GNSS reference source. The BMCA will choose one SPG9000 (primary) to be the active leader, by the lower Clock Identity value if all else is equal. If the GNSS signal is lost on the active leader, it's Clock Class would change from 6 to 7 as the SPG9000 went into holdover mode. The BMCA would choose the backup SPG9000 to be the new active leader because its Clock Class is still 6. This is all expected and desired behavior.

However, when the GNSS signal is restored for the primary SPG9000 and holdover recovery completes, that leader would change its Clock Class back to 6. At that time, the BMCA would select the primary SPG9000 as the active leader, just as it was before the previous grandmaster change to the backup.

Strictly speaking, the second grandmaster change was not necessary, because both primary and backup SPG9000s are synchronized to the same GNSS signal and both have the same clock class. In some environments, it might be desirable to maintain the backup as the active leader and avoid the second GM change. Some ST 2110 systems might interrupt active IP connections when the GM is changed.

The SPG9000 can use Dynamic Priority mode to automatically adjust the Priority 1 or Priority 2 values in response to grandmaster changes, to prevent subsequent GM changes. The current priority value of the active leader is the configured (base) priority minus a configurable offset. The current priority of all passive leaders is the base priority with no offset applied.

For example, the primary leader is initially configured with a Priority 2 value of 100, the backup leader has a Priority 2 value of 101, and the dynamic offset is set to 2. When the leaders begin operation, the primary leader will become active since it has the better priority (lower number):

Leader	State	Clock Class	Priority 2
Primary	Active	6	100
Backup	Passive	6	101

At that point, the offset is applied to the active leader, so the new priorities are:

Leader	State	Clock Class	Priority 2
Primary	Active	6	98 (100 - 2)
Backup	Passive	6	101

Upon GNSS signal loss on the primary SPG9000, its Clock Class changes and the backup assumes the active leader role. Since the primary leader is no longer active, its Priority 2 resets to the base value.

Leader	State	Clock Class	Priority 2
Primary	Passive	7	100
Backup	Active	6	101

As before, the active leader then applies the dynamic offset:

Leader	State	Clock Class	Priority 2
Primary	Passive	7	100
Backup	Active	6	99 (101 - 2)

When the GNSS signal returns for the primary SPG9000, its Clock Class changes. But since the backup SPG9000 has a better Priority 2 (lower number), it remains the active leader.

Leader	State	Clock Class	Priority 2
Primary	Passive	6	100
Backup	Active	6	99 (101 - 2)

At a later time, if there is a GNSS signal loss to the backup, then the process will repeat in reverse and the primary GM will again become active. The two SPG9000s can operate indefinitely without intervention. The active leader will be determined by the Clock Class, and will not switch unnecessarily.

At a convenient time, you can manually reset the Dynamic Priority on the active leader, which will remove the dynamic offset and allow the PTP clocks to apply the BMCA and choose the best lead clock. Normally, this will result in a GM change back to the primary SPG9000.

After a GM becomes active, it will wait for an interval before applying the dynamic offset. This is necessary to allow all the potential GMs time to apply the BMCA and ensure the best GM has been chosen. The length of this delay is the announce period multiplied by the announce timeout count, multiplied by 2.

This example explains a use case for dynamic priority using priority 2. There are also use cases for dynamic priority for priority 1. Some of these use cases involve GMs that are not locked to a reference such as GNSS, but are in internal or Ordinary Clock mode.

Communication Models

PTP can operate over several types of networks. The SPG9000 only uses Internet Protocol version 4 (IPv4) for message transport.

PTP messages are carried by User Datagram Protocol (UDP) packets using port 319 for event messages (Sync and Delay_Req) and port 320 for general messages (Announce, Follow_Up, Delay_Resp, Management, and Signaling).

Depending on the profile and mode, PTP can use one of three different communication models:

Multicast

Using IPv4 multicast, multiple hosts on the local network receive all messages destined for the multicast group address. Hosts use the Internet Group Management Protocol (IGMP) to join or leave specific multicast groups. The multicast group address for PTP is 224.0.1.129.

With full multicast operation, the leader can send one Announce, Sync, or Follow_Up message to the multicast group address and it is received by all followers. However, every exchange of Delay_Req and Delay_Resp messages between each follower and the leader is received by all instances.

The multicast communication model is the simplest model from a configuration perspective. A follower simply joins the PTP multicast group and it discovers the leader from the Announce messages it receives.

The leader sets the rate for the Announce and Sync messages that it sends. The leader also includes the maximum allowed Delay_Req message rate as a parameter within the Delay_Resp message. Ideally, the follower uses that value to set its Delay_Req message rate. This rate is typically the same as the Sync message rate.

Because any potential leader in a network receives multicast Announce messages from the active leader, it can use the BMCA to determine if it is better. If so, it sends its own Announce messages and transitions from passive to active state. The previous active leader also receives the new Announce messages and also concludes that it is no longer the best leader. It stops sending Announce messages and transition to the passive state.

Unicast

Unicast operation is the usual method of point-to-point communication on IP networks, but for PTP there is additional configuration and additional complexity. Each follower is required to be configured with the Unicast Discovery List of the set of possible leaders.

When a unicast follower starts operation, it first sends a Signaling message to each address in the Unicast Discovery List. This message includes type-length-value (TLV) parameters to request the leader start sending Announce messages to the follower.

The leader may grant or deny the request. If denied, the follower can try again by sending a new request with a slower message rate.

After the follower starts receiving Announce messages from one or more leaders, it uses the BMCA to determine the preferred leader. It then sends additional Signaling messages to that leader with TLVs to request the leader send Sync and Delay_Resp messages at the requested rates. Again, the leader might grant or deny those requests and the follower can try again with slower message rates. When the follower starts receiving Sync and Delay_Resp messages, it can synchronize with the leader clock.

Leaders using the unicast model do not communicate with each other. Therefore, the leaders do not use the BMCA and are in the active state as long as they are serving followers that have grants for Announce, Sync, and Delay_Resp messages.

If the unicast communication model is used, all PTP instances in the domain must use unicast. If the followers in the network do not have the same set of leaders in their respective Unicast Discovery Lists, they may choose different leaders. It is important to configure all unicast followers the same way.

Mixed Multicast/Unicast

Mixed mode utilizes multicast for Announce, Sync, Follow_Up and Management messages and unicast for Delay_Req and Delay_Resp messages. This mode minimizes the message processing load for leaders, so they can support a larger number of followers. The mode also reduces the message processing load for followers because each one does not have to receive and discard the Delay_Req and Delay_Resp messages from the other followers. Multicast is used for messages that can be shared among all followers. Unicast is used for one-to-one messages.

A mixed mode follower does not need to be configured with a Unicast Discovery List. It receives Announce messages from the leader and it can extract the IP address from the Announce message for the unicast destination address for subsequent Delay_Req messages. Mixed mode also does not require unicast negotiation.

The multicast and mixed multicast/unicast communication models may co-exist in the same domain. Followers can use either model and leaders must support both. A leader responds to received Delay_Req messages using the same model for the Delay_Resp message.

Mixed mode does not provide any advantage in a network that uses switches in Boundary Clock mode, because each port of the Boundary Clock is a leader with only one follower.

Profiles

A PTP profile is a set of features, constraints, and parameter values that are used for a PTP instance. Profiles are published by various organizations to suit the needs for their specific applications. The SPG9000 supports three profiles:

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SMPTE ST 2059-2

Profile name	SMPTE profile for synchronization in a professional broadcast environment
Version	1.0
Profile identifier	68-97-E8-00-01-00
Organization	Society of Motion Picture and Television Engineers
Specification	SMPTE ST 2059-2:2021 (section 6)

AES67

Profile name	PTP profile for media applications
Version	1.0
Profile identifier	00-0B-5E-00-01-00
Organization	Audio Engineering Society Standards Committee
Specification	AES67-2018 (Annex A)

IEEE 1588-2019 Default

Profile name	Default delay request-response profile
Version	1.0
Profile identifier	00-1B-19-01-01-00
Organization	IEEE Precise Networked Clock Synchronization Working Group of the IM/ST Committee
Specification	IEEE Std 1588-2019 (Annex I.3)

Each profile includes a set of mandatory, optional, and prohibited PTP features; default values and permissible ranges for several PTP attributes and parameters; and other profile-specific behavior.

For the SPG9000 PTP instances, the profile-specific differences are:

- The SMPTE profile includes support for the SM TLV in Management messages. The grandmaster sends a Management message once per second and whenever its locking status changes. Each follower can use the TLV information to adjust its time code outputs. See *Synchronization Metadata*.
- The Mixed Multicast/Unicast communication model is not available with the AES67 profile, only full multicast or full unicast.

● Parameters such as Announce and Sync message intervals have different default values and permissible ranges. See *Set Profile Parameters to Default*.

Synchronization Metadata

The ST 2059-2 specification defines how a grandmaster can share metadata with its followers so they can generate time code outputs consistent with each other and with PTP time. The Synchronization Metadata (SM) TLV includes parameters such as the system frame rate (for example 25 fps for PAL-based time code outputs and 29.97 fps for NTSC-based time code outputs), the offset between TAI time and local time, and the time of the next daily jam sync. See *Daily Jam Sync*.

On the SPG9000, a PTP instance configured as a leader with the ST 2059-2 profile sends Management messages with the SM TLV once every second. These messages can be sent as multicast messages for the multicast or mixed communication models, or as unicast messages to each follower for the unicast model.

Most SM TLV parameters are automatically inserted based on other configuration settings and the current state. For example, the Local Offset is calculated from the time zone offset (configured from the Time tab or front-panel menu), the current DST offset, and the difference between TAI and UTC (37 seconds). The Next Jam Time is calculated from the Jam Sync Scheduled Time converted to TAI time.

See *SMPTE Synchronization Metadata* for the user-configurable SM TLV parameters for the leader. See *Details of Follower PTP Status* for a description of the decoded SM TLV.

Asymmetric Delay Compensation

Asymmetric delay compensation allows correcting the follower timing for any asymmetric delay in the network. If the network only uses PTP-aware switches (Boundary Clocks or Transparent Clocks), delay asymmetry is typically not a problem.

Several factors can cause the propagation delay for PTP messages to be different for the leader-to-follower direction than the follower-to-leader direction. Unless corrected, this propagation delay asymmetry will cause an offset in the clock phase that will be equal to half of the difference of the two path delays.

There are five main causes of asymmetric delay:

● **Rate mismatch** in a switch is when two ports operate at different line speeds (for example 1 Gbps and 10 Gbps). In this case delay asymmetry occurs because of the effects of message processing; the entire message must be stored in a buffer before it is forwarded from the switch on the output port.
For example, using a 1 Gbps input port and a 10 Gbps output port, the switch must wait for the entire message to clock in at the slower rate before it can start outputting the message at the higher rate. Conversely, with a 10 Gbps input port and a 1 Gbps output port, the entire packet is received at the faster rate and the output can start sooner (but at a slower rate).
Although the total transit time is the same for both directions, the delay on the fast-in, slow-out direction is shorter for the packets which contain the PTP timestamps.

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This effect is more significant at lower port speeds, such as the mismatch between 100 Mbps and 1 Gbps ports.

If the switch can operate as a Transparent Clock or Boundary Clock, the rate mismatch delay effect is corrected by the switch.

- **Traffic mismatch** between the two paths occurs when there is significantly higher traffic utilization on one path than on the other. PTP message processing may be delayed because the switch is busy processing other types of traffic. This effect can be quite large depending on the amount of traffic, the quality of the switch, and the number of switches in the network.

  Transparent Clock switches insert residence time information to allow the follower to correct for this delay, and Boundary Clock switches correct for traffic mismatch effects because the switch port is a new leader for its follower or followers. Also, switches that support Differentiated Services give PTP Event messages priority over most other traffic types. See *DiffServ Code Points*.

- **Route path difference** can happen if the leader-to-follower path takes a different route in the network than the follower-to-leader path. This is uncommon in local area networks, but it is not uncommon when PTP is used over wide area networks.

- **Message type mismatch** may happen when using the mixed multicast/unicast communication model. Some switches may process multicast Sync messages differently than unicast Delay_Req messages.

- **Cable delay variation** occurs when the propagation delay through the cable is different in one direction than the other. In electrical network cable, such as Category 5 cable, it can be due to the twist rate on the pairs, routing inside the sheath, or material differences. With optical fiber it is primarily due to cable length differences for the two strands.

See *Delay Asymmetry* for how to set the delay asymmetry correction factor for the follower instance.

PTP Configuration

Most PTP configuration parameters are set from the PTP tab of the web interface or by pressing the PTP button on the front-panel interface, but the network interface settings are configured from the System tab of the web interface or the SYSTEM ⋮ NETWORK menu of the front-panel menu.

Web Interface for Network Settings

On the web interface, click the **System** tab and then click **Network Settings**.
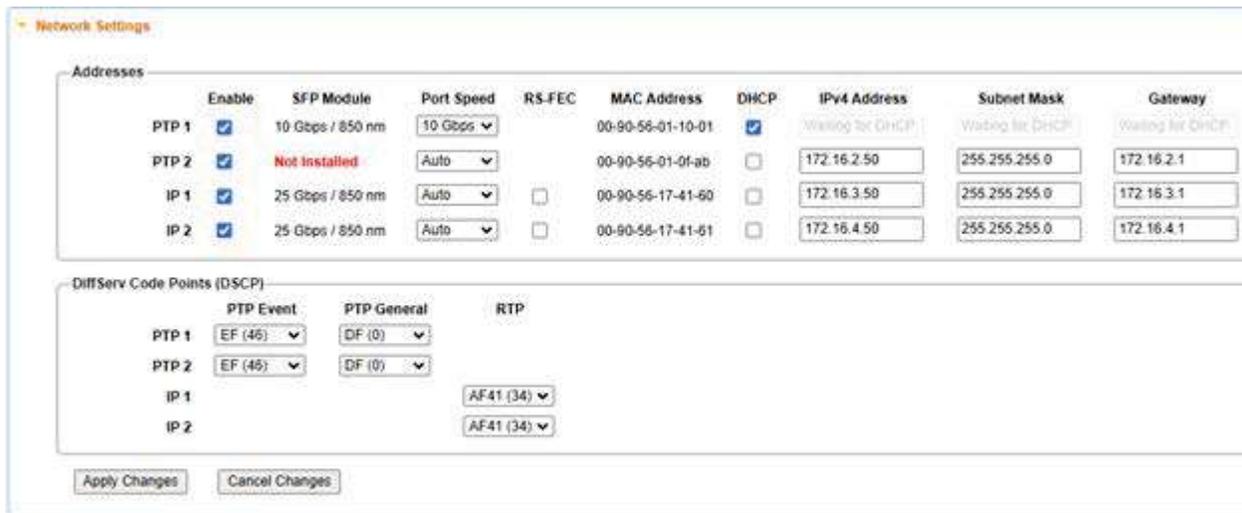
Front-Panel Menu for NETWORK

To use the front panel of the SPG9000 for this process, press **SYSTEM** and then select the **NETWORK** option. See *Menu Operations* for details of using the front-panel menus. The table shows the NETWORK menu, and submenus for PTP 1 and PTP 2.

SYSTEM :

    PRESET :

    INFO :

    NETWORK :

      MGMT :

      PTP 1 :

          PORT

          SPEED

          DHCP

          IP ADDRESS

          SUBNET MASK

          GATEWAY

          MAC ADDRESS

          DSCP (PTP Event)

          DSCP (PTP General)

      PTP 2 :   Same menu and submenus as PTP 1

      IP 1 :

      IP 2 :

    FRONT PANEL :

    WEB :

    GENERAL PURPOSE INTERFACE :

    POWER SUPPLY :

FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Configuration Settings for PTP Network Interfaces

Before configuring PTP instance settings, check that the network interfaces for the two ports are configured appropriately for the network. The factory default settings are IPv4 addresses of 172.16.1.50 for PTP 1 and 172.16.2.50 for PTP 2. These almost certainly need to be changed for the local network.

Enable

Check this box to enable the network interface. This setting is distinct from the PTP Instance Enable selection (see *Instance*) because it is possible to enable the network interface but disable the PTP instance. In that case, the network interface would respond to ping messages but would not respond to PTP messages.

SFP Module

This is a read-only status of the SFP module. This is only displayed on the web interface. If no SFP module is detected, "Not Installed" appears in the status. If the interface is enabled, this text is red to highlight the error condition,

If an SFP module is detected, the status indicates the interface speed and the laser wavelength, if applicable. For example, this can help identify mismatches between short-reach (850 nm) and long-reach (1310 nm) transceivers on the SPG9000 side and the switch side of the link.

Port Speed

Selects the data rate of the network port. The **Auto** selection will select the most appropriate speed based on parameters read from the SFP module. In some cases, such as when Direct Attach Cables (DACs) are used, the port speed may not be available from SFP data. Select **1 Gbps** or **10 Gbps** to manually set the desired port speed.

MAC Address

This is a read-only value of the physical address of the network interface. The first three octets of a MAC address indicate an Organizationally Unique Identifier (OUI), to help identify equipment on the network. The OUI for Telestream is 00-90-56, so the MAC addresses always begin with these three octets.

The MAC address is also used to create the PTP clock identity, as seen on the PTP status (see *Clock Identity*). The OUI is followed by hexadecimal values of FF FE, followed by the three remaining digits of the MAC address. For example, a MAC address displayed as 00-90-56-01-10-01 in the network interface configuration would appear as a PTP clock

identity of 00:90:56:FF:FE:01:10:01. This makes it easier to identify SPG9000 units in the PTP network. The OUI for Tektronix is 08-00-11, so earlier SPG8000A units (Tektronix manufacture) use a clock identity starting with 08:00:11:FF:FE and recent SPG8000A units (Telestream manufacture) use a clock identity starting with 00:90:56:FF:FE.

DHCP

Check this box to enable Dynamic Host Configuration Protocol (DHCP) on the interface. In this case, a DHCP server must be present on the network and it assigns the IPv4 address, subnet mask, and gateway address. If the user enables DHCP, manual configuration of those values is disabled but the values provided by the DHCP server are displayed.

IPv4 Address

Enter the four octets of the IPv4 address, in dotted decimal notation. On the front-panel interface, an edit menu (see *Edit Menus*) is used to enter the address, using three digits for each octet with leading zeros if necessary. For example, an address displayed as 192.168.1.50 on the web interface appears as 192.168.001.050 on the front-panel interface. If DHCP is enabled, the IPv4 address supplied by the DHCP server is displayed instead and cannot be edited.

Subnet Mask

Enter the four octets of the subnet mask, in dotted decimal notation. If DHCP is enabled, the subnet mask supplied by the DHCP server is displayed instead and cannot be edited.

Gateway

Enter the four octets of the gateway address for this subnet, in dotted decimal notation. If DHCP is enabled, the gateway address supplied by the DHCP server is displayed instead and cannot be edited.

Note: When setting up connections and network addresses for the PTP and IP ports, care should be taken to isolate the ports. The default settings for the address, subnet mask, and gateway put the four ports on different subnets. If the ports are configured to use the same subnet, then ARP message responses may be sent on a different port than the port from which the ARP request was received. This can confuse the routing of signals.

Do not connect the ports to separate physical networks reusing the same addresses. This configuration results in inherently ambiguous unicast routing and requires advanced routing configuration to work correctly.

For multicast traffic, keeping the ports isolated does not cause an issue. The multicast packets will traverse across subnets so PTP and IP traffic will be unaffected. For unicast

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and mixed mode PTP using layer 2 routing, the source and destination must be in the same subnet. This may impose some restrictions on how the networks are designed.

In a PTP network using boundary clocks, it is easy to set up each point-to-point link from the switch to the SPG9000 on a narrow subnet, such as using a 30-bit subnet mask. This should make it easy to define different address ranges for the two PTP ports.

DiffServ Code Points

Select the DSCP values for PTP Event messages and PTP General messages.

Differentiated Services (DiffServ) is a mechanism for applying quality of service (QoS) to IP networks. A DiffServ Code Point (DSCP) is a 6-bit value (between 0 and 63) that is included in the header of an IP packet. It identifies the type of traffic and its associated priority.

PTP messages types are grouped into two message classes:
- **Event** messages include Sync and Delay_Req.
- **General** messages include Announce, Follow_Up, Delay_Resp, Management, and Signaling.

PTP Event messages typically use the Expedited Forwarding (EF) class, which is intended for low-loss and low-latency traffic. EF is assigned a DSCP value of 46. It is important for the timestamp of transmitted Sync and Delay_Req messages to be as accurate as possible; this is why Event messages use a higher priority class.

PTP General messages can simply use the Default Forwarding (DF) class for best-effort traffic, which has a DSCP value of 0.

Apply Changes

Click to accept any changes made to the network settings since opening the panel on the web interface.

Cancel Changes

Click this button to cancel any changes made to the network settings and restore the previously saved settings.

Web Interface for PTP Instances

On the web interface, click the **PTP** tab for the configuration menus for the two instances. When the tab is first opened, the two sections labeled "PTP 1" and "PTP 2" are collapsed:

The section headers for PTP 1 and PTP 2 each show a summary of the current configuration, displaying the selected mode, communication model, and domain number. This makes it easy to view the configuration of both instances together, in a table-like format. Click on a header to open that section to see the menus for that PTP instance.

The menus available for a PTP instance depend on the selected Mode, Profile, and Communication Model as noted. For example, the menus available for a Follower Only instance using the mixed multicast/unicast model are:

The menus available for a Leader Only instance using the SMPTE profile are:

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Front-Panel Menu for PTP Instances

To use the front panel of the SPG9000 for this process, press **PTP** repeatedly to alternate between the two instance submenus and then press **ENTER** for the selected instance. See *Menu Operations* for details of using the front-panel menus. The table shows the menus and submenus for PTP 1 and PTP 2.

PTP 1 :	
INSTANCE	
MODE	
HEADER VERSION	
PROFILE	
COMMUNICATION MODEL	
DOMAIN	
PRIORITY 1	Not available for Follower Only mode
PRIORITY 2	Not available for Follower Only mode
DYNAMIC PRIORITY	Not available for Follower Only mode
DYNAMIC OFFSET	Not available for Follower Only mode
MAX STEPS REMOVED	Not available for Leader Only mode
DELAY ASYMMETRY	Not available for Leader Only mode

MESSAGES :	
ANNOUNCE INTERVAL	Not available for Follower Only mode for multicast and mixed models
ANNOUNCE TIMEOUT	
SYNC INTERVAL	Not available for Follower Only mode for multicast and mixed models
SMPTE SYNC METADATA :	Only available for Leader Only or Ordinary Clock modes and ST 2059-2 profile
Video Frame Rate	
Drop-Frame Flag	
Color Frame ID Flag	
UNICAST DISCOVERY LIST :	Only available for Follower Only or Ordinary Clock modes and Unicast communication model
IP 1 - IP 8	
PTP 2 :	Same menus as PTP 1

Configuration Settings for PTP Instances

The PTP Instances section on the Status tab contains information about the current reference source, the genlock input signal, and the received GNSS signal.

Instance

Check this box to enable the PTP instance. When disabled, the instance does not send or receive any PTP messages on the network interface. It may still respond to "ping" messages if the port is enabled but the instance is disabled. See *Enable*.

Mode

Selects the operational mode of the PTP instance. See *Clock Types and Modes of Operation*.

Leader Only: The instance only functions as a leader for this domain. It can be in the Active state, in which case it is the current grandmaster (GM), or it can be in the Passive state, in which case another leader in this domain is the current GM.

Follower Only: The instance only functions as a follower in this domain. If one or both of the PTP instances are configured as follower, the reference source for the instrument can be set to PTP Follower. See *Configuration Settings for Reference*. If a follower instance is not used for the reference source, it can still lock to a leader for the domain and report its status information. See *PTP Status*.

Ordinary Clock: The instance can function either as a leader or a follower, depending on network conditions. When the BMCA selects this instance, it assumes the Active leader role. But unlike a Leader Only instance that assumes a passive role when the BMCA selects another leader, an Ordinary Clock assumes a follower role and tracks the active leader.

Note: Do not configure both PTP instances of the same SPG9000 to use Ordinary Clock mode with a reference source of PTP Follower. This might lead to a "loop" whereby the instrument is synchronized to itself, which is an unstable configuration.

If the reference source is set to GNSS Signal (Clock Class 6 or 7), an Ordinary Clock instance can never be in the follower state per the IEEE 1588 specification. It can only be an active leader or a passive leader. Therefore, it is simpler to use the Leader Only mode for a GNSS reference source.

Header Version

Selects the version number (2) and minor version number (0 or 1) that are signaled in the second octet of the header of all transmitted PTP messages. Version 2.0 refers to the 2008 revision of the IEEE Std 1588 specification and version 2.1 refers to the 2019 revision, Some PTP devices will not accept version 2.1 messages, so selecting 2.0 may mitigate some interoperability issues. The SPG9000 will operate equally with either 2.0 or 2.1 header version.

Note: This selection does not affect any operational behavior of the PTP instance. It only affects the value signaled in the header of transmitted PTP messages.

Profile

Selects the PTP profile for the instance. See *Profiles*.

SMPTE ST 2059-2: The SMPTE profile is the preferred profile for professional networked media applications.

AES67: The AES67 Media profile is typically used for audio-only applications or for video applications that cannot process the management SM TLV messages used by the SMPTE profile.

IEEE 1588-2019: The IEEE profile is the default for use with the delay request-response mechanism.

Set Profile Parameters to Default

Click this button to reset certain parameters to the default values for the selected profile.

	SMPTE ST 2059-2	AES67	IEEE 1588-2019
Domain 0	127	0	0
Priority 1	128	128	128
Priority 2	128	128	128

	SMPTE ST 2059-2	**AES67**	**IEEE 1588-2019**
Announce Interval	1 s (1 Hz)	2 s (0.5 Hz)	2 s (0.5 Hz)
Announce Timeout	3	3	3
Sync Interval	125 ms (8 Hz)	125 ms (8 Hz)	1 s (1 Hz)

Communication Model

Selects the communication model used by the instance. See *Communication Models*. The list of available models depends on the selected Mode and Profile.

Multicast: With the multicast model, all PTP messages between the leader and its followers use multicast addressing.

Unicast: With the unicast model, all PTP messages between the leader and each individual follower use unicast addressing. Followers must be preconfigured with a list of addresses of possible leaders.

Mixed Multicast/Unicast: With the mixed model, leaders use multicast addressing for Announce, Sync, Follow_Up, and Management messages (SMPTE profile). Followers use the address from the Announce message to send unicast Delay_Req messages to that leader. The leader sends the Delay_Resp message back to the follower using its unicast address. The mixed model is only available for SMPTE and IEEE profiles, and for the Follower Only mode.

Both Multicast and Mixed: This selection is only available for the SMPTE and IEEE profiles and for the Leader Only mode. Leaders are required to simultaneously support followers that use Multicast and followers that use Mixed Multicast/Unicast models.

Domain

Select the domain number for this PTP instance, within the range 0-127. See *Domains*.

The default domain number is profile dependent; SMPTE uses 127, and AES and IEEE profiles use 0. We advise using a different domain number from the default to prevent improperly configured devices from assuming the grandmaster role.

Priority 1 and Priority 2

Enter the priority 1 and priority 2 values for the leader, which are used for BMCA decisions. See *Best Master Clock Algorithm*. These menus are not available for Follower Only mode. Priority values of 0-255 may be entered, but values of 128-255 are used for devices that will not become active leaders.

Dynamic Priority

Select the Priority 1 or Priority 2 to enable Dynamic Priority mode for this PTP instance or select Off to disable Dynamic Priority mode. See *Dynamic Priority*.

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Restore

Click this button to remove the dynamic offset from an active leader's priority value and to reset the priority to its initial base value. When Dynamic Priority is in effect, the Applied value will be displayed next to the configured value. If no Applied value is displayed, the Restore button has no effect.

When the priority of the active leader is restored to its base value, the BMCA will select the new grandmaster for the current conditions. In most cases this will be the original top priority leader.

Dynamic Offset

Select the offset to be used for Dynamic Priority mode, between 2 and 10. The selected value must be large enough to accommodate the base priority values of all potential grandmasters in the domain. For example, if the base priority values for four leaders (two SPG9000s with two leaders each) are 10, 12, 14, and 16, then the dynamic offset must be at least 7 for the fourth leader to have the lowest value if it becomes active.

Note: Do not choose a base Priority 1 or Priority 2 value less than the Dynamic Offset value, because the priority value cannot be less than 0 if the leader becomes active.

Max Steps Removed

Enter the upper limit for the stepsRemoved value for Announce messages received from the leader. This menu is not available for Leader Only mode.

Steps removed refers to the number of steps or hops between the PTP instance and the grandmaster. Each Boundary Clock in a path counts as a step or hop. A follower with a path to the grandmaster that goes through a PTP-unaware switch or Transparent Clock has a step count of 1. If the switch is replaced with a Boundary Clock, the step count is 2.

If the stepsRemoved value in a received Announce message is greater than or equal to the Max Steps Removed value, that Announce message is ignored.

Delay Asymmetry

Enter the delay asymmetry value for the follower instance. See *Asymmetric Delay Compensation*.

The value must be a floating point number of microseconds between −99.999 and +99.999 μs, with 0.001 μs (1 ns) resolution. A positive value means the leader-to-follower propagation time is longer than the follower-to-leader propagation time, and a negative value means the opposite. This menu is not available for Leader Only mode.

Announce Interval

Select the time interval between successive Announce messages transmitted by the leader. The available choices are described both in terms of the time interval and the corresponding message rate. For example, an interval of 2 seconds represents a message rate of 0.5 messages per second.

This menu is not available for Follower Only mode with multicast or mixed multicast/unicast communication models. For Follower Only mode with unicast communication model, the Announce Interval setting is the requested value sent to a leader in a grant request Signaling message. See *Unicast*.

Announce Timeout

Select the maximum number of Announce messages that are missing before the PTP instance assumes the leader is no longer present. After that time, instances in the domain start the process of selecting a new leader by the BMCA.

It is a good practice to configure all devices in the domain with the same announce interval and timeout count so they all respond in a similar time-frame. For example, using the multicast communication model with an Announce interval of 1 second and a timeout count of 3, a passive leader starts sending its own Announce messages 3 seconds after the active leader stops sending Announce messages.

Sync Interval

Select the time interval between successive Sync messages transmitted by the leader. The available choices are described both in terms of the time interval and the corresponding message rate. For example, an interval of 125 milliseconds represents a message rate of 8 messages per second.

The Sync Interval has a significant effect on the lock time and stability of PTP followers. The SMPTE profile default value of 8 messages per second was chosen to provide a trade-off between PTP performance and network load. Most PTP devices are optimized for the default rates. If other rates are chosen, additional testing is necessary to ensure acceptable performance.

This menu is not available for Follower Only mode with multicast or mixed multicast/unicast communication models. For followers using the unicast communication model, the Sync Interval setting is the requested value sent to a leader in a grant request Signaling message. See *Unicast*.

Unicast Discovery List

Enter the IP addresses of up to 8 potential leaders. Use a value of 0.0.0.0 for entries that are not used. See *Unicast* for more about the Unicast Discovery List. These menus are only available for the unicast communication model and the Follower Only or Ordinary Clock modes.
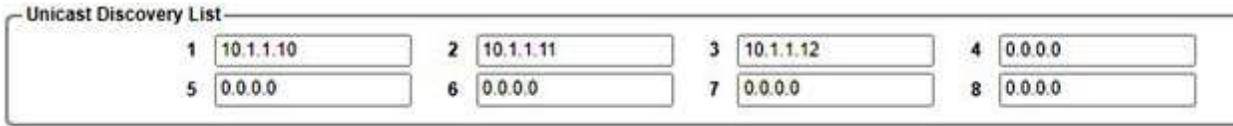
telestream

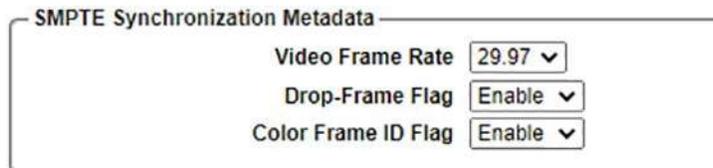To use the front panel for this process, see Front-Panel Menu for PTP Instances.

SMPTE Synchronization Metadata

When the ST 2059-2 profile is used, the active leader sends Management messages with the SM TLV at a rate of one per second. See *Synchronization Metadata*.

Most parameters of the SM TLV are automatically computed, but three are user-configurable. These menus are only available for Leader Only and Ordinary Clock modes with the SMPTE profile.

To use the front panel for this process, see Front-Panel Menu for PTP Instances.

Video Frame Rate

Select the frame rate for the video outputs of the follower. Interlaced formats typically refer to fields per second, so be sure to choose the frames-per-second value. For example, NTSC uses 59.94 fields per second, which is 29.97 frames per second.

Drop-Frame Flag

Select whether the drop-frame format should be enabled or disabled for the time code outputs of the follower. Normally this flag is only enabled for a video frame rate of 29.97 fps or 59.94 fps.

Color Frame ID Flag

Select whether color frame identification should be enabled or disabled for the time code outputs of the follower. The color frame flag appears in the LTC and VITC code words, according to ST 12-1.

Synchronization Outputs

The SPG9000 has multiple outputs that can deliver synchronization signals to downstream devices that genlock to the SPG. There are six outputs (BLACK 1 to BLACK 6) that can generate signals such as NTSC or PAL black burst or HD tri-level sync. Four linear time code outputs (LTC 1 to LTC 4) can distribute time code to the facility. Two more outputs deliver audio reference signals: Word Clock and Digital Audio Reference Signal (DARS).

Black Outputs

The SPG9000 includes six outputs labeled BLACK 1 to BLACK 6, which can be configured for a variety of analog synchronization signal formats.

Web Interface for Black

On the web interface, click the **Black** tab for the configuration menus for the six outputs. When the tab is first opened, the six sections labeled Black 1 to Black 6 are collapsed:
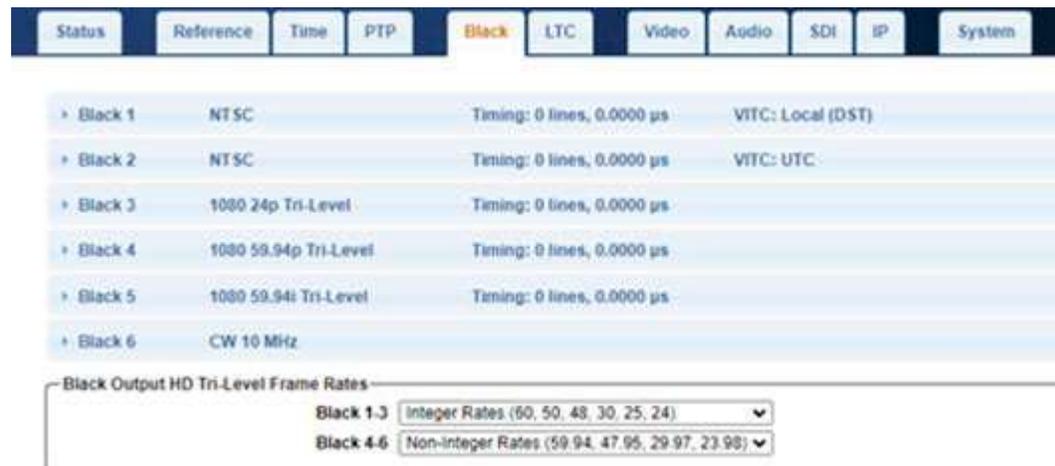
Below these six output sections is an additional menu section to select the available frame rates for any outputs configured for HD tri-level sync formats. See *HD Tri-Level Frame Rate*.

The section headers for Black 1 to Black 6 each show a summary of the current configuration, displaying the selected format and timing offsets. This makes it easy to

view the configuration of all outputs at one time, in a table format. Click a Black header to open that section and see the menus for that output.

Front-Panel Menu for BLACK

To use the front panel of the SPG9000 for this process, press **BLACK** repeatedly to select from the six output submenus and the two HD TRI-LEVEL SYNC RATE submenus. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the BLACK menu and the submenus for BLACK 1.

BLACK 1 :	
FORMAT	
FIELD REFERENCE	Only available if FORMAT is NTSC, NTSC-J, or PAL
10-FIELD SEQUENCE ID	Only available on Black 4-6 outputs and if FORMAT is NTSC or NTSC-J
TIMING :	Not available for 1 PPS format
Vertical	
Horizontal Coarse	
Horizontal Fine	
TIME CODE :	Only available if FORMAT is NTSC, NTSC-J, or PAL
SOURCE	
OFFSET	
DROP-FRAME	Only available if FORMAT is NTSC or NTSC-J
VITC 1	
VITC 1 LINE	

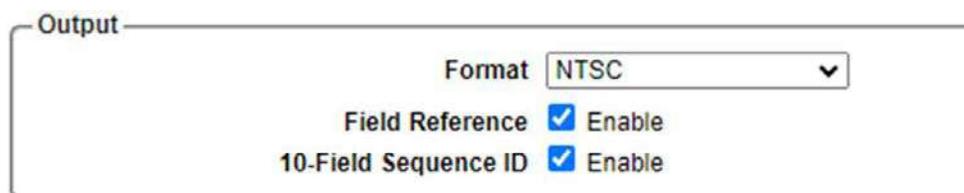|	
VITC 2	
VITC2 LINE	
BLACK 2-6	Same menu options as Black 1
BLACK 1-3 : HD TRI-LEVEL SYNC RATE	
BLACK 4-6 : HD TRI-LEVEL SYNC RATE	

Configuration Settings for Output

Configure the specific black output:

On the web interface, click the **Black** tab, and then click the specific Black section (1-6) to configure.

```
┌─Output──────────────────────────────────────────────┐
│                                                      │
│                    Format  │ NTSC            ▾ │     │
│           Field Reference  ☑ Enable                  │
│       10-Field Sequence ID ☑ Enable                  │
│                                                      │
└──────────────────────────────────────────────────────┘
```

To use the front panel for this process, see *Front-Panel Menu for BLACK*.

Format

Selects the output format. The list of available formats in this menu is variable.

These formats are available on all outputs:

NTSC: Selects NTSC black burst (525 lines at 59.94 interlaced fields per second). The signal has a black level of 7.5 IRE, according to NTSC-M as used in North America and several other countries.

NTSC-J: Selects NTSC black burst with a black level of 0 IRE as used in Japan.

PAL: Selects PAL black burst (625 lines at 50 interlaced fields per second).

1 PPS: Selects a pulse-per-second signal. The signal level is 2 V for the Black 1-3 outputs and 5 V for the Black 4-6 outputs when unterminated. The signal levels are half those amplitudes into a 75 Ω termination.

This format is available on outputs 3-6, but not outputs 1-2:

CW 10 MHz: Selects a continuous wave (CW) signal with a frequency of 10 MHz and a signal level of 1.5 Vp-p.

The set of available HD tri-level sync formats depends on the selection in the Black Output HD Tri-Level Frame Rates menu. Either the set of non-integer rates or the set of integer rates is available for each of Black 1-3 and Black 4-6.

Frame Type	Non-Integer Rates	Integer Rates
Interlaced	1080 59.94i	1080 60i
		1080 50i
Progressive	1080 59.94p	1080 60p
	1080 47.95p	1080 50p
	1080 29.97p	1080 48p
	1080 23.98p	1080 30p
	720 59.94p	1080 25p
		1080 24p
		720 60p
		720 50p
Segmented Frame	1080 23.98sF	1080 24sF

Field Reference

Check this box to enable the field reference signal. This menu is only applicable if the selected format is black burst (one of NTSC, NTSC-J, or PAL). When enabled, a 700 mV (white) signal appears for the complete active line duration on line 10 (NTSC) or line 7 (PAL) of field 1 only. This makes it easier to identify the first field in the 4-field (NTSC) or 8-field (PAL) sequence.

10-Field Sequence ID

Check this box to enable the 10-field sequence ID pattern as defined in ST 318M. This pattern is only defined for NTSC (and NTSC-J) and appears as a series of pulses on line 15 (odd fields) and line 278 (even fields). When enabled, the black output is aligned with Frame Reset 1 (2.997 Hz) and is therefore synchronized with other outputs that use this ID pattern. See *Epoch-Based Synchronization*.

Note: This option is only available in outputs 4-6.

Configuration Settings for Timing

The Timing settings adjust the timing offset of the output signal relative to the internal frame reset. See *Epoch-Based Synchronization* to understand how frame resets are synchronized with respect to the reference source.

The total timing offset is a combination of whole lines (vertical delay) and partial lines (horizontal delay). A negative value means the internal clock is advanced relative to the frame reset.

On the web interface, click the **Black** tab, and then click the specific Black section (1-6) to configure.

To use the front panel for this process, see *Front-Panel Menu for BLACK*.

Vertical Delay

Enter an integer number of lines, in 1 line increments.

Horizontal Delay

Enter the horizontal delay values, the sum of a coarse value (in microseconds) and a fine value (in nanoseconds). Enter the horizontal coarse value in increments of the clock used for the output format. For NTSC and PAL, a 54 MHz clock is used so each coarse step is about 0.0185 µs. For HD tri-level sync formats, a 74.25 MHz clock (integer frame rates) or a 74.1758 MHz clock (non-integer frame rates) is used so each coarse step is about 0.,0135 µs. Enter the horizontal fine value in increments of 0.1 ns.

The range of the timing adjustment depends on the selected signal format:

Format	Vertical (lines)	Horizontal Coarse (µs)	Horizontal Fine (ns)
NTSC and NTSC-J	± 525	± 63.5556	± 10.00
PAL	± 1250	± 64.0000	± 10.00
1080 60i	± 562	± 29.6296	± 7.00
1080 59.94i	± 562	± 29.6593	± 7.00
1080 50i	± 562	± 35.5556	± 7.00
1080 60p	± 562	± 14.8148	± 7.00
1080 59.94p	± 562	±14.8296	± 7.00
1080 50p	± 562	± 17.7778	± 7.00
1080 48p	± 562	± 18.5185	± 7.00
1080 47.95p	± 562	± 18.5370	± 7.00
1080 30p	± 562	± 29.6296	± 7.00

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Format	Vertical (lines)	Horizontal Coarse (µs)	Horizontal Fine (ns)
1080 29.97p	± 562	± 29.6593	± 7.00
1080 25p	± 562	± 35.5556	± 7.00
1080 24p	± 562	± 37.0370	± 7.00
1080 23.98p	± 562	± 37.0741	± 7.00
1080 24sF	± 562	± 37.0370	± 7.00
1080 23.98sF	± 562	± 37.0741	± 7.00
720 60p	± 375	± 22.2222	± 7.00
720 59.94p	± 375	± 22.2444	± 7.00
720 50p	± 375	± 26.6667	± 7.00

Configuration Settings for VITC

Outputs configured to one of the black burst formats (NTSC, NTSC-J, or PAL) can also carry time code in the vertical blanking area of the video frame. Vertical Interval Time Code (VITC) on each output can use different time sources and independent offsets.

On the web interface, click the **Black** tab, and then click the specific Black section (1-6) to configure.

To use the front panel for this process, see *Front-Panel Menu for BLACK*.

Source

Select the time source for the time code counter:

Disabled: No time code will be inserted in the video output signal.

Local (DST): Use the main time-of-day and the time zone offset and the daylight saving time offset to compute the local time.

Local (No DST): Use the main time-of-day and the time zone offset, but exclude any daylight saving time offset to compute the local time.

UTC: Use Coordinated Universal Time instead of a local time.

Program Time: Use the program time counter instead of a time-of-day value. See *Program Time Counter*.

The VITC data includes the hours, minutes, seconds, and frames digits (in the format HH:MM:SS:FF) according to ST 12-1 and the year, month, day, and time zone information according to ST 309.

Offset

Enter a time offset (hours, minutes, seconds, and frames) relative to the selected source time. For example, you could use the time code for a different time zone than the system normal time zone by specifying an offset of ±1 -or-more hours.

Line Numbers

Enter the required line numbers in the vertical interval and check the boxes to enable the lines. The SPG9000 can insert the VITC data into one or two different lines in the vertical interval. One line is always enabled; to disable VITC altogether, select **Disabled** from the **Source** menu. When two lines are enabled, they should be nonconsecutive lines.

According to ST 12-1, the preferred locations and limits for VITC are:

	NTSC	PAL
Preferred Line	14	19
Optional Line	16	21
Earliest Line	10	6
Latest Line	20	22

Drop-Frame (30 fps)

Check this box to enable drop-frame time code. This option is only available when the format is NTSC or NTSC-J. This option should be selected for most applications where the time code represents time-of-day; this is so the time code is similar to the real-time clock. See *Daily Jam Sync* for keeping 30 fps drop-frame time code aligned with the main time-of-day (MTOD).

Non-drop frame (NDF) time code is sometimes used in editing and post-production, typically when also using the Program Time source.

HD Tri-Level Frame Rate

The six black outputs of the SPG9000 are grouped into two sets (Black 1-3 and Black 4-6). In each group, any of the three outputs configured to HD tri-level sync formats must have an integer frame rate (30, 25, 24, etc.) or all have a non-integer frame rate (29.97, 23.98, etc.). If your application requires both 1080i 59.94 and 1080i 50 signals, for example, you must use any of Black 1-3 for one output and any of Black 4-6 for the other output. There are no restrictions on which outputs are NTSC or PAL.

On the web interface, click the **Black** tab, and then click the specific Black section (1-6) to configure.

Select either Integer Rates or Non-Integer Rates for Black 1-3 and Black 4-6.

To use the front panel for this process, see *Front-Panel Menu for BLACK*.

Linear Time Code Input and Outputs

The SPG9000 has four sets of pins on the rear-panel LTC/GPI connector for LTC input and outputs. These can be configured as one input and three outputs, or as four outputs.

See *LTC/GPI Connector* for the connector pin diagram.

Web Interface for LTC

On the web interface, click the **LTC** (Linear Time Code) tab for the configuration menus for the four outputs. When the tab opens, the four sections LTC 1 through LTC 4 are collapsed as shown:
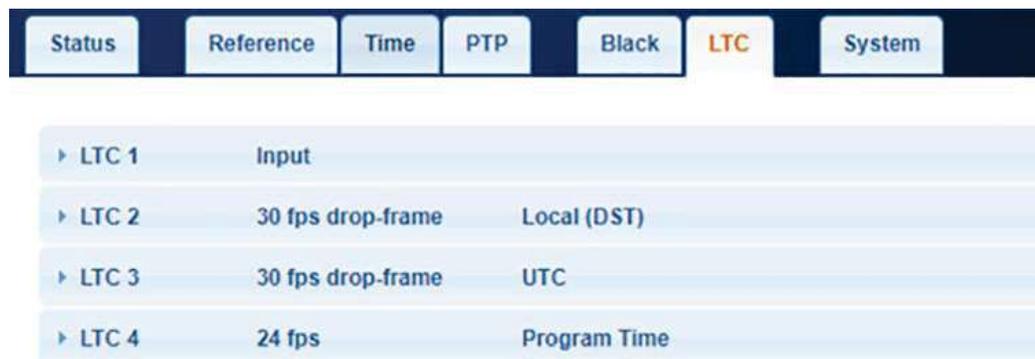
The section headers for LTC 1 to LTC 4 each show a summary of the current configuration, displaying the selected format and time source. This makes it easy to

view the configuration of all outputs at the same time, in a table-like format. Click on a header to open that section and see the menus for that output.
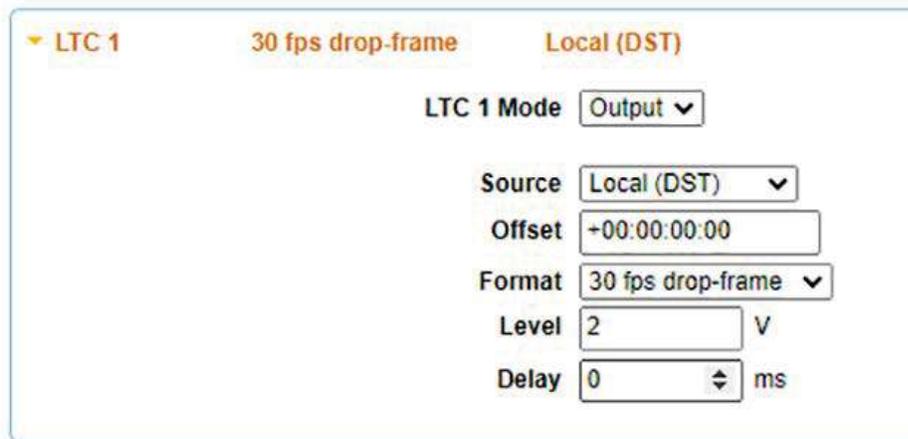
Front-Panel Menu for LTC

To use the front panel of the SPG9000 for this process, press **LTC** repeatedly to select from the four output submenus. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the LTC 1 menu.

LTC 1 :	
MODE	Only available for LTC 1
FORMAT	
SOURCE	
OFFSET	
DELAY	
OUTPUT LEVEL	
LTC 2-4 :	

Configuration Settings for LTC

These settings can be configured from both the web interface and the front-panel menus.

LTC 1 Mode

Select Output or Input for the LTC 1 pins on the rear panel connector. This menu is only available for LTC 1; LTC 2-4 are always configured as outputs. When LTC 1 is configured as an input, it can be used as a time-of-day source when the reference source is either Genlock Input or Internal. See *Configuration Settings for Time of Day*.

Source

Select the time source for the time code counter:

Disabled: The LTC output is disabled.

Local (DST): Use the main time-of-day plus the time zone offset plus the daylight saving time offset to compute the local time.

Local (No DST): Use the main time-of-day plus the time zone offset, but exclude any daylight saving time offset to compute the local time.

UTC: Use Coordinated Universal Time instead of a local time.

Program Time: Uses the program time counter instead of a time-of-day value. See *Program Time Counter*.

The LTC data includes the hours, minutes, seconds, and frames digits (HH:MM:SS:FF) according to ST 12-1 and the year, month, day and time zone information according to ST 309.

Offset

Enter a time offset (hours, minutes, seconds, and frames) relative to the selected source time. For example, you could use the time code for a different time zone than the system's normal time zone by specifying an offset of ± 1 or more hours.

Format

Selects the linear time code format and frame rate.

The LTC format refers to the allowed range of digits for the frame count, along with the method in which they are counted and roll over at the end of each second. For example, 24 fps time code counts frames from 00 to 23 each second, and then rolls over back to 00. 30 fps drop-frame time code counts frames from 00 to 29 in most seconds, but skips the 00 and 01 counts at specific times. See *Daily Jam Sync*.

An LTC frame is the period over which the LTC codeword (80 bits long) is transmitted, aligned with the corresponding video frame. For example, a LTC frame rate of 25 fps results in an LTC signal with a bit rate of 2000 bps, with the start of each LTC frame aligned with the start of 25 fps video frames, such as PAL black outputs.

Select one of the LTC formats:

24 fps: Select 24 fps time code, with frames counted from 00 to 23 for every second.

25 fps: Select 25 fps time code, with frames counted from 00 to 24 for every second.

30 fps: Select non-drop frame time code, with frames counted from 00 to 29 for every second, at a frame rate of 30 fps.

30 fps drop-frame: Select drop-frame time code at a frame rate of 29.97 fps.

24 fps @ 23.98 Hz: frames are counted from 00 to 23 each second, but the frame rate is 23.98 fps. Five frames at this rate are aligned with four complete video frames at 29.97 fps.

Level

Enter the signal level for the LTC output. Valid values are from 0.5 V to 5.0 V in 0.5 V steps.

Delay

Enter the time offset (in milliseconds) by which the LTC frame will be delayed from its normal video frame alignment.
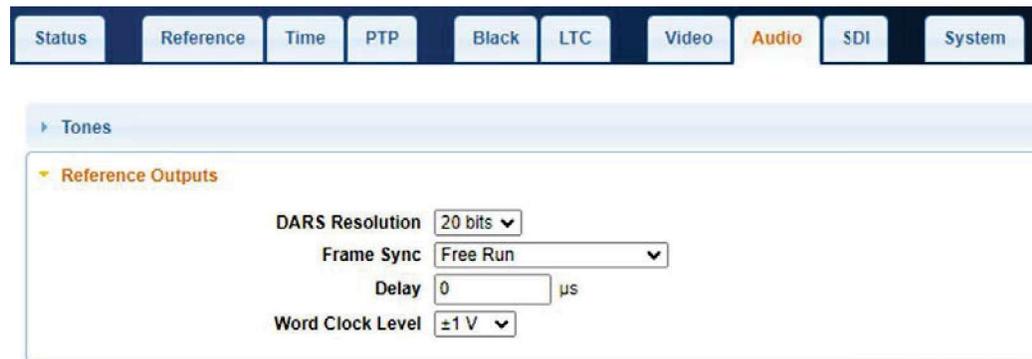
Audio Reference Outputs

The Word Clock output generates a simple 48 kHz square wave at an output level of ± 1.0 V or 0-5 V.

The DARS (Digital Audio Reference Signal) output generates an AES3 digital audio signal that can be used as a synchronization reference for audio equipment.

Web Interface for Audio Reference Outputs

On the web interface, click the **Audio** tab, and then click **Reference Outputs**.

Front-Panel Menu for Audio Reference Outputs

To use the front panel of the SPG9000 for this process, press **AUDIO** and then select the **REFERENCE** option. See *Menu Operations* for details of using the front-panel menus.

The table shows the menus for AUDIO and the submenus for REFERENCE.

AUDIO :
TONES :
REFERENCE :

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> **DARS RESOLUTION**
> **FRAME SYNC**
> **DELAY**
> **WORD CLOCK LEVEL**

Configuration Settings for Audio Reference Outputs

DARS Resolution

Select the resolution of the AES3 signal, as 20 bits or 24 bits per sample.

Frame Sync

Select the frame reset signal to synchronize the Word Clock and DARS outputs:

> **Frame Reset 1 (2.997 Hz)**
>
> **Frame Reset 2 (6.25 Hz)**
>
> **Frame Reset 3 (3 Hz)**

If a frame reset signal is not used to synchronize the Word Clock and DARS outputs, select **Free Run**.

For information on frame reset signals, see *Epoch-Based Synchronization*.

Delay

Set the timing offset (in microseconds) of the Word Clock and DARS outputs relative to the internal reference. The delay value has a range of ±160000 μs (0.16 s).

Note: The delay value has no effect when the Frame Sync parameter is set to Free Run.

Word Clock Level

Set the signal level voltage for the Word Clock output to either ±1 V, when AC-coupled, or to 0–5 V, when DC-coupled.

Test Signal Generation

In addition to its main function as a synchronization source for a video facility, the SPG9000 can also generate test signals in a variety of different formats on multiple outputs. The SPG9000 includes four independent Serial Digital Interface (SDI) outputs and two network interfaces for IP (ST 2110) stream generation.

Note: The SPG9000-SDI license must be enabled for test signal generation using the SDI outputs.

The SPG9000-IP license must be enabled for test signal generation using the IP interfaces.

The SPG9000 uses a set of video sources and audio sources to define the test signal content, and a set of output interfaces for the test signal transport. In general, a specific source may be sent to multiple outputs. For example, you can configure a video source to generate a color bars video test pattern for a specific format, and re-use that video source for both SDI and IP outputs.

To completely configure the test signal generators, first configure the video and audio sources, then configure the SDI outputs and IP streams.

Video Sources

The SPG9000 has up to six video sources that can be independently configured. Each video source is described by its format (including image size, frame rate, and more), its test pattern (such as color bars), and its timing relative to the system clock.

Video sources are numbered from 1 to 6. Video source 1 is always associated with the SDI 1 output, source 2 with SDI 2, source 3 with SDI 3, and source 4 with SDI 4. Video sources 1 to 4 can also be used for IP video streams, so the same test signal will be used for both output types. Video sources 5 and 6 can only be used for IP video streams. If the SPG9000-IP license is enabled, all 6 sources are available. If only the SPG9000-SDI license is enabled, only sources 1-4 are available.

The complete set of formats supported by the SPG9000 is:

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

Image Size	Scan Type	Frame Rate	Sampling	Color Space	Bit Depth
1280×720	Progressive	60/59.94/50	4:2:2	YCbCr	10
		30/29.97/25/24/23.98	4:4:4	YCbCr	10
			4:4:4	RGB	10
1920×1080	Progressive	60/59.94/50	4:2:2	YCbCr	10
		30/29.97/25/24/23.98	4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	12
	Interlaced	30/29.97/25	4:2:2	YCbCr	10
			4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	12
	Segmented	30/29.97/25/24/23.98	4:2:2	YCbCr	10
			4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:2:2	YCbCr	12

Image Size	Scan Type	Frame Rate	Sampling	Color Space	Bit Depth
2048×1080	Progressive	60/59.94/50/48/47.95	4:2:2	YCbCr	10
		30/29.97/25/24/23.98	4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	12
		30/29.97/25/24/23.98	4:4:4	XYZ	12
	Segmented	30/29.97/25/24/23.98	4:2:2	YCbCr	10
			4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	12
			4:4:4	XYZ	12
3840×2160	Progressive	60/59.94/50	4:2:2	YCbCr	10
		30/29.97/25/24/23.98	4:2:2	YCbCr	10
			4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	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	YCbCr	10
			4:4:4	YCbCr	10
			4:4:4	RGB	10
			4:4:4	YCbCr	12
			4:4:4	RGB	12
			4:2:2	YCbCr	12

Note: The IP outputs only support 4:2:2 YCbCr 10-bit progressive and interlaced formats at all frame rates and 4:4:4 RGB and YCbCr 12-bit progressive and interlaced formats up to 30 fps.

Web Interface for Video Sources

On the web interface, select the **Video** tab for the configuration menus for the four or six sources. When the tab is first opened, the Source sections are collapsed:

The section headers for Source 1 to Source 4 or Source 6 each show a summary of the current configuration, displaying the user-defined label, selected format, and selected video test signal. This makes it easy to view the configuration of all sources at the same time in a table format. Click a Video Source header to open that section and see the submenus for that source.

Select the header for Format, Test Signal, Time Code, Overlay, or Timing to open those subsections.

Note: The Time Code and Overlay subsections are only available for video sources 1-4.

Front-Panel Menu for VIDEO

To use the front panel of the SPG9000 for this process, press **VIDEO** repeatedly to select from the source submenus. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the VIDEO 1 menu.

VIDEO 1:

    LABEL

    FORMAT :

        IMAGE SIZE

        SCAN TYPE

        FRAME RATE

        SAMPLING

        COLORIMETRY

        TRANSFER CHAR

        RANGE

    TEST SIGNAL :

        SIGNAL TYPE

        TEST PATTERN :   Only available if SIGNAL TYPE is Test Pattern

            COLOR BARS

            LINEARITY

            FLAT FIELD

            MULTIBURST

            MONITOR

            PULSE BAR

            TIMING

            SDI

        IMAGE FILE   Only available if SIGNAL TYPE is Image File

        COMPONENT (for Y)

        COMPONENT (for Cb)

        COMPONENT (for Cr)

        EDGE FILTER

        AV TIMING MODE

    TIME CODE :

        SOURCE

        OFFSET

        DROP FRAME   Only available if the frame rate is 29.97 or 59.94 fps

    OVERLAY :

        ID TEXT :

            (ENABLE)

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<table>
<tr><td>**EDIT**</td><td></td></tr>
<tr><td>**SIZE**</td><td></td></tr>
<tr><td>**BORDER**</td><td></td></tr>
<tr><td>**X POS**</td><td></td></tr>
<tr><td>**Y POS**</td><td></td></tr>
<tr><td>**BURNT-IN TIME CODE :**</td><td></td></tr>
<tr><td>(ENABLE)</td><td></td></tr>
<tr><td>**SIZE**</td><td></td></tr>
<tr><td>**DATE**</td><td></td></tr>
<tr><td>**X POS**</td><td></td></tr>
<tr><td>**Y POS**</td><td></td></tr>
<tr><td>**LOGO**</td><td></td></tr>
<tr><td>(ENABLE)</td><td></td></tr>
<tr><td>**FILE**</td><td></td></tr>
<tr><td>**X POS**</td><td></td></tr>
<tr><td>**Y POS**</td><td></td></tr>
<tr><td>**TIMING :**</td><td></td></tr>
<tr><td>**VERTICAL**</td><td></td></tr>
<tr><td>**HORIZONTAL**</td><td></td></tr>
<tr><td>**RELATIVE TO**</td><td>Only available for 270 Mbps and 1.485 Gbps SDI formats</td></tr>
</table>

Configuration Settings for Video Sources

Configure the specific video source:

1. On the web interface, select the **Video** tab.

2. Select the specific Source section (1-4 or 1-6) to configure.

To use the front panel for this process, see *Front-Panel Menu for VIDEO*.

Label

Enter a user-defined label to identify the video source, such as "HDR UHD Color Bars" for example. The source label is used on the SDI output and IP stream configuration menus to make it easier to describe the source content.

Current Destination Outputs

Displays the current set of outputs for this source. If the source is used with an SDI output, the interface speed is also displayed. For 3G-SDI formats, "3G-A" indicates Level A mapping and "3G-B" indicates Level B mapping. If the source is used with an IP video stream, the estimated bit rate (including L2 overhead) is also displayed.

Format

The format of a video source is comprised of several interrelated parameters. Not all combinations are possible, so the user interface only shows available options for the current selection. Start to set the format with the first format parameter (image size) and continue in order.

Select the Source needed (1-4 or 1-8), then select **Format**.
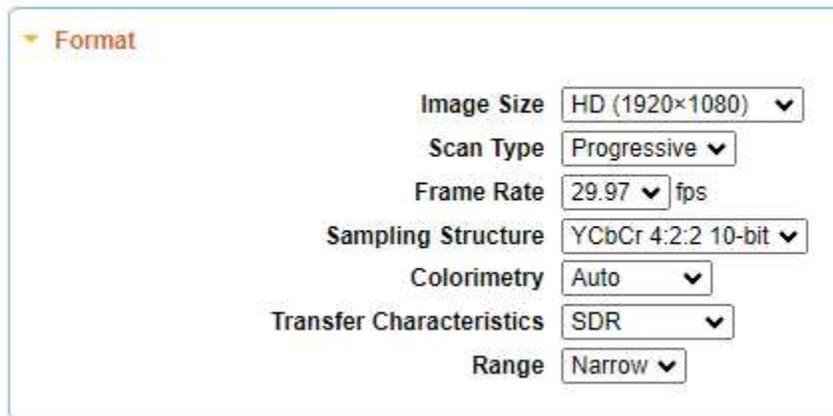
Image Size

Select the size of the active video region as width-by-height (W×H). The SPG9000 supports these image sizes:

Standard Definition	High Definition, 2K	Ultra High Definition, 4K
720×486	1280×720	3840×2160
720×576	1920×1080	4096×2160
	2048×1080	

Note: The SD formats commonly referred as 525-line and 625-line have 486 and 576 lines of active video respectively.

Scan Type

Select the scan type, as progressive, interlaced, or segmented frame. Not all scan types are available for certain image sizes and frame rates.

Frame Rate

Select the number of frames per second for the video signal. Non-integer frame rates are written with a rounded decimal but the precise frame rate is used. For example, "59.94 fps" is displayed for the actual rate of 60/1.001 fps.

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Note: For interlaced formats, the field rate is twice the frame rate. For example, "1080i 50" refers to 50 fields per second, which is 25 frames per second.

Sampling Structure

Select the sampling structure, a combination of:

- Color space: YCbCr, RGB, or XYZ;
- Color sub-sampling: 4:2:2 or 4:4:4; and
- Bit depth: 10-bit or 12-bit.

Not all sampling structures are available for certain image sizes, frame rates, and scan types.

Colorimetry

Select the colorimetry:

Auto

Rec. 709

Rec. 2020

The Auto option is usually the best selection for most applications. The colorimetry choice that is automatically used depends on the selected image size and transfer characteristics:

Image Size	SDR	HDR
Standard Definition	Rec. 601	not available
720-line High Definition	Rec. 709	not available
1080-line HD/2K	Rec. 709	Rec. 2020
2160-line UHD/4K	Rec. 2020	Rec. 2020

The Rec. 709 and Rec. 2020 options can be used to force a specific colorimetry for the current format.

Transfer Characteristics

Select the transfer characteristics:

SDR: Standard Dynamic Range

HDR HLG: High Dynamic Range, Hybrid Log-Gamma

HDR PQ: High Dynamic Range, Perceptual Quantization

Unspecified

Standard definition (720×486 and 720×576) and 720-line high-definition formats only use SDR. The 2K XYZ formats use unspecified transfer characteristics.

Range

Select either **Narrow** range or **Full** range quantization of the 10-bit or 12-bit sample values.

Narrow range is the default and widely used. For 10-bit formats, the video data range is from 4 through 1019 (with 0-3 and 1020-1023 reserved for SDI outputs), but the black (0%) level is 64 and the peak (100%) level is 940. This leaves "headroom," which is space below 0% and above 100%.

Full range utilizes the entire set of 10-bit or 12-bit values, and is typically used with some HDR formats.

Test Signal

Use the test signal settings to select the needed video pattern and set parameters that affect its appearance.

Select the Source needed (1-4 or 1-6), then select **Test Signal**.

Signal Type

Select the type of test signal for the video source.

> **Test Pattern**: Select one of the predefined test patterns, such as color bars.

> **Image File**: Select a TIFF image file that has been uploaded to the instrument.

Note: The Image File option is not available for video sources 5 and 6.

Test Pattern Parameters

The SPG9000 includes a large set of predefined test patterns, grouped into eight categories.

To select a specific test pattern:

1. Select the **Category** menu and highlight an option.

2. Select the **Pattern** menu and highlight an option. A short description of the selected test pattern appears below the menus.

The next sections describe the different test pattern categories, and the test patterns available in each category.

Color Bars

Color bar test patterns are widely used to verify the integrity of video signal paths and the correct calibration of display monitors. Each bar is a rectangular region of the image with a specific color value, usually expressed as a percentage, such as 75% or 100%. For example, 0% refers to the minimum value for each of the green, blue, and red (GBR) color components and 100% is the maximum value, regardless of whether the format is SDR or HDR. Most video formats use narrow-range quantization, so the 10-bit value corresponding to 0% is 64 (040h) and the value for 100% is 940 (3ACh). Full-range quantization uses the entire 10-bit range from 0-1023 for 0%-100%, although the values 0-3 and 1020-1023 are not used for SDI outputs because they are reserved values for SDI synchronization.

Color bars can also differ depending on the colorimetry used with the YCbCr color space. Standard definition uses Rec.601 coefficients to convert from GBR values to YCbCr, HD (750- and 1080-line formats) uses Rec.709 coefficients, and UHD (2160-line formats) uses Rec.2020 coefficients. Rec. 2020 is also used for 1080-line HD/2K formats when using HDR transfer characteristics. The SPG9000 generates the correct color values depending on the image size and transfer characteristics of the selected format.

Pattern	Description
100% Color Bars 75% Color Bars (100% White) 75% Color Bars (75% White)	Eight full-height bars of white, yellow, cyan, green, magenta, red, blue, and black. This pattern is available with three variations, at 100% value for all bars, at 75% value for colors and 100% for white, and at 75% value for all bars.
100% Color Bars Over Red 75% Color Bars Over Red	These variations on color bars are only available in the 720x576 image size. They consist of the 75% or 100% color bars signal on the top half of the raster, and a matching 75% or 100% red field on the lower half.
SMPTE EG 1 Color Bars	Color bars according to EG 1-1990. This pattern includes 75% color bars, reverse blue bars, −I and +Q sections, black, white, and pluge sections. This pattern is only available for YCbCr formats, since the −I and +Q sections contain color components outside the legal RGB gamut. For standard definition formats, this pattern is only available for the 720×486 image size.

Pattern	Description
SMPTE RP 219-1 HD Color Bars SMPTE RP 219-1 SD Color Bars SMPTE RP 219-2 UHD Color Bars	Color bars according to RP 219-1:2014 and RP 219-2:2016. The RP 219-1 HD pattern is intended for 16×9 aspect ratio displays, with additional elements as compared to EG1 bars. The SPG9000 implementation includes −I and +Q sections, but unlike the similar sections in EG1 bars, they have additional luminance to stay within RGB gamut. The −2% patch of the pluge section is clipped to 0% black for XYZ formats. For SD, the color bars are the 4:3 aspect ratio version, as if converted from the 16:9 image with a center cut. The "sub-black valley" and "super-white peak" ramps are also included. The RP 219-2 pattern is available for UHD formats and 2K/4K formats that are wider than the 16:9 RP 219-1 pattern. The −I and +Q sections are not included.
SMPTE RP 219 with Moving Box	Color bars based on RP 219-1, but with a black region cut out from the main color bars within which a smaller 100% white square moves vertically and horizontally, "bouncing" off the edges of the black region.
SMPTE EG 432-1 Color Accuracy	Split-screen color bars using values from RP 431-2-2007. The upper half of the pattern is essentially the same as 100% color bars, corresponding to the "−1" set of colors defined in Table A.4 of the RP. The lower half is a set of desaturated color bars, corresponding to the "−2" color patch values.
ARIB B28 HD Color Bars ARIB B66 UHD Color Bars	Color bars according to ARIB STD-B28 and STD-B66 for 1920×1080 HD and 3840×2160 UHD formats respectively. The B28 HD pattern is very similar to the SMPTE RP 219-1 bars, without the sub-black and super-white ramps added in the 2014 revision of RP 219. The B66 UHD pattern replaces the 75% white bar with a set of Rec. 709 color bars at 75%. The B66 standard also describes two optional 4K and 8K test sections with a "cyclone" pixel pattern, but these are not included in the SPG9000 version.
BT.2111 HLG Narrow Color Bars BT.2111 PQ Narrow Color Bars BT.2111 PQ Full Color Bars Sony S-Log3 Color Bars	Color bars according to ITU-R BT.2111. These patterns are intended for HDR systems. For best results, select the appropriate transfer characteristics value for the video format. The patterns include 100% color bars at the top, 75%/58%/68.5% color bars, a monochrome step scale from 0% to 109% luminance, a full-scale ramp, BT.709 color bars on the lower left and right, and near-black patches.

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Pattern	Description
EBU 3373 HDR Color Bars	Color bars according to EBU Tech 3373, for use in the production of HDR HLG television. The pattern consists of 100% color bars, 75% bars, display-light BT.709 bars, scene-light BT.709 bars, full-range luma ramp, and red, green and blue saturation test patches. The two-sample interleave (2SI) test section from Tech 3373 is not included.
NBCU HDR-SDR Color Bars	"Fancy" color bars are defined by NBCUniversal for their single-master broadcast production and distribution workflow. This pattern is based on the BT.2111 color bars HLG pattern, but it also includes HDR highlight pillars and a LUT pyramid (ramps) on the top left, a clip text indicator (block letter "H") in the 109% patch of the monochrome step scale section, and both display-light and scene-light BT.709 color bars on the bottom left and right.
EBU 3305 Color Bars with Motion	Color bars based on EBU Tech 3305. This document specifies the pattern definition for SD formats only, but the SPG9000 pattern has been extended to include HD/2K and UHD/4K image sizes. The pattern includes motion sequence 1 ("transmission alive check"), which consists of a thin black bar (with a white center line) that moves vertically within the large red field at the base of the pattern.

Linearity

Linearity test patterns are used to ensure that all expected signal values are processed by the digital system. Ramp patterns are widely used because they include every sample value in the tested range. Visually, a luma ramp (which has only the Y channel for a YCbCr signal or all three channels for an RGB signal) appears as a gradual transition from black to white. On a waveform monitor display set to SDR, the ramp appears as a straight diagonal line. If banding is seen on the displayed image, this could indicate a drop in resolution, such as when a 10-bit signal is viewed on an 8-bit display.

Pattern	Description
5-Step Staircase 10-Step Staircase	Series of vertical bars of equal steps on all three channels. These patterns are color-independent so they will appear differently in YCbCr, RGB, or XYZ color spaces. Since the range of valid levels is not evenly divisible by 5 or 10 steps, the first and last bars slightly exceed the valid range, but are still well within legal limits. For example, the valid range for 10-bit YCbCr formats is from 64–940 for the Y channel (876 steps) and from 64–960 for the Cb/Cr channels (896 steps). Therefore, the level of the first bar is 62 and the level of the last bar is 942/962, which results in equal step sizes across the pattern.

Pattern	Description
Valid Ramp Y Valid Ramp B-Y Valid Ramp R-Y Valid Ramp	The Valid Ramp is a matrix of three different ramps, designed to test the video component channels for YCbCr, and for gamut range testing in all color spaces. These three ramps are also available as individual patterns that span the picture width. First, the Y Valid Ramp spans from black to white, across the valid range of the luminance (Y) channel. Next, the B–Y Valid Ramp spans from yellow to cyan, across the valid range of the Cb color difference channel. Last, the R–Y Valid Ramp spans from cyan to red, across the valid range of the Cr color difference channel.
3 Channel Ramp	Wide ramp from the lower valid value to the upper valid value for all three channels. This pattern is color-independent, so it will appear differently in YCbCr, RGB, or XYZ color spaces. On each side of the ramp there are small plateaus at the blanking level (black) and at the valid level.
Limit Ramp	Wide ramp that spans the legal limit range (4–1019 for 10-bit formats and 16–4079 for 12-bit formats) for all three channels. On each side of the ramp there are small plateaus at the blanking level, the valid level, and the limit level.
Shallow Ramp Matrix	Vertical matrix of shallow ramps that together span the range between legal limits (4–1019 for 10-bit formats and 16–4079 for 12-bit formats). Each bit value is held for 16 pixels for 10-bit formats and for 4 pixels for 12-bit formats. There is overlap between the end of one ramp and the start of the next ramp.
Color Ramp Matrix	Vertical matrix of ramps across the colors available in the valid RGB gamut. Each set of ramps transitions between adjacent hues: red–yellow–green–cyan–magenta–blue–red. From the top of the pattern, the first three rows of ramps are at 25%, 50%, and 75% saturation. The fourth row of ramps includes fully saturated colors at 100% value. The next three rows of ramps are at 75%, 50%, and 25% value. The bottom row of ramps is monochrome.

Flat Field

Flat field patterns are full-frame images of a single color. They are used to verify uniform luminance and chromaticity levels for the entire span of the displayed image. For YCbCr formats, the SPG9000 uses Rec.601 colorimetry for SD image sizes, Rec.709 colorimetry for 720-line and 1080-line HD image sizes, and Rec.2020 colorimetry for 2160-line UHD image sizes.

Pattern	Description
0% Flat Field (Black) 50% Flat Field 100% Flat Field (White)	Full-frame monochrome flat fields.

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Pattern	Description
100% Red Field	Full-frame color flat fields.
100% Green Field	
100% Blue Field	
100% Cyan Field	
100% Magenta Field	
100% Yellow Field	
Interlaced Field Test	Full fields, of 100% red for field 1 and 100% blue for field 2, are available only for interlaced formats. When viewed, the combined image should appear purple. If the image is red or blue, only one field from the interlaced signal is present.

Multiburst

Multiburst patterns consist of five or six sine wave packets, each of fixed frequency. This pattern is typically used for frequency response testing for one or three video channels, or for testing monitor resolution. The packets have a 60% amplitude range upon a 50% level, so a range between 20% and 80% levels.

For comparison to these peak limits, flat pedestals at 80% and 20% levels are present on the left side of the pattern. The set of packet frequencies used in each pattern is determined by the maximum bandwidth of the output format.

For 4:2:2 YCbCr formats, one multiburst pattern consists only of a Y channel signal, up to the maximum frequency limit, and the second multiburst pattern is identical for all three channels, up to half of the Y channel frequency limit.

For 4:4:4 formats, each multiburst pattern is identical for all three channels.

Pattern	Description
Multiburst 0.5–2.75 MHz	(SD formats only) Three channel pattern with packet frequencies of 0.5, 1.0, 1.5, 2.0, and 2.75 MHz.
Y Multiburst 0.5–5.75 MHz	(SD formats only) Y channel pattern with packet frequencies of 0.5, 1.0, 2.0, 3.0, 4.0 and 5.75 MHz.
Multiburst 1–15 MHz	(1.5G and 3G formats only) Three channel pattern with packet frequencies of 1, 3, 6, 9, 12, and 15 MHz.
Y Multiburst 15–30 MHz	(1.5G formats only) Y channel pattern with packet frequencies of 15, 18, 21, 24, 27, and 30 MHz.
Multiburst 15–30 MHz	(4:4:4 and fast-progressive 3G formats only) Three channel pattern with packet frequencies of 15, 18, 21, 24, 27, and 30 MHz.

Pattern	Description
Y Multiburst 35–60 MHz	(Fast-progressive 3G formats only) Y channel pattern with packet frequencies of 35, 40, 45, 50, 55, and 60 MHz.

Monitor

The monitor category of test patterns contains images that are used to verify correct color representation, luminance levels, and image geometry for display systems. Color reference charts extend beyond color bars by including more patches than fully-saturated primary colors. Pluge (Picture Line Up Generating Equipment) patterns are used to calibrate brightness at near-black levels. Aperture and convergence patterns are used to verify that the complete image is displayed and centered, and the RGB channels are correctly aligned.

ChromaDuMonde	Color reference chart, used with permission of DSC Laboratories. The pattern consists of a series of DSC standard color patches representing the six primary colors, 18 evenly spaced intermediate colors, and four skin tone reference patches. The 24 primary and intermediate colors will show as a hexagonal shape on a vectorscope display, providing a reference for comparison with a camera-generated image of a physical DSC ChromaDuMonde chart. The pattern also includes an 11-step crossed grayscale section and a center section with 0% black and 100% white patches.
SMPTE 303M Color Reference	Color reference chart according to SMPTE 303M, also known as the GretagMacbeth ColorChecker® chart. Cyan patch #18 cannot be reproduced properly in the RGB and XYZ color spaces because the red component lies at approximately -14%, which exceeds legal limits for RGB formats. This patch will appear as a cyan and black checkerboard pattern, where the cyan patches are of a different hue than the full cyan patch as seen in YCbCr formats because the red component is clipped at 0%. The color values used from SMPTE 303M are those with respect to the D_{65} illuminant.
Black-White Step Scale Black-Dark Gray Step Scale	Gray scale patterns according to §6.9 of SMPTE EG 432-1-2007. A series of ten different monochrome patches at increasing luminance values is centered on a gray background, to verify gray scale tracking. The ten steps of the black to white scale are normalized gamma-corrected values of 10% to 100% and the ten steps of the black to dark gray scale are 1/31 to 10/31.
Pluge and Luma Reference	Includes two elements to help in black and white balance. The left side of the pattern contains a pluge pattern, with three vertical bars of -2%, 0%, and +2% black. The right side of the pattern contains four gray boxes corresponding to luminance levels of 110 mV, 200 mV, 450 mV, and 700 mV (100% white) in the analog domain. The -2% patch of the pluge section is clipped to 0% black for XYZ formats.

Checkerboard	4×4 grid of alternating black and white patches, used to measure intra-frame contrast according to §6.8 of EG 432-1-2007.
Window	White square centered on a black background. This pattern can be used as an alternative to a full-field white pattern when it is useful for the average picture level (APL) to approximate normal program content.
Screensaver	Small 75% color bars (about 22% of screen width and 20% of screen height) in motion both vertically and horizontally on a black field, "bouncing" off the edges of the image.
Production Aperture	Includes single-pixel wide lines at the extreme edges of the active video area, marking the complete production aperture. Vertical lines are implemented as single-sample pulses with no edge filtering, so this pattern is not legal as a broadcast signal.
Clean Aperture	Grid pattern according to SMPTE RP 187-1995. The clean aperture is marked by the outer markers, with overscan markers at approximate 2.5% increments. The center 4:3 section of a 16:9 image has an additional set of aperture and overscan markers. Each line on the grid is implemented with two horizontal lines or a double-width pulse centered on two samples, because the actual aperture boundary and the center of the image each lie midway between lines and samples. This pattern is only available for 1080-line, 720-line, and standard definition formats.
Convergence Convergence 4:3	Grid pattern of equal size squares with a dot at the center of each square. Each line and dot is implemented as a single horizontal line or single-sample pulse. This pattern is used to verify convergence of RGB channels, and no color fringing should be visible on the white lines and dots when the channels are aligned.
EBU 3374 EOTF Validation	EOTF (Electro-Optical Transfer Function) chart for HDR calibration and monitoring. The center third of the pattern (vertically) consists of a monochrome step scale with full-range values in 10% steps from 0% to 50%, then 5% steps from 55% to 100%. The left side of the scale has a higher resolution section with steps of 0%, 3%, 6%, and 10% and the right side has a similar section with steps of 90%, 91%, 92%, and 95%.

BT.814 SD Pluge BT.814 SDR Pluge BT.814 HDR Pluge	Pluge patterns for SD and HD/UHD systems as defined in ITU-R BT.814-4. The SD pattern is described in Annex 1. It includes three vertical rectangles on the left, at −1.8%, 0% and +1.8% black, respectively, and four rectangle on the right at luma levels of 100% (white), 63%, 35.2% and 15.1% respectively. The SDR and HDR patterns for HD and UHD formats are defined in Annex 2. The left side of the image has a series of near-black stripes at approximately ±1.8%. The center section has a single rectangle window at 100% white for the narrow-range SDR pattern and 38.2% for the HDR pattern. This level is the same luminance for both PQ and HDR HLG, at approximately 27 nits. The right side of the image has two near-black rectangle windows, at +1.8% and -1.8%.

Pulse Bar

The pulse and bar test signal is used to test bandwidth and group delay. The pulse has high-frequency content, so if the bandwidth of the signal path is good, the pulse waveform rises to the top of the bar. To view the phase response, examine the ringing on the base of the pulse waveform. If the ringing is low and symmetric, the group delay is good.

Pattern	Description

2T Pulse and Bar	Two pulses of 2T half-amplitude width and full-scale amplitude. A positive pulse is added to a base level at the minimum valid value, and a negative pulse is added to a bar level at the maximum valid value. The 2T pulse is used for Short Time response testing and the bar is used for Line Time response testing.
	
	The type of 2T pulse depends on the signal format:
	
	    For SD-525 format, this is a 2T4 pulse.
	
	    For SD-625 format, this is a 2T5 pulse.
	
	    For HD and slow-progressive 3G formats, this is a 2T30 pulse.
	
	    For 3G fast progressive formats, this is a 2T60 pulse.
	
	    For UHD slow-progressive formats, this is a 2T60 pulse.
	
	    For 6G and 12G fast-progressive formats, this is a 2T120 pulse.
	
	    For 4:2:2 formats, chroma pulses are at half the bandwidth.

Color Pulses	Eight color pulses of 2T half-amplitude width upon black and white backgrounds. The upper half of the pattern has positive pulses on a black background, testing each combination of the three color channels. The lower half of the pattern has a white background, so negative pulses are used to result in the same line colors. For example, the yellow pulse in the upper half is 100% red plus 100% green, resulting in yellow on a black background. At the same horizontal location in the lower half, a pulse of −100% blue added to the white background also results in a yellow line.

Timing

The timing pattern is used to verify timing alignment between the three channels of a component video system.

Pattern	Description
Co-siting Pulse	One single-sample wide pulse in the center of the image, used to show the timing relationship and alignment between chroma and luma channels. Different amplitudes are used to distinguish the three channels.

SDI Pathological

A pathological test pattern is a flat field (or a matrix of several flat fields) with a specific set of 10-bit values that is designed to cause stress in an SDI system. These signals can be used to characterize system limits for cable lengths, for example:

An SDI signal is bit stream encoded using the NRZI (non-return-to-zero, inverted) format. The bit stream is scrambled so a long sequence of consecutive 1s or 0s is not usually transmitted. This is preferred because the receiver uses frequent signal transitions to synchronize with the signal. However, a specific sequence of bits at the scrambler input can result in a stressful sequence on the output. Because the scrambler equation is a 9th degree polynomial, the state of the scrambler will statistically be in the necessary initial state for the test signal on 1 out of every 512 lines. The stressful pattern then persists for the full active-video line.

The receiver equalizer can be stressed with a pattern with maximum DC content—or a long sequence of consecutive 1s or 0s—followed by a single bit at the other level. The phase-locked loop of the receiver can be stressed with a pattern that has a low frequency of level transitions, such as 20 consecutive 1s (or 0s) followed by 20 consecutive 0s (or 1s). The bandwidth of the signal path can be stressed with a pattern of as many transitions as possible, such as alternating 1s and 0s in the bit stream.

The equalizer test pattern creates an output signal with a DC bias because of the unequal distribution of bits at the high and low levels. Therefore, an additional component is added to the test pattern to ensure that both polarities of DC bias are generated. RP 198 defines a polarity control word, in which one bit of the first sample in the first active video line is alternated on successive frames. This method has been proven to be ineffective in some cases, so the SPG9000 uses a 10-bit counter for the polarity control word.

The SPG9000 includes "half-length" variations of these test patterns, so named because the output sequence is half the duration of the original patterns defined in SMPTE RP 198-1988. For example, the half-length equalizer test has a sequence repeat pattern of 9 + 1 bits instead of 19 + 1 bits, and the half-length, phase-locked loop test has a sequence repeat pattern of 10 + 10 bits instead of 20 + 20 bits.

The SDI pathological patterns in the SPG9000 are independent of color space and sampling structure, so the displayed color of each field is format-dependent. The RP 198 equalizer test field and PLL test field appear as a shade of magenta and a 24% gray field respectively, only for YCbCr 4:2:2 10-bit HD and SD formats.

Pattern	Description
SDI Checkfield	Checkfield pattern as defined in RP 198, the top half of the field is the equalizer test, which alternates 10-bit words of 300h and 198h. The scrambler output pattern uses 19 consecutive 1s or 0s followed by one bit at the other level. The bottom half of the field is the phase-locked loop test, which alternates 10-bit words of 200h and 110h. The scrambler output pattern uses 20 consecutive 1s or 0s followed by 20 consecutive bits at the other level. This pattern is not available for 2160-line UHD/4K formats because the two-sample interleave (2SI) encoding of those formats.
SDI Checkfield, Half-Length	Checkfield pattern similar to RP 198, but it can be used for all formats, including 6G-SDI and 12G-SDI. The equalizer test repeats a 10-bit word of 14Ch, resulting in an output sequence of 9 consecutive 1s or 0s followed by one bit at the other level. The PLL test repeats a 10-bit word of 218h to produce an output sequence of 10 consecutive bits at each level.
SDI Matrix, Half-Length	Matrix pattern made of the half-length signals, is suitable for all formats. The top third of the image is the equalizer test pattern, the middle third is the PLL test pattern, and the bottom third is the bandwidth test pattern. This pattern is not available for 2160-line UHD/4K formats with 12-bit sampling.
SDI Matrix and Rec.709 Bars	Matrix pattern made of the three half-length signals plus 100% narrow-range color bars, is available for HD/2K formats with YCbCr 4:2:2 10-bit sampling structure.
SDI Matrix and Rec.2020 Bars	Matrix pattern made of the three half-length signals plus 100% narrow-range color bars, is available for UHD/4K formats with YCbCr 4:2:2 10-bit sampling structure.
Equalizer Test, Full-Length	Full-field pattern of the equalizer test signal from RP 198, alternates 10-bit words of 300h and 198h. The scrambler output pattern uses 19 consecutive 1s or 0s followed by one bit at the other level.
Equalizer Test, Half-Length	Full-field pattern of the half-length equalizer test signal, repeats a 10-bit word of 14Ch. The scrambler output pattern uses 9 consecutive 1s or 0s followed by one bit at the other level.
PLL Test, Full-Length	Full-field pattern of the phase-locked loop test signal from RP 198, alternates 10-bit words of 200h and 110h. The scrambler output pattern uses 20 consecutive 1s or 0s followed by 20 consecutive bits at the other level.
PLL Test, Half-Length	Full-field pattern of the half-length, phase-locked loop test signal, repeats a 10-bit word of 218h. The scrambler output pattern uses 10 consecutive 1s or 0s followed by 10 consecutive bits at the other level.

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Pattern	Description
Bandwidth Test	Full-field pattern of the half-length bandwidth test signal, repeats a 10-bit word of 277h. The scrambler output pattern uses 9 bits that alternate between levels with the 10th bit repeated from the 9th bit.

Image File Parameters

You can use your own image files as video test signals. These can be custom test patterns or photographic images, depending on your test signal requirements. You will need to upload the file to the SPG9000 before it can be selected.

The SPG9000 supports the Tag Image File Format (TIFF) for image files. There are several encoding options for TIFF files; the SPG9000 supports the RGB color space at 8-bit or 16-bit resolution per channel.

If the output format is configured for YCbCr sampling, the SPG9000 will convert the source RGB pixel values to the output sample values according to the **Colorimetry** setting (Auto, Rec. 709, or Rec. 2020). Similarly, the **Range** setting (Narrow or Full) is used to determine how source RGB pixel values should be processed. It is important to understand how the source image file is encoded so that the desired output signal is generated. For example, if the minimum (black) color level in the source file is 0 and the maximum (white) level is 65535 (16-bit) or 255 (8-bit), the image uses full range. Narrow range files will use 4096 (16-bit) or 16 (8-bit) for the black level and 60160 (16-bit) or 235 (8-bit) for the white level.

If the file image size is smaller than the output image size, the image will be centered and padding space will be black. If the file image size is larger than the output image size, the center of the larger image will be visible but the remainder will be cropped.

To select a specific image file:

1. If necessary, upload the file to the SPG9000. See File Management.

2. Select the **TIFF File Name** menu and choose a file from the list. The file header is examined and metadata for the file is displayed. If the file format is unsupported, the corresponding metadata value will be highlighted in red text.

3. Select the **Load Image** button to load the TIFF file into the SPG9000 display memory. This will take a few seconds depending on the image size.

Video Components

Select or clear the checkboxes to enable or disable any of the constituent component channels of the test pattern. For example, if a YCbCr format is selected, you could disable the Cb and Cr (chroma) channels to only view the Y (luma) component of the current test pattern.

Edge Filter

Select or clear the checkbox to enable or disable the edge filter. When enabled, a low-pass filter is used for certain data transitions between adjacent levels to set rise times, pulse widths, and to prevent ringing on the output signal.

If the filter is disabled, the edges are not filtered. The filter should not be disabled in broadcast environments.

Note: The edge filter is not available when the Signal Type is set to Image File. It is the responsibility of the image file creator to ensure that pixel transitions within the image and at the left and right edges are appropriate for the test signal application.

AV Timing Mode

Select or clear the checkbox to enable or disable the AV timing mode. When enabled, the active video will switch to black for 4.5 seconds and then switch back to the current test signal for $.5$ seconds in a repeating cycle. The embedded audio for an SDI output or the associated audio stream for an IP output will simultaneously be muted on all channels for the same duration that the video is blanked. The resulting "flash/pop" effect can be used to measure the audio-video delay using a Telestream waveform monitor such as the PRISM or WFM/WVR series.

To use AV Timing Mode with a ST 2110-20 video stream and a 2110-30 audio stream, you will need to enable the mode for the video source and also select the video source in the IP audio stream configuration. See *Configuration Settings for IP Streams*.

Time Code

Video sources have an associated time code counter that are used when the burnt-in time code overlay is enabled, and when ancillary time code is enabled for SDI outputs. The same time code digits are used simultaneously for both purposes, so they are configured together with the video source.

Note: The time code configuration is only available for video sources 1-4, but not sources 5-6 as they are not used for SDI outputs and they do not support the overlay feature.

On the web interface, select the video Source (1-4), then select **Time Code**.

Source

Select the time source for the time code counter:

Local (DST): Uses the main time-of-day plus the time zone offset plus the daylight saving time offset to compute the local time.

Local (No DST): Uses the main time-of-day plus the time zone offset, but excludes any daylight saving time offset to compute the local time.

UTC: Uses Coordinated Universal Time instead of a local time.

Program Time: Uses the program time counter instead of a time-of-day value. See *Program Time Counter*.

The time code data includes the hours, minutes, seconds, and frames digits (HH:MM:SS:FF) according to ST 12-1 and the year, month, day, and time zone information according to ST 309.

Offset

Enter a time offset (hours, minutes, seconds, and frames) relative to the selected source time. For example, you could use the time code for a different time zone than the system normal time zone by specifying an offset of ± 1 or more hours.

Drop-Frame (30 fps)

Select this checkbox to enable drop-frame time code. This option is only available when the format has a frame rate of 29.97 fps or 59.94 fps. This option should be selected for most applications where the time code represents time-of-day; this is so the time code is similar to the real-time clock. See *Daily Jam Sync* for keeping 30 fps drop-frame time code aligned with the main time-of-day (MTOD). Non-drop frame (NDF) time code is sometimes used in editing and post-production, typically when also using the Program Time source.

Overlay

The video generator of the SPG9000 can add optional overlays to the active test signal. If the background test signal changes, the overlays remain unchanged.

There are three independent overlays:

ID Text: Static text to identify the signal source, for example.

Burnt-In Time Code: Dynamic text for the current digits of the video source's time code.

Logo: Color image for a network or company logo, for example.

All three overlays with a color bars test pattern are shown. The position of all overlays is adjustable, and the character sizes of the ID text and time code overlays are also independently adjustable.
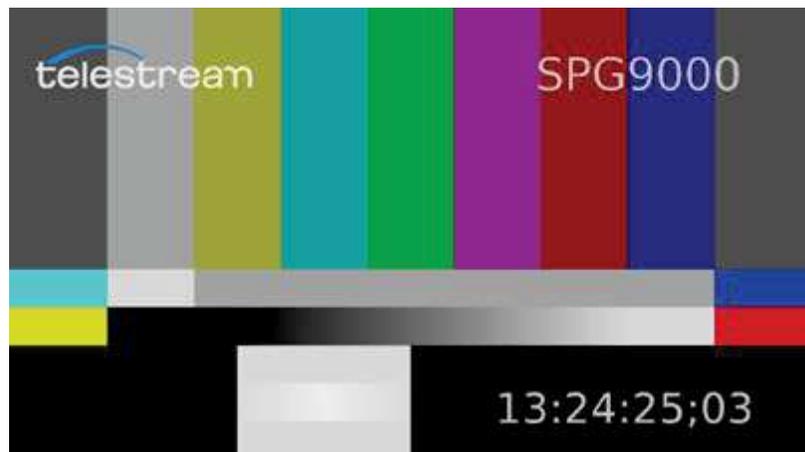
On the web interface, select the video Source (1-4), then select **Overlay**.

Note: The overlay feature is only available for video sources 1-4, but not sources 5-6. Sources 1-4 can be used for both SDI outputs and IP video streams.

ID Text

The ID Text overlay displays a static string of one or more lines of text, which is useful for identification of the channel or the signal source, for example. The text is composed from Unicode characters so that most written languages can be represented. See Fonts.

ID Text Overlay

Select or clear the checkbox to enable or disable the text overlay.

Display Text

Enter the text to be displayed. On the web interface, you can enter multiple lines of text and you can enter any Unicode character, such as text from languages such as Chinese or Japanese. On the front-panel menu, you can only edit the first line of text and you can only use the 95 displayable characters in the Unicode range U+0020 to U+007E (ASCII).

Text Size

Enter the character size for the display text, expressed as a percentage of active picture height (% APH). For example, for a 1080-line HD image size, 10.0% APH would be 108 pixels. If the test signal format is changed to 720-line HD, the text size would change to 72 pixels and therefore the text will scale along with the test pattern. The maximum text size is 25% APH.

Border

Select the checkbox to display the near-white (90%) text inside a near-black (10%) rectangular box background. If the border is disabled, the text is displayed with transparency between the characters. The border is useful if the background test pattern does not have enough contrast with the near-white text.

X Position

Enter the position of the left edge of the text overlay, expressed as a percentage of the active picture width (% APW). The X position is relative to the left edge of the image (0%).
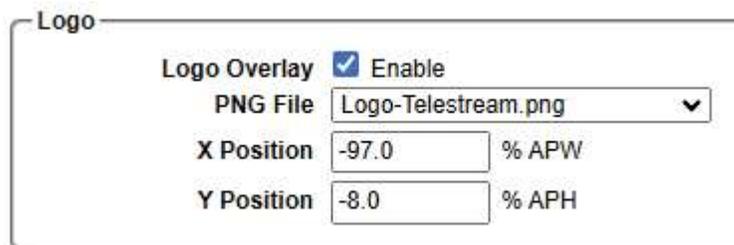
Y Position

Enter the position of the top edge of the text overlay, expressed as a percentage of the active picture height (% APH). The Y position is relative to the top edge of the image (0%).

Burnt-In Time Code

Burnt-in time code (BITC) Displays the digits of the time code counter for the video source. For SDI outputs, the Ancillary Time Code (ATC) digits will exactly match the BITC digits for every frame.

The BITC digits are displayed as HH:MM:SS;FF or HH:MM:SS:FF with two digits for hours, minutes, seconds and frames respectively. The separator between the seconds digits and the frames digits will be a semicolon if the time code uses drop-frame format or a colon for non-drop format. If the frame rate is higher than 30 fps, ".0" or ".1" will be appended to the frames digits to indicate the first or second frame in the frame pair.

BITC Overlay

Select or clear the text box to enable or disable the time code overlay.

Text Size

Select the size to be used for BITC text: The **Small** size is approximately 11% of the active picture height, and the **Large** size is twice as big as the small size.

Display YYYY-MM-DD

Select the checkbox to include the year, month and day in the BITC overlay. These digits will appear on a second line of text, beneath the HH:MM:SS:FF digits.

X Position

Enter the position of the left edge of the time code overlay, expressed as a percentage of the active picture width (% APW). The X position is relative to the left edge of the image (0%).

Y Position

Enter the position of the top edge of the time code overlay, expressed as a percentage of the active picture height (% APH). The Y position is relative to the top edge of the image (0%).

Logo

The logo overlay displays a full-color picture file (PNG format) such as a network or company logo. The logo image can include a transparency (alpha) channel so that the background is visible around curved edges, for example.

To use a logo image, the file must first be uploaded to the SPG9000. See File Management.

Note: The logo image does not scale when the test signal format is changed. For example, a logo that appears as the desired size when the image size is 1920×1080 HD will look larger than expected if the image size changes to SD and will look smaller than expected if the image size changes to UHD. You may want to create multiple versions of your logo for different sizes of the test signal.

Logo Overlay

Select or clear the checkbox to enable or disable the logo overlay.

PNG File

Select the logo image file from the list. To add, delete, or rename files in the list, select the **System** tab of the web interface and then select **File Manager**.

X Position

Enter the position of the right edge of the logo overlay, expressed as a percentage of the active picture width (% APW). The X position is relative to the right edge of the image (0%). Therefore, the X Position value will be a negative number, with −100% representing the left side of the image.

Y Position

Enter the position of the bottom edge of the logo overlay, expressed as a percentage of the active picture height (% APH). The Y position is relative to the bottom edge of the image (0%). Therefore, the Y Position value will be a negative number, with −100% representing the top side of the image.

Note: The positions of the ID text and BITC overlays are relative to the top left corner of the image, but the position of the logo overlay is relative to the bottom right. This is intentional because logos are often inserted in the bottom right corner.

Timing

The Timing settings adjust the timing offset of the output signal relative to the internal frame reset. See *Epoch-Based Synchronization* to understand how frame resets are synchronized with respect to the reference source.

The total timing offset is a combination of whole lines (vertical delay) and partial lines (horizontal delay). A negative value means the internal clock is advanced relative to the frame reset.

On the web interface, select the Source needed (1-4 or 1-6), then select **Timing**.

Vertical Delay

Enter an integer number of lines, in 1 line increments. The delay range is from -½ to +½ frame. For example, the range for a 1080-line HD format is ± 562 lines, because the complete frame size, including vertical ancillary data space, is 1125 lines.

Horizontal Delay

Enter the delay value in microseconds. The timing adjustment range is ± 1 line, where the line length depends on the selected signal format. For example, the duration of one video frame at 25 fps is 40 milliseconds. Each line of the 1125-line HD format has a duration of 35.5556 µs, so the horizontal delay range is from -35.5556 µs to +35.5556 µs.

Relative To

Select the zero-timing compensation factor for the delay adjustment. The default (0H) is correct for most applications. Select Analog (DAC) to apply a compensation factor for a nominal digital-to-analog converter in the timing measurement circuitry, which was present in some older waveform monitors.

Note: This menu is only available for 1.485 Gbps (HD) and 270 Mbps (SD) output formats.

Audio Sources

The SPG9000 has 32 audio tone sources that can be independently configured. Each audio tone source is described by its amplitude, frequency, and identification. Changing the configuration settings for an audio source affect all outputs that use that specific source.

Web Interface for Audio Sources

On the web interface, select the **Audio** tab and then select **Tones**.
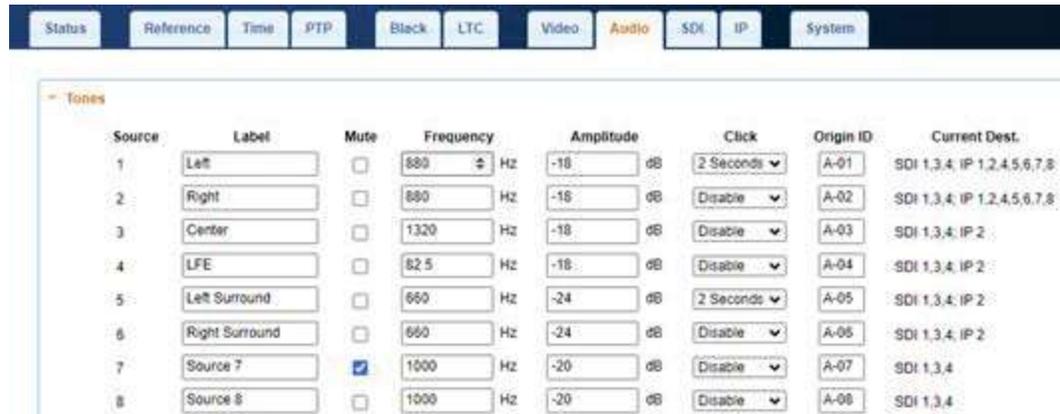
Front-Panel Menu for AUDIO

To use the front panel of the SPG9000 for this process, select **AUDIO** and then select **TONES**. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the SOURCE 1 menu.

AUDIO:
TONES :
SOURCE 1 :
LABEL
MUTE
FREQUENCY
AMPLITUDE
CLICK
ORIGIN ID
REFERENCE :

Configuration Settings for Audio Sources

Configure and label the specific video source. There are several options to select in this menu.

To use the front panel for this process, see *Front-Panel Menu for AUDIO*.

Label

Enter a user-defined label to identify the audio source, such as "Program Left." The source label is used on the SDI and IP output configuration menus to make it easier to describe the source content.

Mute

Select this checkbox to mute the audio channel. Audio sample values are set to zeros instead of the tone data sample values.

Frequency

Enter the tone frequency for the audio source, from a minimum of 10 Hz to a maximum of 20000 Hz, in 0.5 Hz steps.

Amplitude

Enter the amplitude for the audio source, from a minimum of -60 dB to a maximum of 0 dB, in 1 dB steps.

Click

Select the total period of the tone and 250 ms of mute. The transition to mute sounds like a click in the continuous tone. Select from 1, 2, 3, or 4 seconds of tone and mute between clicks. For example, a time of 3 seconds has 2.75 seconds of audio followed by a click and 0.25 seconds of mute. This can be useful to identify one channel of a stereo pair. Disable the click for an uninterrupted tone.

Origin ID

Set the channel origin value used in AES3 channel status metadata. This is an alphanumeric field of four characters, which can be used to identify the specific audio channel by equipment that decodes this value from received audio streams.

SDI Outputs

The SPG9000 has four serial digital interface (SDI) outputs, labeled SDI 1 to SDI 4 on the back panel of the instrument. Each output is used with an independent video source, so any supported combination of video formats and test signal content can be used on the four outputs simultaneously.

Each SDI output is directly connected with a specific video source. The SDI 1 output uses video source 1, SDI 2 uses video source 2, and so on. See *Video Sources* to configure the format, test signal, and timing information.

Each SDI output has an independently configurable, embedded audio configuration. The outputs use sources from the Audio tab, in Tones, for the 16 available channels. See *Audio Sources* to configure the amplitude and frequency of each audio tone source.

SDI outputs can also generate ancillary time code (ATC) with a selectable time source and offset. Both LTC and VITC variants of ATC can be included simultaneously in the ancillary data space.

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Web Interface for SDI Outputs

On the web interface, select the **SDI** tab, then select from the SDI 1-4 to open the configuration menus for the outputs. When the SDI tab is first opened, the four sections labeled SDI 1 to SDI 4 are collapsed:

The section headers for SDI 1 to SDI 4 each show a summary of the current configuration. Each displays the interface speed for the current format, user-defined label, selected format, and selected video test signal. Select an SDI output header to open that section and see the output submenus: Video, Embedded Audio, and Ancillary Time Code.

Front-Panel Menu for SDI

To use the front panel of the SPG9000 for this process, press **SDI** repeatedly to select from the four output submenus. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the SDI 1 menu.

SDI 1 :
    VIDEO :
        SOURCE
        PAYLOAD ID MODE
        PAYLOAD ID VALUE   Only available if PAYLOAD ID MODE is Manual
        EDH   Only available if the video format is standard definition
        3G MODE   Only available if the interface speed is 3 Gbps
    EMBEDDED AUDIO :
        GROUP 1 :

SDI 1 :

      (ENABLE)

      CHANNEL 1 (active)

      CHANNEL 1 (source)

      CHANNEL 2 (active)

      CHANNEL 2 (source)

      CHANNEL 3 (active)

      CHANNEL 3 (source)

      CHANNEL 4 (active)

      CHANNEL 4 (source)

      SAMPLING

    GROUP 2 :   Same submenus as GROUP 1

    GROUP 3 :   Same submenus as GROUP 1

    GROUP 4 :   Same submenus as GROUP 1

  ANCILLARY TIME CODE :

    ATC_LTC

    ATC_VITC

Configuration Settings for SDI Outputs

Configure the specific SDI output:

On the web interface, select the **SDI** tab, and then select the specific output section (SDI 1 to SDI 4) to configure.

To use the front panel for this process, see *Front-Panel Menu for SDI*.

Video

The Video section is used to configure the SDI-specific options for the video output signal. See *Configuration Settings for Video Sources* to change the format, test signal, or timing.

Source

Displays the video source number and its user-defined label used for the output.

SMPTE 352 Payload ID

Select the mode for the insertion of the video payload identifier (VPID) in the ancillary data space of the SDI signal. The VPID is defined in ST 352 and subsequent specifications, and is used by SDI equipment to correctly interpret or display the received signal. VPID carries information such as the sampling structure, colorimetry, transfer characteristics, bit depth, and range. Without that metadata, a receiver would not be able to automatically know if the signal is YCbCr or RGB, SDR, or HDR, or other essential parameters.

The VPID is a 32-bit (four byte) value that is carried in an ancillary data packet that is inserted once per frame or field, and for each internal data stream. For example, a 12G-SDI signal is composed of 8 data streams so there are 8 copies of the VPID in the ancillary data for each video frame.

Select from the options:

Automatic: The system automatically inserts the correct VPID based on current video format values.

Manual: Enter the VPID value as 8 hexadecimal digits. This option can be used to signal video formats not supported directly by the instrument. For example, to signal the IC_TC_P color difference signal instead of $Y'C'_BC'_R$, use a VPID value with bit 4 of byte 4 set to 1 instead of 0.

Disable: The system will not insert the VPID in the ancillary data space.

Note: Automatic mode is recommended for most applications. Changing or disabling the VPID should be done with care. If the video format is changed when manual mode is used, the VPID value must also be updated.

3G-SDI Mode

Select the mapping for 3G-SDI formats, as defined in SMPTE ST 425-1, from the options:

Level A: Select the direct mapping for the two data streams comprising the 3G-SDI signal.

Level B: Select the dual-link mapping for transporting a ST 372 Dual-Link interface over a single 3G-SDI link.

This menu is only available if the selected video format requires a 3G-SDI output and both levels are supported, as listed in the table. For the 1280×720 image size with 4:4:4 sampling, only Level A is defined.

Image Size	Scan Type	Frame Rate	Sampling	Color Space	Bit Depth
1920×1080	Progressive	60/59.94/50	4:2:2	YCbCr	10
	Any	30/29.97/25/24/23.98	4:4:4	Any	Any
			4:2:2	YCbCr	12

Image Size	Scan Type	Frame Rate	Sampling	Color Space	Bit Depth
2048×1080	Progressive	60/59.94/50/48/47.95	4:2:2	YCbCr	12
	Any	30/29.97/25/24/23.98	4:4:4	Any	Any
			4:2:2	YCbCr	12

Note: If Level B is selected for a 3G-SDI signal, the corresponding video source cannot be used for a ST 2110-20 video IP stream. See *Video Streams*.

SD-SDI EDH

Check this box to enable the automatic insertion of Error Detection and Handling (EDH) packets in the ancillary data space of the SDI signal according to SMPTE RP 165. This option is only available for standard definition (SD-SDI) formats. It is not needed for 1.5 Gbps and higher SDI formats because they include a CRC checksum on each line of the SDI signal.

Embedded Audio

The Embedded Audio section is used to map audio sources into embedded audio groups in the SDI output signal. See *Configuration Settings for SDI Outputs* to change the frequency, amplitude, and other parameters for the individual audio tones.

Audio is carried in the ancillary data space of an SDI signal and is organized into 4 groups of 4 channels each according to SMPTE ST 299-1. Each group can be individually enabled or disabled.

Note: For wide image formats (2048×1080 and 4096×2160) at higher frame rates (60, 59.94, 30, or 29.97 fps), there is not enough horizontal ancillary data space to carry 4 groups of audio. For these formats, only groups 1 and 2 are used.

Enable

Select this checkbox to enable the respective group. Ancillary data packets with the corresponding DID value are inserted into the SDI signal as shown in the table:

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Group	Audio Data DID	Audio Control DID
1	E7	E3
2	E6	E2
3	E5	E1
4	E4	E0

Channel 1 to Channel 4

Select the checkbox to set the active bit in the audio control packet, marking this channel as active. Clear the checkbox to mark the channel as inactive.

Select the audio source for the embedded audio channel. Any of the 32 audio sources can be used for any embedded audio channel, and the same audio source can be used more than one time.

Sampling

Select the audio sampling alignment status that is signaled in the audio control packets (ACP) for the group:

Frame: Selects synchronous sampling with audio frame numbers included in the ACP.

Frame w/o Frame #: Selects synchronous sampling without audio frame numbers in the ACP.

Asynchronous: Selects asynchronous sampling.

Ancillary Time Code

The ancillary time code (ATC) section is used to configure the insertion of ATC packets in the SDI output signal. ATC is described in the SMPTE ST 12-2. The SPG9000 supports the ATC_LTC and ATC_VITC payload types, which identify the carriage of linear time code (LTC) and vertical interval time code (VITC) code words respectively. Both packet types can be inserted simultaneously in the same SDI output signal.

The time code source, offset, and drop-frame format are configured with the video source. This ensures that the same time code digits are used for both ancillary time code packets and burnt-in time code overlay in the video signal. See *Time Code*.
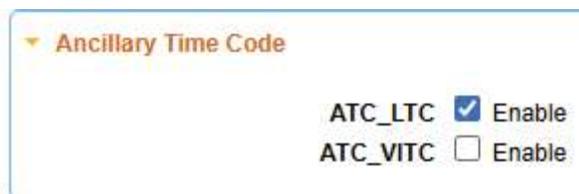
ATC_LTC

Select this checkbox to enable the insertion of ATC_LTC packets in the SDI output signal, on line 10 in the horizontal ancillary data space. One packet is included per frame for all frame rates. For frame rates higher than 30 fps, the same ATC_LTC packet is repeated for two frames.

ATC_VITC

Check this box to enable the insertion of ATC_VITC1 and ATC_VITC2 packets in the SDI output signal, on line 9 in the horizontal ancillary data space. For interlaced and segmented formats, ATC_VITC1 packets are used for field 1 or segment 1, and ATC_VITC2 packets are used for field 2 or segment 2. For progressive formats with frame rates greater than 30 fps, the field mark bit in the VITC code word is used to identify the first or second frame in a pair that share the same time code digits.

IP Streams

The SPG9000 has two SFP ports, labeled IP 1 and IP 2 on the back panel of the instrument. When SFP28 (25 Gbps) or SFP+ (10 Gbps) modules are installed, the SPG9000 can generate multiple ST 2110 streams simultaneously, each on one or both interfaces. The SPG9000 supports up to 6 ST 2110-20 video streams, up to 6 ST 2110-30 audio streams and up to 6 ST 2110-40 ancillary data streams, each with independent content.

When a stream is configured to use both IP ports, RTP packets are duplicated, creating redundant IP flows compliant with ST 2022-7.

Each video stream may be used with an independent video source, so any supported combination of video formats and test signal content can be used on the six streams simultaneously. See *Video Sources* to configure the format, test signal, time code, overlay, and timing information. Video sources 1-4 are used by SDI outputs, so the same video test signal can be generated using SDI and IP at the same time. The port utilization is monitored so that the capacity of the interface (25 Gbps or 10 Gbps) is not exceeded.

Audio streams can each be configured with an independent number of channels, from 1 to 16 per stream. Audio sources are shared between different streams and with embedded audio channels on SDI outputs. See *Audio Sources* to configure the amplitude and frequency of each audio tone source.

Data streams are used to carry ancillary time code (ATC) with a selectable time source and offset. Both LTC and VITC variants of ATC are supported.

Web Interface for Network Settings

Most IP configuration parameters are set from the IP tab of the web interface or by pressing the IP button on the front-panel interface, but the network interface settings are configured from the System tab of the web interface or the SYSTEM : NETWORK menu of the front-panel menu.

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On the web interface, click the **System** tab and then click **Network Settings**.

Front-Panel Menu for Network

To use the front panel of the SPG9000 for this process, press SYSTEM and then select the NETWORK option. See *Menu Operations* for details of using the front-panel menus. The table shows the NETWORK menu, and submenus for IP 1 and IP 2.

SYSTEM :	
PRESET :	
INFO :	
NETWORK :	
MGMT :	
PTP 1 :	
PTP 2 :	
IP 1 :	
PORT	
SPEED	
DHCP	
IP ADDRESS	
SUBNET MASK	
GATEWAY	
MAC ADDRESS	
RS-FEC	
DSCP (RTP)	
IP 2 :	Same menu and submenus as IP 1
FRONT PANEL :	

WEB :
GENERAL PURPOSE INTERFACE :
POWER SUPPLY :
FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Configuration Settings for IP Network Interfaces

Before configuring IP stream settings, check that the network interfaces for the two ports are configured appropriately for the network. The factory default settings are IPv4 addresses of 172.16.3.50 for IP 1 and 172.16.4.50 for IP 2. These almost certainly need to be changed for the local network.

Enable

Check this box to enable the network interface. When disabled, no streams will be transmitted and the interface will not respond to received messages such as ping messages.

SFP Module

This is a read-only status of the SFP module that is only displayed on the web interface. If no SFP module is detected, "Not Installed" appears in the status. If the interface is enabled, this text is red to highlight the error condition.

If an SFP module is detected, the status indicates the interface speed and the laser wavelength, if applicable. For example, this can help identify mismatches between short-reach (850 nm) and long-reach (1310 nm) transceivers on the SPG9000 side and the switch side of the link.

Port Speed

Selects the data rate of the network port. The **Auto** selection will select the most appropriate speed based on parameters read from the SFP module. In some cases, such as when Direct Attach Cables (DACs) are used, the port speed may not available from SFP data. Select **10 Gbps** or **25 Gbps** to manually set the desired port speed.

RS-FEC

Check this box to enable Reed-Solomon Forward Error Correction (RS-FEC) for the link. The SPG9000 uses the IEEE 803.3by Clause 108 standard for 25 Gigabit Ethernet. If a 10 Gbps SFP+ module is installed, this option is not available.

Note: Some switches may use a different FEC protocol. In this situation, we recommend disabling RS-FEC on both the SPG9000 and the switch sides of the link.

MAC Address

This is a read-only value of the physical address of the network interface. The first three octets of a MAC address indicate an Organizationally Unique Identifier (OUI), to help identify equipment on the network. The OUI for Telestream is 00-90-56, so the MAC addresses always begin with these three octets.

DHCP

Check this box to enable Dynamic Host Configuration Protocol (DHCP) on the interface. In this case, a DHCP server must be present on the network and it assigns the IPv4 address, subnet mask, and gateway address. If the user enables DHCP, manual configuration of those values is disabled but the values provided by the DHCP server are displayed.

IPv4 Address

Enter the four octets of the IPv4 address, in dotted decimal notation. On the front-panel interface, an edit menu (see *Edit Menus*) is used to enter the address, using three digits for each octet with leading zeros if necessary. For example, an address displayed as 192.168.1.50 on the web interface appears as 192.168.001.050 on the front-panel interface. If DHCP is enabled, the IPv4 address supplied by the DHCP server is displayed instead and cannot be edited.

Subnet Mask

Enter the four octets of the subnet mask, in dotted decimal notation. If DHCP is enabled, the subnet mask supplied by the DHCP server is displayed instead and cannot be edited.

Gateway

Enter the four octets of the gateway address for this subnet, in dotted decimal notation. If DHCP is enabled, the gateway address supplied by the DHCP server is displayed instead and cannot be edited.

DiffServ Code Points

Select the DSCP value for transmitted RTP packets.

Differentiated Services (DiffServ) is a mechanism for applying quality of service (QoS) to IP networks. A DiffServ Code Point (DSCP) is a 6-bit value (between 0 and 63) that is included in the header of an IP packet. It identifies the type of traffic and its associated priority.

RTP media streams default to using the Assured Forwarding class (defined in RFC 2597) with the AF41 codepoint (value of 34) as specified in AES67-2018.

Apply Changes

Click to accept any changes made to the network settings since opening the panel on the web interface.

Cancel Changes

Click this button to cancel any changes made to the network settings and restore the previously saved settings.

Web Interface for IP Streams

On the web interface, select the **IP** tab, then select **Video Streams, Audio Streams,** or **Data Streams** to select the stream type. When the IP tab is first opened, the sections are collapsed:

The **Port Utilization** section is always visible at the top of the tab, and shows the bit rate estimate for video streams currently enabled for each of the IP 1 and IP 2 ports. The total capacity (Used plus Free plus Reserved) is determined by the SFP type. When all video streams are disabled, the port utilization will still show 1.3 Gbps is reserved. This bandwidth is reserved for all audio and data streams that may be in use, and for all non-ST 2110 traffic that may be present on the interface.

Video Streams

Select **Video Streams** to configure ST 2110-20 video streams. When the section is first opened, the six individual video stream sections are collapsed.

The section headers for the 6 video streams each show a summary of the current configuration, displaying the selected video source, format, and destination IP address(es) This makes it easy to view the configuration of all video streams together, in a table-like format. Click on a header to open that section to see the menus for that video stream.

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When a section is opened, the parameters for the video stream can be configured.

Audio Streams

Select **Audio Streams** to configure ST 2110-30 audio streams. When the section is first opened, the six individual audio stream sections are collapsed.

The section headers for the 6 audio streams each show a summary of the current configuration, displaying the number of channels and destination IP address(es) This makes it easy to view the configuration of all audio streams together, in a table-like format. Click on a header to open that section to see the menus for that audio stream.

When a section is opened, the parameters for the audio stream can be configured.

Data Streams

Select **Data Streams** to configure ST 2110-40 ancillary data streams. When the section is first opened, the six individual data stream sections are collapsed.

The section headers for the 6 data streams each show a summary of the current configuration, displaying the time code format, time code source and destination IP address(es) This makes it easy to view the configuration of all data (time code) streams together, in a table-like format. Click on a header to open that section to see the menus for that data stream.

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When a section is opened, the parameters for the data stream can be configured.

Front-Panel Menu for IP Streams

To use the front panel of the SPG9000 for this process, press SYSTEM and then select the NETWORK option. See *Menu Operations* for details of using the front-panel menus. The table shows the NETWORK menu, and submenus for IP 1 and IP 2.

IP :
    VIDEO STREAMS :
      VIDEO 1 :
        (ENABLE)
        LABEL
        SOURCE
        PACKING MODE
        TR OFFSET MODE
        TR OFFSET
        RTP PAYLOAD TYPE
        IP 1 :
          (ENABLE)
          DEST ADDRESS
          SOURCE PORT
          DEST PORT
        IP 2 :   Same menu and submenus as IP 1
      VIDEO *N* :   Same menu and submenus for streams 1 to 6
    AUDIO STREAMS :
      AUDIO 1 :
        (ENABLE)
        LABEL
        NUM CHANNELS
        CHANNEL ORDER
        CHANNEL 1 SOURCE
        CHANNEL *N* SOURCE   Additional menus per NUM CHANNELS value
        PACKET TIME
        RTP PAYLOAD TYPE
        IP 1 :   Same menu and submenus as IP 1
          (ENABLE)
          DEST ADDRESS
          SOURCE PORT
          DEST PORT
        IP 2 :   Same menu and submenus as IP 1
      AUDIO *N* :   Same menu and submenus for streams 1 to 6
    DATA STREAMS :
      TIME CODE 1 :
        (ENABLE)
        LABEL
        TYPE
        SOURCE
        OFFSET

FORMAT		
FRAME HEIGHT		
SCAN TYPE		
FRAME RATE		
DELAY (Vertical)		
DELAY (Horizontal)		
RTP PAYLOAD TYPE		
IP 1 :		
(ENABLE)		
DEST ADDRESS		
SOURCE PORT		
DEST PORT		
IP 2 :	Same menu and submenus as IP 1	
TIME CODE *N* :	Same menu and submenus for streams 1 to 6	

Configuration Settings for IP Streams

Configure the specific IP stream:

On the web interface, select the **IP** tab, select the stream type (Video, Audio, or Data), and select the specific stream section to configure.

To use the front panel for this process, see *Front-Panel Menu for IP Streams*.

Each ST 2110 stream includes Transport Parameters for configuration of IP, UDP and RTP packet headers. Video, audio, and data stream each also have type-specific configuration parameters.

Every IP stream has a Session Description Protocol (SDP) object that can be viewed from the web interface and copied to external ST 2110 connection management systems.

Transport Parameters

The Transport Parameters include the source and destination information for the stream.

RTP Payload Type

Enter the value of the Payload Type (PT) inserted into the RTP header for transmitted packets. The ST 2110-10 specification limits the range of payload type values to 96–127.

Port 1 and Port 2 Enable

Select to enable the port for this stream. When both ports are enabled, the same RTP header and payload is transmitted on a packet from each interface, thereby creating a redundant path for the stream per ST 2022-7. The IP and UDP headers are configured independently.

Source IP Address

Displays the source IP address for the respective port. This is a read-only value; see *Configuration Settings for IP Network Interfaces* to update the port address parameters.

Destination IP Address

Enter the four octets of the IPv4 address, in dotted decimal notation. On the front panel interface, an edit menu (see *Edit Menus*) is used to enter the address, using three digits for each octet with leading zeros if necessary. For example, an address displayed as 229.0.1.1 on the web interface appears as 229.000.001.001 on the front-panel interface.

The SPG9000 supports multicast destination addresses in the range 224.0.2.0 to 239.255.255.255.

Source Port

Enter the source UDP port number as an integer in the range 0-65535. Port numbers in the dynamic or private range (from 49152 to 65535) are typically used for ST 2110 networks.

Dest. Port

Enter the destination UDP port number, as an integer in the range 0–65535.

Note: If NMOS is enabled, the destination IP address and the source and destination UDP port numbers may be updated by the connection manager, depending on configuration values set from that external application. See *NMOS Services*. The source IP address cannot be updated via NMOS, and can only be changed by SPG9000 network interface settings.

Video Streams

The Stream sections are used to configure the video-specific options for each ST 2110-20 video stream.

Stream

Select to enable the stream. When a stream is enabled, it is included in the Port Utilization calculations. At least one port also needs to be enabled for packets to be transmitted.

Label

Enter a user-defined label to identify the IP video stream. The stream label is used in the IS-04 sender object in the NMOS Node API, and as the session name ("s=" field) in the SDP object for the stream. See *NMOS API* and *Session Description Protocol*.

Video Source

Select the video source for this IP stream. The video source defines the format, test signal content and timing parameters. See *Configuration Settings for Video Sources* to change these parameters.

The menu shows all 6 video sources, but some sources may be unavailable for selection if there is insufficient bandwidth for this stream. Use the estimated bandwidth of the stream and the Port Utilization graph to check if the stream can be enabled.

Note: If the selected video source changes format such that the new bandwidth for the stream would cause the port to be over-subscribed, the stream will automatically be disabled.

If any video source 1-4 is used for a Level B 3G-SDI signal, that source cannot be used for a video IP stream. Select Level A instead. See *Configuration Settings for SDI Outputs*.

Packing Mode

Select General Packing Mode (GPM) or Block Packing Mode (BPM) for the video stream. These modes are defined in the ST 2110-20 specification. General Packing Mode attempts to make packets which are close to the UDP size limit of 1460 octets. Block Packing Mode uses a video payload size of 1260 octets, which is an integer multiple of 180-octet "blocks". General Packing Mode is slightly more efficient, and will have a lower bandwidth estimate for the stream.

TROFFSET

The TROFFSET value is defined in the ST 2110-21 specification in the context of the Packet Read Schedule. It represents the time (in microseconds) from the virtual start of the video frame to the time at which the receiver is expected to start reading packets from its internal buffer. The SPG9000 uses the narrow sender model (Type N), which uses the gapped PRS. This approximates the delivery of sample data to an SDI signal.

Select Default to choose the format-specific default value of TROFFSET for the stream. Select Manual to select a user-specified value.

Audio Streams

The Stream sections are used to configure the audio-specific options for each ST 2110-30 audio stream.

Stream

Select to enable the stream. At least one port also needs to be enabled for packets to be transmitted.

Label

Enter a user-defined label to identify the IP audio stream. The stream label is used in the IS-04 sender object in the NMOS Node API, and as the session name ("s=" field) in the SDP object for the stream. See *NMOS API* and *Session Description Protocol*.

Number of Channels

Select the number of channels for the stream. The SPG9000 supports 1, 2, 4, 6, 8, or 16 channels per each audio stream.

Channel Order

The channel order is a string that appears in the Session Description Protocol (SDP) object for the audio stream, to signal how the set of channels in the stream should be interpreted by the receiver. The string is composed from a set of specific symbols defined in the ST 2110-30 specification.

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Use the buttons to construct the string from start to end:

Add Program: Append the selected channel grouping symbol from the pull-down menu to the end of the channel order string. The pull-down menu will only show available channel groupings based on the number of channels for the stream and the remaining channel count. For example, if the stream has 4 channels and the channel order string is empty, the pull-down menu will show all groupings with 4 or fewer channels. If Standard Stereo (2 channels) is selected and the Add Program button is pressed, the "ST" symbol will be added to the string and the pull-down menu will then show available channel groupings of 2 or fewer channels. If Mono (1 channel) is then selected and the Add Program button is pressed again, the "M" symbol is appended to the string and the pull-down menu will show Mono as the only remaining grouping for the one remaining channel.

Clear: Press the button to reset the channel order string to an empty string. The default channel order is "Unn" (where nn is the number of channels for the stream) to indicate an undefined grouping. Clear the string first to replace this symbol with the desired grouping(s).

Apply: Press the button to complete the channel order string. If any unused channels remain, the "Unn" symbol will be appended to the string for those channels.

Audio Sources

Select the audio source for each channel in the audio stream. See *Configuration Settings for Audio Sources* to change the tone frequency, amplitude, and other settings for each audio source.

Any audio source can be used for any audio channel, and the same source can be used for multiple channels in multiple streams. Changing a source setting will affect all SDI and IP outputs that use that source.

Packet Time

Select the packet time for audio sample data. The SPG9000 supports packet times of 1 ms or 125 µs. For 48 kHz sampling, a packet time of 1 ms corresponds to 48 audio samples per channel per RTP packet, and an IP packet rate of 1000 packets per second. A packet time of 125 µs corresponds to 6 audio samples per channel per packet and a rate of 8000 packets per second. Due to the overhead of the Ethernet, IP, UDP and RTP layers, the 1 ms packet time uses less bandwidth, but fewer channels per packet are available.

Note: When the Number of Channels is set to 16, the packet time is forced to 125 µs because there are too many channels to fit into a single packet at 1 ms.

AV Timing Video Source

Select the video source that will be used with this audio stream for AV Timing mode. The video source must also have AV Timing Mode enabled. See *Configuration Settings for Video Sources*. When both the video source and the audio stream are enabled for AV

Timing Mode, the "flash/pop" effect will be synchronized between all IP video streams that use the selected video source and for this IP audio stream.

Data Streams

The Stream sections are used to configure the data-specific options for each ST 2110-40 data stream. The SPG9000 supports ancillary time code (ATC) in IP data streams.

Stream

Select to enable the stream. At least one port also needs to be enabled for packets to be transmitted.

Label

Enter a user-defined label to identify the IP data stream. The stream label is used in the IS-04 sender object in the NMOS Node API, and as the session name ("s=" field) in the SDP object for the stream. See *NMOS API* and *Session Description Protocol*.

ATC Type

Select the type of ancillary time code. ATC_LTC is typically used with progressive scan video formats and sends one time code value per video frame. ATC_VITC is used with interlaced scan video formats and sends one time code value per video field (two packets per frame).

Source

Select the time source for the time code counter:

Local (DST): Use the main time-of-day and the time zone offset and the daylight saving time offset to compute the local time.

Local (No DST): Use the main time-of-day and the time zone offset, but exclude any daylight saving time offset to compute the local time.

UTC: Use Coordinated Universal Time instead of a local time.

Program Time: Use the program time counter instead of a time-of-day value. See *Program Time Counter*.

The ATC data includes the hours, minutes, seconds, and frames digits (HH:MM:SS:FF) according to ST 12-1 and the year, month, day, and time zone information according to ST 309.

Offset

Enter a time offset (hours, minutes, seconds, and frames) relative to the selected source time. For example, you could use the time code for a different time zone than the system normal time zone by specifying an offset of ± 1 or more hours.

Time Code Format

Selects the time code format and frame rate.

The ATC format refers to the allowed range of digits for the frame count, along with the method in which they are counted and roll over at the end of each second. For example, 24 fps time code counts frames from 00 to 23 each second, and then rolls over back to 00. 30 fps drop-frame time code counts frames from 00 to 29 in most seconds, but skips the 00 and 01 counts at specific times. See *Daily Jam Sync*.

Select one of the ATC formats:

24 fps

25 fps

30 fps

30 fps drop-frame

Associated Video Format

Unlike SDI, in which ancillary data is carried in the same signal as frames of video, ST 2110-40 streams are completely independent from ST 2110-20 video streams. However, a time code data stream needs to be synchronized with a virtual video stream with a compatible format so that the packets arrive at the receiver at the time at which they would appear within the SDI ancillary data space. This requires a partial video format configuration for the data stream.

Frame Height

Select the number of lines of the associated video format. The number of active lines and total lines (including vertical blanking) are both shown for each option.

Scan Type

Select Progressive or Interlaced scan.

Frame Rate

Select the frames per second for the associated video. Available options for this menu correspond to the selected Time Code Format. For example, if 30 fps drop-frame format is chosen, only 29.97 and 59.94 fps frame rates are available.

Timing

The Timing settings adjust the timing offset of the time code stream relative to the internal frame reset. See *Epoch-Based Synchronization* to understand how frame resets are synchronized with respect to the reference source.

The total timing offset is a combination of whole lines (vertical delay) and partial lines (horizontal delay). A negative value means the internal clock is advanced relative to the frame reset.

Vertical Delay

Enter an integer number of lines, in 1 line increments. The delay range is from -½ to +½ frame.

Horizontal Delay

Enter the delay value in microseconds. The timing adjustment range is ± 1 line, where the line length depends on the selected frame height and frame rate.

Session Description Protocol

Each IP stream has an associated Session Description Protocol (SDP) object. The SDP object is a series of lines of text that include format information and connection (transport) parameters so that the receiver can correctly process the stream of packets. SDP fields and attributes are defined in RFC 8866 and are further extended and constrained by ST 2110 standard documents.

When a stream is disabled, the SDP object is undefined. When enabled, the SDP object is created. Any subsequent changes to the stream parameters or the video, audio, or data sources will cause the SDP object to be updated immediately.

The SDP object can be viewed from the web interface. Within each Stream configuration section, click the **View SDP** button to open the panel.

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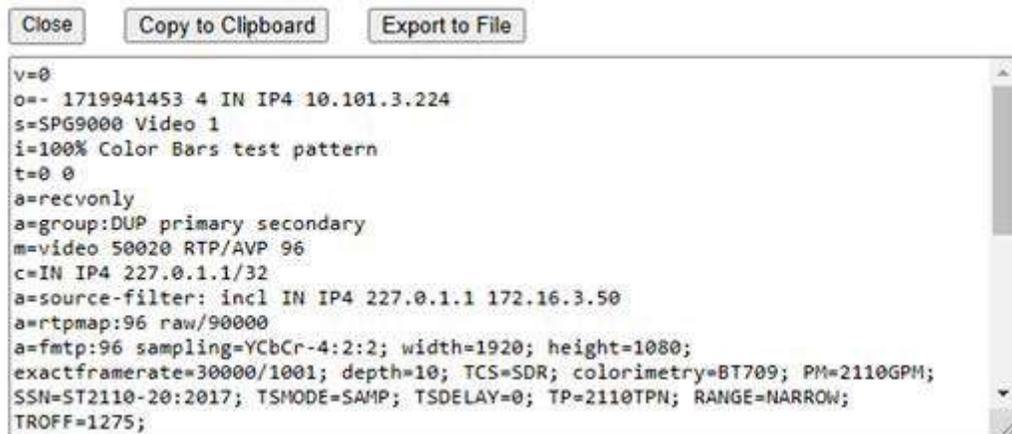
```
v=0
o=- 1719941453 4 IN IP4 10.101.3.224
s=SPG9000 Video 1
i=100% Color Bars test pattern
t=0 0
a=recvonly
a=group:DUP primary secondary
m=video 50020 RTP/AVP 96
c=IN IP4 227.0.1.1/32
a=source-filter: incl IN IP4 227.0.1.1 172.16.3.50
a=rtpmap:96 raw/90000
a=fmtp:96 sampling=YCbCr-4:2:2; width=1920; height=1080;
exactframerate=30000/1001; depth=10; TCS=SDR; colorimetry=BT709; PM=2110GPM;
SSN=ST2110-20:2017; TSMODE=SAMP; TSDELAY=0; TP=2110TPN; RANGE=NARROW;
TROFF=1275;
```

The panel can be resized by grabbing and moving the bottom right corner.

Press **Copy to Clipboard** to copy the text to the clipboard so that you can paste it into another application, such as a ST 2110 connection manager.

Press **Export to File** to open a dialog to save the file to a location on your computer.

Note: The SDP objects can also be read programmatically using the /ip/video/{stream}/transportfile, /ip/audio/{stream}/transportfile and /ip/time-code/{stream}/transportfile endpoints in the application programming interface. See *HTTP API*.

System Maintenance

This section describes how to maintain the SPG9000 system functionality, including how to:

- operate with dual power supplies,
- upgrade the instrument with new licensed features,
- upgrade the instrument firmware,
- generate a service report for the system when requested by Telestream technical support, and
- calibrate the internal oscillator.

This section also documents the security considerations when using the SPG9000 in your network.

Power Supply Monitoring and Replacement

This section describes how the SPG9000 operates with one or two power supply modules, how to check the status of the power supplies, and how to replace a power supply module if necessary.

Dual Power Supply Operation

When ordered with option SPG9000-SPW, the instrument has one power supply module installed. When ordered with option SPG9000-DPW, two power supply modules are installed. With two power supply modules installed in the instrument, one operates as the active supply and the other is a backup supply. Power is only drawn from the active power supply and the backup supply remains idle. This ensures that the two supplies do not age at the same rate. Once each day, the system automatically performs a load test on the backup supply.

If the active power supply fails, the system automatically switches to the backup supply, which becomes the new active supply. This switch is instantaneous so power to the instrument is uninterrupted. You can remove and replace a failed supply without having to remove the instrument from operation. See *Hot-Swap Power Supply Module*.

Temperature-Weighted Hours

The instrument keeps track of the age of each power supply module by calculating a metric of temperature-weighted hours (TWH). When the operating temperature is

25 °C or cooler, the power supply module is expected to last 15 years. At the maximum operating temperature of 50 °C, the expected life of the supply decreases to only 5 years.

Every hour, the instrument measures the temperature and updates the TWH total for each power supply. The active supply operates at a warmer temperature than the backup supply so the TWH of the active supply increases faster than the TWH of the backup supply. When the TWH value reaches 131400 hours, the associated PWR 1 or PWR 2 indicator on the front panel changes to orange to indicate the power supply should be replaced.

Preferred Power Supply

When two power supply modules are installed, one can be selected as the preferred power supply. The preferred power supply is the active supply if possible.

The system keeps track of the most recent load test result for each power supply. When the system first powers on, new test results are required, so the active power supply may not be the preferred power supply until each power supply has been tested and passes.

The recommended usage strategy is to configure one supply as preferred and use the second supply only in case the first supply has a failure. This strategy allows the backup supply to have the maximum remaining life when it is needed.

The preferred supply configuration is not saved as part of the preset system, so it does not change when you activate any of the system presets, including the Factory Default preset. See *Presets*.

Web Interface for Power Supplies

To use the web interface of the SPG9000 to select a preferred power supply:

1. On the web interface, click **Status**.

2. In the System section, select the Preferred Power Supply option.

Front-Panel Menu for POWER SUPPLY

To use the front panel of the SPG9000 for this process, press **SYSTEM** and then select the **POWER SUPPLY** option. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the POWER SUPPLY menu.

SYSTEM :
PRESET :
INFO :
NETWORK :
FRONT PANEL :
WEB :
GENERAL PURPOSE INTERFACE :
POWER SUPPLY :
PREFERRED
LOAD TEST
FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Load Test

One time every 24 hours the backup power supply undergoes a load test—a load test is run when the instrument is turned on and every 24 hours from that time. The backup supply, which normally runs as a powered standby, has a load applied to it, similar to that of the operating instrument, for several seconds. The voltage is measured to check if it is within tolerance for the expected 12 V value. The load test results are reported on the Status tab of the web interface.

If the load test passes, that power supply can be selected as the preferred supply. The system switches the preferred supply to active if possible. Depending on which power supply starts first when the system is powered up, the preferred supply may not be used as the active supply until the first successful load test (either manually or scheduled).

Manually Start Load Test

- On the web interface:

   A. Click the **Status** tab, and in the System section at the bottom of the page, below the list of power supplies, click **Show Details** to open the power supply status.
   B. Click **Load Test PS#**.

Note: The load test can only be performed on the backup supply.

- On the front-panel interface:

  A. Go to the SYSTEM : POWER SUPPLY : LOAD TEST menu.

  B. Follow the instructions on the front panel.

Change Preferred Power Supply

If a second power supply is not available, connect one. See *Hot-Swap Power Supply Module*.

- On the web interface:

  A. Click the **Status** tab, and in the System section at the bottom of the page, below the list of power supplies, click **Show Details** to open the power supply status.

  B. In the Preferred Power Supply menu, select the backup power supply. If the backup power supply has had a recent successful load test, the instrument will switch the power supply set as preferred to active.

Note: A successful load test on the backup power supply is required before the instrument will change the power supply.

  C. If the power supply does not switch, check for a recent successful load test. If no load test is recorded (for example on a recently installed power supply), run a load test. See *Manually Start Load Test*.

- On the front-panel interface:

  A. On the front-panel interface, go to the SYSTEM : POWER SUPPLY : PREFERRED menu.

  B. Select the other power supply as preferred. If the backup power supply has had a recent successful load test, the instrument will switch the power supply set as preferred to active.

  C. If the power supply does not switch, run a load test (for example on a recently installed power supply). See *Manually Start Load Test*.

Power Supply Status

The status of each power supply module can be viewed from the front or rear of the instrument. On the front panel, the PWR 1 and PWR 2 indicators illuminate in different colors to show the status of the power supply modules. The rear panel of each power supply module has a STATUS indicator that matches the status shown on the PWR 1 and PWR 2 front-panel indicators. See *PWR 1 and PWR 2*.

To see more detailed information on the web interface:

1. On the web interface, click the **Status** tab.

2. In the System section at the bottom of the page, click **Show Details**.

The information for the power supplies status appears. A table shows the voltage measurement, usage data (active, standby, and temperature-weighted hours) and the load test history.

Hot-Swap Power Supply Module

This procedure describes how to replace a power supply module while the instrument is in operation. To hot-swap a power supply module:

⚠ **WARNING: Disconnect the power cord from the power supply module before you remove the module from the instrument. Also, do not connect a power cord to the power supply module while the module is not installed in the instrument. There are dangerous high voltages inside the module when the power cord is connected.**

⚠ **CAUTION: To prevent an unexpected shutdown of the instrument, be sure to disconnect the correct power cord if you are replacing a faulty power supply module.**

When viewed from the front of the instrument, Power Supply 1 is the left power supply module and Power Supply 2 is the right power supply module. This matches the orientation of the PWR 1 and PWR 2 indicators on the front panel. The STATUS indicator on the rear panel of each power supply module matches the status shown by the front-panel PWR 1 and PWR 2 indicators.

1. Remove the power cable from the power supply module that you are removing or replacing.

2. Pull out the handle located at the bottom of the supply.
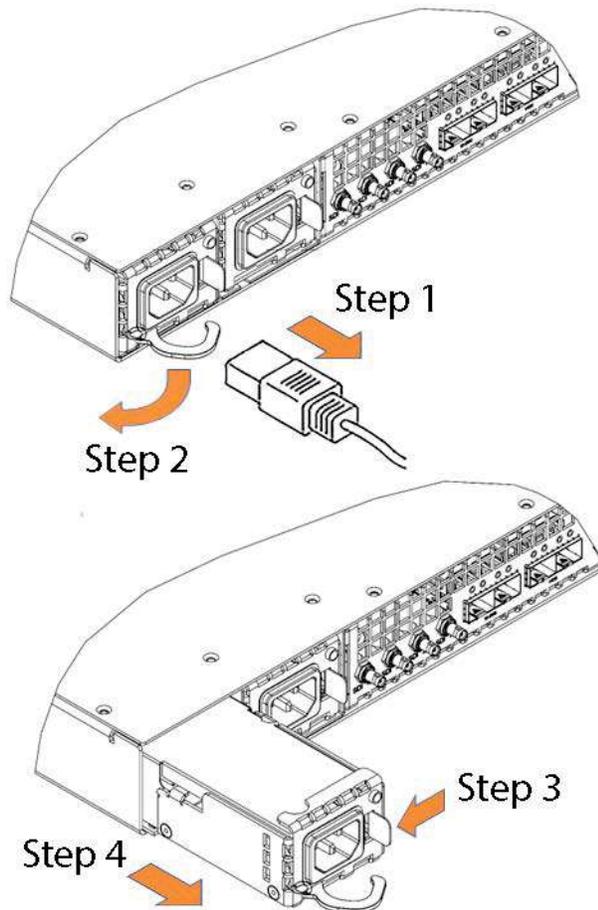
3. Push the retaining latch to the left and hold.

4. Use the handle to pull the power supply module out of the instrument (release the retaining latch when the latch clears the instrument).

5. Insert the replacement supply into the instrument until it latches into place.

6. If necessary, push the handle of the supply into the storage position.

7. Connect the power cable to the power supply module you installed.

8. Check that the status of the power supply module you just installed is bright or dim green.

9. If needed, change the preferred supply configuration. See *Change Preferred Power Supply*.

We recommend you configure the supply with the most TWH to be used as the primary preferred supply. This allows for the newer supply to be preserved so it can provide the best possible backup if the primary supply fails.

Licensed Features

The SPG9000 has several features that are available when the corresponding license is enabled. Licenses are preinstalled on the system if they are purchased at the same time as the base unit. Licenses can also be added at any later time by purchasing them as upgrades.

There are four licensed options for the SPG9000:

SPG9000-GNSS: This enables the internal GNSS receiver and its associated time synchronization features. This licensed is required to view the GNSS signal status on the Status tab of the web interface and the STATUS : GNSS menu of the front-panel interface. The license is also required to configure the GNSS Receiver settings from the Reference tab of the web interface and the REFERENCE : GNSS RCVR menu of the front-panel interface.

SPG9000-PTP: This enables the PTP instances associated with the network interfaces labeled as PTP 1 and PTP 2. This license is required to view the PTP 1 and PTP 2 status on the Status tab of the web interface and the STATUS : PTP 1 and PTP 2 menus of the front-panel interface. The license is also required to configure the two instances from the PTP tab of the web interface and the PTP button on the front-panel interface.

SPG9000-SDI: This enables the SDI outputs for test signal generation. This license enables the Video, Audio (tones), and SDI tabs of the web interface and the VIDEO, AUDIO : TONES, and SDI menus of the front-panel interface.

SPG9000-IP: This enables the IP ports for test signal generation. This license enables the Video, Audio (tones), and IP tabs of the web interface and the VIDEO, AUDIO : TONES, and IP menus of the front-panel interface.

View Installed Licenses

Check the installed Licenses to find details of the licenses. This includes what licenses have been purchased, when they expire, and their uses.

Web Interface for Licensed Options

To use the web interface, select the **System** tab and then select **System Information**.

The Expiration column in the Licensed Options table shows if the license is Permanent, Not Installed, or has a specific expiration date.

Licensed Options

	Expiration	Description
SPG9000-GNSS	Permanent	Enable internal GNSS receiver and time synchronization features
SPG9000-PTP	Permanent	Enable PTP (IEEE 1588) support on two ports
SPG9000-SDI	2023-07-31	Enable SD/HD/UHD test signal generation on four SDI outputs
SPG9000-IP	Not Installed	Enable ST 2110 test signal generation on two IP ports

Update Licenses

Front-Panel Menu for LICENSED OPTIONS

To use the front panel, press **SYSTEM**, then select the **INFO** option, and then select **LICENSED OPTIONS**. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the INFO menu.

SYSTEM :
PRESET :
INFO :
VERSIONS
LICENSED OPTIONS
HOST ID
SERIAL NUMBER
NETWORK :
FRONT PANEL :
WEB :
GENERAL PURPOSE INTERFACE :
POWER SUPPLY :
FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Install New Licenses

When you purchase a licensed option, you receive a Software Serial Number from Telestream. This string is associated with this specific SPG9000 instrument, as identified by the Host ID and (hardware) Serial Number listed at the top of the license application information. The Software Serial Number is a set of 20 digits and letters such as SG7J-U6E8-2S4F-UQRJ-6CL2.

1. In the SPG9000 web page, select the **System** tab and then select **System Information**.

2. Under the Licensed Options table, select **Update Licenses**. The Update Licenses panel opens.

3. Enter the Software Serial Number in the first field.

4. Select **Get Activation Code**.

    The activation code appears in the next field.

5. Select **Copy to Clipboard**.

6. Select the link to the Telestream Offline Activation Site (https://cws.telestream.net/offlineactivation.aspx). If the SPG9000 is not on a network connected to the outside Internet, you will have to manually transfer the activation code to another computer.

7. Paste the activation code into the text box and select **Submit**.

    Your browser prompts you to save a file named "TelestreamLicense."

    If the SPG9000 is not on a network connected to the Internet, you will have to transfer this file to a computer that is connected to the SPG9000.

Note: This process is the only time the SPG9000 needs to access the Internet.

8. Save the TelestreamLicense file.

9. In the SPG9000 web page, select **Choose File** and select the TelestreamLicense file.

   The license file is checked and a summary of its contents is displayed in the last text box on the web page, as in the sample:

```
Host ID: SPG-FA2BAM2LTVY4AR6A8PPCAAJ54U

Licenses:
SPG9000-SPG9000
SPG9000-GNSS
SPG9000-PTP
```

   If the Host ID matches the SPG9000 and the set of licenses is correct, the Apply Licenses button becomes available.

10. Select **Apply Licenses**. The table at the top of the web page is updated and any new features are now available.

Note: The SPG9000-SPG9000 license code in the TelestreamLicense file contents refers to the base unit and is always present in the license file, but it is not in the optional license table.

Upgrade Instrument Firmware

Telestream releases software and firmware updates for products to add new features and to fix product problems. You can find the latest firmware for your product at the Telestream website: www.telestream.net/video/resources.htm#Software and select *Signal and Synchronization Generators*.

Check Current Firmware Version

You can check the current version of the instrument firmware by looking at the Version number on the right of the banner of the web interface. The version number consists of two or three numbers separated by periods:
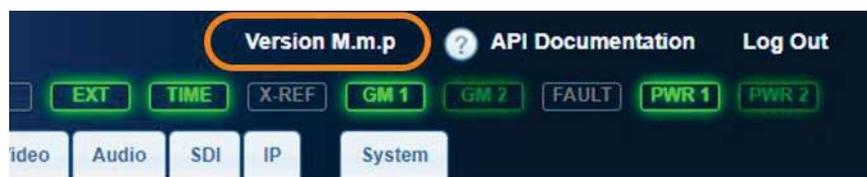
- Major version number (M) indicates a significant change from the previous major release.

- Minor version number (m) indicates several new features since the previous major or minor release.

- Patch version number (p) indicates defect fixes from the previous release. The patch version number is not always present.

Web Interface for Hardware and Software Versions

More version information (for software components, hardware board versions, etc.) is available on the web interface.

On the web interface, click the **System** tab, and then click **System Information**.

┌─ Hardware and Software Versions ──────────────────
│   Firmware 4.0
│   Firmware Date 2024-08-29 21:36:10
│   Firmware Build 2856
│   PTP Manager 2.07
│   PTP4L 4.3-00168-g90a09b9
│   NMOS Library 1.0-07b20a1
│   Main Board 1.0
│   Reference I/O Board 3.12
│   TSG Board 2.48.1
│   GNSS Receiver 3100-1.02
└──

Front-Panel Menu for INFO

More version information is available through the front-panel interface.

Press **SYSTEM** and then select the **INFO** option. See *Menu Operations* for details of using the front-panel menus.

The table shows the submenus for the INFO menu.

SYSTEM :
PRESET :
INFO :
VERSIONS
LICENSED OPTIONS
HOST ID
SERIAL NUMBER
NETWORK :
FRONT PANEL :

WEB :
GENERAL PURPOSE INTERFACE :
POWER SUPPLY :
FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Upgrade Firmware from Front Panel

The SPG9000 firmware can be upgraded by copying the new firmware package to a USB memory device and installing it from the front-panel USB port.

SYSTEM :
PRESET :
INFO :
NETWORK :
FRONT PANEL :
WEB :
GENERAL PURPOSE INTERFACE :
POWER SUPPLY :
FIRMWARE UPGRADE
CALIBRATE OVEN
DIAGNOSTICS

Note: The time required to complete the firmware upgrade is about 10-25 minutes, depending on the contents of the new firmware. After the upgrade has completed, you should refresh the browser if you use the web interface. Press Ctrl-F5 in most browsers.

⚠️ **CAUTION: The instrument will automatically reboot one or more times during the upgrade process. Do not upgrade the instrument while the instrument is in use as a sync reference. When the instrument has started to erase the internal flash, do not remove power from the instrument.**

To upgrade the system firmware:

1. On a computer with an Internet connection, go to https://www.telestream.net/video/resources.htm.

2. In the Software & Downloads section, select **Signal and Synchronization Generators**.

3. Select the current firmware release for the SPG9000.

   A .zip file is downloaded to the local drive.

4. Open the .zip file and extract the firmware file.

5. Rename the .deb file to spg9000.deb. If the file does not have this specific title, the instrument cannot find it.

6. Insert a USB memory device into a USB port in the computer containing the latest instrument firmware.

7. Open the USB device to view its file contents.

8. On the USB device, create a folder named SpgUpgrd.

9. Open the SpgUpgrd folder and copy the spg9000.deb file to the USB device. The USB device should have a directory path of SpgUpgrd\spg9000.deb.

10. Eject and safely remove the USB device from the computer.

11. Insert the USB device into the front-panel USB port on the instrument.

12. On the front panel of the SPG9000, press **SYSTEM**.

13. Select the **FIRMWARE UPGRADE** option and press **ENTER.**

    A confirmation message appears.

```
*! Continue with firmware upgrade?  ! *
 *      Yes : ENTER / No : BACK        *
```

14. Select ENTER to continue with the upgrade or select BACK to cancel the upgrade.

    During the upgrade process, the instrument displays messages indicating the upgrade status.

Note: The upgrade process may take approximately 10-25 minutes to complete. The SPG9000 may reboot several times during the process. Do not remove power until the process has completed.

---

15. After the firmware upgrade, remove and reconnect the power cables. This forces a hard power cycle.

16. After the upgrade is complete, remove the USB device.

Upgrade Firmware from Web Interface

The SPG9000 firmware can be upgraded by uploading the new firmware package to the instrument and installing it from the web interface.
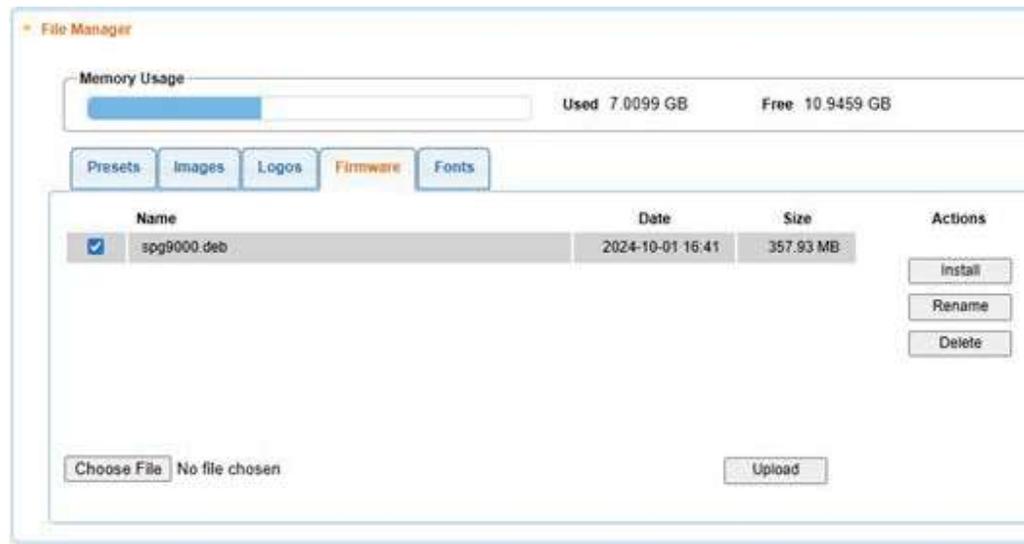
Note: The time required to complete the firmware upgrade is about 10-25 minutes, depending on the contents of the new firmware. After the upgrade has completed, you should refresh the web browser. Press Ctrl-F5 in most browsers.

CAUTION: **The instrument will automatically reboot one or more times during the upgrade process. Do not upgrade the instrument while the instrument is in use as a sync reference. When the instrument has started to erase the internal flash, do not remove power from the instrument.**

To upgrade the system firmware:

1. On a computer with an Internet connection, go to https://www.telestream.net/video/resources.htm.

2. In the Software & Downloads section, select **Signal and Synchronization Generators**.

3. Select the current firmware release for the SPG9000. A .zip file is downloaded to the local drive.

4. Open the .zip file and extract the firmware file.

5. On the web interface, click the **System** tab and then click **File Manager**.

6. Select the **Firmware** tab in the File Manager.

7. Select **Choose File**.

8. Locate the file saved in step 4 and select **Open**.

9. Select **Upload**. The firmware file will commence uploading to the firmware folder on the SPG9000. This may take up to several minutes, and a progress bar will be displayed.

10. When the file has completely uploaded (and the progress bar disappears), select the file by its checkbox in the leftmost column of the File Manager table.

11. Select **Install**. When prompted to confirm or cancel the upgrade, press **OK**. The upgrade process will start, and you should not interact with the web interface while the upgrade process is in progress.

Note: The upgrade process may take approximately 10-25 minutes to complete. The SPG9000 may reboot several times during the process. Do not remove power until the process has completed.

Service Report

You may have questions about SPG9000 configuration or operation, or you may have issues that require technical support. Please see *Telestream Contact Information* for website, email, or phone information.

The technical support team may ask you to generate a Service Report and send it back for their inspection. A Service Report is a package of files containing the complete configuration and status for the instrument.

To generate the Service Report, select the **System** tab of the web interface and then select the **System Information** section.

Select **Generate** to create a new Service Report file or to update an existing file. This process will take a few seconds. If a report file had previously been generated, its date and time will be shown. After the file has been generated, select **Download** to copy the file to your computer.

The Service Report is a compressed archive file (ZIP format) that includes the serial number as part of the filename, in case you need to send the report files for multiple SPG9000 systems.

Note: Some browsers may consider .zip files as insecure and block the file download. It is safe to keep these files.

System Oscillator Calibration

Because the oscillator frequency was adjusted accurately at the factory, you should not need to adjust the oven oscillator frequency immediately after the initial installation. However, you can adjust the oscillator frequency at any time to improve the accuracy of the internal frequency.

Calibration might be needed occasionally to compensate for drift in the oven oscillator. The drift is typically greater during the first 30 days of operation. After the first 30 days we recommend using the calibration procedure to check and calibrate the oscillator if appropriate. After that a yearly calibration is typically adequate to maintain good frequency accuracy when in internal mode.

When option SPG9000-GNSS or option SPG9000-PTP is installed, you might be able to improve the accuracy slightly after installation because the instrument is at the normal temperature for your specific installation site. If you intend to use the Internal reference source, recent calibration is recommended. Prior to calibration, the SPG9000 should have a stable lock for a few hours or more to a good external reference such as a GNSS signal or a lab-quality 10 MHz signal.

Note: The calibration can only be done through the front panel.

Do not perform the calibration process when the system is currently locked to the secondary reference. See *Secondary Reference*. Wait for the system to return to a stable lock to the primary GNSS reference.

Check if the oven oscillator needs to be calibrated:

1. While the instrument is locked to a GNSS signal, a PTP follower, or a precise genlock reference (such as a CW 10 MHz signal from a calibration source), press **SYSTEM**.

2. Select the **DIAGNOSTICS** option. See *Menu Operations* for details of using the front-panel menus.

SYSTEM :
    PRESET :
    INFO :
    NETWORK :
    FRONT PANEL :
    WEB :
    GENERAL PURPOSE INTERFACE :
    POWER SUPPLY :
    FIRMWARE UPGRADE
    CALIBRATE OVEN
    DIAGNOSTICS

---

1. Press **ENTER** to view the TUNE submenu.
2. On the first page of the TUNE submenu, there is a status menu similar to:

```
SYSTEM : DIAGNOSTICS : TUNE
  Tune: -0.00e-6 (2078823 --> 2078823)
```

3. Press the left or right arrow button to view the second page of the TUNE submenu. There is a status menu similar to:

```
SYSTEM : DIAGNOSTICS : TUNE
  Phase: 0x7FFFFFFA  DDS: 2078823   Fine
```

4. Verify the second page reads "Fine" not "Coarse".

5. Check if the Tune value is greater than ±0.10e–6

○ If the value is less than ±0.10e–6, no calibration is required.

○ If it is greater, calibrate the oven oscillator.

   i. Press **BACK** to exit the DIAGNOSTICS submenu and select the **CALIBRATE OVEN** option.

   ii. Press **ENTER** to calibrate the oven oscillator.

Security Considerations

The SPG9000 is designed for secure environments, in accordance with the recommendations in EBU Tech R 143 *Cybersecurity Recommendation for Media Vendors' Systems, Software & Services, Annex B (Media Appliance Security Requirement)*. However, several recommendations require user action.

Users and Passwords

The SPG9000 has user logins for web interface access, a passkey for API usage, and a remote login user for technical support.

Web Interface

The web interface uses a rudimentary form of role-based access control (RBAC) via two dedicated users. The "admin" user has full read/write access and can make any configuration change. The "operator" user has read-only access and can only view system status and configuration, without the ability to make changes.

The default passwords for these accounts when a new system is manufactured are also "admin" and "operator," respectively. It is strongly recommended that these passwords are changed from the defaults. See Front-Panel Menu for WEB to change both passwords from the front-panel interface. If you forget the web interface password and

cannot login, you can always view the front-panel menu to recover the password. If you have physical access to the system, you are considered to be a trusted user.

The web interface can also be used to change the password for the logged-in user. Select the **System** tab and then select **Management Settings**. Go to the Web Server subsection. The **Web Page Password** refers to either the "admin" user's password or the "operator" user's password, whichever was used to log in. The characters are normally obscured by asterisks. Select **View** to enable the text box and edit the password string. Select **Change** to accept the new password from the value in the text box.

Note: When you change the web user password from the web page itself, you will be logged out immediately and will have to log in again with the new password.

Strong web passwords can be created, up to 20 characters in length and using the following characters:

- Upper- and lower-case letters A-Z and a-z
- Digits 0-9
- Special characters ! ? @ # & ' ( ) , . - / : ; < > ^
- Space character, except for trailing spaces at the end of the string

API Key

The HTTP API for the SPG9000 requires authentication using the X-API-Key field in the HTTP message header. The factory default for the API key is "apikey", and it is strongly recommended that the key is changed from this default to a strong password. The API key can be updated from the front panel SYSTEM : WEB : API KEY menu or from the Management Settings section of the web interface. The API key string may be up to 20 characters in length and use any letter or digit character plus any of four special characters: period, hyphen, underline, or tilde.

Remote Login

The SPG9000 has one Linux user account that can only be used by Telestream support staff. The login name and password are never shared with end users. This support account has a password that is unique for that system only. If the password is inadvertently shared or cracked, that password will only work for a single SPG9000 unit.

Network Port Usage

The management interface for the SPG9000 uses several network ports for normal operation. It uses a firewall to block packets received for all other network ports.

Port Number	Transport	Protocol	Application Usage
22	TCP	SSH	Login shell for technical support
53	TCP and UDP	DNS	Requests to the DNS server when resolving fully qualified domain names
67 and 68	UDP	DHCP	Dynamic IP address assignment
80	TCP	HTTP	Default web interface when no certificates are installed
123	UDP	NTP	Network Time Protocol server or client
161	UDP	SNMP	Simple Network Management Protocol for status queries
443	TCP	HTTPS	Secure web interface using SSL certificates
5353	UDP	mDNS	Multicast DNS requests for NMOS discovery
n/a	n/a	ICMP	Internet Control Message Protocol, primarily for "ping" messages to check interface connectivity

Additionally, UDP port 162 is used for sending SNMP TRAP messages, and UDP port 514 is used for sending Syslog messages. TCP port 6514 may be used for sending Syslog messages using TLS. These ports are used for transmit only and are closed for received messages.

The media ports (PTP 1, PTP 2, IP 1, IP 2) have a smaller set of network ports in use:

Port Number	Transport	Protocol	Application Usage
67 and 68	UDP	DHCP	Dynamic IP address assignment
319 and 320	UDP	PTP	Precision Time Protocol

telestream

Port Number	Transport	Protocol	Application Usage
n/a	n/a	ICMP	Internet Control Message Protocol, used primarily for "ping" messages to check interface connectivity
n/a	n/a	IGMP	Internet Group Management Protocol, used to join the multicast group address for PTP (224.0.1.129)
n/a	n/a	LLDP	Link Layer Discovery Protocol, used to advertise device and port information to the neighboring switch port

On the media ports, all received ST 2110 (RTP over UDP) packets are discarded by a hardware filter even before the software firewall.

Bullet™ 720 Dual-Band Multi-GNSS Active Antenna

Dual Band

The Bullet™ 720 is a ruggedized weatherproof dual-band (L1 & L5) multi-GNSS active antenna. It is designed with a high out-of-band rejection filter and a built-in LNA to compensate for feedline losses and provide improved performance in harsh GNSS environments.

Additionally, Bullet 720 offers the benefits of using the higher power L5 signals (twice as much power as L1). With its greater bandwidth and advanced signal design, it lowers the risk of interference and improves multi-path protection. The dual-band capability of the Bullet 720 allows GNSS receivers to compensate for ionosphere errors allowing the reduction of the timing error under clear skies to a few nanoseconds.

When used with a dual-band GNSS receiver, such as Protempis' RES720 module, the system offers unparalleled accuracy to meet the stringent synchronization needs of the next generation networks in various industry verticals including 5G X-Haul, Smart Grid, Data Center, SATCOM, Calibration Services and Industrial Automation applications.

Multi-GNSS

The Bullet 720 is an active Antenna that supports GPS L1 & L5, Galileo E1 & E5, Beidou B1 & B2C, GLONASS G1 and IRNSS bands.

Anti-Jamming

The Bullet 720 antenna protects GNSS receivers from interference and intentional jamming. The filtering apparatus implemented in the antenna improves immunity to other RF signals for reliable performance in hostile RF jamming environments.

High Out-Of-Band (OOB) Rejection

Bullet 720 provides class-leading out-of-band rejection characteristics of >75dB for L1 and > 65dB for L5 band. It provides significant improvements in performance and robustness in environments with high interference and multipath.

Key Features

- Dual Band (L1 and L5) Active Antenna with built-in LNA.

- Multi-constellation – GPS, GLONASS, Galileo & Beidou

- High Gain, low noise, high out-of-band rejection

- Built-in lightning surge protection that meets/exceeds of handling IEC 61000-4 specifications.

- Ruggedized IP67 enclosure and supports extended temperature environments.

- Wide operating voltage range.

Datasheet

| Characteristics	Specification		
Frequency Range	L1: 1559-1610 MHz L5: 1164-1214 MHz		
Gain	1559 MHz	40.8±3.0 dB	
	1575.42 MHz	42.9±3.0 dB	
	1610 MHz	37.9±3.0 dB	
	1164MHz	40.1±3.0 dB	
	1176.45 MHz	39.3±3.0 dB	
	1214 MHz	36.0±3.0 dB	
Output VSWR	2.0 typ.		
Noise Figure	3.5 dB typ. (Pre-Saw)		
Filter Out of Band Attenuation	F1= 1561 MHz	F1-50 MHz	>75 dB
	F2= 1601.5 MHz	F2+50 MHz	>83 dB
	F3= 1176.45 MHz	F3-50 MHz	>85 dB
	F4= 1201.5 MHz	F4+50 MHz	>81 dB
Polarization	RHCP		
Axial Ratio	3.0 dB typ.		
Impedance	50 ohms		
Operation Voltage	2.7V – 9V		
Current	26.0±3.0 mA (5.0±0.1V) 25.0±3.0 mA (3.0±0.1V)		

Package

- Multiple installation options and pole diameters ½ to 3 ½ inch.
- 126.6 x 126.6 x 90.52 mm (L x W x H)
- Connector: N-type Jack

Weight

- 530 g (Antenna only)
- 930 g (Antenna with brackets)

Environmental Data, Quality & Reliability

- Operating temp.–40 °C to +85 °C
- Storage temp. –55 °C to +105 °C
- Humidity 5%-95% (non-condensing)
- RoHS compliant (lead-free)
- Green (halogen-free)
- V0 Flammability Rated
- ETSI-RED Complaint
- Weatherproof with IPX7 compliance
- Surge Protection: IEC-61000-4-5 compliant

1. Survivability < 28V
2. From 2.7 - 2.9V, the gain will be 3 dB lower than specified.
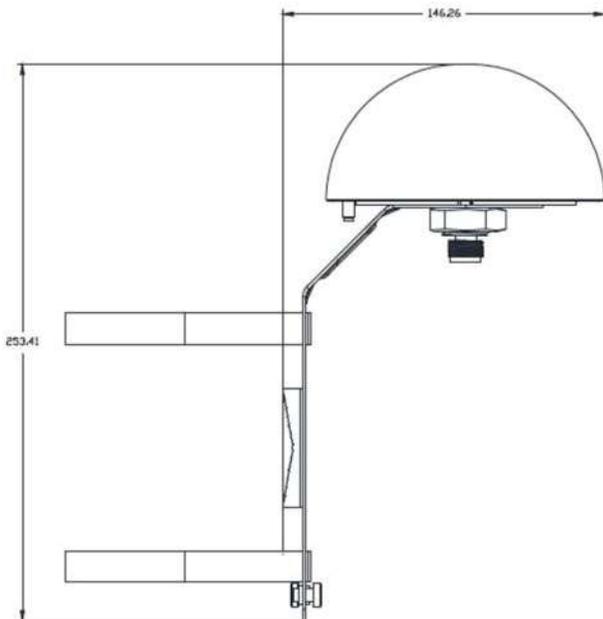
Please go to **www.protempis.com** for the latest documentation and tools, part numbers and ordering information.

www.protempis.com

848 Gold Flat Road
Nevada City, CA 95959
+1 530 470 1300
www.telestream.net

30th October 2025

To Whom It May Concern:

This letter is to confirm that all synchronization signals generated by SPG9000 Generator fully complies to EBU, ITU-R, and SMPTE specifications as per the Telestream User Guide.

Sincerely,

TIMES MICROWAVE SYSTEMS

LMR®-240
Flexible Low Loss Communications Coax

Ideal for...
- Jumper Assemblies in Wireless Communications Systems
- Short Antenna Feeder runs (e.g. WLL, GPS, LMR, Mobile Antennas)
- Any application (e.g. WLL, GPS, LMR, WLAN, WISP, WiMax, SCADA, Mobile Antennas) requiring an easily routed, low loss RF cable

Part Description

Part Number	Application	Jacket	Color	Stock Code
LMR-240	Outdoor	PE	Black	54021
LMR-240-DB	Outdoor/Watertight	PE	Black	54090
LMR-240-FR	Indoor/Outdoor Riser CMR	FRPE	Black	54029
LMR-240-FR-PVC	Indoor/Outdoor Riser CMR	FRPVC	Black	54214
LMR-240-PVC	General Purpose	PVC	Black	54140
LMR-240-PVC-W	General Purpose	PVC	White	54202
LMR-240-MA	Indoor & Mobile Antenna	PVC	Black	54046

Environmental Specifications

| Performance Property	°F	°C
Installation Temperature Range	-40/+185	-40/+85
Storage Temperature Range	-94/+185	-70/+85
Operating Temperature Range	-40/+185	-40/+85

Mechanical Specifications

Performance Property	Units	US	(metric)
Bend Radius: installation	in. (mm)	0.75	(19.1)
Bend Radius: repeated	in. (mm)	2.5	(63.5)
Bending Moment	ft-lb (N-m)	0.25	(0.34)
Weight	lb/ft (kg/m)	0.034	(0.05)
Tensile Strength	lb (kg)	80	(36.3)
Flat Plate Crush	lb/in. (kg/mm)	20	(0.36)

Construction Specifications

Description	Material	In.	(mm)
Inner Conductor	Solid BC	0.056	(1.42)
Dielectric	Foam PE	0.150	(3.81)
Outer Conductor	Aluminum Tape	0.155	(3.94)
Overall Braid	Tinned Copper	0.178	(4.52)
Jacket	(see table)	0.240	(6.10)

Electrical Specifications

Performance Property	Units	US	(metric)
Velocity of Propagation	%	83	
Dielectric Constant	NA	1.42	
Time Delay	nS/ft (nS/m)	1.21	(3.97)
Impedance	ohms	50	
Capacitance	pF/ft (pF/m)	24.2	(79.4)
Inductance	uH/ft (uH/m)	0.060	(0.20)
Shielding Effectiveness	dB	>90	
DC Resistance			
Inner Conductor	ohms/1000ft (/km)	3.2	(10.5)
Outer Conductor	ohms/1000ft (/km)	3.89	(12.8)
Voltage Withstand	Volts DC	1500	
Jacket Spark	Volts RMS	5000	
Peak Power	kW	5.6	

TIMES MICROWAVE SYSTEMS

Attenuation vs. Frequency (typical)
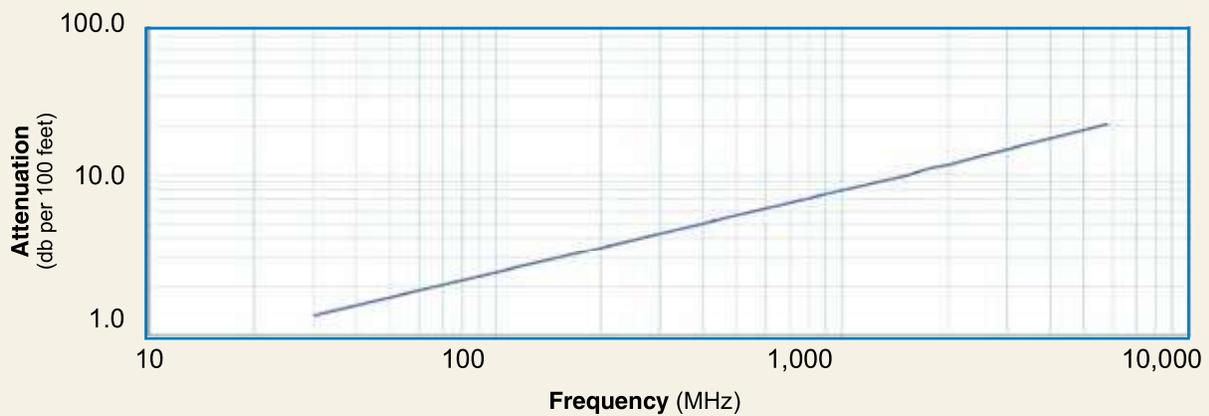
Frequency (MHz)	30	50	150	220	450	900	1500	1800	2000	2500	5800	8000
Attenuation dB/100 ft	1.3	1.7	3.0	3.7	5.3	7.6	9.9	10.9	11.5	12.9	20.4	24.3
Attenuation dB/100 m	4.4	5.7	9.9	12.0	17.3	24.8	32.4	35.6	37.7	42.4	66.8	79.7
Avg. Power kW	1.49	1.15	0.66	0.54	0.38	0.26	0.20	0.18	0.17	0.15	0.10	0.08

Calculate Attenuation =
$(0.242080) \cdot \sqrt{FMHz} + (0.000330) \cdot FMHz$ (interactive calculator available at http://www.timesmicrowave.com/cable_calculators)
Attenuation:
VSWR=1.0 ; Ambient = +25°C (77°F)
Power: VSWR=1.0; Ambient = +40°C; Inner Conductor = 100°C (212°F); Sea Level; dry air; atmospheric pressure; no solar loading

TIMES MICROWAVE SYSTEMS

LMR®-240
Flexible Low Loss Communications Coax

1 TC-240-FM-X 3190-2891	2 EZ-240-NMH-X 3190-2893	3 EZ-240-NMH-RA-X 3190-6143	4 TC-240-NMH-RA-D 3190-2426
5 TC-240-NMH-X 3190-2887	6 TC-240-NMC 3190-244	7 EZ-240-1023M 3190-6283	8 TC-240-NF-BH-X 3190-2888
9 TC-240-NF-PM-X 3190-2889	10 EZ-240-NF-X 3190-2795	11 TC-240-BMC 3190-242	12-13 EZ-240-BM-X / TC-240-BM-X 3190-6120 - 3190-2890
14 TC-240-BM-RA-D 3190-2869	15 EZ-240-BM-RA-X 3190-2868	16 EZ-240-TM-X 3190-2725	17 TC-240-TM-X 3190-2797
18 EZ-240-TM-RP-X 3190-2892	19 TC-240-TM-RA-D 3190-2798	20 EZ-240-TF-X 3190-6204	21 EZ-240-TF-RP-X 3190-6167
22 EZ-240-QM-X 3190-2894	23 EZ-240-QM-RA-X 3190-2895	24 EZ-240-SM-X 3190-2897	25 TC-240-SM-SS-X 3190-2898
26 TC-240-SM-RA-SS-X 3190-2900	27 EZ-240-SM-RA-X 3190-2899	28 TC-240-SM-RP 3190-326	29 TC-240-SF-SS-BH-X 3190-2896
30 TC-240-MUHF 3190-445	31 TC-240-716M 3190-2982	32 TC-240-716M-RA-D 3190-2983	

Connectors

Interface	Description	Part Number	Stock Code	VSWR** Freq. (GHz)	Coupling Nut	Inner Contact Attach	Outer Contact Attach	Finish* Body /Pin	Length in (mm)	Width in (mm)	Weight lb (g)
1. F Male	Straight Plug	TC-240-FM-X	3190-2891	<1.25:1 (2.5)	Knurl	Solder	Crimp	N/G	1.1 (28)	0.45 (11.4)	0.014 (6.4)
2. N Male	Straight Plug	EZ-240-NMH-X	3190-2893	<1.25:1 (2.5)	Hex/Knurl	Spring Finger	Crimp	A/G	1.5 (38.1)	0.78 (19.8)	0.086 (39.0)
3. N Male	Right Angle	EZ-240-NMH-RA-X	3190-6143	<1.35:1 (6)	Hex	Spring Finger	Crimp	A/G	1 (25.1)	1.04 (26.4)	0.115 (52.0)

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TIMES MICROWAVE SYSTEMS

Connectors

Interface	Description	Part Number	Stock Code	VSWR** Freq. (GHz)	Coupling Nut	Inner Contact Attach	Outer Contact Attach	Finish* Body /Pin	Length in	Length (mm)	Width in	Width (mm)	Weight lb	Weight (g)
4. N Male	Right Angle	TC-240-NMH-RA-D	3190-2426	<1.35:1 (6)	Hex/Knurl	Solder	Crimp	A/G	1.2	(32.4)	1.22	(31.0)	0.091	(41.7)
5. N Male	Straight Plug	TC-240-NMH-X	3190-2887#	<1.25:1 (2.5)	Hex/Knurl	Solder	Crimp	N/S	1.5	(38)	0.75	(19.1)	0.086	(39.0)
6. N Male	Straight Plug	TC-240-NMC	3190-244	<1.25:1 (2.5)	Knurl	Solder	Clamp	S/G	1.5	(38)	0.75	(19.1)	0.082	(37.2)
7. 1.0/2.3 DIN	Straight Plug	EZ-240-1023M	3190-6283	<1.35:1 (2.5)	knurl	Spring Finger	Crimp	N/G	1.1	(228.5)	0.33	(8.5)	0.014	(6.63)
8. N Female	Bulkhead Jack	TC-240-NF-BH-X	3190-2888	<1.25:1 (2.5)	NA	Solder	Crimp	A/G	1.7	(44)	0.88	(22.2)	0.115	(52.2)
9. N Female	Panel Mount	TC-240-NF-PM-X	3190-2889#	<1.25:1 (6)	NA	Solder	Crimp	A/G	1.7	(44)	0.88	(22.2)	0.115	(52.2)
10. N Female	Straight Jack	EZ-240-NF-X	3190-2795	<1.25:1 (6)	NA	Spring Finger	Crimp	A/G	1.4	(35.4)	0.62	(15.8)	0.040	(18.0)
11. BNC Male	Straight Plug	TC-240-BMC	3190-242	<1.25:1 (2.5)	Knurl	Solder	Clamp	S/G	1.7	(43)	0.56	(14.2)	0.040	(18.1)
12. BNC Male	Straight Plug	EZ-240-BM-X	3190-6120	<1.25:1 2.5	Knurl	Spring Finger	Crimp	A/G	1.3	(34)	0.58	(14.7)	0.043	(19.5)
13. BNC Male	Straight Plug	TC-240-BM-X	3190-2890	<1.25:1 (2.5)	Knurl	Solder	Crimp	A/G	1.3	(34)	0.58	(14.7)	0.043	(19.5)
14. BNC Male	Right Angle	TC-240-BM-RA-D	3190-2869	<1.25:1 (2)	Knurl	Solder	Crimp	A/G	1.0	(25.1)	0.57	(14.5)	0.115	(52.0)
15. BNC Male	Right Angle	EZ-240-BM-RA-X	3190-2868	<1.30:1 (4)	KNURL	Spring Finger	Crimp	A/G	1.3	(33.6)	1.19	(30.1)	0.091	(41.7)
16. TNC Male	Straight Plug	EZ-240-TM-X	3190-2725	<1.25:1 (2.5)	Knurl	Spring Finger	Crimp	N/G	1.4	(34.3)	0.59	(15.0)	0.043	(19.5)
17. TNC Male	Straight Plug	TC-240-TM-X	3190-2797	<1.25:1 (2.5)	Knurl	Solder	Crimp	N/G	1.7	(43)	0.59	(15.0)	0.043	(19.5)
18. TNC Male	Reverse Polarity	EZ-240-TM-RP-X	3190-2892	<1.25:1 (6)	Knurl	Spring Finger	Crimp	A/G	1.4	(36)	0.59	(15.0)	0.043	(19.5)
19. TNC Male	Right Angle	TC-240-TM-RA-D	3190-2798	<1.25:1 (6)	Hex	Solder	Crimp	A/G	1.0	(25.1)	0.62	(15.7)	0.115	(52.0)
20. TNC Female	Straight Jack	EZ-240-TF-X	3190-6204	<1.25:1 (6)	NA	Spring Finger	Crimp	A/G	1.1	(27.2)	0.87	(22.0)	0.033	(15.0)
21. TNC Female	Reverse Polarity	EZ-240-TF-RP-X	3190-6167	<1.35:1 (6)	NA	Spring Finger	Crimp	A/G	1.1	(27.2)	0.87	(22.0)	0.033	(15.0)
22. QMA Male	Straight Plug	EZ-240-QM-X	3190-2894	<1.25: (6)	Knurl	Spring Finger	Crimp	N/G	1.2	(30.0)	0.41	(10.5)	0.014	(6.35)
23. QMA Male	Right Angle	EZ-240-QM-RA-X	3190-2895	<1.25: (<6)	Knurl	Spring Finger	Crimp	N/G	0.8	(20.3)	0.65	(16.5)	0.019	(8.62)
24. SMA Male	Straight Plug	EZ-240-SM-X	3190-2897	<1:25: (6)	Hex	Spring Finger	Crimp	N/G	1.0	(25.4)	0.32	(8.1)	0.016	(7.26)
25. SMA Male	Straight Plug	TC-240-SM-SS-X	3190-2898#	<1.25:1 (10)	Hex	Solder	Crimp	SS/G	1.0	(25)	0.32	(8.1)	0.016	(7.3)
26. SMA Male	Right Angle	TC-240-SM-RA-SS-X	3190-2900#	<1.35:1 (6)	Hex	Solder	Crimp	SS/G	0.8	(20)	0.65	(16.5)	0.019	(8.6)
27. SMA Male	Right Angle	EZ-240-SM-RA-X	3190-2899	<1.25:1 (6)	Hex	Spring Finger	Crimp	A/G	0.9	(22.8)	0.31	(7.9)	0.019	(8.6)
28. SMA Male	Reverse Polarity	TC-240-SM-RP	3190-326	<1.25:1 (2.5)	Hex	Solder	Crimp	SS/G	1.0	(25)	0.32	(8.1)	0.016	(7.3)
29. SMA Female	Bulkhead Jack	TC-240-SF-SS-BH-X	3190-2896#	<1.25:1 (2.5)	NA	Solder	Crimp	SS/G	1.1	(29)	0.31	(7.9)	0.019	(8.6)
30. Mini-UHF	Straight Plug	TC-240-MUHF	3190-445	<1.25:1 (2.5)	Knurl	Solder	Crimp	N/G	1.1	(28)	0.45	(11.4)	0.014	(6.4)
31. 7/16 Din Male	Straight Plug	TC-240-716M	3190-2982	<1.35:1 (3)	Hex	Spring Finger	Crimp	A/S	2.0	(50.5)	1.26	(32.0)	0.186	(84.4)
32. 7/16 Din Male	Right Angle	TC-240-716M-RA-D	3190-2983	<1.35:1 (3)	Hex	Solder	Crimp	A/S	1.4	(34.3)	1.60	(40.6)	0.239	(108.5)

*Finish metals: N=Nickel, S=Silver, G=Gold, SS=Stainless Steel, A=Alballoy **VSWR spec based on 3 foot cable with a connector pair #Available in bulk pack

Hardware Accessories

Type	Part Number	Stock Code	Description
Ground Kit	GK-S240TT	GK-S240TT	Standard Ground Kit (each)
Weatherproof Kit	WSB-240	3109-400	Weatherproof/Strain relief kit for LMR-240

WSB-240 3109-400

GK-S240TT

CT-240/200/195/100 3190-667

CCT-02 3192-165

CST-240A 3192-152

DBT-U 3192-001

RB-CST 3192-086

Install Tools

Type	Part Number	Stock Code	Description
Crimp Tool	CT-240/200/195/100	3190-667	Crimp tool for LMR-100, 195, 200 and 240 connectors
Strip Tool	CST-240A	3192-152	Prep tool for LMR-240 connectors
Deburr Tool	DBT-U	3192-001	Removes center conductor rough edges
Cutting Tool	CCT-02	3192-165	Cable end flush cut tool
Replacement Blade	RB-02	3192-166	Replacement blade for cutting tool
Replacement Blade Kit	RB-CST	3192-086	Replacement blade kit for all CST strip tools

KOMPETENTINGŲ INSTITUCIJŲ TVARKOMŲ JUNGTINIŲ DUOMENŲ APIE VIEŠŲJŲ PIRKIMŲ PROCEDŪROJE DALYVAUJANTĮ TIEKĖJĄ (JURIDINĮ ASMENĮ) PAŽYMA

2025-06-23 Nr. 774744

Tiekėjo pavadinimas	**UAB "HANNU PRO Vilnius"**
Tiekėjo kontaktinė informacija:	
mobilusis telefonas	**+370 686 33 799**
elektroninio pašto adresas	**vilnius@hannu-pro.com**
interneto svetainės adresas	**www.hannu-pro.com**
Buhalterio (buhalterių) ar kito (kitų) asmens (asmenų), turinčio (turinčių) teisę surašyti ir pasirašyti tiekėjo apskaitos dokumentus, vardas, pavardė	
Juridinių asmenų registras:	
kodas	**123918132**
teisinė forma	**Uždaroji akcinė bendrovė**
teisinis statusas	**Teisinis statusas neįregistruotas**
buveinė (adresas)	**Vilnius, A. Juozapavičiaus g. 6, LT-09310**
Vadovo, kito valdymo ar priežiūros organo nario ar kito asmens, turinčio (turinčių) teisę atstovauti tiekėjui ar jį kontroliuoti, jo vardu priimti sprendimą, sudaryti sandorį, vardas, pavardė	
įregistravimo data	**1997-02-14**
Valstybinė mokesčių inspekcija prie Lietuvos Respublikos finansų ministerijos:	
duomenys apie tiekėjo atsiskaitymą su valstybės, savivaldybių biudžetais ir valstybės pinigų fondais	**Atsiskaitęs**
Duomenų suformavimo data	**2025-06-19**
Valstybinio socialinio draudimo fondo valdyba prie Socialinės apsaugos ir darbo ministerijos:	
duomenys apie tiekėjo atsiskaitymą su Valstybinio socialinio draudimo fondu	**Neįsiskolinęs**
Duomenų suformavimo data	**2025-06-19**
Įtariamųjų, kaltinamųjų ir nuteistųjų registras:	
duomenys apie tiekėją	**Dėl UAB "HANNU PRO Vilnius", kodas 123918132, per pastaruosius 5 metus nėra priimtas ir įsiteisėjęs apkaltinamasis teismo nuosprendis už nusikalstamas veikas, nurodytas Lietuvos Respublikos viešųjų pirkimų įstatymo 46 straipsnio 1 dalyje ir 3 dalyje. Nėra paskirta baudžiamojo poveikio priemonė - uždraudimas juridiniam asmeniui dalyvauti viešuosiuose pirkimuose pagal Viešųjų pirkimų įstatymo 46 straipsnio 2-1 dalį.**
duomenys apie tiekėjo vadovą, kitą valdymo ar priežiūros organo narį ar kitą (kitus) asmenį (asmenis), turintį (turinčius) teisę atstovauti	**per pastaruosius 5 metus nėra priimtas ir įsiteisėjęs apkaltinamasis teismo nuosprendis ir jis neturi**

tiekėjui ar jį kontroliuoti, jo vardu priimti sprendimą, sudaryti sandorį	**neišnykusio ar nepanaikinto teistumo už nusikalstamas veikas, nurodytas Lietuvos Respublikos viešųjų pirkimų įstatymo 46 straipsnio 1 dalyje.**
duomenys apie tiekėjo buhalterį (buhalterius) ar kitą (kitus) asmenį (asmenis), turintį (turinčius) teisę surašyti ir pasirašyti tiekėjo apskaitos dokumentus	**per pastaruosius 5 metus nėra priimtas ir įsiteisėjęs apkaltinamasis teismo nuosprendis ir ji neturi neišnykusio ar nepanaikinto teistumo už nusikalstamas veikas, nurodytas Lietuvos Respublikos viešųjų pirkimų įstatymo 46 straipsnio 1 dalyje.**
Duomenų suformavimo data	**2025-06-20**

Pažymą išspausdino:

Asmenų registravimo centro Juridinių asmenų registro
Vilniaus skyriaus Vilniaus 3 Juridinių asmenų registro
duomenų tvarkymo grupės
Registratorė

A. V.