SEL-3031

Serial Radio Transceiver

Instruction Manual

20211103

SEL SCHWEITZER ENGINEERING LABORATORIES

PM3031-01

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This product is covered by the standard SEL 10-year warranty. For warranty details, visit selinc.com or contact your customer service representative.

PM3031-01

Table of Contents

Appendix A: Firmware and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL-3044 Encryption Card

List of Tables

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List of Figures

Preface

Manual Overview

The SEL-3031 Serial Radio Transceiver manual includes the information needed to properly install and operate the product.

The scope of this manual includes specifications, installation, mechanical information, self-monitoring, and alarming.

An overview of each manual section and topics follows.

Preface. Describes the manual organization and conventions used to present information.

Section 1: Introduction and Overview. Describes the basic features and functions of the SEL-3031, and lists the specifications.

Section 2: Installation. Describes how to mount and wire the SEL-3031; illustrates wiring connections for various applications.

Section 3: Job Done Examples. Describes common SEL-3031 applications.

Appendix A: Firmware and Manual Versions. Details differences between firmware versions. Provides a record of changes made to the manual.

Appendix B: Firmware Upgrade Instructions. Provides instructions for upgrading the firmware in the SEL-3031.

Appendix C: SEL-3044 Encryption Card. Describes how the encryption card operates to secure wireless data. Provides installation information.

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.

General Safety Marks

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Terminal Ratings Wire Materials Use copper conductors only. Wire Size 12–26 AWG Tightening Torque Terminal Blocks: 0.8 Nm (7 in-lb)	Spécifications des bornes Type de filage Utiliser seulement conducteurs en cuivre. Calibre de fil 12–26 AWG Couple de serrage Borniers : 0,8 Nm (7 livres-pouce)

Other Safety Marks (Sheet 1 of 2)

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	**⚠DANGER** Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠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.
⚠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 Atmospheric electrical charge accumulation can cause potential between the conductor and shield of the feedline, or cause lightning to strike an antenna. A lightning protector should be installed to prevent damage to equipment or injury to personnel.	**⚠AVERTISSEMENT** L'accumulation de charges électriques de type atmosphérique peut être la cause d'une différence de potentiel entre le conducteur et le blindage de la ligne d'alimentation ou peut attirer la foudre sur l'antenne. Un parafoudre devrait être installé pour prévenir les dommages à l'équipement ou les blessures au personnel.

Other Safety Marks (Sheet 2 of 2)

⚠WARNING Do not look into the fiber (laser) ports/connectors.	**⚠AVERTISSEMENT** Ne pas regarder vers l'extremité des ports ou connecteurs de fibres pour laser.
⚠WARNING Do not look into the end of an optical cable connected to an optical output.	**⚠AVERTISSEMENT** Ne pas regarder vers l'extrémité d'un câble optique raccordé à une sortie optique.
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	**⚠AVERTISSEMENT** Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.
⚠CAUTION Although the power level is low, concentrated energy from a directional antenna may pose a health hazard. Do not allow users to come closer than 34 cm (14 in) to the antenna when the transmitter is operating in indoor or outdoor environments in the 900-MHz band.	**⚠ATTENTION** Bien que le niveau de puissance soit bas, l'énergie concentrée d'une antenne directionnelle peut être un danger pour la santé. Ne pas autoriser les usagers à s'approcher à moins de 34 cm (14 po) de l'antenne quand l'émetteur est en opération dans un environnement intérieur ou extérieur dans la bande des 900-MHz.
⚠CAUTION The radio contains devices 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** La radio contient des circuits 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.

Section 1
Introduction and Overview

Overview

The SEL-3031 is a 900-MHz, license-free, spread-spectrum radio. The radio operates in the ITU Region 2 ISM band of 902–928 MHz through the use of a fast frequency-hopping algorithm for noise immunity and long-distance operation.

The SEL-3031 prevents the need for multiple sets of radios or expensive dedicated fiber transmitting over long distances. *Figure 1.1* shows the flexibility of the SEL-3031 in providing DNP3 SCADA information, MIRRORED BITS® control for reclosing coordination, and engineering access to the SEL-651R Recloser Control.

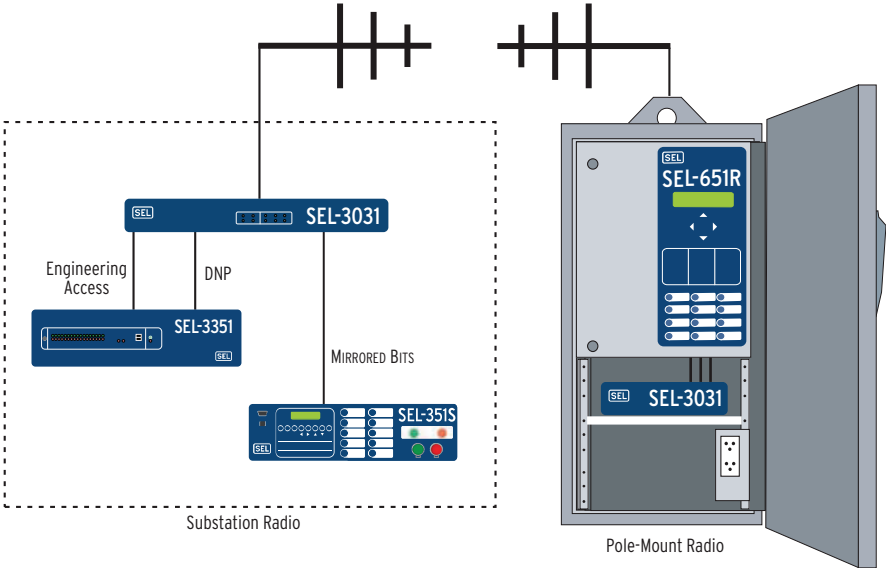


Figure 1.1 Point-to-Point Product Overview

Figure 1.2 shows the flexibility obtained when using the SEL-3031 in point-to-multipoint (P2MP) applications providing DNP3 or Modbus SCADA information from many remotes to one master.

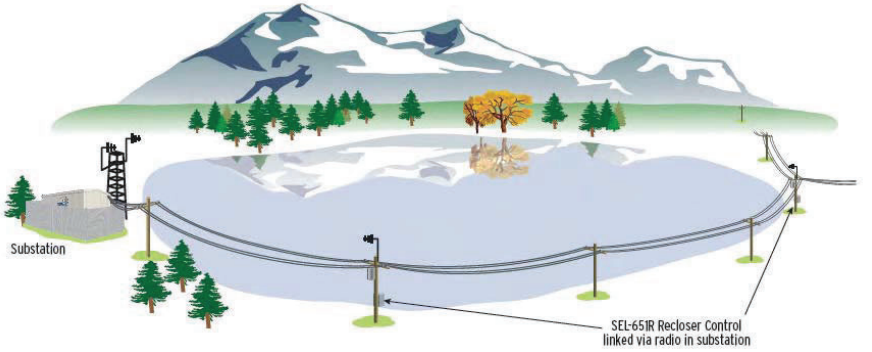


Figure 1.2 Point-to-Multipoint Product Overview

Features, Benefits, and Applications

- **Dual Radio Operating Modes Provide Flexibility.** Supports point-to-point (P2P) radio operation for fast teleprotection, distribution automation, distributed generation, and economical backup protection. Apply point-to-multipoint (P2MP) radio operation for SCADA and other data-gathering from remote locations.
- **Three Ports in One Radio Reduce Costs.** Simultaneously communicates with as many as three independent ports and protocols via point-to-point radio operation.
- **Low Latency Enables Fast Control.** Transfers control commands with a typical 4.8 ms latency with SEL MIRRORED BITS® communications.
- **Strong Security Thwarts Attackers.** Protects critical data and repels malicious attacks with optional encryption card, using session authentication and strong 256-bit Advanced Encryption Standard (AES) technology.
- **Tough Radio Operates in Extreme Conditions.** Is designed, built, and tested for trouble-free operation in extreme temperature, electromagnetic interference, shock, and vibration conditions.
- **No Licensing Reduces Delays and Expenses.** Uses the license-free, 900-MHz ISM band for on-time, on-budget projects.
- **Mounting Options Simplify Installation.** Order your SEL-3031 in either a rack-mount or wall-mount form factor.

- **Multiple Protocols Satisfy Interconnection Requirements.** Communicate with industry-standardized byte-oriented protocols, such as DNP3, Modbus®, SEL MIRRORED BITS communications, IEEE C37.118 Synchrophasors, SEL Fast Messaging, and SEL ASCII.
- **Flexible Serial Port Options Match Integration Needs.** Order serial Port 1 as EIA-232, EIA-485, or optical fiber to easily connect to your existing devices.
- **Simple Settings Streamline Radio Commissioning.** Use ACSELERATOR QuickSet® SEL-5030 Software for all settings.
- **USB Management Port Conveniently Connects to PC.** Make settings changes, verify status information for proper installation, and verify radio performance without affecting the three serial channels.

Models, Options, and Accessories

Standard Features

- P2P and P2MP operation modes
- Three EIA-232 serial ports
- IRIG-B time code input
- Radio synchronization with collocated radios
- Power supply
  - Wall mount: 9–30 Vdc
  - Rack mount: 24–48 Vdc, 110–240 Vac, or 125–250 Vdc
- ACSELERATOR QuickSet software
- Protocol pass-through support
  - DNP3
  - Modbus
  - SEL MIRRORED BITS
  - SEL Fast Messaging
  - SEL ASCII
  - IEEE C37.118 Synchrophasors

Optional Features

- One port EIA-485
- One port fiber-optic (SEL-2812 and SEL-9220 compatible)
- SEL-3044 Encryption Card
- Special frequencies for Brazil

Accessories

Table 1.1 Radio Antenna and Cable Accessories

Description	Part Number
Feedline	
RG-8X TNC Male to N Male Cable	SEL-C964
RG-8X TNC Male to TNC Male Cable	SEL-C965
LMR®-400 TNC Male to N Male Cable	SEL-C966
LMR-400 TNC Male to TNC Male Cable	SEL-C961
LMR-400 N Male to N Male Cable	SEL-C968
7/8" HELIAX® N Male to N Male Cable	SEL-C978
N Female to TNC Male Adapter	240-1809
Antenna	
Low-Profile 3 dBi Gain Omnidirectional, N Female Connector	235-0003
Vertical 7.15 dBi Gain Omnidirectional, N Female Connector	235-0232
Vertical 9.15 dBi Gain Omnidirectional, N Female Connector	235-0233
3-Element 8.15 dBi Gain Yagi, N Female Connector[a]	235-0009
5-Element 11.1 dBi Gain Yagi, N Female Connector[a]	235-0220
11-Element 14.15 dBi Gain Yagi, N Female Connector[a]	235-0222
Indoor 8" Vertical, TNC Male Connector	235-0108
Antenna Mounting	
Vertical Omnidirectional Mount for 14" Maximum Diameter Poles	240-0103
Yagi Mount for 14" Maximum Diameter Poles	240-0104
Mast Mount for Large Omnidirectional Antennas (2.5" Maximum Diameter Antenna to 2.5" Maximum Diameter Mast)	240-0106
Mounting Bracket for Low-Profile Omnidirectional Radio Antennas (235-0003)	915900494
Surge Protection	
Radio Surge Protector With N Male Connectors	200-2004

[a] Comes equipped with pipe-mounting hardware.

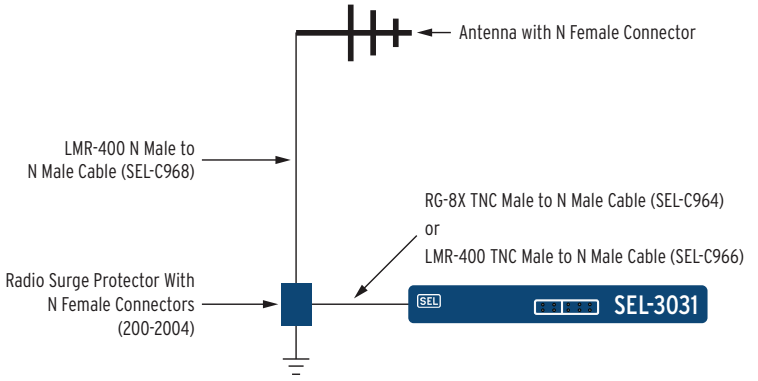


Figure 1.3 Radio Antenna Connections

Product Diagrams

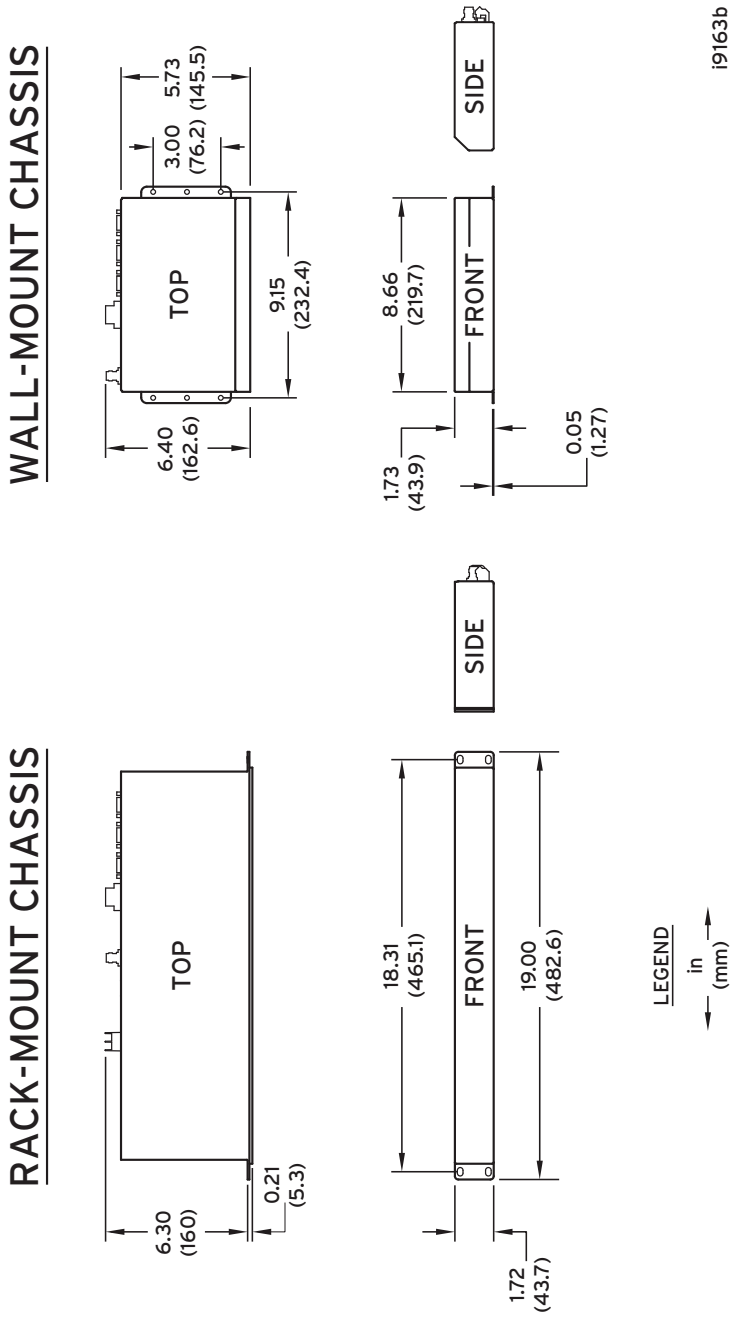


Figure 1.4 SEL-3031 Dimensions

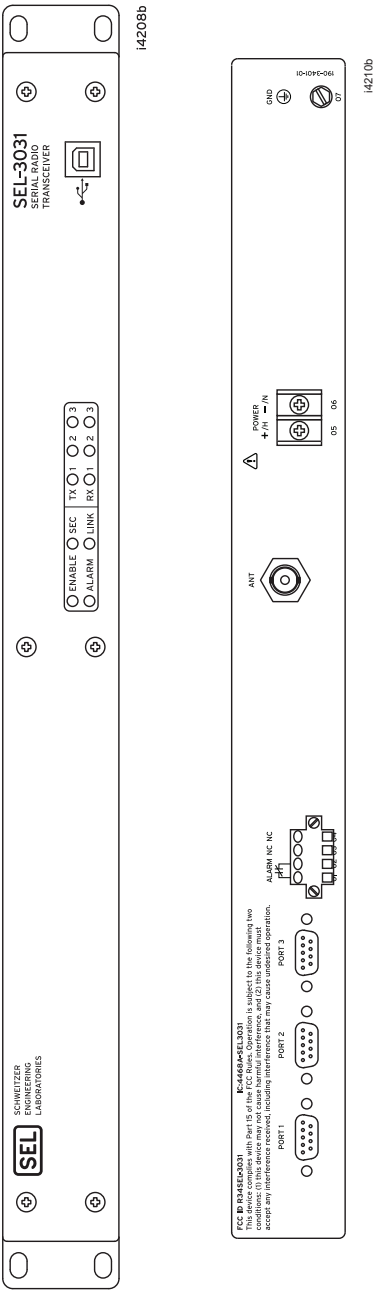


Figure 1.5 SEL-3031 Rack Mount (Front and Rear)

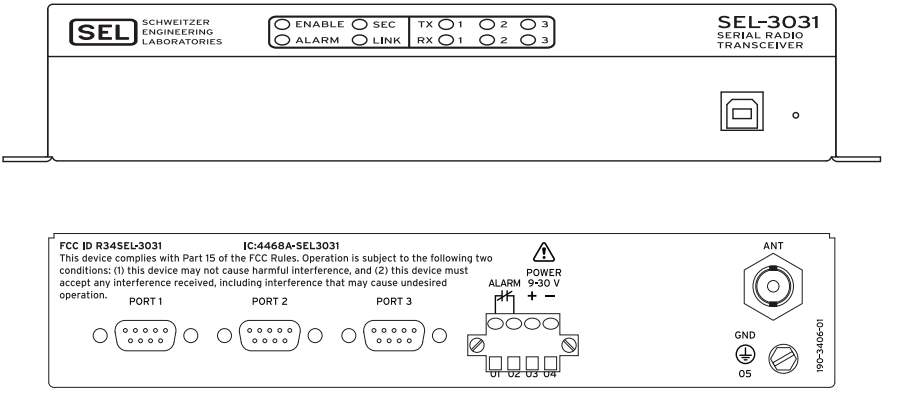


Figure 1.6 SEL-3031 Wall Mount (Front and Rear)

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, NRAQ7)
SEP (SEL-3044 encryption card): FIPS 140-2 Level 2 historical
Also see *Table 1.2*.

General

Temperature Range

–40° to +85°C per IEC 60068-2-1 and 60068-2-2

Operating Environment

Pollution Degree:	2
Relative Humidity:	5–95%, noncondensing
Maximum Altitude:	2000 m

Dimensions

Wall Mount:	43.9 mm x 219.7 mm x 162.6 mm (1.73 in x 8.66 in x 6.40 in)
Rack Mount:	43.7 mm x 482.6 mm x 160.0 mm (1.72 in x 19.00 in x 6.3 in)

Time-Code Input

Port 2, Pins 4 and 6

Format:	Demodulated IRIG-B
Input Impedance:	333 Ω
Accuracy:	±5 milliseconds

Alarm Contact

Form B Contact

(open when energized and passes diagnostics)

Operating Voltage*:	250 Vdc or 190 Vac
Dielectric Test Voltage*:	500 Vrms
Continuous Carry*:	6 A
Pilot Duty Ratings**:	B300, R300
Resistive Ratings**:	250 Vac, 24 Vdc, 6 A

*Parameters verified by SEL per IEC 60255-1:2009 and IEEE C37.90-2005.
**Per UL 508.

Communications

Communications Ports

Serial Port 1

Data Speed Without Encryption Card:	38400 bps (disables Port 2), 19200 bps, or 9600 bps
Data Speed With Encryption Card:	19200 bps (disables Port 2) or 9600 bps

EIA-232, EIA-485 (ordering option)

Connector:	9-Pin D-Subminiature

Fiber-Optic Ordering Option

Connectors:	2 ST (Tx and Rx)
Encoding SEL-2812/SEL-9220 Compatible	
Wavelength:	850 nm multimode
Typical Tx Power:	–13 dBm
Min. Rx Sensitivity:	–29 dBm
Optical Budget:	16 dB

Compatible Fiber-Optic Core Diameter: 50, 62.5, or 200 µm

Serial Port 2, 3 Standard EIA-232

Data Speed Without Encryption Card: 19200 bps or 9600 bps

Data Speed With Encryption Card: 9600 bps

Connector: 9-Pin D-Subminiature

Protocols

Modbus, DNP3, SEL MIRRORED BITS Communications (MB8), ACSELERATOR QuickSet SEL-5030 Software Support, SEL ASCII and Compressed ASCII, SEL Fast Messaging, IEEE C37.118 Synchrophasors

Typical Latency

SEL-3031

MIRRORED BITS: 8.9 ms at 9600 bps
5.6 ms at 19200 bps
4.8 ms at 38400 bps

Standard: 4.9 ms at 9600 bps
4.3 ms at 19200 bps
3.8 ms at 38400 bps

SEL-3031 With SEL-3044 Encryption Card

MIRRORED BITS: 9.7 ms at 9600 bps
7.4 ms at 19200 bps

Standard: 5.7 ms at 9600 bps
5.3 ms at 19200 bps

Radio

Transmitter

Frequency Band: 902–928 MHz ISM band

Modulation: GFSK

Operating Mode: Point-to-Point

RF Connector: TNC

Power Output: 1 W (30 dBm) to 100 mW (20 dBm) in steps of 1 dBm

Channel Bandwidth: 250 kHz

Receiver

Sensitivity: –97 dBm, –104 dBm with ARQ on

Bit Error Rate (BER): $<10^{-6}$ at –97 dBm

Distance: 32 km (20 mi), line of sight

Error Detection: 32-bit CRC

Power Supply

Rated Supply Voltage

Wall-Mount Model: 9–30 Vdc

Low-Voltage Model: 24–48 Vdc

High-Voltage Model: 125–250 Vdc
110–240 Vac, 50/60 Hz

Input Voltage Range

Wall-Mount Model: 9–30 Vdc

Low-Voltage Model: 18–60 Vdc

High-Voltage Model: 85–275 Vdc; 85–264 Vac

Power Consumption

Wall Mount: <5 W

Rack Mount: <8 W/30 VA

Power Consumption With SEL-3044 Card

Wall Mount: <6 W

Rack Mount: <9 W/31 VA

Type Tests

Communications Equipment Tests

IEEE 1613-2003

Environmental Tests

Enclosure Protection: IEC 60529:2001

Vibration Resistance: IEC 60255-21-1:1988
Class 1 Endurance
Class 2 Response
IEC 60255-21-3:1993
Class 2

Shock Resistance:	IEC 60255-21-2:1988 Class 1 shock withstand, bump Class 2 shock response
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 +85°C, 16 hours

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-5:2000 IEEE C37.90–2005
Impulse:	IEC 60255-5:2000 0.5 J, 5 kV

RFI and Interference Tests

EMC Immunity

Standard:	IEEE 1613, Class 2
Electrostatic Discharge:	IEC 61000-4-2:2008 8 kV contact discharge 15 kV air discharge IEEE C37.90.3–2001 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2008 10 V/m IEEE C37.90.2–2004 35 V/m
Fast Transient, Burst Immunity:	IEC 61000-4-4:2004 4 kV @ 2.5 kHz, and 5.0 kHz for communications ports, power supply, alarm contacts
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 2.5 kV common-mode 1 kV differential-mode IEEE C37.90.1–2002 2.5 kV oscillatory, 4 kV fast transient for communications ports, power supply, alarm contacts
Conducted RF Immunity:	IEC 61000-4-6:2008 10 Vrms
Digital Radio Telephone RF Immunity:	ENV 50204-1995 Severity Level: 10 V/m at 900 MHz and 1.89 GHz

EMC Emissions

Radiated Emissions

FCC Part 15.247; ICES-001; RSS-247

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

FCC Part 15, 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 is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Section 15.21

Users manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Canada ICES-001(A) / NMB-001(A)

Table 1.2 Certifications by Country

Country	Authority	Reference	Part Number Starts With
USA	FCC	ID: R34SEL-3031W	3031
Canada	ISED	ID: 4468A-SEL3031W	3031

Section 2
Installation

Overview

RF Exposure Notice

The SEL-3031 transmitter module is approved for use only with specific antenna, cable, and output power configurations that have been tested and approved for use. Modifications to the SEL-3031, the antenna system, or to the power output that have not been explicitly specified by the manufacturer are not permitted and may render the radio non-compliant with applicable regulatory authorities. The radio equipment described in this manual emits radio frequency energy. Professional installation is required. The antenna(s) for this transmitter must not be collocated or operated in conjunction with any other antenna or transmitter.

⚠CAUTION

Although the power level is low, concentrated energy from a directional antenna may pose a health hazard. Do not allow users to come closer than 34 cm (14 in) to the antenna when the transmitter is operating in indoor or outdoor environments in the 900-MHz band.

FCC Part 15 Notice

NOTE: Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This equipment has been tested and found to comply with the limits for Class A digital devices, pursuant to FCC Part 15 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 radiates 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 environment is likely to cause harmful interference, in which case the user will be required to correct the interference at his/her own expense.

ISED Canada Notice

English

This device complies with Innovation, Science and Economic Development Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference that may cause undesired operation of the device.

Under Innovation, Science and Economic Development Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Innovation, Science and Economic Development Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that necessary for successful communication.

The radio transmitter described herein (ISED ID: 4468A-SEL3031W) has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

French

Ce dispositif conforme aux normes Innovation, Sciences et Dévelopment économic Canada pour les appareils exempts de licence. Son utilisation est soumise à deux conditions: (1) ce dispositif ne peut causer des interférences, (2) cet appareil doit accepter toute interférence pouvant causer un mauvais fonctionnement du dispositif.

En vertu des règlements d'Innovation, Sciences et Dévelopment économic Canada, cet émetteur radio ne peut fonctionner avec une antenne d'un type et un maximum (ou moins) approuvés pour gagner de l'émetteur par Innovation, Sciences et Dévelopment économic Canada. Pour réduire le risqué d'interférence aux autres utilisateurs, le type d'antenne et son gain doivent être choisies de façon que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas ce qui est nécessaire pour une communication réussie.

L'émetteur radio décrit ci-après (ISDE ID: 4468A-SEL3031W) a été approuvé par Innovation, Sciences et Dévelopment économic Canada pour fonctionner avec les types d'antennes énumérées ci-dessous avec le gain maximal admissible et nécessaire antenne d'impédance pour chaque type d'antenne indiqué. Types d'antennes ne figurent pas dans cette liste, ayant un gain supérieur au gain maximum indiqué pour ce type, sont strictement interdites pour une utilisation avec cet appareil.

Antennas

Low-Profile 3 dBi Gain Omnidirectional, N Female Connector	235-0003
Vertical 7.15 dBi Gain Omnidirectional, N Female Connector	235-0232
Vertical 9.15 dBi Gain Omnidirectional, N Female Connector	235-0233
3-Element 8.15 dBi Gain Yagi, N Female Connector[a]	235-0009
5-Element 11.1 dBi Gain Yagi, N Female Connector[a]	235-0220
11-Element 14.15 dBi Gain Yagi, N Female Connector[a]	235-0222
Indoor 8" Vertical, TNC Male Connector	235-0108

Connections

Rear-Panel Connections

The physical layout of the SEL-3031 connections is shown in *Figure 2.5*.

Figure 2.5 Wall-Mount and Rack-Mount Rear Connections

Power Connections

The **POWER** terminals on the rear panel (labeled **+/H** and **-/N**) must connect to the correct supply voltage. The supply voltage range is located on the serial label. The wall-mount configuration accepts only 9–30 Vdc. The rack-mount configuration accepts 24–48 Vdc, 110–240 Vac, or 125–250 Vdc.

Do not apply power to the SEL-3031 without having a proper 50 Ω load on the antenna port. If you do not have the proper 50 Ω load connected, the radio antenna port will shut off, the alarm contact will pulse, and the **ALARM** LED will illuminate. This functionality protects the radio circuitry and indicates an antenna or cable failure. The **POWER** terminals on the rack-mount version are isolated from chassis ground. The **POWER** terminals on the wall-mount version are not isolated from chassis ground. Use 2.5 mm^2 (14 AWG) size wire to connect to the **POWER** terminals on the rack mount. Place an external circuit breaker or switch no more than 3 m (10 ft) from the equipment. The circuit breaker (or equivalent approved disconnect device appropriate for the country of installation) must comply with IEC 60947-1 and IEC 60947-3, be identified as the disconnect device for the equipment, and be located near the equipment. This disconnect device must interrupt both the hot (**+/H**) and the neutral (**-/N**) power leads. The maximum current rating for the power disconnect circuit breaker or overcurrent device (fuse) must be 20 A. An internal power supply fuse protects the operational power supply. Be sure to use fuses that comply with IEC 60127-2.

Lightning Protection

⚠WARNING

Atmospheric electrical charge accumulation can cause potential between the conductor and shield of the feedline, or cause lightning to strike an antenna. A lightning protector should be installed to prevent damage to equipment or injury to personnel.

Mounting the antenna on an equipment building roof or tower is safest because the potential rise on the outside of either of these structures will approximately equal the potential on the inside. A lightning protector (Radio Surge Protector, SEL part number 200-2004) 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 radio. The higher the 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. Ground the radio to the same point as the surge-protector ground to avoid ground-rise-potential damage.

When using the surge protector, order an additional SEL-C964 or SEL-C966 cable and place this cable between the SEL-3031 and the surge protector. Because the distance varies from the SEL-3031 to the surge protector, be sure to specify this cable at approximately the correct length (plus 10 to 20 percent for installation variability).

Grounding (Earthing) Connections

You must connect the ground terminal labeled **GND** to a rack frame or switchgear ground for proper safety and performance. Use 2.5 mm^2 (14 AWG) wire less than 2 m (6.6 ft) in length for the ground connection.

Serial Ports

Because all ports (1, 2, and 3) are independent, you can communicate to any combination simultaneously. All EIA-232 ports accept DB-9 male connectors. The serial port EIA-485 option for Port 1 is also a DB-9 male connector. If Port 1 is ordered with the EIA-485 option the product will ship with a DB-9-to-terminal adapter to easily wire to EIA-485 systems. Port 2 includes the IRIG-B time-code signal input (see *Table 2.8*). SEL offers fiber-optic transceivers or fiber-optic port options on Port 1 (SEL-2812 and SEL-9220 compatible fiber-optic) for connecting devices at distances over 15 meters (50 feet) where copper cable is not appropriate. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and longer distances, overcoming the limitations of electrical EIA-232 interfaces. Contact SEL for further information on these products.

IRIG-B Time-Code Input

The SEL-3031 accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external time source. IRIG-B is available on Port 2 utilizing Pins 4 and 6 for time communications. The SEL-3031 supports the IRIG-B002 standardized time format.

Table 2.8 Communications Cables for Time and Communications Connections

EIA-232 Serial Port	Connect to Device	SEL Cable No.
Port 2	IRIG-B BNC with time only	C256
	SEL communications processors and computing platform data with IRIG-B[a]	C387
	IRIG-B only from DB-9 on SEL-2407®	C388

[a] If connecting to an SEL communications processor you must turn the 5V_EN Global setting in the SEL-3031 to OFF.

Front-Panel Indicators

The SEL-3031 has ten front-panel LED indicators. *Table 2.9* further describes these indicators that display the current status of the radio. The **LINK** LED indicates when the SEL-3031 has properly connected to another SEL-3031. The **SEC** LED deals with the SEL-3044 Encryption Card. See *Appendix B: Firmware Upgrade Instructions* for more information on using this card.

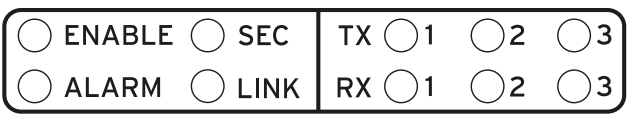


Table 2.9 Front-Panel Status Indicator LEDs

Label	Color	Description
ENABLE	Green	All self-tests are passing and unit is operational
ALARM	Red	ON: Self-test failure detected Flashing: Antenna failure
SEC	Green	ON: Encryption card detected and wireless data secured Flashing: Encryption card detected and in RESET OFF: No encryption card present or card failed
LINK	Green	Communications link established between master and remote radio
TX 1, 2, 3	Green	Serial data received by the port and transmitted out of the radio
RX 1, 2, 3	Red	Radio data received and transmitting out of serial port

Communications

Serial Ports

Table 2.10 shows the physical interfaces of the SEL-3031. Several options are provided for Port 1 physical interfaces, including EIA-232, EIA-485, and fiber.

Table 2.10 SEL-3031 Port Description

Port	Communications Interface	Location
Port 1	EIA-232, EIA-485, or fiber	Rear (Port 1 has three ordering options)
Port 2	EIA-232	Rear
Port 3	EIA-232	Rear
USB	USB 1.1	Front (management port)

Serial (EIA-232 and EIA-485)

Use the EIA-232 port for communications distances of ≤ 15.2 m (50 ft) in low-noise environments. Use the optional EIA-485 Port 1 for communications of ≤ 1200 m (3937 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

If Port 1 is an EIA-485 connection, there are two types of connections that will work on multidrop systems. *Table 2.11* shows the standard pinout of a recommended four-wire EIA-485 connection. If your system only works on a two-wire EIA-485 connection, you will need to connect Pins 1 and 7 together and Pins 2 and 8 together. *Figure 2.6* shows how to wire this configuration.

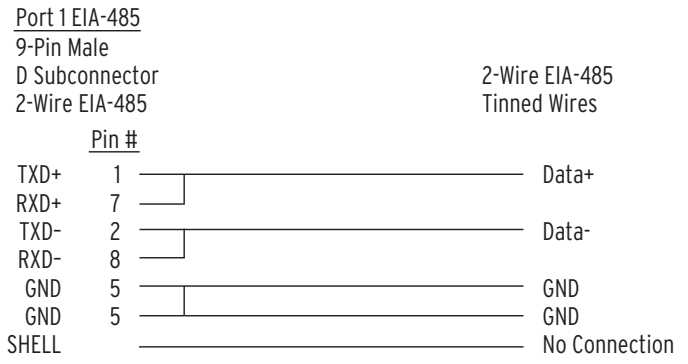


Figure 2.6 SEL-C693 Cable: Two-Wire EIA-485 Connections

Fiber-Optic Serial Port

Order the fiber-optic option for Port 1 for safety and long-distance communications as far as 4 km (2.5 mi). The fiber-optic port is an SEL-2812-compatible device that can connect directly to any SEL-2812-compatible device or SEL-2812 Fiber-Optic Transceiver, using multimode fiber-optic cable with a core diameter of 50 to 200 µm. When working with this device, observe the following safety precautions:

⚠WARNING

- 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.

Port Connector and Communications Cables

Figure 2.7 shows the EIA-232 and EIA-485 DB-9 connector pin numbering for the SEL-3031.

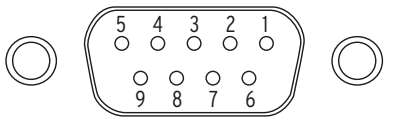


Figure 2.7 EIA-232 and EIA-485 DB-9 Connector Pin Numbers

Table 2.11 shows the pin function of the serial ports.

Table 2.11 SEL-3031 Port Description

Pin	Port 1 EIA-232	Port 2 EIA-232	Port 3 EIA-232	Port 1 EIA-485
1	+5 Vdc	+5 Vdc	+5 Vdc	TX+
2	RXD	RXD	RXD	TX-
3	TXD	TXD	TXD	N/C
4	N/C	IRIG+	N/C	N/C
5	GND	GND	GND	GND
6	N/C	IRIG–	N/C	N/C
7	RTS	RTS	SYNC IN	RX+
8	CTS	CTS	SYNC OUT	RX–
9	N/C	N/C	N/C	N/C

Cleaning

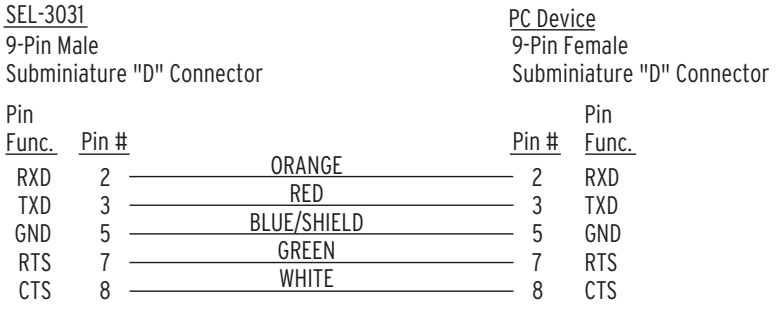
Use care when cleaning the SEL-3031. Perform the following steps:

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.

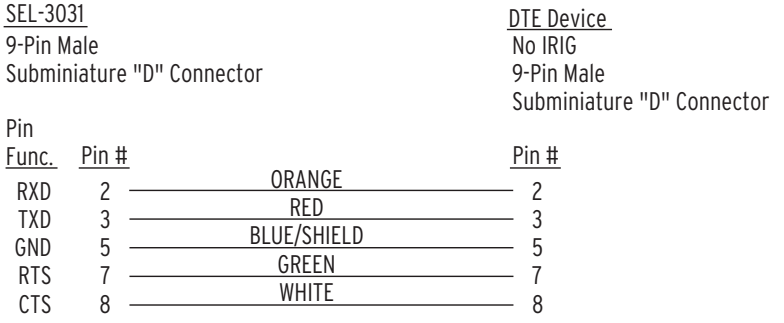
Do not use abrasive materials, polishing compounds, or harsh chemical solvents (such as xylene or acetone) on any surface.

Cables



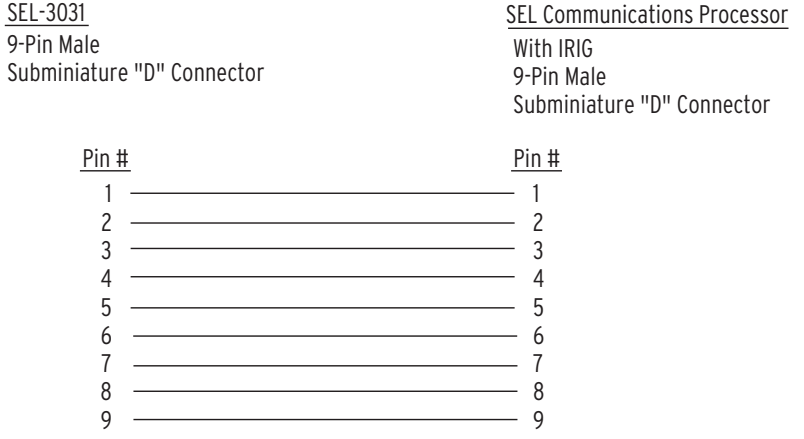
NOTE: For best results, limit the cable length to 15 m (~50 ft)

Figure 2.8 SEL-C245A Cable: SEL-3031 to Computer



NOTE: For best results, limit the cable length to 15 m (~50 ft)

Figure 2.9 SEL-C285 Cable: SEL-3031 to DTE Device (SEL Relays)



NOTE: For best results, limit the cable length to 15 m (~50 ft)

⚠CAUTION
You must turn off the +5 V on Pin 1 of the SEL-3031 when connecting to a communications processor.

Figure 2.10 SEL-C387 Cable: SEL-3031 to SEL Communications Processor With IRIG-B

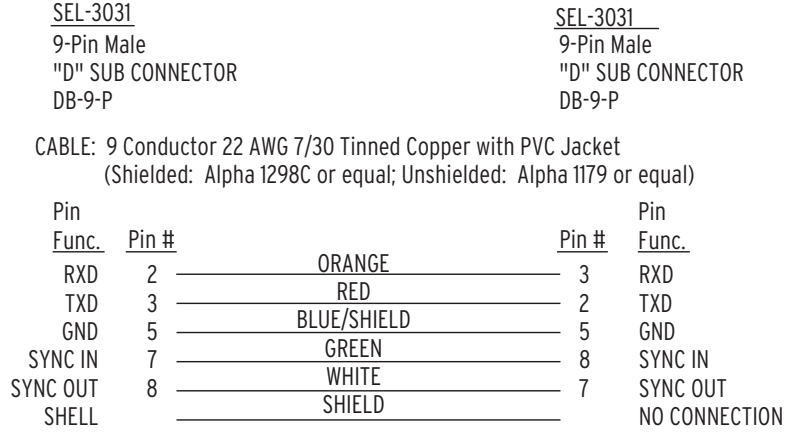
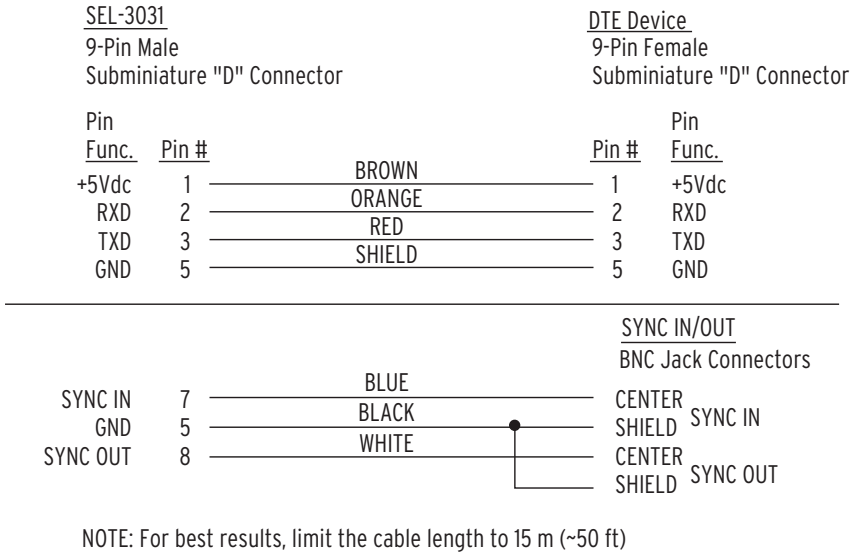


Figure 2.11 SEL-C273A Cable: SEL-3031 Repeater and Synchronizing Cable



NOTE: For best results, limit the cable length to 15 m (~50 ft)

Figure 2.12 SEL-C576 Cable: Synchronizing Cable for SEL-3031

USB Interface

The SEL-3031 uses a standard USB Type-B interface for the management port. The USB interface is used for settings management, initial radio installation, and reporting data from long-term radio statistics. The management port may be used while the SEL-3031 is in service without disrupting the radio communications. To use this interface, plug a USB Type-B cable into the radio and plug the other end into your PC. This will automatically prompt your PC to install a USB-to-serial driver that creates a virtual serial port. The virtual serial port needs to be set to 9600 bps, 8 data bits, 1 stop bit, and no parity to properly communicate with the SEL-3031. This virtual serial port can now be used with ACSELERATOR QuickSet® SEL-5030 Software to help set and view settings and obtain report information.

Figure 2.13 USB Interface

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Section 3
Job Done Examples

Overview

This section has four job done examples of how to easily set up the SEL-3031 for common applications. This section assumes you have established a radio link. If you are having problems setting up the radio link, refer to *Section 2: Installation* and *Section 5: Performance Monitoring, Testing, and Troubleshooting* for more information.

This section contains four Job Done examples for the following applications.

- *High-Speed Teleprotection or Control With MIRRORED BITS Communications*
- *Using an SEL Information Processor to Collect Relay Status and Measurements*
- *Setting Up a Point-to-Multipoint Link Using DNP3 SCADA Protocol*
- *Configuring Collocated Antennas Using SEL Hop-Sync Technology*

High-Speed Teleprotection or Control With MIRRORED BITS Communications

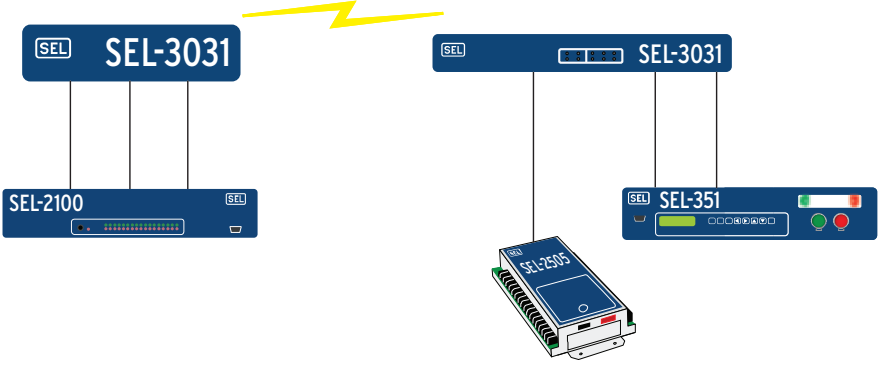

Figure 3.1 SEL MIRRORED BITS Connection Example

The SEL-3031 can handle as many as three MIRRORED BITS® connections simultaneously over one radio link. For this example, there are three MIRRORED BITS channels over the SEL-3031. This example shows you how to set the radio and set different end devices to properly use the radio as a MIRRORED BITS link.

SEL-3031 MIRRORED BITS Settings

For *Figure 3.2*, we set Port 1 on both SEL-3031 devices as a MIRRORED BITS connections.

On each radio, set the following settings on the Port 1 settings.

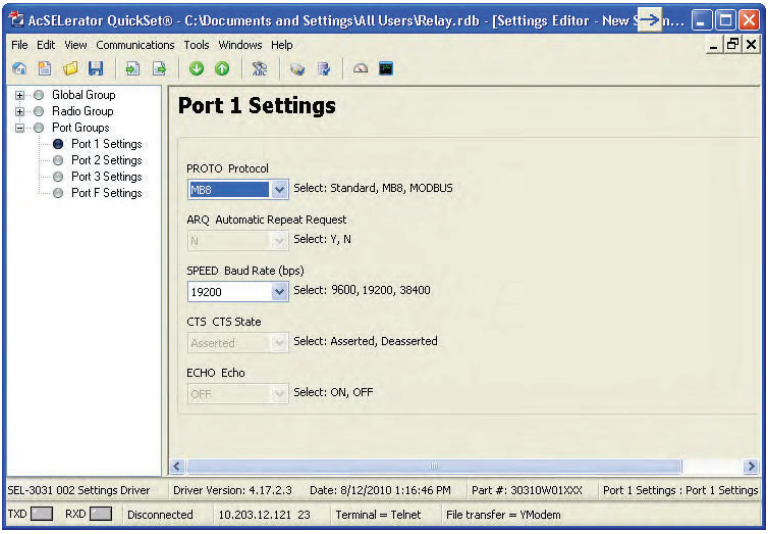

Figure 3.2 SEL-3031 Port Settings for MIRRORED BITS Connection

The SEL-3031 makes it very simple to set a MIRRORED BITS connection. Set the PROTO setting to MB8 to make it a MIRRORED BITS port. The SEL-3031 without an encryption card has data rate of 9600, 19200, or 38400 bps (8, N, 1). Setting the speed to 38400 provides the lowest latency at the cost of disabling Port 2. Port 3 can still be used for data at 9600 or 19200 bps speeds.

On Port 1 on each radio, install an SEL-C285 cable to the IED. As an alternative, the SEL-3031 can be ordered with a fiber-optic serial port that works with SEL-2812 transceivers. If you use the fiber-optic port on the SEL-3031, the IED connection needs to be an SEL-2812MR Fiber-Optic Transceiver.

SEL-351, SEL-311, and SEL-700 Series MIRRORED BITS Settings

The required settings for the SEL-351 are shown below. These settings are similar to all of the SEL-351, SEL-311, and SEL-700 series of relays. To establish a communications link via the radio, the most critical settings are PROTO, SPEED, RTSCTS, RXID, and TXID.

```
=>SHO P 2 <Enter>
Port 2

PROTO = MB8A
SPEED = 19200    RTSCTS= N      RBADPU= 60       CBADPU= 1000
RXID  = 1        TXID  = 2      RXDFLT=XXXXXXXX
RMB1PU= 1        RMB1DO= 1      RMB2PU- 1        RMB2DO= 1
RMB3PU= 1        RMB3DO= 1      RMB4PU- 1        RMB4DO= 1
RMB5PU= 1        RMB5DO= 1      RMB6PU- 1        RMB6DO= 1
RMB7PU= 1        RMB7DO= 1      RMB8PU- 1        RMB8DO= 1
```

Figure 3.3 SEL-351 Port Settings for MIRRORED BITS Connection

The SEL-3031 allows you to set Port 1 to 9600, 19200, or 38400 bps (8, N, 1). If the SEL-3044 Encryption Card is used, the data rate changes to 9600 or 19200 bps (8, N, 1).

Set PROTO equal to MB8*x*, where *x* equals A or B depending on which MIRRORED BITS channel is used.

NOTE: This setting is slightly different in the SEL-2100 Logic Processor, SEL-3530 Real-Time Automation Controller (RTAC), and SEL-321 Relay.

Set SPEED equal to 9600, 19200, or 38400 bps (or 9600/19200 if the encryption card is installed).

Set RTSCTS (hardware handshaking) to N to disable that option.

Set the RXID equal to one and TXID equal to two at the master end. At the remote end, set the RXID equal to two and the TXID equal to one. The relays use these addresses to prevent a relay from receiving messages from a secondary MIRRORED BITS device if the paths are accidentally connected wrong. The relay only receives messages sent by a relay with the matching transmit address and vice versa.

To connect the relay to the radio, use an SEL-C285 cable (DB-9 male-to-DB-9 male straight-through). If complete electrical isolation is desired between the radio and a relay EIA-232 communications port, use the SEL-2812MR Fiber-Optic Transceiver and fiber-optic cable to connect the relay to the radio.

SEL-400 Series Mirrored Bits Settings

The required port settings for SEL-400 series relays are shown below. To establish communication via the radio, the most critical settings are PROTO, MBT, SPEED, STOPBIT, TXID, RXID, and TXMODE. All other settings are per the application requirements.

```
Protocol Selection
PROTO   := MBA
Communications Settings
MBT     := N        SPEED   :=19200    STOPBIT := 2

Mirrored Bits Protocol Setting

TX_ID   := 2        RX_ID   := 1       RBADPU  := 10       CBADPU  := 20000
TXMODE  := P        MBNUM   := 8       RMB1FL  := P        RMB1PU  := 1
RMB1DO  := 1        RMB2FL  := P       RMB2PU  := 1        RMB2DO  := 1
RMB3FL  := P        RMB3PU  := 1       RMB3DO  := 1        RMB4FL  := P
RMB4PU  := 1        RMB4DO  := 1       RMB5FL  := P        RMB5PU  := 1
RMB5DO  := 1        RMB6FL  := P       RMB6PU  := 1        RMB6DO  := 1
RMB7FL  := P        RMB7PU  := 1       RMB7DO  := 1        RMB8FL  := P
RMB8PU  := 1        RMB8DO  := 1
```

Figure 3.4 SEL-451 Port Settings for Mirrored Bits Connection

Set PROTO equal to MB*x*, where *x* equals A or B depending on which Mirrored Bits channel is being used. Set MBT equal to N to disable that option.

Set SPEED equal to 19200 (or 9600 if the encryption card is installed).

Set STOPBIT equal to 2.

> **NOTE:** If you are using the SEL-3044 Encryption Card, you must change the connected devices' RMBxPU and RMBxDO settings = 2 to maintain the same level of channel security as the standard MB8 protocol. This will delay operation by one processing interval but will give you a higher level of channel security.

Set the RXID equal to one and TXID equal to two at the master end. At the remote end, set the RXID equal to two and the TXID equal to one. The relays use these addresses so that the master relay only receives messages sent by a relay with the matching transmit address and vice versa.

Set TXMODE equal to P (Paced).

To connect the relay to the radio, use an SEL-C285 cable (DB-9 male-to-DB-9 male straight-through). If complete electrical isolation is desired between the radio and antenna and the EIA-232 communications port of the relay, use the SEL-2812MR Fiber-Optic Transceiver and fiber-optic cable to connect the relay to the radio.

SEL-2505 and SEL-2506 Settings

The SEL-2505 and SEL-2506 use control (DIP) switches to set the MIRRORED BITS connection. For easy installation order the SEL-2505 with the SEL-2812 fiber-optic option (SEL-2505x6xXX). Use multimode SEL-C808 or SEL-C807 ST terminated fiber-optic cable to directly connect the SEL-2505 to an SEL-3031 equipped with a fiber-optic option for Port 1. Other transceiver models can be used as long as the corresponding SEL-2800 family transceiver is used on both ends.

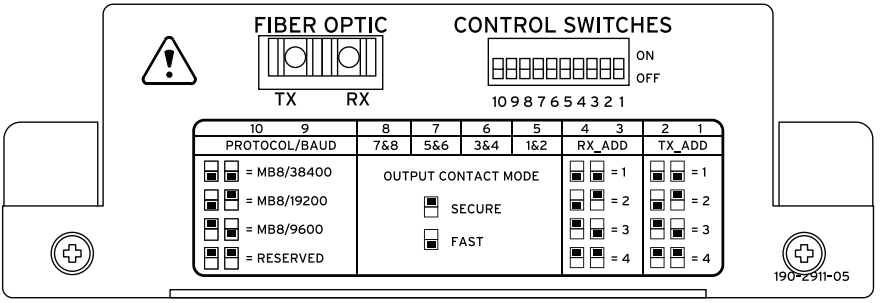

Figure 3.5 SEL-2505 DIP Switch Settings for MIRRORED BITS Connection

Set the TX_ADD equal to one and set RX_ADD equal to two at the local end. At the remote end, set the RXID equal to two and the TXID equal to one. The devices use these addresses so that the master relay only receives messages sent by a relay with the matching transmit address and vice versa.

Set Switch 9 and 10 equal to MB8/9600, MB8/19200, or MB8/38400 for the Protocol/Baud setting. If the SEL-3031 contains the SEL-3044 Encryption Card then the Protocol/Baud setting must be MB8/9600 or MB8/19200.

To connect the SEL-2505 to the radio, use a 62.5 µm multimode SEL-C808 or SEL-C807 fiber-optic cable. Order these cables equipped with ST® connectors and your choice of zipcord or waterproof heavy-duty jacketed fibers.

Initial Checkout

An easy way to verify that the relays are communicating is to use the **TARget** command, as shown below.

```
=>TAR ROKA <Enter>
LBOKB    CBADB    RBADB    ROKB     LBOKA    CBADA    RBADA    ROKA
0        0        0        0        0        0        0        1
```

Figure 3.6 TAR ROKA Command From an SEL-351

The results shown here are from an SEL-351 Relay. ROKA is asserted, meaning that the two relays have established MIRRORED BITS communication. For longer-term channel tests, use the **COM** report command available in the relay and suggestions described in *Monitoring Radio Performance on page 5.1*.

Using an SEL Information Processor to Collect Relay Status and Measurements

SEL information processors and computing platforms easily collect relay status and measurement information. SEL information processors include the SEL-3530 Real-Time Automation Controller, SEL-2032, SEL-2030, and SEL-2020 Communications Processors, and ruggedized SEL computers configured as intelligent servers or gateways. An SEL information processor can be used as a data collection point, port switch, and to control operations all through one serial port. The SEL-3031 serial interface allows you to obtain all of this relay information from remote IEDs through the use of the wireless connection. The example below will show you how to set the radio, relays, and communications processors to allow the Fast Messaging protocol to operate over a wireless connection.

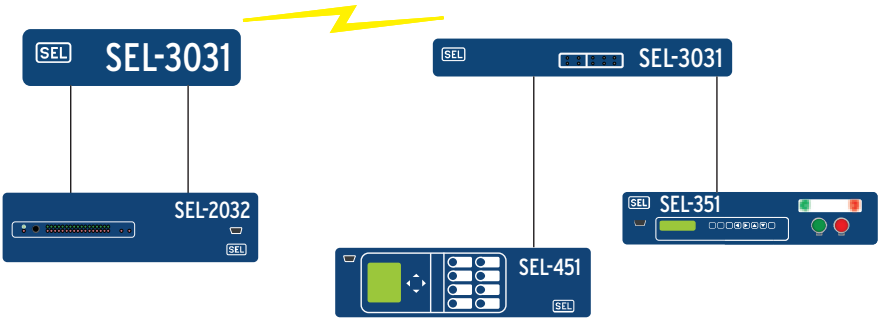

Figure 3.7 SEL-3031 Linking Information Processors to Relays

SEL-3031 Settings

The SEL-3031 requires very few inputs for setting up the serial port to the correct protocol. *Figure 3.8* shows the settings needed for Port 1.

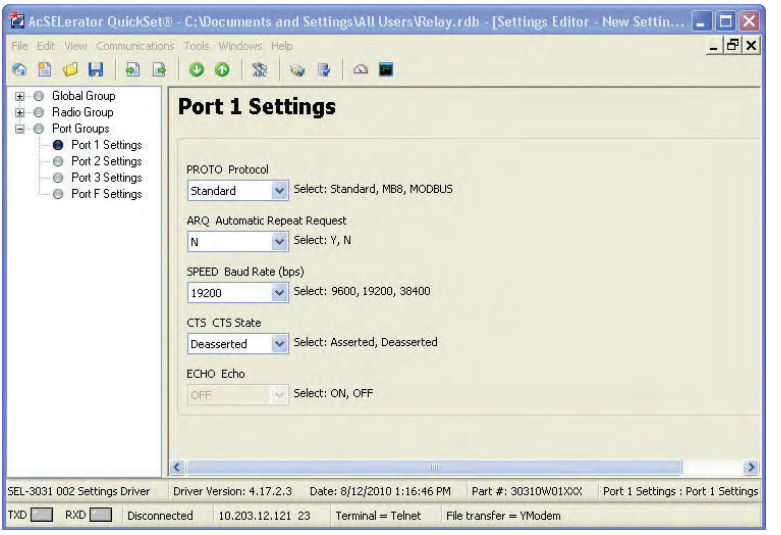

Figure 3.8 SEL-3031 Port 1 Settings for Fast Messaging

The PROTO setting must be set to **Standard**. The Standard setting is the default for use on any byte-oriented protocol. The Standard setting is used with connections such as DNP3, SEL ASCII, Compressed ASCII, Fast Operate, Fast SER, and SEL Fast Meter with Configuration.

The ARQ setting should be set to Y. This allows data retransmission when an error is detected. The SPEED setting can be set 9600, 19200, or 38400 bps. If you set it to 38400, it will disable Port 2. Port 3 will still operate at 9600 or 19200 bps. The CTS1 setting should be set to **Deasserted**. This will deassert the control lines on the SEL-3031. Some protocols in devices require the control line to be in a high or low state to permit proper communication. For example, with DNP3, some remote devices will not reply back to the master until the control line is deasserted. If the control line is asserted the DNP3 device is told to wait. Again, this setting is based upon how the vendor implemented flow control in the devices. For most all SEL products this setting should always be set to **Deasserted**.

On Port 1 of each radio, install an SEL-C285 cable to the IED. As an alternative, the SEL-3031 can be ordered with a fiber-optic serial port that works with SEL-2812 transceivers. If you use the fiber port on the SEL-3031, the connection at the IED needs to be an SEL-2812MR transceiver or compatible built-in port.

SEL-300 Series Settings

The required settings for the SEL-351 are shown in *Figure 3.9*. These settings are similar to all of the SEL-351, SEL-311, and SEL-700 series of relays. To establish a communications link via the radio, the most critical settings are PROTO, SPEED, BITS, PARITY, STOP, and RTSCTS.

```
=>>SHO P 2 <Enter>
Port 2

PROTO = SEL
SPEED = 19200    BITS  = 8        PARITY= N        STOP  = 1
T_OUT = 10       AUTO  = Y        RTSCTS= N        FASTOP= Y

=>>
```

Figure 3.9 SEL-351 Port Settings for Fast Messaging

Set AUTO = Y if you want the relay to send automatic messages to indicate specific conditions.

Set FASTOP = Y if you want the communications processor to issue control commands to the relay.

SEL-2032/SEL-2030 Settings

The following steps demonstrate on how to set SEL-2032 to initially connect and configure an SEL-351 Relay.

Step 1. Use the SEL-C285 cable to connect one of the SEL-2032 ports; this example uses Port 2 to Port 1 of the SEL-3031.

Step 2. Enter Access Level 2 on the SEL-2032 and issue the **SET P 2** command to configure Port 2. The SEL-2032 prompts for the type of device connected to the port.

a. Enter **S** for the SEL IED.

b. Enter **Y** to autoconfigure the port.

c. Press the **<Enter>** key to confirm the configuration prompts.

The SEL-2032 establishes communication with the relay; determines the type of relay, relay ID, and communications data rate; and determines if the relay is capable of Fast Meter.

d. Enter **Y** to save port configuration changes at the final prompt.

Step 3. Issue the **AUTO 2** command to see what Fast Message features are supported by the SEL-351S. *Figure 3.10* shows an example output for the **AUTO** command.

```
*>>AUTO 2 <Enter>
FID: FID=SEL-351S-7-R106-V0-Z003003-D20010110
DEVICE ID: FEEDER 1
BAUD RATE: 19200
OPERATE SUPPORT: Binary (1 Breakers, 16 Remote Bits S-C-P)
LEVEL 1 PASSWORD: OTTER
COMMANDS SUPPORTED:
B 20METER
B 20DEMAND
B 20TARGET
A 20HISTORY
A 20STATUS
A 20EVENT
A 20EVENTS
A 20EVENTL
*>>
```

Figure 3.10 Example AUTO Command Output

The **AUTO** command verifies initial configuration is set up. Refer to the *SEL-2032 Instruction Manual* for more information on setting up Fast Messaging.

Setting Up a Point-to-Multipoint Link Using DNP3 SCADA Protocol

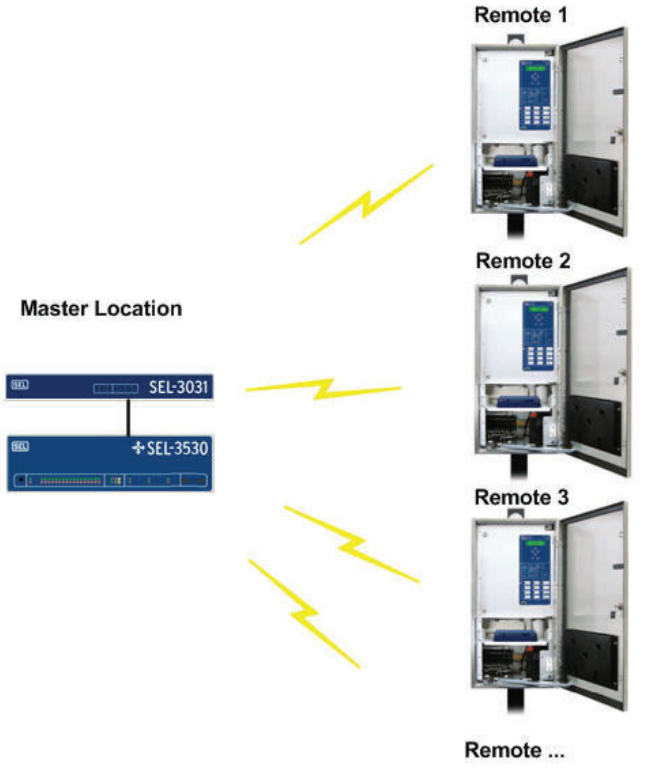

Figure 3.11 SEL-3031 Point-to-Multipoint Example

The SEL-3031 is designed to work in P2P (Point-to-Point) and P2MP (Point-to-Multipoint) modes. In P2MP mode Port 1 is the only active port. Port 2 and Port 3 are disabled in this mode. This example will show how to setup a P2MP radio connection where there is one radio at the master location connected to an SEL-3530 RTAC and the other end will be three or more remote radios connected to SEL-651R recloser controls. The protocol used in this example is DNP3. In P2MP mode, the radio works with most multidrop addressable protocols, including MODBUS.

The radios set in P2MP mode operate by allowing the master to send information to all of the remotes. Only the remote that is connected to the IED (SEL-651R) with the correct SCADA address will respond back to the master. Data will collide if the remote is not set up correctly where two remotes share the same address or sending unsolicited data. All remote radios have the ability to transmit data to the master and the protocol addressing determines which remote should respond to the master.

SEL-3031 Settings

The SEL-3031 requires very few settings to set up the radios. This example assumes the radios have been set up and are currently linked. You should use an SEL-C285 cable to connect the SEL-3031 to the SEL-3530 RTAC and SEL-651R. If you are having problems setting up the radio link, refer to *Section 2: Installation* and *Section 5: Performance Monitoring, Testing, and Troubleshooting* for more information.

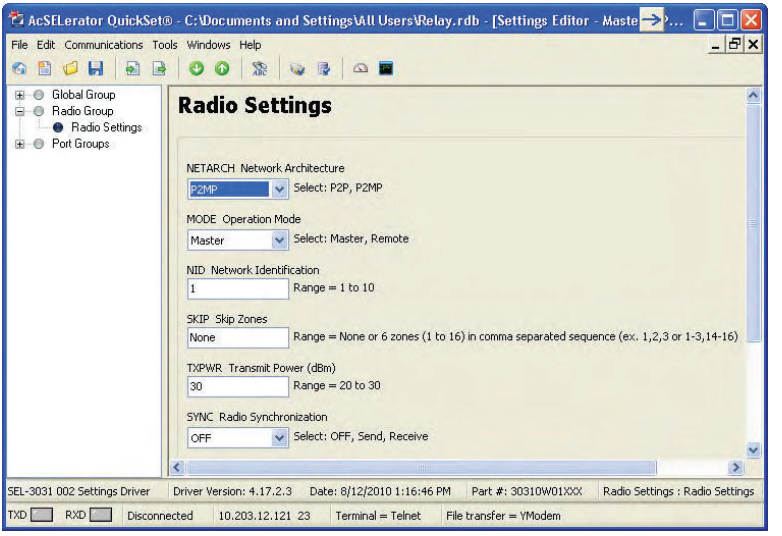

Figure 3.12 Radio Settings for Point-to-Multipoint

In the Radio Settings, the NETARCH setting must be set to P2MP. The P2MP mode disables Port 2 and Port 3 and allows multiple remote radios to connect to one master.

The MODE setting must be set to MASTER for the radio located at the master location connected to the RTAC. All of the remote radios must have this setting set as REMOTE.

The rest of the Radio Settings can be left to default.

NOTE: You must set the TXPWR correctly to stay in compliance with the FCC and IC with a maximum allowed 36 dBm EIRP transmitted signal. See Transmitted Signal on page 2.3 for more information.

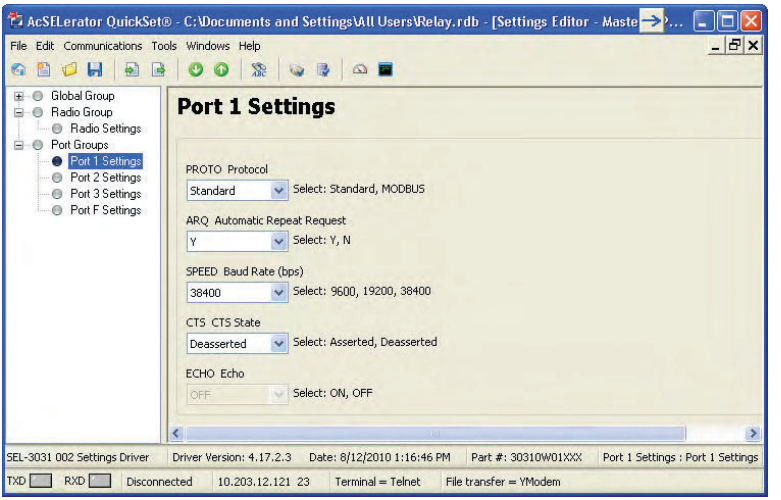

Figure 3.13 Port 1 Settings for Point-to-Multipoint

Figure 3.13 shows the correct settings needed for creating a DNP channel for P2MP. The PROTO setting should be set to STANDARD. Setting the PROTO to Standard allows all byte-oriented multidrop protocols to pass through the port. If you are using MODBUS, set PROTO to MODBUS.

Leave the ARQ setting to Y. In P2MP mode, this allows the message being sent from the remote to the master to retransmit on error. In P2MP mode, this will not allow the master transmit message to retransmit on error.

The SPEED setting can be set for 9600, 19200, or 38400 bps. It is preferred to set this to 38400 to take advantage of higher throughput to reduce the overall polling time. If any of the end devices do not support 38400, the whole system must be set down to 9600 or 19200 bps.

The CTS State should be set to DEASSERTED by default. Setting to deasserted allows proper communication with most SEL devices. If the remote device is not responding to DNP messages, this setting may need to get set to ASSERTED. Most DNP devices look at the CTS line and will not send the DNP message unless the CTS line is in an asserted or deasserted state. This setting allows you to set the line high or low to always give the device permission to transmit.

SEL-3530 RTAC Settings

To properly set the RTAC it is best to review the SEL-3530 manual under *Section 4: DNP3*. This section explains how to setup a DNP3 connection.

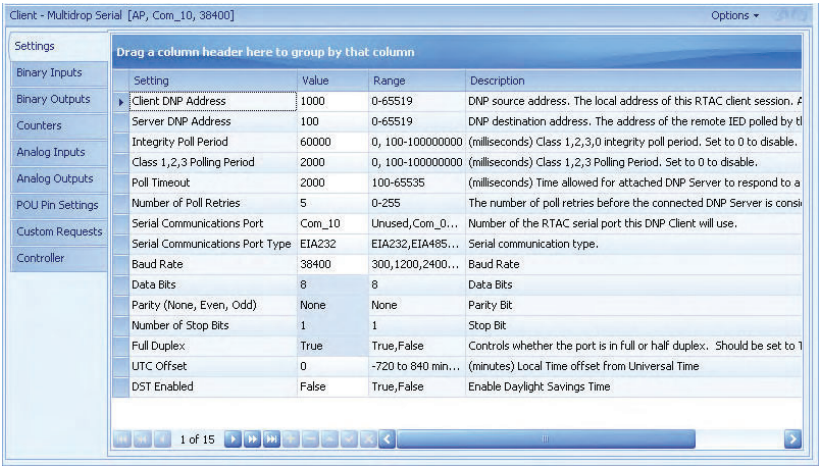

Figure 3.14 SEL-3530 RTAC DNP3 Settings

Once a DNP port is set on the RTAC to a "Client-Multidrop Serial" a list of settings are shown in *Figure 3.14*. One of these devices must be set for each remote SEL-651R on the system. The **Client DNP Address** in the example is set to 1000. This is the address of the RTAC DNP master. All devices set up on the RTAC must be set to communicate to the same master address. Similarly, on the SEL-651R all settings for REPADR should be set to 1000.

The Server DNP Address is the address of the remote SEL-651R device. Each RTAC device must have a unique address. The corresponding DNPADR in the SEL-651R must be set to the same corresponding device.

The Integrity Poll and Class polling should be set such that there is enough time to poll all remote devices in the allocated time. The more remote devices that are in a system the longer time is needed for the polling.

The Number of Poll Retries in this example is set to 5. The given availability of the radio system will change this setting. If the SEL-3031 has a greater than 95 percent availability and the ARQ in the radio is turned on then you would not expect to see many poll retries.

The Baud Rate should be set to 38400 to match the system baud rate. The rest of the settings are either fixed or you can leave as default.

SEL-651R Settings

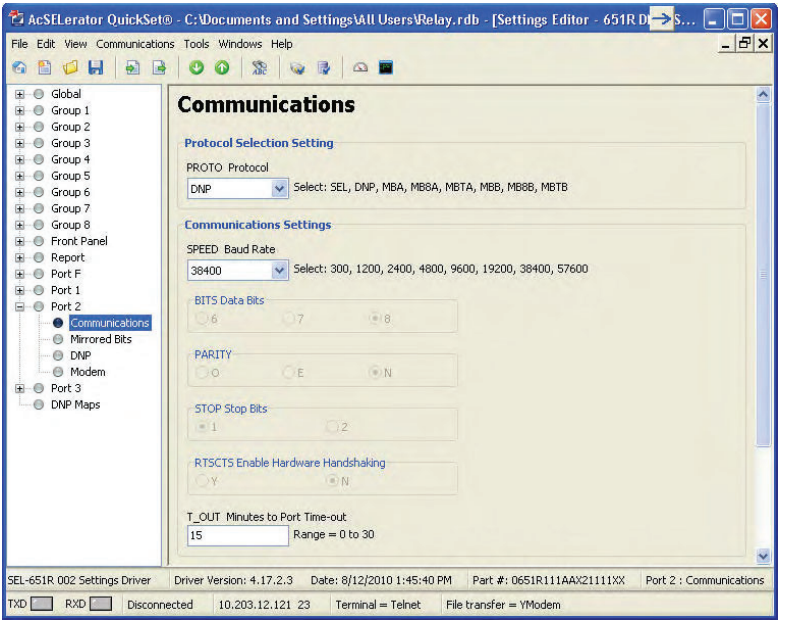

Figure 3.15 SEL-651R Communications Settings for P2MP

The SEL-651R has a minimum of four settings to get the link up and running. There are more settings to determine types and mapping of digital and analog data but are not needed to verify initial operation. This example only demonstrates on how to get the RTAC communicating to the SEL-651R through the SEL-3031 in P2MP mode.

Figure 3.15 shows the first setting needed in the SEL-651R. The settings are needed in all remote SEL-651R units communicating to the RTAC. The PROTO needs to be set to DNP for the current protocol used. The SPEED needs to be set to 38400 to match the system baud rate. The rest of the settings in this group can be left as default.

Figure 3.16 shows the settings for the DNP port set in the SEL-651R.

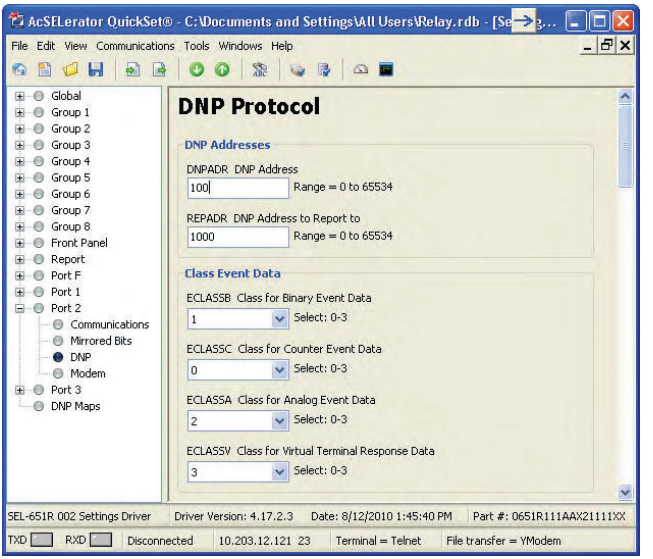

Figure 3.16 SEL-651R DNP Port Settings for P2MP

The DNPADR is set to 100 in this example. Each remote SEL-651R must be set to a unique address. This corresponding address must match the RTAC device address called “Server DNP Address“.

The REPADR is set to 1000 in this example. This is the address the SEL-651R is to report back to, otherwise called the master address. All remote SEL-651R units should be set to the same master address. All the other settings can be left as default and are not needed for initial configuration. If a different type or class of event data is needed, then more of these settings need to be changed along with settings in the RTAC. This is not covered under the scope of this example.

Verifying Proper Operation

Once all the settings in the SEL-3031 radios, RTAC, and SEL-651R are set correctly, the next step is to verify proper operation. Easily check this by looking at the master SEL-3031 Tx and Rx LEDs on Port 1. If the Tx LED illuminates, and the Rx LED illuminates shortly after, the link is up and working. If you only see the Tx LED illuminate and not the Rx LED illuminate you either have a problem with the settings in the radio, settings problem on the SEL-651R, or you are using the wrong cable. You can also review the data LED at each remote location. These LEDs will help troubleshoot the problem. If you do not see the Tx LED on the master radio illuminating then you are either using the wrong cable or do not have the correct settings in the RTAC.

Configuring Collocated Antennas Using SEL Hop-Sync Technology

There are radio applications that require multiple links at one location. Using multiple antennas at one location operating at the same frequency band causes interference issues with adjacent placed antennas. To improve the dependability when using collocated antennas the radio comes with SEL Hop-Sync™ technology. SEL Hop-Sync technology allows you to connect collocated antennas together and synchronizes all the radios connected so they hop at the exact same time. This greatly reduces adjacent channel noise and allows each radio to receive data without interference from the adjacent antennas.

There are three applications where collocated antennas are typically applied.

1. Setting up a repeater location where two back-to-back radios are used.
2. Setting up two links going to and from the same location as a primary/backup radio installation.
3. Creating two or more links from a central location going to separate locations.

This example will show how to set up collocated antennas in a repeater location using MIRRORED BITS communications. Once you understand how to setup up collocated antennas applications 2 and 3 can be easily extrapolated. See *Collocated Antenna Systems on page 2.8* for more information.

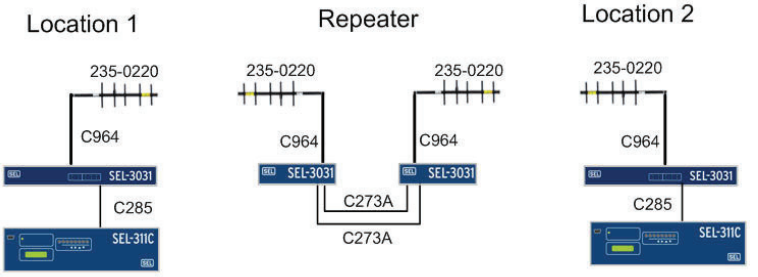

Figure 3.17 Setting up Collocated Antennas at a Repeater Location

Figure 3.17 is the connection diagram with the cables and antennas needed for this application. This example uses two SEL-311C relays communicating MIRRORED BITS over the radio link. The line of site between location 1 and 2 is obstructed by a hill. A repeater location is set up to transmit around the hill.

SEL-311C and SEL-3031 Settings at Location 1 and 2

The SEL-311C serial port needs to be set to MB8 MIRRORED BITS protocol. Follow the job done Example 1 to configure the SEL-311C and the SEL-3031 radios located at Location 1 and Location 2.

SEL-3031 Settings at Repeater Location

Set the two collocated SEL-3031 radios at the repeater location with settings similar to the radios at Location 1 and 2. Set the radio at the Repeater location that is communicating to Location 1 the same as the setting of the SEL-3031 at Location 2. Do the same for SEL-3031 at the Repeater location communicating to Location 2 set the same as the SEL-3031 at Location 1. This setup will start as two independent P2P links. At the repeater location use an SEL-273A cable to connect Port 1 on each radio. This setup should allow the repeater link to pass information to the next radio and the relays should be communicating MIRRORED BITS. This link will work adequately if the repeater antennas are placed far enough apart to prevent the adjacent antenna from interfering. To improve this link and to allow the antennas to be placed closer you will need to synchronize the radios.

Synchronizing the Radios at the Repeater Location

To synchronize the system, we need to synchronize the radios at the repeater location so that the collocated radios transmit and receive at the same time. To do this you must connect an SEL-273A cable between Port 3 of the radios at the repeater location. The radios will use Pin 7 and Pin 8 in the communications cable to synchronize each other. The last step to synchronizing radios is to set the SYNC setting in each of the radios at the repeater location. You must make one radio the master SYNC SEND and the other a master SYNC RECEIVE.

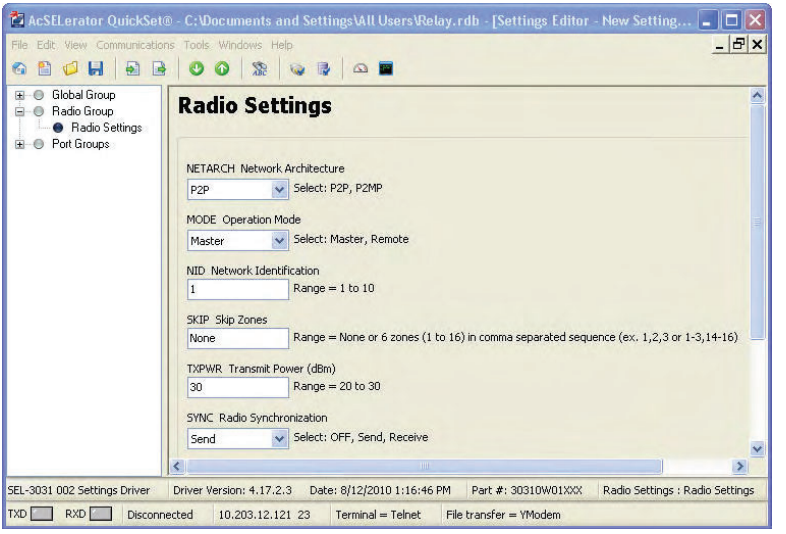

Figure 3.18 SYNC Settings for Master Radio

Figure 3.18 shows the settings for the master radio at the Repeater location. The SYNC setting for this device must be set to SEND. This tells the radio to generate a pulse to synchronize connected radios. On the second master radio at the Repeater location you must set SYNC to RECEIVE.

Table A.1 Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Fixed an issue in the SEL-3044 where the rollover of the encryption key could get repeated indefinitely and cause communications to stop. ➤ Fixed an issue in the SEL-3044 where the master could receive a repeated message from the radio that should have been dropped, causing the SEL-3044 to stop processing incoming data.	
Firmware Version: SEL-3031-R103-V0-Z003001-D20110818 FPGA Version: SEL-3031-R101-D20101018 **Note:** You must update both firmware and FPGA for proper operation.	➤ Fixed issue that prevented the encryption card from rekeying under certain conditions, which also stopped communication. ➤ Created Brazil frequency compatible version. ➤ Added 9600 bps speed setting option to all ports in radios without encryption cards.	20110818
Firmware Version: SEL-3031-R102	➤ This firmware version was not production released.	—
Firmware Version: SEL-3031-R101-V0-Z002001-D20101108 FPGA Version: SEL-3031-R101-D20101018 **Note:** You must update both firmware and FPGA for proper operation.	➤ Added P2MP capability. ➤ Added the capability to synchronize collocated radios. ➤ Added ARQ for non-MIRRORED BITS applications. ➤ Improved the **STA** command with more radio information. ➤ Added 38400 bps option on Port 1 (19200 bps with Encryption Card).	20101108
SEL-3031-R100-V0-Z001001-D20091009	➤ Initial version.	20091009

Instruction Manual

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

Table A.2 lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table A.2 Instruction Manual Revision History (Sheet 1 of 4)

Date Code	Summary of Revisions
20211103	Section 1 ➤ Updated *Table 1.2: Certifications by Country.* Section 2 ➤ Updated *Radio Interference*.
20210820	Section 1 ➤ Updated *Compliance* in *Specifications*. Appendix C ➤ Updated *NIST FIPS 140-2 Level 2 Security Requirements*.
20210715	Section 1 ➤ Updated *EMC Emissions* in *Specifications.*
20191219	Section 1 ➤ Updated mounting options information in *Features, Benefits, and Application*s.
20190214	Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*. ➤ Updated language on FIPS 140-2 Level 2 revalidation. Appendix C ➤ Updated language on FIPS 140-2 Level 2 revalidation.
20181011	Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*. ➤ Updated *Figure 1.3: Radio Antenna Connections*.
20181001	Section 1 ➤ Updated *Specifications*.
20180613	Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*. Section 2 ➤ Updated *Table 2.2: Antennas Permitted for Use with the SEL-3031*. Section 4 ➤ Updated *Table 4.14: Factory-Default Passwords*. ➤ Updated *Table 4.18: SER Command*.
20180330	Section 1 ➤ Updated *Compliance* in *Specifications*. Appendix B ➤ Updated *Technical Support*.
20160804	Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*.

Table A.2 Instruction Manual Revision History (Sheet 2 of 4)

Date Code	Summary of Revisions
20160203	General ➤ Updated cable information to include RG-8X. Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*.
20150203	Preface ➤ Updated *Safety Information*. Section 1 ➤ Updated *Table 1.1: Radio Antenna and Cable Accessories*. ➤ Added *Figure 1.1: Radio Antenna Connections*. ➤ Changed *Certifications* to *Compliance*, and moved it to the beginning of *Specifications*. ➤ Added *Power Consumption With SEL-3044 Card* in *Specifications*. ➤ Updated *Table 1.2: Government Approvals*. Section 2 ➤ Updated *Figure 2.6: SEL-C693 Cable: Two-Wire EIA-485 Connections.* Section 4 ➤ Added CAL Level information. Section 5 ➤ Updated fade margin and radio availability information in *Monitoring and Improving Radio Link Performance*. Appendix A ➤ Updated *Table A.1: Firmware Revision History* with correct FPGA version.
20141120	Section 1 ➤ Updated surge protection description and part number in *Table 1.1*. Section 2 ➤ Updated surge protection information in *Lightning Protection.*
20130208	Section 1 ➤ Added UL, cUL, and FIPS 140-2 certification information to *Specifications*.
20111228	Appendix A ➤ Updated for SEL-3031 firmware version R104. ➤ Updated for SEL-3044 firmware version R102.
20111005	Section 1 ➤ Added certification information for Colombia to *Specifications*. ➤ Added Brazil ANATEL Numbers to *Specifications*.

Table A.2 Instruction Manual Revision History (Sheet 3 of 4)

Date Code	Summary of Revisions
	Section 2 ➤ Added Colombia to list of countries allowing six skip zones.
20110818	Section 1 ➤ Added 9600 bps SPEED setting option for radios without encryption cards. ➤ Updated port speed option and latency tables in *Specifications* to reflect 9600 bps SPEED setting option for radios without encryption cards. ➤ Added certification information for Brazil, Mexico, and Peru to *Specifications*. Section 2 ➤ Added 9600 bps SPEED setting option for radios without encryption cards. ➤ Added 303011Brazil locked skip frequencies. ➤ Added *Table 2.4: 900 MHz Frequency Skip Zones for Brazil (part numbers starting with SEL-30311)*. Section 3 ➤ Added 9600 bps SPEED setting option for radios without encryption cards. Section 4 ➤ Added 9600 bps SPEED setting option for radios without encryption cards. ➤ Added 303011Brazil locked skip frequencies. ➤ Added *Table 4.6: Skip Zone Frequencies (SEL-30311 Brazil)*. Appendix A ➤ Updated for firmware version R103.
20101108	Section 1 ➤ Added P2MP capability to product features. ➤ Included additional antenna accessories in *Table 1.1: Radio Antenna and Cable Accessories*. Section 2 ➤ New SEL Sync-Hop for collocated radios. ➤ Updated *Table 2.9: SEL-3031 Port Description* for Port 3 radio synchronizing capability. ➤ Added *Figure 2.12: SEL Cable C576: Synchronizing Cable for SEL-3031*, new cables for synchronizing radios. Section 3 ➤ Added two more Job Done examples.

Table A.2 Instruction Manual Revision History (Sheet 4 of 4)

Date Code	Summary of Revisions
	Section 4 ➤ Added P2MP capability to product features. ➤ Updated *Figure 4.9: Radio Strength and Channel Availability* with new graphical Radio Status. ➤ Updated *Table 4.4: Radio Settings* with P2MP and synchronizing settings. ➤ Added information on SYNC and KEY settings. ➤ Updated *Table 4.6: Port Settings* with SPEED and ARQ. Appendix A ➤ Updated for firmware version R101. Appendix B ➤ Added *Firmware Upgrade Instructions*.
20091009	➤ Initial version.

Appendix B
Firmware Upgrade Instructions

Overview

SEL may occasionally offer firmware upgrades to improve the performance of your radio. The radio stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-3031. These instructions give a step-by-step procedure to upgrade the radio firmware by uploading a file from a personal computer to the radio via direct connection to the USB management 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)
- USB Type-B cable (SEL-C664 or equivalent)
- The firmware upgrade file (Rxxx3031.img)

Firmware Upgrade Procedure

Step 1. Connect a standard USB Type-B cable from the PC to the management port of the SEL-3031, and enter Access Level 2.

a. Type **ACC <Enter>**.

b. Enter the Access Level 1 password.

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

d. Enter the Access Level 2 password.

Step 2. Start the upgrade process.

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

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

```
Device disabled
```

Step 3. Issue the **BAU 115200** command. On your terminal or computer terminal program, change the terminal data rate to 115200 bps.

Step 4. Begin the transfer of the new firmware to the radio by issuing the **REC** command.

Step 5. Type **Y** to erase the existing firmware, or press **<Enter>** to abort.

Step 6. 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 radio reboots and returns to Access Level 0. Change the terminal data rate back to 9600 bps to access the radio management port.

Step 7. Press any key (e.g., **<Enter>**) when the radio sends a prompt.

Step 8. Type **ACC <Enter>**. Enter the Access Level 1 password.

```
=>>L_D <Enter>
Disable device to receive firmware (Y,N) ? <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 9. 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.
e. Type **ACC <Enter>**.
f. Enter the Access Level 1 password
g. Type **2AC <Enter>**.
h. Enter the default Access Level 2 password.
i. Use the **PAS** command to change the default password to your secure password (refer to the *SEL-3031 Instruction Manual*).

Step 10. Turn the radio off and back on.

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

FPGA Configuration Upgrade Procedure

Step 1. Connect input power.

Step 2. Connect a standard USB Type-B cable from the PC to the management port of the SEL-3031, and enter Access Level 2.

Step 3. Start upgrading of firmware.

a. Issue the **L_D** command to the radio.
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 radio will respond with the following message and send the !> prompt.

```
Device disabled
```

Step 4. Issue the **BAU 115200** command, and change the terminal data rate to 115200.

Step 5. Begin the transfer of the new FPGA configuration file (RTL_Rxxx3031.cxf) to the radio by issuing the **REC FPGA** command.

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

Step 7. Press any key (e.g., **<Enter>**) when the radio sends a prompt.

Step 8. 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 radio will reboot and return to Access Level 0.

Step 9. The FPGA upgrade will cause the radio to restart (equivalent to removing and restoring power). On most PCs, you will need to exit and restart the terminal program for it to re-recognize the serial port. Change the terminal data rate back to 9600 bps to access the radio management port.

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

!>REC FPGA <Enter>
Caution! This command erases the FPGA.
Do not interrupt power during FPGA upload
or the device may require factory reprogramming.

Are you sure you want to erase the existing FPGA (Y/N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.

Completed FPGA configuration upload into RAM.
Beginning FPGA reconfiguration.
Erasing FPGA ... (15 seconds) ... Done.
Configuring FPGA.
 37 ................................................................
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 35 ................................................................
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  4 ..............................................................
  3 ..............................................................
  2 ..............................................................
  1 ..............................................................
FPGA Configuration complete.............
```

The SEL-3031 now is ready for commissioning.

Technical Support

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 USA
Telephone: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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Appendix C
SEL-3044 Encryption Card

Overview

The SEL-3044 Encryption Card is a standalone card that can be added to the SEL-3031 to encrypt the radio data being sent between SEL-3031 radio links. The SEL-3044 can be ordered at time of purchase or added as an upgrade. The SEL-3044 requires one setting to provide a very strong level of encryption over the radio link. Use of the SEL-3044 is strongly advised for any application of the SEL-3031 for critical data. If you do not use the SEL-3044, the data between the radios can be compromised. If you want to encrypt the radio link, an SEL-3044 is required in both radios.

NOTE: The SEL-3044 is NOT a PCMCIA card. Do not install in a laptop computer.

Figure C.1 SEL-3044 Encryption Card

NIST FIPS 140-2 Level 2 Security Requirements

The National Institute of Standards and Technology (NIST) developed the Federal Information Processing Standards (FIPS) 140-2 standard that defines the security requirements for a cryptographic module used within a security system protecting sensitive information in computer and telecommunications systems.

Protection of a cryptographic module within a security system is necessary to maintain the confidentiality and integrity of the information protected by the module. FIPS 140-2 Level 2 covers areas related to the secure design and implementation of a cryptographic module.

These areas include the following:

- Cryptographic module specification
- Cryptographic module ports and interfaces
- Roles, services, and authentication
- Finite state model
- Physical security
- Operational environment
- Cryptographic key management
- Electromagnetic interference/electromagnetic compatibility (EMI/EMC)
- Self-tests
- Design assurance
- Mitigation of other attacks

The SEL-3044 meets FIPS 140-2 Level 2 historical. This level of data security provides assurance that best practices have been applied to the design, testing, and manufacturing of the SEL-3044.

Theory of Operation—SEL Protocol

Encryption Components

A cryptographic device consists of three components: encryption algorithm, key management, and device security functions.

Encryption Algorithm

The Advanced Encryption Standard (AES) algorithm with a key length of 256 bits is implemented in the SEL-3044. This algorithm is a secure means of encrypting data. The AES algorithm and key length provide proven resistance to modern cryptanalysis.

Key Management

System key (256 bits): The system key is set by a passphrase of 8 to 80 characters. The passphrase is used to generate a system key. The system key is used to encrypt and securely transmit unique session keys (see following text). It also provides a cryptographic authentication mechanism for rejecting session requests by unauthorized SEL-3044 devices.

Session key (256 bits): Session keys are used to encrypt all protected user data prior to transmission. They are produced at system startup and periodically during sessions. Session keys are generated using the process outlined by FIPS 186-2. They are produced using an integrated physical random number generator (RNG) and a statistical data whitening algorithm. Session keys are purely random and are not linked to the system key. The use of unique session keys limits the amount of data that is encrypted with a single key value, thus strengthening the system against cryptanalytical attack. The session keys are encrypted using the system key prior to being exchanged between SEL-3044 devices.

Device Security

The SEL-3044 incorporates a hardware RNG and FIPS-approved data whitener to guarantee that all session keys contain 256 bits of entropy (i.e., completely random). This guarantees that encoded messages are protected by a true cryptographic strength of 256 bits.

Multilevel password authentication defines user security roles.

Changing the system key can only be performed by authorized users who have Access Level 2 passwords.

If required, an authorized user can reset the entire device. This allows the user to reinitialize the system key should the security parameters need to change because of IT security procedures or if the programmed system key value is lost.

NOTE: This process requires physical access to the SEL-3031 and cannot be done remotely.

Security of the Transferred Data

The SEL-3044 provides data encryption with a cryptographic key strength of 256 bits. The SEL-3044 RNG is designed so that all possible key values are equally likely. It is widely accepted throughout the cryptographic community that it is not realistically possible to mount a successful brute force (key guessing) attack on a 256-bit key space with technology available today.

Application Consideration

Two messaging structures exist to establish and maintain a secure, coherent communications link between two SEL-3044 devices: In-Band (IB) frames and Out-of-Band (OOB) frames. IB frames transmit encrypted user data (i.e., data received on the trusted data interface) between the two protected devices (computer, IED, RTU, etc.). OOB frames transmit connection control data between the two SEL-3044 devices in the communications link. Control frames are required to implement key exchanges, status checks, and other functions necessary to maintain the communications link.

In-Band Message Format

IB messages consist of the encrypted data plus the frame overhead necessary to maintain synchronization and channel security. *Figure C.2* shows the format of an IB frame. The shaded area is the encrypted data portion of the message.

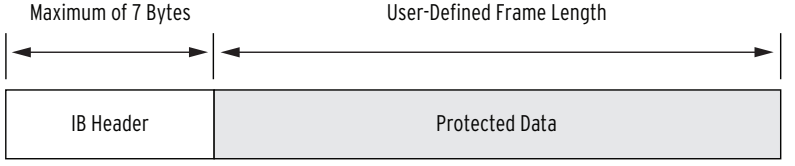

Figure C.2 In-Band Data Packet Format

Out-of-Band Message

Out-of-Band (OOB) messages are used to exchange control information between SEL-3044 cards. These exchanges include loss of synchronization, request for rekey, and rekey information.

IMPORTANT: During OOB message communication, data exchange between the devices connected to the SEL-3044 cannot occur. Communication will be temporarily halted during a rekey.

System Settings

The system key provides encryption and secure transmission of unique session keys between SEL-3044 devices. It also provides a cryptographic authentication mechanism for rejecting session requests by unauthorized devices. Session keys provide encryption of all protected user data prior to transmission. An SEL-3044 produces session keys at system startup, and periodically during sessions, using the process outlined by FIPS 186-2. An integrated physical RNG and statistical data-whitening algorithm generate purely random session keys. Through the use of these unique session keys, the SEL-3044 limits the amount of data encrypted by any single key value, thus strengthening the system against attack.

NOTE: Both SEL-3044 transceivers that communicate with each other must share the same system key.

AES Overview

The AES encryption function uses a 256-bit-long secret key and scrambles the contents of each frame prior to transmission to provide cryptographically strong data confidentiality.

Encryption is the process of transforming a digital message from its original form into a form that an unauthorized individual cannot interpret. The output of the encryption process is a function of the message and an encryption key (see *Figure C.3*).

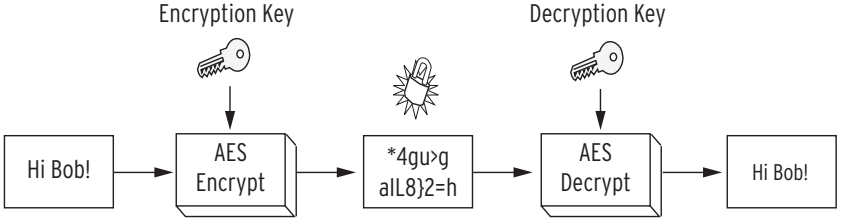

Figure C.3 Operation of the AES Encryption Function

This encryption process must be completely reversible by an authorized individual with access to the secret decryption key. Authority to read a message is only granted by sharing knowledge of the secret decryption key. Ideally, only individuals with knowledge of the decryption key can reverse the encryption operation and interpret the protected message. There are two main classes of encryption functions. Symmetric key encryption relies on the same secret key value, K, to perform both the encryption and decryption transformations. Asymmetric key encryption, on the other hand, uses a different key for encryption and decryption for example, asymmetric encryption might use K1 for encryption and K2 for decryption. The AES encryption algorithm the SEL-3044 uses is a symmetric block cipher with an encryption/decryption key size of 256 bits.

The AES is the latest encryption standard adopted by NIST. In 1997, NIST challenged the cryptographic community to develop the next generation encryption algorithm to replace the aging DES and 3DES encryption standards. In 2000, NIST chose the Rijndael encryption algorithm as the AES encryption standard. During the evaluation of candidates for the AES standard, some of the world's best cryptanalysts analyzed and approved Rijndael. Since its adoption in 2001, AES has proven to be very effective against known attacks, very efficient, and simple to implement.

Frame Replay Protection

Every frame in a given session contains a sequence number field. The value in this field increments every time a frame is transmitted. The SEL-3044 will not accept any frame that contains a sequence number value that is less than, or equal to, the sequence number value received in the last frame. It is exceedingly difficult to maliciously alter the sequence number in any given frame to bypass this functionality because the sequence number field is protected by the strong cryptographic authentication mechanisms. Because of the protection these mechanisms provide, an attacker cannot capture a previously transmitted frame and resend the frame to the SEL-3044 to cause harmful actions.

Resetting the SEL-3044

At some point, it may be necessary to reset the SEL-3044. You must have access to the front USB port on the SEL-3031. The SEL-3044 must be installed in the SEL-3031 to reset. Use either ACSELERATOR QuickSet® SEL-5030 Software or a terminal interface to access the Radio settings. In the Radio settings, set the KEY setting to None, save the setting, then set a new passphrase and save.

If you have lost your passwords to access the SEL-3031, you must disable passwords by temporarily installing a jumper. Refer to *Password Jumper on page 2.14* and *Table 2.7* for information and instructions on disabling passwords.

Installing an SEL-3044 in the SEL-3031

The SEL-3044 can be ordered at time of purchase of the radio, or it may be added later as a field upgrade. The process involves powering down the radio, removing hardware, installing the card, and setting the radio.

⚠CAUTION

The radio contains devices sensitive to Electrostatic Discharge (ESD). When working on the radio with the front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

Step 1. Remove the power from the radio and remove all connections from the device.

Step 2. Rack-mount SEL-3031: Loosen the six front-panel screws and remove the front panel.

Wall-mount model: Use a Torx® T15 screwdriver and remove the four screws located on the sides of each corner. Slide the cover up and back to reveal the front of the unit.

Step 3. Between the main board and radio board there is a PCMCIA card slot. Gently slide the SEL-3044 straight into the card slot. Push firmly until it is fully seated.

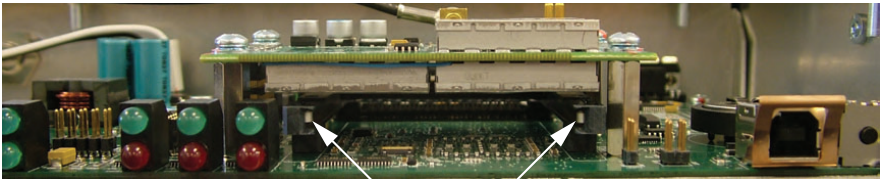

Figure C.4 Encryption Card Location

Step 4. Reassemble the unit in reverse order of Step 2.

Step 5. Apply power to the unit and verify the **SEC** light is flashing. The flashing LED indicates that the SEL-3044 is functioning properly and is currently in Reset.

If the **SEC** LED is not flashing, then you must turn off the unit and verify the card is properly seated in the pins.

If the **SEC** LED does not flash upon your removing and restoring power and you have verified that the card is seated properly, you will need to send the radio and encryption card back for repair.

Step 6. Use QuickSet to connect to the device and set the KEY setting to enable the SEL-3044.

Step 7. The KEY setting must be set the same on both SEL-3031 transceivers for proper operation.

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SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Phone: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com