SEL-632

Network Protector Relay

Instruction Manual

20130111

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM632-01

⚠CAUTION

Enter all settings for a new scheme before issuing the **PE** command. The relay immediately begins using the entered settings when the **PE** command is issued.

⚠ATTENTION

Entrer tous les réglages pour une nouvelle application avant d'utiliser la commande **PE**. Le relais commence à utiliser les derniers réglages introduits quand la commande **PE** est activée.

⚠CAUTION

The SEL-632 retains settings for inactive trip modes. When changing the TM setting, be sure to enter or confirm all settings required for the new trip mode before executing the **PE** command.

⚠ATTENTION

Le module SEL-632 applique les réglages courants pour les modes de déclenchement inactifs. Quand le réglage TM est changé, assurez-vous que tous les réglages ont été entrés et confirmés avant d'exécuter la commande **PE**.

⚠DANGER

The SEL-632 does not prevent a network protector from being closed manually when phases are rolled or crossed. Closing a protector under such conditions may result in damage to equipment, severe injury, or death. Verify proper phasing before attempting any manual close operation.

⚠DANGER

Le SEL-632 n'empêche pas un protecteur de réseau d'être enclenché manuellement quand les phases ont été l'objet d'une rotation ou sont interverties. Enclencher un protecteur sous de telles conditions peut causer des dommages à l'équipement, des blessures graves ou la mort. Vérifier que les phases sont raccordées normalement avant de procéder à un enclenchement manuel.

⚠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.

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Preface

Overview

This manual provides information and instructions for installing, setting, configuring, and operating the SEL-632 Network Protector Relay. The manual is for use by power engineers and others experienced in low-voltage secondary networks. Detailed technical descriptions of the relay and application examples are included.

An overview of each manual section and section topics follows.

Conventions

Typographic Conventions

There are two ways to communicate with the SEL-632:

- ➤ Using a command line interface in a PC terminal emulation window
- ➤ Using SEL-632 Network Protector Relay Software

The instructions in this manual indicate these options with specific font and formatting attributes. The following table lists these conventions.

Example	Description
STATUS	Commands, command options, and command variables typed at a command line interface on a PC.
n **TAR *n***	Variables determined based on an application (in bold if part of a command).
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
File > Open	PC software dialog boxes and menu selections.
CLOSE	Relay front-panel LCD menus. The > character indicates submenus. Relay responses visible on the PC screen.

Safety Information

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

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

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

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

Technical Assistance

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

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Section 1
Introduction and Specifications

Introduction

The SEL-632 Network Protector Relay is constructed to high standards and offers proven features from SEL's popular lineup of protective relays and recloser controls. The SEL-632 comes with a 10-year warranty, and can be used with many Westinghouse-style network protectors. The SEL-632 is available for both new and retrofit applications.

The powerful event recording feature allows analysis of the trip and close operations of the protector. Analog data recorded at 256 samples per cycle supports accurate harmonic content assessment.

Configure the relay using either an ASCII terminal emulator or through SEL-632 Network Protector Relay Software.

Features

The SEL-632 front panel is shown in *Figure 1.1*.

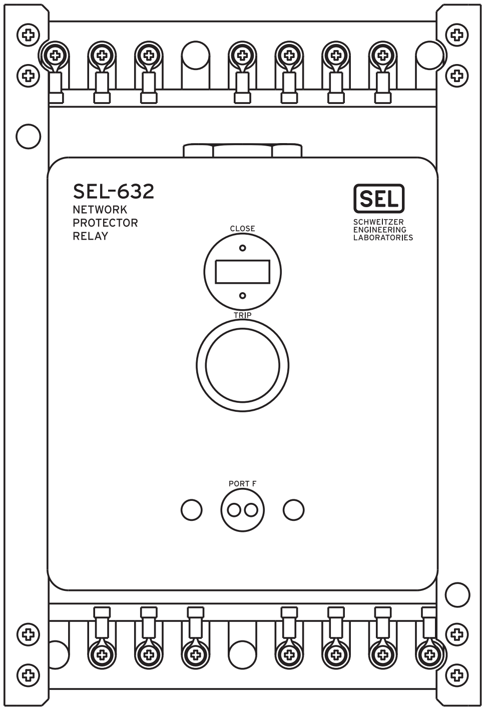

Figure 1.1 SEL-632 Relay Front Panel

Indicating LEDs

The TRIP and CLOSE LEDs indicate network protector relay outputs status.

HMI Display

A high visibility, four-character dot matrix LED display provides voltage and current metering along with the relay status.

Optical Serial Port

An optical serial port on the relay front panel provides communication between the relay and a PC.

Traditional Trip and Close Characteristics

The SEL-632 provides sensitive, time-delay, and insensitive trip modes, and allows the protector to be opened from a PC (remote trip). The close characteristic emulates the straight line characteristic provided by traditional electromechanical relays. Closing can be blocked via a command from a PC (remote block).

Event Reporting

Analyze trip and close events using SEL-632 Network Protector Relay Software or ACSELERATOR® Analytic Assistant SEL-5601 Software. Manually trigger an event to analyze existing operating conditions. The SEL-632 captures one 64-cycle event at 256 samples per cycle.

PC Software

Use SEL-632 Network Protector Relay Software to easily configure the SEL-632 and analyze event reports.

Metering Functions

The SEL-632 provides three-phase rms magnitudes and angles of the network voltage, difference voltage, and current along with the relay temperature, and maintains a breaker cycle counter to help detect pumping or cycling and schedule breaker maintenance.

Models and Options

Two models of the SEL-632 are available. The SEL-632-0 includes firmware-based dead-network closing and special trip output logic. The SEL-632-1 includes rolled- and crossed-phase trip logic and holds the trip output closed for trip conditions. This manual covers the SEL-632-0. A separate manual is available for the SEL-632-1.

Consult the SEL-632 Model Option Table (available at www.selinc.com) to determine the ordering options for your SEL-632 application. Energized or grounded-wye current transformer wiring are available as options.

Contact the SEL factory or your local Technical Service Center for particular part number and ordering information (see *Factory Assistance on page 7.4*).

Applications

The SEL-632 can be used on new Westinghouse-style network protectors or to replace electromechanical network protector relays, when properly configured. A typical SEL-632 retrofit installation is shown in *Figure 1.2*, where existing electromechanical network protector master and phasing relays are removed and replaced with an SEL-632 network protector relay. The SEL-632 is installed in place of the master relay, and the phasing relay is replaced with a dummy plate. A desensitizing (BN) relay dummy plate may also be required on network protectors so equipped.

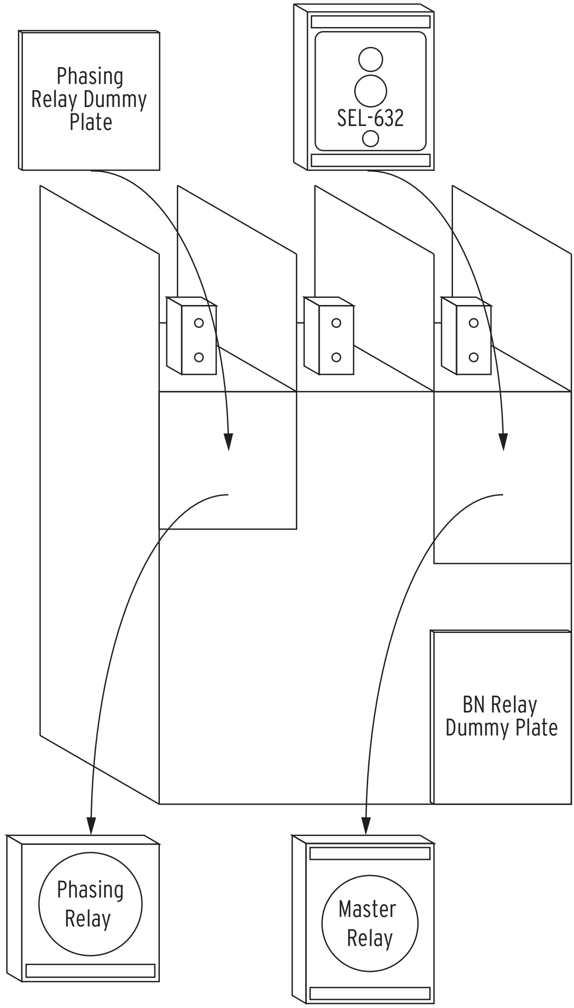

Figure 1.2 Network Protector Retrofit With SEL-632

Specifications

General

AC Current Input

5.0 A Nominal:	5.0 A continuous, 10 A for four hours, linear to 20 A symmetrical.
1 Second Thermal:	500 A
Burden:	< 0.1 Ω

AC Voltage Inputs

Network and Transformer Voltages

Nominal Rating:	125 Vac
Range:	13–190.0 Vac line-neutral

Difference Voltage Range

0.0 to 25.0 Vac

Frequency

60 Hz

Digital Output Contacts

Trip/Close Contact:	Form C
Trip Contact:	Form A side 200,000 operations under 480 Vac 20 A resistive load 3000 one-second make/break PF = 0.28 inductive
Close Contact:	Form B side 200,000 operations under 480 Vac 20 A resistive load 10,000 make/break operations at 480 Vac, 20 A, PF = 0.7 inductive with 3-cycle transient of 50 A and an inrush of 40 A for 2 seconds on each close operation
Update Rate:	≥ 2 times/cycle

Temperature Transducer

Range:	–40°C to +140°C
Accuracy:	±4°C

Optical Communications Port (Port F)

Baud Rate:	9600 bps
Data Bits:	8
Parity:	None
Stop Bits:	1
Receiver Wavelength:	0.8 µm (typical)
Receiver Response Time:	50 ns (typical)
Receiver Sensitivity:	6.0 mA/mW/cm^2(min) 7.0 mA/mW/cm^2 (typical)
Transmitter Spectral Line Half Width:	40 nm
Peak Emission Wavelength:	860 nm (min) 940 nm (typical)
Power Output:	2.0 mW (min) 2.5 mW (typical)
Radiant Intensity:	6.0 mW/steradian (min) 6.6 mW/steradian (typical)

Power Supply

Nominal Voltage:	125 Vac
Range:	13–190.0 Vac line-neutral
Frequency:	60 Hz
Burden:	≤ 10 VA

Operating Temperature

–40° to +125°C (–40° to +257°F)

Storage Temperature

–40° to +125°C (–40° to +257°F)

Maximum Altitude

2000 meters

Atmospheric Pressure

80 to 110 kPA

Weight

<15 lbs.

Startup Time

500 ms or less with minimum voltage available on one phase

Type Tests

Environmental Tests

Cold:	IEC 60068-2-1:2007, Test Ad, –40°C for 16 hours IEEE Std. 1613-2003
Dry Heat:	IEC 60068-2-2:2007, Test Bd, +125°C for 16 hours IEEE Std. 1613-2003
Fungus:	Mil-Std-810 Method 508
Salt Spray:	Mil-Std-810 Method 509
Humidity:	Mil-Std-810 Method 103, condition B
Submergibility:	Waterproof to a 25' depth
Corrosion:	30-week salt bath test to verify seal integrity

Dielectric Strength Tests

Dielectric:	IEC 60255-5:2000, Section 6 IEEE C37.90-2005, Section 8 IEEE Std. 1613-2003 2500 Vac for one minute on contact outputs

Electrostatic Discharge Test

ESD:	IEC 60255-22-2:2008 IEC 61000-4-2:2001 IEEE C37.90.3-2001 IEEE Std. 1613-2003 2, 4, 6, 8 kV contact discharge, 2, 4, 8, 15 kV air discharge, Performance class 1

RFI and Interference Tests

Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 60255-22-4:2008 Class A. 4 kV, 2.5 kHz on voltage and current inputs, 2 kV, 5 kHz on outputs
Radiated RFI (Radio Frequency Interference Immunity):	IEC 61000-4-3:2008 IEC 60255-22-3:2007, 10 V/m IEEE C37.90.2-2004 IEEE Std. 1613-2003, 35 V/m, Performance class 1 7 V/m 25–1000 Mhz
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 2.5 kV peak common mode, 1.0 kV peak differential mode IEEE C37.90.1-2002 IEEE Std. 1613-2003 2.5 kV oscillatory; 4 kV fast transient, Performance class 1
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-22-5:2008 0.5 and 1.0 kV line-to-line; 0.5, 1.0, 2.0 kV line-earth
Conducted Immunity:	IEC 61000-4-6:2008 IEC 60255-22-6:2001), 10 Vrms
Power Frequency Magnetic Field Immunity:	IEC 61000-4-8:2001, 100 A/m (60 sec), 1000 A/m (3 sec), Level 5
Pulse Magnetic Field Immunity:	IEC 61000-4-9:2001 1000 A/m pulse, Level 5

Vibration and Shock Tests

Vibration Resistance:	Mil Std 810D Method 514.1 procedure 9 and 10, curve AX IEC 60068-2-6:2007 IEEE Std. 1613-2003, Sinusoidal 3G, 10–150 Hz IEC 60255-21-1:1988, Endurance Class 1, Response Class 2
Shock Resistance:	Mil Std 810D Method 516.1 procedure 1 (15 g 11 ma half sine) and procedure 2 IEC 60255-21-2:1988
Seismic:	IEC 60255-21-3:1993, Class 2

Harmonic Content Withstand

The relay shall not exhibit spurious output when subjected to the following differential voltage harmonic content while the network voltage is 125 Vac with no harmonic content:

Fundamental:	41%
3rd:	6%
5th:	50%
7th:	2%
9th:	1%

Processing Specifications

Voltage and Current Sampling:	256 samples per power system cycle
Event Report Resolution:	256 samples per power system cycle
Filtering:	Root mean squared (rms) on 64 samples per cycle data
Protection and Control Processing:	2 times per power system cycle

Protection Element Accuracy

Sensitive Trip Mode Steady-State Pickup (Nominal Voltage)

Magnitude:	±0.5 mA (I ≤ 10 mA) ±3%, ±0.2 mA (10 mA < I ≤ 15 A)
Phase:	±10.0° (1 mA ≤ I < 5 mA) ±2.0° (5 mA ≤ I ≤ 10 mA) ±1.0° (10 mA < I ≤ 15 A)

Time-Delay Trip Mode Steady-State Pickup (Nominal Voltage)

Instantaneous Current:	±100 mA

Insensitive Trip Mode Steady-State Pickup (Nominal Voltage)

Instantaneous Current:	±100 mA

Trip Timers

±0.5 cycle, ±0.1% of setting

Normal Reclose Steady-State Pickup (Master and Phasing Characteristics)

Magnitude:	±1.1% difference voltage, ± 50 mV
Phase:	±4.0° (0.1 V ≤ difference voltage < 0.2 V) ±2.0° (0.2 V ≤ difference voltage < 0.4 V) ±1.0° (0.4 V ≤ difference voltage < 10.0 V)

Close Delay Timer

±0.5 cycle, ±0.1% of setting

Dead Network Reclose Steady-State Pickup

Magnitude:	13 V ± 2.0 V
Pickup/Dropout Time:	10 cycles ± 0.5 cycle

Metering Accuracy

Current

Magnitude:	±0.4 mA (I ≤ 10 mA) ±2.4%, ±0.16 mA (10 mA < I ≤ 15 A)
Phase:	±10.0° (1 mA ≤ I < 5 mA) ±2.0° (5 mA ≤ I ≤ 10 mA) ±1.0° (10 mA < I ≤ 15 A)

Network Voltage

Magnitude:	±1.0 V (13–190 V)

Difference Voltage

Magnitude:	±0.1 V (0–10 V)
Phase:	±4.0° (0.1 V ≤ difference voltage < 0.2 V) ±2.0° (0.2 V ≤ difference voltage < 0.4 V) ±1.0° (0.4 V ≤ difference voltage < 10.0 V)

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Section 2
Installation

⚠WARNING
Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

The SEL-632 is designed to replace electromechanical CN-33 master relays and CN-J phasing relays in Westinghouse CM-22 and CMR series network protectors. It can also replace microprocessor-based network protector relays in these and other Westinghouse-style network protectors. Separate versions are available for network protectors with energized current transformers (*Figure 2.3*) or network protectors with grounded-wye current transformers (*Figure 2.4*). *Figure 2.1* shows the dimensions of the SEL-632. *Figure 2.2* shows the physical pin locations as viewed from the rear of the relay.

Remove the existing CN-33 master relay and install the SEL-632 Network Protector Relay in its place. Secure the relay with the two thumbscrews. Remove the existing CN-J phasing relay and insert a phasing relay jumper plate in its place. Similarly, if the protector has a desensitizing (BN) relay, remove the relay and install a BN relay jumper plate.

⚠WARNING
When completely installed, the SEL-632 chassis is grounded at several locations, and remains at a safe potential. However, during installation, these ground connections may not ensure the SEL-632 chassis remains at a safe potential for certain failure conditions. It is recommended that operators wear insulated gloves while installing the SEL-632.

Protectors already fitted with microprocessor-based relays will have jumper plates installed or will be wired without provision for separate phasing and time-delay/ instantaneous relays. In this case, replace the existing microprocessor relay with the SEL-632.

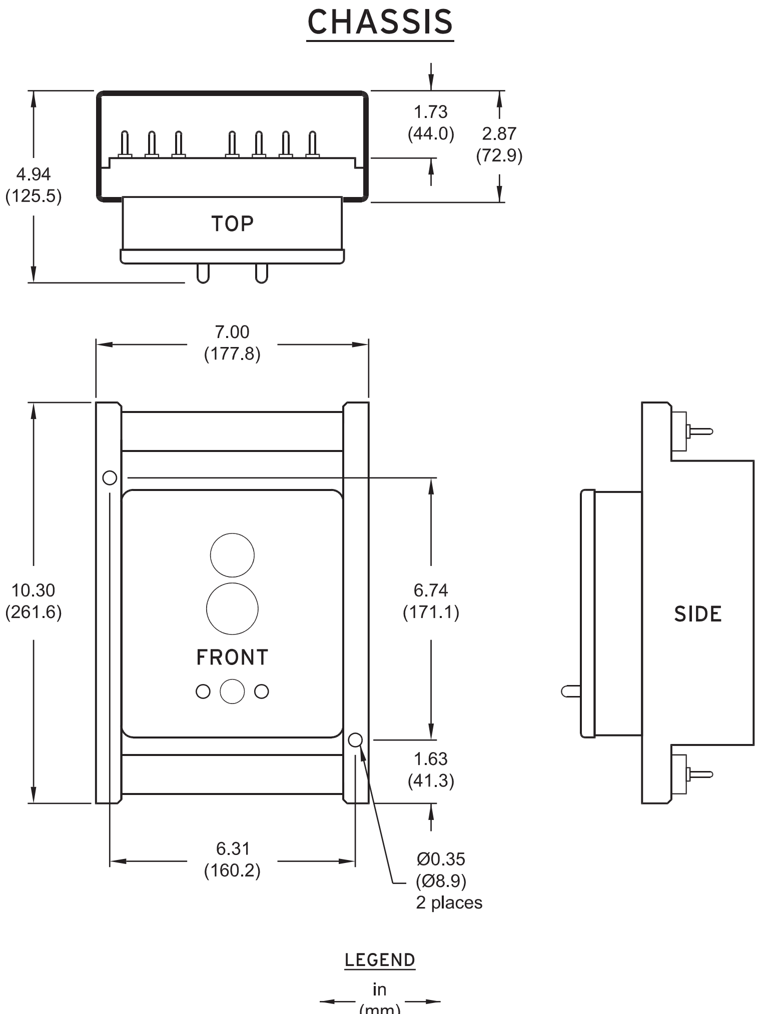

Figure 2.1 SEL-632 Dimensions

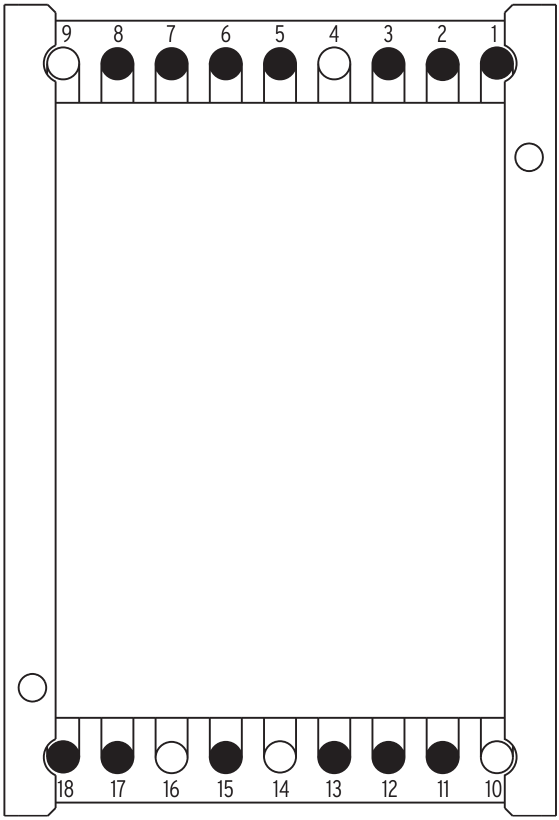

Figure 2.2 Physical Pin Location (Rear View)

Table 2.1 shows the pin connections between the SEL-632 and the network protector. The SEL-632 always identifies pins 6, 7, and 8 as Phase 1; pins 15, 17, and 18 as Phase 2; and pins 11, 12, and 13 as Phase 3 in metering, event reports, and Device Word bits. Pin connections in some protectors may be different than the connections shown in *Table 2.1*. The relay trip and close functions are not affected as long as the three pins associated with a given phase are connected to the same phase of the protector. For example, some protectors may be wired with Pins 11, 12, and 13 connected to the center phase and Pins 15, 17, and 18 connected to the right phase. This does not affect trip and close.

The SEL-632 is not sensitive to phase rotation.

Table 2.1 Pin Functions

Pin	Function
1	Output common
2	Trip output
3	Close output
4	Not connected
5	Ground
6	Phase 1 network voltage
7	Phase 1 transformer voltage
8	Phase 1 current
9	Not connected
10	Not connected
11	Phase 3 current
12	Phase 3 transformer voltage
13	Phase 3 network voltage
14	Not connected
15	Phase 2 current
16	Not connected
17	Phase 2 transformer voltage
18	Phase 2 network voltage

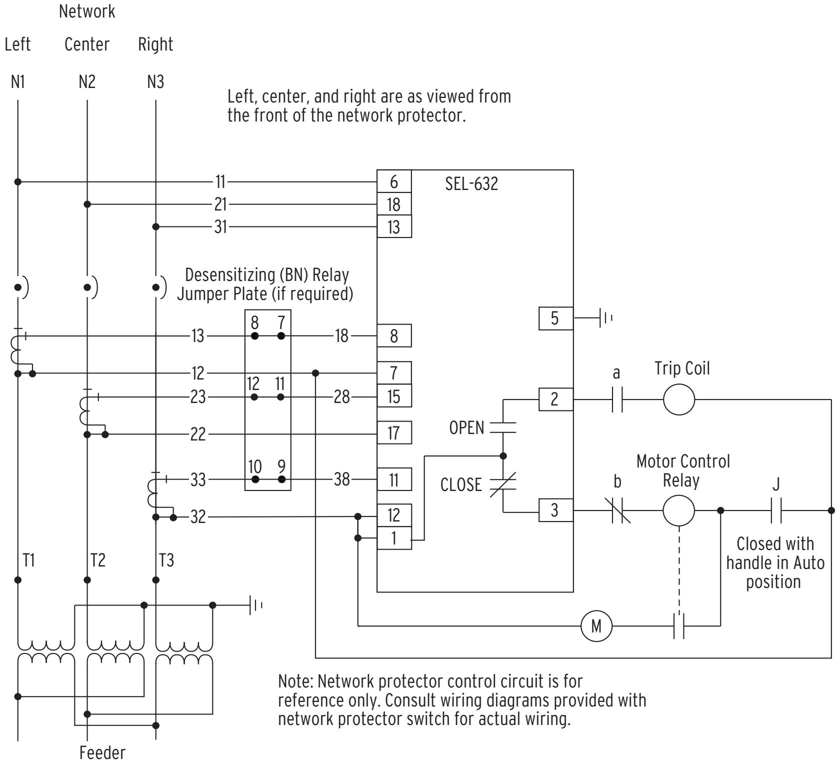

Figure 2.3 SEL-632 Wiring Diagram—Energized CT

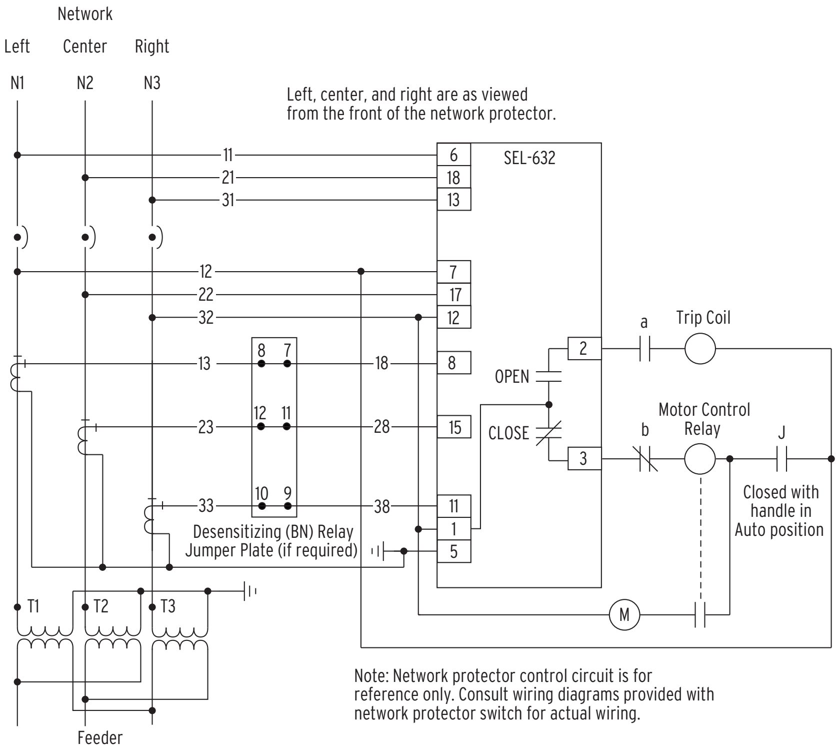

Figure 2.4 SEL-632 Wiring Diagram—Grounded-Wye CT

Section 3
Theory of Operation and Settings

The SEL-632 Network Protector Relay trip and close characteristics are based on the traditional watt trip and close characteristics of electromechanical master and phasing network protector relays. The SEL-632 replaces the master, phasing, and desensitizing relays.

The SEL-632 is a microprocessor-based relay that samples system currents and voltages, calculates the magnitude and angle of these signals, and compares the magnitude and angle values to user-defined and fixed thresholds to produce trip and close signals. The following sections describe the basic operating algorithms and settings. In most cases, these descriptions are sufficient to understand how the various settings affect relay operation. The logic diagrams in *Appendix D: Logic Diagrams* provide an alternate description of relay operation. Device Word bits shown on the logic diagrams make relay operation visible for testing. Refer to *Appendix C: Device Word Bits* for more information on Device Word bits.

Trip Operation

The eight settings shown in *Table 3.1* control how the relay trips in response to reverse power.

Table 3.1 Trip Settings

Description	Name	Range	Step	Default
Trip Mode	TM	1, 2, 3		1
Sensitive Trip Threshold	ST	1.0–5,000.0 mA	0.1	7.5
Sensitive Trip Delay	SD	1–255 cycles	1	6
Trip Tilt Angle	TA	85–95 degrees	1	90
Time Delay	TD	1–9,999 seconds	1	150
Instantaneous Current Threshold	IC	0.1–15.0 A	0.1	2.5
Insensitive Current Threshold	IT	0.1–15.0 A	0.1	2.5
Extended Delay	XD	0–255 seconds	1	0

The relay provides three automatic tripping modes: Sensitive, Time Delay, and Insensitive. Only one mode is active at a time. The active mode is selected using the Trip Mode Setting (TM) as follows:

- TM = 1 Sensitive Trip Mode
- TM = 2 Time Delay Trip Mode
- TM = 3 Insensitive Trip Mode

Sensitive Trip Characteristic

Figure 3.1 shows the sensitive trip characteristic of the SEL-632 plotted on real and imaginary power axes (the P-Q plane). Positive real power flow is towards the network, while negative real power flow is towards the network transformer. When Sensitive Trip Mode is enabled (TM = 1), the SEL-632 can trip if it detects reverse power flowing from the low-voltage network into the network transformer and distribution feeder. The sensitive trip characteristic is controlled by three settings: Sensitive Trip Threshold (ST), Sensitive Trip Delay (SD), and Trip Tilt Angle (TA). The relay continuously measures real power (P), imaginary power (Q), and network voltage (V_N) for all three phases. Measured P and Q are adjusted by multiplying each by $125/V_N$. The adjusted P and Q values for the three phases are added and compared to the trip characteristic. The relay starts the SD timer if the adjusted three-phase P and Q fall to the left of the trip characteristic defined by the ST and TA Settings. If the reverse power conditions continue until the SD timer expires, a Sensitive Trip condition is declared and a trip signal is issued to the network protector.

P_{set} is the desired trip threshold for three-phase reverse real power. Setting ST, in milliamps, is P_{set} expressed as a single-phase current. Setting ST is calculated for unity power factor, according to *Equation 3.1*.

$$ST = \frac{P_{set}}{3 \cdot NV \cdot 1000 \cdot CT/5} \qquad \textbf{Equation 3.1}$$

where:

P_{set} = Three-phase primary trip value in watts
NV = nominal voltage = 125 V
CT = CT primary rating

Because the measured power is adjusted by the network voltage magnitude, the current needed to trip is constant for any network voltage within the rated range. However if one or two phases of network voltage are lost, power cannot be calculated for those phases, which changes the amount of current needed in the remaining phase(s) to cause a trip.

Setting TA, in degrees, tilts the trip characteristic to adjust the effective real power threshold for a given imaginary power. TA values less than 90° rotate the trip characteristic clockwise in the P-Q plane (*Figure 3.2*) and TA values greater than 90° rotate the trip characteristic counterclockwise in the P-Q plane (*Figure 3.1*). Setting TA to values other than 90° does not change the trip threshold for unity power factor reverse power flows, but does change the real power sensitivity to inductive or capacitive backfeeds. For example, TA Settings less than 90° can be used to ensure tripping for bolted three-phase faults on the primary feeder when transformer X/R ratio is high. TA Settings greater than 90° can be used to ensure tripping for backfeed to primary feeders with significant capacitive cable charging currents.

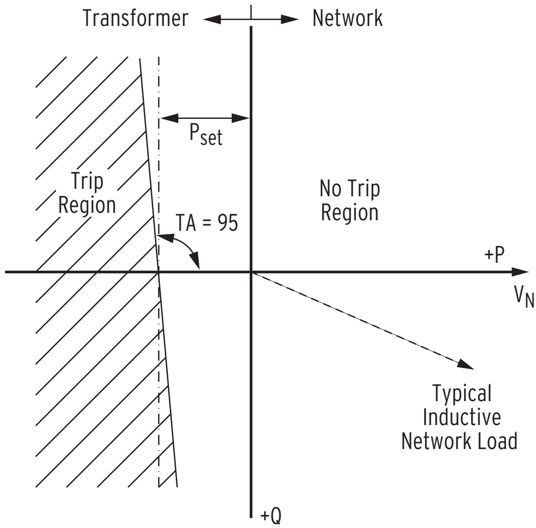

Figure 3.1 Sensitive Trip Characteristics With TA = 95 Degrees

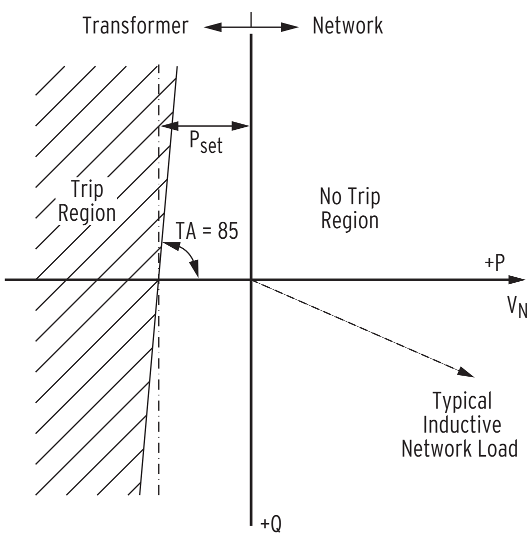

Figure 3.2 Sensitive Trip Characteristics With TA = 85 Degrees

Time-Delay Trip Characteristic

When TM = 2, if a reverse power condition occurs and persists long enough to cause a Sensitive Trip, an Instantaneous Trip condition is declared if the current is greater than the Instantaneous Current Threshold, IC. The Instantaneous Trip condition is further time qualified by the Extended Delay timer, discussed in *Extended Delay Timer*.

However, if the current is less than the Instantaneous Current Threshold, a timer is started. If the reverse power conditions persist for the Time-Delay Setting, TD, a Time Delay Trip condition is declared and a trip signal is issued to the network protector. If an Instantaneous Trip condition is declared and the Extended Delay timer is timing towards a trip, the Time Delay timer is reset.

The time-delay trip characteristic with instantaneous overcurrent override models the behavior of the Westinghouse BN relay. The time-delay characteristic is useful to prevent tripping on temporary reverse power flows caused by regenerative network loads.

Insensitive Trip Characteristic

When TM = 3, if a reverse power condition occurs and persists long enough to cause a sensitive trip, an insensitive trip condition is declared if the maximum phase current is greater than the Insensitive Current Threshold, IT. The insensitive trip condition is further time qualified by the Extended Delay timer, discussed in *Extended Delay Timer*. The insensitive trip mode can be used to prevent improper tripping due to regenerative loads, but may cause a failure to trip when the substation breaker on a dedicated feeder opens when there is no fault.

When using time-delay or insensitive trip characteristics, consider time coordination with network protector fuses. In general, it is desirable for the network protector relay to open the protector before the fuses open.

Extended Delay Timer

Instantaneous and Insensitive Trip conditions must persist long enough for the Extended Delay time, XD, to expire. If the Extended Delay timer expires, an Extended Delay trip condition is declared and a trip signal is issued to the network protector.

Communications Trip

Issuing the Open Protector (OP) command through Port F via an ASCII terminal program, such as HyperTerminal®, trips the network protector. The network protector can also be opened using the SEL-632 Network Protector Relay Software.

Overall Trip Logic

When a sensitive trip, time-delay trip, extended delay trip, or communications trip is declared, the trip output contact closes for one second, opens for one second, and then closes again, for a total of six close-open operations. The trip LED lights when the trip output is closed. After six close-open operations, if the initiating trip conditions are still present, the trip output opens and the trip LED blinks rapidly. If, however, the initiating trip conditions are no longer present, the trip output opens and the trip LED is extinguished. See *Figure D.6* and *Figure D.8* for logic details.

Close Operation

Automatic Reclose Function

The SEL-632 measures voltage on both sides of the network protector. The transformer-side voltage, V_T, for each phase is compared to the reference network-side voltage, V_N, for each phase, producing the difference voltage, $\overrightarrow{V_D} = \overrightarrow{V_T} - \overrightarrow{V_N}$. The network and difference voltages are used to calculate the real and reactive power which would flow in each phase if the network protector were closed. These values are scaled by $125/V_N$, where V_N is the measured magnitude of the network voltage. The scaled values are called the prospective real power and prospective imaginary power in *Figure 3.3*. The prospective real and imaginary power values are used to calculate the average prospective real and imaginary power values for the three phases. The single-phase and three-phase power values are compared to the close characteristic shown in *Figure 3.3*.

Network protector closing control has historically been provided by separate master and phasing relays. The SEL-632 closing characteristic emulates the traditional electromechanical master and phasing relays. To understand this close characteristic, it is helpful to realize that the current that flows after the network protector closes, labeled I (prospective) in *Figure 3.3*, lags the difference voltage by the system impedance angle, θ. In *Figure 3.3*, the network voltage, V_N, is the reference and the difference voltage, V_D, is shown leading V_N. If the network protector closes under these conditions, the current flowing though the protector lags V_N by an angle less than the system impedance angle. Real power and imaginary power flow into the network, which is the desired condition. The Master Relay characteristic ensures that the relationship between the difference and network voltages is such that imaginary power flows into the network after the network protector closes. The Phasing Relay characteristic ensures that the relationship between the difference and network voltages is such that real power flows into the network on closing.

In the SEL-632, when the three-phase average prospective power values satisfy the master relay close characteristic Device Word bit 3PMC asserts. There are similar Device Word bits 1MC, 2MC, and 3MC indicating that the master relay close characteristic is satisfied for each phase. When the three-phase average prospective power values satisfy the phasing relay characteristic Device Word bit 3PPC asserts. There are similar Device Word bits 1PC, 2PC, and 3PC indicating that the phasing relay close characteristic is satisfied for each phase.

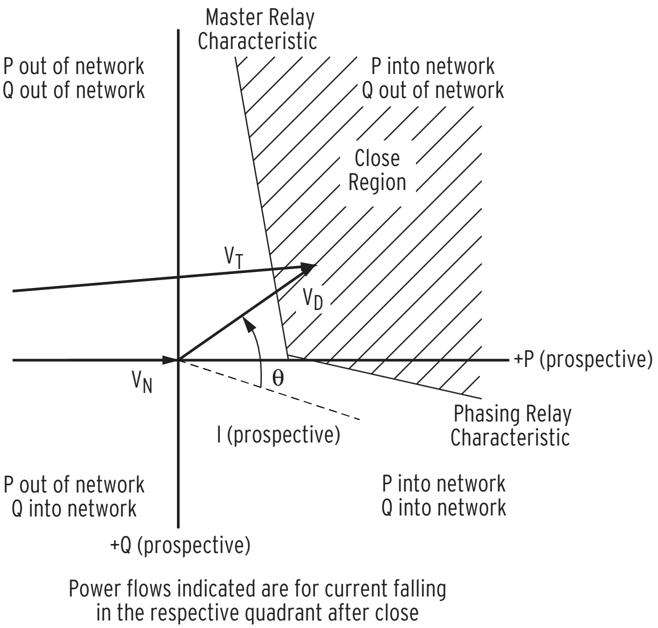

Figure 3.3 Close Characteristics of the SEL-632 Network Protector Relay

The four settings shown in *Table 3.2* control the size and shape of the relay close region. See *Figure 3.4* for a graphical representation of the settings.

Table 3.2 Close Settings

Description	Name	Range	Step	Default
Reclose Voltage	RV	0.1–10.0 V	0.1	1.4
Close Tilt Angle	CA	85–95 degrees	1	95
Reclose Angle	RA	–25 to +5 degrees	1	–5
Close Time Delay	CD	1–65,535 cycles	1	6

Reclose Voltage, RV, establishes the minimum difference voltage magnitude required to issue a close command when the difference voltage and network voltage are in phase. Allowing the network protector to close with small difference voltage magnitude can lead to excessive operations, a condition known as pumping. The Close Tilt Angle, CA, allows Master Relay characteristic adjustment to increase or decrease the size of the close region. Setting CA to 95 degrees rotates the Master Relay characteristic counterclockwise, as shown in *Figure 3.4*, while setting CA to 85 degrees rotates the Master Relay characteristic clockwise.

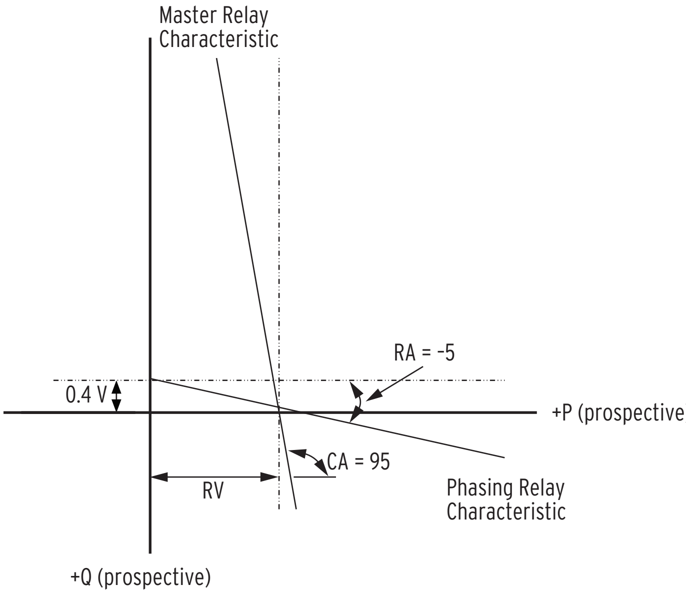

Figure 3.4 Close Characteristic Settings

Reclose Angle, RA, adjusts the Phasing Relay characteristic angle. Reclose Angle Settings less than zero are used to make the close region as large as possible, although setting the angle too wide may cause power flows out of the network when the network protector closes and lead to pumping.

When the three phase average prospective power values and the values for at least one of the individual phases fall into the close region, the Close Delay timer, CD, starts, as long as the Block Close command is not active (*Figure D.7*). If the prospective power values remain within the close region, the Close Delay timer expires and the close output asserts. If the prospective power values do not remain within the close region, the Close Delay timer resets.

Rolled and Crossed-Phases Detection

The SEL-632 automatic reclose logic will not operate when phases on the network or transformer are rolled or crossed. This does not prevent the network protector from being manually closed with rolled or crossed phases.

⚠DANGER

The SEL-632 does not prevent a network protector from being closed manually when phases are rolled or crossed. Closing a protector under such conditions may result in damage to equipment, severe injury, or death. Verify proper phasing before attempting any manual close operation.

Dead Network Close

The SEL-632 receives control power from any of the three phases on the network side of the network protector. The close output is a Form-B contact that closes whenever control power is lost, as would occur in the event of a dead network. This means that a close signal is applied to the network protector close coil whenever the relay is without control power, and if closing power is available, the network protector will close. As soon as relay control power is available from at least one phase, the close output contact opens while the relay performs diagnostic checks, enables, and begins to evaluate the trip and close characteristics. If the close characteristics are satisfied, the relay issues a **CLOSE** command to energize the network protector close coil. The relay also contains dead network close logic that issues a close command when all three phases of the network voltage are less than 13 V phase-neutral, even if the relay is still enabled. If, however, the relay determines that the network protector should trip, the dead network close logic is defeated. See *Figure D.7* and *Figure D.8* for logic details.

Communications Block Closed

Issuing the Block Protector (BP) command via an ASCII terminal program asserts Device Word bit BLOCK. When BLOCK is asserted, the automatic reclose function does not operate (*Figure D.8*). The relay may still energize the network protector close circuit though the dead network close function. The close output contact closes to energize the network protector close circuit when control power is lost regardless of the status of BLOCK.

Issuing the Unblock Protector (UP) command unblocks the protector and returns automatic reclosing to normal operation. The protector may also be blocked and unblocked using the SEL-632 Network Protector Relay Software.

Close Output Logic

The close output contact energizes the close circuit of the network protector whenever the automatic reclose or the dead network close functions issues a close command and a trip is not in progress. The close output is blocked when a trip is in progress. See *Figure D.7* and *Figure D.8* for logic details.

The close LED illuminates whenever the relay logic is issuing a close signal. The close LED does not illuminate when the relay is without control power and the Form-B close output contact is closed. The close LED indicates only that the relay is attempting to close the switch—it does not indicate switch position.

General Settings

In addition to the settings for the trip and close characteristics discussed in *Trip Operation on page 3.1* and *Close Operation on page 3.5*, there are two General Settings required to properly configure the relay. See *Table 3.3*.

Table 3.3 General Settings

Description	Name	Range	Step	Default
Current Transformer Primary Current Rating	CT	50–12750	50	1600
Phase Sequence Selection	PS	1 = ABC 2 = ACB 3 = BAC 4 = BCA 5 = CAB 6 = CBA		1

Set Current Transformer Primary Current Rating (CT) equal to the current transformer primary value. This setting is used for metering and reporting only. In some cases, this may not be the same as the rating of the network protector. The SEL-632 is designed only for connection to current transformers with a 5 A nominal secondary.

Select the numerical setting for Phase Sequence Selection (PS) that corresponds to the phase sequence matching the relay connections. For example, setting PS = 1 indicates that Phase A network voltage is connected to Terminal 6 of the relay, Phase B network voltage is connected to Terminal 18, and Phase C network voltage is connected to Terminal 13. The PS Setting is used only to record the phase connections. It does not affect how the relay operates, displays metering information, or produces event reports.

Entering Settings

Relay settings can be entered using the ASCII interface (see *Using Terminal Commands on page 5.16*) or via the SEL-632 Network Protector Relay Software (see *PC Software on page 5.1*).

Relay Operating Modes

The SEL-632 can operate in any one of four modes. The mode is included in the rotating front-panel displays (see *Section 4: Front-Panel Messages and Monitoring*), on the Relay Status screen of SEL-632 Network Protector Relay Software, and in the **RS** command (see *Using Terminal Commands on page 5.16*). The four modes are as follows:

- OPEN—Relay trip is in progress
- CLOSE—Relay close is in progress
- BLOCKED—Remote block signal has been issued and TRIP is not active. Note that the automatic reclose logic cannot cause CLOSE to assert when the relay is blocked.
- FLOAT—None of the other three modes are active.

The relay operating mode does not necessarily indicate the status of the network protector. For example, the relay logic may be attempting to trip the network protector, causing the operating mode to be OPEN, but the network protector may in fact be closed. This could occur if the network protector trip coil has failed, tripping voltage has been lost, or the breaker has failed to open due to a problem with the mechanism.

Cycle Counter

Each time the relay issues a normal close signal followed by a trip, the Cycle Counter is incremented. The counter increments to 999,999 cycles before rolling over to zero. The value of the cycle counter is included in the rotating front panel displays (see *Section 4: Front-Panel Messages and Monitoring*), on the Relay Status screen of SEL-632 Network Protector Relay Software, and in the **RS** command (see *Using Terminal Commands on page 5.16*).

Section 4

Front-Panel Messages and Monitoring

The SEL-632 provides a four-character LED display and two LEDs for indication. The display continuously rotates through the messages shown in *Table 4.1*. Messages longer than four characters are scrolled across the display. If a diagnostic warning or failure occurs, an appropriate diagnostic message from *Table 7.2* is added to the rotation and displayed after each of the messages shown in *Table 4.1*. Trip and close LED operation is discussed in *Overall Trip Logic on page 3.5* and *Close Output Logic on page 3.8*.

Table 4.1 Front-Panel Display Messages (Sheet 1 of 2)

Message Description	Message Contents	Display Format/Values
Mode of Operation	Relay operating mode	OPEN CLOSE BLOCKED FLOAT
Trip Mode	Trip Mode Setting	SENSITIVE TIME DELAY INSENSITIVE
CT Setting	Current Transformer Primary setting *xxxxx* from CT setting	CT = *xxxxx*:5
Network Voltages	Phase 1 network voltage (V) Phase 2 network voltage (V) Phase 3 network voltage (V)	N1 = *xxx* N2 = *xxx* N3 = *xxx*

Table 4.1 Front-Panel Display Messages (Sheet 2 of 2)

Message Description	Message Contents	Display Format/Values
Line Currents (displayed when protector is closed)	Phase 1 primary current (amps)	I1 = *xx,xxx*
	Phase 1 current angle relative to network voltage 1[a] (degrees)	P1 = *xxx*
	Phase 2 primary current (amps)	I2 = *xx,xxx*
	Phase 2 current angle relative to network voltage 2[a] (degrees)	P2 = *xxx*
	Phase 3 primary current (amps)	I3 = *xx,xxx*
	Phase 3 current angle relative to network voltage 3[a] (degrees)	P3 = *xxx*
Difference Voltage (displayed when protector is open)	Phase 1 difference voltage (volts)	D1 = S*xx.x*[b]
	Phase 1 difference voltage angle relative to network voltage 1[a] (degrees)	P1 = *xxx*
	Phase 2 difference voltage (volts)	D2 = S*xx.x*[b]
	Phase 2 difference voltage angle relative to network voltage 2[a] (degrees)	P2 = *xxx*
	Phase 3 difference voltage (volts)	D3 = S*xx.x*[b]
	Phase 3 difference voltage angle relative to network voltage 3[a] (degrees)	P3 = *xxx*
Cycle Counter	Total number of close/trip operations	CYCLES = *xxx,xxx*
Temperature	Relay internal temperature (°C)	TEMP = *xxx*C

a. See Relay Readings on page 5.19 for definition of current and difference voltage angles.
b. S is + when difference voltage is leading network voltage. S is – when difference voltage is lagging network voltage.

Section 5
Terminal Commands and PC Software

Communications Port and Cable Requirements

Use an optical serial port (Port F) to access metering data, event reports, relay status, and settings. The port parameters are fixed.

- Speed: 9600 bps
- Data bits: 8
- Parity: None
- Stop bits: 1

Figure 5.1 shows the physical arrangement of Port F. See *Specifications on page 1.5* for detailed port receiver and transmitter information. Use SEL C667 or other appropriate communications cable.

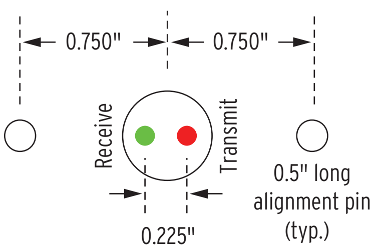

Figure 5.1 Port F Physical Arrangement

PC Software

Overview

SEL provides several PC software solutions that support the SEL-632 and other SEL devices. SEL-632 software solutions are listed in *Table 5.1*.

Table 5.1 SEL Software Solutions

Product Name	Function
SEL-632 Network Protector Relay Software	Create and manage settings, view SEL-632 metering and status, and retrieve event reports.
ACSELERATOR® Analytic Assistant SEL-5601 Software	Plot SEL compressed ASCII event report files
SEL-5801 Cable Selector Software	Select the proper SEL cables for your application.

This section describes how to get started with the SEL-632 and SEL-632 Network Protector Relay Software. SEL-632 Network Protector Relay Software is a powerful setting, event analysis, and measurement tool for setting the SEL-632, viewing metering and relay status, and retrieving and viewing event reports. The suite of SEL-632 Network Protector Relay Software applications for the SEL-632 includes the following:

Settings Editor	Provides online and offline settings editing. Use this feature to create and modify settings for multiple network protector relays.
Relay Status	Provides device identification and status information.
Event Analysis	Provides oscillography for event analysis.
Metering	Provides metering data for inspection and reporting.
Control	Provides control functions for the network protector relay.

Installation

To install the SEL-632 Network Protector Relay Software, double-click on the file named "setup.exe." A wizard will appear to guide you through the installation process. As part of this process, two empty subfolders will be automatically created to make it easy for you to store settings and waveform files on your PC.

Uninstallation

To uninstall the SEL-632 Network Protector Relay Software, select the **Start > Settings > Control Panel > Add or Remove Programs** menu. Locate SEL-632 Network Protector Relay in the list and press the **Remove** button. If you have previously saved either settings or waveform files, those files will not be automatically deleted by the uninstallation process. However, all other application files will be automatically and completely deleted by the uninstall process. If you would like settings or event files permanently deleted from your hard drive, you must delete them manually.

Upgrading From Previous Versions of SEL-632 Network Protector Relay Software

Before you can install a new (upgraded) version of the SEL-632 Network Protector Relay Software, you must first uninstall the previously installed version of the software (see the *Uninstallation* section). When you run the installer for a new (upgraded) version of SEL-632 Network Protector Relay Software, the installation process will preserve any settings or event files that were left on the hard drive after uninstalling a prior version of the product. These data files will be available for use in the new version of the software.

Prepare the Relay and Begin Communication

Prepare the network protector relay for communication as follows:

Step 1. Connect the appropriate communications cable between the SEL-632 and the PC.

Step 2. Apply power to any one phase of the network voltage inputs on the SEL-632.

Step 3. Start SEL-632 Network Protector Relay Software.

The SEL-632 Network Protector Relay Software main window is displayed (see *Figure 5.2*).

Step 4. Select the appropriate communications port using the Port menu.

The Port menu is shown in *Figure 5.3*.

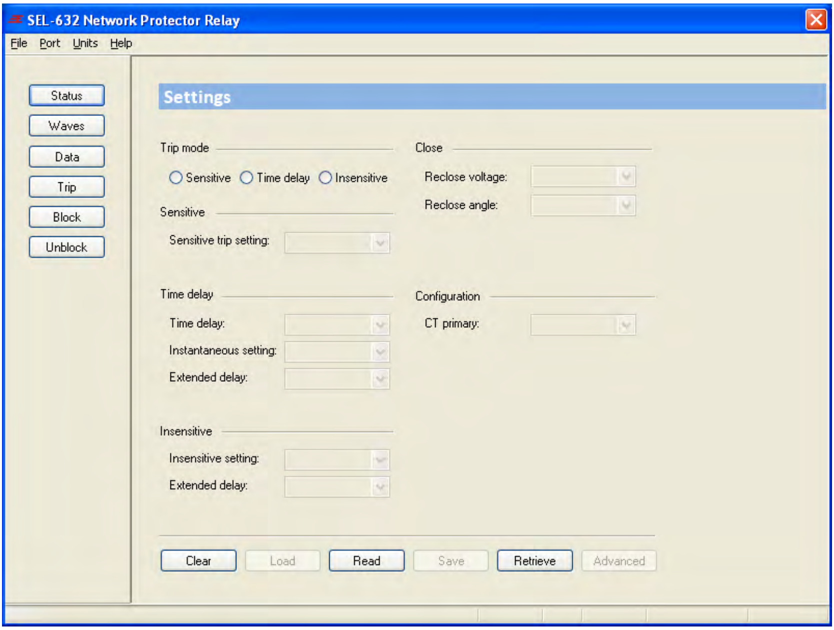

Figure 5.2 Main Window

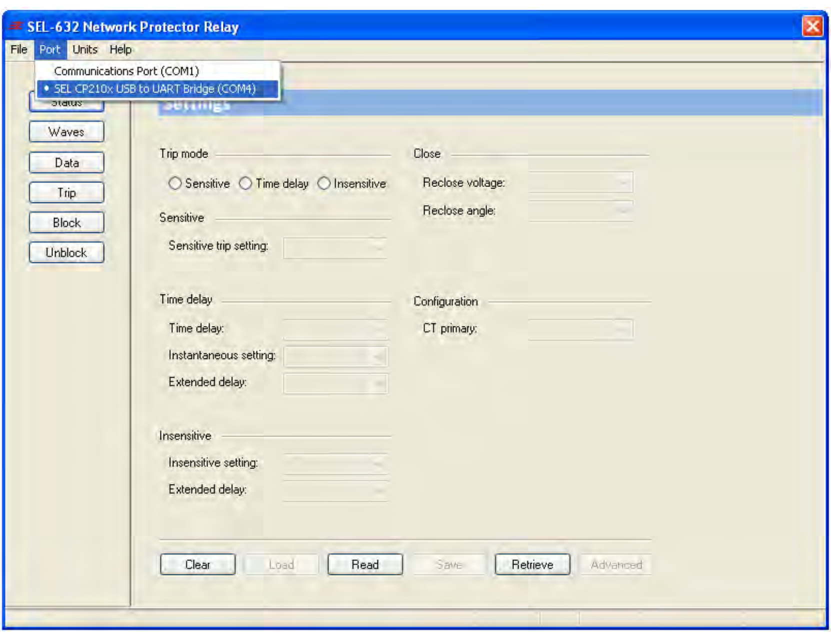

Figure 5.3 Port Menu

The SEL-632 Network Protector Relay Software main menu and navigation button bar are shown in *Figure 5.4*. Submenu options are explained in detail in *Table 5.2*.

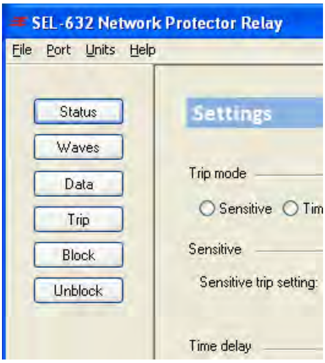

Figure 5.4 SEL-632 Network Protector Relay Software Main Menu

Table 5.2 SEL-632 Network Protector Relay Software Main Menu and Submenu Options

Main Menu	Submenu	Description
File	Print	Print the current view
	Print Preview	Preview the current view
	Print Setup	Edit printer setup
	Exit	Quit the SEL-632 Network Protector Relay software
Port		Displays a list of available communications ports
Units	Protector	Displays metering and settings on the protector base
	Relay	Displays metering and settings on the relay base
	Percentage	Displays metering and settings as percentages of the secondary rating (5 A)
Help	Diagnostic Information	View Device Identification, Device Status, Channel Offsets, Power Supply Voltages, and Integrated Circuit Status
	About	View application information

Offline Operations

When the PC is not connected to an SEL-632, SEL-632 Network Protector Relay Software supports editing existing settings files and viewing waveform files stored on the PC.

Online Operations

When the PC is connected to an SEL-632, SEL-632 Network Protector Relay Software supports editing settings in the connected device, triggering an event, retrieving event waveforms from the device, viewing metering data, and viewing relay status, in addition to the offline functions.

Settings Editor

A button bar is located across the bottom of the Settings Editor, presenting the user with buttons for reading settings from the relay, loading settings to the relay, saving settings to disk, retrieving settings from disk, clearing changes, and accessing Advanced Settings.

Edit Device Settings

Select the **Read** button located on the button bar at the bottom of the Settings Editor to read the active settings from the relay and display them in the editor.

The settings editor will display all of the settings associated with Trip, Close, and Configuration on one screen. Underneath the Configuration heading, select the appropriate **CT Primary** rating to match the current transformer installed in the network protector. Underneath the Close heading, enter the desired settings for the **Reclose Voltage** and **Reclose Angle**. Selecting the desired **Trip Mode** enables the appropriate trip settings; disabled settings will be grayed out and cannot be modified.

When the Sensitive trip mode is selected, the Sensitive Settings group is enabled for modification, while the Time Delay and Insensitive Settings remain disabled.

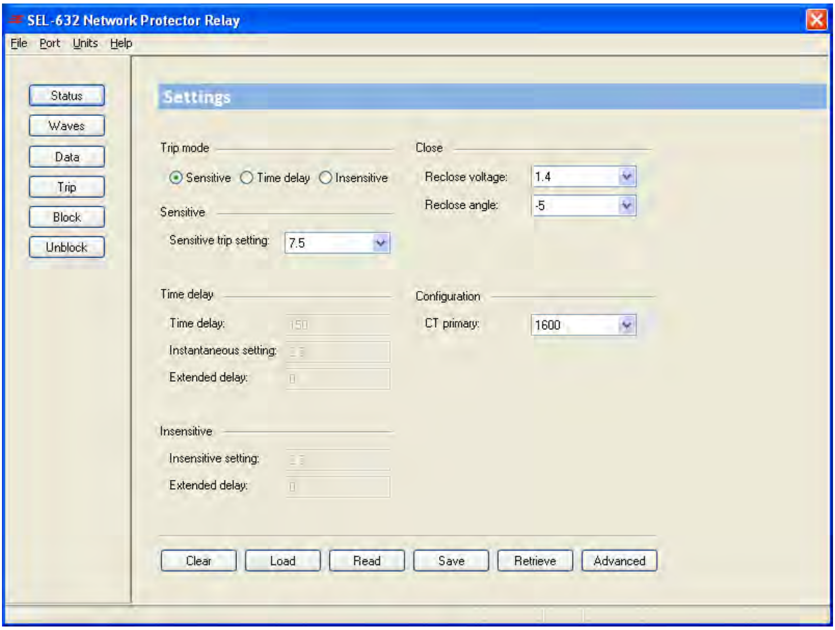

Figure 5.5 Settings Editor—Sensitive Trip Mode

When the Time-Delay trip mode is selected, the Time Delay Settings group is enabled for modification in addition to the Sensitive Settings, while the Insensitive Settings remain disabled.

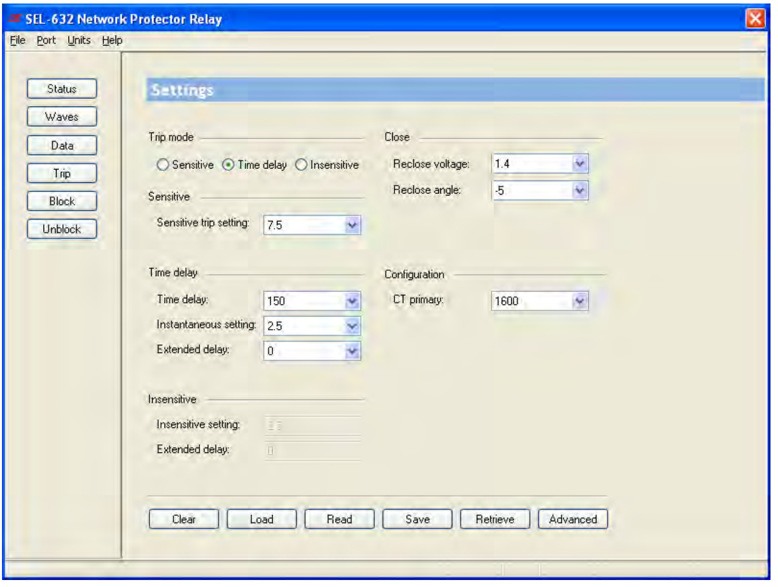

Figure 5.6 Settings Editor—Time-Delay Trip Mode

When the Insensitive trip mode is selected, the Insensitive Settings group is enabled for modification in addition to the Sensitive Settings, while the Time-Delay Settings remain disabled.

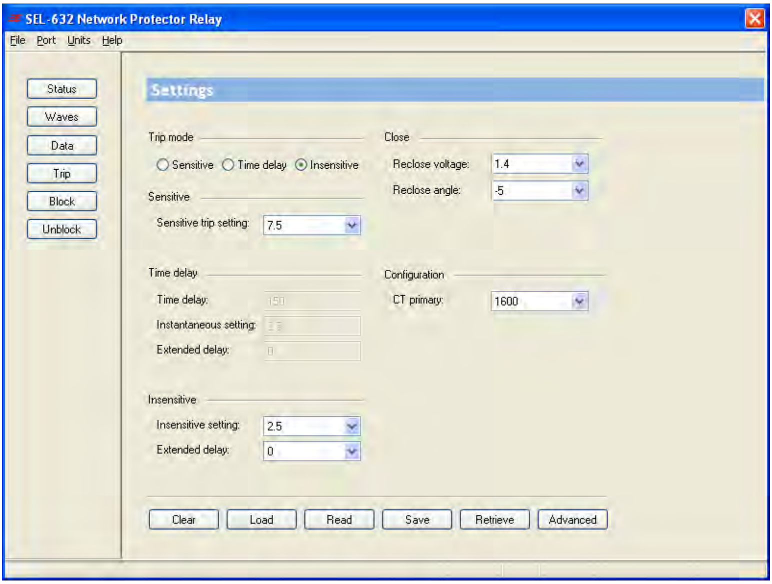

Figure 5.7 Settings Editor—Insensitive Trip Mode

To access the Advanced Settings click on the **Advanced** button; after which the software will request confirmation (*Figure 5.8*). Select **Yes** to access the Advanced Settings or **No** to cancel the request. If **Yes** is selected, the Advanced Settings editor is shown (*Figure 5.9*) and the Advanced Settings editor may be exited and returned to again without an additional confirmation request.

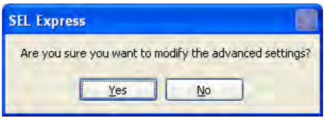

Figure 5.8 Confirmation Window

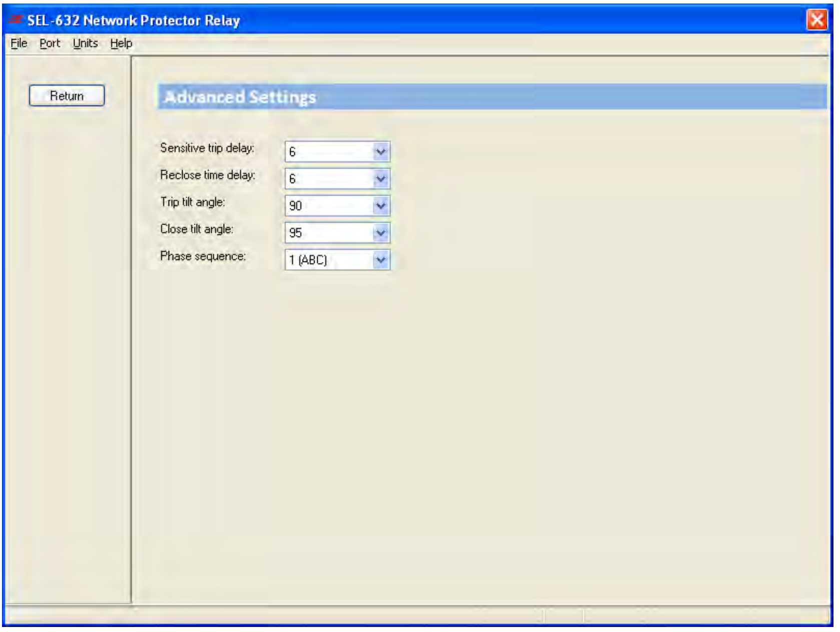

Figure 5.9 Advanced Settings Editor

Edit the Advanced Settings as desired and click the **Return** button when completed.

Use the **Save** button to specify a filename and save the settings to the PC (*Figure 5.10*). Use the **Send** button to send the settings to the relay. The software issues a **Program Enable** command automatically and provides notification that the settings have been successfully transferred to the device or if the settings failed to transfer.

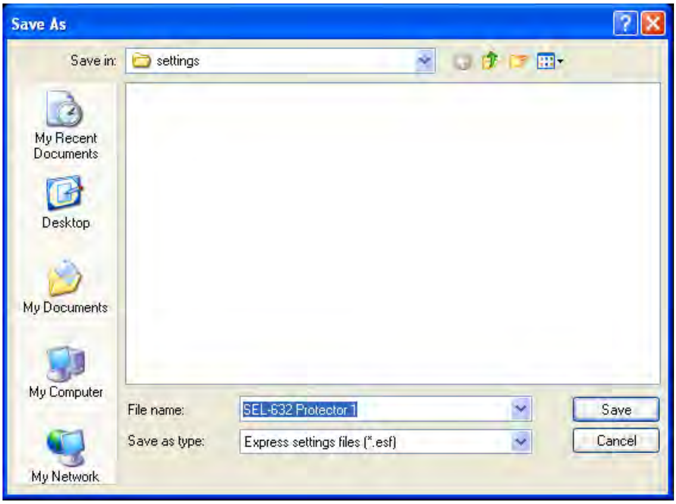

Figure 5.10 Save As Window

Open an Existing Settings File

Select the **Retrieve** button to open existing relay settings stored on the PC. SEL-632 Network Protector Relay Software displays the **Open** window (*Figure 5.11*) and prompts for a device to load into the **Settings Editor**.

Highlight the desired settings file and select **Open**.

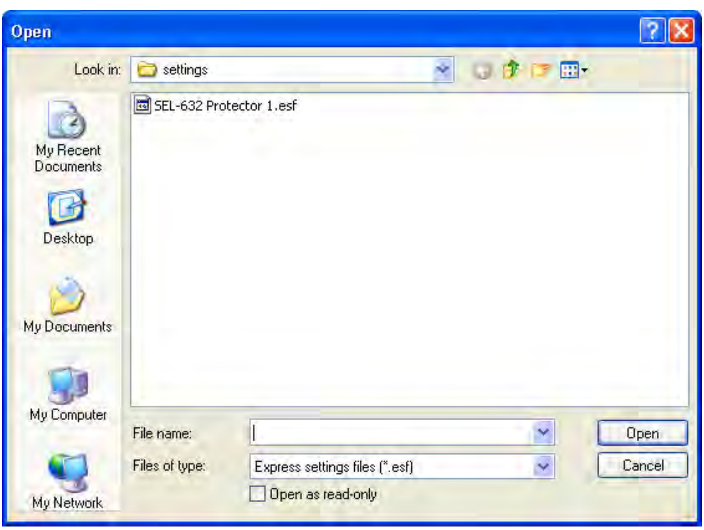

Figure 5.11 Settings Open Window

Control Functions

Select the **Trip** button to manually open the network protector. See *Communications Trip on page 3.4* for additional information.

Select the **Block** button to block automatic reclose. See *Communications Block Closed on page 3.8* for additional information.

Select the **Unblock** button to remove the automatic reclose block. See *Communications Block Closed on page 3.8* for additional information.

View Device Status, Waveforms, and Metering

Select the **Status** button to view information pertaining to the current mode of operation, number of relay trip/close cycles, relay temperature, and phase sequence. Detailed self-status information may be viewed by selecting **Help** > **Diagnostic Information**. See *Relay Self-Tests on page 7.2* for additional information.

Select the **Waves** button to retrieve a stored event report and open the waveform viewer. See *Section 6: Event Report Retrieval and Analysis* for additional information.

Select the **Data** button to see the measured currents and voltages, as shown in *Figure 5.12*.

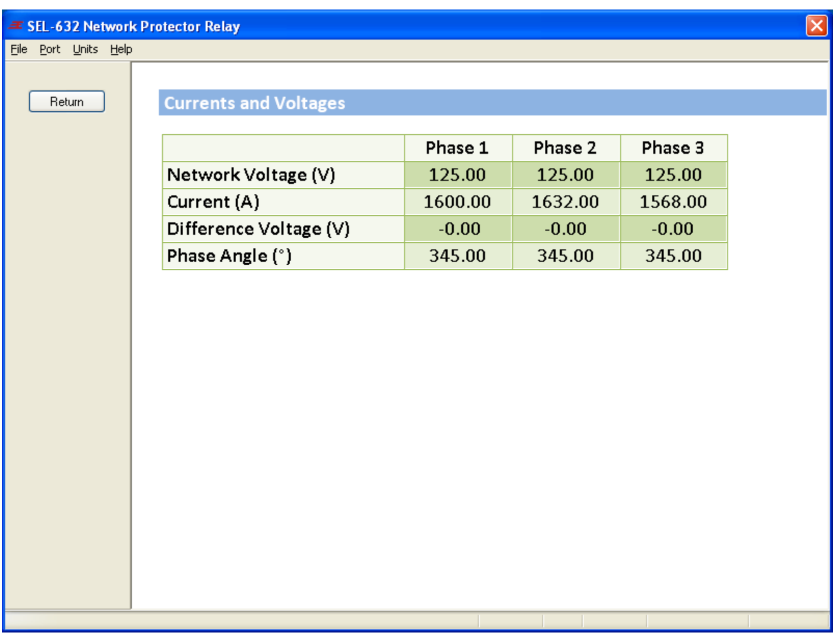

Figure 5.12 Metering Screen

ASCII Terminal Interface

Although the SEL-632 Network Protector Relay Software provides the same functions in an intuitive, easy-to-use interface, it is possible to retrieve metering and event reports, view status, and set the SEL-632 using ASCII terminal commands. The ASCII commands consist of basic commands, used for retrieving reports and setting the relay, and a set of advanced commands, used for troubleshooting, testing and software interface. Any terminal emulator, such as HyperTerminal®, can be used.

Establishing a Terminal Connection

To prepare the network protector relay for communications follow these steps.

Step 1. Connect the appropriate communications cable between the SEL-632 and the PC.

Step 2. Apply voltage to any one phase of the network voltage inputs on the SEL-632.

Step 3. Start HyperTerminal or other terminal emulator software. (HyperTerminal was used in the following steps.)

On a personal computer running Windows, you would typically click **Start** > **Programs** > **Accessories** > **Communications** to access HyperTerminal.

Step 4. Enter a name, select any icon, and click **OK** (*Figure 5.13*).

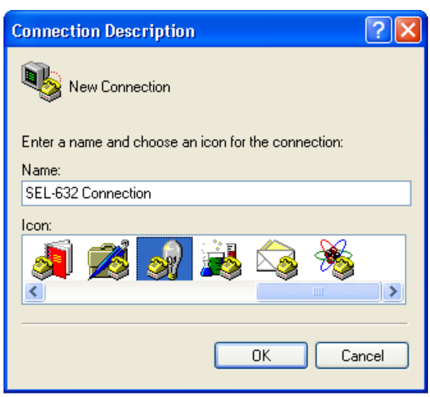

Figure 5.13 Enter Connection Name and Select Icon

Step 5. Select the computer serial port you are using to communicate with the relay and click **OK** (*Figure 5.14*). USB-optical communications cables, such as the SEL C667, are assigned a virtual port number. To see what virtual COM port has been created, select **Start > Settings > Control Panel > System**, click the **Hardware** tab, and click **Device Manager** to inspect the available COM ports as shown in

Figure 5.15. Use the Device Manager to verify which virtual COM port is associated with a particular USB port. The Device Manager updates the available COM ports each time a cable is inserted or removed.

Figure 5.14 Select PC Serial Port Number

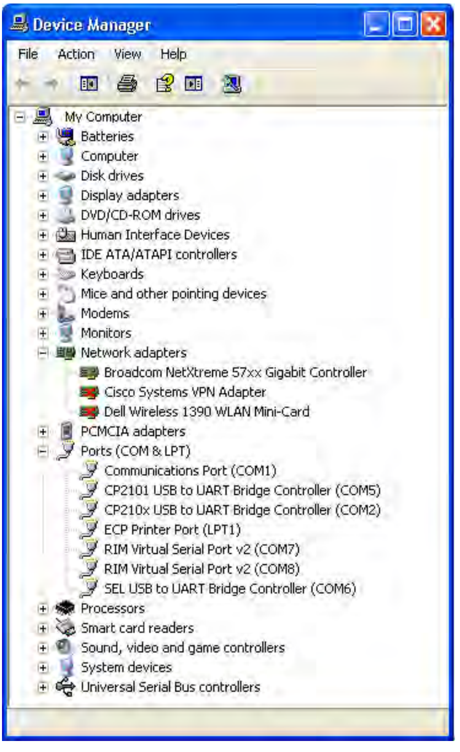

Figure 5.15 Windows Device Manager

Step 6. In the connection properties window, select the communications port parameters as shown in *Figure 5.16*. Click **OK**.

Figure 5.16 Select Communications Parameters

Step 7. In the HyperTerminal main window, choose **File** > **Properties**, then select the **Settings** tab. Select **VT100** from the **Emulation** list box and click **OK** (see *Figure 5.17*).

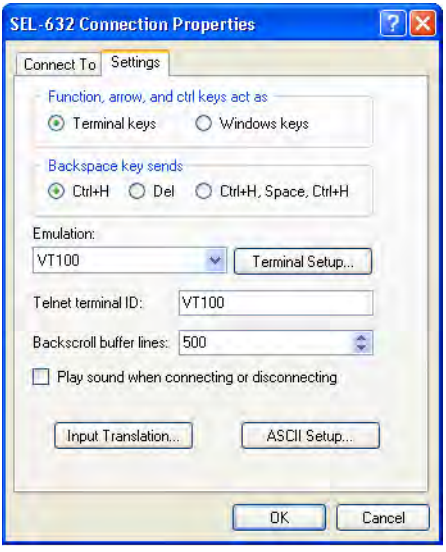

Figure 5.17 Select VT100 Terminal Emulation

Using Terminal Commands

Press **<Enter>** to establish communications with the device. A prompt (>) is returned indicating that communications are active (see *Figure 5.18*). All commands must be entered at the prompt and be followed by **<Enter>**. If a command is not entered within 30 seconds, the communications port times out and the session ends. Press **<Enter>** again to gain access to the prompt.

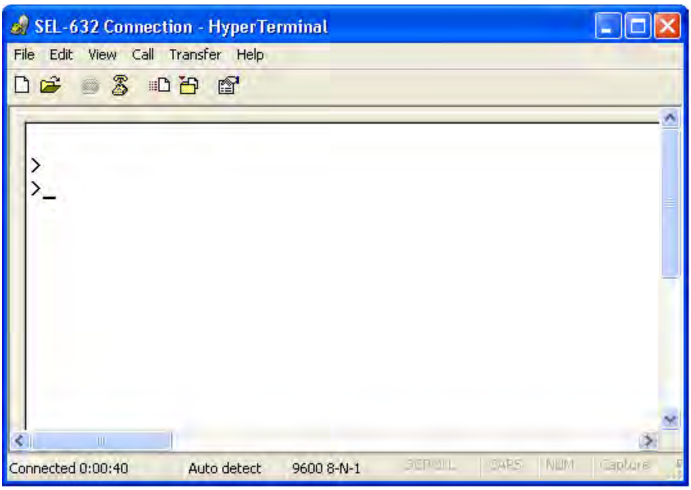

Figure 5.18 Confirm Serial Communication

When terminal commands are used to enter settings (see *Setting Commands on page 5.21*), any settings not saved by issuing a **PE** (program enable) command are lost if the port is allowed to time out.

Table 5.3 and *Table 5.4* show basic and advanced terminal commands. Advanced commands are used by the SEL-632 Network Protector Relay Software, during testing, or when upgrading firmware. For commands longer than three characters, only the first three characters are required.

Table 5.3 Basic Terminal Commands (Sheet 1 of 3)

Command	Command Description	Usage	Function
Operating Commands			
BP	Block Protector	BP	Block automatic reclose
UP	Unblock Protector	UP	Remove automatic reclose block
OP	Open Protector	OP	Manual open protector command

Table 5.3 Basic Terminal Commands (Sheet 2 of 3)

Command	Command Description	Usage	Function
Report Commands			
PQ	Program Query	PQ	Display active relay settings, or pending settings if new settings have been entered but no **PE** command has been issued
RS	Relay Status	RS	Display relay status, including mode of operation, number of close/trip cycles, firmware revision and date, and serial number
RR	Relay Readings	RR	See *Relay Readings on page 5.19*
WV	Waveform Upload	WV	See *Section 6: Event Report Retrieval and Analysis*
Program Enable			
PE	Program Enable	PE	Store previously entered settings to memory and begin using settings for operation
Setting Commands			
CT	Current Transformer Primary Current Rating	CT=*nnnnn*	Enter Current Transformer Primary Current Rating setting value *nnnnn*
PS	Phase Sequence Selection	PS=*n*	Enter Phase Sequence Selection setting value *n*
CD	Reclose Time Delay	CD=*nnnnn*	Enter Reclose Time Delay setting value *nnnnn*
RV	Reclose Voltage	RV=*nn.n*	Enter Reclose Voltage setting value *nn.n*
RA	Reclose Angle	RA=*snn*	Enter Reclose Angle setting value *snn*, where *s* is + or – sign and *nn* is the angle value
CA	Close Tilt Angle	CA=*nn*	Enter Close Tilt Angle setting value *nn*
TM	Trip Mode	TM=*n*	Enter Trip Mode setting value *n*
XD	Extended Delay	XD=*nnn*	Enter Extended Delay timer setting value *nnn*
ST	Sensitive Trip	ST=*nnnn.n*	Enter Sensitive Trip threshold setting value *nnnn.n*
TA	Trip Tilt Angle	TA=*nn*	Enter Trip Tilt Angle setting value *nn*
SD	Sensitive Trip Delay	SD=*nnn*	Enter Sensitive Trip Delay setting value *nnn*

Table 5.3 Basic Terminal Commands (Sheet 3 of 3)

Command	Command Description	Usage	Function
TD	Time Delay	TD=*nnnn*	Enter Time Delay setting value *nnnn*
IC	Instantaneous Current	IC=*nn.n*	Enter Instantaneous Trip Current setting value *nn.n*
IT	Insensitive Trip Current	IT=*nn.n*	Enter Insensitive Trip Current setting value *nn.n*

Table 5.4 Advanced Terminal Commands (Sheet 1 of 2)

Command	Command Description	Usage	Function
BEVent	Binary Event	**BEV L*y***	Request relay to send via Y-modem protocol a compressed file containing the last event report in a binary format. Command is used by SEL-632 Network Protector Relay Software and the transmitted file is readable only by that software. Optional L*y* parameter returns the first *y* cycles of the event, where *y* is 15–64. If L*y* is not included, the relay displays 64 cycles
CAL	Calibration Access Level	**CAL**	Enter calibration access level. Use only under the direction of SEL.
CEVent	Compressed Event	**CEV L*y***	Display last event report in a device-readable format. Optional L*y* parameter returns the first *y* cycles of the event, where *y* is 15–64. If L*y* is not included, the relay displays 64 cycles. Record the displayed event report using text-capture function in terminal software. Use SEL-632 Network Protector Relay Software or SEL-5601 software to view the event report.
ID	Display identification	**ID**	Display firmware and part number information
L_D	Load firmware	**L_D**	Prepare relay to load new firmware. Use only under the direction of SEL.
LT	Lamp test	**LT**	Initiate relay front-panel display and lamp test sequence
SHOw	Show settings	**SHO**	Same as PQ
		SHO C	Show calibration settings

Table 5.4 Advanced Terminal Commands (Sheet 2 of 2)

Command	Command Description	Usage	Function
STAtus	Display relay status	**STA**	Display relay self-test status report
		STA C	Clear self-test warnings and reboot device
TARget	Display targets	**TAR *row k***	Display row *row* from Device Word. Repeat *k* times (defaults to 1 if *k* is omitted).
		TAR *name k*	Display Device Word bit *name*. Repeat *k* times (defaults to 1 if *k* is omitted).
		TAR	Display last Device Word row displayed using TAR row or TAR name. Defaults to Row 0.
		TAR R	Displays Device Word Row 0 and resets TAR command to default row
TRIgger	Event trigger	**TRI**	Request relay to trigger event report capture

Operating Commands

Issuing the Open Protector (**OP**) command via Port F requests the relay to open the network protector. Once the protector is open, if system conditions are appropriate for automatic reclose, the relay will close the protector. To prevent automatic reclose, issue the Block Protector (**BP**) command before issuing the **OP** command.

Relay Readings

Issuing the **RR** command via Port F requests the relay to display Relay Readings in the terminal window. The Relay Reading report displays the following quantities:

- N1: Phase 1 network voltage in volts
- N2: Phase 2 network voltage in volts
- N3: Phase 3 network voltage in volts
- I1: Phase 1 line current in primary amps
- I2: Phase 2 line current in primary amps
- I3: Phase 3 line current in primary amps
- D1: Phase 1 difference (phasing) voltage in volts
- D2: Phase 2 difference (phasing) voltage in volts
- D3: Phase 3 difference (phasing) voltage in volts

- P1: Phase 1 line current angle or difference voltage angle referenced to network voltage
- P2: Phase 2 line current angle or difference voltage angle referenced to network voltage
- P3: Phase 3 line current angle or difference voltage angle referenced to network voltage
- TP: Relay internal temperature in degrees Celsius

Difference voltages D1–D3 display `XX.X` when the network protector is open and the transformer is de-energized or the difference voltage is greater than 25 V. Difference voltage is positive when transformer voltage is leading the network voltage and negative when transformer voltage is lagging the network voltage.

The angle displayed in P1, P2, and P3 changes based on the position of the network protector. When the network protector is closed, P1, P2, and P3 indicate the line current angle with respect to the network voltage for each phase. These angles are defined in *Figure 5.19*.

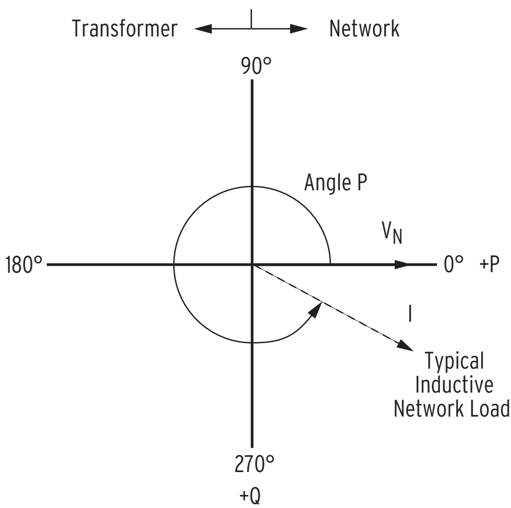

Figure 5.19 Definition of Current Angle

When the network protector is open, P1, P2, and P3 indicate the difference voltage angle with respect to the network voltage for each phase. These angles are defined in *Figure 5.20*.

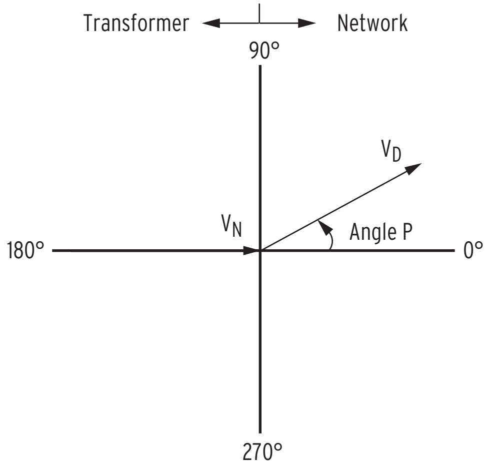

Figure 5.20 Definition of Phasing Voltage Angle

Setting Commands

When any of the 14 setting commands are entered with a valid setting value, the relay responds with `OK` and stores the value pending execution of the **Program Enable** command. If the setting value is out of range, the relay responds with `?` and rejects the setting.

⚠CAUTION
Enter all settings for a new scheme before issuing the **PE** command. The relay immediately begins using the entered settings when the **PE** command is issued.

⚠CAUTION
The SEL-632 retains settings for inactive trip modes. When changing the TM setting, be sure to enter or confirm all settings required for the new trip mode before executing the **PE** command.

When all setting changes have been entered, issue the **Program Enable** (**PE**) command to store and begin using the settings. When the **PE** command is issued, the relay immediately begins using the settings without disabling. If the **Program Query** (**PQ**) command is issued before the **PE** command, the relay displays the settings just entered, and not the settings that the relay is currently using for protection. This allows the user to verify that the proper settings have been entered before issuing the **PE** command.

If the 30 second port timeout expires before the **PE** command is issued, the session ends, and any settings changes entered in the session are lost. Therefore, when entering settings, do not allow more than 30 seconds to elapse between keystrokes.

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Section 6
Event Report Retrieval and Analysis

The SEL-632 stores one 64-cycle event report in volatile memory, which means that the event report is not available if the relay loses control power. In response to an event trigger, the relay stores 256 samples per cycle of analog data for network voltages, difference voltages, and line currents. Line current data is reported in primary amps. The relay also stores the state of the Device Word bits every 1/2 cycle.

Event Triggers

Event report capture is triggered by any of the following:

- Issuing **WV** command via Port F
- Issuing **TRI** command via Port F
- Assertion of Device Word bits TRIP or CLOSE
- SEL-632 Network Protector Relay Software

If multiple event report triggers are received during an event report window, the data from the last trigger is saved.

Event Retrieval

Stored event reports can be retrieved in a number of ways.

1. Issuing the **WV** command, in addition to triggering an event, causes the relay to immediately begin sending event data to the PC. Only the current and voltage data are sent. Record the event for future analysis using the text capture feature of the terminal software. The WV report represents the measured analog data.
2. Issuing the **CEV** command causes the relay to send the current and voltage data plus the Device Word data in SEL compressed event format. The **CEV** command syntax is:

   CEV L*y*, where Ly is an optional event length parameter, such that $15 \leq y \leq 64$. If the L*y* parameter is included, the relay responds with the first *y* cycles of the event. If the Ly parameter is not included, the relay responds with the full 64-cycle event report. For example, to retrieve the first 30 cycles of an event report, type **CEV L30 <Enter>** at the command prompt.

The SEL compressed event format is a device-readable format and is not intended to be interpreted manually. Use ACSELERATOR® Analytic Assistant SEL-5601 software or SEL-632 Network Protector Relay Software to read and interpret the event. To generate the CEV report, measured analog data are divided by $\sqrt{2}$ to match standard CEV format.

3. Issuing the **BEV** command causes the relay to send the current and voltage data plus the Device Word data in a binary format using Y-modem file transfer. The **BEV** command syntax is:

   BEV L*y*, where L*y* is an optional event length parameter, such that $15 \leq y \leq 64$. If the L*y* parameter is included, the relay responds with the first *y* cycles of the event. If the L*y* parameter is not included, the relay responds with the full 64 cycle event report.

   The **BEV** command is intended for use only by SEL-632 Network Protector Relay Software. In practice, the **BEV** command is issued with appropriate L*y* parameters by the software, and it is never necessary to issue the **BEV** command in a terminal session. The **BEV** format is the preferred method for retrieving event reports, as the total file size is smaller than the **WV** or **CEV** formats and therefore can be retrieved in less time. Once SEL-632 Network Protector Relay Software has retrieved the event in BEV format, it can be saved as a CEV or WV file for further analysis.

In SEL-632 Network Protector Relay Software, select **View > Waveforms (device)** to retrieve the stored event report and open the waveform viewer (*Figure 6.1*). The number of cycles retrieved can be modified by selecting **Tools > Options** and changing the Event Length. A full 64-cycle event requires about nine minutes to retrieve. Use shorter event lengths to reduce the time required to retrieve events when fewer than 64 cycles are needed.

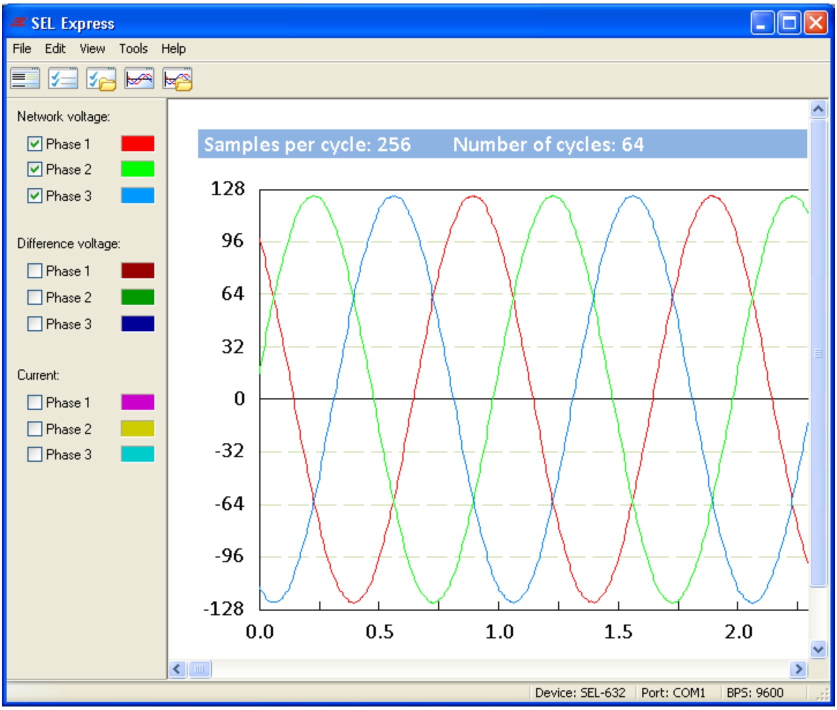

Figure 6.1 Waveform Viewer

The SEL-632 Network Protector Relay Waveform Viewer displays all 64 cycles of the event report. Use the scroll bar at the bottom of the Waveform Viewer window to change the portion of the event report displayed in the window. Select **File > Print** to print the entire waveform.

Use the check boxes within the Chart bar to select the analog quantities to view. The vertical axis represents current and voltage magnitude, and is automatically scaled based on the largest magnitude in the plot. The color bars next to the check boxes indicate the color of the associated waveform plot. All quantities are shown on the same plot, so it may be necessary to deselect large values, such as network voltages or current, to view smaller values, such as difference voltage, at full scale. Note that waveforms are scaled by $\sqrt{2}$ so that the peak values shown represent the rms values of the signals. This is for consistency with standard CEV format.

The waveform can be saved by selecting **File > Save As**. Two save formats are available (*Figure 6.2*). The CEV format saves the event in SEL standard compressed event format for use with ACSELERATOR Analytic Assistant. ACSELERATOR Analytic Assistant can be used to view the analog data and status of the Relay Word (digital data) simultaneously. The WV format saves the event as a space-delimited text file suitable for analysis using Excel or other software. Analog values are stored in the WV format as recorded by the device and are not scaled by $\sqrt{2}$.

Select **View > Waveform (file)** to open a CEV file stored on the PC.

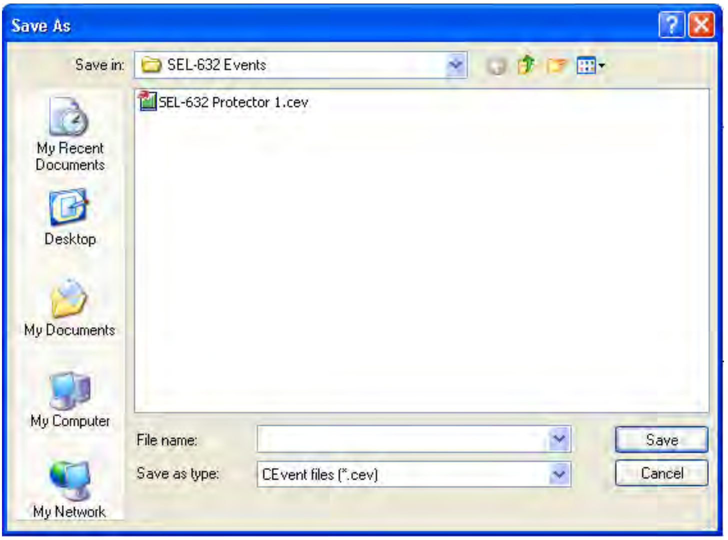

Figure 6.2 Event Save As Window

Section 7
Testing and Troubleshooting

Test Features

The features listed in *Table 7.1* are helpful for relay testing.

Table 7.1 Test Features Provided by the Relay

Command	Description
RR	The **RR** command shows the ac currents and voltages in primary values. Compare these quantities against other devices of known accuracy. The **RR** command is available at Port F. Metering data are also shown on the front-panel display. See *Relay Readings on page 5.19*. Metering data are also available through the SEL-632 Network Protector Relay Software. See *View Device Status, Waveforms, and Metering on page 5.12*.
WV	The relay generates and transmits a 64-cycle event report in response to the **WV** command. The report contains current and voltage information and can be used to evaluate the existing power system conditions. The **WV** command is available at Port F.
TRI	The relay generates a 64-cycle event report in response to the **TRI** command. The report contains current and voltage information and relay element status (Device Word bits). The **TRI** command is available at Port F.
CEV	The relay transmits the stored event report in response to the **CEV** command. The **CEV** command is available at Port F. The event report can be interpreted using ACSELERATOR® Analytic Assistant SEL-5601 Software or SEL-632 Network Protector Relay Software.
BEV	The relay transmits the stored event report in a compressed binary format in response to the **BEV** command. See *Table 5.4*. The **BEV** command is available at Port F. The SEL-632 Network Protector Relay Software can be used to view the event and convert the event to CEV format to use with ACSELERATOR Analytic Assistant.
TAR	Use the **TAR** command to view the state relay elements individually during a test. The **TAR** command is available at Port F. See *Table 5.4*.

Relay Self-Tests

The relay runs a variety of self-tests and takes corrective actions for out-of-tolerance conditions (see *Table 7.2*). The relay displays a message on the HMI for warnings and failures. For certain failures, the relay automatically restarts. In some cases, a restart will correct the error. The failure message is displayed twice before automatic restart occurs.

Use Port F **STATUS** command to view the self-test status (see *Table 5.4*). The relay shows a Warn (W) or Fail (F) for any self-tests results that are out of tolerance.

Table 7.2 Relay Self Tests (Sheet 1 of 2)

Self-Test Description	Nominal Value	Range	Relay Disabled/ Restart	Front Panel Message on Failure
Analog/digital *n* 25% uncalibrated ref. warn[a]	25%	21 to 29%	No	Warn: REF25U*n*[a]
Analog/digital *n* 75% uncalibrated ref. warn[a]	75%	71 to 79%	No	Warn: REF75U*n*[a]
Analog/digital *n* 25% uncalibrated ref. fail[a]	25%	20 to 30%	Yes	Fail: REF25U*n*[a]
Analog/digital *n* 75% uncalibrated ref. fail[a]	75%	70 to 80%	Yes	Fail: REF75U*n*[a]
Analog/digital *n* 25% calibrated ref. warn[a]	25%	24.90 to 25.10%	No	Warn: REF25C*n*[a]
Analog/digital *n* 75% calibrated ref. warn[a]	75%	74.90 to 75.10%	No	Warn: REF75C*n*[a]
Analog/digital *n* 25% calibrated ref. fail[a]	25%	24.85 to 25.15%	Yes	Fail: REF25C*n*[a]
Analog/digital *n* 75% calibrated ref. fail[a]	75%	74.85 to 75.15%	Yes	Fail: REF75C*n*[a]
Master offset *m* warn[b]	–2.5 V	–2.62 V to –2.38 V	No	Warn: MOF*m*[b]
Master offset *m* fail[b]	–2.5 V	–2.74 V to –2.26 V	Yes	Fail: MOF*m*[b]
Current channel *x* offset warn[c]	–2.5 V	–2.77 V to –2.23 V	No	Warn: I*x*[c]
Network voltage channel *y* offset warn[d]	–2.5 V	–2.77 V to –2.23 V	No	Warn: VN*y*[d]
Difference voltage channel *y* offset warn[d]	–2.5 V	–2.77 V to –2.23 V	No	Warn: VD*y*[d]

Table 7.2 Relay Self Tests (Sheet 2 of 2)

Self-Test Description	Nominal Value	Range	Relay Disabled/ Restart	Front Panel Message on Failure
10 V power supply warn	10.50 V	0 V to 10.50 V	No	Warn: PS10V
10 V power supply fail	10.50 V	0 V to 12.50 V	Yes	Fail: PS10V
5 V power supply warn	5.00 V	4.77 V to 5.23 V	No	Warn: PS5V
5 V power supply fail	5.00 V	4.54 V to 5.46 V	Yes	Fail: PS5V
–5 V power supply warn	–5.03 V	–5.51 V to –4.57 V	No	Warn: PSN5V
–5 V power supply fail	–5.03 V	–5.70 V to –4.30 V	Yes	Fail: PSN5V
3.3 V power supply warn	3.30 V	3.14 V to 3.46 V	No	Warn: PS3.3V
3.3 V power supply fail	3.30 V	3.10 V to 3.50 V	Yes	Fail: PS3.3V
1.5 V power supply warn	1.50 V	1.39 V to 1.61 V	No	Warn: PS1.5V
1.5 V power supply fail	1.50 V	1.30 V to 1.7 0 V	Yes	Fail: PS1.5V
Temperature warn		–40° to 125°C	No	Warn: TEMP
Data flash			Yes	Fail: NON_VOL
External Static RAM			Yes	Fail: SRAM
Display health			Yes	Fail: HMI
CPU Failure			Yes	Fail: *nn*[e]

a. n = 0 or 1.
b. m = 1 or 2.
c. x is a 3–4 digit channel identifier.
d. y = 1, 2, or 3.
e. nn is a number for SEL use only.

Relay Calibration

The SEL-632 is factory-calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Servicing the Relay

The SEL-632 is permanently sealed to meet submersion requirements. There are no user-serviceable parts inside and internal access is not possible. If you suspect that the relay needs service, please contact the factory.

Factory Assistance

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
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com
E-mail: info@selinc.com

Appendix A
Firmware and Manual Revision History

Firmware

Determining the Firmware Version in Your Device

To find the version number of the firmware in your SEL-632, use the **STA** command (see *Table 5.4* for more information). The firmware revision number is after the R, and the release date is after the D. For example, the following string shows firmware version number 101 with a release date of February 15, 2010:

FID=SEL-632-R101-V0-Z001001-D20100215

Table A.1 lists the firmware versions, a description of any modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-632-R101-V0-Z001001-D20100215	➤ Manual update only (see *Table A.2*).	20130111
SEL-632-R101-V0-Z001001-D20100215	➤ Manual update only (see *Table A.2*).	20110217
SEL-632-R101-V0-Z001001-D20100215	➤ Initial version.	20100215

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 release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.2 Instruction Manual Revision History

Revision Date	Summary of Revisions
20130111	Section 2 ➤ Added installation warning. ➤ Changed Pin 16 description in *Table 2.1: Pin Functions* to Not Connected.
20110217	Section 5 ➤ Replaced *Software Setup* with *Installation*. ➤ Added *Uninstallation*. ➤ Updated *Upgrading From Previous Versions of SEL-632 Network Protector Relay Software*. ➤ Updated figures. ➤ Updated *Table 5.2*.
20100215	➤ Initial version.

Appendix B
Firmware Upgrade Instructions

Upgrade Procedure

A. Obtain Firmware File

The firmware file is usually provided on a CD-ROM. Locate the firmware file on the disk. The file name is of the form R*xxx*632.s19, where R*xxx* is the firmware revision number, 632 indicates the relay type, and .s19 is the standard firmware file extension. Copy the firmware file to an easily accessible location on the PC.

Firmware is designed to be used with specific relays. A list of relay serial numbers is provided as part of the firmware upgrade package. The firmware provided is for use only with the listed relays. Attempts to upgrade relays not listed might not be successful and can result in relay failure.

B. Remove Relay From Service

Step 1. If the relay is in use, follow your company practices for removing a relay from service. Typically, these include disconnecting external voltage sources or output contact wiring to disable relay control functions.

Step 2. Apply power to the relay.

Step 3. Connect an SEL C667 or equivalent optical communications cable to relay Port F and to the PC.

C. Establish Communications With the Relay

To establish communication between the relay and a personal computer, you must be able to modify the computer serial communications parameters (i.e., data transmission rate, data bits, parity) and set the file transfer protocol to 1K Xmodem or Xmodem protocol.

1. From the computer, open HyperTerminal® or other terminal emulation software.

   On a personal computer running Windows, you would typically click **Start > Programs > Accessories > Communications** to access HyperTerminal.

Step 2. Enter a name, select any icon, and click **OK** (*Figure B.1*).

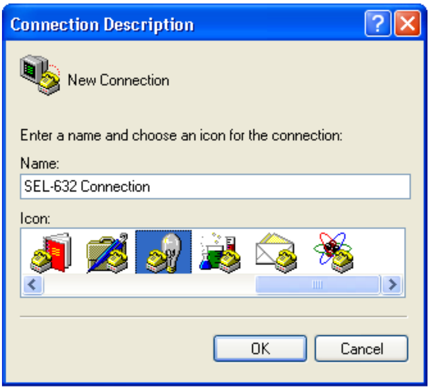

Figure B.1 Enter Connection Name and Select Icon

Step 3. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**. USB-optical communications cables, such as the SEL C667, are assigned a virtual port number. To see what virtual COM port has been created, select **Start > Settings > Control Panel > System**, click the **Hardware** tab, and click **Device Manager** to inspect the available COM ports as shown in *Figure B.3*. Use Device Manager to verify which virtual COM port is associated with a particular physical USB port. Device Manager updates the available COM ports each time a cable is inserted or removed.

Figure B.2 Select PC Serial Port Number

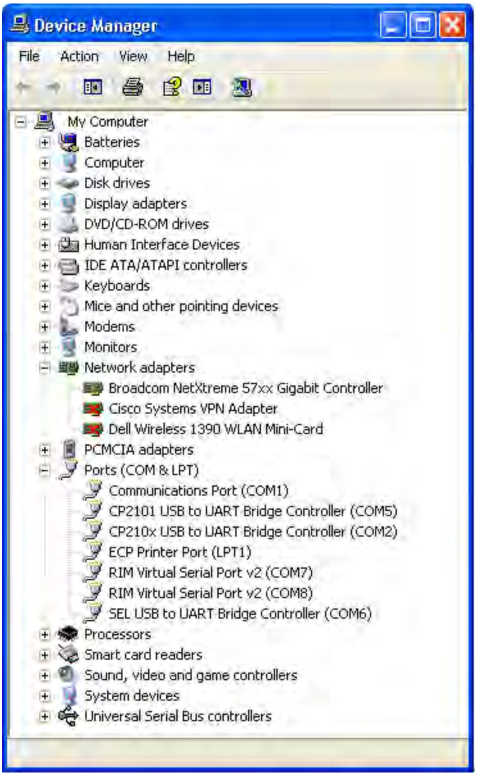

Figure B.3 Windows Device Manager

Step 4. Set the relay serial port communications parameters as follows (*Figure B.4*):

- ➢ Bits per second: 9600
- ➢ Data bits: 8
- ➢ Parity: None
- ➢ Stop bits: 1
- ➢ Flow control: None

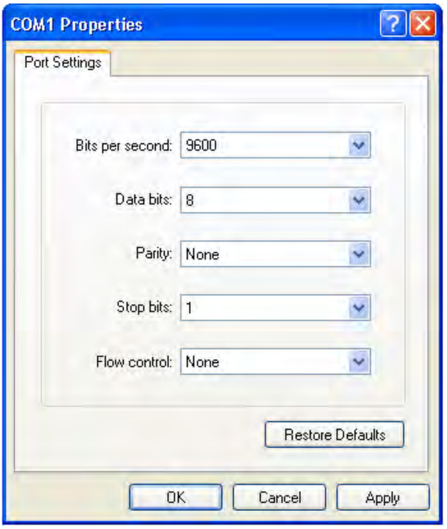

Figure B.4 Select Communications Parameters

Step 5. In the HyperTerminal main window, choose **File > Properties**, then select the **Settings** tab. Select **VT100** from the **Emulation** list box and click **OK** (*Figure B.5*).

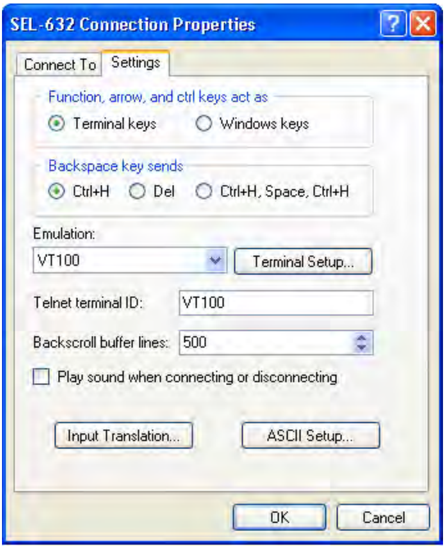

Figure B.5 Select VT100 Terminal Emulation

Step 6. Confirm serial communication.

Press **<Enter>**. In the terminal emulation window, you should see the > prompt (*Figure B.6*).

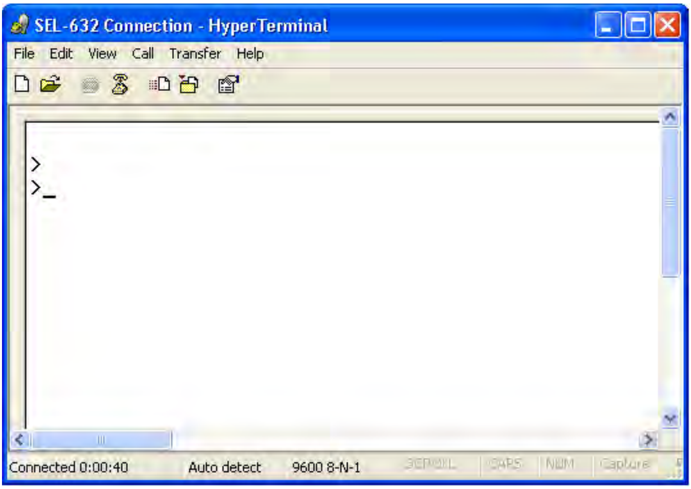

Figure B.6 Confirm Serial Communication

If this is successful, proceed to *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.6*. Otherwise, continue to *Failure to Connect*.

Failure to Connect

If you do not see the > prompt, press **<Enter>** again. If you still do not see the > prompt, you have either selected the incorrect serial communications port on the computer, or the computer speed setting does not match the data transmission rate of the relay (9600 bps). Perform the following steps to reattempt a connection:

Step 7. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 8. Correct the port setting:

a. From the **File** menu, choose **Properties**. You should see a dialog box similar to *Figure B.2*.

b. Select a different port in the **Connect using** list box.

Step 9. Correct the communications parameters:

a. From the filename **Properties** dialog box shown in *Figure B.2*, click **Configure**. You will see a dialog box similar to *Figure B.4*.

b. Change the parameters in the appropriate list boxes as shown in *Step 4 on page B.3* and click **OK** twice to return to the terminal emulation window.

Step 10. Press **<Enter>**. In the terminal emulation window, you should see the > prompt.

D. Prepare the Relay (Save Relay Settings and Other Data)

It is possible for data to be lost during the firmware upgrade process. Follow the steps in this section carefully to ensure that important data are saved.

Before upgrading firmware, retrieve and record any event data that you want to retain (see *Section 6: Event Report Retrieval and Analysis* for an explanation of the commands).

Backup Relay Settings and Other Data

The relay preserves settings during the firmware upgrade process. However, interruption of relay power during the upgrade process can cause the relay to lose settings. Record the original relay settings in case you need to reenter the settings.

Step 1. From the **Transfer** menu in HyperTerminal, select **Capture Text**.

Step 2. Enter a directory and filename for a text file where you will record the existing relay settings.

Step 3. Click **Start**.

Step 4. The Capture Text command copies all the information you retrieve and all the keystrokes you type until you send the command to stop capturing text. The terminal emulation program stores these data in the text file.

Step 5. Type **SHO C <Enter>** to retrieve the relay calibration constants.

Step 6. Issue the **Program Query** (**PQ**) command to retrieve the relay settings.

Step 7. Issue the **STA** command and record the relay FID string.

Step 8. Issue the **RS** command to record the value of the cycle counter.

Step 9. From the **Transfer** menu in HyperTerminal, select **Capture Text** and click **Stop**.

Step 10. The computer saves the text file you created to the directory you specified in *Step 2 on page B.6*.

E. Start SELBOOT

Step 1. From the computer, start SELBOOT.

a. From the prompt, type **L_D <Enter>**.

The relay responds with the following:

```
Disable relay to send or receive firmware (Y/N)?
```

b. Type **Y <Enter>**.

The relay responds with the following:

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

c. Type **Y <Enter>**.

The relay responds with the following:

```
Device Disabled
```

Step 2. Wait for the SELBOOT program to load.

The front-panel LCD screen displays SLBT. The computer displays the SELBOOT !> prompt after SELBOOT loads.

Step 3. Press **<Enter>** to confirm that the relay is in SELBOOT. You will see another SELBOOT !> prompt.

F. Maximize Port Data Rate

If your optical cable supports higher data rates, the port speed can be changed to speed the firmware download process.

Step 1. Type **BAU 19200 <Enter>** at the SELBOOT !> prompt.

Step 2. From the **Call** menu, choose **Disconnect** to terminate communication.

NOTE: Some optical cables do not fully support communications with port speed set to 19200 bits per second. If you experience difficulty uploading firmware, start SELBOOT and proceed directly to G. Upload New Firmware on page B.8 without changing the port speed.

Step 3. Correct the communications parameters.

a. From the **File** menu, choose **Properties**.

b. Choose **Configure**.

c. Change the computer communications speed to 19200 to match the new data transmission rate in the relay (*Figure B.7*).

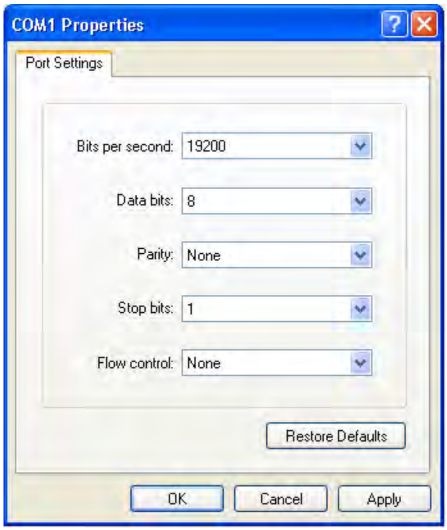

Figure B.7 Changing Communications Parameters for the PC

d. Click **OK** twice.

Step 4. Press **<Enter>** to check for the SELBOOT !> prompt indicating that serial communication is successful.

G. Upload New Firmware

Step 1. Type **REC <Enter>** at the SELBOOT !> prompt to command the relay to receive new firmware.

```
!>REC <Enter>
Caution! - This command erases the relays firmware. If you erase the firmware, new firmware
must be loaded into the relay before it can be put back into service.
```

The relay asks whether you want to erase the existing firmware.

```
Are you sure you wish to erase the existing firmware? (Y/N) Y <Enter>
```

Step 2. Type **Y** to erase the existing firmware and load new firmware. To abort, type **N** or press **<Enter>**.

The relay responds with the following:

```
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <Enter>
```

Step 3. Press **<Enter>** to start the file transfer routine.

Step 4. Send new firmware to the relay.

a. From the **Transfer** menu in HyperTerminal, choose **Send File**.

b. In the **Filename** text box, type the location and filename of the new firmware or use the **Browse** button to select the firmware file (*Figure B.8*).

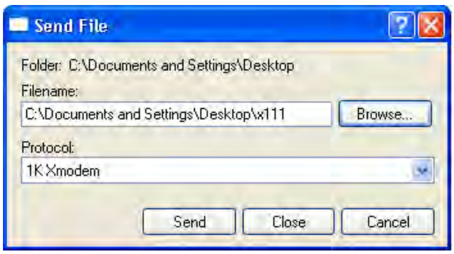

Figure B.8 Selecting New Firmware to Send to the Device

c. In the **Protocol** drop-down menu, select **1K Xmodem**.

d. Click **Send** to send the file containing the new firmware.

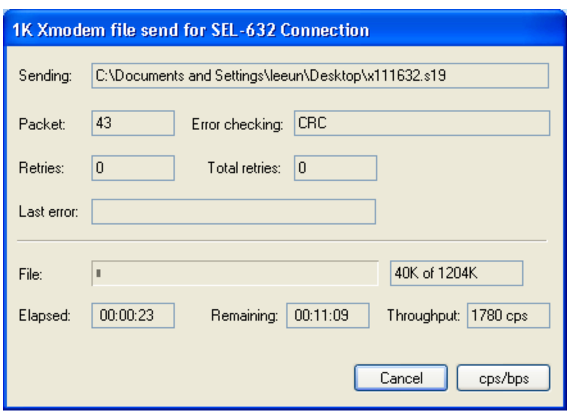

Figure B.9 Transferring New Firmware to the Device

You should see a dialog box similar to *Figure B.9*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate that a transfer is in progress. If you see no indication of a transfer in progress within a few minutes after clicking **Send**, use the **REC** command again and reattempt the transfer.

Step 5. Wait for the transfer to be completed. The relay displays the following:

```
Upload completed successfully. Attempting a restart.
```

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware. Upon power-up, the relay serial port is at 9600 bps. Perform the steps beginning in C. Establish Communications With the Relay on page B.1 to increase the serial connection data speed. Then resume the firmware upgrade process at G. Upload New Firmware on page B.8.

Step 6. Wait for relay to restart. A successful restart sequence can take as long as two minutes, after which the relay leaves SELBOOT. You will see no display on your PC to indicate a successful restart.

Step 7. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 8. Correct the communications parameters:

a. From the **File** menu, choose **Properties**.

b. Choose **Configure**.

c. Change the computer communications speed to 9600 to match the data transmission rate in the relay

Step 9. Press **<Enter>** and confirm that the > prompt appears on the computer screen.

Step 10. If you see the > prompt, proceed to *H. Check Relay Self-Tests on page B.11*. Otherwise, proceed to *No > Prompt*.

No > Prompt

If no > prompt appears in the terminal emulation window, recheck for the SELBOOT !> prompt.

If you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. Check for the > prompt. If you see the > prompt, proceed to *H. Check Relay Self-Tests on page B.11*.

If the relay will not exit SELBOOT, reattempt to upload the new firmware (beginning at *Step 1 on page B.8*) or contact SEL for assistance.

H. Check Relay Self-Tests

The relay can display various self-test fail status messages. The troubleshooting procedures that follow depend upon which status message the relay displays.

Step 1. Press **<Enter>** and verify the relay responds with the > prompt.

Step 2. Enter the **STATUS** command (**STA <Enter>**) to view relay status messages.

If the relay displays no fail status message, proceed to *I. Verify Relay Settings on page B.11*.

If failures are displayed in the status message, proceed to *Solving Firmware Upgrade Issues on page B.12*.

I. Verify Relay Settings

Step 1. Use the **PQ** command to view the relay settings and verify that these match the settings you saved earlier (see *Backup Relay Settings and Other Data on page B.6*). If the settings do not match, reenter the settings you saved earlier.

Step 2. Use the **SHO C** command to view the relay calibration settings and verify that these match the settings you saved earlier (see *Backup Relay Settings and Other Data on page B.6*). If the settings do not match, contact SEL for assistance.

J. Return the Relay to Service

Step 1. Issue the **STATUS** command and compare the firmware revision (R*xxx*) displayed in the FID string against the number from the firmware envelope label. If the numbers match, proceed to *Step 3*.

Step 2. For a mismatch between a displayed FID and the firmware envelope label, reattempt the upgrade or contact SEL for assistance.

Step 3. Apply current and voltage signals to the relay.

Step 4. Issue the **RR** command to verify that the current and voltage signals are correct.

Step 5. Use the **TRI** and **WV**/**CEV** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report. If these values do not match, check the relay settings and wiring.

Step 6. Follow your company procedures for returning a relay to service.

Solving Firmware Upgrade Issues

If a FAIL message is returned in response to the **STA** command, perform the following steps.

Step 1. Type **STA C <Enter>**. Answer **Y <Enter>** to the `Clear warnings/failures and restart the device` prompt. The relay responds with `Restarting the relay`. Wait for about 5 seconds, then press **<Enter>** until you see the > prompt.

Step 2. Type **STA <Enter>**.

If there are no fail messages, go to *I. Verify Relay Settings on page B.11*.

If there are fail messages, continue with *Step 3*.

⚠CAUTION
Step 3 causes the loss of settings and other important data. Be sure to retain relay settings and other data downloaded from the relay at the start of the firmware upgrade process.

Step 3. Type **R_S <Enter>** to restore factory default settings in the relay.

The relay asks whether to restore default settings. Answer **Y <Enter>**. If the relay does not accept the **R_S** command, contact SEL for assistance.

Appendix C
Device Word Bits

Device Word bits show the status of functions within the relay. Bit status is available using the **TAR** command via Port F.

In the SEL-632, Device Word bits are used to indicate the status of fixed logic. Unlike some other SEL products, the SEL-632 does not have programmable SELOGIC®.

The Device Word bit row numbers correspond to the row numbers used in the **TAR** command (see *Table 5.4*). *Table C.1* includes cross-reference information for most Relay Word bits.

Table C.1 Device Word Bits

Bit / Row[a]	7	6	5	4	3	2	1	0
0	ENABLED	*	*	*	*	*	TRP_LED	CLS_LED
1	*	*	*	*	*	REM_BP	REM_UP	REM_OP
2	*	*	*	*	*	*	3PMC	3PPC
3	*	*	*	*	*	1MC	1PC	1_CLS
4	*	*	*	*	*	2MC	2PC	2_CLS
5	*	*	*	*	*	3MC	3PC	3_CLS
6	*	CLS	3P_CLS	1P_CLS	NRM_CLS	CLOSE	CLS_OUT	BLOCK
7	*	*	*	*	*	REV_PWR	SENSITV	SEN_TRP
8	*	*	*	*	INST_OC	TMDLY	INSTANT	TD_TRP
9	*	*	*	*	*	*	INSEN	INS_TRP
10	*	*	*	*	*	*	XD_TRP	HRD_TRP
11	*	*	*	*	TR	TRIP	TRP_OUT	TRP_PRG

a. * is reserved for future use.

Table C.2 Device Word Bit Definitions by Row (Sheet 1 of 4)

Row	Bit	Definition	Reference
0	ENABLED	Indicates that relay is operating normally	
	*		
	*		
	*		
	*		
	*		
	TRP_LED	Trip output LED	*Figure D.6*
	CLS_LED	Close output LED	*Figure D.7*
1	*		
	*		
	*		
	*		
	REM_BP	Asserts for one processing interval when Block Protector (BP) command is executed	
	REM_UP	Asserts for one processing interval when Unblock Protector (UP) command is executed	
	REM_OP	Asserts for one processing interval when Trip Protector (OP) command is executed	
2	*		
	*		
	*		
	*		
	*		
	3PMC	Three-phase master relay close	*Figure D.7*
	3PPC	Three-phase phasing relay close	*Figure D.7*

Table C.2 Device Word Bit Definitions by Row (Sheet 2 of 4)

Row	Bit	Definition	Reference
3	*		
	*		
	*		
	*		
	*		
	1MC	Phase 1 master relay close	*Figure D.7*
	1PC	Phase 1 phasing relay close	*Figure D.7*
	1_CLS	Phase 1 close satisfied	*Figure D.7*
4	*		
	*		
	*		
	*		
	*		
	2MC	Phase 2 master relay close	*Figure D.7*
	2PC	Phase 2 phasing relay close	*Figure D.7*
	2_CLS	Phase 2 close satisfied	*Figure D.7*
5	*		
	*		
	*		
	*		
	*		
	3MC	Phase 3 master relay close	*Figure D.7*
	3PC	Phase 3 phasing relay close	*Figure D.7*
	3_CLS	Phase 3 close satisfied	*Figure D.7*

Table C.2 Device Word Bit Definitions by Row (Sheet 3 of 4)

Row	Bit	Definition	Reference
6	*		
	CLS	Untimed close satisfied	*Figure D.7*
	3P_CLS	Three-phase close satisfied	*Figure D.7*
	1P_CLS	Single-phase close satisfied	*Figure D.7*
	NRM_CLS	Normal reclose satisfied	*Figure D.7*
	CLOSE	Instantaneous output of the close logic	*Figure D.7*
	CLS_OUT	Close output contact	*Figure D.8*
	BLOCK	Close inhibited	*Figure D.7*
7	*		
	*		
	*		
	*		
	*		
	REV_PWR	Instantaneous output of the sensitive trip characteristic	*Figure D.1*
	SENSITV	Time qualified output of the sensitive trip characteristic	*Figure D.1*
	SEN_TRP	Sensitive trip	*Figure D.1*
8	*		
	*		
	*		
	*		
	INST_OC	Instantaneous overcurrent output	*Figure D.2*
	TMDLY	Instantaneous output of the time-delay trip logic	*Figure D.3*
	INSTANT	Instantaneous current qualified output of the instantaneous trip logic	*Figure D.2*
	TD_TRP	Time qualified output of the time-delay trip characteristic	*Figure D.3*

Table C.2 Device Word Bit Definitions by Row (Sheet 4 of 4)

Row	Bit	Definition	Reference
9	*		
	*		
	*		
	*		
	*		
	*		
	INSEN	Instantaneous output of the insensitive trip logic	*Figure D.4*
	INS_TRP	Phase current qualified output of the insensitive trip characteristic	*Figure D.4*
10	*		
	*		
	*		
	*		
	*		
	*		
	XD_TRP	Time qualified output of the extended time-delay trip characteristic	*Figure D.5*
	HRD_TRP[a]	Not used	*Figure D.6*
11	*		
	*		
	*		
	*		
	TR	Trip equation output	*Figure D.6*
	TRIP	Trip logic output	*Figure D.6*
	TRP_OUT	Trip output contact	*Figure D.8*
	TRP_PRG	Trip in progress	*Figure D.6*

a. HRD_TRP is forced to zero.

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Appendix D
Logic Diagrams

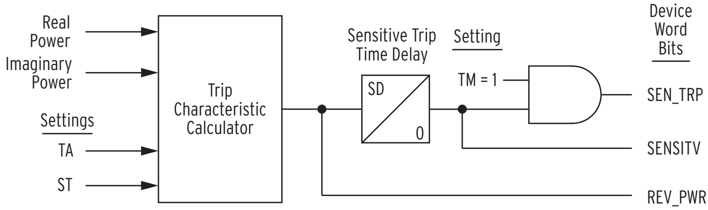

Figure D.1 Sensitive Trip Logic

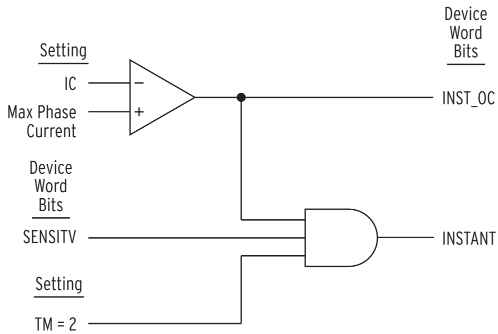

Figure D.2 Instantaneous Trip Logic

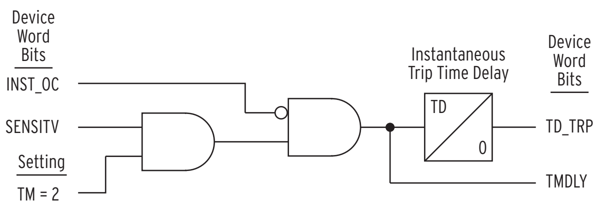

Figure D.3 Time-Delay Trip Logic

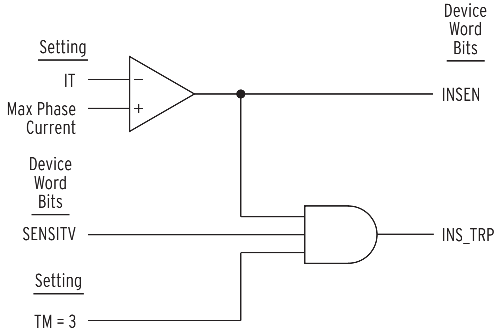

Figure D.4 Insensitive Trip Logic

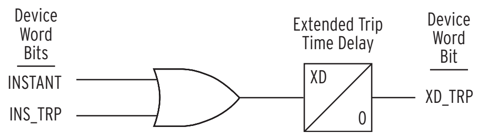

Figure D.5 Extended Trip Delay Timer Logic

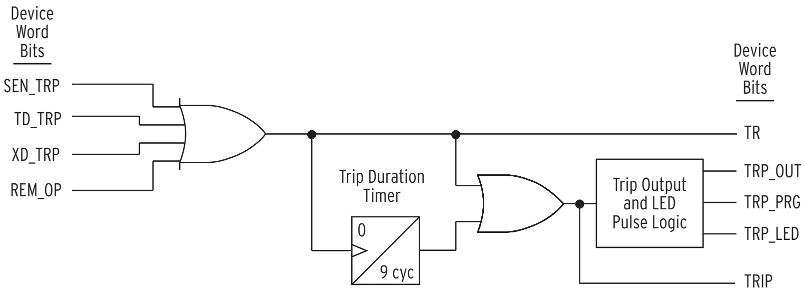

Figure D.6 Overall Trip Logic

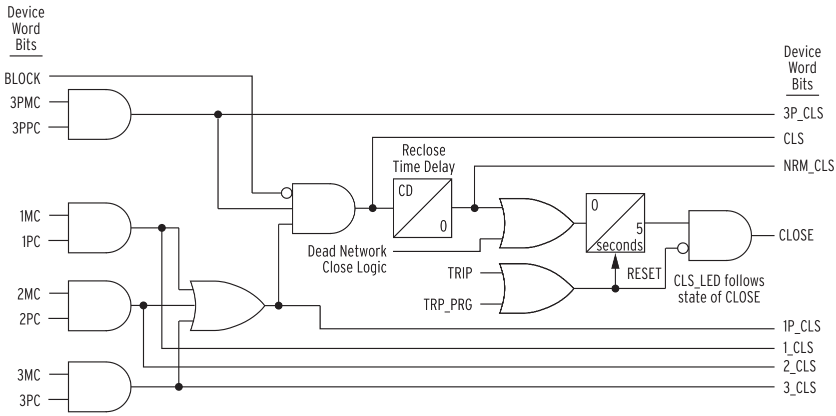

Figure D.7 Overall Close Logic

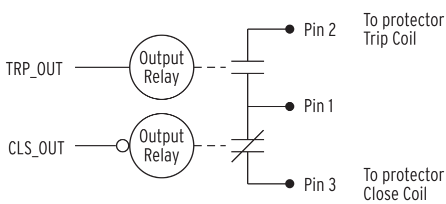

Figure D.8 Contact Output Logic

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Appendix E
Overview of Low-Voltage Networks

From the earliest days of electric power usage, the distribution of power in concentrated urban areas has been a major concern of electric utilities. High concentrations of load, requirements for interruption-free service, and the need for well-regulated utilization voltage have influenced the design of systems that serve these loads. The physical congestion in these areas and the difficulties in locating heavy equipment and circuits overhead have resulted in the use of underground distribution systems in most large cities.

Grid (Street) Networks

Low-Voltage (secondary) Networks are classified as either grid or spot networks.

A grid network is a secondary network distribution system with geographically separated network units. The network-side terminals of the network units are connected to paralleling buses that in turn are connected by low-voltage cables. The low-voltage cable circuits of the grid networks are typically highly meshed and supplied by numerous network units.

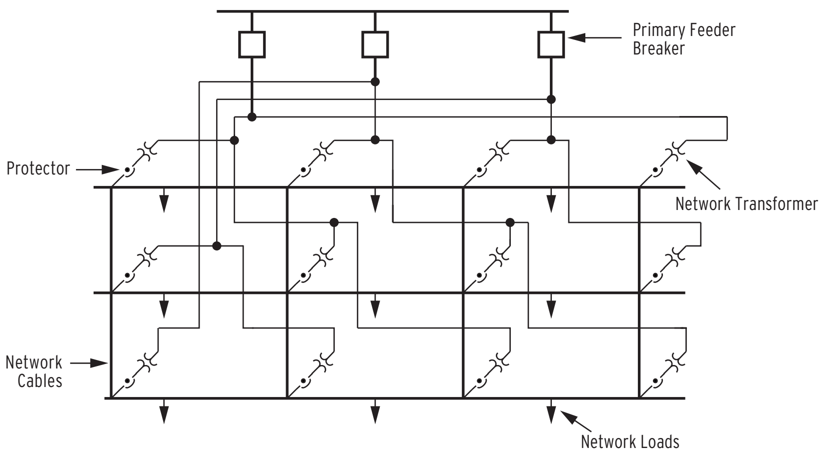

Figure E.9 Secondary Grid Network System

Spot Networks

A spot network is a secondary network distribution system that consists of two or more network units at a single site. The secondary network-side terminals of these network units are connected to the paralleling bus. In spot networks, the paralleling bus does not have low-voltage ties to adjacent or nearby networks.

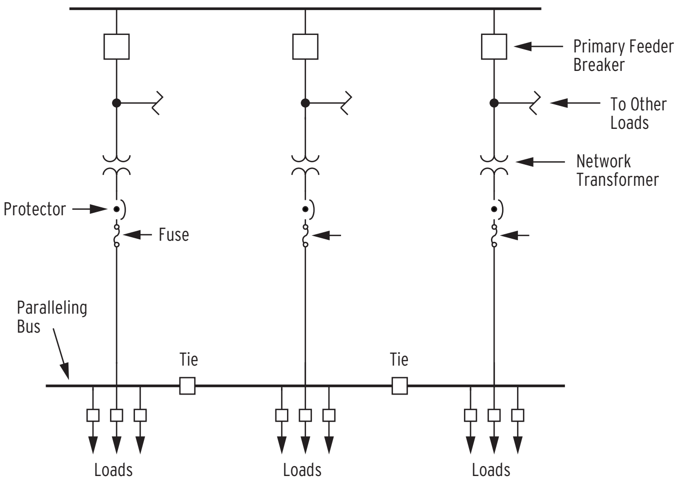

Figure E.10 Spot Network

Low-voltage networks share the following characteristics:

- ➤ Network systems are designed to be redundant. Any single equipment failure will not result in service outage on the network. Some low-voltage networks are designed for multiple contingencies.
- ➤ A primary feeder may serve a single network unit or many network units at different sites.
- ➤ The primary feeders for a network system are generally served from a single substation but may be served by different substations. When supplied from different substations, phase angle difference and voltage magnitude difference must be minimized to reduce circulating currents.
- ➤ The primary feeder can be either a three-wire or four-wire system.
- ➤ The primary feeder voltages range from 4.16–34.5 kV.
- ➤ Typical network transformer sizes are 300, 500, 750, 1000, 1500, 2000, and 2500 kVA.
- ➤ The transformer connections are commonly delta/grounded-wye for three-wire feeders and grounded-wye/grounded-wye for four-wire feeders.

Basic Components of Low-Voltage Networks

Distribution Substation

The distribution substation might have multiple transmission feeds into the substation supplying one or more power transformers. Each transformer supplies multiple feeders, and tie breakers between feeder buses are closed.

Primary Feeders

Primary feeders are either dedicated feeders that supply network transformers only, or non-dedicated feeders that supply network transformers and other loads.

Network Unit

A network unit consists of:

- Two or three position high-voltage switch used to ground the primary feeder and isolate the network unit from the primary feeder (three-position switch) when the network protector is open and network transformer is de-energized.
- Network transformer (208Y/120 or 480Y/277) with leakage impedances varying from 4 to 7 percent and X/R ratio from 3–12.
- Network protector, which includes the following:
  - Low-voltage circuit breaker
  - Network protector relay
  - Network protector fuses acting as a backup device for faults on the primary feeder or in the transformer

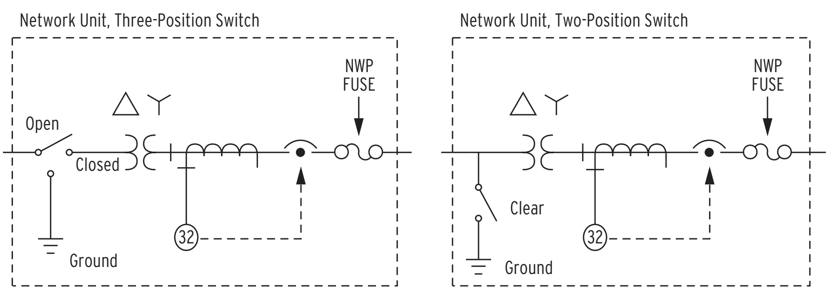

Figure E.11 Network Protector Unit

Network Protector Relay

Network protector relays (NPR) are designed to trip upon loss of the primary feeder or for faults on the primary feeder or in the transformer. The relay closes the network protector when power will flow into the network.

Faults on the low-voltage network are typically allowed to burn clear or are isolated by fuse-like devices called cable-limiters that are installed at the ends of the cables that make up the network. The network protector relay does not protect the network from internal faults, but is intended to keep power flowing into the network and prevent power from flowing out of the network toward the source.

Network Protector Relay Trip Characteristics

Network protector relays have different responses to different types of faults.

- Balanced Faults: Three-phase faults on the primary feeder cables, primary disconnect switch, or the transformer itself are detected by medium-voltage feeder relays that trip the feeder breaker. Such faults also fall within the tripping area of the network protector relay, and the relay will issue a trip. Faults between the transformer secondary bushings and the network protector CTs trip the network protector or blow the protector fuses. Such faults are not detected by the feeder protection and can result in significant damage to the network protector.
- Unbalanced Faults: Network transformer primary windings are usually connected in delta. Line-to-ground faults on the primary feeder cables operate residual-ground relays and cause the feeder breaker to trip. This generates a delta-zone with one phase grounded, and there is no fault-current contribution from the low-voltage network. In this case, the network protector must trip because of transformer excitation current and feeder charging current, which are unbalanced because of the grounded phase.

Sensitive Trip Characteristic

The tripping characteristic of the relay is a reverse-looking three-phase watt element. The relay operates due to a real power flow to a fault on the primary feeder or within the transformer, but also must be able to detect magnetizing current of the transformer, charging currents of the distributed capacitance of the high-voltage cables, or real power flowing from the network to loads connected to a non-dedicated primary feeder. Transformer core loss current can be about 0.1–0.5 percent of the transformer rating and lags the network voltage by 60–80 degrees. Also, charging currents might be quite large but lead the network voltage by 80 degrees or more resulting in a very little real power content. For these reasons, the network protector must be very sensitive.

Network protector relays with watt-trip characteristics make their trip contact when the net three-phase power flow in the protector is in the reverse direction and above the trip threshold in watts. However, the trip characteristics are usually plotted as a function of the current needed to trip the relay under balanced three-phase conditions with rated line-to-ground voltage applied to the relay.

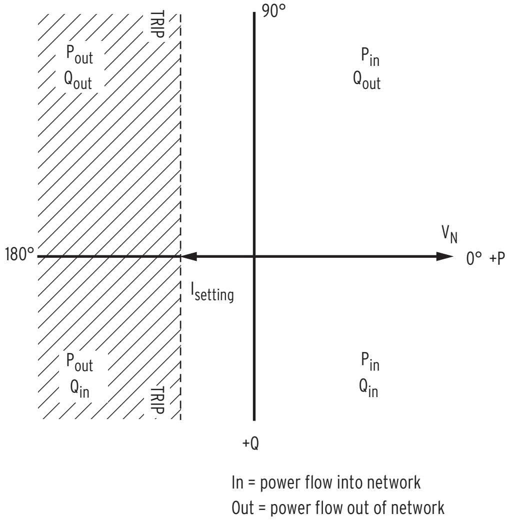

Figure E.12 Sensitive Trip Characteristic

The three-phase real power measured by the relay is given by *Equation E.1*:

$$P_{measured} = V_a I_a \cos\theta_a + V_b I_b \cos\theta_b + V_c I_c \cos\theta_c$$ **Equation E.1**

The relay trips when the measured power is negative and the absolute value of measured power is greater than the trip threshold, as shown by *Equation E.2*:

$$|P_{measured}| > P_{threshold}$$ **Equation E.2**

When the system is balanced, the trip threshold can be expressed in terms of the measured current as shown in *Equation E.3*:

$$|I_a| > \frac{P_{threshold}}{3V_{Na}\cos\theta_a}$$ **Equation E.3**

Although *Figure E.13* shows the relay trip curve perpendicular to the network line to ground voltage, it might be rotated a few degrees clockwise or counter-clockwise, changing the real power sensitivity for inductive or capacitive back-feeds.

Insensitive Trip

When an insensitive trip function is used, the network protector relay trips the protector if the sensitive watt trip characteristic is satisfied and the current magnitude in any one phase of the protector is greater than the insensitive trip setting.

With this feature the protector can be prevented from tripping under sizable reverse power conditions. However, it might prevent the protector from tripping in a dedicated feeder system if the primary feeder breaker is opened with no fault.

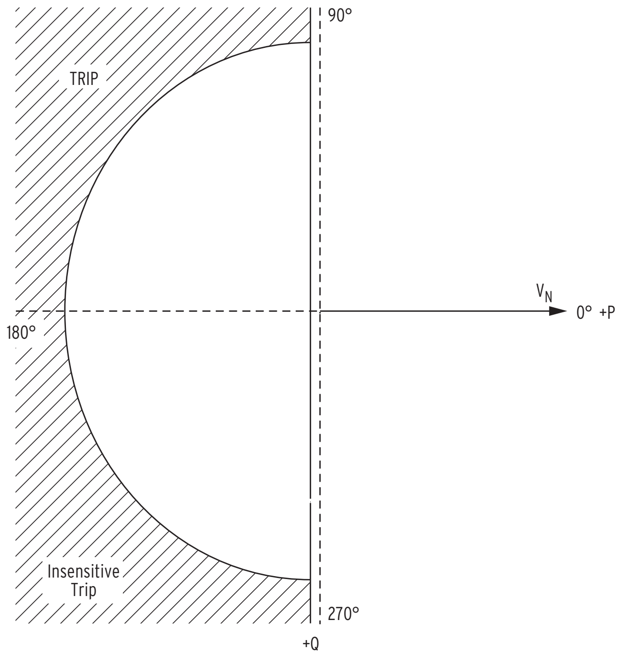

Figure E.13 Insensitive Trip Characteristic

Time-Delay Trip Characteristic

In applications where large regenerative loads such as cranes or elevators may cause transient reverse power flow during regenerative braking, the net power might be in the reverse direction if the network is lightly loaded. In these conditions a time delay is introduced to prevent unnecessary tripping of the protector. For faults on the primary feeder, where back-feed currents can be very high, an instantaneous overcurrent element is used to bypass the time delay and trip the protector.

Network Protector Fuse

The network unit is equipped with a fuse to backup the network protector in the event the protector fails due to relay or protector mechanical malfunction. The network protector fuse should clear before the network transformer is thermally damaged, but the fuse must be slow enough to allow the network protector to open when it is operating properly.

Network Protector Relay Close Characteristics

Once the faulted primary feeder has been repaired and re-energized, the network protectors are expected to automatically reclose. Closing control for network protectors has in the past been provided by separate electromechanical master and phasing relays. The master close function was provided by the same relay that provided the trip function. Microprocessor-based relays eliminate the need for these two relays by incorporating the master and phasing close functions in one relay.

The master close function measures the difference between the transformer voltage and the network voltage ($\overrightarrow{V_D} = \overrightarrow{V_T} - \overrightarrow{V_N}$) and operates when this voltage, often called the phasing voltage, falls within the master relay characteristic.

The master close function allows the network protector to close whether the phasing voltage is either leading or lagging the network voltage. When the phasing voltage is lagging the network voltage, the master function could allow the network protector to close when the real power flow would be out of the network, causing the protector to rapidly cycle open and closed. This undesirable condition is known as pumping. The phasing close function ensures that the protector will not close for significantly lagging phasing voltage, thus preventing pumping. The network protector is allowed to close if the network conditions satisfy the composite close characteristics (shown in *Figure E.14*) between the master close function and phasing close function.

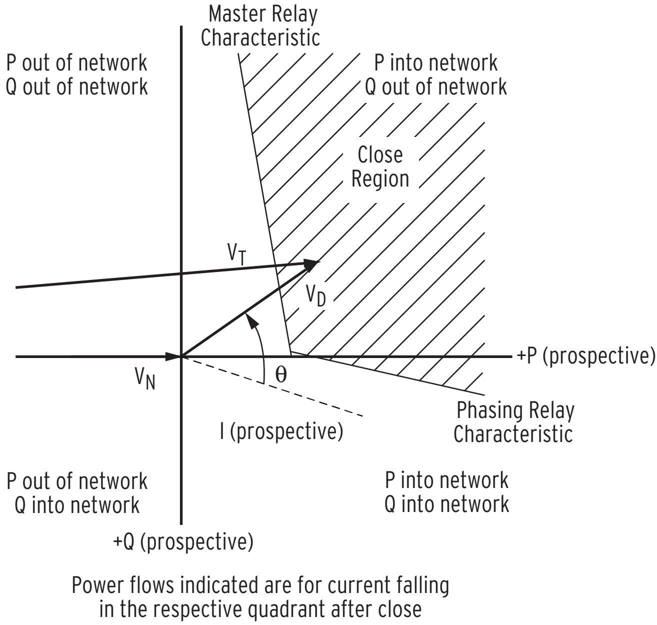

Figure E.14 Close Characteristics

When adjacent network transformers are supplying large loads with low power factor, the difference voltage may slightly lag the network voltage. In these cases it might be permissible to allow closing of the protector as long as the resulting current will not fall within the trip characteristic. For this reason, the setting range of the phasing relay includes small negative (lagging) angles.

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