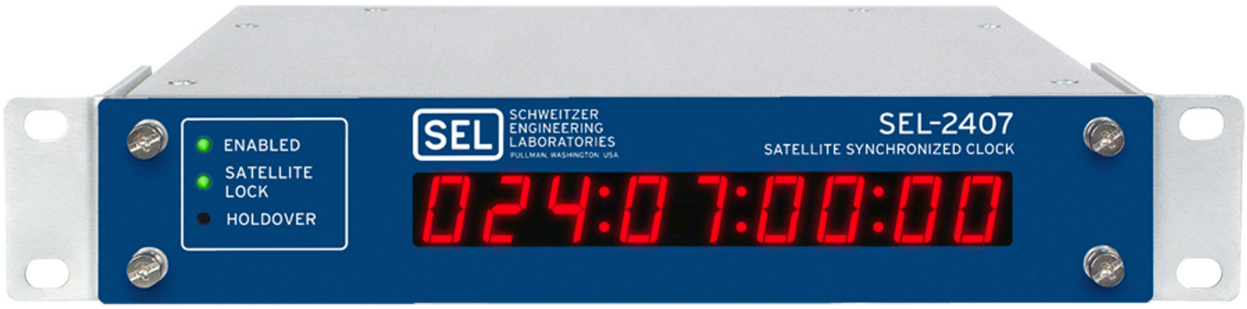
SEL-2407 Satellite-Synchronized Clock Instruction Manual



Features, Benefits, and Applications

The role of satellite clocks has grown from basic sequence-of-event and fault recorder time referencing to mission-critical roles such as synchrophasor measurement and detailed event analysis. These new applications require that satellite clocks meet the same environmental standards and be as reliable as the protective relays and other high-reliability devices with which these clocks are used.

The SEL-2407® Satellite-Synchronized Clock provides the following features:

- **Reliability.** Apply in harsh substation environments. Meets IEEE C37.90 and IEC 60255 protective relay surge and environmental standards. Universal power supply operates from 18–300 Vdc and 85–264 Vac.
- **Accuracy.** Apply for synchrophasor, relay event correlation, and other high-accuracy timing needs. Demodulated IRIG-B outputs with accuracy of ±100 ns average (±500 ns peak) meet requirements for existing and future timing applications.
- **Low Cost, High Function.** Drive numerous point and distributed applications with six demodulated IRIG-B time-code outputs. Outputs are user-selectable for 1 PPS, 1k PPS, or IRIG-B output and exceed performance requirements specified by IEEE 1344 and IEEE C37.118-2005 (Standards for Synchrophasors for Power Systems). For testing and confirming critical timing applications, the SEL-2407 provides unique time-quality forcing and display functions to configure extended control functions time-quality values in the IRIG-B outputs. Built-in display provides easy readability.
- **Flexibility.** Use the control switches and port commands to set any of the timed outputs to UTC or local time reference. Use the serial or fiber-optic port to broadcast serial time in many popular formats.

Product Overview

Figure 1 provides a functional overview of the SEL-2407.

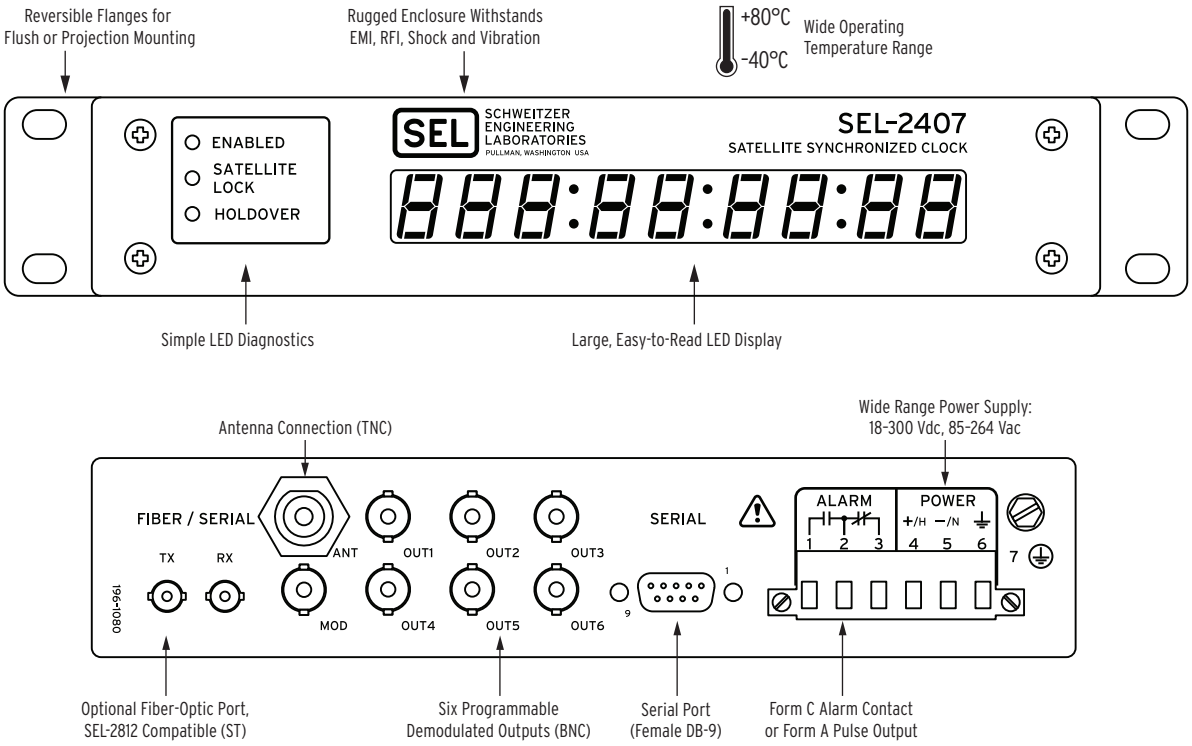


Figure 1 SEL-2407 Functional Overview

Accessories

Accessories enhance your SEL-2407 application. For a complete list of available accessories refer to the SEL Satellite-Synchronized Clocks Accessory Guide at selinc.com/SEL-2407/.

Safety Information

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

⚠WARNING
Indicates a potentially hazardous situation that, if not avoided, **could** result in death or serious injury.

⚠CAUTION
Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

Safety Symbols

The following symbols are often marked on SEL products.

	**⚠CAUTION** Refer to accompanying documents.	**⚠ATTENTION** Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d'instructions

Safety Marks

The following statements apply to this device.

⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	**⚠DANGER** Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠WARNING Operator safety may be impaired if the device is used in a manner not specified by SEL.	**⚠AVERTISSEMENT** La sécurité de l'opérateur peut être compromise si l'appareil est utilisé d'une façon non indiquée par SEL.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	**⚠AVERTISSEMENT** Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	**⚠ATTENTION** Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Class 1 LASER Product. This product uses visible or invisible LASERs based on model option. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	**⚠ATTENTION** Produit LASER de Classe 1. Ce produit utilise des LASERS visibles ou invisibles dépendant des options du modèle. Regarder vers les connecteurs optiques, les extrémités des fibres ou les connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.

Installation and Maintenance

IMPORTANT: Do not connect power to the SEL-2407 until you have completed these procedures.

It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner the manufacturer specifies. If such is not the case, any safety protection the equipment provides may be impaired.

Unit Mounting

Panel-mount, rack-mount, and wall-mounting options are available. The SEL-2407 should only be installed using one of these mounting options. See *Mechanical Diagrams* for dimension and panel cutout size for the unit. Ventilation is unnecessary for a unit used within its normal operating range.

Grounding

Establish your ground connection prior to making power connections. Ground terminals 6 and 7 (labeled ⏚ on the rear panel) are internally connected, so connect only one of these terminals to the rack frame ground or main station ground. In this connection, use appropriately sized wire based on your overcurrent protection (maximum 20 A) and local electrical codes.

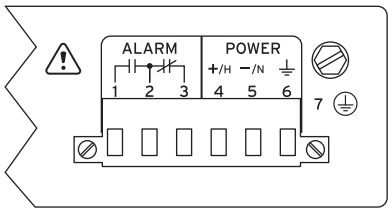


Figure 2 SEL-2407 Rear-Panel Power and Ground Connections

Antenna

The SEL-9524A GPS GNSS Antenna must be installed in accordance with national electrical codes. An unobstructed 360-degree view of the sky is required for reliable operation. The antenna is housed in waterproof packaging designed to withstand exposure to shock, excessive vibration, extreme temperatures, rain, snow, and sunlight. Position the antenna so that the radome points skyward. The antenna is designed for pole mounting on a 1-inch 14-tpi straight thread (typical marine antenna mount) or a 3/4-inch NPT.

The TNC female antenna connector is located inside the threaded socket, which allows the antenna cable to be routed inside the pole, protecting the cable connection and adding reliability.

The GPS antenna should be located low and close to the control house roof (above maximum snow accumulation and away from roof maintenance activities). If the SEL-2407 is in an outdoor cabinet, mount the antenna on the side of the cabinet.

Lightning Protection

Mounting the antenna on an equipment building roof or cabinet is safest because the potential rise on the outside of either of these structures would be more or less equal to the potential on the inside. An SEL Surge Protector Kit (915900139) should be used to equalize the difference in potential that can occur between the center conductor and the shield of the coaxial cable between the antenna and the clock. The higher the GPS antenna is mounted on a support structure, the greater the probability of equipment damage resulting from a lightning strike.

In all surge-protector applications, you should mount the surge protector at the building or enclosure entrance, and ground the surge-protector body as shown in *Figure 3*. Ground the clock to the same point as the surge-protector ground to avoid ground potential rise damage.

When using the surge protector, order an additional SEL-C961 cable and place this cable between the SEL-2407 and the surge protector. Because the distance varies from the SEL-2407 to the surge protector, be sure to specify this cable at approximately the correct length (plus 10 to 20 percent for installation variability). Refer to the SEL Satellite-Synchronized Clocks Accessory Guide for complete information and part numbers of clock accessories.

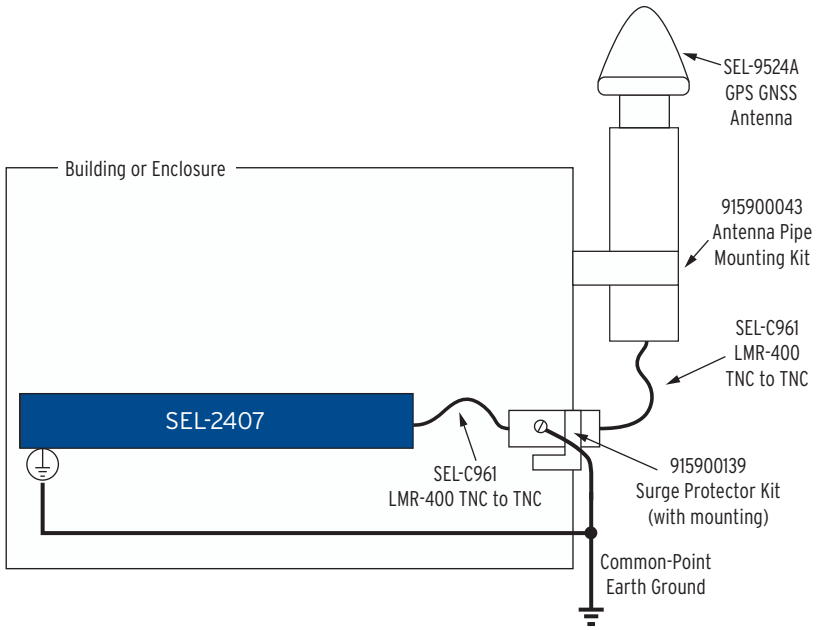


Figure 3 Typical Surge-Protector Installation

Antenna Cabling

The SEL-9524, the Gas Tube Coaxial Surge Protector, and the SEL-2407 are all equipped with TNC female connectors. The SEL-2407 supports a maximum cable length of 152 m (500 ft) for LMR-400 (SEL-C961) antenna cable. Users can choose RG-8X (SEL-C965) cables if long distances are not required.

Power Connections

The SEL-2407 has a wide input range power supply. The voltage ranges are listed in *Specifications on page 30*. The SEL-2407 should be installed in accordance with local electrical codes.

Use 1.5 mm^2 (16 AWG) wire (or heavier) with a minimum temperature rating of 90°C to connect to the **POWER** terminals. When you use a dc power source, you must connect the source with the proper polarity, as indicated by the **+/H** (Terminal **4**) and **–/N** (Terminal **5**) symbols on the power terminals. Upon connecting power, you will see the **ENABLED** LED illuminate.

Disconnect Device

For installations requiring IEC compliance, place an external circuit breaker no more than 3.0 m (9.8 ft) from the equipment. The circuit breaker must comply with IEC 60947-1 and IEC 60947-3 or an equivalent approved disconnect device appropriate for the country of installation and be identified as the disconnect device for this equipment. The maximum current rating for the power disconnect circuit breaker or overcurrent device must be 20 A.

Operational power is internally fused. This fuse is user-replaceable. If a failure occurs, use the procedure described in *Testing and Troubleshooting on page 25*.

Rear-Panel Symbols

There are important safety symbols on the rear of the SEL-2407, as indicated in *Figure 4*.

Observe proper safety precautions when you connect the SEL-2407 at terminals marked by these symbols. In particular, the danger symbol located on the rear panel corresponds to the following:

> Contact with instrument terminals can cause electrical shock that can result in injury or death.

Limit access to terminals marked with the danger symbol.

Figure 4 Safety Symbols on the Rear of the SEL-2407

Compression Terminal Connectors

Terminate connections to the SEL-2407 compression terminal by stripping 8.0 mm (0.31 inches) of the wire insulation. Tightening torque for the terminal connector screws is 0.8 Nm (7 in-lb).

Indicators

The SEL-2407 has three status indicator LEDs on the front panel. *Table 1* further describes these indicators that annunciate the current status of the clock. The Holdover mode is the operating mode where the SEL-2407 has lost satellite lock and is operating on the internal clock without disciplining input from the GPS satellites.

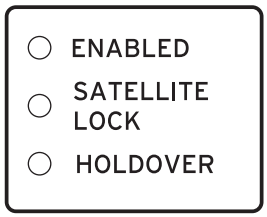


Table 1 Front-Panel Status Indicator LEDs

Label	Color	Description
ENABLED	Green	All self-tests are passing and clock is active
	Yellow	All self-tests are passing, and the clock is in Force-Time-Quality mode (see the **FTQ** command in *Settings and Commands on page 8*) or manual time mode
SATELLITE LOCK	Green	Clock has locked on at least four satellites and is tracking one or more satellites
HOLDOVER	Green	Clock is in holdover mode and the time quality is <1 µs
	Yellow	Clock is in holdover mode and the time quality is ≥1 µs and ≤100 µs
	Red	Clock is in holdover mode and the time quality is greater than 100 µs

Display

The SEL-2407 shows day and time information on the front-panel LEDs. The first three digits indicate the ordinal day of the year (the number of days since the beginning of the year). The next display positions are the time in HH:MM:SS format, where H is hours, M is minutes, and S is seconds.

Lock Sequence

The SEL-2407 front-panel LEDs show clock progress from start to satellite lock. The clock uses the colon separators to indicate states in the lock process, as shown in *Figure 5*.

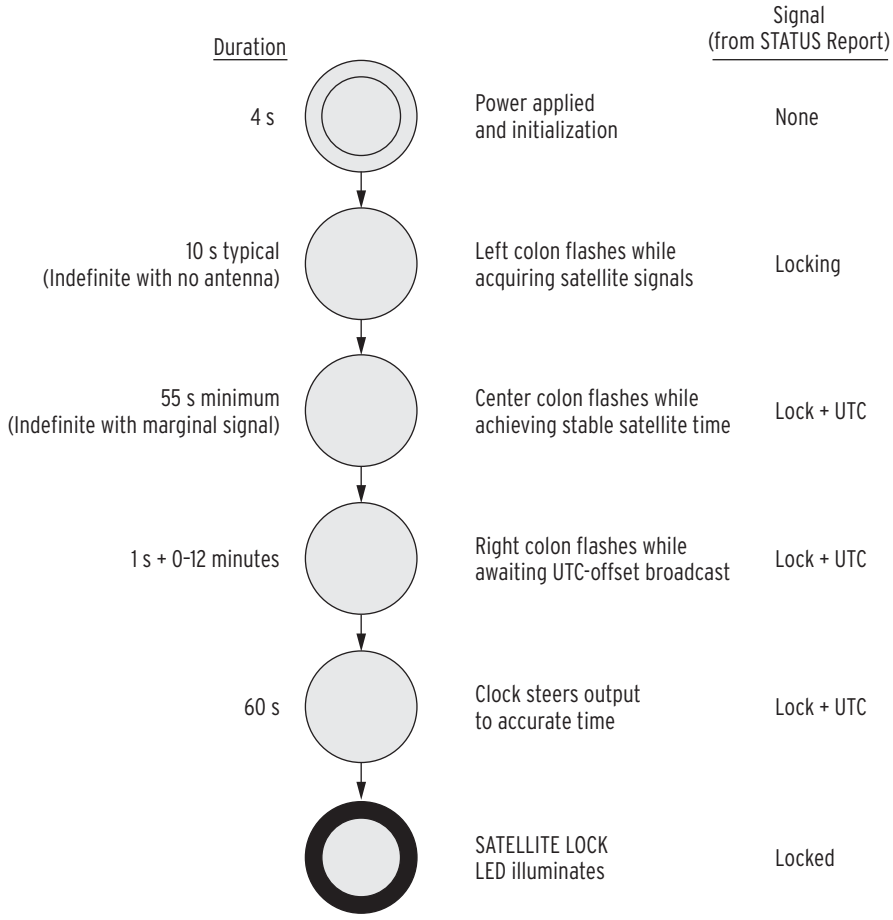


Figure 5 Typical Lock Sequence (Hot Start and Warm Start)

When initially powered and operating without satellite lock, the clock displays SEL2407. Once the clock is satellite-locked, the display will show the current time. The clock will not display the time or send out IRIG-B time until it is satellite-locked. This prevents the SEL-2407 from sending out incorrect time to connected devices.

IRIG-B

IRIG-B is a serial data time format consisting of a 1-second frame that contains 100 pulses divided into fields. The time-synchronized device decodes the second, minute, hour, and day fields and sets the device internal time clock upon detecting valid time data in the IRIG-B time mode.

The SEL-2407 provides both modulated and demodulated IRIG-B outputs according to the IRIG-B 200-04 standard. Modulated IRIG-B is IRIG-B12X. Demodulated IRIG-B timecode is IRIG-B00X. The last digit, either 2 or 0, indicates the coded expression(s).

The time-code format IRIG-BXX2 is binary-coded decimal (BCD) time code (HH,MM,SS,DDD). This format represents traditional or legacy IRIG-B.

NOTE: Select IRIG-B control function extensions for outputs **OUT4**, **OUT5**, **OUT6**, **MOD**, serial port, and optional fiber port with a control (DIP) switch setting. See Switch **SW5** in Table 2. For IRIG-B control function extensions on outputs **OUT1**, **OUT2**, and **OUT3**, use switches **SW6**–**SW11**, as described in Table 2.

The time-code format IRIG-BXX0 consists of BCD time code (HH,MM,SS,DDD), plus straight binary seconds (SBS) of the day (0–86400 s), and also contains control function extensions that include data for the following: year, leap second, daylight-saving time, UTC time offset, time quality, parity.

These control function extensions are described in IEEE C37.118-2005.

Fiber-Optic Port

When equipped with the optional fiber-optic port, the SEL-2407 uses a fiber-optic transmitter. When working with this device, observe the following safety precautions:

⚠CAUTION
Class 1 LASER Product. This product uses invisible LASERs based on model option. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

- Do not look into the fiber (laser) ports/connectors.
- Do not look into the end of an optical cable connected to an optical output.
- Do not perform any procedures or adjustments that this instruction manual does not describe.
- During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.
- Incorporated components, such as transceivers and laser emitters, are not user-serviceable. Return units to SEL for repair or replacement.

Cleaning

Use care when cleaning the SEL-2407. Perform the following steps:

Step 1. Use a mild soap or detergent solution and a damp cloth to clean the chassis.

Step 2. Be careful cleaning the front and rear panels because a permanent plastic sheet covers each panel.

Do not use abrasive materials, polishing compounds, or harsh chemical solvents (such as xylene or acetone) on any surface.

Settings and Commands

Settings

Most settings for the SEL-2407 are performed through dual in-line package (DIP) switches located behind the front panel, as shown in *Figure 6*. To access these switches, disconnect input power from the clock, then remove the front panel by loosening the four captive screws located on the front panel.

NOTE: There is a small circuit board located on the back side of the front panel. Care should be taken not to damage or short this circuit board when removing the front panel.

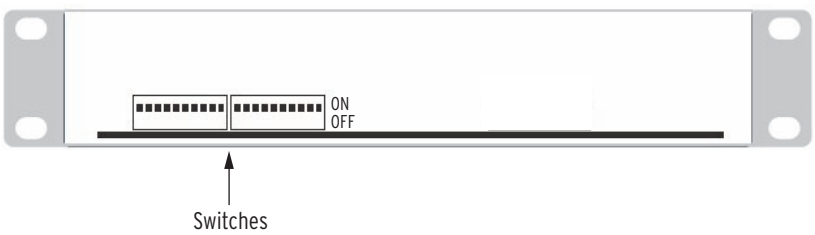


Figure 6 DIP Switch Location

The DIP switches are labeled 1 through 20 starting from the left side. The switch settings are listed in *Table 2*.

Table 2 Control (DIP) Switch Settings and Functions

Switch	Function		
1	ON = Password protection disabled (only use to reset password when lost) OFF = Password protection enabled[a]		
2	ON = **ALARM** output does not include loss of satellite lock[a] OFF = Adds loss of satellite lock to **ALARM** output and alarm pickup delay is enabled		
3, 4	When Switch 2 is OFF = Loss of satellite lock Pickup Delay **ALARM** Pickup Delay:		
	OFF	OFF	= None[a]
	ON	OFF	= 30 seconds
	OFF	ON	= 1 minute
	ON	ON	= 1 hour
5	IRIG-B output format for outputs **OUT4**, **OUT5**, **OUT6**, **MOD**, and serial and fiber ports ON = extended IEEE C37.118-2005 IRIG-BXX0 format[a] OFF = standard IRIG-BXX2 format		
6, 7 8, 9 10, 11	**OUT1** configuration: **OUT2** configuration: **OUT3** configuration:		
	OFF	ON	= IRIG-B002 format
	OFF	OFF	= 1 PPS
	ON	OFF	= 1k PPS
	ON	ON	= IRIG-B000 format with IEEE C37.118-2005 extensions[a]
12–17	Local Time Offset[b]:		
	12	ON OFF	= add to UTC = subtract from UTC
	13	ON	= 8-hour increment
	14	ON	= 4-hour increment
	15	ON	= 2-hour increment
	16	ON	= 1-hour increment
	17	ON	= 1/2-hour increment
18	ON = Daylight-Saving Time (DST); advance and return local time display by one hour OFF = Daylight-Saving Time (DST); always display local standard time[a]		
19	ON = Even parity for IRIG-B000 (IEEE C37.118-2005) OFF = Odd parity for IRIG-B000; default position[a]		
20	**OUT6** to UTC configuration and ASCII FOR command: ON = **OUT6** set at UTC IRIG-B format and ASCII FOR commands enabled OFF = **OUT6** to standard format and ASCII FOR commands disabled[a]		

[a] Factory default switch position.

[b] Factory default switch position for switches 12-17 is OFF.

The local time on the clock is affected by the local time offset setting and the status of daylight-saving time.

Setting Local Time Offset

Control the local time offset with switches **SW12**–**SW17**. The clock output time is UTC when these control switches are all in the OFF position. To display local time, set the appropriate offset from UTC.

Always set the clock to the local region standard time (for DST seasonal offsets, see *Daylight-Saving Time (DST)*). Set the control switches **SW13**–**SW17** incrementally. For example, to set the local time to Eastern Standard time (EST), use the following settings:

SW12 = **OFF** (subtract from UTC)

SW13 = **OFF**

SW14 = **ON** (4 hour)

SW15 = **OFF**

SW16 = **ON** (1 hour)

SW17 = **OFF**

These settings will set the local time to five hours less than UTC.

Daylight-Saving Time (DST)

The clock supports five modes of DST: Off, Manual, Custom, and two preset modes (EU, USA). Switch **SW18** determines whether the clock adjusts for DST, and it must be switched to ON for any of the modes other than Off to operate. The status page **SW18** setting reflects the current DST mode.

Preset DST

The clock has two preset DST configurations: European Union (EU) and North America (USA). When **SW18** is ON and a custom DST is not set, the clock determines from its GPS location whether one of these modes should be selected.

If the GPS location is within the area boundary defined by the latitude and longitude, then that preset DST rule is enabled. The status page under **SW18** will reflect either Auto (EU) or Auto (USA). *Table 3* defines the preset DST conditions and when the offsets will be active.

Table 3 Preset DST Conditions

DST Rule	Latitude	Longitude[a]	Start Month	Start Week	Start Day	Start Hour	End Month	End Week	End Day	End Hour
North America (USA)	15° N → 89°N	–170° → –60°	Mar	2nd	Sunday	2:00 a.m. Local	Nov	1st	Sunday	2:00 a.m. Local
European Union (EU)	35° N → 89°N	–15° → 40°	Mar	Last	Sunday	1:00 a.m. UTC	Oct	Last	Sunday	1:00 a.m. UTC

[a] All longitude ranges West to East.

Custom DST

In all areas you can use the **DST ASCII** command to set the date and time when daylight-saving time begins and ends (see *DST Command (Access Level 1 and Access Level 2) on page 16*). This custom DST setting method must be used in areas outside the European Union and North America for implementing automatic daylight-saving time changes. For areas in the preset regions, the **DST** command changes the preprogrammed daylight-saving time, which is useful where local rules differ from regional practice. **SW18** must be set to ON for the Custom DST to operate, and the status page under **SW18** will reflect Auto (CUSTOM).

Manual DST

When the clock is operating without a custom daylight-saving time and outside of the defined preset DST areas, the clock is operating in manual DST mode. This will be reflected on the status page under **SW18** as MANUAL. **SW18** advances the time manually by one hour when ON. When you set Manual DST, the time changes when the seconds output reaches 00 after crossing 25 seconds. For example, if the present time is 08:09:10 when the DST setting is turned to ON, the time will change at the end of the immediate minute from 08:09:59 to 09:10:00. However, if the current time is 03:45:28 when the DST setting is turned to ON, the time will change at the end of the following minute from 03:46:59 to 04:47:00. The clock uses this delay to transmit the correct IRIG-B time-change notification sequence to downstream relays and other equipment.

SW20

Switch **SW20** has a special purpose. When set to ON it sets the IRIG-B stream on Output 6 to UTC time, and then it enables the use of the **ASCII FOR** command discussed in *SEL ASCII Commands*. When set to OFF the IRIG-B stream on Output 6 is set to local time, and the **ASCII FOR** commands are disabled.

Serial Port Communications

The SEL-2407 Clock has one rear-panel EIA-232 serial port. An optional rear fiber-optic port is also available. This optional port is compatible with SEL-2812 fiber-optic transceivers.

The fixed serial port settings are shown in *Table 4*. The SEL-2407 does not support hardware or software flow control.

Table 4 Serial Port Settings

Data Rate:	9600 bps
Data Bits:	8
Stop Bits:	1
Parity:	None
Port Timeout:	15 minutes

Serial Port Connections

Pinout functions on the rear-panel EIA-232 port are shown in *Table 5*. In addition to ASCII communication, the EIA-232 serial port uses Pin 4 and Pin 6 to output an demodulated IRIG-B signal (as defined by the setting on Control Switch **SW5**). The IRIG-B time accuracy of this signal is ±1 µs peak. The IRIG-B output from the serial port can drive one SEL serial-port IRIG-B input.

Table 5 Pinout Functions

Pin	Function
Pin 1	+5 Vdc (via internal jumper JMP1)
Pin 2	RXD
Pin 3	TXD
Pin 4	+IRIG-B
Pin 5	GND
Pin 6	–IRIG-B
Pin 7	RTS
Pin 8	CTS
Pin 9	GND

Optional Fiber-Optic Port

⚠CAUTION
Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

The optional fiber-optic port multiplexes an demodulated IRIG-B signal on the data communications signal (as defined by the setting on Control Switch **SW5**). This demodulated IRIG-B signal is available on Pin 4 and Pin 6 of the SEL-2812MR or SEL-2812FR Fiber-Optic Transceivers and on the side-port **J1** output of these transceivers (a total of two drive outputs). The IRIG-B time accuracy of this signal is ±1 µs peak. The data delay of the optical port is 6 µs for serial data and 15 µs for the IRIG-B time code, plus 5 µs/km of fiber, over a complete link. (These times include both the fiber-optic ports on the clock and the transceiver.)

The lasers are not user-serviceable. Return the clock to the factory for repair or replacement.

Communications Ports Access Levels

Table 6 shows communications port commands available at each access level. There are two access levels (1 and 2); all commands available at Access Level 1 are also available at Access Level 2.

Table 6 Communications Port Command Summary (Sheet 1 of 2)

Serial Command	Access Level	Description
ACC	1	Enter Access Level 1
2AC	1	Enter Access Level 2
B*x*	1	Set broadcast command on serial port
CON	1	Display time-controlled pulses for **ALARM** and **OUT1**–**OUT6**
DST	1	Display custom daylight-saving time settings
FOR	1	Display current format for each time output
LOC	1	Request current location of clock
STA	1	Request status of clock
TIM	1	Request local time
UTC[a]	1	Request UTC
CLO	2	Close **ALARM** contact
CON	2	Set time-controlled pulses for **ALARM** and **OUT1**–**OUT6**
DST	2	Modify custom daylight-saving time settings

NOTE: Unlike most SEL products, the SEL-2407 Clock does not have an Access Level 0.

Table 6 Communications Port Command Summary (Sheet 2 of 2)

Serial Command	Access Level	Description
DTQ	2	Display time quality
FOR	2	Change format for each time output
FTQ	2	Force time quality (expires after 18 hours)
L_D	2	Prepare device for firmware upgrade
OPE	2	Open **ALARM** contact
PAS	2	Change password
R_S	2	Restore factory-default settings
STA	2	Request clock status and satellite signal strength
TIM	2	Manually set clock time

[a] UTC = Coordinated Universal Time, also known as GMT, or Greenwich Mean Time.

ACC (Access Level 1)

The default access level is Access Level 1. Use the **ACC** command from Access Level 2 to return to Access Level 1. The => prompt indicates Level 1 access. There is no password protection at this level.

2AC (Access Level 2)

Use the **2AC** command to enter Access Level 2. At this level, the clock issues a password prompt. See *PAS Command (Access Level 2) on page 20* for the factory-default password and information on changing this password. When you enter the correct password, the **ALARM** contact pulses for one second to indicate that the settings level was accessed. Level 2 access is indicated with the =>> prompt. Note that all user commands are available at this level.

SEL ASCII Commands

For all commands, use a terminal-emulation program to enter the selected command string followed by a carriage return to issue the command to the clock. **B*x*** ASCII commands do not require a carriage return.

Bx Commands (Access Level 1 and Access Level 2)

The **B*x*** commands give the ability to control and format time broadcasts from the serial port from Access Level 1 and Access Level 2 and does not require a carriage return for the command to execute. When using the **B*x*** broadcast messages, the accuracy of the message will be ±500 µs. These broadcast commands allow for synchronization of a remote PC or RTU through a serial connection.

The broadcast commands have the format B*x* with one parameter *x*.

Parameter *x* can have one of the following values:

0 = Deactivates broadcast mode

1 = Activates broadcast of ddd:hh:mm:ss

5 = Activates broadcast of l YY ddd:hh:mm:ss.000

6 = Activates broadcast of ddd:hh:mm:ss q

8 = Activates broadcast of YYYY:ddd:hh:mm:ss q

L = Configures B1, B5, B6 and B8 broadcasts to send local time

U = Configure B1, B5, B6 and B8 broadcasts to send UTC time

The following are definitions of the formats used above:

YY = The last 2 digits of the year (00–99)

YYYY = Date year (2000–9999)

ddd = Day of the year (1–366)

hh = Time hours (00–23)

mm = Time minutes (00–59)

ss = Time seconds (00–59)

l = The satellite lock status, with the values:

<SP> = Locked

? = Unlocked

q = The time quality, with the values:

<SP> = Locked

. = <1 microsecond

* = <10 microsecond

= <100 microsecond

? = >100 microsecond

If the **B1** command is issued, then the Satellite-Synchronized Clock will enter time broadcast mode and respond with `ddd:hh:mm:ss` once per second. Note that any time the broadcast commands are issued they are not echoed to the screen.

```
=>B1
313:11:17:14
313:11:17:15
313:11:17:16
313:11:17:17
313:11:17:18
313:11:17:19
313:11:17:20
313:11:17:21
313:11:17:22
313:11:17:23
313:11:17:24
313:11:17:25
```

This broadcast will continue indefinitely until the cancel command **B0** is issued.

CLO Command (Access Level 2)

The **CLO** command forces the **ALARM** contact to the closed state. The **ALARM** contact is reset when any key is pressed.

CON (Access Level 1 and Access Level 2)

The **CON** command shows the time-controlled output settings.

```
=>CON <Enter>
Port   Status    Start Date    Start Time     Pulse Width    Repetition Period
 ----   ------    ----------    ----------     -----------    -----------------
 OUT1   N/A
 OUT2   N/A
 OUT3   Ready
 OUT4   N/A
 OUT5   Active      Today       12:34:56.75        0.05       00:00:00.25
 OUT6   N/A
 ALARM  Active     Tomorrow     06:30:00.00        1.00       Daily
```

The **CON** command forces the ALARM contact closed (**CON ALARM ...**) or OUT1–OUT6 high (**CON OUT *n* ...** [*n* = 1–6]) one or more times, beginning at a specified time and with a specified duration. This command implements a precise alarm clock function with an accuracy of ±0.5 ms and a user-configurable pulse duration.

NOTE: Alarm contacts must be set to the open condition before the alarm clock function can be used. Enter the **CON ALARM** command without any other parameters to close the alarm contact. When the alarm clock function is no longer needed, enter **CON ALARM C** to restore normal contact operation.

The **CON** command is the following format:

CON [OUTPUT][C] [xxxxx.xx] [[yyyy-mm-dd] [Thh:mm:ss.ff]] [P[dd] [Thh:mm:ss.ff]]

where:

- **OUTPUT** is the chosen output for timed control. Permissible values are ALARM or OUTn (where n = 1–6).
- **C** cancels the command. When this parameter is present, the clock ignores all other parameters.
- **xxxxx.xx** is the pulse width in the range 0.01 to 64800.00 seconds. When this parameter is not present, the default pulse width is 1.00 seconds.
- **yyyy-mm-dd** is the pulse local start date. When this parameter is not present, the default start date is today.
- **Thh:mm:ss.ff** is the pulse local start time. When this parameter is not present, the default start time is the local time now.
- **PddThh:mm:ss.ff** is the pulse "period time" or repetition period in the range 0T00:00:00.05 to 99T23:59:59.99. When this parameter is not present, the clock outputs a single pulse (single shot). If the dd parameter is not present, then the clock assumes 0 days. If the Thh:mm:ss.ff parameter is not present, the clock assumes 00:00:00.00.

Controlling the ALARM causes the contact to close. Controlling OUT1–OUT6 pulses 5 V on the BNC connector when activated.

Once you have entered the **CON** command parameters to output a pulse, the clock displays a confirmation message similar to the following.

```
Timed Alarm Settings are:
Start Date    Start Time     Pulse Width    Repetition Period
yyyy-mm-dd    hh:mm:ss.ff    xxxxx.xx       hh:mm:ss.ff
or            or                            or
Today       Immediately                   Single Shot
Begin Timed Alarm Contact Operation  (Y,N)?
```

Answer **Y <Enter>** to begin Timed Alarm operation. To return to Normal Alarm operation you must issue the **CON ALARM C <Enter>** command. CON settings are stored in non-volatile memory, so timed outputs will resume after a power-off/power-on cycle.

Table 7 CON Command Examples

Command	Description
CON ALARM	Begin timed alarm contact operation
CON ALARM 5	Single shot 5-second pulse, starting immediately
CON ALARM T17:00:00	Single shot 1-second pulse, starting at 5:00 p.m. local time
CON ALARM 5.5 T8:29:24.5	Single shot 5.5-second pulse, starting at 8:29:24.50 a.m. local time
CON ALARM C	Cancel timed alarm contact operation
CON OUT1[a] PT00:00:10	1-second pulse, repeating every 10 seconds, starting immediately
CON OUT6[a] 0.05 PT00:00:00.25	0.05-second pulse, repeating every 0.25 seconds, starting immediately
CON OUT3[a] T6:30:00 P1	1-second pulse, repeating daily, starting at 6:30:00 a.m. local time
CON OUT2[a] 5 2006-9-25 T12:00:00 P7	5-second pulse, repeating weekly, starting at noon local time on September 25, 2006
CON OUT4[a] 30 T8:00:00 PT1:00:00	30-second pulse, repeating hourly, starting at 8:00:00 a.m. local time
CON C	Cancel timed operation on all outputs

[a] To use OUT1–OUT6 in the **CON** command you must first change the output to ALARM using the **FOR** command, e.g., **FOR OUT1 ALARM.**

DST Command (Access Level 1 and Access Level 2)

At Access Level 1, the **DST** command shows the custom daylight-saving time (DST) setting that the clock uses to automatically advance and return local time by one hour.

```
=>DST <Enter>
Custom Daylight Saving Settings
Begin DST at 2:00 hours on the second Sunday of March
End DST at 2:00 hours on the third Sunday of October

=>
```

The SEL-2407 reports "`Custom DST not set`" when there is no valid custom daylight-saving time setting.

To change the custom DST setting you must enter Access Level 2 (see *2AC (Access Level 2) on page 13*).

At Access Level 2, the **DST** command customizes the date and time when daylight-saving time begins and ends. This custom method must be used in areas outside the European Union and North America for implementing automatic daylight-saving time changes; for areas in the preset regions the **DST** command changes the pre-programmed daylight-saving time, which is useful where local rules differ from regional practice.

The clock **DST** command uses the following format:

DST [C] [HH,N,D,MM] [hh,n,d,mm]

- **C** clears any previously set custom DST setting. When this parameter is present, the clock ignores all other parameters.
- **HH,N,D,MM** sets the DST begin rule
  - HH = local time hour to begin DST (range is 0–23)

NOTE: The minimum separation for Begin DST and End DST settings is three hours.

For testing the beginning of daylight-saving time, set the Begin DST time at the next hour change and the End DST time at least three hours in the future. For testing the end of daylight-saving time, set the Begin DST time at least three hours in the past, and set the End DST time at the next hour change.

With these methods, you can examine whether time-consuming devices correctly apply the daylight-saving time changeover bits in the extended IRIG-B time code (IRIG-BXXO).

- N = week of the month to begin DST (range is 1–4, L [first, second, third, fourth, last])
- D = day of week to begin DST (range: 1–7 [Sunday–Saturday])
- MM = month to begin DST (range: 1–12 [January–December])

➤ **hh,n,d,mm** sets the DST end rule

- hh = Local time hour to end DST (range: 0–23)
- n = Week of the month to end DST (range: 1–4, L [first, second, third, fourth, last])
- d = Day of week to end DST (range: 1–7 [Sunday–Saturday])
- mm = Month to end DST (range: 1–12 ([January–December])

```
=>>DST <Enter>
Custom Daylight Saving Settings
Custom DST not set.
To clear Custom DST rules: DST C
To set Custom DST rules: DST HH,N,D,MM hh,n,d,mm
HH,N,D,MM is the begin rule
hh,n,d,mm is the end rule

Setting ranges are:
 HH/hh = Hour, range 0-23 (local time hour)
 N/n   = Occurrence in month, range 1-4, L (first, second, third, fourth, last)
 D/d   = Day-of-week, range 1-7 (Sunday - Saturday)
 MM/mm = Month, range 1-12 (January - December)
=>>
```

Upon issuing the **DST** command, the clock reports the present setting and help information on how to correctly use the **DST** command. Entering the **DST** command followed by the correct date parameters will set the custom DST settings. If you enter an incorrect range parameter, the clock replies with an invalid setting prompt. Once valid DST arguments are entered, the clock reports the new custom daylight-saving time changes and prompts you to save these new times. Answer **Y** to change to (new) custom DST settings, or **N** to retain the previous settings.

Use the **DST C** command to clear both the Begin DST and End DST settings. This command returns the settings values to the default, which enables manual DST operation outside of the European Union and North America regions.

Use the custom DST setting for areas where time changes occurring at midnight must be set differently. For example, if DST is observed the second Saturday in October to the second Saturday in March, with the transitions at 24:00 local time, the DST setting would be set to the following:

DST 0,3,1,10 0,3,1,3

The local time hour change for daylight saving is at 24 but the setting only allows 0–23. In this case the setting must be set one day ahead with an hour setting of 0. This change causes the day of the week to occur on Sunday, which now is the third week of the month. The week of the month needs to get set to three instead of two because the daylight saving occurs on Sunday at 0:00:00 local time.

DTQ Command (Access Level 2)

The **DTQ** command changes the normal time display to the time-quality display. The SEL-2407 changes the time display to `QUALIty:n` and reports the normal operation time-quality values listed in *Table 8*. In addition, you can use this command with the **FTQ** command to report the preset IEEE C37.118-2005 extensions time-quality value during FTQ testing mode, as listed in *Table 10*. The **FTQ** command will expire after 18 hours, and the SEL-2407 will then return to normal operation.

Table 8 Normal Operation Values for Time Quality

n	Time Quality
0	Locked
4	1 microsecond
5	10 microseconds
6	100 microseconds
15	Fault

FOR Command (Access Level 1 and Access Level 2)

The **FOR** command allows the user to format each of the time outputs independently. This command is enabled when control switch **SW20** is in the ON position. If **SW20** is OFF, the **FOR** command is disabled and all time outputs are set to their default format.

At Access Level 1, the **FOR** command allows you to view the current configuration of the time outputs. The port setting is preceded by a **+** when the default time outputs have been overridden by a **FOR** command. For the case below where **OUT3** and **OUT6** are preceded by a **+**, these outputs are no longer configured by the control switches.

```
=>FOR <Enter>
Port   Function  Reference        Port   Function  Reference
----   --------  ---------        ----   --------  ---------
OUT1   IRIG-B000  Local Time       OUT2    IRIG-B000 Local Time
+OUT3  IRIG-B000  UTC Time         OUT4    IRIG-B000 Local Time
OUT5   IRIG-B000  Local Time       +OUT6   ALARM     Local Time
SERIAL IRIG-B000  Local Time       FIBER   IRIG-B000 Local Time
MOD    IRIG-B120  Local Time
```

At Access Level 2, the **FOR** command allows you to view the current configuration or change the time outputs. To change the time outputs, use the following format:

FOR [OUTPUT] [C] [FORMAT [REFERENCE]]

where:

- **OUTPUT** is the selected output. The values allowed are OUT1, OUT2, OUT3, OUT4, OUT5, OUT6, MOD, SERIAL, and FIBER.
- **C** without a selected OUTPUT will restore all time outputs to their default settings determined by the control (DIP) switch settings. If **C** is used with an **OUTPUT** parameter, then it will only restore the selected output back to the default state.
- **FORMAT** allows the user to choose the time format for the specified OUTPUT. The possible values are B000, B002, B122, PPS, KPPS, and ALARM. Setting OUT1–OUT6 to ALARM enables the output to be used in the **CON** command.
- **REFERENCE** is the time source for the IRIG-B transmitted data. The possible values are either LOCAL or UTC. If left blank, the parameter will default to LOCAL.

Table 9 lists all the possible combinations for the **FOR** command.

Table 9 FOR Command Combinations

Command	First Parameter	Second Parameter	Third Parameter	Action
FOR	–	–	–	Display output formats
FOR	C	–	–	Restore all outputs to default format
FOR	MOD	B120	Local	Transmit IRIG-B120 using Local time
			UTC	Transmit IRIG-B120 using UTC time
		B122	Local	Transmit IRIG-B122 using Local time
			UTC	Transmit IRIG-B122 using Local time
		C	–	Restore default format
FOR	OUT1 OUT2 OUT3 OUT4 OUT5 OUT6	B000	Local	Transmit IEEE C37.118-2005 IRIG-B000 using local time
			UTC	Transmit IEEE C37.118-2005 IRIG-B000 using UTC time
		B002	Local	Transmit standard IRIG-B002 using local time
			UTC	Transmit standard IRIG-B002 using UTC time
		PPS	–	Transmit 1 pulse per second
		KPPS	–	Transmit 1000 pulses per second
		ALARM	–	Precision alarm clock
		C	–	Restore default format
FOR	SERIAL FIBER	B000	Local	Transmit IEEE C37.118-2005 IRIG-B000 using local time
			UTC	Transmit IEEE C37.118-2005 IRIG-B000 using UTC time
		B002	Local	Transmit standard IRIG-B002 using local time
			UTC	Transmit standard IRIG-B002 using UTC time
		C	–	Restore default format

FTQ Command (Access Level 2)

The **FTQ** command forces a selected value for the IEEE C37.118-2005 extensions time-quality output (useful for testing whether IEDs connected to the clock outputs are properly receiving and decoding these extended control function bits). To force a time-quality output, issue the command **FTQ *n***, where *n* represents a time-quality value shown in *Table 10*. The **ENABLED** LED changes to yellow, and the remaining indicator LEDs show clock status based upon the selected time-quality value. To return to normal operation, issue the **FTQ C** (clear) command. The SEL-2407 forces and reports the time-quality values listed in *Table 10* during this testing mode. To display the time quality, see *DTQ Command (Access Level 2)*. Only use the **FTQ** command when the clock is in Satellite Lock or manual time mode. The **FTQ** command will expire after 18 hours, and the SEL-2407 will then return to normal operation.

Table 10 Test Operation Forced Values for Time Quality (Sheet 1 of 2)

n	Time Quality	n	Time Quality
0	Locked	8	10 milliseconds
1	1 nanosecond	9	100 milliseconds

Table 10 Test Operation Forced Values for Time Quality (Sheet 2 of 2)

n	Time Quality	n	Time Quality
2	10 nanoseconds	10	1 second
3	100 nanoseconds	11	10 seconds
4	1 microsecond	12	100 seconds
5	10 microseconds	13	1000 seconds
6	100 microseconds	14	10000 seconds
7	1 millisecond	15	Fault

LOC Command (Access Level 1 and Access Level 2)

The **LOC** command shows the current location of the GPS clock. If the clock is not satellite locked or does not have the previous location the latitude, longitude, and altitude will display all 0. The **LOC** command has two arguments to show two different formats of the GPS location. If the **LOC** command is entered either without any arguments or with the argument **D**, the clock will display GPS coordinates as shown in *Figure 7*.

```
=>LOC <Enter>
46°44'33.069"N 117°11'25.794"W 00752.724m
=>
```

Figure 7 LOC Command Example Without Any Arguments

The **LOC** command is also set to send in a digital format that is easier for computers to read and parse. Issuing the **LOC** command with the argument **H** will display the clock's location in a digital format, as shown in *Figure 8*.

```
=>LOC H <Enter>
+464433.08–1171125.73+00755.623CRSWGS_84/
=>
```

Figure 8 LOC H Command Example For Digital Format

OPE Command (Access Level 2)

The **OPE** command forces the **ALARM** contact to the open state. The **ALARM** contact is reset when any key is pressed.

PAS Command (Access Level 2)

The **PAS** command allows changing serial-port access passwords.

The default password for Access Level 2 is TAIL (firmware versions before R113 had a default Access Level 2 password of ACCESS+2407).

Passwords can include as many as 12 characters. The printable characters from the 7-bit ASCII set (i.e., values between 0x21 and 0x7e) are the only allowed password characters.

There is also a calibration access level used at the factory as a part of testing and validation procedures. There are no commands valuable to the user at this level. Some security processes require that there must be a means for security officers to change any password in the device. To change the CAL level password you must first move to the CAL level. At Access Level 2, type **CAL <Enter>** and the CAL level password. The default CAL level password is CLARKE (firmware versions

before R113 had a default CAL access level password of HAWKING+2407). The CAL access level is indicated with the ==>> prompt. At the CAL access level, use the **PAS** command to change the CAL password.

R_S Command (Access Level 2)

Use the **R_S** command to restore factory-default settings and passwords and reboot the system. This command is only available after a settings change or critical RAM failure (or after selected firmware upgrades).

STA Command (Access Level 1 and Access Level 2)

The **STA** command displays the clock status, firmware version, and control (DIP) switch setting information.

The SEL-2407 provides additional firmware information in the Access Level 2 **STA** command.

```
=>>STA <Enter>
SEL-2407 Satellite Synchronized Clock     Local Date/Time = 2013-06-11  08:21:00
FID=SEL-2407-R200-V0-Z003002-D20130627    CID=38D0
RFID=SEL-2407-R106-V0-D20130531
RXFID=NAV-V02.02-D20130117 DSP-V02.07-D20080813 HW-3017-SN1031003564


SELF TEST RESULTS
RTL          FLASH       SDRAM       DISPLAY     ANTENNA     GPS_RX
OK           OK          OK          OK          OK          OK


SETTINGS
SW 1         SW 2        SW 3-4      SW 5        SW 20
PASSWORD     ALARM       PU DELAY    IRIG FORMAT OUTPUT 6
Disabled     Lock        None        Extended    Local Time

SW 6-7       SW 8-9      SW 10-11    SW 12-17    SW 18           SW 19
OUTPUT 1     OUTPUT 2    OUTPUT 3    OFFSET      DST             Parity
IRIG-B000    IRIG-B000   IRIG-B000   -8.0        Auto (USA)      Odd


SATELLITES
   # Signal   # Signal   # Signal   # Signal   # Signal   # Signal   # Signal
  20  47.0   32  48.0   23  44.0   31  50.0   16  41.0    1  44.0   13  44.0

   # Signal   # Signal   # Signal   # Signal   # Signal   # Signal   # Signal
   4  38.0   25  45.0   14  20.0   11   0.0    -   -.-    -   -.-    -   -.-


STATUS
CLOCK        SIGNAL      ALMANAC
Enabled      Locked      Complete
=>>
```

If SW 2 is "LOCK", then the description of SW 3-4 is "PU DELAY" instead of "RATE"

SW 2	SW 3-4
ALARM	PU DELAY
Lock	30 seconds

Table 11 Status Report Elements (Sheet 1 of 2)

Report Element	Range	Description
FID	N/A	Firmware identifier string (identifies the firmware version)
CID	N/A	Firmware checksum identifier
RTL	OK, FAIL	Processor status
RFID	N/A	FPGA firmware identifier string
RXFID	N/A	GPS receiver firmware ID
FLASH, SDRAM	OK, FAIL	Memory status
DISPLAY	OK, FAIL	Display panel status

Table 11 Status Report Elements (Sheet 2 of 2)

Report Element	Range	Description
ANTENNA	OK, FAIL	Antenna status (FAIL indicates a cable or antenna problem or insufficient satellites in view)
GPS_RX	OK, FAIL	GPS receiver module status
SW1 PASSWORD	Required, Disabled	Password protection status
SW2 ALARM	Enable, Lock	Enable: Alarm does not include loss of satellite lock Lock: Adds loss of satellite lock to ALARM output and enables alarm pickup delay
SW3-SW4 RATE (if SW2 = Enable)	OFF, 1/30-seconds, 1/minute, 1/hour	N/A
SW3-SW4 PU DELAY (if SW2 = Lock)	None, 30 seconds, 1 minute, 1 hour	Configured pickup delay time for the alarm contact when loss of satellite lock has occurred
SW5 IRIG FORMAT	Extended, Standard	IRIG-B output format for **OUT4**, **OUT5**, **OUT6**, **MOD**, serial port, and fiber port Extended: IEEE-1344 and IEEE C37.118-2005 extensions IRIG-BXX0 format Standard: IRIG-BXX2 format
SW6-SW7 OUTPUT 1	IRIG-B002, IRIG-B000, 1PPS, 1KPPS	**OUT1** configuration setting
SW8-SW9 OUTPUT 2	IRIG-B002, IRIG-B000, 1PPS, 1KPPS	**OUT2** configuration setting
SW10-SW11 OUTPUT 3	IRIG-B002, IRIG-B000, 1PPS, 1KPPS	**OUT3** configuration setting
SW12-17 OFFSET	±*hh.h*	Local time offset in hours
SW18 DST	OFF, AUTO (USA), AUTO (EU), AUTO (CUSTOM), MANUAL	Daylight-saving time status
SW19	Even, Odd	IRIG-B parity setting
SW20	UTC Time, Local Time	**OUT6** configuration setting
# Signal	*nn pp.p*	*nn* = GPS satellite number (0–32) *pp.p* = GPS received signal power in dB-Hz
CLOCK	Enabled, Disabled	Device status
SIGNAL	Locked, Locking, Lock+UTC, Holdover, None	GPS signal status
ALMANAC	Complete, Acquiring	Satellite tracking status

TIM Command (Access Level 1 and Access Level 2)

Use the **TIM** command to either view the current local time or to manually set the time if no satellite lock is available. This command is useful for either testing roll-over date and time values for downstream devices or for areas where a satellite lock is not available. At Access Level 1, the **TIM** command will respond with the local time in hours, minutes, seconds (hh:mm:ss). At Access Level 2, the **TIM** command allows you to manually set the date and time. Manually setting the date and time will set the clock display, enable IRIG-B outputs, and set the time quality to 4. The date can only be set between the years 2006 and 2100. Dates set outside of this range will not be accepted. Once the date and time are manually set the clock will not synchronize to the current date and time even if the clock picks up satellite lock. To clear the manual date and time, either cycle power or issue the **TIM C** command. The **TIM** command has a time-out period of 18 hours. When the time-out expires, the clock will return to normal operation. The **TIM** command has the following parameters:

TIM [C] [YYYY-MM-DDThh:mm:ss]

where:

- **C** cancels the user time setting.
- **YYYY-MM-DDThh:mm:ss** is the local date and time setting.
  - YYYY = 4 digit year
  - MM = Month
  - DD = Day of Month
  - T = Required separator between date and time
  - hh = Hour of day in 24 hour format
  - mm = Minutes
  - ss = Seconds

UTC Command (Access Level 1 and Access Level 2)

Upon receipt of the **UTC** command, the SEL-2407 responds with the UTC date, time, and local time offset in the following format (ISO 8601:2000):

YYYY-MM-DDThh:mm:ss±HH:NN

Table 12 UTC Format

YYYY =	UTC Date Year (2000–9999)
MM =	UTC Date Month (01–12)
DD =	UTC Day of the Month (01–31)
T =	Literal Time Separator
hh =	UTC Time Hours (00–23)
mm =	UTC Time Minutes (00–59)
ss =	UTC Time Seconds (00–60)
±HH =	Local Time Hours Offset including Daylight-Saving Time (–15 to +16)
NN =	Local Time Minutes Offset (00 or 30)

The **UTC *n*** command repeats the UTC time output for *n* times at the beginning of each second. A special case of this command is **UTC 0**, which outputs UTC time continually until the communications port receives any valid ASCII character (including **<Ctrl+X>**).

Applications

Time-Code Distribution

The SEL-2407 has sufficient driving capacity to provide demodulated and modulated time-code signals to many products simultaneously.

Demodulated Timecode

Table 13 shows typical drive capabilities per demodulated BNC output for the SEL-2407 to other SEL equipment. The demodulated BNC outputs provide a standard IRIG-B00X DC level-shift (TTL) signal. The accuracy of this signal is ± 100 ns, average. A series/parallel connection of SEL-100 and SEL-200 series products consists of two relays in series, with as many as 10 of these series pairs connected in parallel.

Table 13 Output Drive Capacity

Product	Connection	Input Impedance (Ohms)	Units Per SEL-2407 Output
SEL-100 Series	AUX INPUT (Conxall®)	56/82	2 parallel, 20 series/parallel[a]
SEL-200 Series	AUX INPUT	56/82	2 parallel, 20 series/parallel[a]
Legacy SEL-300 Series	(DEMODULATED) IRIG-B	333	10[b]
New SEL-300 Series	IRIG-B	1K	10[b]
SEL-351R and SEL-351R Falcon	(DEMODULATED) IRIG-B	333	10[b]
SEL-400 Series	IRIG-B, serial port	2.5K	20[c]
New SEL-400 Series	IRIG-B, BNC	>1K	20[c]
SEL-500 Series	(DEMODULATED) IRIG-B	333	10[b]
SEL-651R	IRIG-B	1.33K	20[c]
SEL-700 Series	IRIG-B	4.5K or 2.5K[d]	20[c]
SEL-734	IRIG-B	2.5K	20[c]
SEL-2032, SEL-2030, SEL-2020	IRIG-B (In) (BNC)	333	10[b]
SEL-2240	IRIG-B	2.5K	20[c]
SEL-2411	IRIG-B	4.5K or 2.5K[d]	20[c]
SEL-2414	IRIG-B	4.5K or 2.5K[d]	20[c]
SEL-2431	IRIG-B	750	10[b]
SEL-2440	IRIG-B	2.5K	20[c]
SEL-2523, SEL-2533	IRIG-B	2.5K	20[c]
SEL-2810MT	IRIG-B	25K	20[c]
SEL-2812MT	IRIG-B	2K	20[c]
SEL-3031	IRIG-B	333	10[b]
SEL-3350 Series, SEL-3530, SEL-3610, SEL-3620, SEL-3622	IRIG-B	2.5K	20[c]
SEL-3401 manufactured before Sept. 2011	IRIG-B (In)	332	10[b]
SEL-3401 manufactured Sept. 2011 or later	IRIG-B (In)	1.33K	15[b]

[a] Do not add external terminating resistor.

[b] Install 50-ohm termination resistor on farthest device for 4 or fewer devices.

[c] Install 50-ohm termination resistor on farthest device.

[d] 2.5 kilohm if no Ethernet or single copper Ethernet port; 4.5 kilohm if fiber-optic or dual Ethernet port(s).

The maximum cable length is 40 m (131.2 ft). Connect multiple devices as illustrated in *Figure 9*.

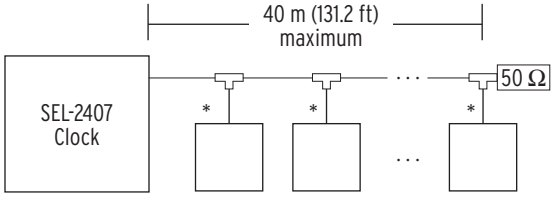


Figure 9 Multiple-Device Connections

Modulated Time Code

The modulated output (**MOD**) is a standard IRIG-B12X amplitude-modulated signal. The accuracy of this signal is ±1 µs peak. The drive capability is 40 mA into 25 ohms at a nominal level of 4.75 V_{pp}. This output drives three to four devices in parallel; maximum cable length is 130 m (425 ft).

Apply a terminator, if required, to obtain a 50-ohm match when driving high-impedance input devices.

Testing and Troubleshooting

Setting the Control (DIP) Switches

You must remove the front panel to set the control (DIP) switches. Remove power and take care not to damage the circuit board attached to the front panel.

You can check the control (DIP) switch settings without removing the front panel. Use the serial port status command **STA** to verify settings.

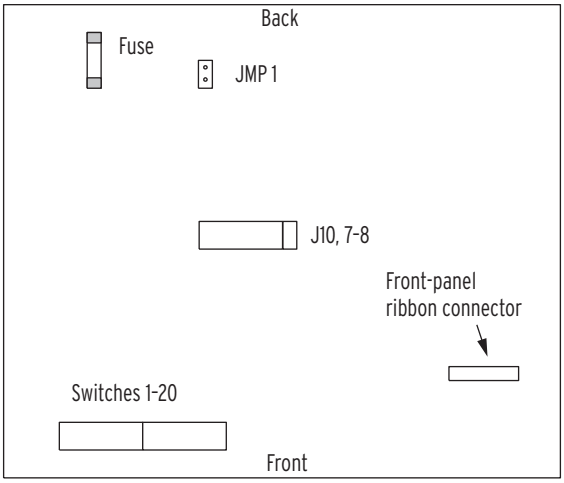


Figure 10 Component Locator

Fuse Replacement

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

If it appears that there is no power to the clock (for example, all display indications are off), take the following steps:

Step 1. Verify that a supply voltage within the power supply range is present on terminals **4** and **5**.

Step 2. If the correct supply voltage is present, remove power and then remove the SEL-2407 from the equipment rack.

Step 3. Remove the top cover.

Step 4. Replace the fuse with a BUSS S505 2 A (ceramic), Schurter T 2 A 250 V, or equivalent (SEL Part Number 915900488).

Step 5. Replace the top cover.

Step 6. Reinstall the SEL-2407.

Step 7. Apply power to the SEL-2407.

The Clock Will Not Lock

When the clock is unable to achieve a lock, the cause of such failure typically is poor receive-signal strength. For the clock to lock, the receiver must initially track at least four satellites. For the clock to remain locked, it must continue to track at least one satellite.

To verify the signal, use the serial port **STA** command from Access Level 2.

Step 1. Verify that the antenna connection displays `OK` in the status window.

If `OK` is not displayed, check the connections and the cable for short or open circuits.

Step 2. Verify the signal strength of the tracked satellites.

There are 14 satellite-status fields listed near the bottom of the status screen. The first two-digit number is the GPS satellite designator for each tracked satellite. The next number is the received signal strength in dB-Hz.

To achieve lock, the clock must have a minimum reading of approximately 30 dB-Hz on four satellites. After lock is achieved, the clock must have the minimum reading on one satellite. If signal strength does not meet these requirements, the signals are too weak.

If signals are too weak to achieve lock, perform the following steps:

Step 1. Reposition the antenna for an unobstructed view of the sky.

Step 2. Verify that the antenna cable or external protection is not damaged.

Mechanical Diagrams

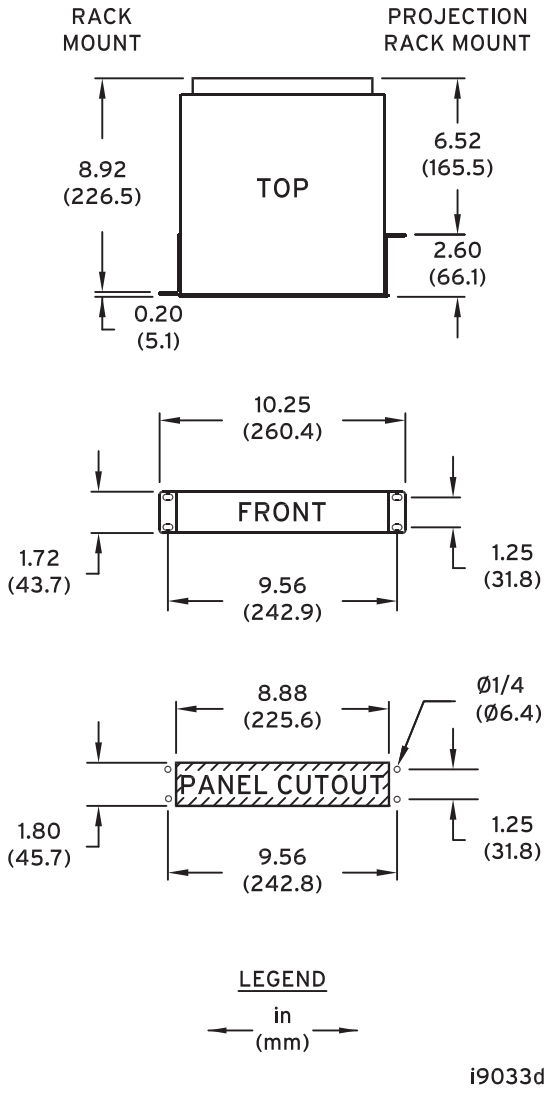


Figure 11 SEL-2407 Horizontal Rack-Mount (Half Rack) Dimension Drawing

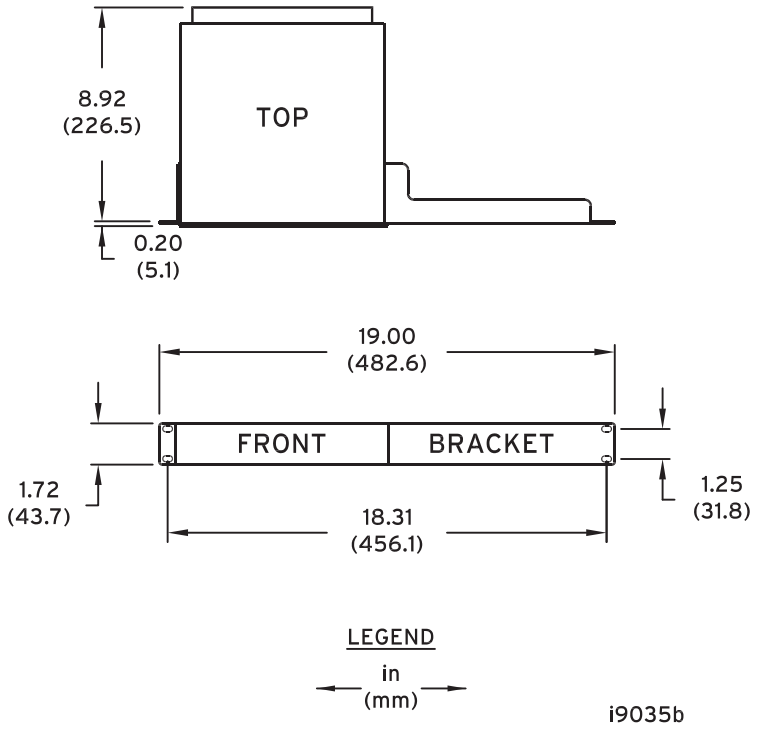


Figure 12 SEL-2407 Horizontal Rack-Mount Dimension Drawing

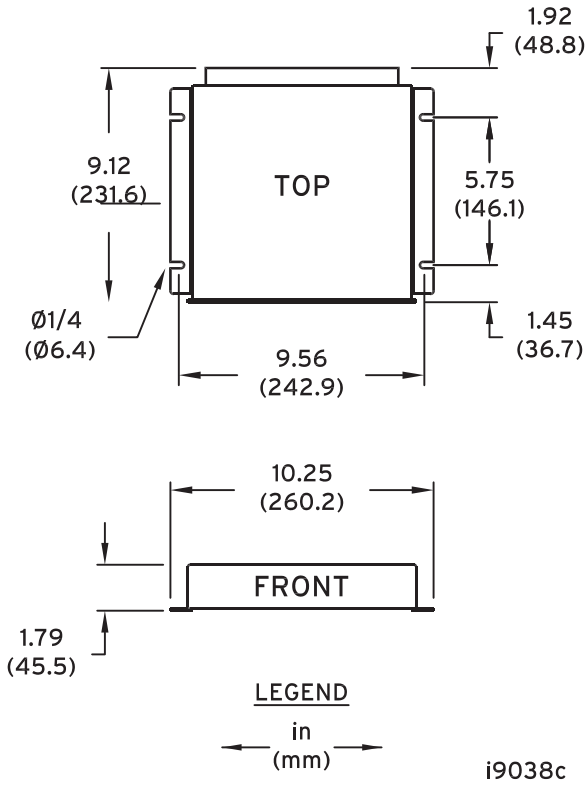


Figure 13 SEL-2407 Surface-Mount Dimension Drawing

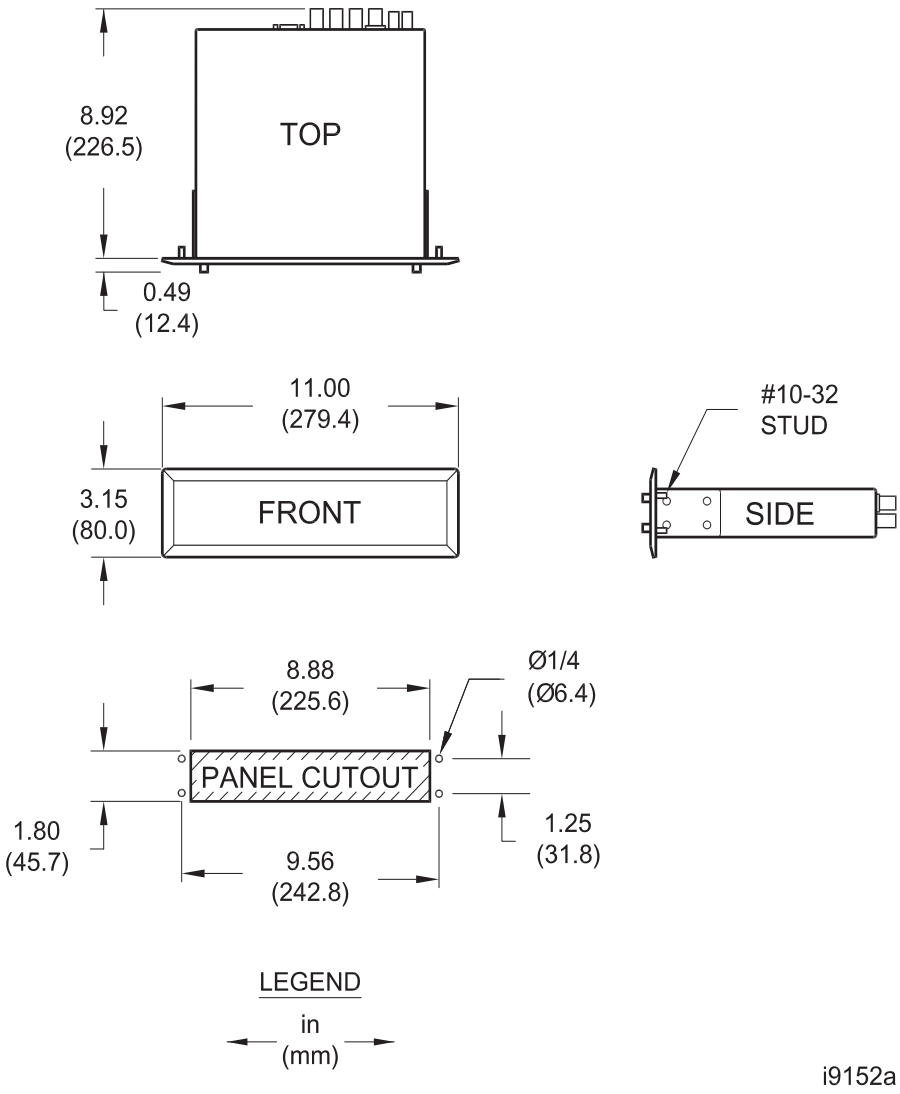


Figure 14 SEL-2407 Panel-Mount Dimension Drawing

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E220228; NRAQ, NRAQ8)

CE Mark

UKCA Mark

47 CFR 15B, Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may be likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Any changes or modifications not expressly approved by the manufacturer can void the user's authority to operate the equipment.

RoHS compliant

General

Terminal Connections

Compression Screw Terminal

Power Wiring

Insulation:	300 V min.
Size:	12–18 AWG

Alarm Wiring

Insulation:	300 V min.
Size:	12–18 AWG

Overvoltage Category

Category II

Insulation Class

I

Pollution Degree

2

Receiver

Satellite Tracking:	GPS L1, C/A Code (1575.42 MHz) 14-channel continuous tracking

Acquisition Times

Hot Start:	135 s
Warm Start:	135 s
Cold Start:	135 s + UTC compensation time
Typical Cold Start:	330 s

Clock Accuracy (to UTC Time)

1 PPS:	±100 ns average, ±500 ns peak
Demodulated IRIG-B:	±100 ns average, ±500 ns peak
Modulated IRIG-B:	±1 µs peak
Serial Port BX Command:	±500 µs peak

Holdover Stability

±0.08 ppm for 20 minutes (from –40° to +80°C)

Antenna Requirements

5 Vdc, <80 mA

35 dB preamp

Electrical Output Drive Levels

Demodulated IRIG-B/PPS, TTL (**OUT1**–**OUT6**):	5 V nominal, 4 V (min.) into 50 ohms
Modulated IRIG-B (**MOD**):	40 mA, 4.75 V_{pp}, 25 ohms
Serial Port, TTL (Pin 4/Pin 6):	2.5 mA, 2.4 Vdc, 1 k ohms

Alarm Contact

Form C Carry:	6 A
Pulse Limit:	1 A
Rated Voltage:	250 Vdc or 190 Vac
MOV Protected:	270 V, 75 J

Power Supply

Rating:	24, 48, 125, 250 Vdc 120 and 230 Vac 50/60 Hz
Range:	18–300 Vdc or 85–264 Vac
Burden:	<15 W, <35 VA

Serial Port

EIA-232 DB-9 Female

Fixed 9600 bps

8 data bits

No parity

1 stop bit

+5 Vdc, 0.5 A, available on Pin 1

15-minute timeout, fixed

Fiber Port

Optical Interface Connector:	ST
Optical Protocol:	SEL-2812 compatible
Port Speed (Data Rate):	9600 bps (fixed)
Fiber-Optic Link Budget:	15 dB
IRIG-B Delay (Including SEL-2812):	15 µs plus 5 µs per kilometer of fiber
Optical Source:	850 nm VCSEL transmitter
Typical transmit level:	–12 dBm
Maximum output level:	–3.0 dBm

IEC 60825-1:1993 + A1:1997 + A2:2001 Class 1 Laser product

21 CFR 1040.10 Class 1 Laser product

Operating Temperature Range

–40° to +80°C (–40° to +176°F)

Note: Not applicable to UL applications

Humidity

0% to 95% without condensation

Altitude

2000 m maximum

Unit Weight

1.1 kg (2.4 lb)

Dimensions

Surface-Mount Version

Height:	80.0 mm (3.15 inches)
Depth:	226.5 mm (8.92 inches)
Width:	279.4 mm (11.00 inches)

Rack-Mount Version (Half Rack)

Height:	43.7 mm (1.72 inches)
Depth:	226.5 mm (8.92 inches)
Width:	260.4 mm (10.25 inches)

Type Tests

Electromagnetic Compatibility General

Measuring Relays and Protection Equipment: IEC 60255-26:2013

Electromagnetic Compatibility Emissions

IEC 60255-26:2013
CISPR 11:2009 + A1:2010
CISPR 22:2008
Canada ICES-001 (A) / NMB-001 (A)
47 CFR Part 15.107 and 109
Severity Level: Class A

Electromagnetic Compatibility Immunity

Note: All tests were conducted using a 10-meter serial cable.

Conducted RF Immunity: IEC 60255-22-6:2001
IEC 61000-4-6:2008
Severity Level: 10 Vrms

Radiated RF Immunity: IEC 60255-22-3:2007
IEC 61000-4-3:2008
Severity Level: 10 V/m
IEEE C37.90.2-2004
Severity Level: 35 V/m

Electrostatic Discharge Immunity: IEC 60255-22-2:2008
IEC 61000-4-2:2008
Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air
IEEE C37.90.3-2001
Severity Level: 2, 4, 8 kV contact; 4, 8, 15 kV air

Fast Transient/Burst Immunity: IEC 60255-22-4:2008
IEC 61000-4-4:2011
Severity Level: ±4 kV, 5 kHz; ±2 kV, 5 kHz on communications ports

Surge Withstand Capability: IEC 60255-22-1:2007
Severity Level:
±2.5 kV peak common mode,
±1.0 kV peak differential mode
IEEE C37.90.1-2002
Severity Level:
±2.5 kV, 1 MHz oscillatory;
±4 kV, 2.5 kHz fast transient

Surge Immunity: IEC 60255-26:2013
IEC 61000-4-5:2005
Severity Level:
±0.5 kV, 1 kV line-to-line;
±0.5 kV, 1 kV, 2 kV line-to-earth;
±0.5 kV, 1 kV, 2 kV on communications ports

Magnetic Field Immunity: IEC 61000-4-8:2009
Severity Level:
1000 A/m for 3 s;
100 A/m for 1 min
IEC 61000-4-9:2001
Severity Level: 1000 A/m

Power Supply Immunity: IEC 60255-11:2008
IEC 61000-4-29:2000

Environmental

Cold: IEC 60068-2-1:2007
Test ad: Cold
Severity Level: 16 hours @ –40°C

Dry Heat: IEC 60068-2-2:2007
Test Bd: Dry heat
Severity Level: 16 hours @ +80°C

Damp Heat, Cyclic: IEC 60068-2-30:2005
Test Bd and guidance: Damp heat, cyclic (12 + 12-hour cycle)
Severity Level: 25° to 55°C, 6 cycles, Relative Humidity: 95%

Vibration: IEC 60255-21-1:1988
Severity Level:
Class 1 (Endurance),
Class 2 (Response)

Shock and Bump: IEC 60255-21-2:1988
Severity Level:
Class 1 (Shock Withstand, Bump);
Class 2 (Shock Response)

Seismic: IEC 60255-21-3:1993
Severity Level:
Class 2 (Quake Response)

Safety

Product Safety: IEC 60255-27:2013 ed. 2.0

Insulation Coordination: IEC 60255-27:2013
IEEE C37.90-2005
Dielectric (HiPot) Severity Level:
Power Supply: 3100 Vdc
Alarm Contact: 2500 Vac
IRIG-B Input: 2100 Vdc
Ethernet Ports: 1500 Vac
Timer Contact (OUT1): 3500 Vdc
Impulse Severity Level:
5 J; ±5 kV, 1.2/50 µs

Protection IP Code: IEC 60529:2001
IP Code: IP3X for category 2 equipment

Firmware and Manual Versions

Determining the Firmware Version in Your Clock

To find the firmware revision number in your clock, use the serial port **STATUS** command to view the status report.

The FID label will appear as follows, with the Part/Revision number in bold:

FID=SEL-2407-R**xxx**-Vx-Z000000-Dxxxxxxxx

The firmware revision number is after the "R," and the release date is after the "D."

For example:

FID=SEL-2407-R104-V0-Z000000-D20050610

is firmware revision number 104, release date June 10, 2005.

Table 14, *Table 15*, and *Table 16* list the firmware versions, a description of modifications, and the product manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table 14 300-Series Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2407-R300-V0-Z003002-D20190725 **NOTE:** R300-series firmware uses new hardware and is not compatible with R200-series or R100-series firmware.	➤ Introduced new GPS receiver hardware on R300 firmware. Not backwards compatible.	20200305

Table 15 200-Series Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2407-R200-V0-Z003002-D20130627 **NOTE:** R200-series firmware uses new hardware and is not compatible with R100-series firmware.	➤ Introduced new clock hardware on R200 firmware. Not backwards compatible with R100-series firmware. ➤ Increased antenna receiver sensitivity. ➤ Updated satellite locking mechanism so that the clock can remain locked with only one satellite in view after initial satellite lock. ➤ Removed battery from product. Time is not sent out until satellite lock so battery is no longer needed.	20130627

Table 16 100 Series Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2407-R116-V1-Z003002-D20190604	➤ Updated firmware to correctly set the date if installed following the recent GPS rollover event experienced on April 6, 2019.	20190604

Table 16 100 Series Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2407-R116-V0-Z003002-D20130828	➤ Corrected leap second time adjustment where time jumped by one minute and one second for a duration of one second, then returned to the correct time. ➤ Corrected leap second time adjustment where SBS had incorrect seconds during the leap second change. ➤ Modified leap second time adjustment so that the Leap Second Pending bit in IRIG-B now triggers one minute before the time change at zero seconds. ➤ Corrected issue where, if a leap second occurred on a Saturday, the clock would increment/decrement the time by one second one week early. ➤ Corrected the status command signal indication when the clock loses lock. ➤ Corrected error that would have occurred on September 15, 2024 where the clock would have rolled back to January 30, 2005 because of an internal week rollover. ➤ Corrected certain custom **DST** command rules that would not increment or decrement the hour properly. ➤ Revised the **TIM** command to require complete date and time as arguments when setting manual time. ➤ Upon initial startup, the clock displays SEL-2407 and no longer displays the time until it is satellite locked. ➤ Revised the **STA** command to show satellite signals in dB-Hz. ➤ Revised custom DST settings to be a command interface and no longer a settings prompt.	20130828
SEL-2407-R115-V0-Z002002-D20130315	➤ Fixed condition where clock can lock exactly one second off. ➤ Removed battery from status command. The battery is no longer used when power is cycled. ➤ Removed **PUL** command. **CON** command can be used in the same manner. ➤ Added **LOC** command for obtaining clock's GPS coordinates. ➤ Battery is no longer used and does not need to be replaced. Time is not sent out until satellite lock so battery is no longer needed.	20130315
SEL-2407-R114-V0-Z002002-D20120309	➤ Fixed issue where the clock could send out the incorrect seconds for as long as five seconds before correcting itself. ➤ Fixed issue where the clock may not obtain satellite lock on cold start. Cycling power would previously fix this problem. ➤ Fixed issue where the clock may not send out time for a few seconds.	20120309
SEL-2407-R113-V0-Z002002-D20110408	➤ Added ability to update GPS chip firmware via SEL firmware upgrade to correct rare failure to reacquire satellite lock condition. ➤ Added definition of SW 3 and SW 4 as PU DELAY when SW 2 is Lock. ➤ Changed **2AC** default password	20110408
SEL-2407-R112-V0-Z002002-D20100504	➤ Corrected very rare condition of the clock getting exactly one second slow for a brief time before automatically correcting itself. ➤ Fixed condition where new leap second would update one day late.	20100504
SEL-2407-R111-V0-Z002002-D20080515 **NOTE:** If you are upgrading from R107 or earlier, you must upgrade both the firmware and FPGA (version R105) for proper operation.	➤ Fixed UTC hour display for GPS clocks located in the positive local time zones.	20080515
SEL-2407-R110-V0-Z002002-D20070411 **NOTE:** If you are upgrading from R107 or earlier, you must upgrade both the firmware and FPGA (version R105) for proper operation.	➤ Made the alarm contact initialize correctly when Control (DIP) Switch 2 is on. ➤ Improved the initialization and transition states of the alarm contact when used in pulse mode.	20070411
SEL-2407-R109-V0-Z002002-D20070209 **NOTE:** If you are upgrading from R107 or earlier, you must upgrade both the firmware and FPGA (version R105) for proper operation.	➤ Made the alarm contact work properly when set to change state from loss of satellite lock. ➤ Fixed upgrading firmware where the status Flash would show a FAIL until the satellite obtained initial satellite lock.	20070209

Table 16 100 Series Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
Firmware Version SEL-2407-R108-V0-Z002002-D20061220 **FPGA Version** SEL-2407-R105-V0-D20061031 **NOTE:** You must update both firmware and FPGA for proper operation.	➤ Added the following ASCII commands: **BX** broadcast, **CON** control alarm contact, **FOR** format the time outputs, **TIM** manually set date and time. ➤ Modified control switch 20 to set OUT6 to UTC and enable the **FOR** commands. ➤ On initial power-up, the IRIG-B outputs are disabled until the satellite locks.	20061220
SEL-2407-R107-V0-Z001001-D20060407	➤ Modified custom **DST** ASCII command; daylight-saving time hour setting range accommodates midnight at the end of the day.	20060407
SEL-2407-R106-V0-Z001001-D20060216	➤ Updated preset USA daylight-saving time for 2007 changes. ➤ Added **DST** command for creating custom daylight-saving time settings. ➤ Added SW19 parity selection for IEEE IRIG-B000 extended control functions (Even or Odd parity). ➤ Added **UTC *n*** command for interface to the SEL-5860 Time Service Software.	20060216
SEL-2407-R105-V0-Z000000-D20050902	➤ Corrected implementation of the parity bit in the IRIG-B IEEE 1344 control function extensions.	20050902
SEL-2407-R104-V0-Z000000-D20050610	➤ Initial version.	20050610

Determining the Manual Version

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table 17 lists the product manual release dates and a description of modifications (only information since November 20, 2009 is shown). The most recent product manual revisions are listed at the top.

Table 17 Manual Revision History (Sheet 1 of 2)

Revision Date	Summary of Revisions
20221027	➤ Updated *Specifications* to include UKCA Mark.
20210630	➤ Updated *Specifications*.
20201008	➤ In *Table 13: Output Drive Capacity*, for the new SEL-400 Series, corrected the termination resistor footnote. ➤ Updated *Table 16: 100 Series Firmware Revision History* to add firmware version R116-V1.
20200305	➤ Added *Antenna Cabling*. ➤ Updated IRIG-B Output Drive Level in *Specifications*. ➤ Update for firmware version R300-V0.
20190604	➤ Updated for firmware version R116-V1.
20180111	➤ Updated *Grounding* under *Installation and Maintenance*. ➤ Added factory default switch position information to *Table 2: Control (DIP) Switch Location*. ➤ Added *Setting Local Time Offset* and added information to *Daylight-Saving Time (DST)*. ➤ Updated *Specifications*.
20160525	➤ Added introductory text to *Installation and Maintenance*. ➤ Added *Unit Mounting*. ➤ Updated *Specifications*.
20160203	➤ Updated *Antenna* and *Lightning Protection*.
20151028	➤ Updated compliance information in *Specifications*.
20150909	➤ Updated *Figure 3: Typical Surge-Protector Installation*.

Table 17 Manual Revision History (Sheet 2 of 2)

Revision Date	Summary of Revisions
20150127	➤ Added *Safety Information*. ➤ Updated description of FTQ command. ➤ Changed *Certifications* to *Compliance* and moved it to the beginning of *Specifications*.
20130627	➤ Updated *Accessories*. ➤ Removed *Remove Battery Tab* in *Installation and Maintenance*. ➤ Updated description of clock locking process. ➤ Removed references to IEEE 13.44. ➤ Updated *DST Command (Access Level 1 and Access Level 2)*. ➤ Updated example screen capture in *STA Command (Access Level 1 and Access Level 2)*. ➤ Updated *TIM Command (Access Level 1 and Access Level 2)*. ➤ Updated *Table 13: Output Drive Capacity*. ➤ Removed *High-Accuracy Timing Applications for SEL-421 and SEL-451 Relays*. ➤ Updated *Specifications*.
20130315	➤ Updated *Table 8: Communications Port Command Summary*. ➤ Added *LOC Command (Access Level 1 and Access Level 2)*. ➤ Removed *PUL Command (Access Level 2)*. ➤ Updated *STA Command (Access Level 1 and Access Level 2)*. ➤ Updated *Table 13: Status Report Elements*. ➤ Removed *Battery Replacement*. ➤ Updated *Specifications*.
20120720	➤ Updated *Specifications*.
20110805	➤ Updated description for **STA** serial command in *Table 8: Communications Port Command Summary*. ➤ Added detail about **STA** command display in *STA Command (Access Level 1 and Access Level 2)*. ➤ Updated *Table 15: Output Drive Capacity* with additional information about SEL-3401 manufacture dates.
20110408	➤ Corrected Bullet Antenna part number in *Table 1: GPS Signal-Acquisition Accessories*. ➤ Updated antenna part number in *Figure 4: Typical Surge-Protector Installation*. ➤ Added GPS firmware upgrade as yellow **ENABLED** LED condition and clarified that satellite lock requires four satellites initially, then three to remain locked in *Table 3: Front-Panel Status Indicator LEDs*. ➤ Changed default **2AC** password and added instruction to change the **CAL** password in *PAS Command*. ➤ Added definition of SW 3 and SW 4 as PU DELAY when SW 2 is Lock in *Table 4: Control (DIP) Switches and Functions* and *Table 13: Status Report Elements*. ➤ Clarified that satellite lock requires four satellites initially, then three to remain locked in *Testing and Troubleshooting*. ➤ Deleted obsolete safety standard references in *Specifications*. ➤ Updated for firmware version R113. ➤ Add GPS firmware upgrade description to *Firmware Upgrade Instructions*.
20091120	➤ Updated *Figure 2*: *Serial Label, Compliance Label, FCC Label, and Patent Label*. ➤ Updated *Table 15: Demodulated BNC Output Drive Capacity.* ➤ Updated *Specifications.*

Firmware and FPGA Upgrade Instructions

Overview

SEL may occasionally offer firmware upgrades to improve the performance of your clock. The clock stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-2407. These instructions give a step-by-step procedure to upgrade the clock firmware by uploading a file from a personal computer to the clock via direct connection to the serial port.

Required Equipment

You will need the following to perform a firmware upgrade.

- Personal computer
- Terminal emulation software that supports the Xmodem/CRC protocol (these instructions use HyperTerminal® from a Microsoft® Windows® operating system)
- Serial communications cable (SEL-C234 or equivalent)
- The firmware upgrade file (Rxxx2407.hex)

Firmware Upgrade Procedure

Step 1. Connect the PC to the serial port of the SEL-2407, and enter Access Level 2.

a. Type **2AC <Enter>**.

b. Enter the Access Level 2 password.

Step 2. Record DST settings.

a. If the clock has custom daylight-saving time settings, issue the **DST** command.

b. Record the beginning and ending daylight-saving time settings.

Step 3. Start the upgrade process.

a. Issue the **L_D** command to the clock.

b. Type **Y <Enter>** at the following prompt:

```
Disable device to receive firmware (Y,N) ?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y, N)?
```

The clock will respond with the following message and send the !> prompt.

```
Device disabled
```

Step 4. Issue the **BAU 115200** command. On your terminal or computer terminal program, change the terminal data rate to 115200 bps.

Step 5. Begin the transfer of the new firmware to the clock by issuing the **REC** command.

Step 6. Type **Y** to erase the existing firmware, or press **<Enter>** to abort.

Step 7. Start the file transfer.

a. Select the send file option in your communications software.

b. Use the Xmodem or 1K Xmodem protocol and send the file that contains the new firmware.

After the file transfer, the clock reboots.

Step 8. If the GPS firmware in the SEL firmware is newer than the firmware in the GPS chip, the clock will upgrade the GPS firmware. While the firmware upgrade is progressing, several progress messages will be sent to the serial port. The display will show `UPDATE`, followed by two digits that show the percentage of progress completed of the GPS firmware upgrade.

On completion of the GPS firmware upgrade, or if there is no GPS firmware upgrade, the **ENABLED** LED will illuminate green, the display will show the time, and the clock will return to Access Level 1. Change the terminal data rate back to 9600 bps to access the clock serial port.

Step 9. Press any key (e.g., **<Enter>**) when prompted as shown in the following example.

```
=>>L_D <Enter>
Disable device to receive firmware (Y,N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
Device disabled

!>REC <Enter>
Caution! This command erases the firmware.
If you erase the firmware then new firmware
must be loaded before returning the IED to service.

Are you sure, you want to erase the existing firmware (Y/N)?
Y <Enter>
Erasing firmware.
Erase successful.

Press any key to begin transfer and then start transfer at the
   terminal.
```

Step 10. Issue the **STA** command, and examine the status report for FAIL messages.

If the status report shows a `FAIL` message, perform the following steps:

a. Type **2AC <Enter>**.

b. Enter the Access Level 2 password.

c. Type **R_S <Enter>**.

d. At this time you must reenter passwords and any custom daylight-saving time settings.

e. Type **2AC <Enter>**.

f. Enter the default Access Level 2 password.

g. Use the **PAS** command to change the default password to your secure password (see *PAS Command (Access Level 2) on page 20*).

h. If necessary, use the **DST** command to set the beginning and ending times for daylight-saving (summer) time (see *DST Command (Access Level 1 and Access Level 2)*).

This completes the firmware upgrade instructions. If you have an FPGA configuration upgrade, continue with the following procedure.

FPGA Configuration Upgrade Procedure

Step 1. Remove the FPGA-Protect jumper.

a. Disconnect clock power.

b. Remove the front panel and the top cover.

c. Remove the jumper from Pins 7 and 8 at J10 on the main board (see *Figure 10*).

The clock issues an error message if this jumper is present and cancels the FPGA upgrade.

Step 2. Place the top cover on the clock and replace the front panel (secure with the lower two captured screws).

Step 3. Reconnect input power.

Step 4. Connect the PC to the serial port of the SEL-2407, and enter Access Level 2.

Step 5. Start upgrading of firmware.

a. Issue the **L_D** command to the clock.

b. Type **Y <Enter>** at the following prompt:

```
Disable device to receive firmware (Y,N) ?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y, N)?
```

The clock will respond with the following message and send the !> prompt.

```
Device disabled
```

Step 6. Issue the **BAU 115200** command. On your terminal or computer terminal program, change the terminal data rate to 115200 bps.

Step 7. Begin the transfer of the new FPGA configuration file (RTL_Rxxx) to the clock by issuing the **CFG** command.

Step 8. Type **Y <Enter>** to erase the existing FPGA configuration or press **<Enter>** to abort.

Step 9. When prompted, press any key (e.g., **<Enter>**) to continue.

Step 10. Start the file transfer.

a. Select the send file option in your communications software.

b. Use the Xmodem protocol and send the file that contains the new firmware.

After the file transfer, the clock will reboot and return to Access Level 1. Change the terminal data rate back to 9600 bps to access the clock serial port.

Step 11. Replace the FPGA-Protect jumper.

a. Disconnect clock power.

b. Remove the front panel and top cover.

c. Replace the jumper on Pins 7 and 8 at J10 on the main board (see *Figure 10*).

Step 12. Place the top cover on the clock and secure with the top-cover screws.

Step 13. Replace the front panel and secure with four captured screws.

Step 14. Restore power and clock connections.

```
=>>L_D <Enter>
Disable device to receive firmware (Y,N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
Device disabled

!>CFG <Enter>
Caution! This command overwrites the FPGA configuration and
   SELboot.

Are you sure, you want to overwrite
the existing FGPA configuration and SELboot (Y/N)? Y <Enter>

Press any key to begin transfer and then start transfer at the
   terminal.
```

The SEL-2407 is now ready for commissioning.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Notes

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