SEL-7000

Fully Integrated Substation Monitoring and Control System

Instruction Manual

SEL Systems and Services Division

20040413

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PM7000-01

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Section 1: Overview

Introduction

This manual contains sections on the following topics:

- Protection and automation settings within each of the SEL relays and the SEL logic processor. This section is best read in tandem with the SEL-7000 schematics and logic diagrams. See Appendix A for a listing of the drawings available.
- Communications processor settings. Due to the large quantity and repetitive nature of these settings, this section details communications processor setting highlights.
- Functional review of the HMI (Human-Machine Interface). First time users of the SEL-7000 HMI should refer to the SEL-7000 User's Guide, which provides detailed step-by-step procedures on basic HMI operation.
- Software necessary for setting the SEL relays and the communications processor. Individual sections are devoted to the SEL-5010 Relay Assistant, SEL-5020 Settings Assistant, and ACSELERATOR®SEL-5030 Software packages. These software programs are provided as part of the SEL-7000 system.
- Software necessary for retrieving and diagnosing relay event reports. The SEL-5040 Power System Report Manager and SEL-5601 Analytic Assistant software packages are reviewed individually. These software programs are provided as part of the SEL-7000 system.

System Overview

One version of the SEL–7000 is shown in Figure 1.1. This system is a complete substation protection and automation package. The basic product consists of 19-inch racks containing a flat-panel display with the HMI, communications processors, telephone line-sharing switch, weather monitor, satellite clock, inverter, protective relays, fuses, terminal blocks, and test switches wired, configured, and tested ready for installation. See the SEL-7000 User's Guide for information on each product.

Figure 1.1: SEL-7000 Integrated Substation System Cabinet

Each rack shown in Figure 1.1 has a distinctive task. The following list details the functions of each rack:

Rack 1. **Communications Rack.** This rack contains the satellite clock, the SEL-2032 Communications Processors, an inverter, a substation line-sharing telephone switch, a weather monitor, a rack-mount PC (not shown in Figure 1.1), and a flat-panel display.

Rack 2. **Feeder Protection Rack.** This rack contains four SEL-351S-6 Relays for protection and control of four distribution or subtransmission feeders.

Rack 3. **Transformer Protection Rack.** This rack contains one SEL-387-6 Current Differential and Overcurrent Relay (primary differential protection), one SEL-2100 Protection Logic Processor, and two SEL-351S-6 Protection and Breaker Control Relays. These relays and the SEL-2100 provide transformer protection, transformer lockout, bus lockout, and breaker failure lockout.

Rack 4. **Transmission Protection Rack.** This rack contains two SEL-421 High-Speed Line Protection Relays, one SEL-311B Distance Relay, and one SEL-311L Line Current Differential Relay. These relays provide protection for two transmission lines.

Rack 5. **Bus Protection Rack.** This rack contains two SEL-587Z High-Impedance Differential Relays and associated lockout relays for the protection of the high-side and low-side buses.

The SEL-7000 System shown in Figure 1.1 is available in many other configurations. It can be easily modified for any of your transmission, subtransmission, distribution, or industrial substation requirements. Any number of distribution feeders, transmission lines, or transformers can be accommodated by the modular nature of the design. For example, to accommodate more distribution feeders, simply add more Feeder Protection Racks or to

accommodate a system with three transformers, just add two more transformer panels.

The SEL-7000 is intended to be an example of “best engineering practices” to make electric power safer, more reliable, and more economical. For pricing and options, please contact your local SEL representative.

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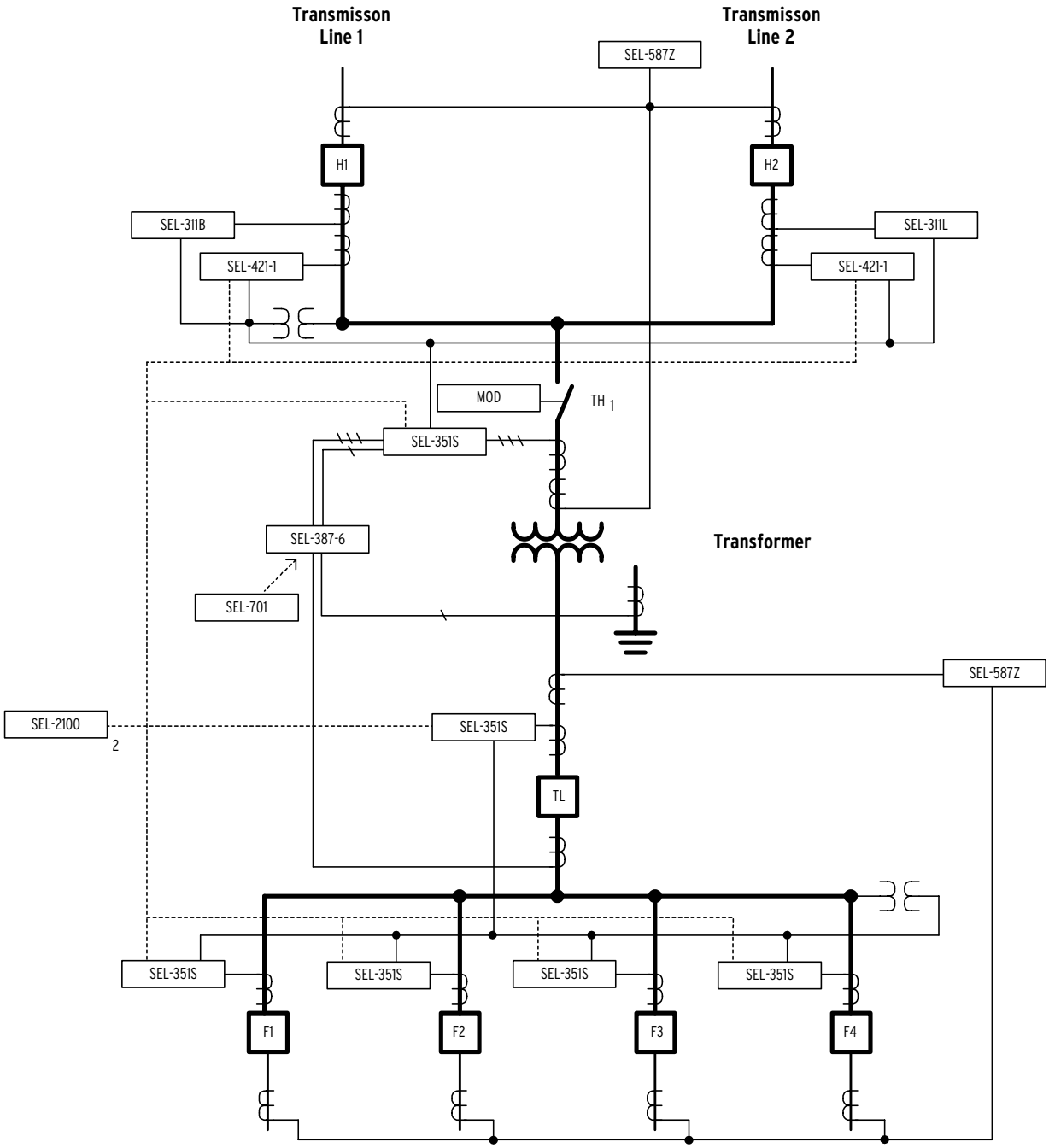
Section 2: SEL Relay and Logic Processor Settings

Introduction

This section goes through the automation and protection-related configuration supplied in a standard SEL-7000. The following sections review the functionality provided by each of the following pieces of equipment:

- SEL-351S Distribution Feeder Relays: 51F1, 51F2, 51F3, 51F4
- SEL-351S Transformer Low-Side (Main) Relay: 51TL
- SEL-351S Transformer High-Side Relay: 51TH
- SEL-387 Transformer Differential Relay: 87T1P
- SEL-421 Primary Transmission Line Relays: 21L1 and 21L2
- SEL-311 Secondary Transmission Line Relays: 121L1 and 121L2
- SEL-2100 Logic Processor: 67/86X
- SEL 701-1 Monitor
- SEL-587Z High-Impedance Bus Relay: 87BL and 87BH

It is highly suggested that the reader refer to the SEL-7000 drawings while reading this chapter. Particular attention should be directed toward the SEL-7000 Logic Drawings and DC Schematics. The SEL-7000 discussed in this section is designed for the substation shown in Figure 2.1.



Notes:

1. Device TH is shown as a motor operated disconnect switch. In this application, the line breakers would be tripped for a fault in the transformer zone, the MOD opened, and the breakers allowed to reclose. A circuit switcher or circuit breaker may be applied. This would affect the tripping logic and location of the transformer zone protection high-side CTs.

2. Both high-side and low-side bus protection is provided by zone interlocked directional elements via the SEL-2100 Logic Processor.

Legend:

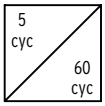
- PT and CT Connections
- MIRRORED BITS
- High Voltage Bus or Line
- Three Phase CT connection
- Single Phase CT connection

Figure 2.1: SEL-7000 Single Line Diagram

Conventions

Table 2.1 describes the logic symbols, acronyms, and conventions used to describe the SELOGIC® control equations inside the SEL-300 and SEL-400 series relays, the logic processor, and the communications processor.

Table 2.1: Conventions

Item	Description
RBx	Remote bit x; x = 1 through 16. The communications processor sends each SEL relay 16 remote bits. The HMI and SCADA use these RBs for control of logic inside the relays.
BRx	Breaker bit x; x = 1 through 16. The communications processor sends each SEL-351S one breaker bit and each SEL-421 two breaker bits. The Human-Machine Interface (HMI) and SCADA use these BRs for control of the manual trip and close logic inside the relay.
PBx	Pushbutton x; x = 1 through 10 residing in the SEL-351S. Used in SELOGIC control equations for control. This is a pulsed version of the pushbutton.
PBx_PUL	Pushbutton x; x = 1 through 8 residing in the SEL-421. This is the rising edge pulsed version of the pushbutton.
LEDx	Light Emitting Diode x; x = 1 through 10 residing in the SEL-351S.
PBx_LED	Light Emitting Diode x; x = 1 through 8 residing in the SEL-421.
DPx	Front Panel Scrolling Display point residing in the SEL-351S. If DPx is logical 1, a text message is displayed. If DPx is logical 0, a different text message is displayed.
DP_ELEx	Front Panel Scrolling Display point residing in the SEL-421. If DP_ELEx is logical 1, a text message is displayed. If DP_ELEx is logical 0, a different text message is displayed.
!, *, +	Logical expressions standing for NOT, AND, and OR respectively. These symbols are used in the SEL-351S, the SEL-2100, and SEL-2032 logic shown in this section.
LTx	Nonvolatile Latch x; x= 1 through 16. Resides in the SEL-351S.
PLTx	Nonvolatile Protection Latch x; x= 1 through 32. Resides in the SEL-421.
	Pickup/Dropout Timer. Pickup of 5 cycles, Dropout of 60 cycles.
{REMOTE ENABLE}	Text in parentheses refers to pushbuttons on the relay front panels. In this case, a pushbutton is labeled with the text **REMOTE ENABLE**.

Distribution Feeder Relays (51F1, 51F2, 51F3, 51F4)

Below is a detailed description of the configuration and settings for selected functions implemented in the SEL-351S Relays. These relays (51F1, 51F2, 51F3, 51F4) are used to provide feeder protection and automation for feeders F1 through F4.

For further information on the configuration of the 51Fn device, refer to SEL-7000 Drawing S7000B-LD02.

Front Panel Disable

The HMI is the preferred interface because of the ease of use gained through complete substation control at a single location. There are also several other benefits of the HMI. The HMI offers confirmation screens, warnings, alarms, and other flexible user interface features that reduce human error when compared to operation through the relay front panel.

If communication with the communications processor or HMI is active, the front panels of the SEL-351S Relays are disabled. If communication is lost, the logic shown in Figure 2.2 and Figure 2.3 enables the relay front-panel pushbuttons. A script in the HMI program is continuously pulsing Remote Bit 15 (RB15) in the relay (the HMI "heartbeat"). If for any reason RB15 does not pulse high for 900 consecutive cycles (15 seconds) then SV4T goes to logical 0 (see Figure 2.2). Display Points 5 and 6 convey this information to the user on the SEL-351S scrolling displays. As shown in Figure 2.3, SV4T locks the front-panel pushbuttons when at a logical 1 state. When SV4T is at a logical 0 state, the front-panel pushbuttons can be unlocked by pressing the **{LOCK}** pushbutton.

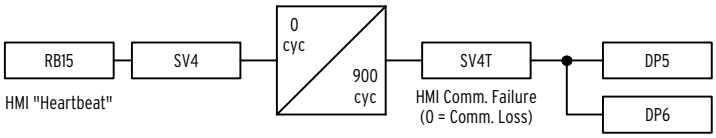


Figure 2.2: Feeder Front-Panel Control Logic

Table 2.2: Feeder Front-Panel Control Logic

Setting Name	Value	Comment
DP5	SV4T	Relay front-panel control display
DP6	SV4T	Relay front-panel control display
SV4	RB15	HMI "heartbeat"

Front Panel Lock

The **{LOCK}** pushbutton locks and unlocks the front-panel pushbuttons on the SEL-351S Relays. When the Lock Operator Control feature is enabled, the front-panel pushbuttons are disabled, preventing control operations. Communication to the HMI or the communications processor must be failed (SV4T = 0) in order to disable the front-panel lock. Then press and hold the

{LOCK} pushbutton for three seconds. The logic diagram for the Lock Operator feature is shown in Figure 2.3. Note that LED5 is directly adjacent to PB5.

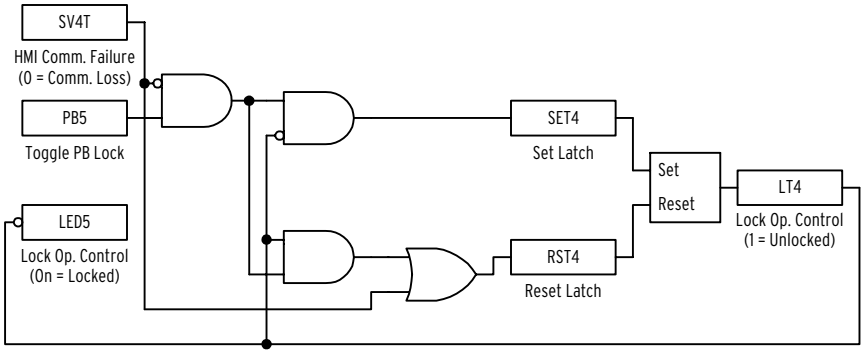


Figure 2.3: Feeder Lock Operator Logic

Table 2.3 contains the settings for the Lock Operator feature.

Table 2.3: Feeder Lock Operator Settings

Setting Name	Value	Comment
SET4	!SV4T*PB5*!LT4	Unlock operator control
RST4	!SV4T*PB5*LT4+SV4T	Lock operator control
LED5	!LT4	Relay front-panel LED indicating operator control lock status

Remote Enable

In the SEL-7000, remote control (typically via SCADA) can be disabled individually for each breaker. The remote control disable latch (LT3) resides in SELOGIC control equations inside an SEL-351S, and the supervision of remote control takes place in logic inside the communications processor.

The logic diagram in Figure 2.4 shows the remote enable logic that resides in the SEL-351S. If LT4 is logical 1 (front-panel pushbuttons are unlocked), then pressing **{REMOTE CONTROL}** toggles the remote control on and off. Remember that the front-panel control can be unlocked only if communication between the HMI and/or the communications processor is not functioning.

RB11 in Figure 2.4 is used to enable remote control, and RB12 is used to disable remote control. These remote bits come from the local HMI.

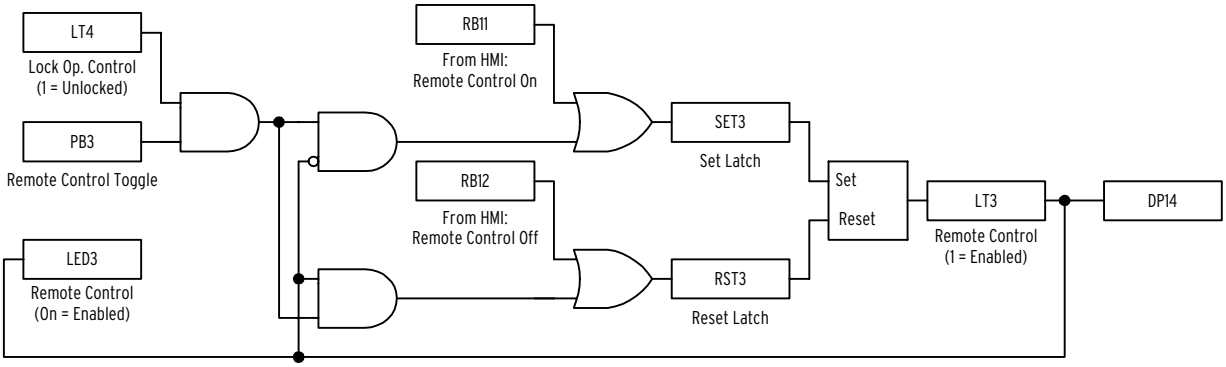


Figure 2.4: Feeder Remote Enable Logic

The settings for the remote mode logic in Figure 2.4 are shown in Table 2.4.

Table 2.4: Feeder Remote Enable Settings

Setting Name	Value	Comment
SET3	!LT3*PB3*LT4+RB11	Enable remote control
RST3	LT3*PB3*LT4+RB12	Disable remote control
DP14	LT3	Relay front-panel control display
LED3	LT3	Relay front-panel LED indicating remote control status

The example logic shown in Figure 2.5 resides in the communications processor. Note how LT3 must be logical 1 for a trip breaker signal from SCADA to reach the relay.

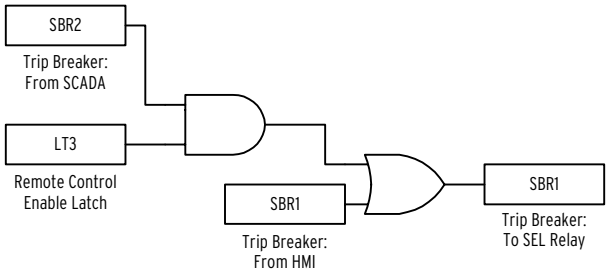


Figure 2.5: Remote Enable Logic in Communications Processor

Operational Tagging

Historically, electrical utility systems have used a system of paper tags attached to control handles with string to prevent others from operating the handle. Most often there was no physical lock or preventative measure, besides trusting your fellow operator, to prevent the handle from actually being rotated. With these paper-tagging systems, documentation of who applied and/or removed the tag, when the tag was applied and/or removed, and any comments associated with the tag required another step of manual effort.

The SEL-7000 provides a complete paper tagging replacement system, answering the major shortcomings of a paper-tagging system. Safety is improved because nonvolatile latches are retained inside the SEL relays to prevent operation of the equipment based on tags. Nonvolatile latches retain their state even if the relay loses power. Documentation is improved by logging each and every tag entry into a database residing in the substation PC. SCADA is informed when a tag is active, and automatically keeps all parties informed. These tags are controllable from the HMI, the relay front panels, or optionally from SCADA.

The descriptions in the following sections are for a very generic system of tagging. SEL-7000 Systems are custom modified to blend seamlessly into each unique tagging procedure.

Information Tag

The information tag does not affect any operations. This tag is used as a way to document a situation, hence the name “information” tag. The operator can set or reset the information tag only through the HMI or SCADA system, not through the relay front panel.

Figure 2.6 shows the logic associated with the information tag. RB10 is used to remove the information tag, and RB9 is used to apply it. The information tag is set when LT7 is logical 1.

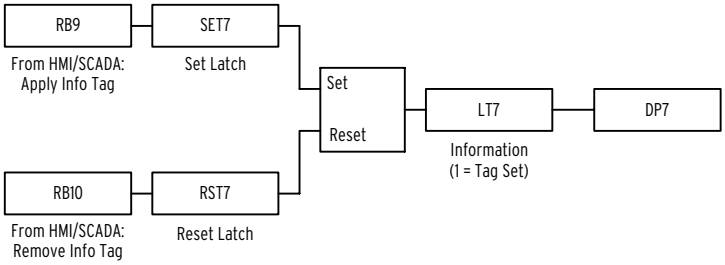


Figure 2.6: Feeder Information Tag Logic

Hot Line Tag

A hot line tag indicates that personnel may be working on the power line associated with the equipment controlled by this relay. Selecting **Hot Line Tag** will disable automatic reclosing and will block closing of the breaker. Remote Bits 5 and 6 (RB5 and RB6) are used to apply and remove the hot line tag from the local HMI or remotely from SCADA. The relay front-panel **{HOT LINE TAG}** pushbutton toggles the hot line tag if the front panel is unlocked (LT4 = 1). Figure 2.7 shows the logic for the hot line tag.

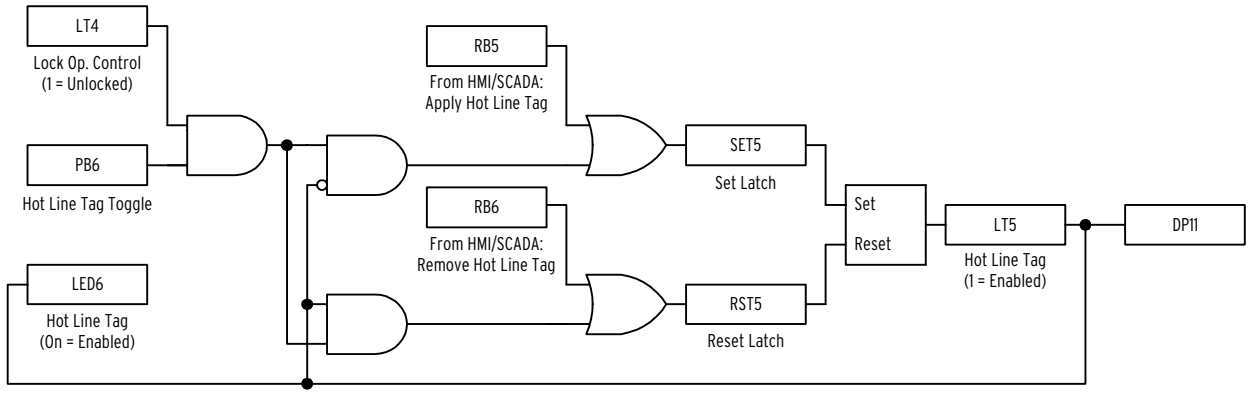


Figure 2.7: Feeder Hot Line Tag Logic

Hold Tag

A hold tag indicates the equipment is de-energized and isolated for personnel safety during maintenance operations. Latch 6 (LT6) indicates a hold tag and is used throughout the relay logic to disable features and functions that may operate the breaker. Remote Bits 7 and 8 (RB7 and RB8) are used to apply and remove the hot line tag from the local HMI or remotely from SCADA. The relay front-panel **{HOLD TAG}** pushbutton toggles the hold tag if the front panel is unlocked (LT4 = 1). Figure 2.8 shows the logic for the hold tag.

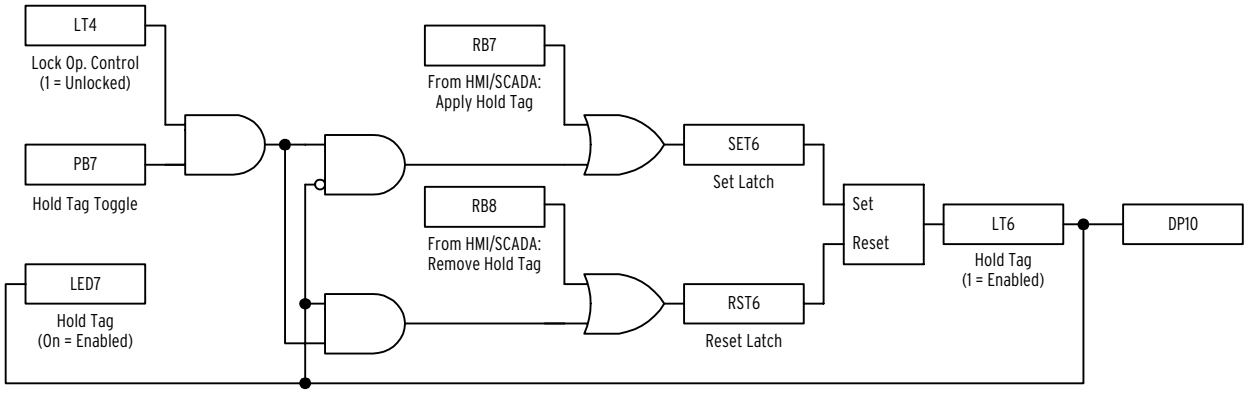


Figure 2.8: Feeder Hold Tag Logic

Settings associated with operation tags are listed in Table 2.5.

Table 2.5: Feeder Operation Tag Settings

Setting Name	Value	Comment
SET7	RB9	Remove information tag
RST7	RB10	Apply information tag
SET5	RB5+LT4*PB6*!LT5	Remove hot line tag
RST5	RB6+LT4*PB6*LT5	Apply hot line tag
SET6	RB7+LT4*PB7*!LT6	Remove hold tag
RST6	RB8+LT4*PB7*LT6	Apply hold tag
DP7	LT7	Relay front-panel display information tag status
DP11	LT5	Relay front-panel display hot line tag status
DP10	LT6	Relay front-panel display hold tag status
LED6	LT5	Relay front-panel LED indicating hot line tag status
LED7	LT6	Relay front-panel LED indicating hold tag status

Ground Protection Enable

Many distribution systems have non-gang, manually operated disconnect switches. During the course of opening or closing these switches, relays may detect slight imbalances in line currents, possibly causing relays to false trip on a ground element. To prevent this operation, many customers disable the ground-tripping elements while these switches are being opened or closed. The

SEL-7000 provides the functionality of enabling or disabling ground elements from the local HMI or the relay front-panel pushbuttons.

Figure 2.9 shows the Ground Protection Enable logic. The **{GROUND ENABLE}** pushbutton is used to toggle LT1 if the lock operator control is off (LT4 = logical 1). The local HMI and SCADA use RB1 and RB2 to enable and disable LT1.

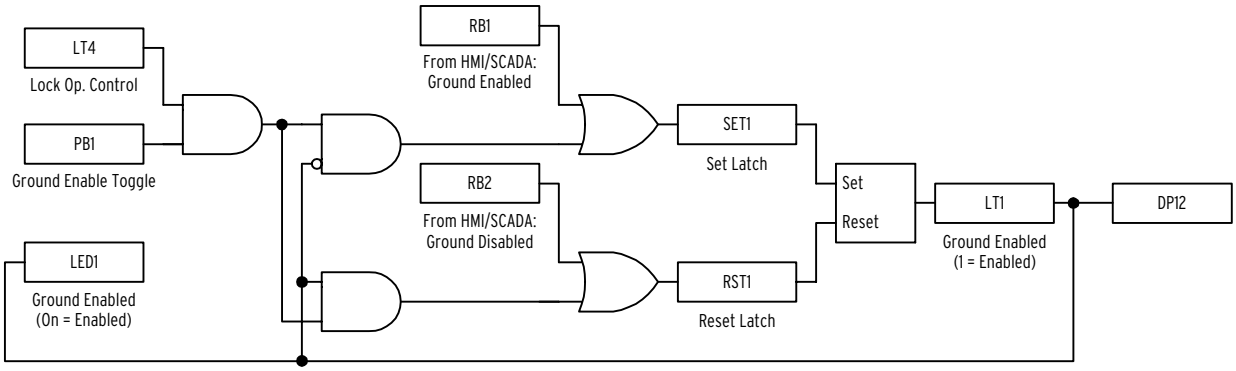


Figure 2.9: Feeder Ground Protection Enable Logic

Settings for the Ground Protection Enable feature are listed in Table 2.6.

Table 2.6: Feeder Ground Protection Enable Settings

Setting Name	Value	Comment
SET1	PB1*LT4*!LT1+RB1	Enable ground protection
RST1	PB1*LT4*LT1+RB2	Disable ground protection
DP12	LT1	Relay front-panel display ground protection status
LED1	LT1	Relay front-panel LED indicating ground protection status

Automatic Reclose Enable

Figure 2.10 shows the Automatic Reclose Enable logic. LT2 is used to drive the recloser to lockout. See *Manual Breaker Close on page 2.14* for more details.

Remote Bits 3 and 4 (RB3 and RB4) provide HMI and SCADA with the ability to enable and disable reclosing. The **{RECLOSE ENABLE}** pushbutton is used to toggle LT2 if the lock operator control is off (LT4 = logical 1).

If a hot line or hold tag is enabled, automatic reclosing is also disabled.

NOTE: SEL latches are reset dominant; i.e., if a set and a reset are present then the latch will reset. Because of this, if a hot line or hold tag is enabled, neither the relay front-panel pushbutton, the local HMI, nor the remote SCADA system can enable reclosing.

If for any reason you do not enable the reclose function, the reclose latch will be forced to a logical 0. This is accomplished by the logic that resets LT2 when 79RS, 79CY, or 79LO are not enabled. If the relay has reclosing enabled, one of these three bits will always be asserted.

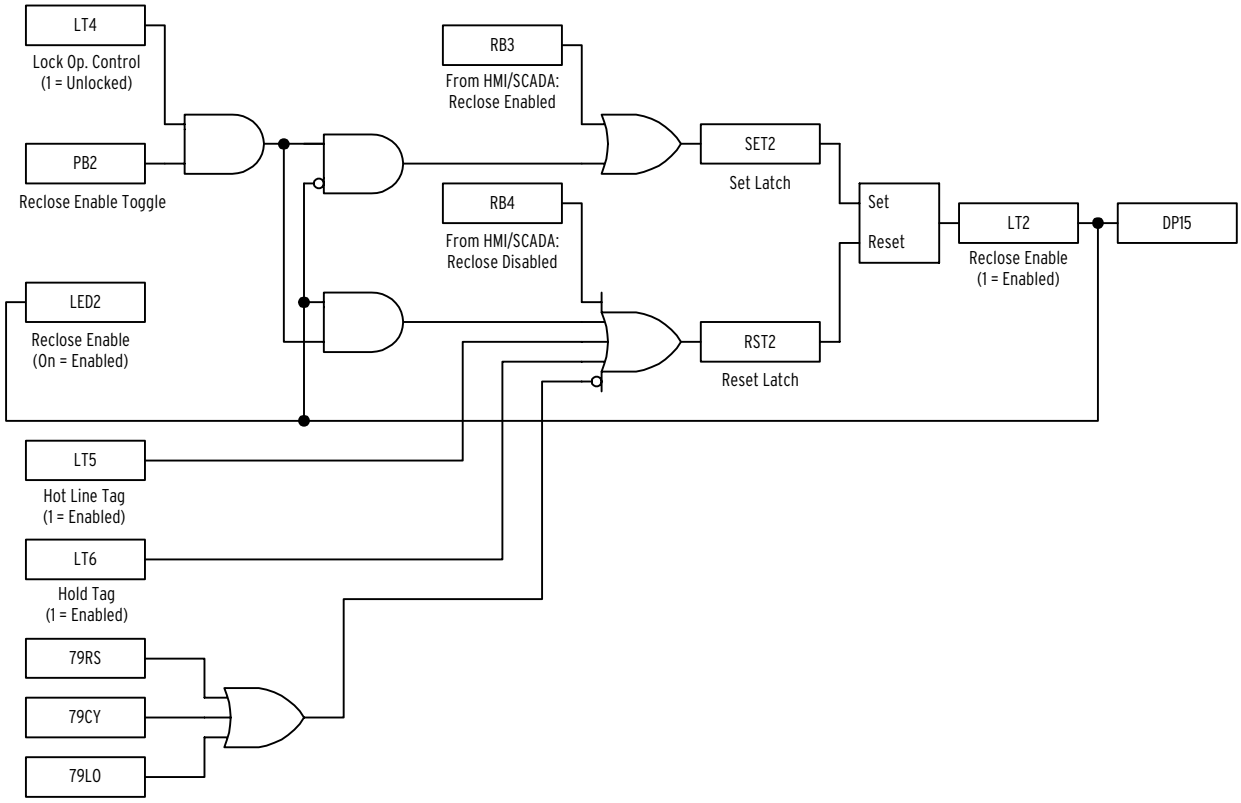


Figure 2.10: Feeder Automatic Reclose Enable Logic

Table 2.7 shows the settings that correspond to the logic shown in Figure 2.10 for the Automatic Reclose Enable feature.

Table 2.7: Feeder Automatic Reclose Enable Settings

Setting Name	Value	Comment
SET2	LT4*PB2*!LT2+RB3	Enable reclose
RST2	LT4*PB2*LT2+LT5+LT6+!(79RS+79CY+79LO)+RB4	Disable reclose
DP16	LT2	Relay front-panel display reclose control status
LED2	LT2	Relay front-panel LED indicating reclose control status

Alternate Settings Enable

The Alternate Settings Enable logic allows the system operator to enable alternate protection settings to adjust for planned periodic changes in system configuration. The SEL-7000 provides this functionality by allowing the active settings to be toggled between two different groups.

The primary settings are Relay Settings Group 1, while the alternate settings are Relay Settings Group 2. SS1 and SS2 initiate the transition into the new settings group, which is then indicated by the Relay Word bit SG1. Figure 2.11 shows the Alternate Settings Enable logic. The SCADA and the local HMI use RB14 to toggle between settings groups. The **{ALTERNATE SETTINGS}** pushbutton toggles the settings from the relay front panel.

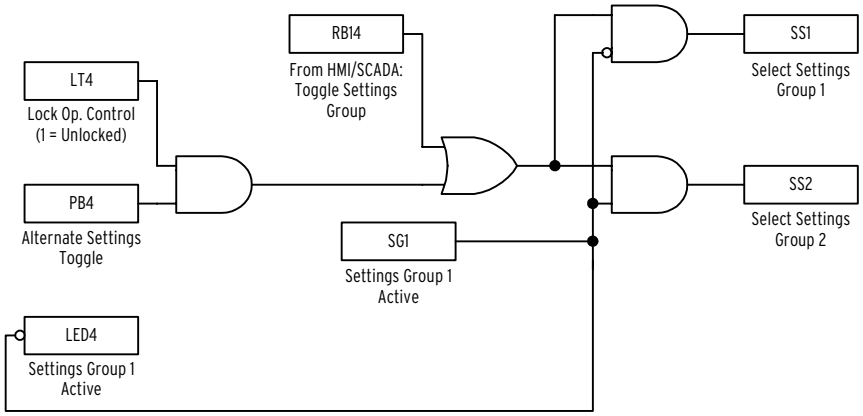


Figure 2.11: Feeder Alternate Settings Enable Logic

Table 2.8 shows the settings that correspond to the logic shown in Figure 2.11 for the Alternate Settings Enable feature.

Table 2.8: Feeder Alternate Settings Enable Settings

Setting Name	Value	Comment
SS1	(LT4*PB4+RB14)*!SG1	Select Settings Group 1
SS2	(LT4*PB4+RB14)*SG1	Select Settings Group 2
LED4	!SG1	Relay front-panel LED indicating alternate setting group active

Breaker Failure Protection

Equipment can be unnecessarily damaged if a breaker fails to open under fault conditions. A properly designed protection system accounts for the contingency of a breaker failing to open. One of the most effective, low-cost, and fastest methods for assuring a controlled reaction to a breaker failure situation is to have a scheme in place to open all breakers surrounding the misoperating breaker. Collectively, the act of detecting and then isolating a breaker failure condition is what is commonly called “breaker failure protection.”

In the SEL-7000, breaker failure detection occurs in the SEL-351S Relays using the logic shown in Figure 2.12. LT8 (nonvolatile latch) asserts if for any reason a breaker failure is detected. In this design, there are two methods for detecting a breaker failure:

1. If the relay is trying to trip the breaker and the breaker does not open after 10 cycles (SV2T).

2. If the trip coil monitor alarm indicates that the trip coil is failed (SV8T) AND the relay tries to trip. Both of these methods for detecting a breaker failure are depicted in Figure 2.12.

Looking at the top-left corner of Figure 2.12, you will see that the **TRIP** command and the remote trip command (RMB1A) is ANDed with IN202 and !SV3. IN202 is a test switch on the panel used to disable the breaker failure detection and the transmission of lockout trips to the SEL-2100 (see the SEL-7000 DC schematics and the SEL-7000 logic drawings for more details on IN202).

!SV3 is also used to supervise the TRIP condition. To see why SV3 is used to supervise the detection of a breaker failure condition, notice that SV3 is used to unlatch the trip (ULTR) in the tripping logic in Figure 2.14. The intent of the ULTR is to stop the **TRIP** command after the trip (TR) logic goes to logical 0. Inside of the SEL-351S trip logic (see the SEL-351S Instruction Manual) is a minimum trip duration timer (TDURD). This timer effectively holds the TRIP output on, even after the TR input goes to logical 0 and even if ULTR is logical 1. Therefore, depending on the TDURD setting, it is very conceivable for the TRIP word to be maintained well after the breaker actually opens. Thus we use the ULTR setting to directly stop the breaker failure timer from proceeding after the breaker has actually opened.

Once a breaker failure is detected, the breaker failure lockout (LT8) information is transmitted to the SEL-2100 using MIRRORED BITS™ communications. The SEL-2100 distributes this information to other adjacent breakers to clear the fault. (See *Logic Processor Configuration (67/86x) on page 2.52* for further details on the SEL-2100.)

Once a breaker failure condition has been resolved, it is necessary to reset the Breaker Failure Lockout (LT8). The local HMI and remote (SCADA) system use RB16 to reset LT8. The **{BKR FAIL}** pushbutton (PB8) on the relay front panel is also available to reset LT8 if the panel pushbuttons are unlocked (LT4 = 1).

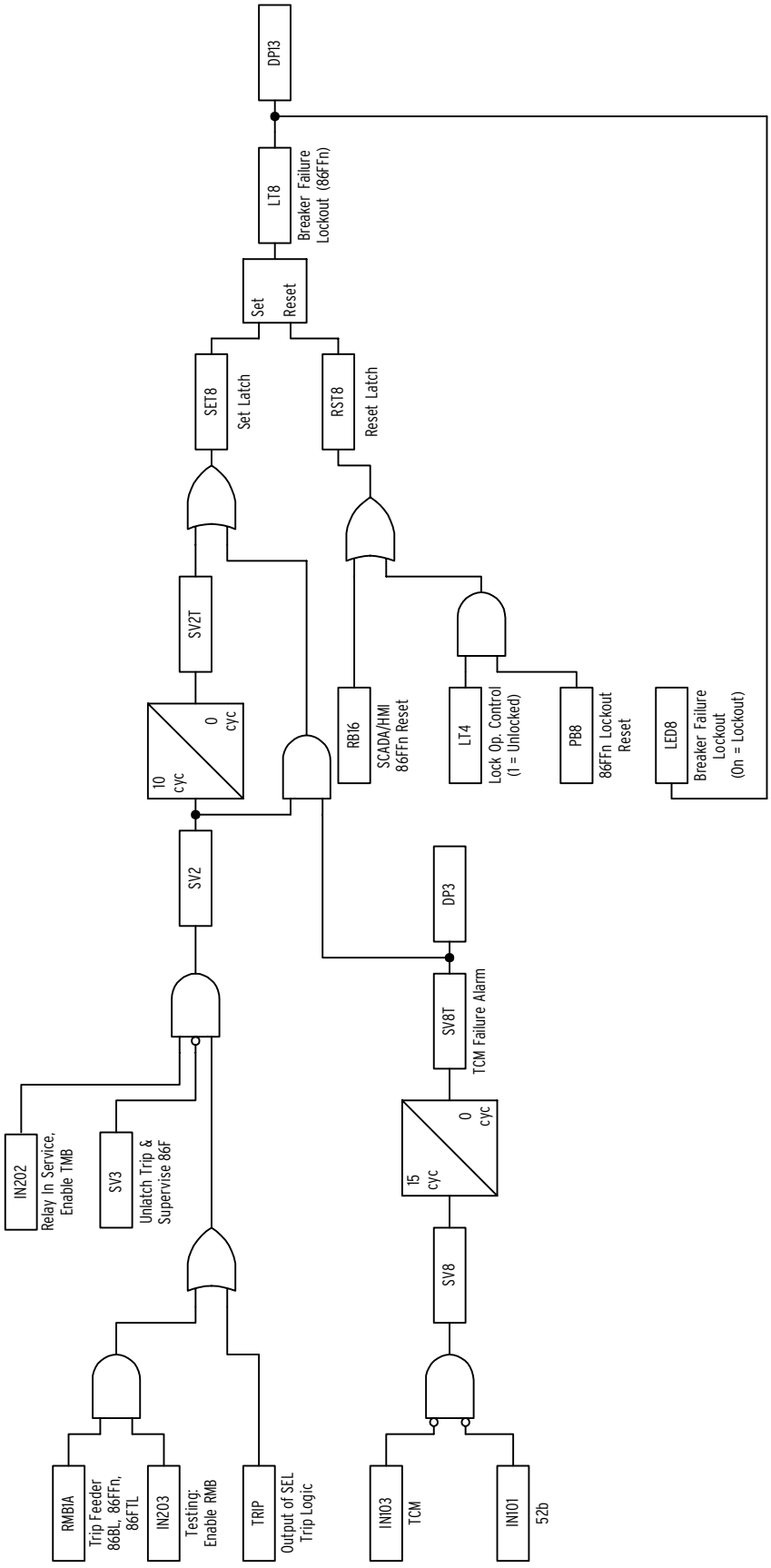


Figure 2.12: Feeder Breaker Failure Logic

Table 2.9 shows the settings that correspond to the logic shown in Figure 2.12 for the Breaker Failure Logic.

Table 2.9: Feeder Breaker Failure Settings

Setting Name	Value	Comment
SET8	SV2T+SV2*SV8T	Initiate breaker failure lockout
RST8	RB16+LT4*PB8	Clear breaker failure lockout
SV2	IN202*!SV3*(TRIP+RMB1A*IN203)	Breaker failure timer
SV8	!IN103*!IN101	Trip coil monitor timer
DP3	SV8T	Relay front-panel display indicating TCM failure alarm status
TMB8A	LT8	Transmit MIRRORED BIT 8, MIRRORED BITS Channel A
DP13	LT8	Relay front-panel display indicating breaker failure status
LED8	LT8	Relay front-panel LED indicating breaker failure status

Manual Breaker Close

Figure 2.13 depicts the Close, Block Close, and Automatic Reclose Logic for the Feeder SEL-351S Relays. This subsection describes the Manual Close and Block Close configuration. See *Breaker Automatic Reclose on page 2.16* for a description of the automatic reclosing logic.

There are three methods to manually close a feeder breaker:

1. Via remote SCADA
2. Via the local HMI
3. Via the relay front panel (if the front panel is unlocked)

Commands by SCADA and the local HMI come into the relay as bit CC, seen in Figure 2.13. The front panel of the SEL-351S used for feeder protection has a devoted **{CLOSE}** pushbutton wired to input IN201 of the relay. The CL logic is the manual close logic for the relay.

The Close Permissive (SV10) and the Manual Close Synchronization Permissive (SV11) supervise all manual close commands. The following conditions block manual close:

- Hold Tag (LT6)
- Hot Line Tag (LT5)
- Trip Output Contact (OUT101)
- Breaker Failure Condition (LT8)
- Breaker in Local (Maintenance) mode (IN106)
- Low energy alarms (SV7T)
- The remotely controlled “enable close” (RMB2A) generated by the SEL-2100

The Manual Close Synchronization Permissive (SV11) blocks manual close unless one of the following three conditions is logical 1:

- The line and the bus voltage are in synchronism (25A1), or
- The bus has no voltage (27A1), or
- The line has no voltage (27S).

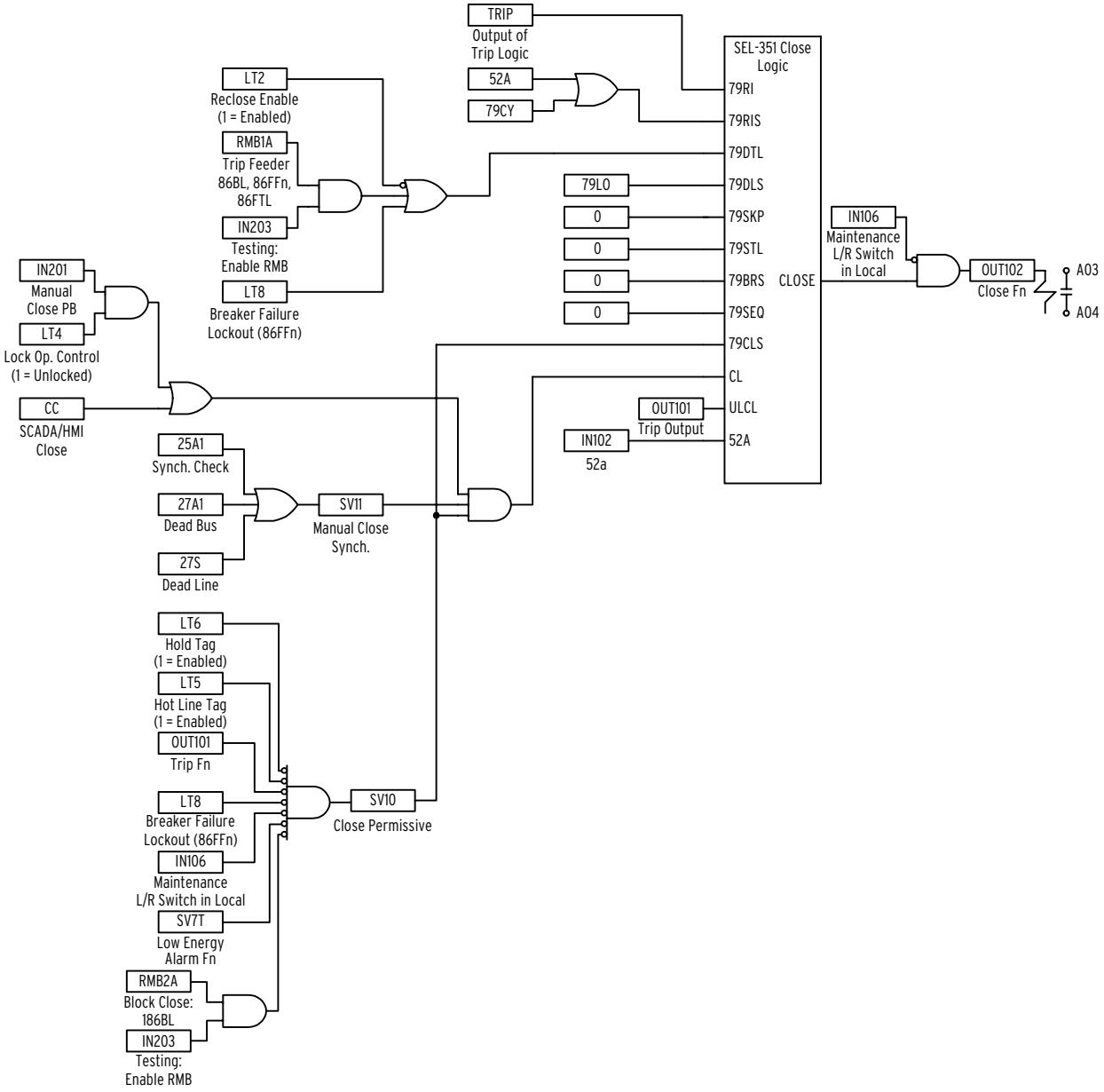


Figure 2.13: Feeder Breaker Close and Automatic Reclose Logic

Table 2.10: Feeder Breaker Manual Close Settings

Setting Name	Value	Comment
OUT102	CLOSE*!IN106	Close output contact
CL	(IN201*LT4+CC)*SV10*SV11	Manual close
ULCL	OUT101	Unlatch close

SV10	!LT6*!LT5*!OUT101*!LT8*!IN106 *!SV7T*!(RMB2A*IN203)	Close permissive
SV11	25A1+27A1+27S	Manual close synchronism permissive

Breaker Automatic Reclose

This section describes the automatic reclose logic present in the SEL-351S feeder relays. The logic associated with this functionality is shown in Figure 2.13. The following comments describe each of these settings.

- 79RI. Reclose Initiate. The reclose is initiated after a protection trip.
- 79RIS. Reclose Initiate Supervision. The reclose is not allowed to initiate unless the trip occurred while the breaker is closed or the relay is in the reclose cycle state (79CY).
- 79DTL. Drive to Lockout. The recloser is shutdown (driven to lockout) if the reclose is disabled (!LT2), if a breaker failure occurs (LT8), or if a remote lockout (RMB1A) occurs. IN203 is wired to a test switch and blocks received MIRRORED BITS.
- 79DLS. Drive to Last Shot. The shot counter is driven to the last shot if the recloser goes to lockout for any reason.
- 79SKP. Skip Shot. No shots are skipped with the default scheme.
- 79STL. Stall Open Interval Timer. There is currently nothing stalling the recloser.
- 79BRS. Block Reset Timing. Always set to zero.
- 79SEQ. Sequence Coordination Setting. This keeps the recloser in step with a downstream recloser. Disabled.
- 79CLS. Reclose Supervision. This supervises the close output logic coming from the automatic reclose logic in the SEL-351S. This is set to the Close Permissive (SV1).

Table 2.11: Feeder Breaker Automatic Reclose Settings

Setting Name	Value	Comment
79RI	TRIP	Reclose initiate
79RIS	52A+79CY	Reclose initiate supervision
79DTL	!LT2*(TRIP+!52A)+LT8+ OC+RMB1A*IN203	Drive to lockout
79DLS	79LO	Drive to last shot
79SKP	0	Skip shot
79STL	0	Stall open interval timing
79BRS	0	Block reset timing
79SEQ	0	Sequence coordination setting
79CLS	SV10	Reclose supervision

Breaker Trip

This section describes the protection trip logic and the manual trip logic in the SEL-351S feeder relays. Figure 2.14 depicts the trip logic present in SELOGIC control equations in the SEL-351S.

There are fundamentally three categories of protection trips: ground element trips, nonground element trips, and remote trips from the SEL-2100. Ground trips are supervised by LT1, whereas nonground trips are not supervised. RMB1A is received from the SEL-2100 when a low-side bus lockout (86BL) occurs or when a breaker failure occurs on an adjacent breaker (86Fn or 86FTL). RMB1A is supervised by IN203, which is wired to a test switch. RMB1A bypasses the TR equation logic to prevent lighting up the **TRIP** LED on this relay for a remote trip. This way, only the relay that registers the trip will have a front-panel LED **TRIP** indication.

All trips are supervised by IN106. IN106 is wired to a switch at the breaker used by a technician to disable all trip and close functionality in the relay. This is commonly a maintenance local/remote switch mounted on the breaker. Notice this supervision is done after the TRIP logic so that that the front-panel LED **TRIP** indication will indicate if a trip occurred while IN106 was active.

The **TRIP** command is latched up in the SEL-351S trip logic. The unlatch trip (ULTR) logic unlatches this trip, so long as the minimum trip duration timer (TDURD) has expired and the trip condition (TR) has gone away. See the SEL-351S Relay Instruction Manual for further information.

The local HMI or SCADA pulses the OC (open command) element. OC is omitted from the trip string to prevent the **TRIP** target LED from illuminating during an HMI- or SCADA-commanded trip. Therefore, the **TRIP** target LED will illuminate only during a protective trip. As shown below, the HMI/SCADA Open command (OC) energizes OUT101 for 60 cycles and is supervised by IN106.

The front-panel auxiliary trip pushbutton labeled **{BREAKER OPEN}** is directly wired to the trip circuit, so it is not shown in Figure 2.14. Use this button only for emergency tripping because it bypasses all of the HMI and relay interlocks.

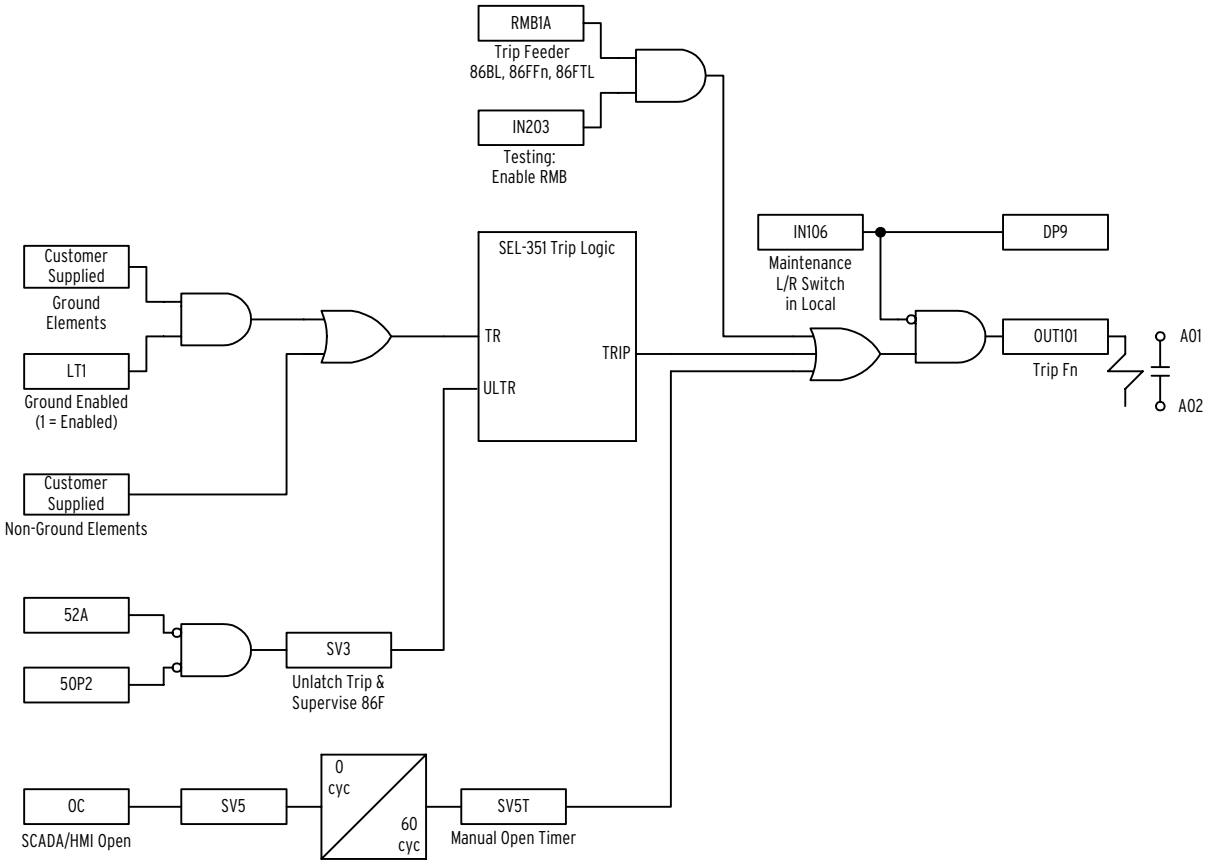


Figure 2.14: Feeder Breaker Trip Logic

Table 2.12: Feeder Breaker Trip Logic Settings

Setting Name	Value	Comment
TR	LT1*ground elements + non-ground element	Relay breaker trip logic
ULTR	SV3	Relay unlatch breaker trip logic
SV3	!52A*!50P2	Unlatch trip logic
OUT101	!IN106*(TRIP+SV5T+RMBIA*IN203)	Relay breaker trip output
SV5	OC	HMI and SCADA open control

MIRRORED BITS Communications

MIRRORED BITS communications from the relay are used for cooperative protection and automation functions that involve information from more than one relay. All of the SEL-421 and SEL-351S relays are connected to the SEL-2100. The SEL-2100 contains logic for breaker failure and bus protection schemes based on data from the relays in the station. A single communications port on the SEL-351S is used for MIRRORED BITS communications and assigned as MIRRORED BITS Port A (Protocol = MBA). The outgoing and incoming MIRRORED BITS are assigned as listed in Table 2.13. See *Logic Processor Configuration (67/86x)* for more information.

Table 2.13: Feeder MIRRORED BITS Assignment for Feeder Relays (MIRRORED BITS not mentioned are not used)

MIRRORED BIT	Assignment	Comment
TMB1A	67P3T+67G3T	Direction element into bus
TMB2A	67P4T+67G4T	Direction element out of bus
TMB3A	LOP	Loss of potential
TMB4A	!IN202	Relay out of service
TMB8A	LT8*!IN106	Breaker failure trip latch
RMB1A		Low-side bus lockout and breaker failure trips
RMB2A		Blocks close for a low-side high-impedance bus lockout (86BL)

Remote Bit Control

Remote SCADA and local HMI control is implemented using the relay remote bits (RBs) and breaker bits (BRs). Both of these bit types are used for remote control of the relay. Breaker Bit 1 (BR1) is a dedicated control that opens and closes the breaker. The communications processor sends 16 remote bits and 1 breaker bit to the SEL-351S. When a remote bit or breaker bit changes state in the communications processor, it automatically sends a binary Fast Operate message to the relay to perform the required control. The remote and breaker bits used for control have the functions listed in Table 2.14. It is important to note that the SET A setting SEND_OPER for all ports on the communications processor are set to YP. This setting sends all of the remote bits in Table 2.14 as pulsed, and not maintained values.

Table 2.14: Feeder Control Bit Assignments

Control Bit	Comment
RB1	Ground enable
RB2	Ground disable
RB3	Reclose enable
RB4	Reclose disable
RB5	Apply hot line tag
RB6	Remove hot line tag
RB7	Apply hold tag
RB8	Remove hold tag
RB9	Apply information tag
RB10	Remove information tag
RB11	Enable remote control
RB12	Disable remote control
RB13	Not used
RB14	Toggle settings
RB15	HMI “heartbeat”
RB16	Reset 86FFn

Set BR1 (OC)	Trip breaker
Clear BR1 (CC)	Close breaker

Main Breaker Relay (51TL) Configuration

The following subsections describe in detail the configuration and settings for selected functions implemented in the SEL-351S. This relay is used to provide backup feeder protection and automation for the low-side transformer or "main" breaker, 51TL.

For further information on the configuration of the 51TL device, refer to SEL-7000 Drawing S7000B-LD03.

Duplicated Logic

Duplication of logic is used wherever possible in the SEL-7000. Reusing code is one very tangible method for increasing engineering productivity, reducing complexity, and improving quality. In pursuance of these goals, much of the logic in the SEL-351S 51TL relay is identical to that in the feeder relays. This section does not review logic duplicated in the 51TL relay. The following is a list of duplicated logic:

- Front Panel Disable logic in the 51TL relay is identical to that in the feeder relays. Refer to *Front Panel Disable on page 2.4* for more details
- The Front Panel Lock Operator logic in the 51TL relay is identical to that in the feeder relays. Refer to section *Front Panel Lock on page 2.4* for more details.
- The Remote Enable logic in the 51TL relay is identical to that in the feeder relays. Refer to *Remote Enable on page 2.5* for more details.
- Operational Tagging in the 51TL relay is identical to that in the feeder relays, except there is no hot line tag. Refer to *Operational Tagging on page 2.6* for more details.
- Alternate settings enable are identical to that in the feeder relays. Refer to *Alternate Settings Enable on page 2.10* for more details.
- Breaker failure detection uses the same settings as in the feeder relays. Refer to *Breaker Failure Protection on page 2.11*.

There are several major differences between the configuration used in the 51TL and the feeder relays. The following is a list of the major differences in the logic:

- The low-side bus fault lockout for the zone-interlocked bus protection scheme (86BL) is displayed and reset at the 51TL relay. The control handles on Panel 5 reset the high-impedance bus lockouts.
- There is no ground enable function.
- There is no reclose function.
- The MIRRORED BITS and remote bits used are slightly different.

Low-Side Bus Fault Reset

Based upon directional tripping elements sent from the 51F1, 51F2, 51F3, 51F4, and 51TL relays, the SEL-2100 can determine if there has been a fault on the low-side bus. If it detects a bus fault, then the SEL-2100 asserts a lockout condition that is a nonvolatile latch bit. A low-side bus fault is labeled 86BL throughout this and other documentation. This lockout condition then transmits a tripping and block close signal to the 51F1, 51F2, 51F3, 51F4, and 51TL relays. The status of the lockout is available to SCADA, the local HMI, and the front panel of the 51TL relay. This lockout can be reset at the local HMI or the 51TL relay. This subsection discusses the indication and reset of an 86BL.

Figure 2.15 shows the Low-Side Bus Fault Reset Logic in the 51TL relay and Table 2.15 shows the settings. PB2 sends a transmit MIRRORED BIT, Bit 6, Channel A (TMB6A) to the SEL-2100 for resetting 86BL if the front panel is unlocked. RB3 (Remote Bit 3) comes from the local HMI and the remote SCADA system.

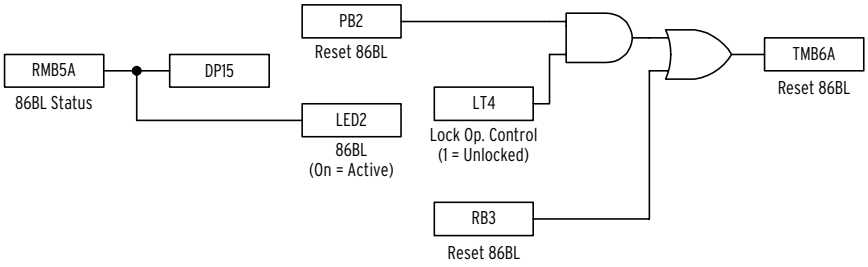


Figure 2.15: 51TL Low-Side Bus Fault Reset Logic

Table 2.15: 51TL Low-Side Bus Fault Reset Settings

Setting Name	Value	Comment
TMB6A	RB3+PB2*LT4	86BL reset
LED2	RMB5A	86BL status
DP15	RMB5A	86BL status

Breaker Close

The manual close logic (CL) for the 51TL relay is nearly identical to that of the feeder relays. Refer to *Manual Breaker Close on page 2.14* for more details.

As shown in Figure 2.16, the main difference is that the close permissive logic (SV10) is slightly different than that for the feeder relays. There is no hot line tag, but there is now a Block Close bit (RMB2A). This bit will block the close if either the low- or high-side bus high-impedance differential lockouts are tripped.

Take note that the recloser has been disabled and all associated elements set to logical 0.

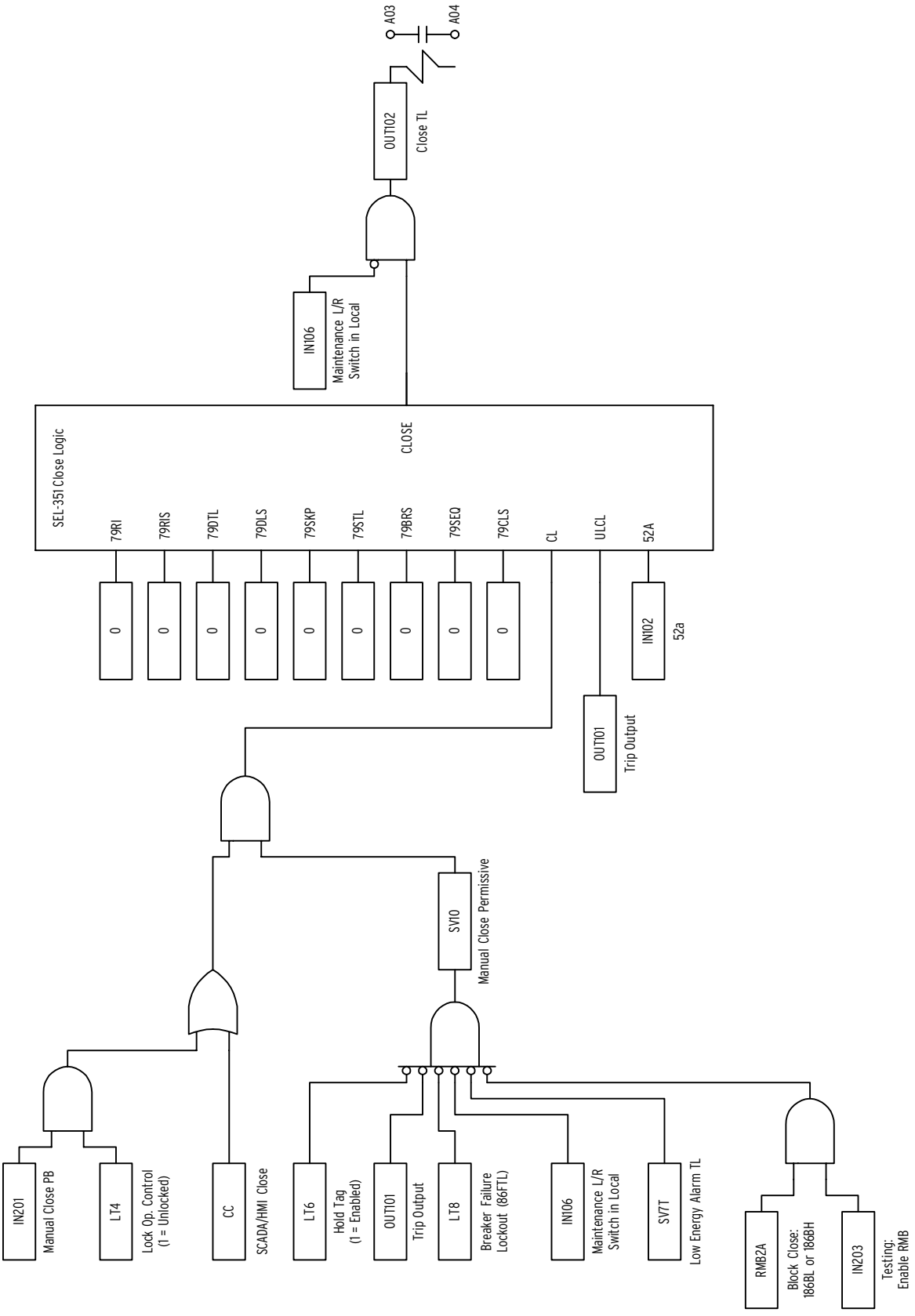


Figure 2.16: 51TL Breaker Close Logic

Table 2.16: 51TL Breaker Close Settings

Setting Name	Value	Comment
OUT102	CLOSE*!IN106	Close output contact
CL	(IN201*LT4+CC)*SV1	Manual close
SV10	!LT6*!OUT101*!LT8*!IN106*!SV7T*!(RMB2A*IN203)	Close permissive
ULCL	TRIP	Unlatch close
52A	IN102	52A status

Breaker Trip

The manual trip and unlatch trip (ULTR) logic for the 51TL relay are nearly identical to the feeder relays (see *Breaker Trip on page 2.17* for more details).

Unlike the feeder relays, the 51TL relay does not have a ground disable button. This is typically not required because the single pole switching that can occur on a feeder will typically not cause the main (51TL) to trip (see *Ground Protection Enable on page 2.8* for more details). 51TL also receives remote trips via RMB1A, but for different reasons. The MIRRORED BIT RMB1A is received from the SEL-2100 when a low-side bus lockout (86BL) occurs, when a transformer lockout occurs (86T1), when a high-side bus lockout (86BH) occurs, or when a breaker failure occurs on an adjacent breaker (86FFn or 86FHn). This MIRRORED BIT is supervised by IN203, which is wired to a test switch that blocks received MIRRORED BITS.

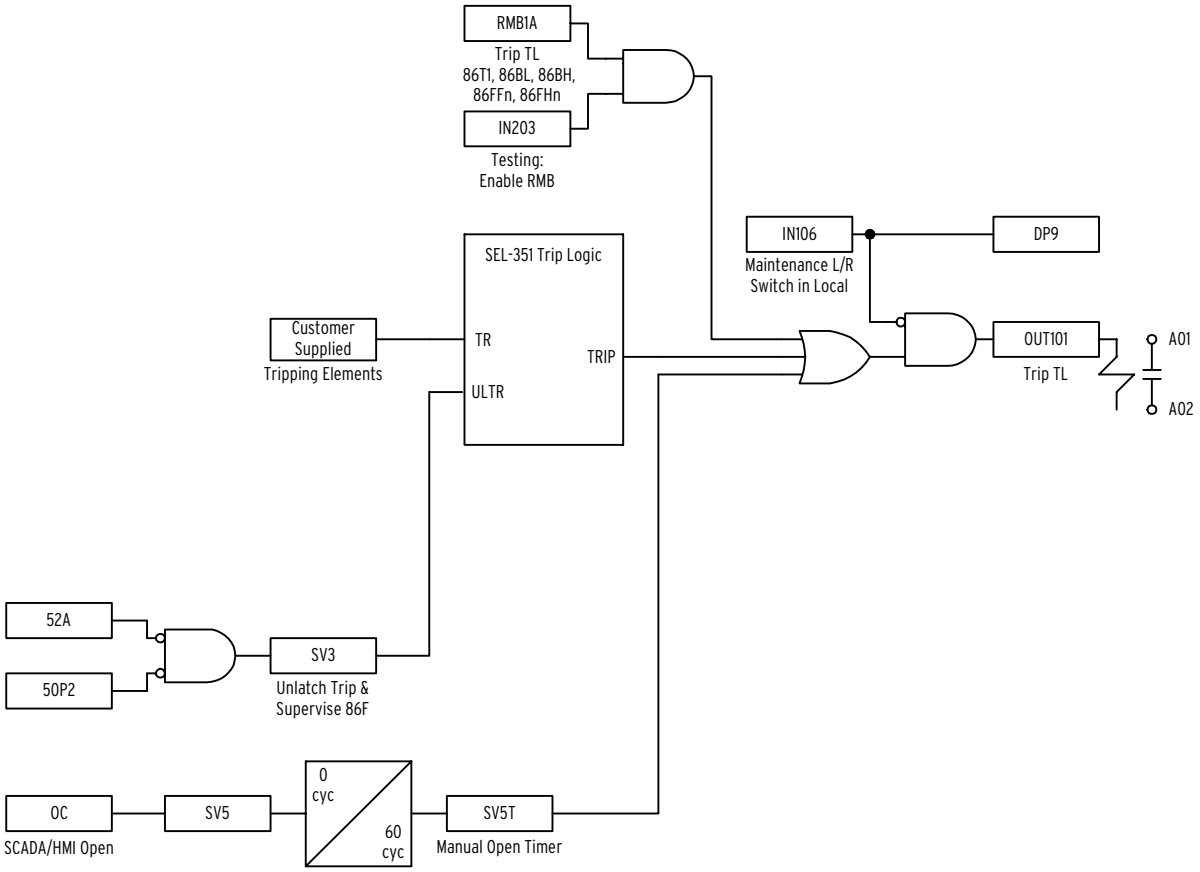


Figure 2.17: 51TL Breaker Trip Logic

Table 2.17: 51TL Breaker Trip Logic Settings

Setting Name	Value	Comment
TR	Customer-supplied tripping elements	Relay breaker trip logic
ULTR	SV3	Relay unlatch breaker trip logic
SV3	!52A*!50P2	Unlatch trip logic
OUT101	!IN106*(SV5T+TRIP+RMB1A *IN203)	Relay breaker trip output
SV5	OC	HMI and SCADA open control

MIRRORED BITS Communications

The MIRRORED BITS usage for 51TL is slightly different than for the feeder. First, the directional elements are swapped. This was done to keep directional Element 4 representing forward (downstream) faults, and Element 3 representing reverse (upstream) faults. The logic shown for TMB1A also includes instantaneous elements 50P4 and 50G4 supervised by the ESOTF (enable switch onto fault) bit. This additional logic provides a much faster reaction to a preexisting bus fault condition by using the ESOTF bit (see the SEL-351S Instruction Manual for further details on ESOTF).

The second difference from the feeders is that the 51TL relay resets low-side bus lockout (86BL). Third, the status of the TL breaker (!52A) is sent to the

SEL-2100. The open contact status is then sent by the SEL-2100 to the high-side relay (51TH).

MIRRORED BITS communications from the relays are used for cooperative protection and automation functions that involve information from more than one relay. All of the SEL-421 and SEL-351S relays are connected to the SEL-2100. The SEL-2100 contains logic for breaker failure and bus protection schemes based on data from the relays in the station.

A single communications port on the SEL-351S is used for MIRRORED BITS and assigned as MIRRORED BITS Port A (Protocol = MBA). The outgoing and incoming MIRRORED BITS are assigned as listed in Table 2.18. See *Logic Processor Configuration (67/86x)* for more information.

Table 2.18: 51TL MIRRORED BITS Assignment for Main Breaker Relay (MIRRORED BITS not mentioned are not used)

MIRRORED BIT	Assignment	Comment
TMB1A	67P4T+67G4T+ESOTF*(50P4+50G4)	Direction element into bus
TMB2A	67P3T+67G3T	Direction element out of bus
TMB3A	LOP	Loss of potential
TMB4A	!IN202	Relay out of service
TMB5A	!52A	Breaker open status
TMB6A	PB2*LT4+RB3	Reset low-side bus lockout
TMB8A	LT8*!IN106	Breaker failure trip logic
RMB1A		Remotely trip 51TL
RMB2A		Enable close
RMB6A		Blocks close if there is a low or high side bus lockout.

Remote Bit Control

Because of the slightly different functionality in 51TL, the remote bits have a different functionality than the feeder relays. See *Remote Bit Control on page 2.19* for more details on remote and breaker bits. Table 2.19 displays the bit usage in the 51TL.

Table 2.19: 51TL Control Bits Assignment

Control Bit	Comment
RB1	Not used
RB2	Not used
RB3	Reset 86BL
RB4	Not used
RB5	Not used
RB6	Not used
RB7	Apply hold tag
RB8	Remove hold tag
RB9	Apply information tag

RB10	Remove information tag
RB11	Enable remote control
RB12	Disable remote control
RB13	Not used
RB14	Toggle settings
RB15	HMI “heartbeat”
RB16	Reset 86FTL
Set BR1 (OC)	Trip breaker
Clear BR1 (CC)	Close breaker

Transformer High-Side (51TH) Relay

The subsections below describe in detail the configuration and settings for selected functions implemented in the SEL-351S. This relay is used to provide transformer protection and automation for the high-side motor-operated disconnect (MOD), TH.

An MOD was chosen as the high-side switching device over a circuit switcher or a breaker. This device can be easily replaced with a breaker or a circuit switcher with very little change to the SEL-7000 SELOGIC.

For further information on the configuration of the 87T1P device, refer to SEL-7000 Drawing S7000B-LD05.

Duplicated Logic

Much of the logic in the SEL-351S 51TH relay is identical to that of the feeder relays. This section does not review logic duplicated in the 51TH relay. The following is a list of duplicated logic:

- Front Panel Disable logic in the 51TH relay is identical to that of the feeder relays. Refer to *Front Panel Disable on page 2.4* for more details
- The Front Panel Lock Operator logic in the 51TH relay is identical to that of the feeder relays. Refer to *Front Panel Lock on page 2.4* for more details.
- The Remote Enable logic in the 51TH relay is identical to that of the feeder relays. Refer to *Remote Enable on page 2.5* for more details.
- Operational tagging in the 51TH relay is identical to that of the feeder relays, except there is no hot line tag. Refer to *Operational Tagging on page 2.6* for more details.
- Alternate settings enable are identical to that of the feeder relays. Refer to *Alternate Settings Enable on page 2.10.*

There are several major differences between the configuration used in the 51TH and the feeder relays. The following is a list of the major differences in the logic:

- There is no breaker failure detection for 51TH because TH is a motor-operated disconnect (MOD).
- There is transformer sudden pressure relay tripping in the 51TH relay.
- Transformer lockout and indication are available on the 51TH relay.
- The high-side bus fault lockout for the zone-interlocked bus protection scheme (86BH) is displayed and reset at the 51TH relay. The control handles on Panel 5 reset the high-impedance bus lockouts.
- There is no ground enable function.
- There is no reclose function.
- The MIRRORED BITS and remote bits used are slightly different.

Sudden Pressure Tripping

Sudden Pressure Rise transducers (63SPR) are used on large, liquid-cooled transformers to detect a fault internal to the transformer. In the 51TH relay, the normally open (NO) contact status of the 63SPR is wired to IN204, while the normally closed (NC) contact status is wired to IN205. 51TH then processes these inputs and asserts a nonvolatile lockout latch inside 51TH. Both the NO and NC contacts are used to help avoid false trips. Tripping through the SEL-351S allows status indication to the HMI and SCADA and allows for the sudden pressure contact status to be included in the event reports. It also allows us to enable or disable sudden pressure tripping with logic inside the 51TH relay.

Figure 2.18 shows the Sudden Pressure Tripping enable logic. RB3 and RB4 are used by the local HMI and remote SCADA to enable and disable sudden pressure relay tripping. If the front panel is unlocked, PB8 can be used to enable or disable this function.

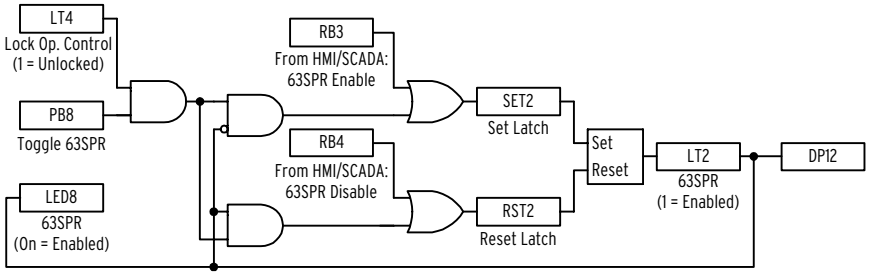


Figure 2.18: 51TH Sudden Pressure Tripping Enable Logic

Table 2.20: 51TH Sudden Pressure Tripping Enable Settings

Setting Name	Value	Comment
SET2	LT4*PB8*!LT2+RB3	Enable 63SPR
RST2	LT4*PB8*LT2+RB4	Disable 63SPR

DP12	LT2	Relay front-panel scrolling display indicating 63SPR status
LED8	LT2	Relay front-panel LED indicating 63SPR status

Sudden Pressure Trip Latch

Similar to breaker failure lockouts, the sudden pressure lockout resides in the relay and not in the SEL-2100. Figure 2.19 details the lockout logic in the 51TH relay. Notice that if the sudden pressure inputs (IN204 and !IN205) are active for more than one cycle, then the lockout asserts. This lockout, like all others in the SEL-7000, is a nonvolatile latch.

As shown in Figure 2.19, SV11T is sent to the trip equation in the 51TH. This directly turns in to a transformer lockout because any protection trip coming from the 51TH relay trips the transformer lockout.

The sudden pressure trip latch and the transformer lockout are reset by the same logic. As shown in Figure 2.19, if the front-panel pushbutton (PB1) is pressed while the relay front-panel controls are unlocked (LT4), the 63SPR latch and the transformer lockout (86T1) are reset. The HMI or the remote SCADA system can do this through Remote Bit 13 (RB13).

The transformer lockout (86T1) condition is indicated on the 51TH relay via a display point (DP11) and via LED1.

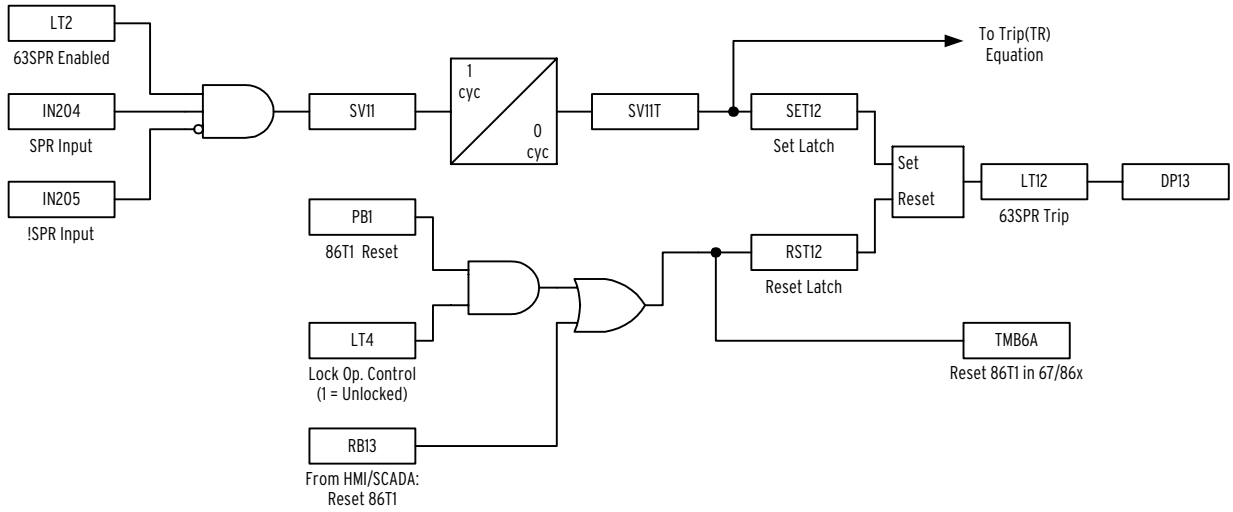


Figure 2.19: 51TH Sudden Pressure Trip Logic

Table 2.21: 51TH Sudden Pressure Trip Settings

Setting Name	Value	Comment
SET12	SV11T	Set sudden pressure latch
RST12	PB1*LT4+RB13	Reset sudden pressure latch
TMB6A	PB1*LT4+RB13	Reset transformer lockout latch
SV11	LT2*IN204*!IN205	Sudden pressure lockout set timer
DP13	LT12	Relay front-panel scrolling display: 63SPR lockout status

DP11	RMB5A	Relay front-panel scrolling display: 86T1 lockout status
LED1	RMB5A	Relay front-panel LED indicating transformer lockout status

High-Side Bus Fault Reset

Based on directional tripping elements sent from the 21L1, 21L2, and 51TH relays, the SEL-2100 can determine if there has been a fault on the high-side bus. If it detects a bus fault, the SEL-2100 asserts a lockout condition as a nonvolatile latch bit. A high-side bus fault is labeled 86BH throughout this and other documentation. This lockout condition then transmits a tripping and block close signal to the 51TL, 21L1, and 21L2 relays.

When a High-Side Bus Fault Lockout occurs, the 51TL relay is sent a trip signal instead of the 51TH relay because the TH device is an MOD and cannot interrupt current. Opening TH would not even guarantee that the fault would be isolated because the CT used by 51TH to detect fault current is downstream of the actual TH breaker. Thus, it is possible that the perceived bus fault may have actually occurred between TH and the CT. Opening TL covers this contingency.

The status of the lockout is available to SCADA, the local HMI, and the front panel of the 51TH relay. This lockout can be reset at the local HMI or the 51TH relay. This subsection discusses the indication and reset of an 86BH.

Figure 2.20 shows the High-Side Bus Fault Reset Logic in the 51TH relay and Table 2.22 shows the settings. PB2 sends transmit MIRRORED BIT 7, Channel A (TMB7A) to the SEL-2100 for resetting 86BH if the front panel is unlocked. RB16 (Remote Bit 16) comes from the local HMI and the remote SCADA system. Note that RMB6A provides indication of the lockout to the 51TH relay through a scrolling display (DP15) and a front-panel LED (LED2).

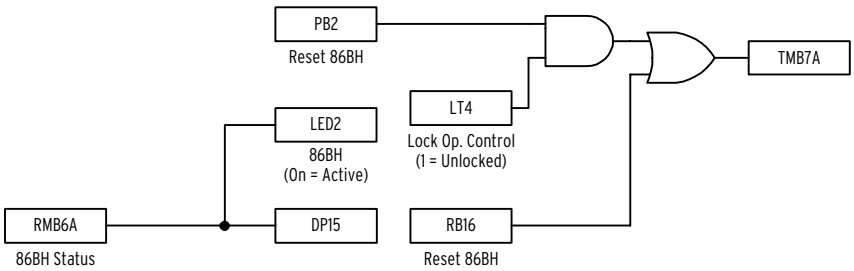


Figure 2.20: 51TH High-Side Bus Fault Reset Logic

Table 2.22: 51TH High-Side Bus Fault Reset Settings

Setting Name	Value	Comment
TMB7A	RB16+PB2*LT4	86BH reset
LED2	RMB6A	86BH status LED
DP15	RMB6A	86BH status

MOD Close

The manual close logic (CL) for the 51TH relay is nearly identical to the feeder relays. See *Manual Breaker Close on page 2.14* for more details.

As shown in Figure 2.16, the close permissive (SV10) is slightly different than for the feeder relays. There is no hot line tag, breaker failure, maintenance local/remote switch, or Enable Close elements in the 51TH.

Take note that the recloser has been disabled and all associated elements set to logical 0.

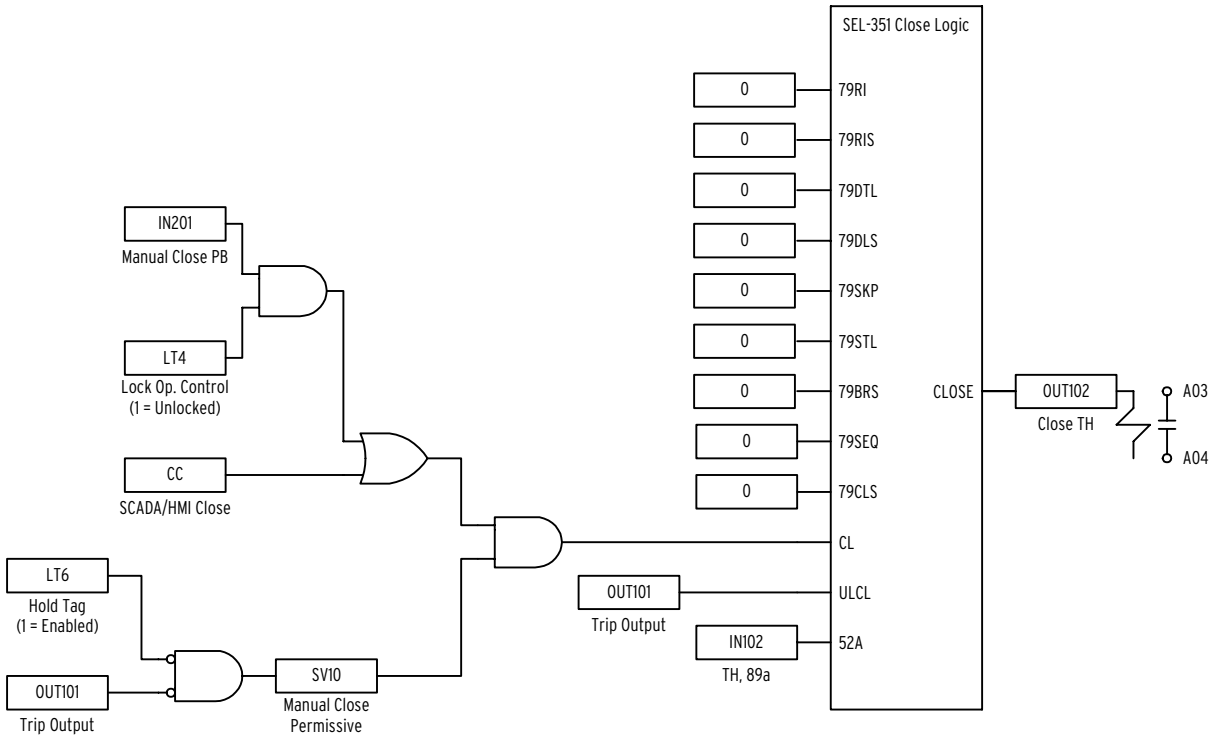


Figure 2.21: 51TH Breaker Close Logic

Table 2.23: 51TH Breaker Close Settings

Setting Name	Value	Comment
OUT102	CLOSE	Close output contact
CL	(IN201*LT4+CC)*SV1	Manual close
SV10	!LT6*!OUT101	Manual close permissive
ULCL	OUT101	Unlatch close

MOD Open

The manual trip and unlatch trip (ULTR) logic for the 51TH relay is nearly identical to the feeder relays (see *Breaker Trip on page 2.17* for more details).

Unlike the feeder relays, the 51TH relay does not have a **{GROUND ENABLE}** pushbutton. 51TH also receives remote trips via RMB1A, but for different reasons. The MIRRORED BIT RMB1A is received from the SEL-2100 when a transformer lockout occurs (86T1) or when the 51TL relay asserts a

breaker failure lockout (86FTL). RMB1A is supervised by IN203, which is wired to a test switch that blocks received MIRRORED BITS.

Notice that the remotely requested trips (RMB1A) bypass the trip equation. This was done to prevent the front-panel **TRIP** LED from lighting up for trip decisions made by other relays.

Another difference from the feeder trip logic is that the manual trip equation is not supervised by the maintenance local/remote switch input. This is because the MOD TH does not have this functionality.

Note that the output of the SEL-351S trip logic trips the TH, H1, H2, and TL breakers. These other devices are tripped because the TH circuit switcher cannot interrupt current. These devices are tripped directly from the 51TH relay as well as through the SEL-2100. The direct contacts reduce fault-clearing time by a fraction of a cycle, while the secondary path through the SEL-2100 increases the reliability of the protection system by acting as a backup path.

H1 and H2 are tripped only if TH is not open. It is unnecessary to trip the transmission line breaker if the high-side MOD is already open. This situation may arise when energizing the transformer from the low side.

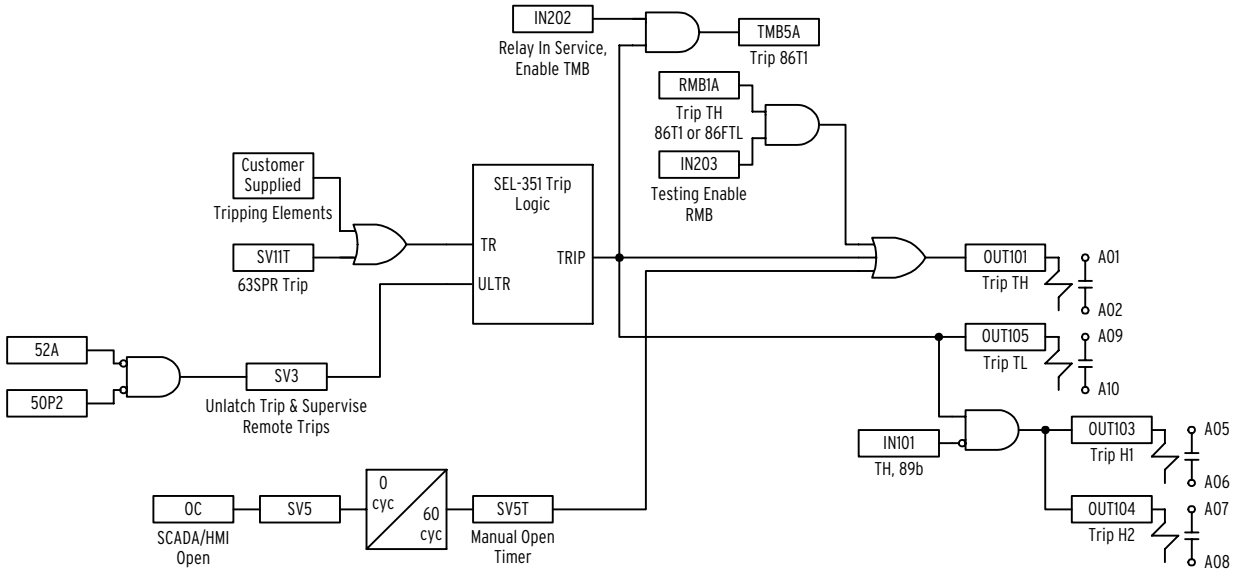


Figure 2.22: TH MOD Open Logic

Table 2.24: TH MOD Open Logic Settings

Setting Name	Value	Comment
TMB5A	TRIP*IN202	Trip transformer lockout
OUT101	TRIP+SV5T+RMB1A*IN203	TH trip
OUT103, OUT104, OUT105	TRIP	Breaker trip output
TR	Customer Tripping Elements	Breaker trip logic
SV3	!52A*!50P2	Unlatch trip logic
ULTR	SV3	Unlatch breaker relay trip logic
SV5	OC	Manual open timer

MIRRORED BITS Communications

The MIRRORED BITS usage for 51TH is slightly different than for the feeder. Table 2.25 lists the settings of the MIRRORED BITS.

Table 2.25: 51TH MIRRORED BITS (MIRRORED BITS not mentioned are not used)

MIRRORED BIT	Assignment	Comment
TMB1A	67P3T+67G3T	67 into bus
TMB2A	67P4T+67G4T	67 out of bus
TMB3A	LOP	Loss of potential
TMB4A	!IN202	Relay out of service
TMB5A	TRIP*IN202	Output of SEL-351S trip logic
TMB6A	RB13+(PB1*LT4)	Reset 86T1
TMB7A	(PB2*LT4)+RB16	Reset 86BH
RMB1A		Trip TH: 86T1 or 86FTL
RMB2A		TL 52B status
RMB5A		Transformer lockout, 86T1
RMB6A		High-side bus lockout, 86BH

Remote Bit Control

Because of the slightly different functionality in 51TH, the remote bits have a different functionality than the feeder relays. See *Remote Bit Control on page 2.19* for more details on remote and breaker bits. Table 2.26 displays the bit usage in the 51TH.

Table 2.26: 51TL Control Bits Assignment

Control Bit	Comment
RB1	Not used
RB2	Not used
RB3	63SPR enable
RB4	63SPR disable
RB5	Not used
RB6	Not used
RB7	Apply hold tag
RB8	Remove hold tag
RB9	Apply information tag
RB10	Remove information tag
RB11	Enable remote control
RB12	Disable remote control
RB13	Reset 86T1 and 63SPR
RB14	Toggle settings

RB15	HMI “heartbeat”
RB16	Reset 86BH
Set BR1 (OC)	Trip breaker
Clear BR1 (CC)	Close breaker

Transformer Differential Relay (87TLP)

The transformer differential relay device 87T1P is an SEL-387. This relay does not have MIRRORED BITS capability, so it sends the tripping command directly to the SEL-2100, where it is held for lockout. The TL, TH, H1, and H2 devices are tripped directly from the 51TH relay, as well as through the lockout residing in the SEL-2100. See Figure 2.23 for further details.

H1 and H2 are tripped only if TH is not open. It is unnecessary to trip the transmission line breaker if the high-side MOD is already open. This situation may arise when energizing the transformer from the low side.

No **CLOSE** command is propagated through the 87T1P relay; therefore, the close logic is disabled in this relay.

For further information on the configuration of the 87T1P device, refer to SEL-7000 Drawing S7000B-LD04.

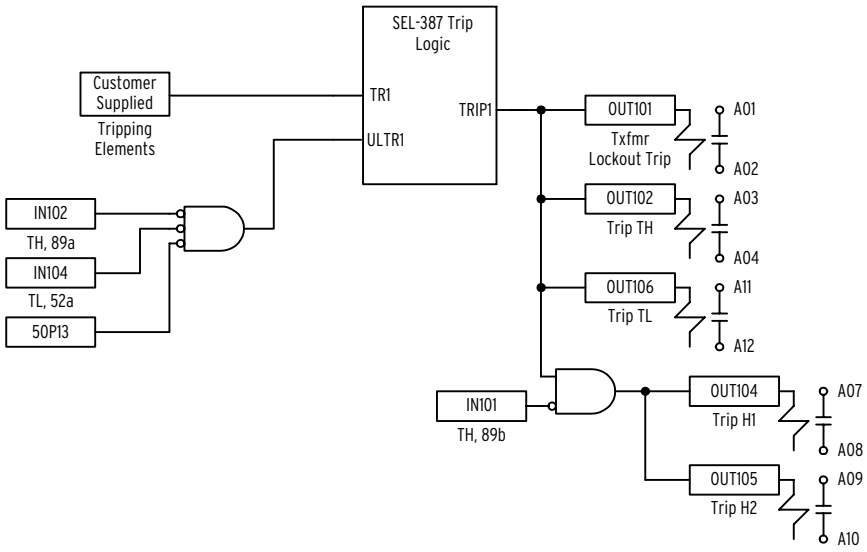


Figure 2.23: 87T1P Tripping Logic

Table 2.27: 87T1P Tripping Settings

Setting Name	Value	Comment
OUT101, OUT102, OUT104, OUT105, OUT106	TRIP1	The relay trips TL, TH, H1, H2, and the lockout in 67/86x.
TR1	Customer supplied settings	Trip equation
ULTR1	!IN102*!IN104*!50P13	Unlatch trip equation

Primary Transmission Relays (21L1, 21L2)

The settings for the primary (21Ln) and secondary (121Ln) transmission line protection relays were created to demonstrate an appropriate way to perform protection and automation using redundant relays. For example, to take advantage of both relays, the front-panel trip and close path is routed through a different relay than the trip and close coming from the HMI and SCADA. This was done to guarantee that there was always a trip and close path if either one of the relays failed.

When referring to the SEL-421 Relays used for primary protection of the two transmission lines, we use the notation 21Ln to generically refer to both the 21L1 and 21L2 relays. A reference of 121Ln is meant to indicate both the 121L1 and 121L2 relays.

For much of the subsequent tagging and enable functions, the logic could have been accomplished in SEL-421 automation logic rather than in SEL-421 protection logic. The choice to use protection logic for nearly all the functionality used in the SEL-7000 was for consistency in documentation and reuse of logic.

Many of the following sets of logic are functionally identical to the logic in the SEL-351S Relays, but applied in the SEL-421, the logic is different in appearance. Because much of the logic in the 21Ln relays is nearly identical to that already described in *Distribution Feeder Relays (51F1, 51F2, 51F3, 51F4) on page 2.4,* many of the following subsections comment only on anything unique about the logic.

For further information on the configuration of the 21Ln devices, refer to SEL-7000 Drawing S7000B-LD06A and S7000B-LD06B.

Front Panel Disable

The HMI is the preferred interface because of the ease of use gained through complete substation control at a single location. There are also several other benefits of the HMI. The HMI offers confirmation screens, warnings, alarms, and other flexible user-interface features that reduce human error when compared to operation through the relay front panel.

If communication with the communications processor or HMI is active, the front panels of the SEL-421 Relays are disabled. If communication is lost, the logic shown in Figure 2.24 enables the relay front-panel pushbuttons. A script in the HMI program is continuously pulsing Remote Bit 15 (RB15) in the relay (the

HMI “heartbeat”). If for any reason RB15 does not pulse high for 900 consecutive cycles (15 seconds), then PCT01Q goes to logical 0. Display Point 14 (DP_ELE14) conveys this information to the user on the scrolling displays. Unlike the SEL-351S pushbuttons that require the additional step of unlocking the front panels, the SEL-421 pushbuttons are immediately available upon communication loss.

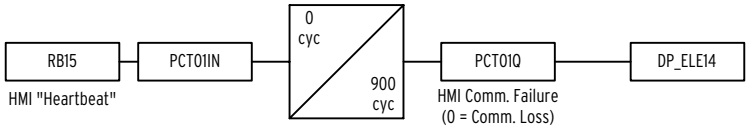


Figure 2.24: 21Ln Front-Panel Disable Logic

Table 2.28: 21Ln Front-Panel Disable Logic

Setting Name	Value	Comment
PCT01IN	RB15	HMI “heartbeat”
DP_ELE14	PCT01Q	Relay front-panel control display

Remote Enable

In the SEL-7000, remote control (typically via SCADA) can be disabled individually for each breaker. The remote control disable latch (PLT03) resides in SELOGIC control equations inside the SEL-421, and the supervision of remote control takes place in logic inside the communications processor.

The logic diagram in Figure 2.25 shows the remote enable logic that resides in the SEL-421. If PCT01Q is logical 0 (communication to the HMI has failed), then pressing the **{REMOTE ENABLED}** pushbutton toggles the remote control on and off.

RB11 in Figure 2.25 is used to enable remote control, and RB12 is used to disable remote control. These remote bits come from the local HMI.

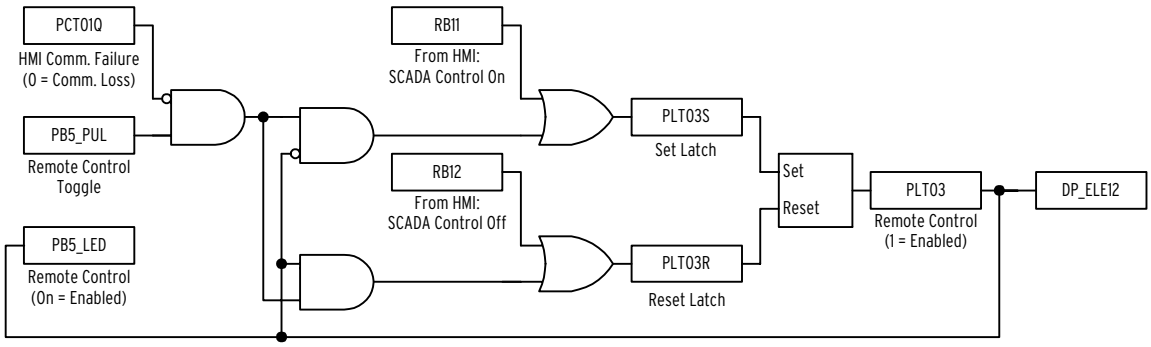


Figure 2.25: 21Ln Remote Enable Logic

The settings for the remote mode logic in Figure 2.25 are shown in Table 2.29.

Table 2.29: 21Ln Remote Enable Logic Settings

Setting Name	Value	Comment
PLT03S	NOT PCT01Q AND PB5_PUL AND NOT PLT03 OR NOT RB11	Enable remote control
PLT03R	NOT PCT01Q AND PB5_PUL AND PLT03 OR RB12	Disable remote control
DP_ELE12	PLT03	Relay front-panel control display
PB5_LED	PLT03	Relay front-panel LED indicating remote control status

Operational Tagging

The operational tagging in the 21L1 and 21L2 relays is identical to that of the feeder relays. Please see *Operational Tagging on page 2.6* for an explanation of the advantages of the SEL-7000 tagging system.

The SEL-421 Relays are configured with tagging capabilities for each of the transmission lines. In the SEL-7000 design, the SEL-311 series relays are used only for secondary protection and HMI and SCADA control. See *Secondary Transmission Relays (121L1, 121L2) on page 2.48* for more details.

Information Tag

The information tag conveys a message associated with substation equipment that may be in operation. The operator can set or reset the information tag only through the HMI or SCADA system, not through the relay front panel. Figure 2.26 shows the logic in the SEL-421 Relays associated with the information tag.

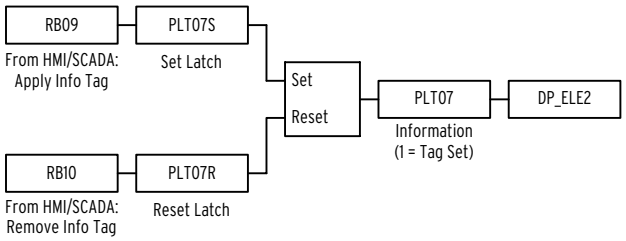


Figure 2.26: 21Ln Information Tag Logic

Hot Line Tag

The hot line tag logic is illustrated in Figure 2.27. Note that this is nearly identical to the feeder relay logic described in *Hot Line Tag*. The main difference is that there is no front-panel unlock required to manually toggle the hot line tag.

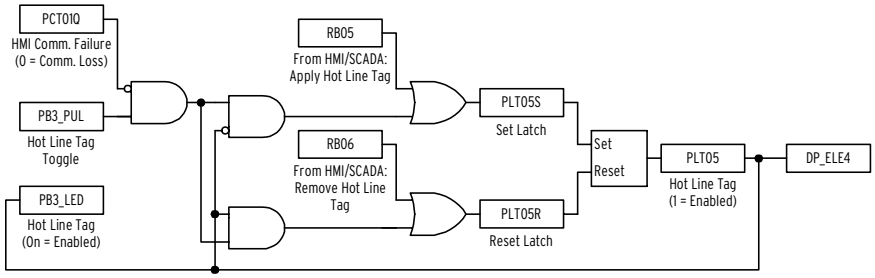


Figure 2.27: 21Ln Hot Line Tag Logic

Hold Tag

The hot line tag logic is illustrated in Figure 2.28. Note that this is nearly identical to the feeder relay logic described in *Hot Line Tag* (the previous subsection). The only difference is that there is no front-panel unlock required to manually toggle the hold tag.

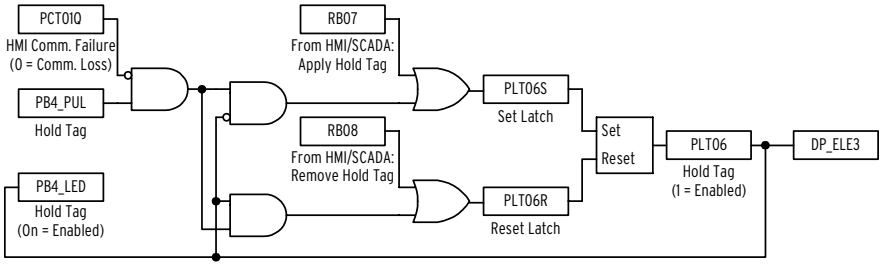


Figure 2.28: 21Ln Hold Tag Logic

Table 2.30: 21Ln Operation Tag Settings

Setting Name	Value	Comment
PLT07S	RB9	Remove information tag
PLT07R	RB10	Apply information tag
PLT05S	NOT PCT01Q AND PB3_PUL AND NOT PLT05 OR RB5	Remove hot line tag
PLT05R	NOT PCT01Q AND PB3_PUL AND PLT05 OR RB6	Apply hot line tag
PLT06S	NOT PCT01Q AND PB4_PUL AND NOT PLT06 OR RB7	Remove hold tag
PLT06R	NOT PCT01Q AND PB4_PUL AND PLT06 OR RB8	Apply hold tag
DP_ELE2	PLT06	Relay front-panel display information tag status
DP_ELE4	PLT05	Relay front-panel display hot line tag status
DP_ELE3	PLT06	Relay front-panel display hold tag status
PB5_LED	PLT05	Relay front-panel LED indicating hot line tag status
PB4_LED	PLT06	Relay front-panel LED indicating hold tag status

Automatic Reclose Enable

The Automatic Reclose Enable logic is illustrated in Figure 2.29. Note that this is nearly identical to the feeder relay logic described in *Automatic Reclose Enable*. The only difference is that there is no front-panel unlock required to manually toggle the Reclose Enable.

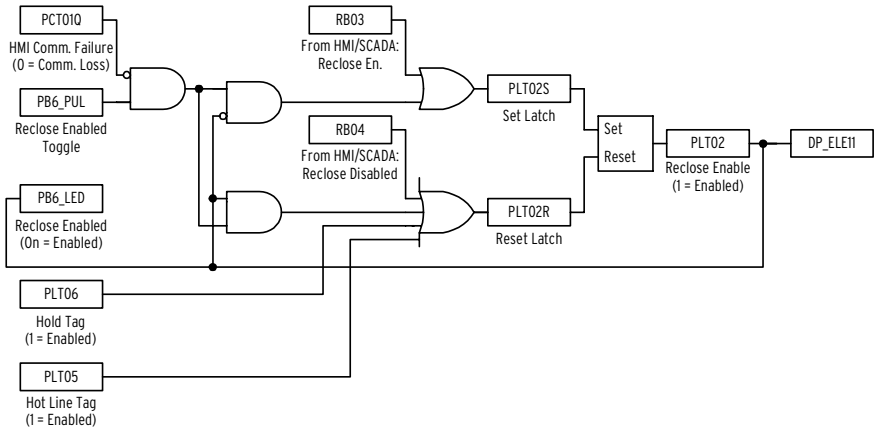


Figure 2.29: 21Ln Automatic Reclose Enable Logic

Table 2.31 shows the settings that correspond to the logic shown in Figure 2.29 for the Automatic Reclose Enable feature.

Table 2.31: 21Ln Automatic Reclose Enable Settings

Setting Name	Value	Comment
PLT02S	NOT PCT01Q AND PB6_PUL AND NOT PLT02 OR RB03	Enable automatic reclose
PLT02R	NOT PCT01Q AND PB6_PUL AND PLT02 OR PLT05 OR PLT06 OR RB04	Disable automatic reclose
DP_ELE12	PLT02	Relay front-panel display reclose control status
PB6_LED	PLT02	Relay front-panel LED indicating reclose control status

Breaker Failure Protection

In the SEL-7000, breaker failure detection occurs in the SEL-421 Relays using the logic shown in Figure 2.30. PLT07 is a nonvolatile latch that maintains the state of the breaker failure lockout.

Once a breaker failure is detected, the breaker failure lockout (PLT07) information is transmitted to the SEL-2100 using MIRRORED BITS TMB8A. The SEL-2100 distributes this information to other adjacent breakers in the substation to clear the fault. (See *Logic Processor Configuration (67/86x) on page 2.52* for further details on the SEL-2100.) The BFTRIP1 information is also transmitted to the relay on the other end of the transmission line via TMB7B.

Once a breaker failure condition has been resolved, it is necessary to reset the Breaker Failure Lockout (PLT07). RB16 is used by the local HMI and remote

SCADA system to reset BFTRIP1. **{RESET 86FHN}** is also available to reset BFTRIP1, if the front-panel pushbuttons are enabled. This is shown near the center of Figure 2.30.

It is extremely important that a proper breaker failure scheme react as quickly as possible to every contingency in a power system. In the SEL-7000 design, three different contingency situations are designed into the 21L1 and 21L2 breaker failure logic:

1. If the SEL-421 (3PT) or the SEL-311 series relay (IN201) detects a fault, then the SEL-421 Failure to Interrupt Fault Current logic is used to detect whether or not the transmission breaker has properly interrupted the fault. This is shown in the lower-left corner of Figure 2.30.

2. If a fault occurs on or downstream of the transformer, it may be difficult for the SEL-421 Failure to Interrupt Fault Current algorithm to detect that the transmission breaker has failed to open. It may also be difficult for this algorithm to detect if a remote relay direct transfer trips the local breaker (RMB7B). This is because either one of these situations may create much less fault current than faults nearby on the transmission system. To cover this contingency, the transformer lockout (86T1), the low-side breaker failure (86FTL), and remote breaker failure (RMB7B) conditions are supervised by the Failure to Interrupt Load Current algorithm shown in Figure 2.30.

3. If a trip occurs and the Trip Coil Monitor (TCM) alarm is set for both coils, then the breaker failure lockout is immediately latched. This is the logic in the upper-left corner of Figure 2.30.

One very nice method commonly used to minimize false breaker failure trips is to attempt to “retrip” the breaker through another path before going into a breaker failure lockout. One opportunity to apply this in the SEL-7000 design is the two different trip coils used by the SEL-311 and SEL-421 breakers. If the SEL-311 breaker detects a trip condition, it sends the breaker failure initiate signal to the SEL-421 via IN201. The SEL-421 Failure to Interrupt Fault current then issues a “retrip” via the RT1 output. RT1 then travels onto the manual trip logic (BK1MTR) so that it can be sealed in by the trip logic. This retrip is not routed through the TR logic so that it will not light the front-panel **TRIP** target LED.

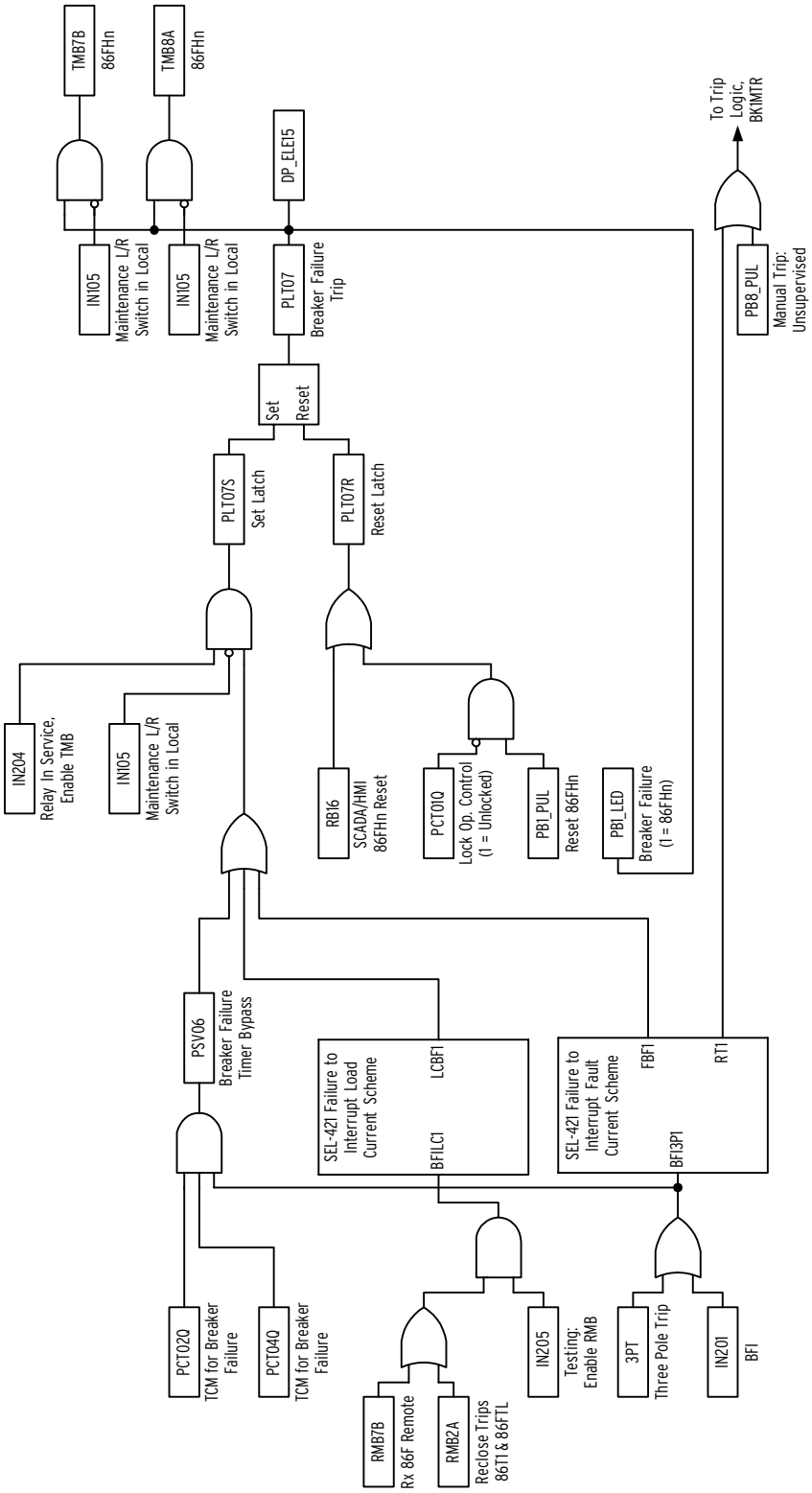


Figure 2.30: 21Ln Breaker Failure Logic

Table 2.32: 21Ln Breaker Failure Settings

Setting Name	Value	Comment
BFILC1	(RMB2A OR RMB7B) AND IN205	Low fault-current breaker failure initiation
BFI3P1	3PT OR IN201	Failure to interrupt fault-current breaker failure
PB1_LED	PLT07	Front-panel display indication
DP_ELE15	PLT07	Front-panel display indication
PLT07S	IN204 AND NOT IN105 AND (3PT AND PCT02Q OR LCBF1 OR FBF1)	Latches the breaker failure lockout
PLT07R	RB16 OR NOT PCT01Q AND PB1_PUL	Unlatches the breaker failure lockout
PSV06	PCT02Q AND PCT04Q AND (3PT OR IN201)	Bypass of breaker failure logic if trip coil monitors both indicate fail
TMB8A	PLT07 AND NOT IN105	Breaker failure lockout issued to SEL-2100
TMB7B	PLT07 AND NOT IN105	Breaker failure lockout issued to the relay on the other end of transmission line

Communications-Assisted Protection Enable

The SEL-421 has many different built-in communications-assisted protection routines, such as POTT (Permissive-Overreaching Transfer Trip), DCUB (Directional Comparison Unblocking), and DCB (Directional Comparison Blocking). The SEL-7000 design leaves users free to select which, if any, of these schemes they wish to use.

Often it is necessary to disable a communications-assisted protection scheme. The SEL-7000 provides this logic as shown in Figure 2.31. Remote Bits 1 and 2 (RB01 and RB02) provide HMI and SCADA control for the communications-assisted protection scheme feature. Relay front-panel Pushbutton 2 labeled **{COMM. SCHEME ENABLED}** toggles the communications protection scheme if the front-panel control is enabled. Table 2.32 shows the settings for the communications-assisted protection scheme.

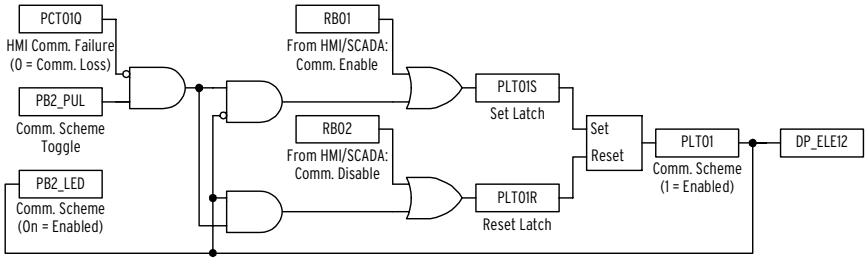


Figure 2.31: 21Ln Communications-Assisted Protection Enable Logic

Table 2.33: 21Ln Communications-Assisted Protection Enable Settings

Setting Name	Value	Comment
PLT01S	NOT PLT01Q AND PB2_PUL AND NOT PLT01 OR RB01	Enable comm scheme
PLT01R	NOT PLT01Q AND PB2_PUL AND PLT01 OR RB02	Disable comm scheme
DP_ELE12	PLT01	Relay front-panel display comm scheme status
PB2_LED	PLT01	Relay front-panel LED indicating comm scheme status

Manual Breaker Close

Figure 2.32 depicts the Close, Block Close, and Automatic Reclose Logic for the Transmission Line SEL-421 Relays. This section describes the manual close logic for the SEL-421. See *Breaker Automatic Reclose on page 2.44* for a description of the automatic reclosing logic.

There are three methods to manually close a transmission line breaker: remote SCADA, the local HMI, and the relay front panel (if the front-panel pushbuttons are enabled). Commands by SCADA and the local HMI are processed by the SEL-311 series relay; refer to *Breaker Close on page 2.49* for details on this functionality. Relay front panel controls are processed by the SEL-421 series relay.

Manual close through the SEL-421 is accomplished only through the relay front-panel **{BREAKER CLOSED}** pushbutton. The BK1MCL input to the close logic is the manual close logic for the transmission breaker. Note that the three bits supervising the front-panel manual close are the Manual Close Permissive PSV03, the Lock Operator Control bit PCT01Q, and the Manual Close Synch Check supervision. This logic is depicted in the center of Figure 2.32.

The Manual Close Permissive (PSV03) permits the breaker to be closed only when the following criteria have been satisfied:

- The hot line tag (PLT05) is off.
- The hold tag (PLT06) is off.
- There is no trip being requested (OUT101).
- There is no breaker failure (PLT07).
- There are no remote lockouts disabling the close (RMB4A).
- The maintenance local/remote switch is not in the local position.
- There is not a Low Stored energy alarm (PCT06Q).
- There is not a Low SF6 Pressure Alarm (PCT07Q).

The Manual Close Synch Permissive (PSV04) permits the breaker to be closed when one of the following criteria have been satisfied:

- The SEL-421 synchronism-check logic has been satisfied, indicating that the voltages on both sides of the breaker are in synchronism.
- If one or both sides of the breaker do not have voltage.

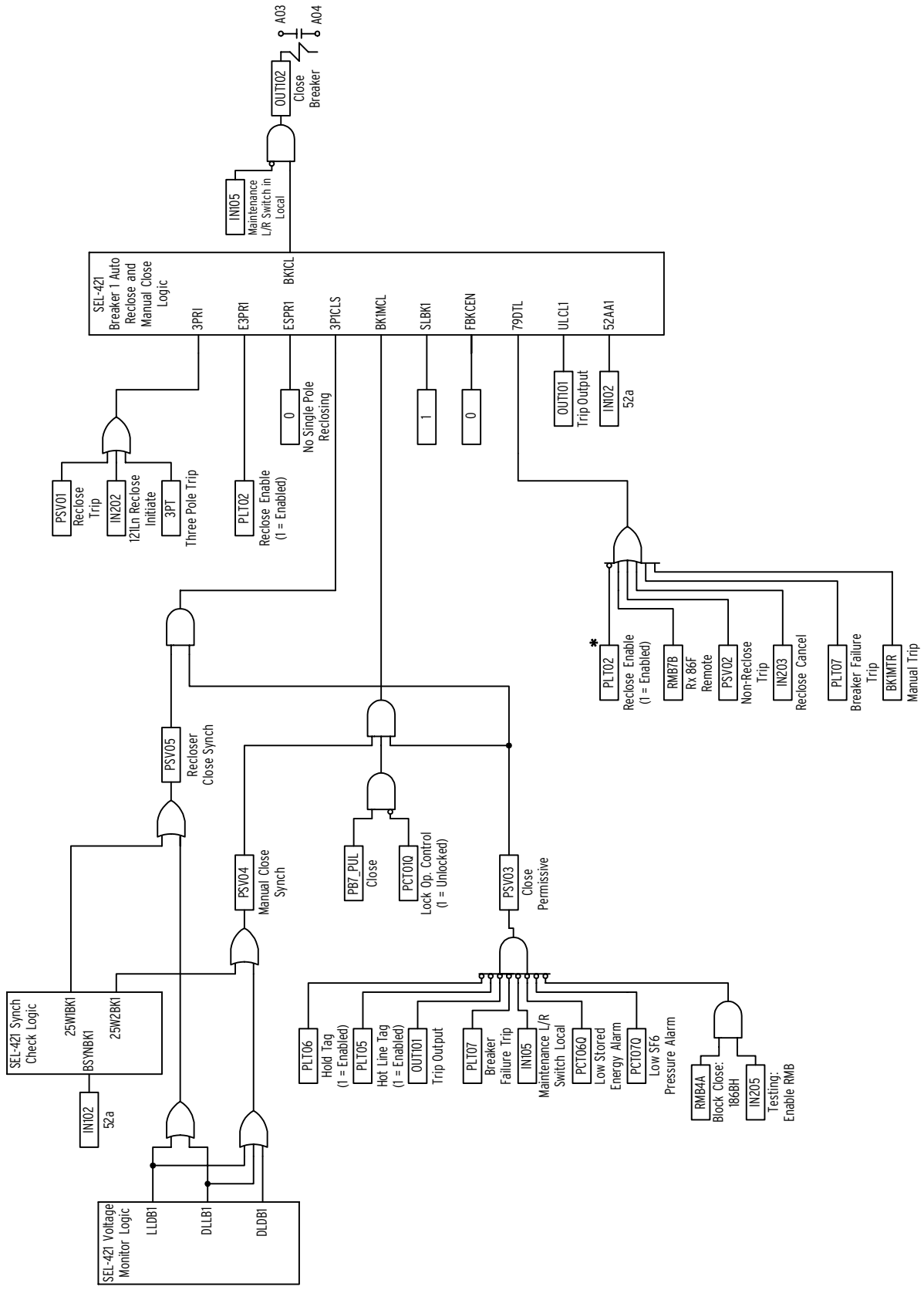


Figure 2.32: 21Ln Breaker Close Logic

Table 2.34: 21Ln Breaker Close Settings

Setting Name	Value	Comment
OUT102	BK1CL AND NOT IN105	Relay breaker close output
BK1MCL	PSV03 AND PB7_PUL AND NOT PCT01Q AND PSV04	Breaker 1 manual breaker close
SLBK1	1	Breaker 1 is the only active circuit breaker
FBKCEN	0	Follower breaker closing off
ULC1	OUT101	Unlatch closing for Breaker 1
PSV03	NOT PLT05 AND NOT PLT06 AND NOT OUT101 AND NOT PLT07 AND NOT IN105 AND NOT PCT06Q AND NOT PCT07Q AND (NOT RMB4A AND IN205)	Close permissive
PSV04	25W2BK1 OR LLDB1 OR DLLB1 OR DLDB1	Manual close synch permissive

Breaker Automatic Reclose

This section describes the automatic reclose logic in the SEL-421. The logic associated with this functionality is shown in Figure 2.32. The following list explains each of the settings associated with reclosing:

- **79DTL**. Drive to Lockout. The recloser is shutdown (driven to lockout) if the reclose is disabled (!PLT02). The recloser is driven to lockout if a remote breaker failure occurs (RMB7B), a nonreclose trip (PSV02) occurs, a remotely requested reclose cancel (IN203) occurs, a breaker failure trip (PLT07), or a manual trip (BK1MTR) occurs. A nonreclose trip (PSV02) in the SEL-7000 design is caused by a bus lockout (86BH) or a breaker failure trip (86FHn).
- **ESPR1**. Enable Single-Pole Reclose, Breaker 1. The SEL-7000 is currently configured for a three-pole tripping arrangement. Single-pole tripping schemes are available at the customer's request.
- **E3PR1**. Enable Three-Pole Reclose, Breaker 1. The recloser is enabled if the reclose enable bit (PLT02) is a logical 1.
- **3P1CLS**. Three-Pole Reclose Supervision, Breaker 1. This bit must be asserted to logical 1 prior to the close supervision delay timing out. If it is not asserted before this times out, the relay will go to recloser lockout. 3P1CLS is held high as long as the close permissive (PSV03) and the recloser close synch (PSV05) are both logical 1. Note that a trip output (OUT101 = 1) will force PSV03 to logical 0 and consequently block reclosing.
- **3PRI**. Three-Pole Reclose Initiate. The reclose sequence is initiated by 121Ln (IN202), locally (3PT), by a transformer lockout, or by TL breaker failure. For the case where the recloser has been initiated by a transformer lockout or TL breaker failure (PSV01), the trip output (OUT101) will block the recloser through EP1CLS until the TH MOD is open (RMB3A). See Figure 2.33 for the PSV01 logic.

Table 2.35: 21Ln Breaker Reclose Settings

Setting Name	Value	Comment
3PRI	PSV01 OR IN202 OR 3PT	Three-pole reclose initiate
E3PR1	PLT02	Three-pole reclose enabled
ESPR1	0	No single pole reclosing
3P1CLS	PSV05 AND PSV03	Three-pole Breaker 1 reclose supervision
79DTL	NOT PLT02 AND (3PT OR IN101) OR RMB7B OR PSV02 OR IN203 OR PLT07 OR BK1MTR	Recloser drive to lockout
PSV05	25W1BK1 OR LLDB1 OR DLLB1	Recloser close synch permissive

Breaker Trip

This section describes the protection and the manual trip logic in the SEL-421. The logic associated with this function is shown in Figure 2.33.

There are three categories of protection trips: communications-assisted tripping, remotely requested trips without reclose, and local and remotely requested trips with reclose. All remotely requested trips (RMB1A and RMB2A) bypass the SEL-421 trip equation to avoid lighting the **TRIP** LED. In the SEL-7000, only the relay that generates a trip will have an illuminated **TRIP** LED.

The MIRRORED BIT RMB1A is received from the SEL-2100 when a bus lockout (86BH) or transmission breaker failure lockout (86FHn) occurs. It is not desirable to reclose the breaker under these conditions.

The MIRRORED BIT RMB2A is received from the SEL-2100 when a transformer lockout (86T1) or a low-side breaker failure (86FTL) occurs. The only reason we are opening the transmission line breaker is to interrupt current because the high-side device TH cannot. Therefore, once TH has opened, we reclose the transmission breakers. This issue is dealt with in detail in *Breaker Automatic Reclose on page 2.44*.

The trip equation (TR) and the communications-assisted trip equation (TRCOMM) are customer supplied. The unlatch trip (ULTR) logic unlatches these trips, so long as the minimum trip duration timer has expired and the trip equations are at a logical 0. See the SEL-421 Reference Manual for further information.

The front-panel pushbutton and the retrip function of the breaker failure logic are included in the manual trip logic of the SEL-421.

Note that if the maintenance local/remote switch (IN105) is in local mode, then all trips are blocked.

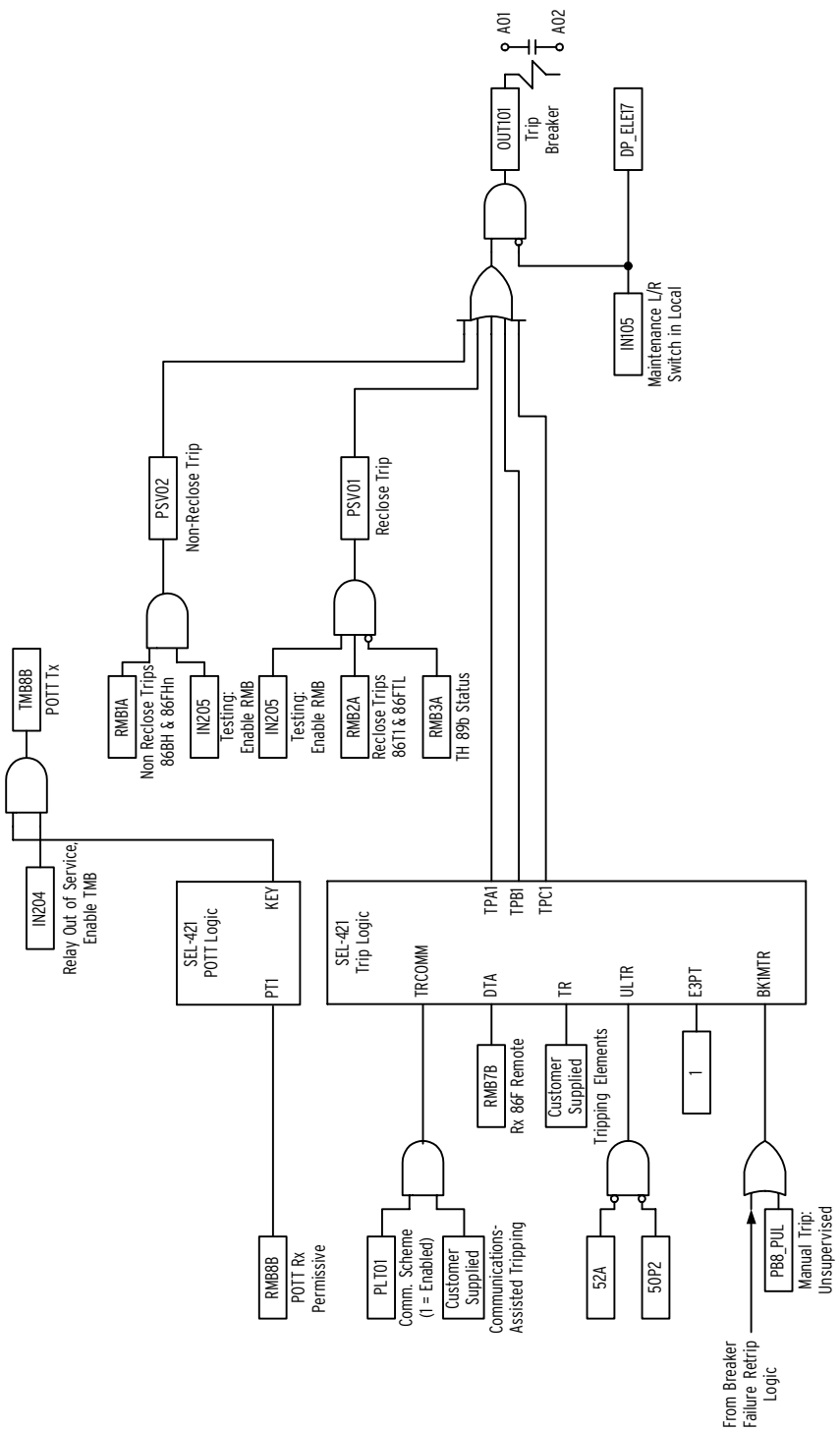


Figure 2.33: 21Ln Breaker Trip Logic

Table 2.36: 21Ln Breaker Trip Settings

Setting Name	Value	Comment
OUT101	NOT IN105 AND (TPA1 OR TPB1 OR TPC1) OR PSV01 OR PSV02	Breaker trip output
PT1	RMB8B	POTT permissive trip received
TRCOMM	PLT01 AND customer supplied logic	Communications-assisted trip logic
DTA	RMB7B	Direct trip
TR	Customer Supplied Logic	Relay breaker trip logic
PSV01	IN205 AND RMB2A AND NOT RMB3A	Reclose trip
PSV02	RMB1A AND IN205	Nonreclose trip
ULTR	NOT 52A AND NOT 50P2	Relay unlatch breaker trip logic
E3PT	1	Three-pole trip, always set to logical 1 (on)
BK1MTR	RT1 OR PB8_PUL	Manual trip

MIRRORED BITS Communications

Two communications ports on the SEL-421 are used for MIRRORED BITS: MIRRORED BITS Port A communicates to the local SEL-2100, and MIRRORED BITS Port B communicates with a relay at the other end of the transmission line. The outgoing and incoming MIRRORED BITS are assigned as listed in Table 2.37.

Table 2.37: 21Ln MIRRORED BITS Assignments (MIRRORED BITS not mentioned are not used)

MIRRORED BIT	Assignment	Comment
TMB1A	67P4T OR 67G4T OR SOTFE AND (50P4 OR 50G4)	67 into bus
TMB2A	67P3T OR 67G3T	67 out of bus
TMB3A	LOP	Loss of potential
TMB4A	NOT IN204	Relay out of service
TMB7A	IN204 AND NOT PSV03	Manual close permissive
TMB8A	PLT07 AND NOT IN105	Breaker failure lockout status
RMB1A		Non reclose trips
RMB2A		Reclose trips
RMB3A		High-side MOD status
RMB4A		Block close for high-side bus lockout
TMB7B	PLT07 AND NOT IN105	Breaker failure lockout status
TMB8B	IN204 AND KEY	POTT logic KEY

RMB7B		Receive remote breaker failure
RMB8B		Receive POTT permissive

Remote Bit Control

Local HMI and remote SCADA control is implemented using the relay remote bits (RBs) and breaker bits (BRs). In the SEL-421, Breaker Bit 1 (BR1) is a dedicated control that opens and closes Breaker 1 and BR2 opens and closes Breaker 2. The SEL-421 (21Ln) in this design does not use breaker bits because all remote breaker control is done through the SEL-311x series relays (121Ln). See *Secondary Transmission Relays (121L1, 121L2) on page 2.48* for more details. The remote bits used for control in the SEL-421 have the functions listed in Table 2.38.

Table 2.38: 21Ln Control Bits Assignments

Control Bit	Comment
RB01	Enable comm scheme
RB02	Disable comm scheme
RB03	Enable reclose
RB04	Disable reclose
RB05	Apply hot line tag
RB06	Remove hot line tag
RB07	Apply hold tag
RB08	Remove hold tag
RB09	Apply information tag
RB10	Remove information tag
RB11	Enable remote control
RB12	Disable remote control
RB13	Not used
RB14	Toggle settings group
RB15	HMI “heartbeat”
RB16	Reset breaker failure

Secondary Transmission Relays (121L1, 121L2)

The SEL-311 series of relays are used for secondary transmission protection and automation. The logic in these relays is sufficiently generic such that any of the following SEL-311 products can be applied for backup protection:

- SEL-311A
- SEL-311B
- SEL-311C
- SEL-311L

There is no automation logic inside the SEL-311 series secondary transmission relays except that necessary for tripping and closing the transmission line breaker. The SCADA and HMI close control for the transmission line breakers is installed in the SEL-311 rather than the SEL-421 Relays. This is done to eliminate a single point of failure for control operations. Because the trip and close front-panel pushbuttons on the SEL-421 are logic controlled, failure of that relay would be a single point of failure for the local HMI, the local panel, and the remote SCADA control.

When referring to the SEL-421 Relays used for primary protection of the two transmission lines, we use the notation 21Ln to generically refer to both the 21L1 and 21L2 relays. A reference of 121Ln is meant to indicate both the 121L1 and 121L2 relays.

For further information on the configuration of the 121Ln devices, refer to SEL-7000 Drawing S7000B-LD07.

Breaker Close

As indicated in *Manual Breaker Close on page 2.42*, the SEL-311 series relay processes trip and close commands by SCADA and the local HMI, whereas the front-panel trip and close controls are routed directly through the SEL-421. Automatic reclose functionality is provided in the SEL-421, so none is provided in the SEL-311 series relay.

Take note that the **CLOSE** command (CC) is supervised by the block close input (IN106) and the manual close synch (SV11). IN106 is a combination of the permissives from the 21Ln relay and various lockout conditions residing in the 67/86x device.

If the 21Ln relay is inoperable, then the block close coming from the 21Ln relay is never asserted and the 121Ln relay must rely on its own local permissive (SV11) and the permissives in the 67/86x (86BH, 186BH, 86FH1, or 86FH2). If either of the 67/86x or 21Ln devices fails, IN106 is never asserted and the 121Ln relay must rely entirely upon its own permissive. In this way, the number of permissives available to the 121Ln relay is eroded as devices fail, but ultimately the most important permissive (manual close synch permissive SV11) is duplicated in the 121Ln relays.

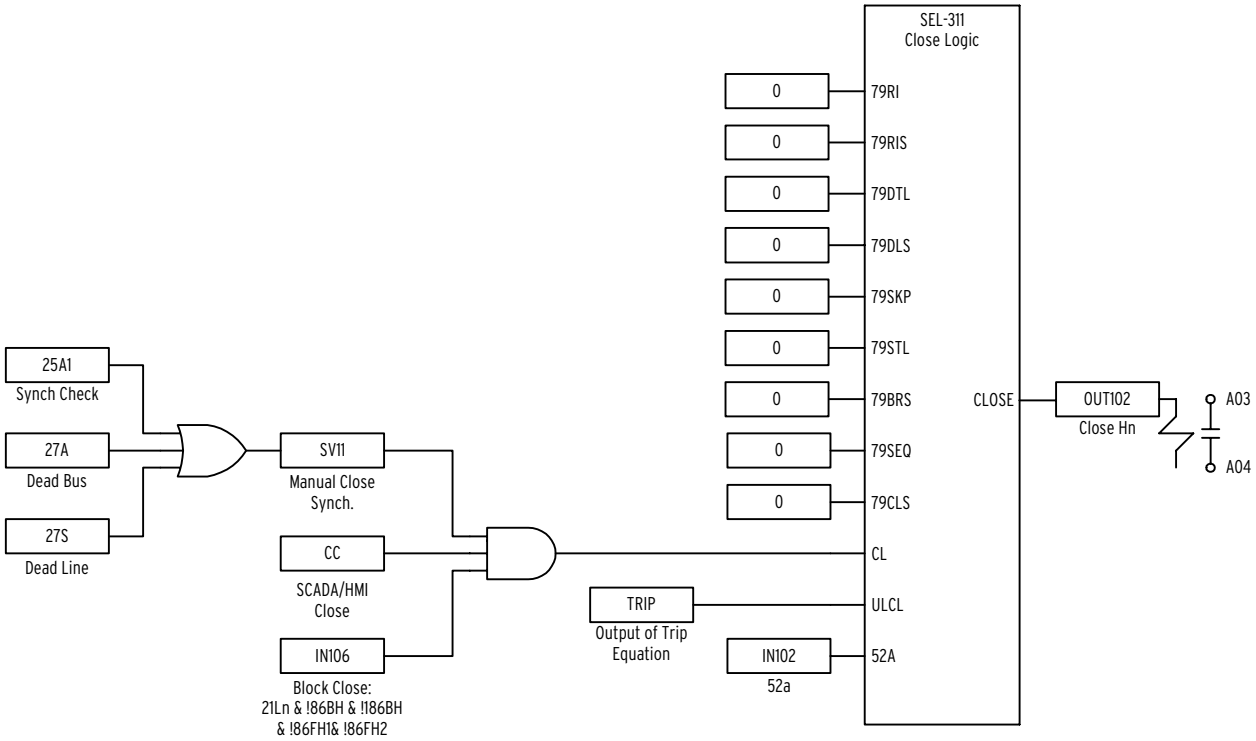


Figure 2.34: SEL-311n Breaker Close Logic

Table 2.39: SEL-311n Breaker Close Settings

Setting Name	Value	Comment
OUT102	CLOSE	Breaker close output
CL	CC*IN106*SV11	Relay breaker **CLOSE** command from remote SCADA or the local HMI
ULCL	TRIP	Remote block close command
SV11	25A1+27A+27S	Manual close synch. permissive
52A	IN102	Breaker closed status

Breaker Trip

This section describes the manual and protection trip logic in the SEL-311 series relays. Figure 2.35 depicts this logic.

Protection tripping elements are selected by the customer and the ULTR logic is functionally identical to the feeder ULTR (see *Breaker Trip on page 2.17*. For the SEL-311L Line Current Differential Relay, there is a high-speed differential protection output shown at the top of Figure 2.35.

The manual open (OC) command is generated by HMI or SCADA. This command is not included in the tripping logic, to prevent the TRIP target LED from lighting during an HMI- or SCADA-commanded trip. Therefore, the TRIP target LED stays off during a manual trip. As shown in Figure 2.35, the OC command holds the TRIP contact closed for 60 cycles.

The Reclose Cancel (OUT107) is sent to the SEL-421 (21Ln). This command drives the 21Ln reclose function to lockout.

The Reclose Initiate (OUT106) is sent to the 21Ln relay, where it initiates the reclose cycle. As expected, the reclose cycle is initiated for protection trips only.

The Breaker Failure Initiate (OUT105) is sent to the 21Ln relay, where it initiates the breaker failure detection logic. As expected, this is initiated for protection trips only.

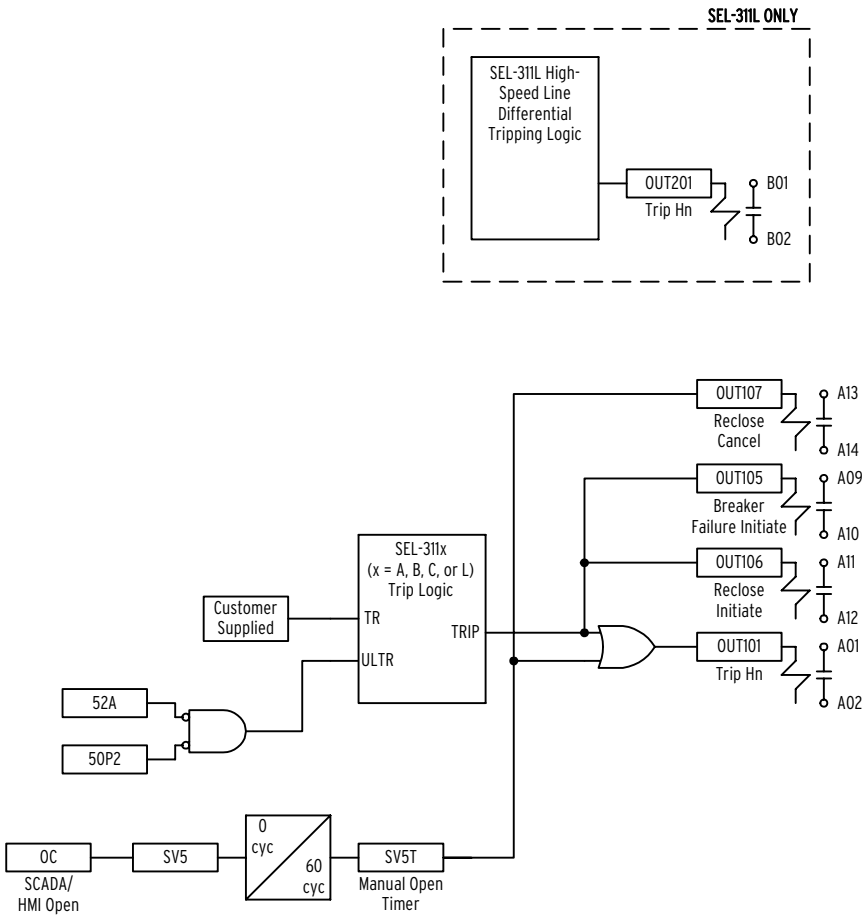


Figure 2.35: SEL-311 Breaker Trip Logic

Table 2.40: SEL-311 Breaker Trip Logic Settings

Setting Name	Value	Comment
OUT101	TRIP+SV5T	Trip output and reclose cancel
OUT107	SV5T	Reclose cancel
OUT105,OUT106	TRIP	Breaker failure and reclose initiate
TR	Customer Supplied Setting	Relay breaker trip logic
ULTR	!52A*!50P2	Relay unlatch breaker trip logic

MIRRORED BITS Communications

There is one port left unused on the SEL-311 series relays. This port is available for communications-assisted tripping schemes using MIRRORED BITS communications to a remote relay. If the customer does not require

communications-assisted tripping, this port can be connected to a spare port on the SEL-2100 (67/86X device).

Logic Processor Configuration (67/86x)

The following subsections explain the SELOGIC control equations provided as part of the standard SEL-7000. The SEL-2100 is given the device designation 67/86X because the primary roles of the device include:

- Using directional tripping elements (67) to determine if a fault has occurred on either the low- or high-side bus. Once it is determined that a bus fault exists, the SEL-2100 retains a bus lockout condition by setting a nonvolatile latch. Nonvolatile latches will not lose their state if the power is cycled. This scheme is often called a Bus Zone Interlocked Directional Tripping Scheme or Fast Bus Tripping Scheme. Refer to the SEL-2100 Instruction Manual for further description of this scheme.
- Managing system lockouts (86X). The transformer lockout (86T1), the low-side bus lockout (86BL), and the high-side bus lockout (86BH) are held in nonvolatile memory in the SEL-2100. All other lockouts in the system reside in the relay that generated the lockout. The SEL-2100 then distributes the lockout trips and blocks **CLOSE** commands to all affected relays.

For further information on the configuration of the 67/86X device, refer to SEL-7000 Drawing S7000B-LD01A and S7000B-LD01B.

Bus Protection

Two forms of bus protection are available in the SEL-7000 design:

1. **The SEL-2100 bus protection scheme.** Lockouts are retained in the SEL-2100. A high-side bus lockout is referred to as 86BH and a low-side bus lockout is referred to as 86BL.
2. **The SEL-587Z high-impedance bus scheme (Panel 5).** Lockouts for this panel reside in hand-reset coil-operated lockout switches. These are referred to as 186BH and 186BL for the high- and low-side buses, respectively.

86BH

The high-side Bus Zone Interlocked Directional Tripping Scheme in the SEL-7000 is shown in Figure 2.36. There are three different criteria that need to be satisfied for the 86BH element to trip a lockout:

1. The 51TH, 21L1, or 21L2 relays cannot detect a fault away from the bus zone in question. If any of these relays detects a fault away from the bus, SV3 asserts and blocks the trip to lockout.
2. At least one of the relays must detect a fault into the bus. This necessitates setting the directional element pickup settings in the relays above load to prevent misoperation. LV19 asserts if one of the relays detects a fault into the bus.

3. All of the relays must be in service, must have good communications, and must have good voltage measurements. If any of these criteria are not satisfied for any of the relays, then LV20 is asserted and the trip to lockout is blocked.

To understand how to set your relay pickups for the 86BH scheme, refer to the SEL-2100 Instruction Manual. The timers in the SEL-2100 are also subject to modification depending on the unique nature of a power system's parameters.

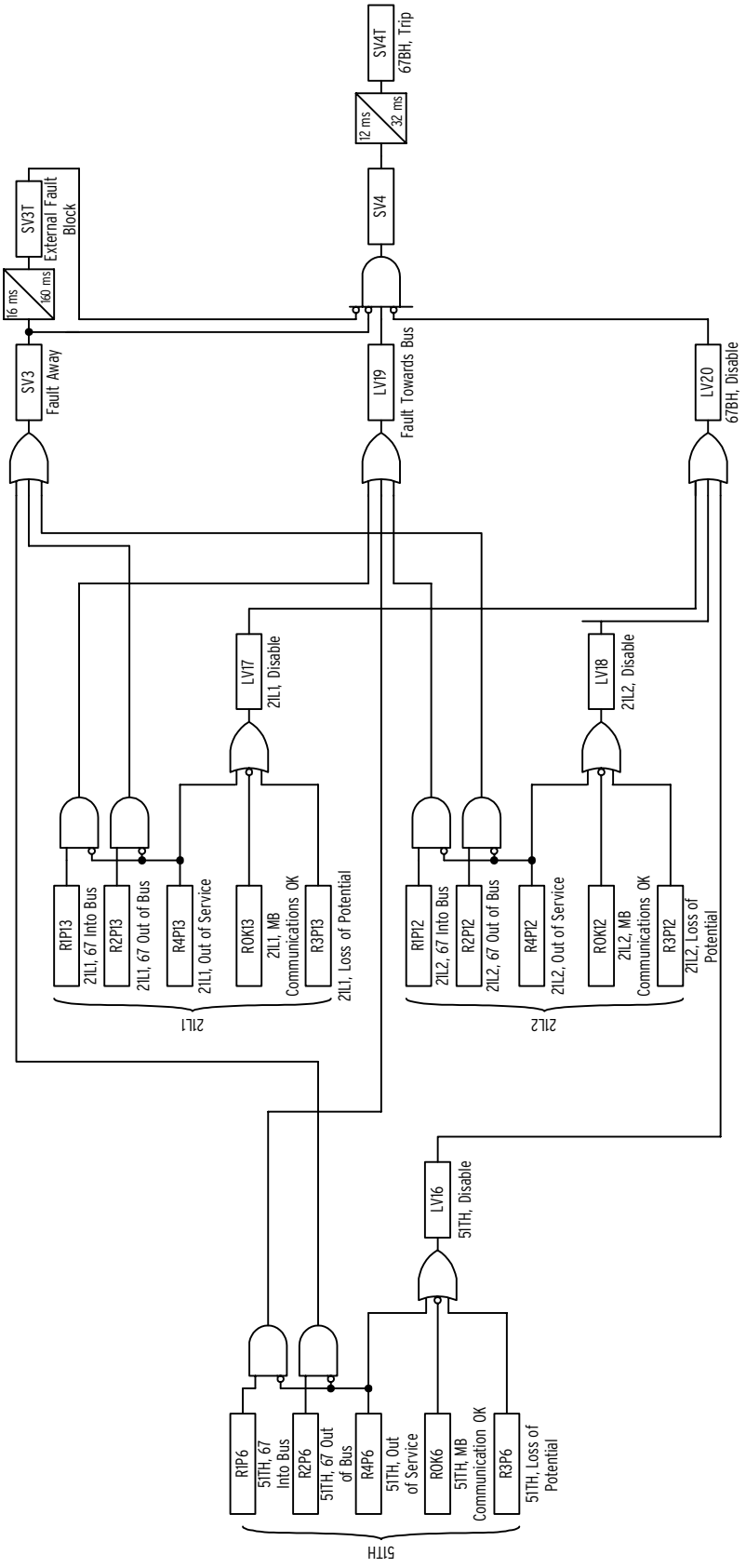


Figure 2.36: SEL-2100 High-Side Bus Zone Interlocked Directional Tripping Scheme Logic

Table 2.41: SEL-2100 High-Side Bus Zone Interlocked Directional Tripping Scheme Setting

Setting Name	Value	Comment
SV4	!SV3T*!SV3*LV19*!LV20	Directional high-side bus trip
SV3	R2P6*!R4P6+R2P13*!R4P13+ R2P12*!R4P12	Fault away from bus
LV19	R1P13*!R4P13+R1P6*!R4P6+ R1P12*!R4P12	Fault toward bus
LV20	LV17+LV18+LV16	Disable directional high-side bus
LV17	R4P13+!ROK13+R3P13	Disable transmission line 1
LV18	R4P12+!ROK12+R3P12	Disable transmission line 2
LV16	R4P6+!ROK6+R3P6	Disable high-side transformer

The 86BH Lockout logic is shown in Figure 2.37. LT9 is then distributed to the relays necessary to clear the bus. Note that the 51TH relay issues the **RESET** command to this lockout.

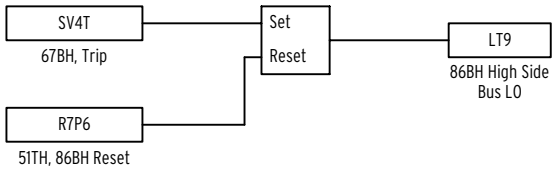


Figure 2.37: 86BH Lockout Logic

Table 2.42: 86BH Lockout Settings

Setting Name	Value	Comment
Set LT9	SV4T	Set high-side bus lockout
Reset LT9	R7P6	Reset high-side bus lockout

86BL

The low-side Bus Zone Interlocked Directional Tripping Scheme in the SEL-7000 is shown in Figure 2.38. The three criteria for tripping this logic are the same as described for the 86BH element in the previous subsection.

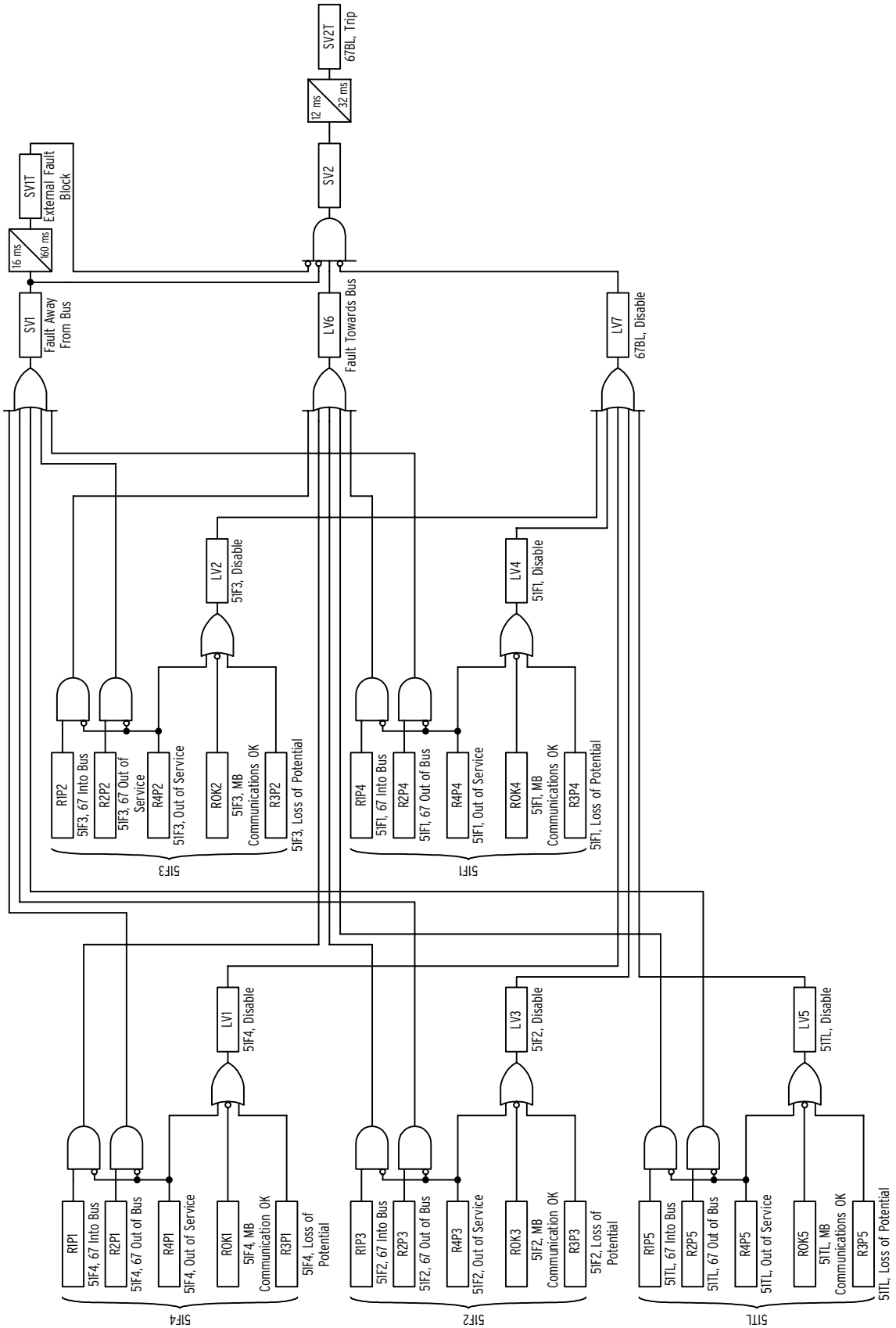


Figure 2.38: SEL-2100 Low-Side Bus Zone Interlocked Directional Tripping Scheme Logic

Table 2.43: SEL-2100 Low-Side Bus Zone Interlocked Directional Tripping Scheme Settings

Setting Name	Value	Comment
SV2	!SV1T*!SV1*LV6*!LV7	Directional lockout pickup/dropout timer
SV1	R2P1*!R4P1+R2P3*!R4P3+R2P5*!R4P5 +R2P2*!R4P2+R2P4*!R4P4	Fault away from bus interlock
LV6	R1P2*!R4P2+R1P1*!R4P1+R1P3*!R4P3 +R1P5*!R4P5+R1P4*!R4P4	Fault towards bus
LV7	LV2+LV4+LV1+LV3+LV5	Disable lockout
LV2	R4P2+!ROK2+R3P2	51F3, disable lockout
LV4	R4P4+!ROK4+R3P4	51F1, disable lockout
LV1	R4P1+!ROK1+R3P1	51F4, disable lockout
LV3	R4P3+!ROK3+R3P3	51F2, disable lockout
LV5	R4P5+!ROK5+R3P5	51TL, disable lockout

The 86BL Lockout logic is shown in Figure 2.39. LT8 is then distributed to the relays necessary to clear the bus. Note that the 51TL relay issues the **RESET** command to this lockout.

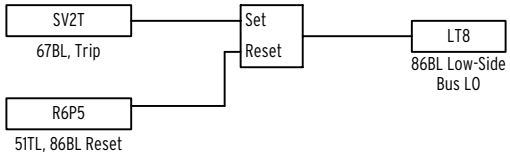


Figure 2.39: 86BL Lockout Logic

Table 2.44: 86BL Lockout Settings

Setting Name	Value	Comment
Set LT8	SV2T	Set low-side bus lockout
Reset LT8	R6P5	Reset low-side bus lockout

Transformer Lockout

The Transformer Lockout (86T1) logic is shown in Figure 2.40. Two conditions can initiate a transformer lockout:

1. A transformer differential or overcurrent trip from 87T1P (IN101).
2. An overcurrent or sudden pressure trip from the 51TH (R5P6), if the relay is in service.

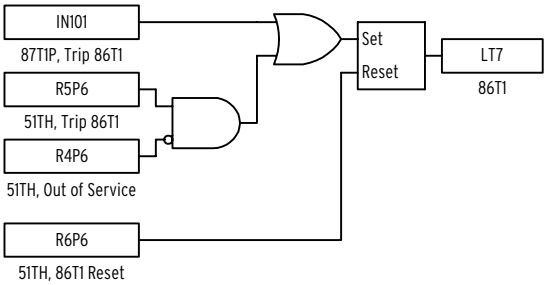


Figure 2.40: SEL-2100 Transformer Lockout Latch Logic

Table 2.45: SEL-2100 Transformer Lockout Latch Settings

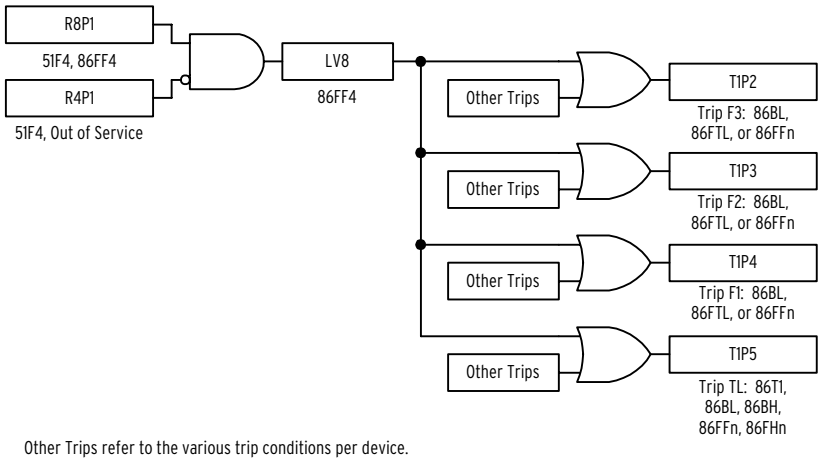
Setting Name	Value	Comment
Set LT7	IN101+R5P6*!R4P6	Set transformer lockout
Reset LT7	R6P6	Reset transformer lockout

Breaker Failure Lockout

Every breaker in the SEL-7000 design has a relay associated with it. Each of these relays contains logic to detect a breaker failure in its respective breaker.

Once a relay detects a breaker failure, the relay asserts a nonvolatile latch. This latch is the breaker failure lockout. The state of this breaker failure lockout latch is sent directly to the 67/86X (SEL-2100). The logic processor then disseminates this information to the relays surrounding the affected breaker. These relays trip and block **CLOSE** commands based upon the breaker failure trip sent by the logic processor.

As an example, Figure 2.41 shows the logic used for Feeder 4 breaker failure. The breaker failure is received by the SEL-2100 as R8P1, and is sent as a trip to the 51F1, 51F2, 51F3, and TL relays. The lockout condition must be reset inside the 51F4 (Feeder 4) relay before any of the other relays can be closed.



Other Trips refer to the various trip conditions per device.

Figure 2.41: SEL-2100 Breaker Failure Logic, Feeder 4 Breaker Failure

Table 2.46: SEL-2100 Breaker Failure Logic, Feeder 4 Breaker Failure Settings

Setting Name	Value	Comment
T1P2	LV8+Other Settings	Feeder 3 close
T1P3	LV8+Other Settings	Feeder 2 close
T1P4	LV8+Other Settings	Feeder 1 close
T1P5	LV8+Other Settings	Transformer low close

SEL-701-1 Monitor Configuration

The SEL-701-1 Monitor configuration described in this subsection is very similar to settings described in the SEL-701-1 Application Guide AG2001-09. Due to the configurable nature of the SEL-701-1, many other configurations are available. For further information, refer to SEL-7000 Drawing S7000B-LD08 for the entire logic within the SEL-701-1.

The main function of the SEL-701-1 is to provide automatic and manual control of two banks of cooling fans for the transformer. The automatic control turns each bank of fans on and off depending on the transformer top oil and winding temperatures. Manual control allows the local HMI or the remote SCADA system to turn on or lock out (turn off) the fans. Interlocks are incorporated to block control if a fire alarm is detected. LEDs on the front panel of the SEL-701-1 indicate alarm conditions.

Additionally, the winding temperatures alarm states in the SEL-701-1 are sent back to the local HMI and the remote SCADA system.

Figure 2.42 and Figure 2.43 show the logic controlling cooling Fan Banks 1 and 2. Figure 2.44 shows the cooling fan lockout logic. Note that we are using the trip logic in the SEL-701-1 only for locking out Fans 1 and 2.

LT3 in Figure 2.42 is the latch that turns on and off Fan Bank 1 from the local HMI and SCADA. Note that the fans cannot be turned on if there is a fire alarm or a lockout condition. The fans cannot be turned off if the automatic controls have the fans turned on or if one of the RTD inputs is in a fault condition. LT4 in Figure 2.43 provides similar manual control functionality for Fan Bank 2.

LT1 in Figure 2.42 is the latch that turns on and off Fan Bank 1 automatically based upon the temperature of RTD1 (Top Oil) and RTD2 (Winding). If either RTD1 or RTD2 is above their Alarm Temperature 2, the fans are turned on. If the temperature of both RTD1 and RTD2 are below their Alarm Temperature 1 values, then Fan Bank 1 is turned off. LT2 in Figure 2.43 provides similar automatic control functionality for Fan Bank 2.

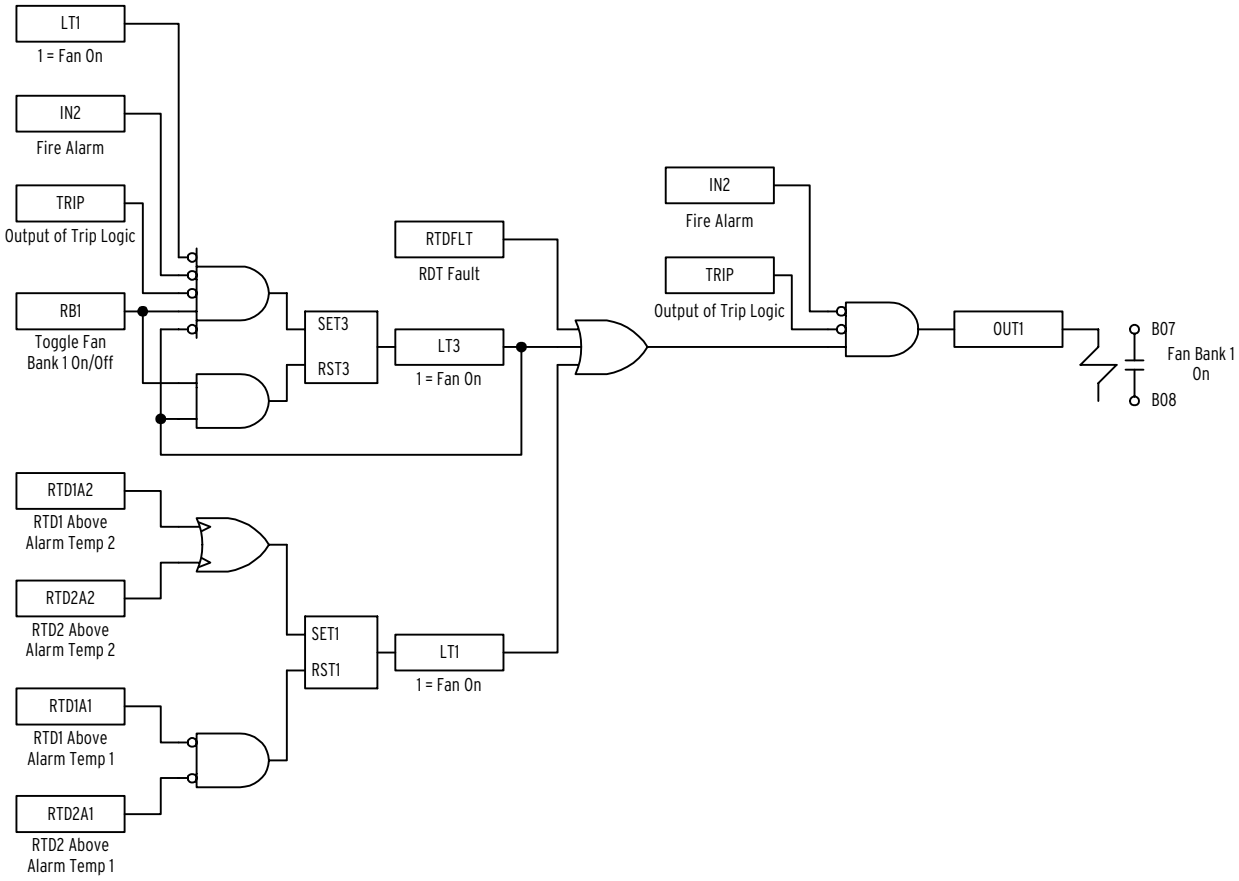


Figure 2.42: Fan Bank 1 Control

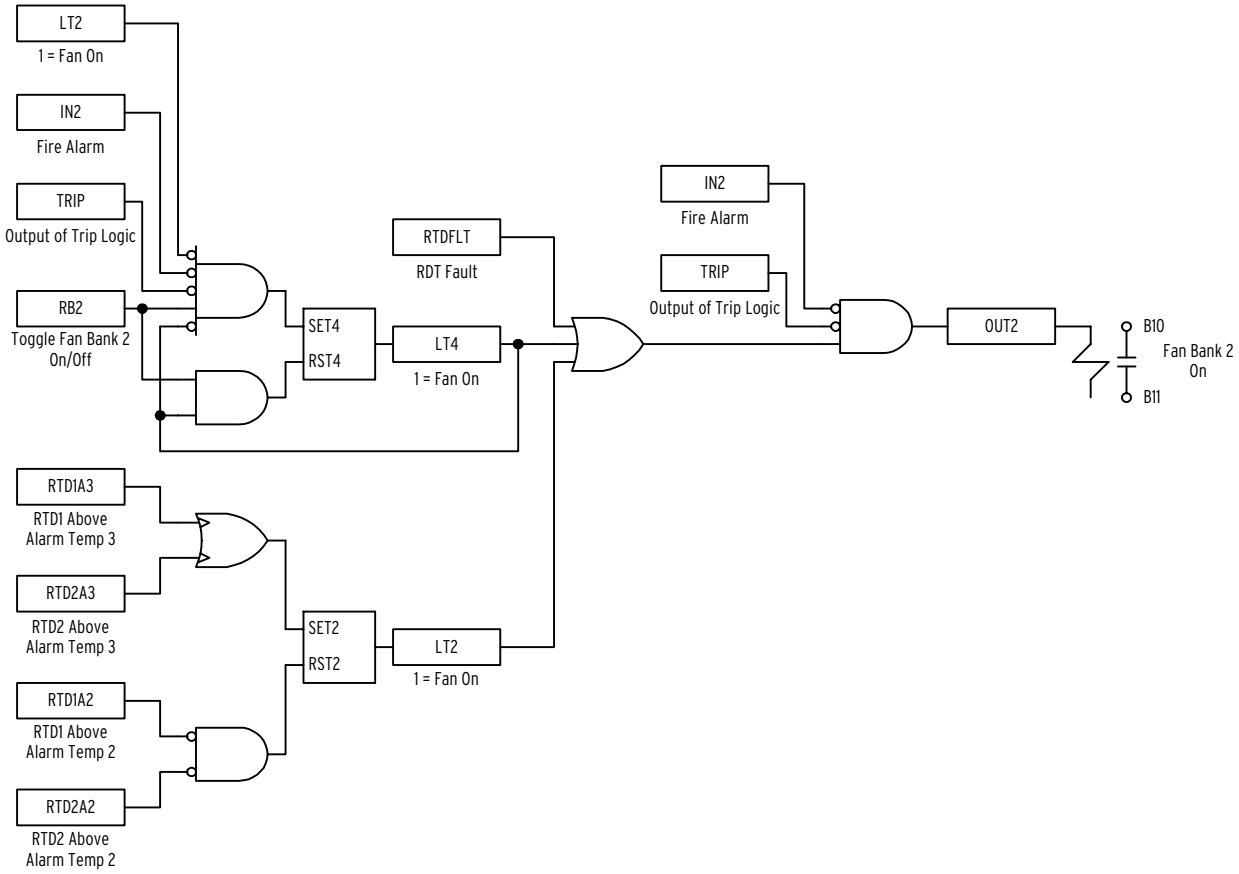


Figure 2.43: Fan Bank 2 Control

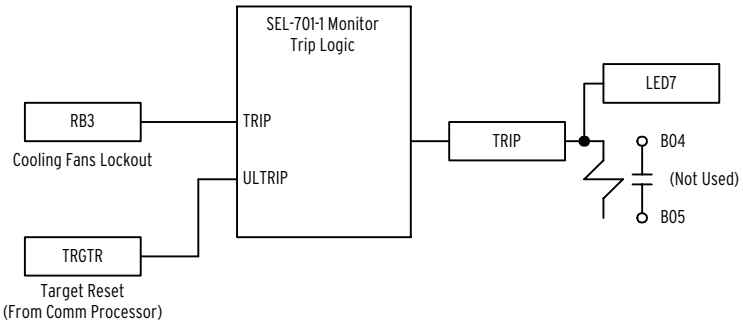


Figure 2.44: Monitor Trip Logic

High-Impedance Bus Differential Relay Configuration (87BL, 87BH)

Refer to SEL-7000 Drawing S7000B-LD09 for the entire logic within the SEL-587 High-Impedance Differential Relays, 87BL and 87BH.

The primary role of the 87BL and 87BH relays is to provide protection of the low- and high-side bus zones. The logic within these relays is shown in Figure 2.45. The 87BL and 87BH relays also provide lockout status and trip coil monitoring status of the lockout relays 186BL and 186BH.

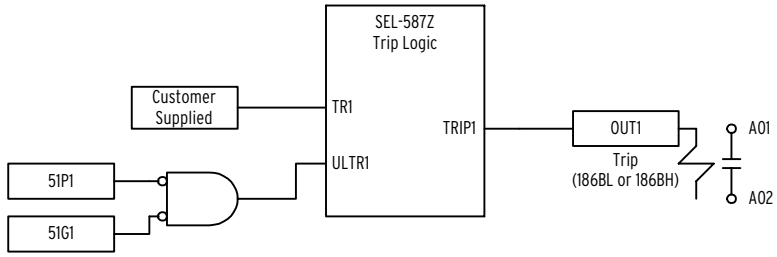


Figure 2.45: 87BL and 87BH Trip Logic

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Section 3: Communications Processor Configuration 3.1

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Section 3: Communications Processor Configuration

Introduction

The communications processors provide the following functionality in the SEL-7000:

- Forwarding discrete and analog data to the customer's SCADA master via serial DNP 3.0 or Modbus.
- Forwarding discrete and analog data to the local HMI via a serial connection.
- Collecting, manipulating, and consolidating data from SEL IEDs (SEL relays and the logic processor). Communications processor settings for an SEL-351S and an SEL-421 are used in the following subsections as examples.
- Collecting, manipulating, and consolidating data from non-SEL IEDs (other IEDs). Communications processor settings for the Davis Weather Monitor are used in the following sections as an example. The communications processor is capable of communication with most non-SEL IEDs.
- Forwarding control messages to SEL and non-SEL IEDs. These control messages come from either the local HMI or the customer's SCADA system. The messages are then sent as remote bits (RBs) and breaker bits (BRs) to the SEL relays via the SEL binary Fast Operate messages. These controls are used to open/close breakers, enable/disable functionality, and to set/clear tags.
- Distributing IRIG-B time synchronization information to the SEL IEDs via the SEL system of Interleaved communications. This guarantees that the event reports generated in all IEDs are time synchronized.
- Providing a path for engineering connections to the IEDs. This is available through a serial port connection to the local rack-mounted PC, through a dial-up connection via the Starcomm modem provided with the SEL-7000, and through an Ethernet Telnet connection via the SEL-2890 serial-to-Ethernet transceiver.

To accomplish this functionality, the following settings need to be installed in the communications processor:

- **Port Settings (SET P).** Use these settings to select the serial protocol, baud rate, parity, etc.
- **Automatic Messages (SET A).** Use these settings to create solicited polls and to parse the responses from IEDs.

- **User Defined Messages (SET U).** Use these settings to handle unsolicited messages from IEDs and to create user-defined controls in the SEL-2030.
- **Math/Movement Settings (SET M).** Use these settings to manipulate digital and analog data via mathematical equations.
- **Logical Settings (SET L).** Use these settings to create Boolean logic.
- **Global Settings (SET G).** Use these settings to create timers, output contact logic, IRIG-B settings, and a device identification string.

Rather than detailing every setting in the SEL communications processor, the following sections review example settings for each of the following device types:

- An SEL-351S configured as the Feeder 4 relay (51F4) connected to Port 6 of SEL-2032-1.
- An SEL-421 configured as the Transmission Line 2 relay (21L2) connected to Port 2 of SEL-2032-1.
- The Davis Weather Station is used as an example of settings used to integrate a non-SEL IED. This is connected to Port 4 of the SEL-2032-2.
- The local HMI, which resides in the local rack-mounted PC. Communication to the HMI is through Port 12 of the SEL-2032-1.
- The SEL-5040 Substation Power System Report Manager also resides on the local rack-mounted PC. Communication to this is through Port 13 of the SEL-2032-1.

Port Settings

Data collection, controls, time synchronization, and ASCII engineering connections with IEDs require a single cable or fiber-optic connection to the communications processor. The port settings configure the communications processor to properly communicate with the attached IED.

The settings displayed in the following subsections can be viewed or modified with the SEL-5020 Settings Assistant Software. They can also be viewed or modified at the command prompt using the **SHOWSET** or **SET** commands. For further information, please refer to the SEL-2032 Instruction Manual.

For SEL IEDs, the communications processor will automatically configure the port settings during the autoconfiguration process. During autoconfiguration, the communications processor collects data from each relay that define what types of information are available, what control points are accessible, and how to parse the relay response to data queries sent by the communications processor.

Table 3.1: Port Settings for an SEL-351S

Setting	Value	Comment
DEVICE	S	SEL device
CONFIG	Y	Auto configure SEL relay

PORTID	SEL-351S FEEDER 4	Collected from SEL relay during autoconfiguration process (RID setting in relay)
BAUD	19200	Communications speed between relay and communications processor
DATABIT	8	Number of data bits in message frame
STOPBIT	1	Number of stop bits in message frame
PARITY	N	Type of parity used in message frame
RTS_CTS	N	RTS/CTS hardware flow control disabled
XON_XOFF	Y	XON/XOFF software flow control enabled
TIMEOUT	15.0	After 15 minutes of idle time, a transparent connection will be terminated

Table 3.2: Port Settings for an SEL-421

Setting	Value	Comment
PORTID	SEL-421A H2	Collected from SEL relay during autoconfiguration process
FID	SEL-421-R105	Relay model and firmware revision of attached SEL relay
DEVICE	S	SEL serial protocol
BAUD	19200	Maximum speed allowed for SEL serial protocol
DATABIT	8	Set to match the attached relay
STOPBIT	1	Set to match the attached relay
PARITY	N	Set to match the attached relay
RTS_CTS	N	RTS/CTS hardware flow control disabled
XON_XOFF	Y	XON/XOFF software flow control enabled
TIMEOUT	15.0	After 15 minutes of idle time, a transparent connection will be closed

Table 3.3: Port Settings for Other IEDs

Setting	Value	Comment
DEVICE	O	“Other” IED
PORTID	WeatherStation	Descriptive name given to port
MODEM	N	Set to No because this device is not a modem
AUTO_BAUD	N	Communications processor will not attempt to automatically detect the attached device’s baud rate; it is set at the rate shown below
PROTOCOL	B	Binary communication
BAUD	2400	Communications speed between IED and communications processor
DATABIT	8	Number of data bits in message frame
STOPBIT	1	Number of stop bits in message frame
PARITY	N	Type of parity used in message frame

RTS_CTS	N	RTS/CTS hardware flow control disabled
XON_XOFF	N	XON/XOFF software flow control disabled
TIMEOUT	0	Time-out disabled for this port

Table 3.4: Port Settings for the Local HMI

Setting	Value	Comment
DEVICE	M	Master port used for master devices to connect to the communications processor
PROTOCOL	S	SEL protocol
FAST_OP	Y	Fast Operate commands enabled. This allows control actions from the HMI
PORTID	HMI SELIOSRV CONNECTION	Descriptive name given to port
MODEM	N	Set to No because this device is not a modem
BAUD	38400	Communications speed between PC and communications processor
DATABIT	8	Number of data bits in message frame
STOPBIT	1	Number of stop bits in message frame
PARITY	N	Type of parity used in message frame
RTS_CTS	N	RTS/CTS hardware flow control disabled
XON_XOFF	Y	XON/XOFF software flow control enabled
TIMEOUT	120.0	120 minute time out for this port
ECHO	N	No characters typed in the terminal will be echoed to the PC
AUTO_HELP	N	No help provided for incorrect commands typed in terminal
TERTIME1	1	One-second-termination time delay. Default value
TERSTRING	\004	This is the code for **<Ctrl+D>**. A **<Ctrl+D>** operation will terminate a transparent connection
TERTIME2	0	0 second termination time delay. Default value

Table 3.5: Port Settings for the SEL-5040

Setting	Value	Comment
DEVICE	M	Master port for master devices to connect to the communications processor
PROTOCOL	S	SEL protocol
FAST_OP	N	Fast Operate commands disabled
PORTID	SEL-5040 EVENT COLLECTION	Descriptive name given to port
MODEM	N	Set to No because this device is not a modem

BAUD	38400	Communications speed between PC and communications processor
DATABIT	8	Number of data bits in message frame
STOPBIT	1	Number of stop bits in message frame
PARITY	N	Type of parity used in message frame
RTS_CTS	N	RTS/CTS hardware flow control disabled
XON_XOFF	Y	XON/XOFF software flow control enabled
TIMEOUT	120.0	After 120 minutes of idle time, a transparent connection will be terminated. The current session will be terminated and the SEL-2032 goes back to level 0 access.
ECHO	Y	Printable characters typed in the terminal will be echoed to the PC
AUTO_HELP	N	No help provided for incorrect commands typed in terminal
TERTIME1	1	One-second-termination time delay. Default value
TERSTRING	\005	This is the code for **<Ctrl+E>**. A **<Ctrl+E>** operation will terminate a transparent connection
TERTIME2	0	0 second termination time delay. Default value

The following settings will require customization per the customer's SCADA master requirements. Refer to the communications processor instruction manual for a more detailed description of these settings.

Table 3.6: Port Settings for DNP 3.0 (SCADA)

Setting	Value	Comment
DEVICE	M	"Master" port
PROTOCOL	D	DNP protocol
ADDRESS	101	DNP Slave Address
CLASS	1	DNP Class. Set to match customer's DNP server.
16BIT	16	16 or 32-bit analog data transfer. Set to match customer's DNP Master.
SO_TIMEOUT	1	One-second maximum time between set and operate commands. Set to match customer's DNP Master.
DL_CONFIRM	0	No DNP DataLink retries
DL_TIMEOUT	1	1 ms DataLink acknowledge time
MIN_DELAY	50	50 ms minimum delay from DCD to transmission
MAX_DELAY	100	100 ms maximum delay from DCD to transmission
SETTLE1	0	0 ms from RTS assertion to transmission
SETTLE2	0	0 ms from end of transmission to RTS deassertion

REPORT_ON	2	A 2% change of full scale in analog values will cause this data to be resent
UNSOL_REP	Y	Unsolicited Event Reporting enabled
UNSOL_POW	N	Unsolicited Event Reporting disabled on power up
REP_ADDR	1	Master Address
NUM_EVENT	1	One event report will cause an unsolicited message to be sent. This is meaningless with event reporting disabled.
AGE_TX	1	Events over one second old will cause an unsolicited event report message to be sent. This is meaningless with event reporting disabled.
CONFIRM_TO	2000	Communications processor waits 2000 ms for an acknowledgement before considering the transmission a failure.
DNP_PAIR	Y	The use of trip/close pairs is enabled.
CLS0_VIEW	Y	Control points are visible in a Class 0 poll (solicited poll).
DNP_CMDNUM	0	0 Command bits assigned per port
DNP_SBONUM	0	0 Set Before Operate bits assigned per port
DNP_BRNUM	2	2 breaker bits available per port
DNP_RBNUM	8	8 remote bit pairs available per port
PORTID	DNP TO SCADA	Descriptive name given to port
BAUD	9600	Set to match customer's DNP Master

Automatic Messaging

Automatic message settings (**SET A**) are used to configure a port on the communications processor to send messages and collect data from the attached IEDs. Control messages and SER data collection are also configured in the automatic message settings. During the autoconfiguration process, the communications processor determines the data available and methods for parsing that data from SEL IEDs. Special "20" messages are used to collect this data. For further information, refer to the communications processor instruction manual.

Table 3.7: Messaging for an SEL-351S

Setting	Value	Comment
AUTOBUF	Y	Enable buffering for unsolicited messages. This provides a great method for troubleshooting should it be needed in the future.
STARTUP	ACC\nOTTER\n	Access Level 1 password allows the communications processor to log in to the relay automatically.

SEND_OPER	YP	Send Fast Operate messages. YP means that all remote bits will be pulsed in the attached SEL relay.
REC_SER	Y	Collect unsolicited SER data from relay.
NOCONN	NA	Do not block transparent connections to the relay.
USER	75	Allocate 75 registers of User Region memory for **SET M** commands.
MSG_CNT	9	Nine auto-messages are configured for this relay.
ISSUE1	P00:00:01.0	Periodically, every second, issue MESG1.
MESG1	20METER	Collect and parse relay meter data.
ISSUE2	P00:00:01.0	Periodically, every second, issue MESG2.
MESG2	20TARGET	Collect and parse relay target data.
ISSUE3	P00:01:00.0	Periodically, every minute, issue MESG3.
MESG3	20DEMAND	Collect and parse relay demand metering data.
ISSUE4	P00:30:00.0 + !6:TARGET:52A	Periodically, every 30 minutes or every time the breaker opens, issue MESG4.
MESG4	BRE\n	Collect breaker wear monitor data.
PARSE4	6	Use flex data parsing method.
DECODE4	'=',I,'=',F,'=',F,'=',F,'=', I,'=',F,'=',F,'=',F,'=',I,' ='=',I,'=',I,'RESET',6I	Parse string for the data. Grab the first Integer (I) after the equal sign (=), then grab the first Float (F) after the equal sign, and so on.
DELAY4	OFF	No idle time required for response to be considered complete. Therefore, upon completion of data capture, any other data response from the IED will be ignored.
ISSUE8	!6:0800h:3+6:CMD1	Issue MESG8 when a new event has been detected (6:CMD1), or when a transparent connection is terminated (!6:0800h:3). The communications processor will miss the unsolicited event summary if the port is in transparent mode.
MESG8	20HISTORY	Collect and parse relay event history data.
ISSUE9	6:SRB14	Issue MSG9 when SRB14 on Port 6 is asserted.
MESG9	TAR R\n	Send the **TARGET RESET** command (**TAR R**) to the relay.
PARSE9	0	Ignore response to command.
DELAY9	ON	Wait for a complete response from the relay.
ARCH_EN	N	Archiving messaging disabled.

Table 3.8: Messaging for an SEL-421

Setting	Value	Comment
AUTOBUF	Y	Enable buffering for unsolicited messages. This provides a great method for troubleshooting should it be needed in the future.
STARTUP	ACC\nOTTER\n	Access Level 1 password allows the communications processor to log in to the relay automatically.
SEND_OPER	YP	Send Fast Operate messages. YP means that all remote bits will be pulsed in the attached SEL relay.
REC_SER	Y	Collect unsolicited SER data from relay.
NOCONN	NA	Do not block transparent connections to the relay.
USER	110	Allocate 110 registers of User Region memory for **SET M** commands.
MSG_CNT	8	Nine auto messages are configured for this relay.
ISSUE1	P00:00:01.0	Periodically, every second, issue MESG1.
MESG1	20METER	Collect and parse relay meter data.
ISSUE2	P00:00:01.0	Periodically, every second, issue MESG2.
MESG2	20TARGET	Collect and parse relay target data.
ISSUE3	P00:01:00.0	Periodically, every minute, issue MESG3.
MESG3	20DEMAND	Collect and parse relay demand metering data.
ISSUE4	P00:30:00.0 + !2:TARGET:52AA1 + !2:TARGET:52AB1 + !2:TARGET:52AC1	Periodically, every 30 minutes or every time one of the breakers opens, issue MESG4.
MESG4	BRE 1\n	Collect breaker wear monitor data for Breaker 1.
PARSE4	6	Use flex data parsing method.
DECODE4	'Wear','(%)',3F,'MSOAL',I,'ESOAL',I,'MRTAL',I,'KAIAL',I,'RESET',6I	Find the first "%" after the text "Wear," then grab 3 floats. Then grab one integer after the word "msoal", and so on.
DELAY4	OFF	No idle time required for response to be considered complete. Therefore, upon completion of data capture, any other data response from IED will be ignored.
ISSUE5	P00:30:00.0 + !2:TARGET:52AA2 + !2:TARGET:52AB2 + !2:TARGET:52AC2	Periodically, every 30 minutes or every time one of the breakers opens, issue MESG4.
MESG5	BRE 2\n	Collect breaker wear monitor data for Breaker 2.

PARSE5	6	Use flex data parsing method.
DECODE5	'Wear','(%)',3F,'MSOAL',I,'ESOAL',I,'MRTAL',I,'KAIAL',I,'RESET',6I	Find the first "%" after the text "Wear," then grab 3 floats. Then grab one integer after the word "msoal", and so on.
DELAY5	OFF	No idle time required for response to be considered complete. Therefore, upon completion of data capture, any other data response from IED will be ignored.
ISSUE6	P00:00:30.0	Periodically, every 30 seconds, issue MESG6.
MESG6	MET SYN\n	Collect synchronism check values.
PARSE6	6	Use flex data parsing method.
DECODE6	'(Hz)','(Hz)',7F	Grab seven floating-point values after two instances of "%" in the text.
DELAY6	OFF	No idle time required for response to be considered complete. Therefore, upon completion of data capture, any other data response from IED will be ignored.
ISSUE7	P00:30:00.0 + !2:TARGET:52AA1 + !2:TARGET:52AB1 + !2:TARGET:52AC1	Periodically, every 30 minutes or every time one of the breakers opens, issue MESG4.
MESG7	20BREAKER	Collect and automatically parse the compressed ASCII circuit breaker report for Breakers 1 and 2. There is some information not available in this report that can be acquired only by using the BRE 1 or BRE 2 as shown in MESG4 and MESG5 above.
ISSUE8	!2:0800h:3+2:CMD1	Collect the ASCII 20History data when a new event has been detected (2:CMD1), or when the port is brought out of a transparent connection (!2:0800h:3). The history data is resolicited when coming out of transparent mode because the communications processor will miss the unsolicited event summary if the port is in transparent mode.
MESG8	20HISTORY	Collect and automatically parse relay ASCII information.
ARCH_EN	N	Archiving messaging disabled.

Table 3.9: Messaging for Other IEDs

Setting	Value	Comment
AUTOBUF	N	Turn buffering for unsolicited messages off
STARTUP		No startup password
NOCONN	NA	Do not block transparent connections to this IED
USER	41	41 registers set up for Math/Move equations
MSG_CNT	1	One message sent to the Weather Station

ISSUE1	P00:00:02.0	Periodically, every two seconds, issue MESG1
MESG1	LOOP\0FF\0FF\00D	Collect data from the Weather Station
PARSE1	3	Parse data as character strings
NUM1	20	Expect 20 character strings
DELAY1	OFF	Upon completion of data capture, ignore any other data response from IED
CHECK1	N	No checksum
ARCH_EN	N	Archiving messaging disabled

The communications processor transfers data to the TrafficWerks SEL I/O Server using unsolicited write messages (\W statements). This is shown in Table 3.10.

The TrafficWerks SEL I/O Server also uses SEL Fast Operate messages to send controls to the communications processor and the attached IEDs.

Table 3.10: Messaging for the Local HMI

Setting	Value	Comment
NOCONN	NA	Do not block transparent connections to/from this port.
USER	44	Allocate 44 registers of User Region memory for **SET M** commands
MSG_CNT	12	12 auto messages are configured for this relay
ISSUE1	P00:00:02.0	Periodically, every 2 seconds, issue MESG1
MESG1	\W;01:USER:0000h;41,01:USER:0000h/	41 registers sent from Port 1 User Region starting at address 0h
ISSUE2	!12:D1	Message sent after MESG1 has been sent
MESG2	\W;02:USER:0000h;103,02:USER:0000h/	103 registers sent from Port 2 User Region starting at address 0h
ISSUE3	!12:D2	Message sent after MESG2 has been sent
MESG3	\W;03:USER:0000h;45,03:USER:0000h/	45 registers sent from Port 3 User Region starting at address 0h
ISSUE4	!12:D3	Message sent after MESG3 has been sent
MESG4	\W;04:USER:0000h;103,04:USER:0000h/	103 registers sent from Port 4 User Region starting at address 0h
ISSUE5	!12:D4	Message sent after MESG4 has been sent
MESG5	\W;05:USER:0000h;113,05:USER:0000h/	113 registers sent from Port 5 User Region starting at address 0h
ISSUE6	!12:D5	Message sent after MESG5 has been sent
MESG6	\W;06:USER:0000h;75,06:USER:0000h/	75 registers sent from Port 6 User Region starting at address 0h
ISSUE7	!12:D6	Message sent after MESG6 has been sent
MESG7	\W;07:USER:0000h;75,07:USER:0000h/	75 registers sent from Port 7 User Region starting at address 0h
ISSUE8	!12:D7	Message sent after MESG7 has been sent

MESG8	\W;08:USER:0000h;75, 08:USER:0000h/	75 registers sent from Port 8 User Region starting at address 0h
ISSUE9	!12:D8	Message sent after MESG8 has been sent
MESG9	\W;09:USER:0000h;75, 09:USER:0000h/	75 registers sent from Port 9 User Region starting at address 0h
ISSUE10	!12:D9	Message sent after MESG9 has been sent
MESG10	\W;10:USER:0000h;75, 10:USER:0000h/	75 registers sent from Port 10 User Region starting at address 0h
ISSUE11	!12:D10	Message sent after MESG10 has been sent
MESG11	\W;11:USER:0000h;67, 11:USER:0000h/	67 registers sent from Port 11 User Region starting at address 0h
ISSUE12	!12:D11	Message sent after MESG11 has been sent
MESG12	\W;12:USER:0000h;44, 12:USER:0000h/	44 registers sent from Port 12 User Region starting at address 0h
ARCH_EN	N	Archiving disabled

Table 3.11: Messaging for the SEL-5040

Setting	Value	Comment
NOCONN	NA	Do not block transparent connections to/from this port
USER	44	Allocate 44 registers of User Region memory for **SET M** commands.
MSG_CNT	2	Two auto messages are configured for this port.
ISSUE1	1:SBR16 + 2:SBR16 + 3:SBR16 + 4:SBR16 + 5:SBR16 + 6:SBR16 + 7:SBR16 + 8:SBR16 + 9:SBR16 + 10:SBR16 + 11:SBR16 + 12:SBR16 + 13:SBR16 + 14:SBR16 + 15:SBR16 + 16:SBR16 + 13:BR15 * P00:00:30.0	Issue MESG1 if logic is asserted in the communications processor recognizing an event report from any of the relay ports. It is also reissued every 30 seconds as long as 13:BR15 is asserted. This helps prevent the SEL-5040 from missing an event.
MESG1	NEW EVENT\n	The notification string used to inform the SEL-5040 software that a new event has occurred.
ISSUE2	13:CMD1	When the SEL-5040 sends the message "WhoAreYou," the communications processor responds with MESG2.
MESG2	%%Upper2030%%\n	The name of the Dial Directory ID used for the SEL-5040.
ARCH_EN	N	Archiving disabled.

Table 3.12: Messaging for DNP 3.0 (SCADA)

Setting	Value	Comment
MSG_CNT	0	No messages sent
ARCH_EN	N	Archiving disabled
USER	143	Number of bytes required for **SET M** setting

User-Defined Commands

In the SEL-7000, user-defined commands (**SET U**) are used to handle unsolicited messages from remote IEDs. The SEL-7000 design does not incorporate any unsolicited commands from the Davis Weather Monitor, the local HMI, or the DNP 3.0 SCADA ports. For further information on user-defined commands, refer to the communications processor instruction manual.

Table 3.13: User Commands for an SEL-351S

Setting	Value	Comment
CMD1	20EVENTQ	When an event occurs on the attached relay, an unsolicited event summary is sent to the communications processor. The "20EVENTQ" command will assert and 6:CMD1 will be pulsed for one processing cycle.

Table 3.14: User Commands for an SEL-421

Setting	Value	Comment
CMD1	20EVENTQ	When an event occurs on the attached relay, an unsolicited event summary is sent to the communications processor. The "20EVENTQ" command will assert and 6:CMD1 will be pulsed for one processing cycle.

Table 3.15: User Commands for the SEL-5040

Setting	Value	Comment
CMD1	WhoAreYou	The SEL-5040 sends the communications processor the text message "WhoAreYou" after the SEL-5040 receives the "NEW EVENT" message. This message pulses bit 13:CMD1 for one processing cycle.

Data Consolidation

Once the communications processor has collected the data from the IEDs, settings in the communications processor scale and manipulate the data, creating a data set in the User Region. The data from each IED is then transmitted to the HMI via unsolicited writes from Relay Port 12 of the communications processor.

The data polled by the SCADA master is concentrated even further on Port 16 to create a highly condensed data set. Because the data for the local HMI is sent using automatic messages, there is no data concentration necessary. The settings to accomplish this are described in the following tables. For further information on Math/Movement (**SET M**) settings, refer to the communications processor instruction manual.

Table 3.16: Data Consolidation for an SEL-351S

Line	Value	Comment
1	# ANALOG VALUES - CONVERTED TO INTEGER	Comment
2	000h;;IA=06:METER:IA	Converts A-phase current measurement from a 32-bit floating point to a 16-bit signed integer.
3	001h;;IB=06:METER:IB	Same for B-phase-to-C-phase current
4	002h;;IC=06:METER:IC	Same for C-phase current
5	003h;;IN=06:METER:IN	Same for neutral current
6	004h;;VA=06:METER:VA/100	Divides A-phase voltage by 100 and converts the 32 bit floating point value to a 16 bit signed integer. This is functionally identical to kV • 10. This gives one decimal place of resolution for SCADA indication of kV.
7	005h;;VB=06:METER:VB/100	Same for B-phase
8	006h;;VC=06:METER:VC/100	Same for C-phase
9	007h;;VS=06:METER:VS/100	Same for the synchronizing voltage
10	008h;;FREQ=06:METER:FREQ*10	Multiplies the frequency measured by the SEL-351S by 10 and converts the 32-bit floating point to a 16-bit signed integer.
11	009h;;VBAT=06:METER:VBAT*10	Multiplies the battery voltage measured by the SEL-351S by 10 and converts the 32-bit floating point to a 16-bit signed integer.
12	00Ah;;VAB=06:METER:VAB(V)/100	Divides A-phase-to-B-phase voltage by 100 and converts the 32-bit floating point value to a 16-bit signed integer. This is functionally identical to kV • 10. This gives one decimal place of resolution for SCADA indication of kV.
13	00Bh;;VCA=06:METER:VBC(V)/100	Same, but for A-phase-to-B-phase voltage
14	00Ch;;VBC=06:METER:VCA(V)/100	Same, but for C-phase-to-A-phase voltage
15	00Dh;;P=06:METER:P(MW)*10	Multiplies the real power measurement by 10 and converts the 32-bit floating point to a 16-bit signed integer.

16	00Eh;;Q=06:METER:Q(MVAR)*10	Multiplies the reactive power measurement by 10 and converts the 32-bit floating point to a 16-bit signed integer.
17	00Fh;;IA_DEM=06:DEMAND:IA	Converts the A-phase demand current from a 32-bit floating point to a 16-bit signed integer.
18	010h;;IB_DEM=06:DEMAND:IB	Same for B-phase-to-C-phase current
19	011h;;IC_DEM=06:DEMAND:IC	Same for C-phase current
20	# STATUS BITS - COMM AND STATUS	Comment
21	028h:15;C=6:0800h:4	Pack status bits into a single register for more efficient handling and reading.
22	028h:14;C=6:0800h:9	“
23	028h:13;C=6:0800h:6	“
24	028h:12;C=6:0800h:5	“
25	028h:11;C=6:0800h:3	“
26	028h:10;C=6:TARGET:STSET	“
27	028h:7;C=6:TARGET:ROKA	“
28	028h:6;C=6:TARGET:RBADA	“
29	028h:5;C=6:TARGET:ROKB	“
30	028h:4;C=6:TARGET:RBADB	“
31	# RELAY FRONT PANEL TARGETS	Comment
32	029h,C;B;TAR_FP=06:TARGET:0005h;2	Pack two 8-bit bytes into a single 16 bit word
33	# RELAY INPUTS	Comment
34	02Ah,C;B;TAR_INP=06:TARGET:001Dh;1	Pack relay input status bits into a register
35	02Bh,C;B;TAR_INP2=06:TARGET:0034h;1	“
36	# RELAY SELOGIC VARIABLES AND REMOTE BITS	Comment
37	02Ch,C;B;TAR_SV=06:TARGET:0020h;8	Pack 8 bytes of relay remote bits into four 16-bit registers
38	# RELAY OUTPUTS	Comment
39	030h,C;B;TAR_OUT=06:TARGET:002Dh;1	Pack relay output status bits into a register
40	031h,C;B;TAR_OUT2=06:TARGET:0032h;2	Pack relay output status bits into a register
41	# RELAY BREAKER STATUS	Comment
42	032h,C;B;TAR_BKR=06:TARGET:002Ah;1	Pack relay breaker status bits into a register.
43	# RELAY FRONT PANEL LEDS	Comment

44	033h,C;B;TAR_LED=06:TARGET:0037h;1	Pack relay front-panel LED bits into a register
45	# RELAY MIRROR BITS	Comment
46	034h,C;B;TAR_MB=06:TARGET:0039h;4	Pack relay MIRRORED BIT status bits into a single register for more efficient handling and reading
47	#BRE DATA FROM FLEX PARSE	Comment
48	03Ah;;A_WEAR=06:FLEX:12h	% wear breaker contact A-phase
49	03Bh;;B_WEAR=06:FLEX:13h	% wear breaker contact B-phase
50	03Ch;;C_WEAR=06:FLEX:14h	% wear breaker contact C-phase
51	03Dh;;R_MON=06:METER:0015h	Month wear monitoring was last reset
52	03Eh;;R_DAY=06:METER:0016h	Day wear monitoring was last reset
53	03Fh;;R_YEAR=06:METER:IN	Year wear monitoring was last reset
54	040h;;R_HR=06:METER:0018h	Hour wear monitoring was last reset
55	041h;;R_MIN=06:METER:0019h	Minute wear monitoring was last reset
56	042h;;R_SEC=06:METER:001Ah	Second wear monitoring was last reset
57	# FAULT INFORMATION (LOC, TYPE)	Comment
58	044h=0	Clearing 44h
59	045h=0	Clearing 45h
60	# CHECK HISTORY RECORD 1 SHOT	Comment
61	044h-=06:HISTORY:SHOT	If the shot count for Record 1 is not zero, then create a negative number in F844h. A negative number in this register puts a 1 in the sign bit, Bit 15.
62	045h:0;B=!6:F844h:15	If the number in F844h Bit 15 is 1, then the shot count for Record 1 must be greater than zero. Therefore Bit 0, word F845h is set to a one (1) only if the shot count for Record 1 was at zero.
63	# CHECK HISTORY RECORD 2 SHOT	“
64	044h=0	“
65	044h-=06:HISTORY:02C7h	“
66	045h:1;B=!6:F844h:15	“
67	# CHECK HISTORY RECORD 3 SHOT	“
68	044h=0	“
69	044h-=06:HISTORY:02C8h	“
70	045h:2;B=!6:F844h:15	“

71	# CHECK HISTORY RECORD 4 SHOT	“
72	044h=0	“
73	044h-=06:HISTORY:02C9h	“
74	045h:3;B=!6:F844h:15	“
75	# CHECK HISTORY RECORD 5 SHOT	“
76	044h=0	“
77	044h-=06:HISTORY:02CAh	“
78	045h:4;B=!6:F844h:15	“
79	# CAPTURE SHOT 0 LOCATION AND TYPE	Comment
80	#	Comment
81	# HISTORY RECORD 5	Comment

The following code grabs the location of the latest event that has a zero shot count. This is because the fault location is most accurate before any reclosing has taken place.

82	IF 6:F845h:4	If the shot count for Record 5 is zero, grab the fault location.
83	046h;;LOCATION_5=06:HISTORY:021Ah,F*100	Grab the fault location
84	047h,C;;TYPE_5=06:HISTORY:0142h;8	Grab the fault type. Overwrite these registers in the next few lines of code only if a more recent event has a shot count of zero.
85	ENDIF	
86	# HISTORY RECORD 4	“
87	IF 6:F845h:3	“
88	046h;;LOCATION_4=06:HISTORY:0218h,F*100	“
89	047h,C;;TYPE_4=06:HISTORY:013Ah;8	“
90	ENDIF	“
91	# HISTORY RECORD 3	“
92	IF 6:F845h:2	“
93	046h;;LOCATION_3=06:HISTORY:0216h,F*100	“
94	047h,C;;TYPE_3=06:HISTORY:0132h;8	“
95	ENDIF	“
96	# HISTORY RECORD 2	“
97	IF 6:F845h:1	“
98	046h;;LOCATION_2=06:HISTORY:0214h,F*100	“
99	047h,C;;TYPE_2=06:HISTORY:012Ah;8	“

100	ENDIF	“
101	# HISTORY RECORD 1	“
102	IF 6:F845h:0	“
103	046h;;LOCATION_1=06:HISTORY:LOCATION,F*100	“
104	047h,C;;TYPE_1=06:HISTORY:EVENT;8	“
105	ENDIF	“

Table 3.17: Data Consolidation for an SEL-421

Line	Value	Comment
1	# ANALOG VALUES - CONVERTED TO INTEGER	Comment
2	000h;;IA1=02:METER:IA1	Converts A-phase, Breaker 1 current measurement from a 32-bit floating point to a 16-bit signed integer.
3	001h;;IB1=02:METER:IB1	Same as for B-phase current, Breaker 1
4	002h;;IC1=02:METER:IC1	Same as for C-phase current, Breaker 1
5	003h;;IA2=02:METER:IA2	Same as for A-phase current, Breaker 2
6	004h;;IB2=02:METER:IB2	Same as for B-phase current, Breaker 2
7	005h;;IC2=02:METER:IC2	Same as for C-phase current, Breaker 2
8	006h;;IA3=02:METER:IA3	Same as for the sum of Breaker 1 and 2, A-A-phase current
9	007h;;IB3=02:METER:IB3	Same as for the sum of Breaker 1 and 2, B-B-phase current
10	008h;;IC3=02:METER:IC3	Same as for the sum of Breaker 1 and 2, C-phase current
11	009h;;VA=02:METER:VA/100	Divides A-phase voltage by 100 and converts the 32-bit floating point value to a 16-bit signed integer. This is functionally identical to kV • 10. This gives one decimal place of resolution for SCADA indication of kV.
12	00Ah;;VB=02:METER:VB/100	Same as for B-phase voltage
13	00Bh;;VC=02:METER:VC/100	Same as for C-phase voltage
14	00Ch;;FREQ=02:METER:FREQ*10	Scales the measured frequency up by a factor of 10 and converts the 32-bit floating point value to a signed 16-bit integer. This is done to give one decimal point of frequency measurement.

15	00Dh;;VAB=02:METER:VAB(V)/100	Divides the phase-to-phase voltage AB by 100 and converts the 32-bit floating point value to a 16-bit signed integer. This is functionally identical to kV • 10. This gives one decimal place of resolution for SCADA indication of kV.
16	00Eh;;VBC=02:METER:VBC(V)/100	Same as for voltage BC
17	00Fh;;VCA=02:METER:VCA(V)/100	Same as for voltage CA
18	010h;;P=02:METER:P(MW)*10	Multiplies the measured three-phase power by 10 and converts the 32-bit floating point value to a signed 16-bit integer. This gives one decimal point of resolution to the measurement.
19	011h;;Q=02:METER:Q(MVAR)*10	Same as for measured three-phase reactive power
20	012h;;PF_3=02:METER:AMV001*100	Multiplies the calculated three-phase power factor by 100 and converts the 32-bit floating point value to a signed 16-bit integer. The power factor is calculated inside the SEL-421 and put into AMV001 (Automation Math Variable 1).
21	013h,F;;MWH_3=02:METER:AMV002*10	Multiplies the measured three-phase MW-hour energy value by 10 and converts the 32-bit floating point value to a signed 16-bit integer.
22	015h;;AMV003=02:METER:AMV003	Places the Automation Math variable into a register as an integer. This is a spare.
23	016h;;AMV004=02:METER:AMV004	“
24	# DEMAND CURRENTS	Comment
25	017h;;IA=02:DEMAND:IA	Converts the sum of Breaker 1 and 2 A-phase-to-A-phase current measurements from a 32-bit floating point to a signed 16-bit integer.
26	018h;;IB=02:DEMAND:IB	Same as for B-phase current
27	019h;;IC=02:DEMAND:IC	Same as for C-phase current
28	# SYNC VALUES COLLECTED FROM FLEX3	Comment
29	01Ah;;VPMAG=02:FLEX3:0004h*100	Multiplies the line phase voltage magnitude by 100 and converts from a 32-bit floating point to a signed 16-bit integer.
30	01Bh;;NVS1MAG=02:FLEX3:0006h*100	Multiplies the synchronizing voltage 1 magnitude by 100 and converts from a 32-bit floating point to a signed 16-bit integer.
31	01Ch;;ANG1=02:FLEX3:0008h*100	Multiplies the synchronizing voltage 1 phase angle by 100 and converts from a 32-bit floating point to a signed 16-bit integer.

32	01Dh;;SLIP1=02:FLEX3:000Ah*100	Multiplies the slip between synchronizing voltage 1 and the line phase voltage by 100 and converts from a 32-bit floating point to a signed 16-bit integer.
33	01Eh;;NVS2MAG=02:FLEX3:000Ch*100	Same as for synch voltage 2 magnitude.
34	01Fh;;ANG2=02:FLEX3:000Eh*100	Same as for synch voltage 2 phase angle.
35	020h;;SLIP2=02:FLEX3:0010h*100	Same as for slip between synch voltage 2 and line phase voltage.
36	023h,C;B;TAR_MB=02:TARGET:004Ah;4	Pack the four bytes of transmit and receive MIRRORED BITS data from Channel A and B into 2, 16-bit words.
37	028h:15;C=2:0800h:4	Pack status bits into a single register for more efficient handling and reading
38	028h:14;C=2:0800h:9	“
39	028h:13;C=2:0800h:6	“
40	028h:12;C=2:0800h:5	“
41	028h:11;C=2:0800h:3	“
42	028h:10;C=2:TARGET:STSET	“
43	028h:9;C=2:TARGET:STFAIL	“
44	028h:8;C=2:TARGET:STWARN	“
45	028h:7;C=2:TARGET:ROKA	“
46	028h:6;C=2:TARGET:RBADA	“
47	028h:5;C=2:TARGET:ROKB	“
48	028h:4;C=2:TARGET:RBADB	“
49	# RELAY FRONT PANEL TARGETS	Comment
50	029h,C;B;TAR_FP=02:TARGET:0005h;1	Front-panel targets
51	# RELAY FRONT PANEL TARGETS	“
52	02Ah,C;B;TAR_FP=02:TARGET:0006h;2	“
53	# RELAY PUSHBUTTON LEDS	Comment
54	02Bh,C;B;TAR_PB=02:TARGET:0049h;1	Front-panel pushbuttons
55	# RELAY INPUTS	Comment
56	02Ch,C;B;TAR_INP12=02:TARGET:0021h;2	As per comment
57	02Dh,C;B;TAR_INP3=02:TARGET:0025h;1	“
58	# RELAY REMOTE BITS	“

59	02Eh,C;B;TAR_RB=02:TARGET:001Eh;2	“
60	# RELAY SELOGIC VARIABLES	Comment
61	02Fh,C;B;TAR_PSV=02:TARGET:0028h;2	Protection SEL Variables
62	030h,C;B;TAR_PLT=02:TARGET:002Ch;2	Protection Latches
63	031h,C;B;TAR_ASV=02:TARGET:0034h;4	Automation SEL Variables
64	033h,C;B;TAR_ALT=02:TARGET:0038h;2	Automation Latches
65	# RELAY BREAKER STATUS	Comment
66	034h,C;B;TAR_BR=02:TARGET:000Dh;3	As per comment
67	# RELAY OUTPUTS	Comment
68	036h,C;B;TAR_OUT=02:TARGET:0044h;4	As per comment
69	# BRE 1 VALUES FROM 2:FLEX1	Breaker Wear monitoring values
70	038h;;WEAR_BR1A=02:FLEX:0004h*10	“
71	039h;;WEAR_BR1B=02:FLEX:0006h*10	“
72	03Ah;;WEAR_BR1C=02:FLEX:0008h*10	“
73	03Bh;;MSOAL1=02:FLEX:000Ah	“
74	03Ch;;ESOAL1=02:FLEX:000Bh	“
75	03Dh;;MRTAL1=02:FLEX:000Ch	“
76	03Eh;;KAIAL1=02:FLEX:000Dh	“
77	03Fh;;B1_MON=02:FLEX:000Eh	“
78	040h;;B1_DAY=02:FLEX:000Fh	“
79	041h;;B1_YEAR=02:FLEX:0010h	“
80	042h;;B1_HR=02:FLEX:0011h	“
81	043h;;B1_MIN=02:FLEX:0012h	“
82	044h;;B1_SEC=02:FLEX:0013h	“
83	# BRE 2 VALUES FROM 2:FLEX2	“
84	045h;;WEAR_BR2A=02:FLEX2:0004h*10	“
85	046h;;WEAR_BR2B=02:FLEX2:0006h*10	“
86	047h;;WEAR_BR2C=02:FLEX2:0008h*10	“
87	048h;;MSOAL2=02:FLEX2:000Ah	“
88	049h;;ESOAL2=02:FLEX2:000Bh	“
89	04Ah;;MRTAL2=02:FLEX2:000Ch	“
90	04Bh;;KAIAL2=02:FLEX2:000Dh	“

91	04Ch;;B2_MON=02:FLEX2:000Eh	“
92	04Dh;;B2_DAY=02:FLEX2:000Fh	“
93	04Eh;;B2_YEAR=02:FLEX2:0010h	“
94	04Fh;;B2_HR=02:FLEX2:0011h	“
95	050h;;B2_MIN=02:FLEX2:0012h	“
96	051h;;B2_SEC=02:FLEX2:0013h	“
97	# BREAKER DATA FROM 20BREAKER	Comment
98	052h;;NUM_OPERS=02:BREAKER:NUM_OPERS;3	As per comment
99	055h;;AVG_CL_ELEC=02:BREAKER:AVG_CL_ELE;3	“
100	058h;;AVG_CL_MECH=02:BREAKER:AVG_CL_MEC;3	“
101	05Bh;;LAST_CL_ELEC=02:BREAKER:LAST_CL_EL;3	“
102	05Eh;;LAST_CL_MECH=02:BREAKER:LAST_CL_MI;3	“
103	061h;;R_MON=02:BREAKER:RESET_MONT	“
104	062h;;R_DAY=02:BREAKER:RESET_DAY	“
105	063h;;R_YEAR=02:BREAKER:RESET_YEAR	“
106	064h;;R_HOUR=02:BREAKER:RESET_HOUR	“
107	065h;;R_MIN=02:BREAKER:RESET_MIN	“
108	066h;;R_SEC=02:BREAKER:RESET_SEC	“

The following logic is identical to that for the SEL-351S on Port 6. See the previous section for details.

109	# FAULT INFORMATION (LOC, TYPE)	“
110	067h=0	“
111	068h=0	“
112	# CHECK HISTORY RECORD 1 SHOT	“
113	067h-=02:HISTORY:SHOT	“
114	068h:0;B=!2:F867h:15	“
115	# CHECK HISTORY RECORD 2 SHOT	“
116	067h=0	“
117	067h-=02:HISTORY:024Fh	“
118	068h:1;B=!2:F867h:15	“

119	# CHECK HISTORY RECORD 3 SHOT	“
120	067h=0	“
121	067h-=02:HISTORY:0250h	“
122	068h:2;B=!2:F867h:15	“
123	# CHECK HISTORY RECORD 4 SHOT	“
124	067h=0	“
125	067h-=02:HISTORY:0251h	“
126	068h:3;B=!2:F867h:15	“
127	# CHECK HISTORY RECORD 5 SHOT	“
128	067h=0	“
129	067h-=02:HISTORY:0252h	“
130	068h:4;B=!2:F867h:15	“
131	# CAPTURE SHOT 0 LOCATION AND TYPE	“
132	#	“
133	# HISTORY RECORD 5	“
134	IF 2:F868h:4	“
135	069h;;LOCATION_5=02:HISTORY:021Ah,F*100	“
136	06Ah,C;;TYPE_5=02:HISTORY:016Ah;8	“
137	ENDIF	“
138	# HISTORY RECORD 4	“
139	IF 2:F868h:3	“
140	069h;;LOCATION_4=02:HISTORY:022Ch,F*100	“
141	06Ah,C;;TYPE_4=02:HISTORY:0162h;8	“
142	ENDIF	“
143	# HISTORY RECORD 3	“
144	IF 2:F868h:2	“
145	069h;;LOCATION_3=02:HISTORY:022Ah,F*100	“
146	06Ah,C;;TYPE_3=02:HISTORY:015Ah;8	“
147	ENDIF	“
148	# HISTORY RECORD 2	“
149	IF 2:F868h:1	“
150	069h;;LOCATION_2=02:HISTORY:0228h,F*100	“

151	06Ah,C;;TYPE_2=02:HISTORY:0152h;8	“
152	ENDIF	“
153	# HISTORY RECORD 1	“
154	IF 2:F868h:0	“
155	069h;;LOCATION_1=02:HISTORY:FAULT_LOC,F*100	“
156	06Ah,C;;TYPE_1=02:HISTORY:EVENT;8	“
157	ENDIF	“

Table 3.18: Data Consolidation for Other IEDs

Line	Value	Comment
1	# ANALOG VALUES	Comment
2	000h,P;I;TEMP_IN=04:CHAR:0006h;2	Pack two bytes of character data into a single integer. This is the current inside temperature.
3	001h,P;I;TEMP_OUT=04:CHAR:0008h;2	Pack two bytes of character data into a single integer. This is the current outside temperature.
4	002h;;WIND=04:CHAR:000Ah	Pack two bytes of character data into a single integer. This is the current wind speed.
5	003h,P;I;WIND_DIR=04:CHAR:000Bh;2	Pack two bytes of character data into a single integer. This is the current wind direction.
6	004h,P;I;BAROM=04:CHAR:000Dh;2	Pack two bytes of character data into a single integer. This is the current barometric pressure
7	005h;;HUM_IN=04:CHAR:000Fh	Pack two bytes of character data into a single integer. This is the current inside humidity.
8	006h;;HUM_OUT=04:CHAR:0010h	Pack two bytes of character data into a single integer. This is the current outside humidity.
9	007h,P;I;TOT_RAIN=04:CHAR:0011h;2	Pack two bytes of character data into a single integer. This is the current total rain accumulation.
10	# STATUS BITS - COMM AND STATUS	Comment
11	028h:15;C=4:0800h:4	Pack status bits into a single register for more efficient handling and reading
12	028h:14;C=4:0800h:9	“
13	028h:13;C=4:0800h:6	“
14	028h:11;C=4:0800h:3	“

Table 3.19: Data Consolidation for the SEL-5040

Line	Value	Comment
1	# 5040 EVENT STATUS WORD	Comment. The SEL-5040 checks the word with the data label "FAULT" during its automated event notification routine.
2	000h:0;B=1:BR16	Lower tier event status
3	000h:1;B=2:BR16	SEL-421 Transmission Line 1 new event status
4	000h:2;B=3:BR16	No SEL relay
5	000h:3;B=4:BR16	SEL-421 Transmission Line 2 new event status
6	000h:4;B=5:BR16	SEL-387 Transformer new event status
7	000h:5;B=6:BR16	SEL-351S Feeder 4 new event status
8	000h:6;B=7:BR16	SEL-351S Feeder 3 new event status
9	000h:7;B=8:BR16	SEL-351S Feeder 2 new event status
10	000h:8;B=9:BR16	SEL-351S Feeder 1 new event status
11	000h:9;B=10:BR16	SEL-351S TL new event status
12	000h:10;B=11:BR16	SEL-351S TH new event status
13	000h:11;B=12:BR16	No SEL relay
14	000h:12;B=13:BR16	No SEL relay
15	000h:13;B=14:BR16	No SEL relay
16	000h:14;B=15:BR16	No SEL relay
17	000h:15;B;FAULT=16:BR16	No SEL relay on this port. Word 0h given the data label "FAULT." The SEL-5040 looks for the word with this label to determine which port has the new event.

The data consolidation for SCADA will vary widely based on customer requirements. In Table 3.20, we show a sample of what can be provided to a DNP master. In this example we are showing only pieces of the SET M settings; a complete DNP map for SCADA is provided with the SEL-7000.

Table 3.20: Data Consolidation for DNP 3.0 (SCADA)

Line	Value	Comment
-----	----Break in Set M-----	--------
15	#	Comment
16	# SEL-421 ANALOG DATA	Comment
17	010h=02:METER:IA1	Breaker 1, A-phase current converted from a 32-bit floating point to a signed 16-bit integer.
18	011h=02:METER:IB1	Same for Breaker 1, B-phase current
19	012h=02:METER:IC1	Same for Breaker 1, C-phase current
20	016h=02:METER:P(MW)*10	Multiplies the real power measurement by 10 and converts the 32-bit floating point to a signed 16-bit integer.

21	017h=02:METER:Q(MVAR)*10	Multiplies the reactive power measurement by 10 and converts the 32-bit floating point to a signed 16-bit integer.
-----	----Break in SET M-----	--------
30	#	Comment
31	# SEL-351S ANALOG DATA	Comment
32	030h=06:METER:IA	A-phase current converted from a 32-bit floating point to a signed 16-bit integer
33	031h=06:METER:IB	Same for B-phase-to-B-phase current
34	032h=06:METER:IC	Same for C-phase current
35	033h=06:METER:IN	Same for neutral current
36	034h=06:METER:VA/100	Multiplies A-phase voltage by 100 and converts the 32-bit floating point value to a signed 16-bit integer. This is functionally identical to kV • 10. This gives one decimal place of resolution for SCADA indication of kV.
37	035h=06:METER:VB/100	Same for B-phase
38	036h=06:METER:VC/100	Same for C-phase
39	037h=06:METER:VS/100	Same for synchronizing voltage
-----	----Break in Set M-----	--------
58	#	Comment
59	# SEL-421 DIGITAL INPUTS	Comment
60	042h:0;B=2:TARGET:EN	Enable front-panel LED
61	042h:1;B=2:TARGET:TRIPLED	Trip front-panel LED
62	042h:2;B=2:TARGET:TLED_1	INST front-panel LED
63	042h:3;B=2:TARGET:TLED_2	TIME front-panel LED
64	042h:4;B=2:TARGET:TLED_3	COMM front-panel LED
65	042h:5;B=2:TARGET:TLED_4	SOTF front-panel LED
66	042h:6;B=2:TARGET:TLED_5	ZONE 1 front-panel LED
67	042h:7;B=2:TARGET:TLED_6	ZONE 2 front-panel LED
68	042h:8;B=2:TARGET:TLED_7	ZONE 3 front-panel LED
69	042h:9;B=2:TARGET:TLED_8	ZONE 4 front-panel LED
70	042h:10;B=2:TARGET:TLED_9	A-phase front-panel LED
71	042h:11;B=2:TARGET:TLED_10	B-phase front-panel LED
72	042h:12;B=2:TARGET:TLED_11	C-phase front-panel LED
73	042h:13;B=2:TARGET:TLED_12	GROUND front-panel LED
74	042h:14;B=2:TARGET:TLED_13	50 front-panel LED
75	042h:15;B=2:TARGET:TLED_14	51 front-panel LED
76	043h:0;B=2:TARGET:TLED_15	79 RESET front-panel LED
77	043h:1;B=2:TARGET:TLED_16	79 LOCKOUT front-panel LED
78	043h:2;B=2:TARGET:PLT03	Remote control status

79	043h:2;B=2:TARGET:PLT07	Information tag status
80	043h:2;B=2:TARGET:PLT06	Hold tag status
81	043h:2;B=2:TARGET:PLT05	Hot line tag status
82	043h:2;B=2:TARGET:PLT02	Automatic reclose status
83	043h:2;B=2:TARGET:PLT01	Comm scheme status
-----	----Break in SET M-----	--------
102	#	Comment
103	# SEL-351S DIGITAL INPUTS	Comment
104	046h:0;B=6:TARGET:TLED11	EN front-panel LED
105	046h:1;B=6:TARGET:TLED12	TRIP front-panel LED
106	046h:2;B=6:TARGET:TLED13	INST front-panel LED
107	046h:3;B=6:TARGET:TLED14	COMM front-panel LED
108	046h:4;B=6:TARGET:TLED15	SOTF front-panel LED
109	046h:5;B=6:TARGET:TLED16	50 front-panel LED
110	046h:6;B=6:TARGET:TLED17	51 front-panel LED
111	046h:7;B=6:TARGET:TLED18	81 front-panel LED
112	046h:8;B=6:TARGET:TLED19	RS front-panel LED
113	046h:9;B=6:TARGET:TLED20	CY front-panel LED
114	046h:10;B=6:TARGET:TLED21	LO front-panel LED
115	046h:11;B=6:TARGET:TLED22	A front-panel LED
116	046h:12;B=6:TARGET:TLED23	B front-panel LED
117	046h:13;B=6:TARGET:TLED24	C front-panel LED
118	046h:14;B=6:TARGET:TLED25	G front-panel LED
119	046h:15;B=6:TARGET:TLED26	N front-panel LED
120	047h:0;B=6:TARGET:LT1	Ground enabling status
121	047h:1;B=6:TARGET:LT2	Automatic reclose status
122	047h:2;B=6:TARGET:LT3	Remote control status
123	047h:3;B=6:TARGET:LT5	Hot line tag status
124	047h:4;B=6:TARGET:LT6	Hold tag status
125	047h:5;B=6:TARGET:LT7	Information tag status
126	047h:6;B=6:TARGET:LT8	Breaker failure status
-----	----Break in SET M-----	--------

Logic Settings

Logic settings in the communications processor are used to perform the following tasks:

- Remote control supervision
- SEL-5040 new event notification

- Send the HMI “heartbeat” bit to the relays

Note that there is no logic required for the Davis Weather Station, the local HMI, or the remote SCADA port; therefore, these examples are not detailed in the following tables.

Table 3.21: Logic Settings for the SEL-351S

Setting	Value	Comment
SBR1	6:SBR2*6:TARGET:LT3	SCADA can open the breaker by setting Breaker Bit 2, Port 6 if the remote control supervision bit (LT3) is enabled.
CBR1	6:CBR2*6:TARGET:LT3	SCADA can close the breaker by clearing Breaker Bit 2, Port 6 if the remote control supervision bit (LT3) is enabled.
SBR16	6:CMD1	Set Breaker Bit 16 when a new event is detected.
SRB15	12:SRB15	HMI “heartbeat” sent to relays.

Table 3.22: Logic Settings for the SEL-421

Setting	Value	Comment
SBR1	2:SBR2*2:TARGET:LT3	SCADA can open the breaker by setting Breaker Bit 2, Port 2 if the remote control supervision bit (LT3) is enabled.
CBR1	2:CBR2*2:TARGET:LT3	SCADA can close the breaker by clearing Breaker Bit 2, Port 2 if the remote control supervision bit (LT3) is enabled.
SBR16	2:CMD1	Set Breaker Bit 16 when a new event is detected.
SRB15	12:SRB15	HMI “heartbeat” sent to relays.

Table 3.23: Logic Settings for the SEL-5040

Setting	Value	Comment
SBR15	1:BR16 + 2:BR16 + 3:BR16 + 4:BR16 + 5:BR16 + 6:BR16 + 7:BR16 + 8:BR16 + 9:BR16 + 10:BR16 + 11:BR16 + 12:BR16 + 13:BR16 + 14:BR16 + 15:BR16 + 16:BR16	The BR16 bit for each port is asserted when an event has occurred on the IED attached to that port. The SEL-5040 will then be notified.
CBR15	!1:BR16 + !2:BR16 + !3:BR16 + !4:BR16 + !5:BR16 + !6:BR16 + !7:BR16 + !8:BR16 + !9:BR16 + !10:BR16 + !11:BR16 + !12:BR16 + !13:BR16 + !14:BR16 + !15:BR16 + !16:BR16	Once an event is collected, the SEL-5040 will clear the port BR16.

Global Settings

Global settings in the communications processor provide timers, intermediate logic elements, logic for the I/O board outputs, IRIG-B signal source selection and input debounce settings not related to a particular port. In the SEL-7000, only the identification string is modified from default.

Table 3.24: Global Settings

Setting	Value	Comment
ID	INTEGRATION 1ST UPPER TIER	Identification string
V	NA	V intermediate logic element not used
W	NA	W intermediate logic element not used
X	NA	X intermediate logic element not used
Y	NA	Y intermediate logic element not used
Z	NA	Z intermediate logic element not used
VPICKUP	OFF	V intermediate logic element pickup timer not used
VDROPOUT	OFF	V intermediate logic element dropout timer not used
WPICKUP	OFF	W intermediate logic element pickup timer not used
WDROPOUT	OFF	W intermediate logic element dropout timer not used
XPICKUP	OFF	X intermediate logic element pickup timer not used
XDROPOUT	OFF	X intermediate logic element dropout timer not used
YPICKUP	OFF	Y intermediate logic element pickup timer not used
YDROPOUT	OFF	Y intermediate logic element dropout timer not used
ZPICKUP	OFF	Z intermediate logic element pickup timer not used
ZDROPOUT	OFF	Z intermediate logic element dropout timer not used
OUT1	NA	The output contacts are not used
OUT2	NA	The output contacts are not used
OUT3	NA	The output contacts are not used
OUT4	NA	The output contacts are not used
DEBOUNCE	0	No debounce time is applied to the inputs of the communications processor
TIME_SRC	IRIG	Time in the communications processor is synchronized to the IRIG-B input

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Section 4: HMI Functionality

Introduction

The following subsections describe each of the screens in the substation HMI. See the SEL-7000 User's Guide for a step-by-step procedure for using each of these screens.

HMI and SCADA Control

The following control functions are available at the local HMI or via the customer's remote SCADA system:

- Circuit breaker trip and close
- Relay target reset
- Reclosing on/off
- Ground relaying on/off
- Local/remote control enable. This HMI is considered a local control.
- Reset lockout (86 lockouts held by nonvolatile latches inside the SEL relays).
- Hot line tag apply/remove
- Hold tag apply/remove
- Information tag apply/remove

In the event of an HMI or PC failure, these functions, except for the information tag, become available from the front panel of the SEL-351S and SEL-421. This is one example of the redundant design practices used throughout the SEL-7000.

HMI and SCADA Data Acquisition

SEL provides the following quantities to the HMI and to SCADA from the SEL relays and the SEL-2032 Communications Processor:

- Three-phase currents
- Residual currents
- Three-phase neutral voltages (optionally phase-to-phase voltages)
- Real and reactive power
- Power factor
- Substation dc battery voltage
- Substation frequency

- Reclosing status
- Ground relaying status
- Local/remote control status
- Breaker failure status
- Breaker wear status
- Spring energy alarm status
- Maintenance local/remote alarm status
- Trip coil monitoring alarm status
- Transformer lockout indication
- Transformer sudden pressure trip status
- Transformer oil temperature status and alarms
- Transformer fan control (manual and automatic control)
- Bus lockout indication
- Communications status of all the communications links in the SEL-7000
- Relay front panel targets for each SEL relay
- Relay failure (watchdog) alarm for each SEL relay
- Breaker status (52A)
- Fault location
- Fault type
- Recloser shot count

The preceding list is just a small sample of the data available from the SEL-7000. Much more information is available at the customer's request.

HMI Screens

The following is a listing of the screens provided with the SEL-7000. See the following subsections for more details.

- Log-on window (username and password entry)
- Header bar
- One-line diagram
- Relay targets screen
- Protection overview screen
- System communications screen
- Alarm summary/history screen
- Weather status screen
- SEL application link screen

- Circuit breaker control screen (one for every breaker in the substation)
- Input/output status screen (one per SEL relay)

HMI screens from SEL are fully customizable per the customer's requirements. The screens described in this list are only a typical example of the screens provided for an SEL-7000.

Header Bar

Figure 4.1 displays the header bar. This is your main navigation tool between the HMI screens, and it is always displayed at the top of every screen. If you are not logged on, these buttons will be inactive. See the next section for details on how to log on.

Figure 4.1: Header Bar

Table 4.1: Function of the Header Bar Buttons

Option	Description
One-Line	Opens the screen shown in Figure 4.4. The One-Line is the default HMI screen and is visible even if you are not logged on to the HMI.
Targets	Opens the screen shown in Figure 4.13.
Alarms	Opens the screen shown in Figure 4.15.
Protection	Opens the screen shown in Figure 4.17.
Comm	Opens the screen shown in Figure 4.18.
Weather	Opens the screen shown in Figure 4.22.
SEL APPS	Opens the screen shown in Figure 4.23.

Logging On

Log on to the system from the header bar by clicking the **Log On** button. Type your username and password into the **Log On Window** that opens, as shown in Figure 4.2. Once you enter the correct password, this window automatically disappears and you will be logged on to the system.

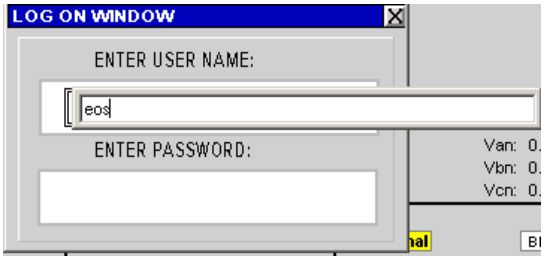

Figure 4.2: Log On Window

The username of the currently logged on user is displayed on the header bar above the **Log On** and **Log Off** buttons. When this display shows **None**, no one is logged on. This is shown in Figure 4.3.

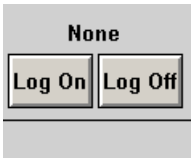

Figure 4.3: Current User Display

Log-On Security

If there is no activity for 30 minutes, the HMI displays a warning that the user will be logged off in 30 minutes. This warning disappears if you click any button. If you do not click a button within 30 minutes, the HMI logs the current user off and indicates that the current user has been logged off. The end result is that it takes one hour for the user to be logged off for inactivity. This functionality can be configured differently at the customer's request.

Four levels of passwords are available in the SEL-7000 HMI. These are indicated in Table 4.2.

Table 4.2: SEL-7000 Password Levels

Access Level		Functionality
1	0–249	Operator can view only the one-line data; no control allowed.
2	250–499	Operator can view all screens; no control allowed.
3	500–9998	Operator can view all screens; control is allowed.
4	9999	Administrator can modify HMI, view all screens, and control is allowed.

Four default passwords are delivered with the default SEL-7000. These are indicated in Table 4.3.

Table 4.3: SEL-7000 Default Passwords

Access Level	User	Password
1	9999	Administrator	Wonderware
2	500	Control	SEL
3	250	View	User
4	0	None	None

SEL can provide a customized password level scheme at the customer's request. One common password scheme is to give every operator a user name, password, and access level.

Substation One-Line Diagram Screen

Figure 4.4 shows the **Substation One-Line Diagram** screen.

Cyan (light blue) colored items on the one-line diagram or any other window in the HMI indicates a loss of communication to that piece of equipment. See the communications screen to diagnose the problem.

CAUTION: Information displayed in cyan may be unreliable. The data displayed should not be used to determine any control actions or be considered the actual operating condition or metering quantities.

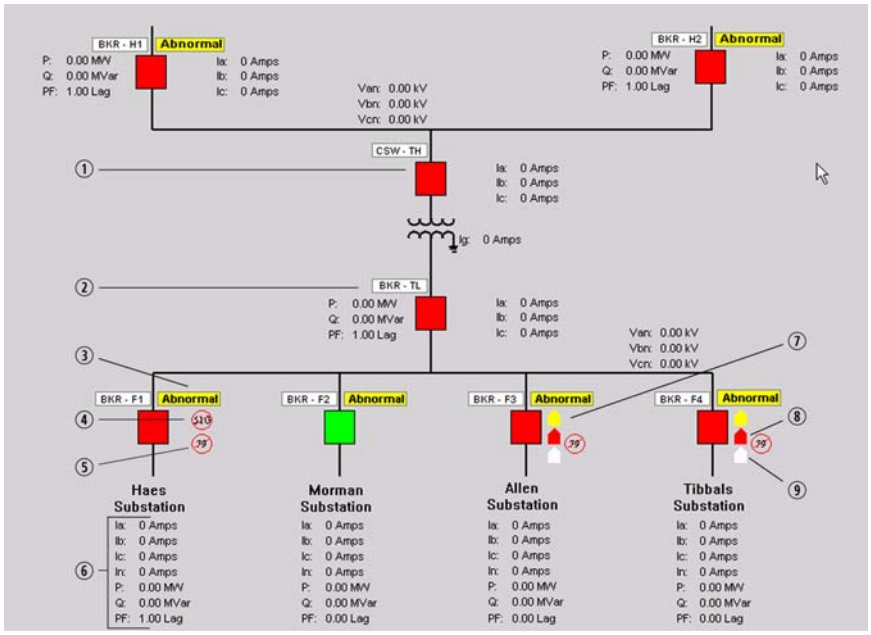

Figure 4.4: Substation One-Line Diagram Screen

① Breaker/Circuit Switcher Status: The circuit switcher status is depicted in red (closed) or green (open). A light blue color (cyan) indicates loss of communication to the relay. Clicking this item opens the Circuit Breaker Control window.

② Breaker Title: This label is used to describe the breaker. This is completely configurable.

③ Abnormal: This warning flag appears if there are any alarms present for this breaker. You can view the alarms on the Alarm Summary screen or on the Alarm Bar.

④ Ground Relay Status: When this symbol is visible, the ground relaying function is disabled for this breaker.

⑤ Recloser Relay Status: When this symbol is visible, the recloser function is disabled for this breaker.

⑥ Metered Values: This area displays Real Power (MW), Reactive Power (MVar), Power Factor (PF), phase currents, and residual currents. These values are derived from the SEL-351S-6 corresponding to this breaker.

⑦ Hot Line Tag: This tag is visible when a hot line tag is applied. Clicking this tag displays the message the operator put into the database when this tag was applied. An example of this is shown in Figure 4.5.

⑧ Hold Tag: This tag is visible when a hold tag is applied. Clicking this tag displays the message the operator put into the database when this tag was applied. An example of this is shown in Figure 4.6.

⑨ Information Tag: This tag is visible when an Information tag is present. Clicking this tag displays the last Information tag applied to the particular breaker. An example of this is shown in Figure 4.7

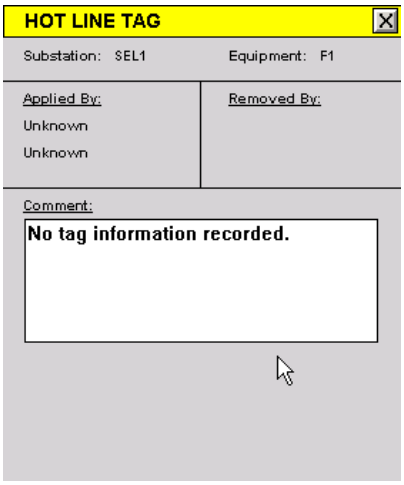

Figure 4.5: Hot Line Tag Window

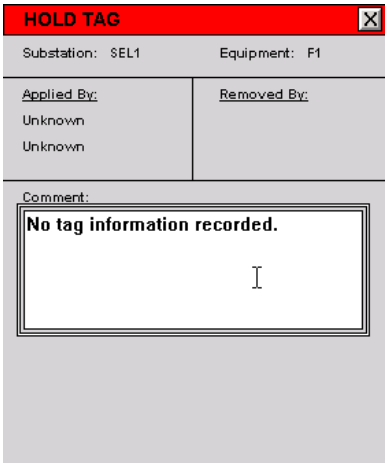

Figure 4.6: Hold Tag Window

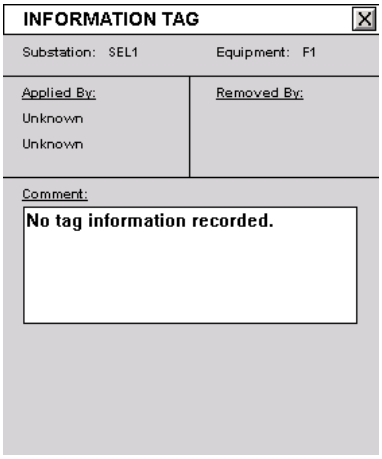

Figure 4.7: Information Tag Window

Circuit Breaker Control Screen

As described in Figure 4.4, selecting a breaker symbol on the one-line diagram brings up a **Circuit Breaker Control** screen, as shown in Figure 4.8. This screen is accessible only if you are logged on and you have the proper authorization level (see *Logging On on page 4.3* for more details).

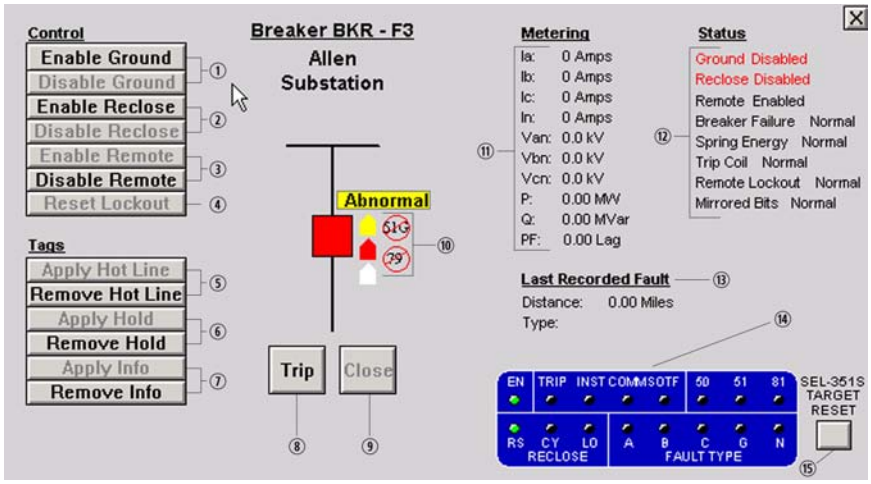

Figure 4.8 Sample Circuit Breaker Control Screen

① Ground Relaying Control: These buttons enable/disable ground relaying for this particular feeder. The status of the ground relaying function is displayed under the Status section of this screen (top-right corner of screen).

② Reclose Control: These buttons enable/disable the automatic recloser in the SEL-351S Relays. They are available only for feeder and transmission relays.

③ Remote Control: These buttons enable/disable remote SCADA operation of the breaker.

④ Reset Lockout: Resets lockouts (86) created by logic within the relays. The trip (lockout) for this resides in nonvolatile latches in the SEL relay. Nonvolatile latches do not lose their state during power loss.

⑤ Hot Line Tag: These buttons apply and remove a hot line tag. You will be asked to include a hot line tag comment, as shown in Figure 4.5. Once a hot line tag is applied, a yellow tag symbol appears next to the breaker on the one-line (Figure 4.4) and the circuit breaker control screen (Figure 4.8).

⑥ Hold Tag: These buttons apply and remove a hold tag (also known as a clearance tag). You can include a hold tag comment, as shown in Figure 4.6. Once a hold tag is applied, a red tag symbol appears next to the breaker on the one-line (Figure 4.4) and the circuit breaker control screen (Figure 4.8).

⑦ Information Tag: These buttons apply and remove an information tag. You can include a tag comment, as shown in Figure 4.7. Once an information tag is applied, a white tag symbol appears next to the breaker on the one-line (Figure 4.4) and the circuit breaker control screen (Figure 4.8).

⑧ Trip: Available only when the breaker is closed and communication to the relay is normal. When you select this button, you will be asked to confirm your action with a window like that shown in Figure 4.10. Selecting Yes in the window displayed in Figure 4.10 trips the breaker. Selecting the Cancel button exits this window and does not operate the breaker. After tripping the breaker, select the Cancel button to exit this window. At the customer's request, this breaker open prompt can be programmed to automatically exit after an operation.

⑨ Close: Available only when the breaker is open, communication to the relay is normal, the hot line tag is off, and the relay front-panel targets have been reset. When you select this button, you will be asked to confirm your action with a window like that shown in Figure 4.11. Selecting Yes on Figure 4.11 closes the breaker. Selecting the Cancel button exits this window and does not operate the breaker. After closing the breaker, select the Cancel button to exit this window. At the customer's request, this breaker close prompt can be programmed to automatically exit after an operation.

⑩ Breaker Status: These items and their locations are the same as shown in Figure 4.4.

⑪ Metering: Displays the current in each phase and the neutral, the line-to-neutral voltage of each phase, the cumulative power flow of all three phases, the cumulative reactive power flow of all three phases, and the cumulative power factor of all three phases.

⑫ Status: Shows the status of ground relaying, the relay recloser, remote control, breaker failure, spring energy, trip coil, remote lockout, and the MIRRORED BITS™ communications channel to the SEL-2100.

⑬ Last Recorded Fault: Displays the type of and distance to the last fault.

⑭ Target LEDs: Summarizes the front-panel LED status of the SEL relay.

⑮ TARGET RESET: Resets the relay targets. After the relay trips, select this button to reset the front-panel target status (this must be done before the breaker can be closed). This may take a few seconds.

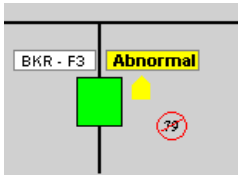

Figure 4.9: Hot Line Tag Indication

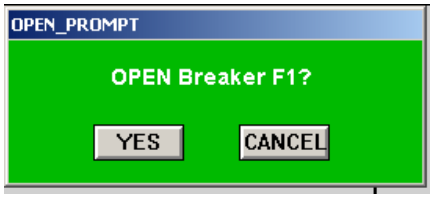

Figure 4.10: Trip Confirmation Window

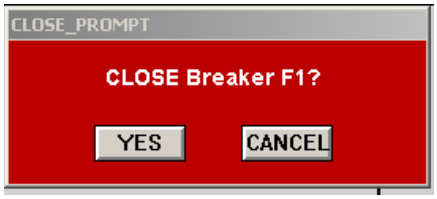

Figure 4.11: Close Confirmation Window

Operational Tags

SEL provides the following standard tags in the SEL-7000:

- Hot line tag
- Hold tag
- Information tag

The functionality of these standard tags is described in the SEL-7000 Application Guide, available at www.selinc.com. These tags are virtual tags that reside in nonvolatile memory of the SEL relays. They represent a complete replacement of a paper-tagging system used by many utilities today.

When you apply a hot line, hold, or information tag, you are prompted for a comment. The tag information plus your comment is written to a file called OperationTags.mdb (Microsoft® Access database file). When one of these tags is removed from the HMI, the tag record is modified to include the current date, time, and user when the tag was removed.

The following information will be logged for each of these tags:

- Tag type
- Substation
- Feeder
- Date and time applied
- Logged-on operator when applied
- Comment
- Date and time removed
- Logged-on operator when tag was removed

It is important to note that operational tags in the SEL-7000 are maintained in the SEL-351S or SEL-421 associated with the piece of equipment being locked out. The tags are maintained as nonvolatile latches, meaning that the state of these tags is not lost during power loss. A significant advantage of having tagging reside in the relay is it gives us the ability to prevent operations. This provides a safe and cost-effective method for replacing a paper-tagging system.

The following forms of operation tags are included in this system:

- **Hot Line Tag:** This tag disables reclose functions in the SEL relays and blocks **CLOSE** commands from the remote SCADA system and the local HMI. The relay recloser goes to lockout if this tag is enabled. Tag information is collected when the tag is set. You can add further comments to this field when the tag is removed.
- **Hold Tag:** A hold tag is a clearance tag that indicates that equipment is de-energized and isolated for personal safety. This tag disables all close functions. Tag information is collected when the tag is set. You can add further comments to this field when the tag is removed.
- **Information Tag:** This tag is for archiving comments associated with a breaker. Tag information is set whenever you make or add comments.

Substation	Type	wwTagName	RemovedBy	Equipment	DateTimeRemoved	DateTimeApplied	Comment	AppliedBy	Active
SEL1	HOT LINE TAG	SEL1_F1_1_P9_Hot		F1		11/11/2002 6:19:31 PM	None	eos	Yes
SEL1	HOLD TAG	SEL1_F1_1_P9_Hold		F1		11/11/2002 6:19:40 PM	None	eos	Yes
SEL1	INFORMATION TAG	SEL1_F1_1_P9_Info	eos	F1	11/11/2002 6:40:32 PM	11/11/2002 6:40:24 PM	None	eos	No

Figure 4.12: Sample of OperationTags.mdb File

Figure 4.12 shows a sample of the file OperationTags.mdb. This file can be viewed with Microsoft Access. The contents of each column are described in Table 4.4.

Table 4.4: OperationTags.mdb File Column Descriptions

Column Heading	Description
Substation	Name of the substation.
Type	Type of applied tag (hot line, hold, or information).
wwTagName	Discrete point read into Wonderware® indicating status of tag.
RemovedBy	User logged on when the hot line, hold, or information tag was removed.
Equipment	Two-character description of the piece of equipment affected. In this case, it is either F1, F2, F3, F4, TH, TL, H1, or H2.

DateTimeRemoved	Date and time that a hot line or hold tag was removed.
DateTimeApplied	Date and time that an information, hot line, or hold tag was applied.
Comment	Comment entered by the user when the hot line, hold, or information tag was created. This is also modified when any of these tags are removed.
AppliedBy	User logged on when the hot line or hold tag was applied.
Active	**Yes** appears when the tag is active; **No** appears when the tag is inactive.

Tags can be applied from the front panel of the relays or via SCADA, as per the customer's requirements.

To apply and remove a tag from the relay front panel, the front panel must first be enabled by a loss of communication to the HMI PC, then by unlocking the front panel. Once the front panel is unlocked, you can apply or remove a tag. SCADA can apply or remove a tag at any time.

NOTE: If a tag is applied or removed from the system via the relay front panel or by SCADA, the tag database will not be accurately updated.

Relay Target Screen

Click the **Targets** button on the header bar to open the **Relay Target** screen. All front-panel LEDs are mimicked on the **Relay Target** screen, as shown in Figure 4.13.

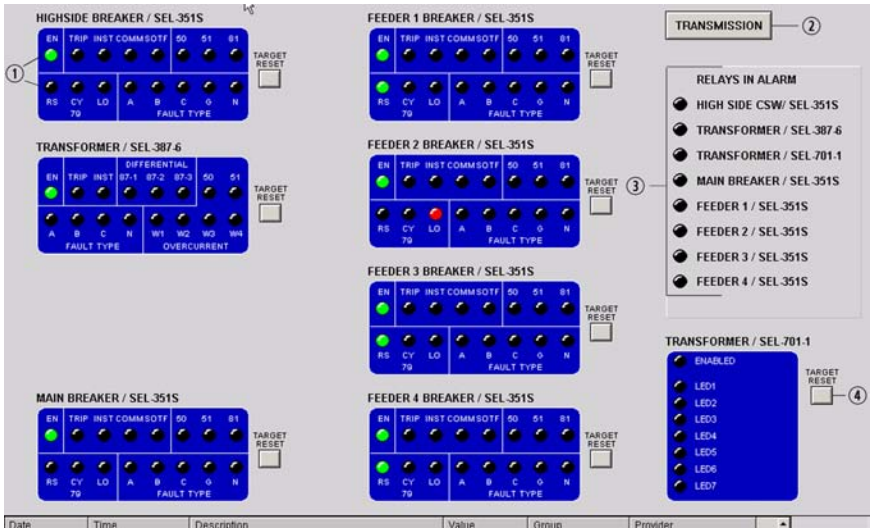

Figure 4.13: Feeder and Transformer Relay Targets

① **LEDs:** Duplicates the LEDs on the front panel of each relay in the substation. The LEDs for the SEL-351S-6 are described in Table 4.5.

② **TRANSMISSION:** Accesses the Transmission Target screen, which contains targets for the two SEL-421-1 Relays, the SEL-311B, and the SEL-311L.

③ **RELAYS IN ALARM:** The red LEDs in this section indicate watchdog timers or communication links that have failed on the relay. A watchdog failure indicates a relay that is completely nonfunctional. This is monitored by the communications processor inputs hardwired to the relays.

④ **TARGET RESET:** Resets the relay targets.

Table 4.5: SEL-351S-6 Relay Front-Panel LEDs

LED Label	Description
EN	On when the unit is powered up and operating properly
TRIP	Indicates that a trip has occurred
INST	Instantaneous trip
COMM	Communications-assisted trip
SOTF	Switch-onto-fault trip
50	Trip generated by instantaneous/definite-time overcurrent element
51	Trip generated by time-overcurrent element
81	Trip generated by frequency element
A	Phase A involved in trip
B	Phase B involved in trip
C	Phase C involved in trip
G	Ground involved in trip
N	Trip generated by neutral ground element
RS	Recloser in reset state; the relay is ready to start another reclose cycle
CY	Recloser in cycle state; the relay is waiting on timer to reclose breaker
LO	Recloser in lockout state; reclosing is disabled

NOTE: The LED functionality itemized in Table 4.5 is the default provided from the factory. Many of these LEDs are configurable; therefore, proper coordination between the HMI and the relay settings is strongly recommended.

Alarm Screens

Three screens in the HMI application detail alarms: the **Alarm Bar**, the **Active Alarms** screen, and the **Historical Alarms** screen.

The **Alarm Bar** (shown in Figure 4.14) is always at the bottom of the screen. It displays the last four unacknowledged alarms. The **ACK** button acknowledges all four alarms shown on the **Alarm Bar** and then displays the next four, if they exist.

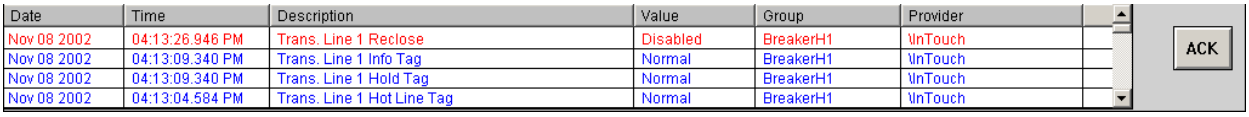

Figure 4.14: Alarm Bar

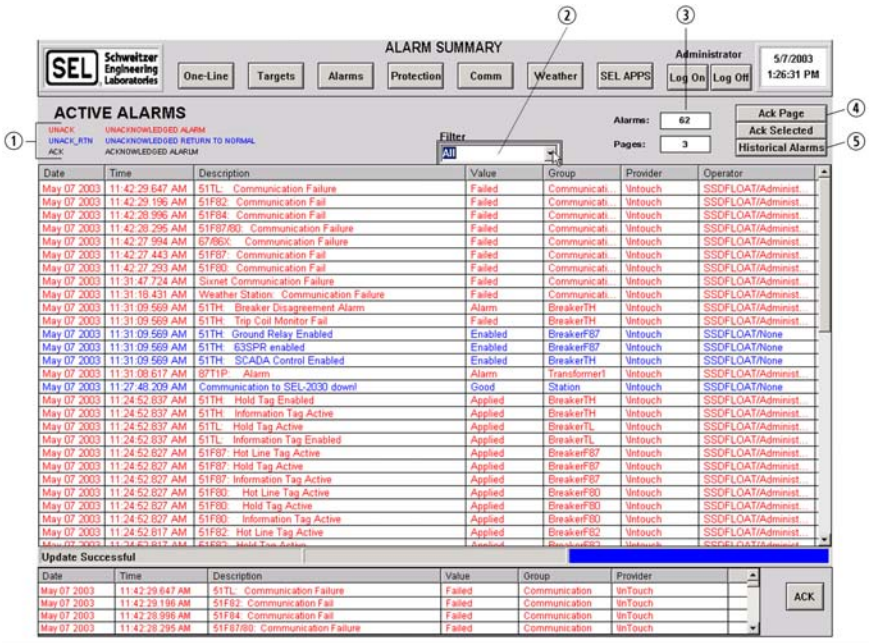

Figure 4.15: Alarm Summary Screen

① Active Alarm Key: Red entries are unacknowledged and active alarms. Blue entries are alarms that have returned to normal but have not been acknowledged. Black entries are alarms that have been acknowledged but are still active. Acknowledged alarms that have returned to normal will disappear from the Active Alarms screen.

② Filter: This drop-down menu allows you to view alarms from individual breakers or the transformer. It also allows you to see all alarms for the substation (All).

③ Alarms and Pages: These fields show the number of alarms and the number of pages of alarms on the current display.

④ Acknowledge Buttons: The Ack Page button allows you to acknowledge all alarms displayed on the current page. The Ack Selected button allows you to acknowledge only those alarms that are selected.

⑤ Alarm Screen Select: Allows you to select either the Historical Alarms or Active Alarms screen. The Active Alarms screen displays only those alarms that have not been acknowledged (red and blue). The Historical Alarms screen displays the chronological history of alarms (black, red, blue, and green).

CAUTION: The historical alarm logger creates data files that reside on the panel-mounted PC. With a lot of alarms in a substation, a hard drive may fill up and local HMI applications will stop responding. SCADA alarms are available to indicate that the disk is becoming full.

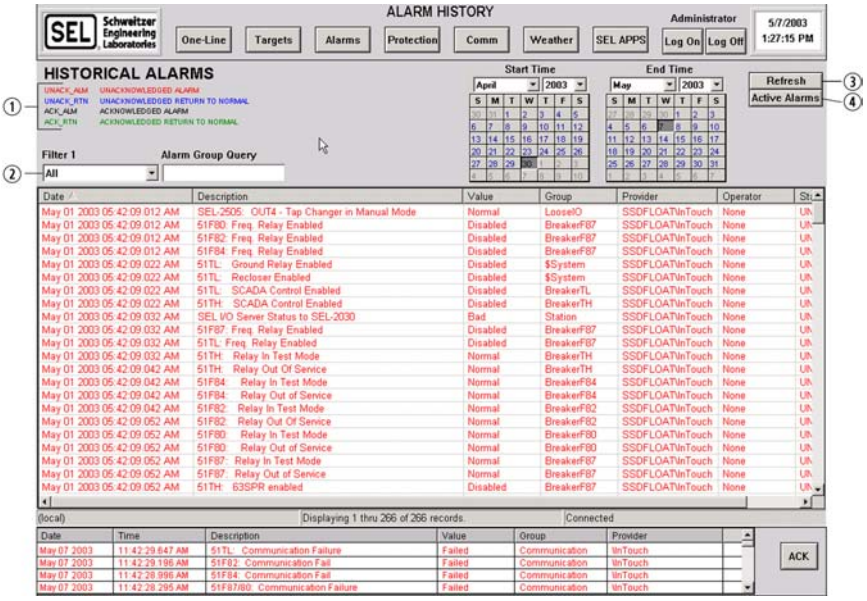

Figure 4.16: Alarm History Screen

① Alarm Key**:** Red entries are unacknowledged and active alarms. Blue entries are alarms that have returned to normal but have not been acknowledged. Black entries are alarms that have been acknowledged but are still active. Acknowledged alarms that have returned to normal are green entries in the Historical Alarms screen.

② Filter**:** This drop-down menu allows you to view alarms from individual breakers or the transformer. It also allows you see all alarms for the substation (All).

③ Refresh**:** This button refreshes the screen. Sometimes this is necessary after first viewing the Historical Alarms screen.

④ Alarm Screen Select**:** This button allows you to select between the Historical Alarms or Active Alarms screen. The Active Alarms screen displays only those alarms that have not been acknowledged (red and blue). The Historical Alarms screen displays the chronological history of alarms (black, red, blue, and green).

NOTE: The HMI alarm functionality is not time synchronized with the IRIG-B time signal in the relays. A true Sequence of Events (SOE) logger is available as an option.

Protection Screen

Click the **Protection** button on the header bar to open the **Protection** screen (shown in Figure 4.17).

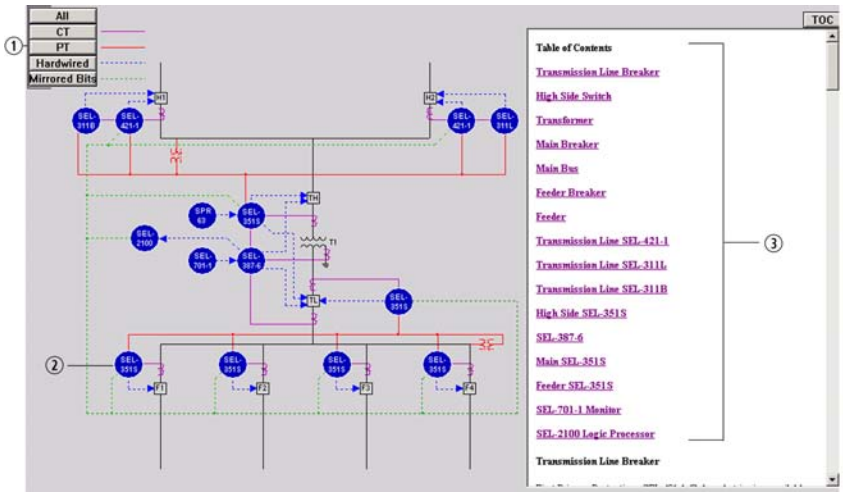

Figure 4.17: Protection Screen

① Toggle Wiring Buttons: These buttons toggle on/off the CT (current transformer), PT (potential transformer), trip and close wiring (hardwired), and MIRRORED BITS communications paths.

② Protective Relay Symbol: Clicking this symbol sends the ProtectionOverview.htm document to the location where this relay is described. This object turns red if the relay trip LED is on; otherwise, it is blue.

③ Protection Document: This section is a display of the ProtectionOverview.htm document. This document is specifically for important notes relating to the protection and automation of this substation. You are highly encouraged to customize this document to describe the protection scheme in the substation.

Communications Overview Screen

Click the **Comm** button on the header bar to open the **Communications Overview** screen for the HMI (Figure 4.18).

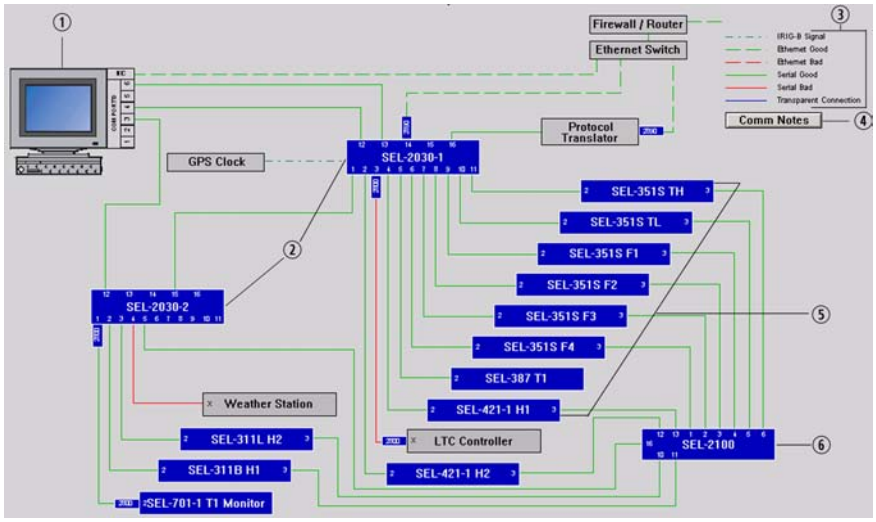

Figure 4.18: Communications Overview Screen

① PC: This icon represents the PC, the serial ports, and the Ethernet network interface card (NIC).

② SEL-2030: Clicking the SEL-2030 icon opens a status screen, as shown in Figure 4.19. This screen shows the status of the 16 serial ports, 16 inputs, 4 outputs, and SEL-2032 communication status. In new versions of the SEL-7000, the SEL-2030 is replaced with an SEL-2032.

③ Communications Status Legend: The status of each communications link is represented by its color. Green means communication is normal, red means the communications link is not functioning, and blue means that a serial port is transparently connected. For example, the SEL-5010 uses a transparent connection to download configurations to relays.

④ Comm Notes: This button shows or hides the display of communication notes for this screen. These notes detail the communications protocol used between each device.

⑤ Relay Icons: Clicking one of the relay icons opens a status screen like that shown in Figure 4.21. This figure shows the status of all inputs, outputs, alarms, and port communications.

⑥ SEL-2100: Clicking the SEL-2100 icon opens a status screen, as shown in Figure 4.20. This screen shows the status of the 16 serial ports, 16 inputs, 4 outputs, and MIRRORED BITS communications status.

Status Screens

Status screens are available for each SEL Intelligent Electronic Device (IED) on the **Communications Overview** screen. Figure 4.19, Figure 4.20, and Figure 4.21 are some examples of available status screens. More status screens are available.

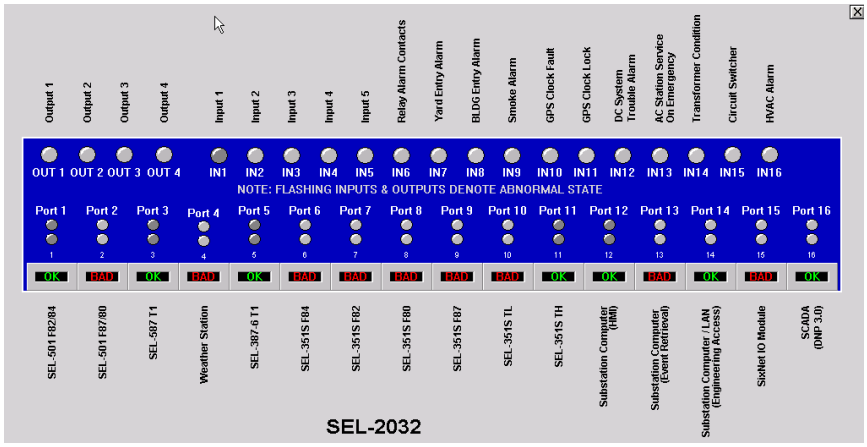

Figure 4.19: SEL-2032 Status

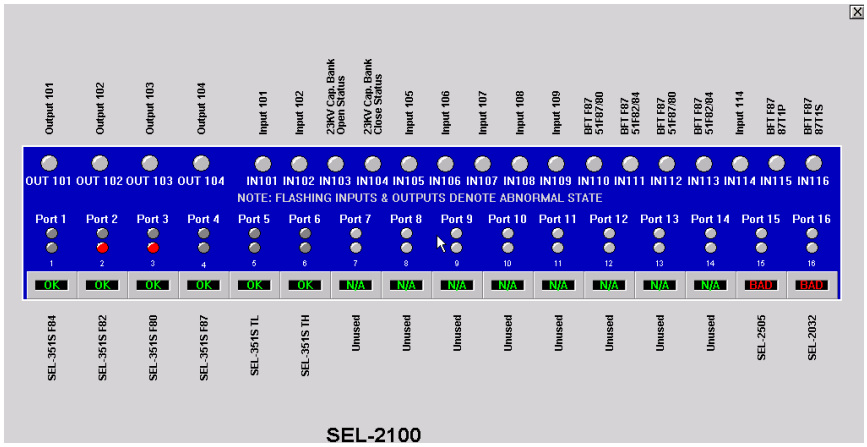

Figure 4.20: SEL-2100 Status

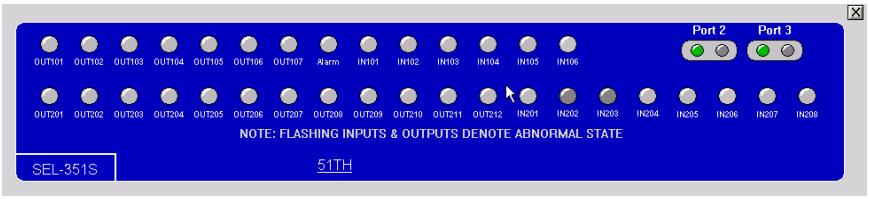

Figure 4.21: SEL Relay Status

Weather Station Screen

Click the **Weather** button on the header bar to open the **Weather Station** screen (Figure 4.22). This screen shows the data from the Davis Weather Monitor II used in the SEL-7000.

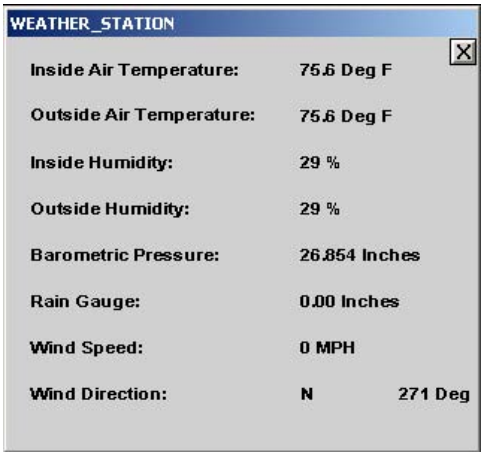

Figure 4.22: Weather Station Screen

SEL Applications

Selecting the **SEL APPS** button on the header bar provides a shortcut to many useful SEL applications, as shown in Figure 4.23. All of these software packages come standard with the SEL-7000.

Figure 4.23: SEL Applications Available From the HMI

Table 4.6: Options Available on the SEL APPS Menu

Option	Description
SEL-5010	This application manages the settings for all SEL relays in the SEL-7000. See *Section 5: SEL-5010 Relay Assistant* for more details.
SEL-5020	This application manages the settings for the SEL-2020, SEL-2030, or SEL-2032 Communications Processors. See *Section 6: SEL-5020 Settings Assistant* for details.
SEL-5030	This application can manage the settings for some of the SEL relays. All of the SEL-7000 relay settings can be provided in this format, except for the SEL-387 relays. See S*ection 7: ACSELERATOR SEL-5030 Software* for details.
SEL-5040	This application manages the event reports for all the relays in the SEL-7000. See *Section 8: SEL-5040 Power System Report Manager* for details.

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Section 5: SEL-5010 Relay Assistant

Introduction

The settings for each relay in the SEL-7000 are stored in an SEL-5010 Relay Assistant settings database. The SEL-7000 comes with the **Connection Directory** and the relay setting schemes already configured.

The following process summarizes the steps typically used with the SEL-5010 to configure an SEL relay.

SEL provides many automation and protection settings for the SEL relays in the SEL-7000. The end user is responsible for many user-specific protection-related settings in each of these relays. Perform the following steps to make user-specific settings:

Step 1. Create a setting scheme for each relay under **Manage Relay Settings**. Ensure that the type of relay selected in the SEL-5010 exactly matches the actual relays.

Step 2. Create an entry for each SEL relay in the **Connection Directory**.

a. Organize the entries by area, substation, and equipment.

b. Associate each connection entry with a relay setting scheme (this is done in the **Connection Directory** under the **Relay Settings** button).

Step 3. Enter your protection and automation settings into all relay setting schemes (see *Edit Relay Settings on page 5.7*).

Step 4. Connect to each individual relay and download all settings from your setting scheme (see *Send Settings to Relay on page 5.8*).

Step 5. Print setting schemes for further documentation (see *Database Reports on page 5.5*).

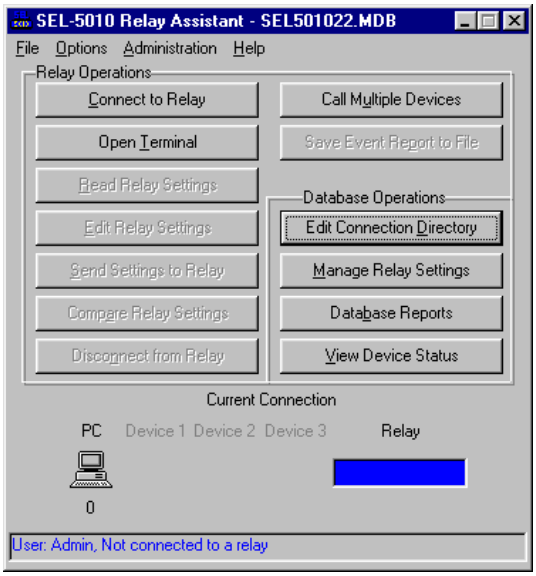

Figure 5.1: SEL-5010 Relay Assistant Main Form

Manage Relay Settings

From the main form (Figure 5.1), select the **Manage Relay Settings** button. The **Manage Relay Setting Schemes** form opens, as illustrated in Figure 5.2. The options available on this form are described in Table 5.1.

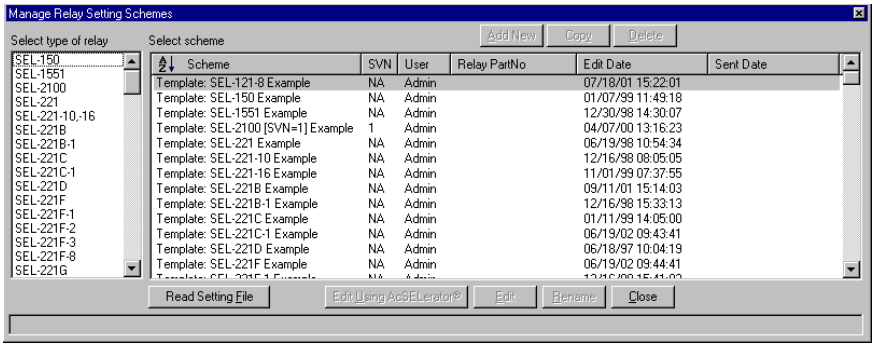

Figure 5.2: Manage Relay Setting Schemes Form

Table 5.1: Options on the Manage Relay Setting Schemes Form

Option	Description
Select type of relay	Displays the types of relay. After the relay type is selected, the associated setting schemes appear in the **Select scheme** list.
Select scheme	Lists the setting schemes associated with relay types. Once a setting scheme is selected, you can edit, copy, rename, or delete the scheme.
Add New	Creates a new empty setting scheme for the selected relay type. This requires that at least one setting scheme exist for the relay type.
Copy	Copies the selected scheme to a new scheme, and then opens the setting editor.

Delete	Deletes the selected scheme from the database.
Read Setting File	Reads the relay settings from a setting text file. Select a relay type from the first list box then click this button.
Edit Using ACSELERATOR®	Allows you to edit a setting scheme using the ACSELERATOR® SEL-5030 software, if supported (see *Section 7: ACSELERATOR SEL-5030 Software* for more information.
Edit	Opens a selected scheme in **Edit** mode. Double-clicking a scheme opens a view-only mode for the selected scheme.
Rename	Allows you to rename a selected setting scheme.

Edit Connection Directory

Click the **Edit Connection Directory** button on the SEL-5010 main form to open the **Connection Directory** screen shown in Figure 5.3. This directory allows you to associate connection records with relay setting schemes.

The SEL-7000 comes with a preconfigured **Connection Directory** for all of the SEL relays.

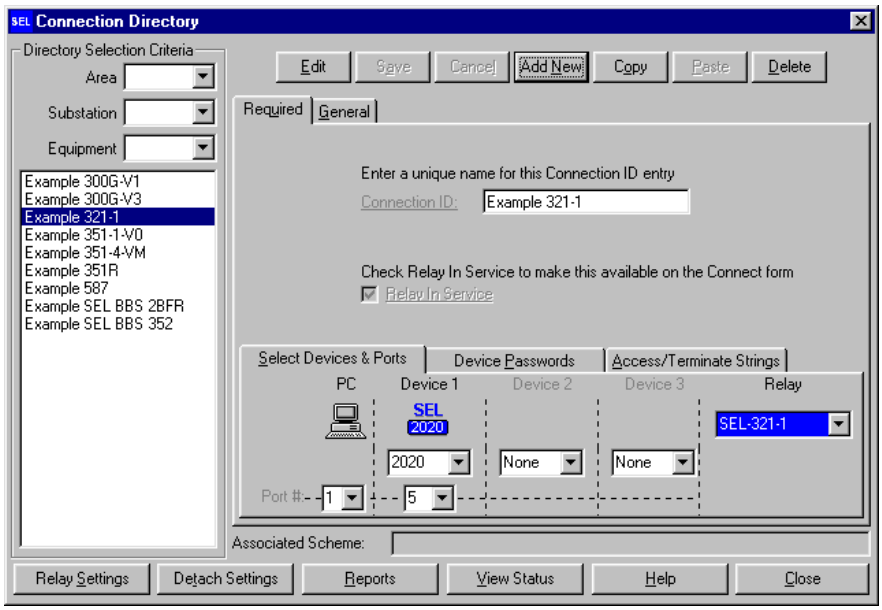

Figure 5.3: Connection Directory

Table 5.2: Options on the Connection Directory Form

Option	Description
Directory Selection Criteria	The **Directory Selection Criteria** at the left of the form narrows the database connection records displayed based on the selected criteria. **NOTE:** You can change selection criteria categories (**Area**, **Substation**, and **Equipment**) by selecting **Options > Program Options** from the main form.
Edit	Edits connection information.

Save	Saves the currently selected **Connection Directory** entry.
Cancel	Ends the edits and closes the **Connection Directory** entry.
Add New	Creates a new **Connection Directory** entry.
Copy	Copies the selected **Connection Directory** entry. Use this with the **Paste** button.
Paste	Creates a new **Connection Directory**. Use this after copying a directory with the **Copy** button.
Delete	Removes the current **Connection Directory** entry.
Required	This setting tab allows you to uniquely define a connection and set up the communication connections to a relay or other IED through intermediate devices.
Connection ID	This tag displays the ID of an existing connection. If you edit an existing connection and change the Connection ID, the SEL-5010 will add a new connection with this ID.
Relay in Service	This check box indicates if the relay is in service. This must be checked for the **Connection Directory** entry to be available to nonadministrator users on the **Connect to a Relay** form.
Relay Settings	Opens the **Edit Setting Scheme** form showing the associated scheme for the selected **Connection Directory** entry. This screen allows you to associate a setting scheme with the selected connection record. You can then edit and update settings in the database.
Detach Settings	Breaks the association with a setting scheme for a selected **Connection Directory** entry. However, the setting scheme will still be in the database. Select **Administration > Cleanup Setting Schemes** or the **Manage Relay Setting Schemes** button on the main form to actually remove the scheme from the SEL-5010 database. To associate a different setting scheme with the **Connection Directory** entry, first detach the current setting scheme association and then click the **Edit** button to associate new settings with the **Connection Directory** entry.
Reports	Opens the **SEL-5010 Database Reports** form. Use this form to print database reports.
View Status	Opens the **Device Status** form to display the current connection status.
Help	Provides help information on the **Connection Directory**.
Close	Closes the **Connection Directory**.

Select Devices & Ports Tab

The **Select Devices & Ports** tab defines the connection path to the SEL relay.

For the PC, the options are COM Ports 1 through 11 or Telnet. If a Telnet connection is used, the IP address of the first device must be entered.

For Device 1, 2, and 3, the options are **SEL-2020**, **SEL-PRTU**, **Modem**, **Other**, and **None**. Select **SEL-2020** if you are using any SEL communications processor. If **Modem** is selected, a field is displayed for the phone number.

Device Passwords Tab

The **Device Passwords** tab selects remote device passwords. This box is disabled for non-SEL devices.

Access/Terminate Strings Tab

The **Access/Terminate Strings** tab allows you to define the remote access strings for devices. For communications processors and modem devices, the access strings are created for you. Access strings for **Other** devices must be entered.

The access string contains the device commands used to establish the connection. The following key words are recognized by the SEL-5010 and can be used with access/termination strings.

<CR> = carriage return + line feed

<W*n*> = wait *n* seconds (not case sensitive); if *n* is not specified, the wait after sending a command is 10 seconds.

^A–^Z = <Ctrl+A> through <Ctrl+Z> control codes (case sensitive)

nnn = replaces hex value (*nnn*) with a control code; example \004 is a <Ctrl+D>.

Database Reports

From the main form, select the **Database Reports** button. The **SEL-5010 Database Reports** form opens, as illustrated in Figure 5.4.

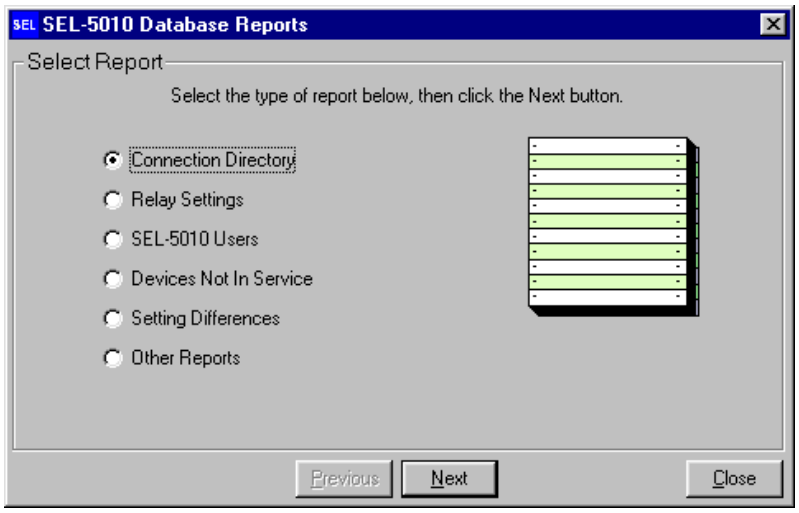

Figure 5.4: Database Reports Form

Table 5.3: Options on the Database Reports Form

Option	Description
Connection Directory	Generates a report of the Connection Directory ID(s), including **Area**, **Substation**, **Equipment**, **Relay type**, and **In Service** options.
Relay Settings	Generates a report of the setting schemes for the relays in the SEL-5010 database.
SEL-5010 Users	Generates a report of the users in the SEL-5010 database and includes the **User Group**, the latest communications settings, and the last connection used.
Devices Not In Service	Generates a report of all devices not in service.
Setting Differences	Generates a report of any differences found between the relay settings.
Other Reports	Generates a report with user-created reports. You can generate your own reports by using Crystal Reports v 4.5. It may be easiest to produce your own reports by copying an existing report and editing it as desired.

View Device Status Button

The **View Device Status** button on the main form displays the current status of the relay (Figure 5.5). The **Device Status Result** tab displays updated results only after the **Call Multiple Devices** feature has been run. Data must be requested (see *Call Multiple Devices Form—Commands*) and saved in the database to be displayed on this form.

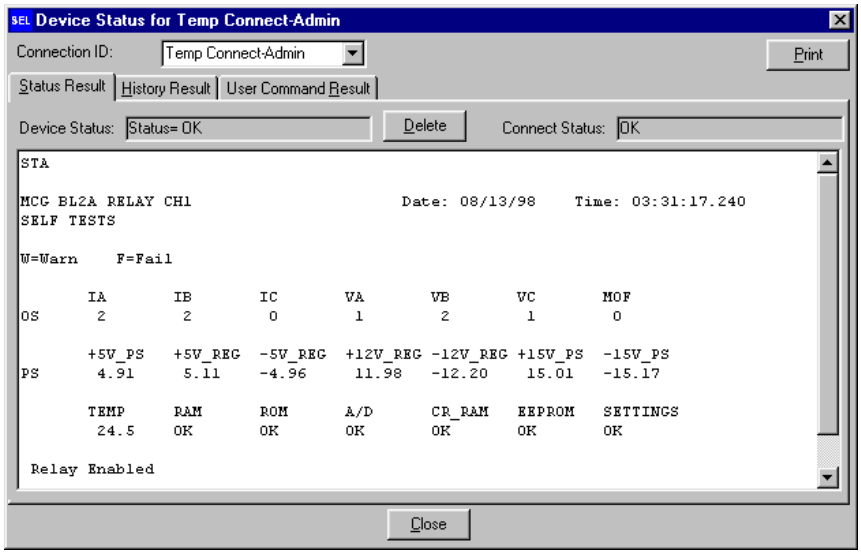

Figure 5.5: Device Status Results Tab

Table 5.4: Options on the Device Status Results Tab

Option	Description
Status Result	Selecting this tab is equivalent to entering the **STATUS** command while connected to the relay. This displays the status of the connected relay.
History Result	Selecting this tab is equivalent to entering the **HISTORY** command while connected to the relay. This displays the event history of the connected relay.
User Command Result	Selecting this tab displays the user-specified command results.

Edit Relay Settings

From the main form, click the **Edit Relay Settings** button to open the **Edit Setting Scheme** form, which is shown in Figure 5.6.

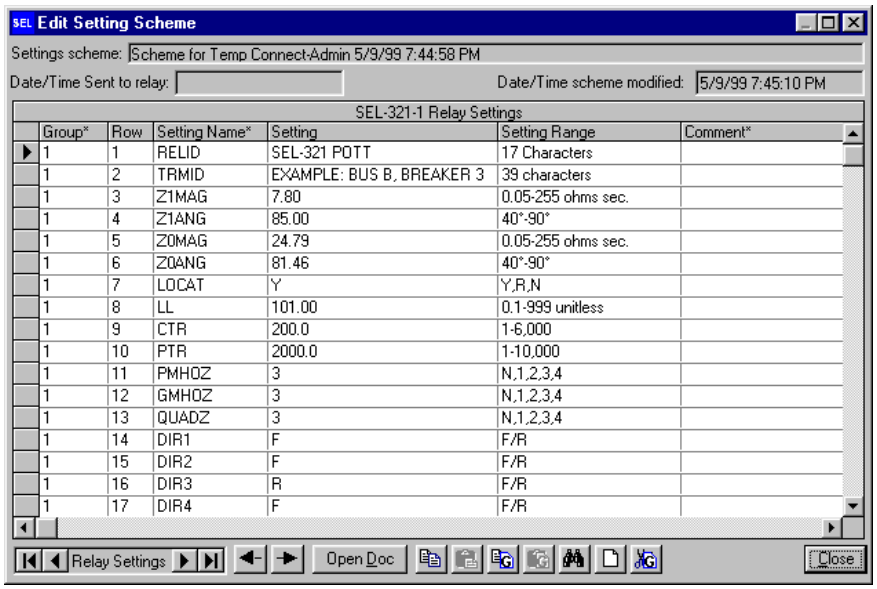

Figure 5.6: Edit Setting Scheme Form

Table 5.5: Options on the Edit Setting Scheme Form

Option	Description
Settings scheme	Displays the selected setting scheme name.
Date/Time Sent to relay	Displays the date and time the settings were sent to the relay. This field is empty if the settings were not sent using the SEL-5010. If the settings were in the relay before the SEL-5010 was put into service, an administrator may edit this field with the correct date and time.
Date/Time scheme modified	Displays the last time the setting scheme was modified with the SEL-5010.

Open Doc	Opens the **Settings Document** form. For the selected setting scheme, any document can be attached, such as application guides, instructional notes, or diagrams.
Group	Displays the setting group in the relay. For relays with only one setting group, this value is 0. Global settings are specified with G. Logic settings are specified with L*x*, where the *x* is the group number. Port settings are specified with P*x*, where the *x* is the port number. Text settings are specified with T. Sequential Event Report settings are specified with R.
Row	Displays the row in the grid display. This is also part of the index used by the database.
Setting Name	Displays the setting name as used in the relay.
Setting Range	Displays the range for the setting. This is a text description. If the setting is a numerical value, the minimum and maximum values may be specified and the SEL-5010 will allow only settings within those values. If the range is *n* chars, the length of the setting will be limited to *n* characters. Administrative users may adjust the setting range to a more strict range if desired.

Send Settings to Relay

Choose the **Send Settings to the Relay** button from the main form to send the settings to the connected relay (see Figure 5.7). After the settings have been sent, the relay settings are verified against the settings in the SEL-5010 database.

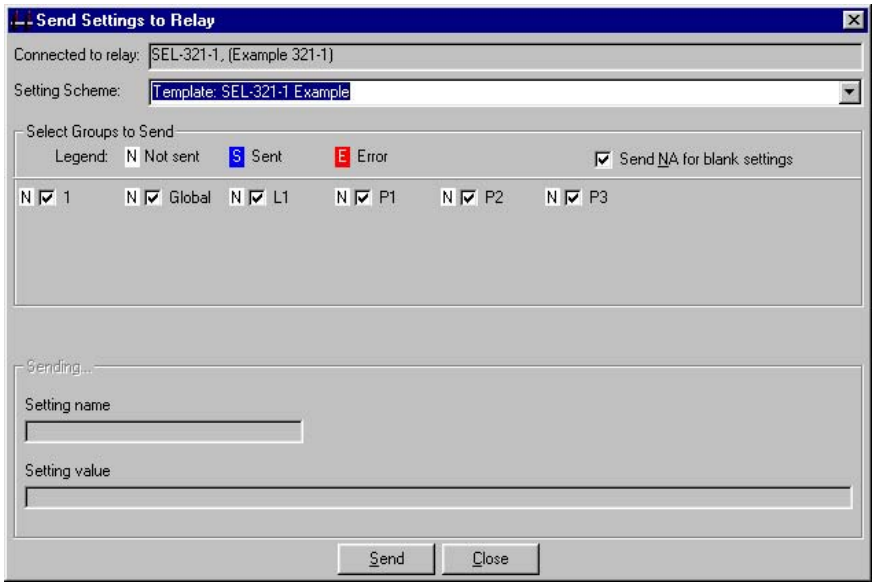

Figure 5.7: Send Settings to Relay Form

Table 5.6: Options on the Send Settings to Relay Form

Option	Description
Connected to relay	Displays the type of relay the SEL-5010 is communicating with and the **Connection Directory ID** label.
Setting Scheme	Displays the currently selected setting scheme name that is to be sent to the relay.
Select Groups to Send	These options allow you to select the setting groups to send to the relay. By default, all of the available groups are selected when the form is opened.
Send NA for blank settings	This check box is checked by default. When it is checked, any blank settings will be sent as NA. For some settings, this effectively turns off the setting. For others, it may result in an Out of Range error. If you get an Out of Range error, either change the setting to something valid or uncheck this option.
Sending …	These fields show the settings as they are sent to the relay.
Send	Sends the settings to the relay. After the settings have been sent, the relay settings are verified against the setting scheme in the SEL-5010. If a relay setting cannot be found in the SEL-5010 database or the relay cannot accept a value, the **Manual Input** form will open and prompt you for the setting value. This value is then stored in the database.
Cancel	Terminates an operation. Clicking the **Cancel** button during the **Send Settings** operation will terminate the operation without saving settings in the relay. Administrative users can right-click the form to open a context menu. Select the **Terminal** menu item to open the **Terminal** form.

Connect to Relay Screen

From the main form, select the **Connect to Relay** button to open the screen shown in Figure 5.8. This screen allows you to select relays, configure the PC serial port, configure modem settings, modify the connection path to the relay, and monitor the status of the connection to the relay.

To connect to a relay in the SEL-7000, select the scheme from the list and click the **Connect** button. The SEL-5010 **Connection Directory** is preconfigured and no modification to the serial port settings is required.

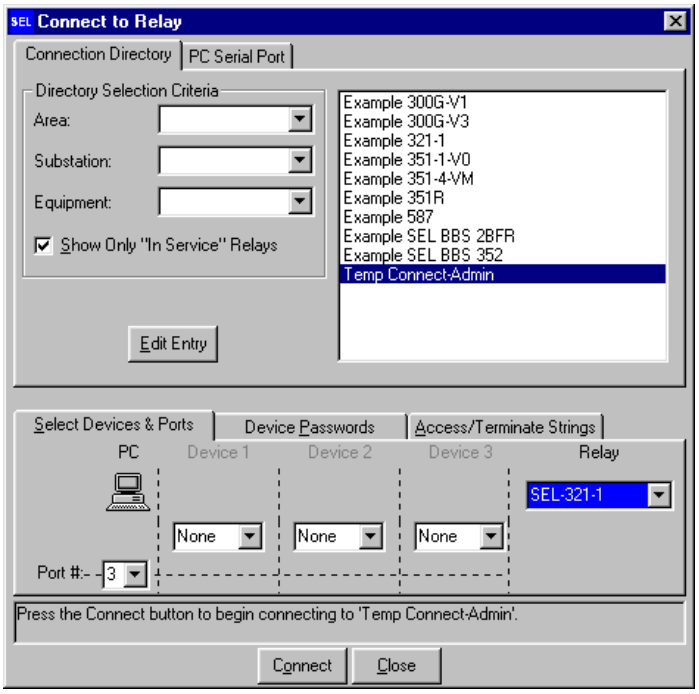

Figure 5.8: Connect to Relay Screen—Connection Directory Tab

Table 5.7: Options on the Connect to Relay Screen

Option	Description
Modem and Non-Modem Ports	If the first remote device is a modem, it is necessary to inform the SEL-5010 about this device. Once you do this, it will continue using the same modem and port selections each time you connect through a modem. On the **Connect to Relay** form, select the **PC Serial Port** tab. Then click the **Modem** button. This opens a new dialog where you must specify the type of modem and its port characteristics.
Directory Selection Criteria	These options allow you to select the **Area**, **Substation**, and **Equipment** and narrow down the directory entries in the list box. If no selections are made, all of the available entries will be shown in the list box. Double-clicking an entry in the list box, or picking the entry from the list box and clicking the **Connect** button will start the connection process.
Edit Entry	Opens the **Connection Directory** form, allowing you to edit the **Connection Directory** entry.
Show Only "In Service" Relays	For administrators only. Only in-service relays are displayed if this option is selected.

Context Menu	Right-clicking a highlighted item inside the **Connection Directory** list box will open the context menu with the following selections: **Show Directory Information**: Displays the **Area**, **Substation**, **Protection**, and **Equipment** information about the **Connection Directory** entry. **Edit Connection Directory**: Opens the **Connection Directory** form with the currently selected record. This is the same action as clicking the **Edit Entry** button. **Connect to Relay**: Connects the relay specified by the selected **Connection Directory** entry. This is the same action as clicking the **Connect** button after selecting a **Connection Directory** entry.
Select Devices & Ports	Opens the table for making remote connection device and port selections. The connection control shows the connection progress as communications are established through the intermediate devices and finally with the relay. The PC port number is shown below the PC graphic. If SEL-2020, SEL-2032, or SEL-PRTU intermediate devices are used, the port number for transparent connection is displayed below the device graphic. **NOTE:** If you select a connection, then change any of the remote device options, these changes are saved in the Temp Connect-*username* record, but not in the connection record associated with the relay settings.
Device Passwords	Allows you to change device passwords.
Access/Terminate Strings	Opens the Access/Terminate Strings for editing.
Close	Closes the form. When you are finished connecting to a relay, close this form and you can then download or upload settings.
PC Serial Port	Allows you to modify the PC serial port settings.

SEL-5010 Main Form

Once you are connected to the relay, the SEL-5010 main form is as shown in Figure 5.9.

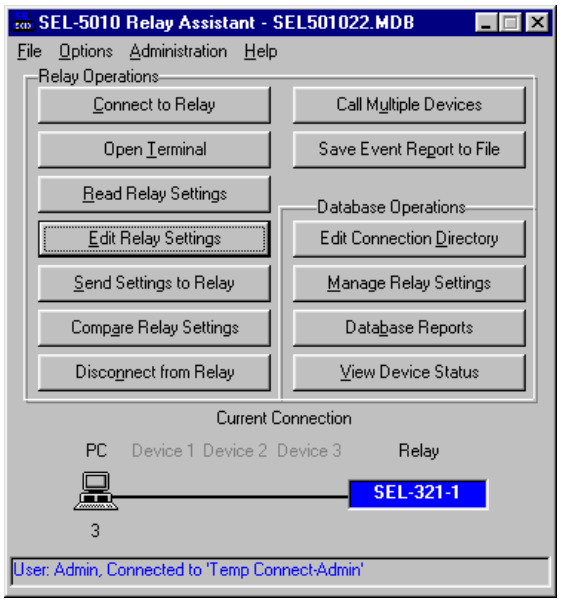

Figure 5.9: SEL-5010 After Connection to an SEL Relay

Terminal Screen

You can access the **Terminal** screen from the main form by clicking the **Open Terminal** button (see Figure 5.1).

All communications are shown in the terminal window. Typing is allowed in the terminal window if the command buttons defined on the **Program Options** form are all enabled for their user group. If any of the command buttons are disabled, the corresponding user group is prohibited from typing commands into the **Terminal** window.

When typing is disabled in the **Terminal** window, several keys are still active. You may use the **<Enter>** key (CR) or enter **Y** or **N** (not case sensitive). If you have not connected to a device, typing in the **Terminal** window will initialize the PC COM port. Provided the baud rate and other settings are correct, you may then use the **Terminal** for general communication purposes.

You can also use the command buttons to issue commands to a relay. The command buttons are not enabled until after successful connection to a relay. The commands are defined using the **Program Options** form.

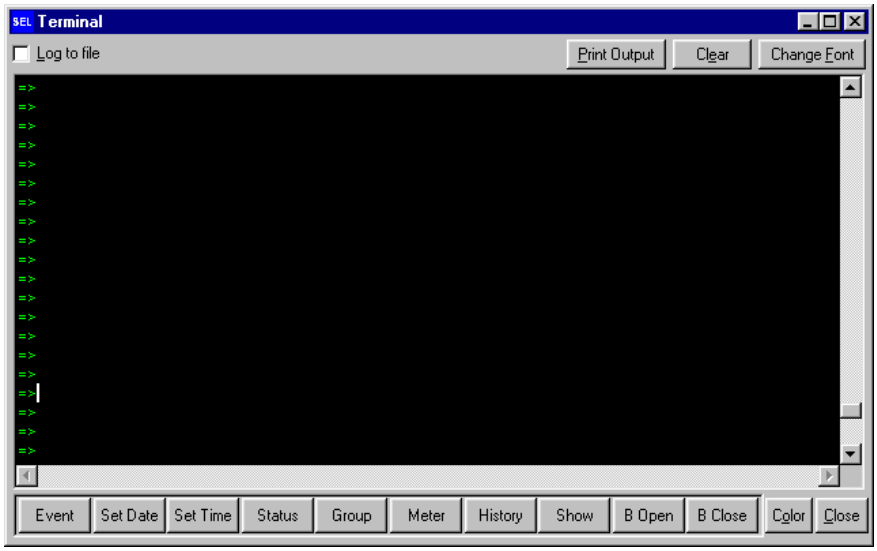

Figure 5.10: Terminal Screen

Table 5.8: Options on the Terminal Screen

Option	Description
Log to file	Logs the **Terminal** text to a file. A dialog will open for the text filename. If an existing file is selected, the **Terminal** text will be appended to this file. Double-click the log filename to view the file.
Print Output	Sends the **Terminal** text to the printer.
Clear	Clears the **Terminal** display.
Change Font	Allows you to change the font and color of the text on the **Terminal**.
Color	Allows you to change the background color of the **Terminal** window.

Read Relay Settings

From the main form, select **Read Relay Settings** (shown in Figure 5.11). Use this form to select the settings to read from the attached device, and to name the setting scheme associated with those settings.

You may either save the settings to an existing scheme (overwrite) or save the settings to a new setting scheme. Select the appropriate option on the form.

If the **Save settings to new scheme** option is selected, the SEL-5010 will create a default setting name. This name can be edited on the form. If you enter a name that already exists, the old scheme will be overwritten.

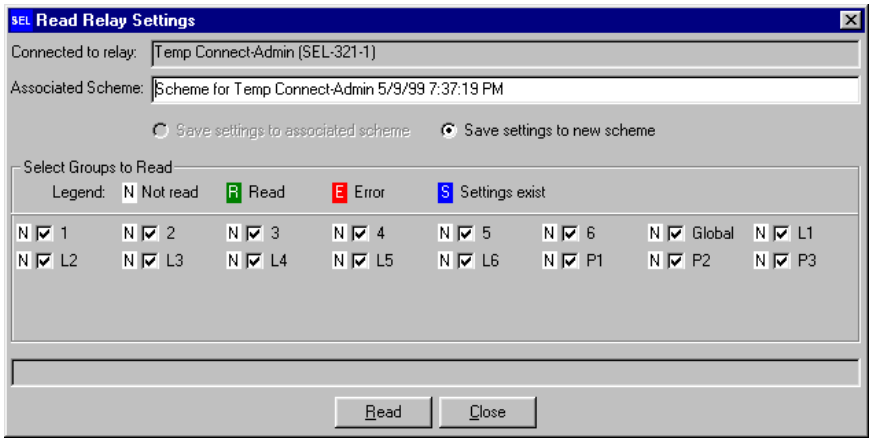

Figure 5.11: Read Relay Settings Form

Compare Relay Settings Form

From the main form, select the **Compare Relay Settings Form** button. Use this form (shown in Figure 5.12) to compare current relay settings with the database values.

The SEL-5010 uses the following process to compare settings between the database and the relay:

1. Establish communications with the relay.

   The SEL-5010 issues a **<CR>** to ensure the relay is responding. If no response is received, it sends the **CAN** character string and commands the relay to cancel any in-process operation.

2. Set the relay to Access Level 1. The SEL-5010 uses the access level passwords defined in the **Connection Directory**.

   The SEL-5010 issues the appropriate **SHOW** command and waits for the relay to complete the transfer of data. The data transfer is considered complete when the relay returns to the Access Level 1 prompt.

   The settings are parsed from the **SHOW** command. Each setting is then compared with the setting in the SEL-5010 database. Differences are saved in the database and displayed on the **Compare Relay Settings** form (see Table 5.9 for a description of the options available on this form).

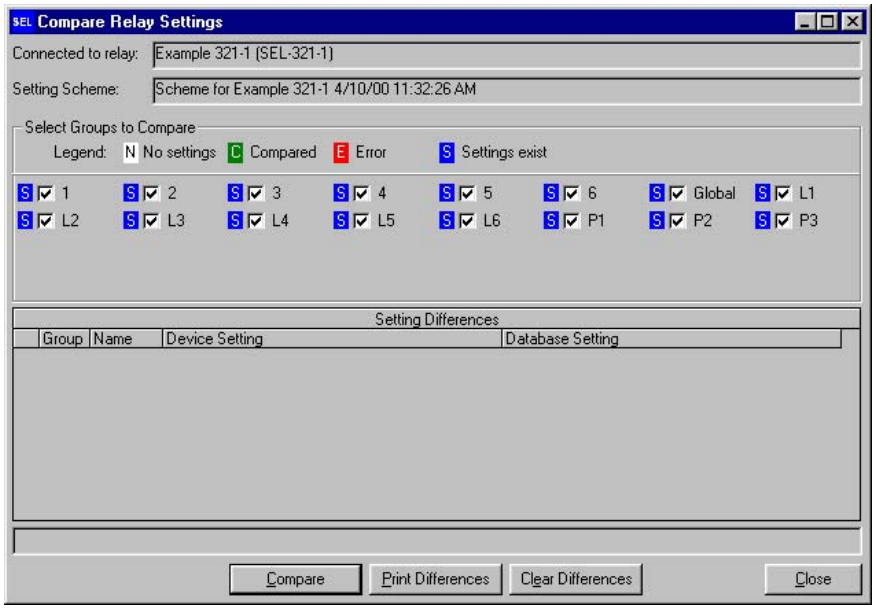

Figure 5.12: Compare Relay Settings Form

Table 5.9: Options on the Compare Relay Settings Form

Option	Description
Connected to relay:	Displays the type of relay with which the SEL-5010 is communicating, the **Connection Directory ID** label, and the connected relay type.
Setting Scheme	Displays the setting scheme name that is currently associated with the connected relay.
Select Groups to Compare	Selects the setting groups to compare to the database. Only groups that have settings will be enabled. Double-click the status character of a check box to set that one and clear all of the others. By default, all of the available groups are selected when the form is opened.
Settings Legend	**N**: No settings are available for comparison for this relay. (Use **Read Relay Settings** to read the settings.) **C**: The compare is finished and no setting differences were found. **E**: The compare is finished and the SEL-5010 found setting differences. **S**: Settings exist for this relay and can be compared to the database.
Setting Differences	Displays all differences the SEL-5010 found between the database and the relay settings.
Group	Displays the specific group where the difference was found.
Name	Displays the name of the setting where the difference was found.
Device Setting	Displays the value the SEL-5010 found while reading the device settings.
Database Setting	Displays the value the SEL-5010 has in its database.
Compare	Starts the process of comparison.

Print Differences	Opens a report listing the setting differences. The report may be printed.
Clear Differences	Deletes the differences from the database for this relay.

Disconnect From the Relay

To disconnect from a relay, click the **Disconnect from Relay** button on the main form. The SEL-5010 will automatically exit from the relay by closing transparent mode with the communications processor.

The SEL-5010 attempts to disconnect from each relay, beginning with the last device. For communications processors, the program issues a **<CR>**, pauses for TERTIME1, sends the TERSTRING, then pauses for TERTIME2. This should break the transparent connection. If it fails to disconnect, the SEL-5010 tries three more times. If the termination string (TERSTRING) is empty, **<Ctrl+D>** is used. The termination times and strings are retrieved from the remote device during the connection process.

When the SEL-5010 is disconnecting from devices of type **Other**, the termination string may contain multiple commands, including control characters and wait times.

Call Multiple Devices

Click the **Call Multiple Devices** button on the main form to get the screen shown in Figure 5.13.

This screen may be used to read the relay settings, issue relay commands, or verify communication with any of the relays in the **Connection Directory**.

The **Device Selection** tab is used to select which **Connection Directory IDs** to connect to during the **Call Multiple Devices** operation. The selections may be filtered using the **Directory Selection Criteria** to limit the display to only the relays of interest to you. You can also create, edit, and delete selection sets from this form.

Reading all of the relay settings is normally done when initially establishing the database. Follow these steps to read all of your relay settings:

Step 1. Edit the **Connection Directory** to identify the relays and any remote devices used to establish the connection.

Step 2. Open the **Call Multiple Devices** form and select all the connections.

Step 3. Click the **Commands** tab, select the **Read setting** option, and check **Save in DB**.

Step 4. Select **Call Now** for the call time.

Step 5. Click **OK** to begin calling each device.

The settings will be named using the connection ID and the date and time the settings were read.

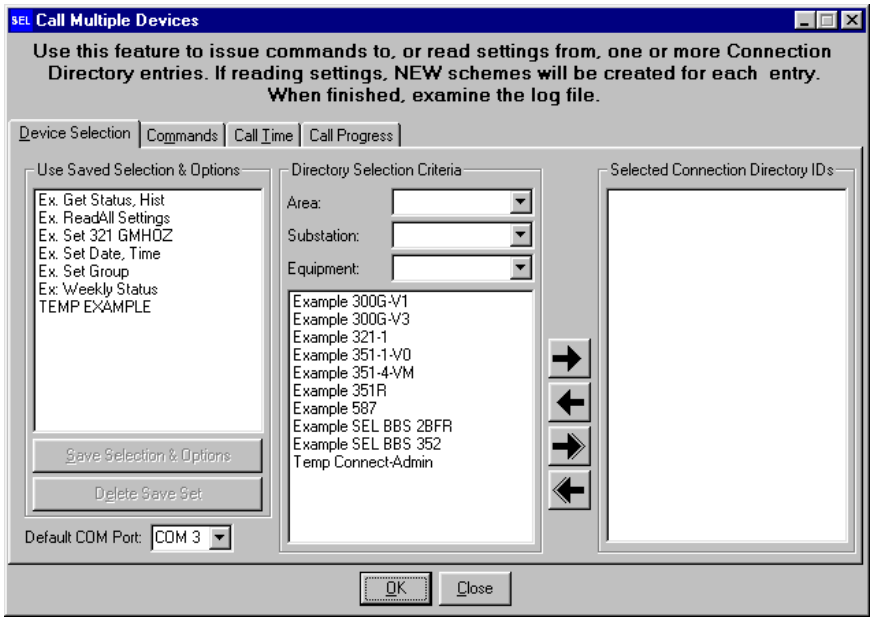

Figure 5.13: Call Multiple Devices Form—Device Selection Tab

Table 5.10: Options on the Call Multiple Devices Form—Device Selection Tab

Option	Description
OK	Starts the **Call Multiple Devices** feature. If the **Call Now** option is selected, the routine will start immediately. If the **Call Later** or **Call Periodically** options are selected, the program will begin calling 10 seconds after the selected date and time.
Save Selection & Options	Saves the currently selected **Connection Directory IDs** and the selected options for the **Call Multiple Devices** routine.
Use Saved Selection & Options	Allows you to select a previously saved selection set (devices and command options).
Delete Save Set	This button is enabled after a set is selected from the list box. Click this button to delete the set from the SEL-5010 database. A verification dialog box will open to confirm the deletion.
Directory Selection Criteria	Lists the available **Connection Directory** entries. These filters narrow the database connection records displayed based on the selected criteria
Selection Arrows	To add an entry to the **Selected Connection Directory IDs** menu, highlight the desired **Connection Directory ID** in the **Directory Selection Criteria** list box and click the right pointing arrow to add the ID(s). To remove an entry, select the **Connection Directory ID** entries in the **Selected Connection Directory IDs** list box and select the left-pointing arrow to remove the ID(s). Press the **<Shift>** or **<Ctrl>** key while clicking to select more than one entry in a list box. To add or remove all entries, click the double-left or double-right arrows.

Selected Connection Directory IDs	Displays all of the currently selected IDs for the multiple device call.
Default COM Port	Determines the default PC COM port when performing the **Call Multiple Devices** actions. If the **Connection Directory** specifies a different port, that port will be used instead of the default.

Call Multiple Devices Form—Commands

Use the **Commands** tab to select command options to be sent to the relays during the **Call Multiple Devices** operation. You can send any combination of relay status, history, read settings, or user-specified commands to the relay(s) during the call.

For example, to match the relay date and time to your PC, use the following commands:

TIME <time><CR><W3>, DATE <date><CR><W3>
(notice there is a space between TIME and <time> and DATE and <date>)

As another example, you can use the following commands to change setting GMHOZ on an SEL-321:

2ac,set 1
GMHOZ<CR><W4>,2<CR><W2>,end<CR><W30>,Y<CR><W5>

To change the active relay group to Group 3 you can use the following commands:

2ac,group 3<CR><w3>,Y<CR><W3>

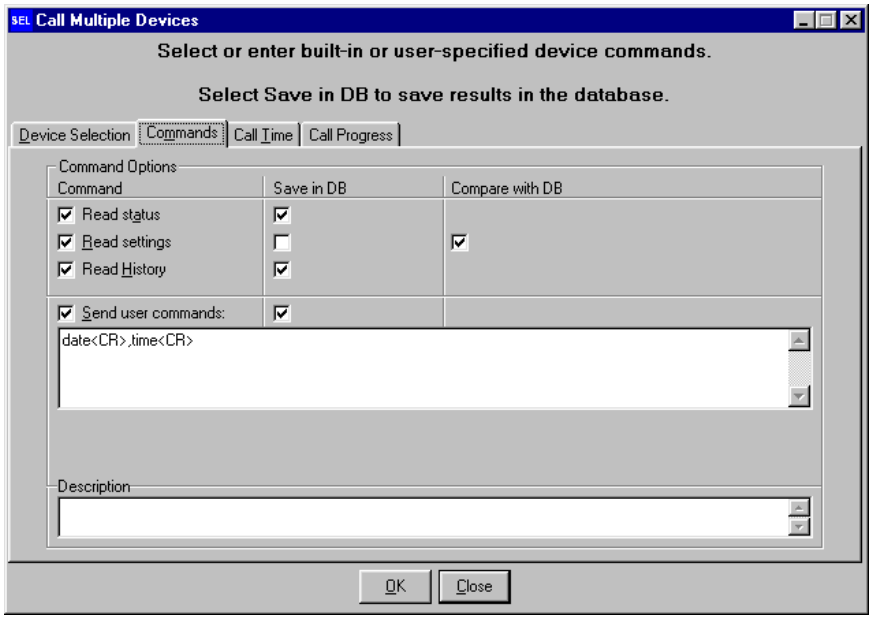

Figure 5.14: Call Multiple Devices Form—Commands Tab

Table 5.11: Options on the Call Multiple Devices Form—Command Tab

Option	Description
Commands	Select the built-in commands to send to the relays during the call operation. The available built in commands are **Read status** (**STA** command), **Read settings** (**SHO** command), or **Read history** (**HIS** command). If no options are selected, the SEL-5010 will connect to each relay to verify communication. You can view the results of all communications with the **View Call Log** form.
Save in DB	Saves the SEL-5010 command responses in the database. By default, the SEL-5010 automatically stores the results from status, history, and user-specified commands into the database. Clicking in the appropriate box and toggling off the check mark can disable this option.
Compare with DB	This is checked by default, so the SEL-5010 will automatically compare relay settings with the database when the **Read Settings** option is selected. You can disable this option by clicking **Save in DB** button or by toggling off **Compare with DB**.

User-Defined Commands

Selecting the **Send user commands** check box allows you to send any relay command. Refer to the relay instruction manual for specific relay commands.

You can send multiple commands by separating each one with a comma or a semi-colon. The following key words are also recognized by the SEL-5010, and can be used with the relay commands:

2AC = login to relay Access Level 2

<CR> = carriage return + line feed
(This character is needed at the end of most command strings for the relay to acknowledge the command.)

<DATE> = inserts system date (not case sensitive)

<TIME> = inserts system time (not case sensitive)

<W*n*> = wait *n* seconds (not case sensitive); if *n* is not specified, the default wait after sending a command is 10 seconds.

^A–^Z = **<Ctrl+A>** through **<Ctrl+Z>** control codes (case sensitive)

nnn = replaces hex value (*nnn*) with control code; example \004 is a **<Ctrl+D>**

Call Multiple Devices—Call Time

The **Call Time** form allows you to configure the SEL-5010 to call devices now, later, or on a periodic basis.

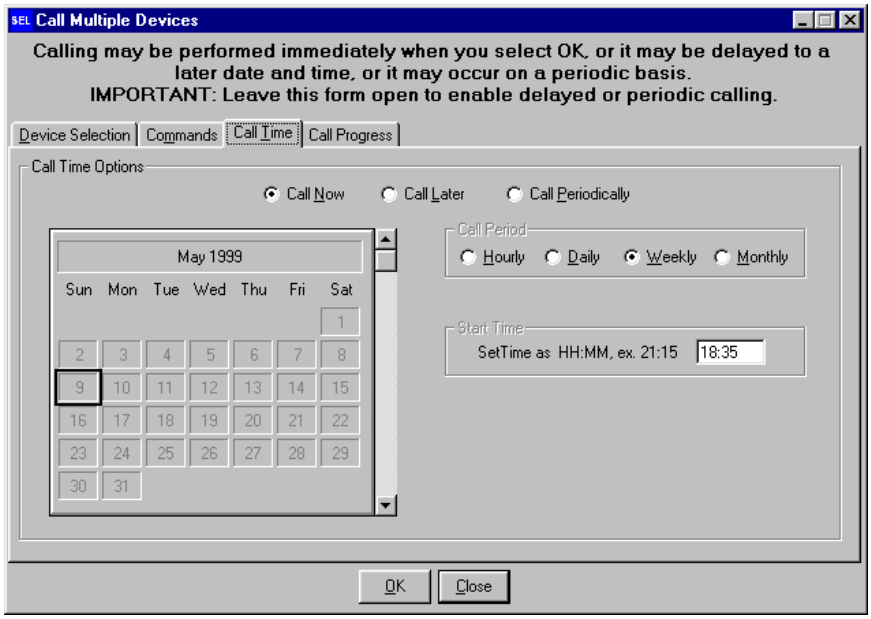

Figure 5.15: Call Multiple Devices Form—Call Time Tab

Table 5.12: Options on the Call Multiple Devices Form—Call Time Tab

Option	Description
Call Now	Starts the call operation immediately after you click **OK**.
Call Later	Sets up the SEL-5010 to call devices at a later time, up to one year in advance.
Call Periodically	Uses the SEL-5010 to call devices on a periodic basis. **NOTE:** To use the delayed or periodic calling options, you must leave the **Call Multiple Devices** form open.
Call Period	This option is available only with the **Call Periodically** option. It allows the devices to be called **Hourly**, **Daily**, **Weekly**, or **Monthly**.
Start Time	This option is enabled with both the **Call Later** and the **Call Periodically** options. It allows the SEL-5010 to call at any time of the day and is set by a 24 hour time format, i.e., 13:00 = 1:00 PM.

Call Multiple Devices—Call Progress

The **Call Progress** form displays the progress of the **Call Multiple Devices** option. If the SEL-5010 cannot make a connection, the program will time out and then go to the next entry in the **Selected Connection Directory ID** list. The **Connection Status:** box will show which connections are successful and which are not.

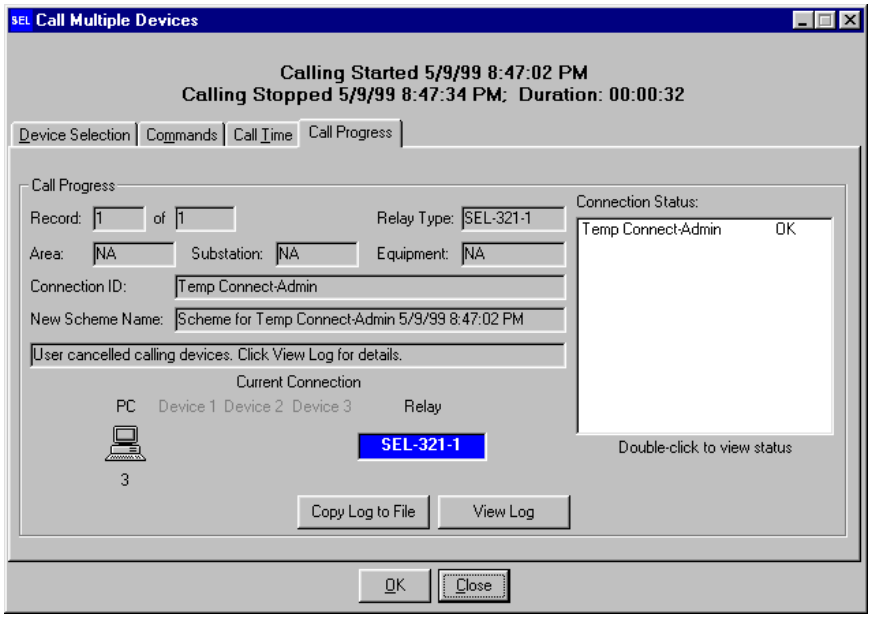

Figure 5.16: Call Multiple Devices Form—Call Progress Tab

Table 5.13: Options on the Call Multiple Devices Form—Call Progress Tab

Option	Description
Copy Log to File	Saves the current **Call Log** to a text file. Unless you copy the current call log to a file, it will be overwritten during the next call operation.
View Log	Displays the **Call Log** on your screen.

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Figures

Section 6: SEL-5020 Settings Assistant

Introduction

The SEL-5020 Settings Assistant is designed to assist you with managing SEL-2020, SEL-2030, or SEL-2032 Communications Processor settings. The SEL-5020 is used for reading, modifying, and downloading settings to and from a communications processor. The SEL-7000 includes a fully preconfigured SEL-5020 file.

The following process summarizes the steps typically used to connect with a communications processor, retrieve current settings, edit settings, and update settings. These steps apply to any communications processor. The SEL-7000 is currently delivered with the SEL-2032.

Step 1. Connect to a master port of the communications processor with your PC that has Echo = Y. PC communication parameters are set in the **Configuration** menu of the main form menu.

Step 2. Once proper communication parameters are set, click the **Connect** button to establish communications between the PC and the communications processor.

Step 3. Read the settings in the communications processor by clicking the **Read Settings** button. This will read all of the communications processor settings into the SEL-5020 memory on your PC.

Step 4. Edit the appropriate settings.

Refer to the SEL-5020 Online Help and the communications processor instruction manual for setting descriptions.

Step 5. Save your settings using the **File > Save** menu of the SEL-5020 main form menu.

Step 6. Go to the **Update Map** of the main form and select the settings to send to the communications processor.

Step 7. Send your new settings to the communications processor by clicking the **Send Settings** button.

This button is enabled only after you have connected your PC to the communications processor and selected settings to send on the **Update Map**.

Setting Map

When the SEL-5020 is started, the **Setting Map** (see Figure 6.1) opens, displaying a map of the available communications processor settings.

To access the settings, click the desired port and setting type. You can also access the settings through the **Edit** drop-down menu of the main form.

The red connection arrow (as shown in the legend) points to the communications processor port that is communicating with the PC. Use caution when changing port setting values for this port.

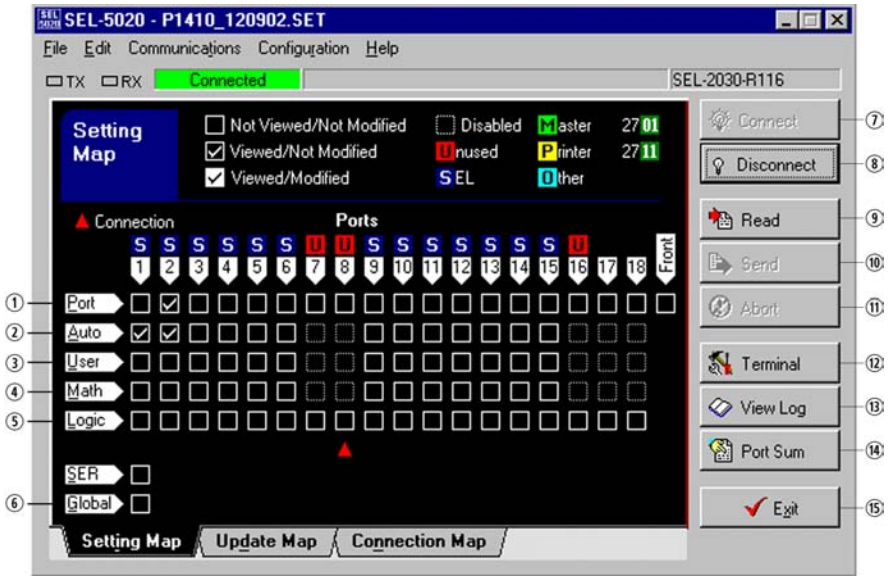

Figure 6.1: SEL-5020 Setting Map

① Port: Configures each port of the communications processor.

② Auto: Defines automatic data collection settings.

③ User: Defines special user-defined commands.

④ Math: Defines Move/Math settings.

⑤ Logic: Defines local SELOGIC® control equations and I/O settings.

⑥ Global: Defines global SELOGIC control equations and I/O settings.

⑦ Connect: Connects the SEL-5020 to the communications processors (see Connect Button on page 6.6).

⑧ Disconnect: Disconnects the SEL-5020 from the communications processor (see Disconnect Button on page 6.7).

⑨ Read: Uploads the settings for the attached communications processor (see Read Button on page 6.7).

⑩ Send: Sends settings to the attached communications processor (see Send Button on page 6.7).

⑪ Abort: Aborts a download of settings to the attached communications processor (see Abort Button on page 6.9).

⑫ Terminal: Opens the terminal window shown in Figure 6.6 (see Terminal Button on page 6.9).

⑬ View Log: Displays the log window. This window displays errors that have occurred during a download to the communications processor (see View Log Button on page 6.9).

⑭ Port Sum: Displays a summary of port settings (see Port Sum Button on page 6.9).

⑮ Exit: Exits the SEL-5020 (see Exit Button on page 6.10). If connected to a communications processor, you will be prompted to disconnect.

Update Map

The **Update Map** is displayed in Figure 6.2. From the **Update Map** tab you can identify which settings have been modified and you can select the settings to send to the communications processor. As the settings are being sent to the communications processor, the status of the operation is displayed for each port (refer to the legend). Settings that have been modified are highlighted in white.

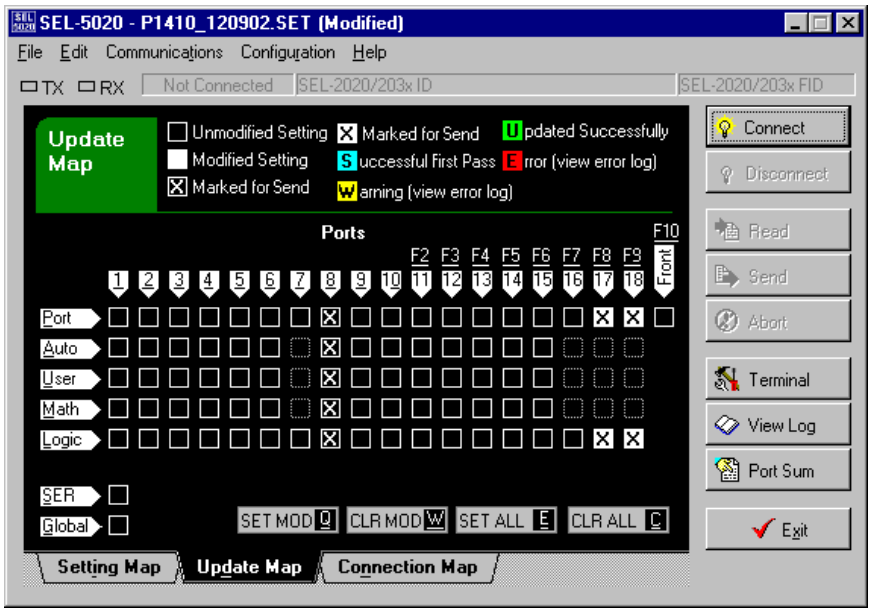

Figure 6.2: SEL-5020 Update Map

Table 6.1: SEL-5020 Update Map Options

Option	Description
Marked for Send	When marked with an **X**, these settings will be sent to the communications processor, whether or not the settings have been modified. Note that in Figure 6.2 all of Port 8, Port 17, and Port 18 are marked for **Send**.
Modified Settings	Settings highlighted in white are those that have changed. Note that Port 17 and Port 18 settings have changed.
SET MOD	Marks all of the modified settings. The marked settings will be sent to the communications processor.
CLR MOD	Clears the marks from all of the modified settings.
SET ALL	Marks all of the settings. The marked settings will be sent to the communications processor, whether or not the settings have been modified.
CLR ALL	Clears the marks from all of the ports.

Selecting Settings to Update

Click the settings class label (**Port**, **Auto**, etc.) to mark all of the ports for that settings class. To toggle the mark on a single port settings class, click the box for the desired settings class. To mark all modified settings classes for a port, click the port number.

Connection Map

Figure 6.3 shows a typical **Connection Map**. This tab is not used to make any settings changes to the communications processor. This tab is for displaying status information.

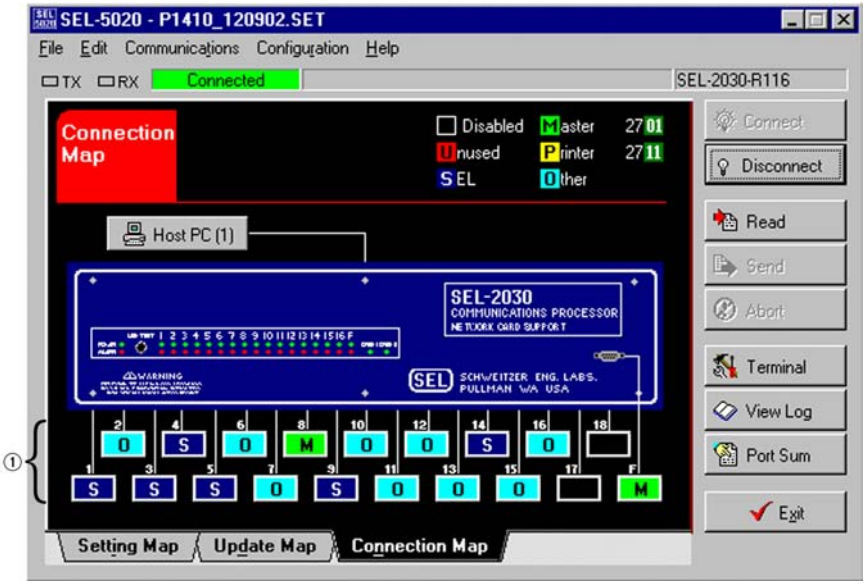

Figure 6.3: Connection Map

① Port Devices: As the legend indicates, the port devices show up as disabled, unused, SEL devices, Master, Printer, other, IED, SEL-2701, or SEL-2711 devices.

Configure Communications Parameters

Under the drop-down menu, select **Configuration > Communication Parameters** to configure the PC for communication with the communications processor. The SEL-5020 can communicate to the communications processor via a serial port or an Ethernet address. If you are using serial communication, configure the communications parameters to match the Master port of the connected communications processor.

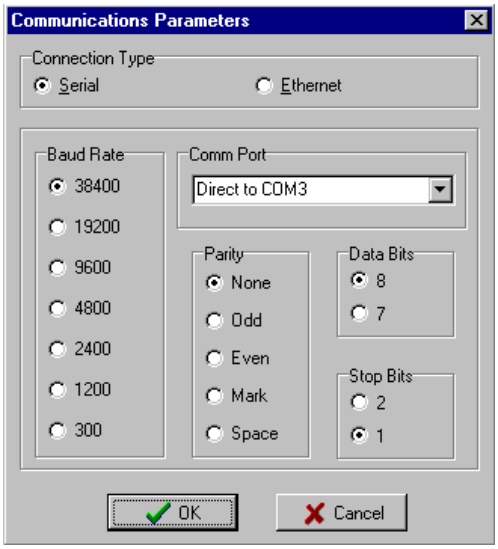

Figure 6.4: Communications Parameters

Configure Options

Under the drop-down menu, select **Configuration > Options**. Figure 6.5 shows the configuration options available for the communications processor.

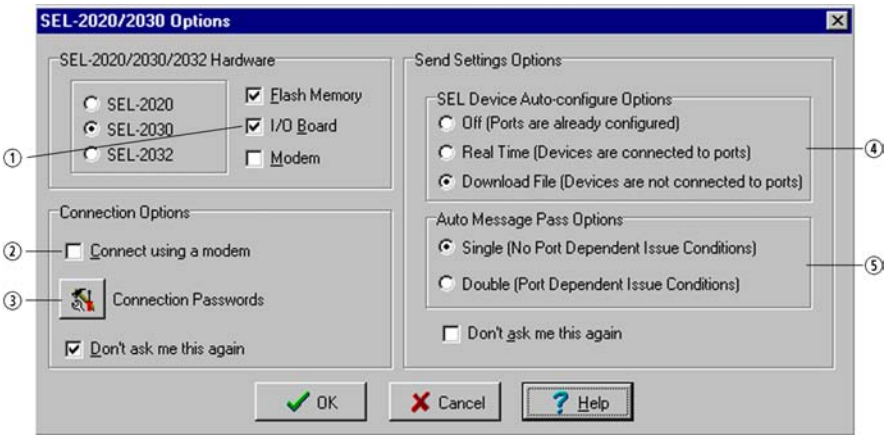

Figure 6.5: SEL-5020 Configuration Options

① SEL-2020/2030/2032 Hardware Options: Allow you to select the communications processor and optional equipment available for the communications processor. If these settings do not match the actual hardware, then an error will appear in the SEL-5020 log when you connect to the communications processor.

② Connect using a modem: Enables connecting the SEL-5020 to a communications processor via modem. This connection must be done manually via the terminal window. A check in this box tells the SEL-5020 not to change communications processor port settings (changing port settings on a port with a modem can cause communication difficulties between the communications processor and the SEL-5020).

③ Connection Passwords: Prompts you for Access Level 1 and Access Level 2 passwords for the communications processor.

④ SEL Device Auto-configure Options: Allow you to select between: 1) not sending a configuration file (Off), 2) uploading the configuration file from the SEL relay (Real Time) to the communications processor, and 3) sending the communications configuration file to the communications processor from the SEL-5020 (Download File). See Communications Processor Auto Configuration on page 6.8 for more information.

⑤ Auto Message Pass Options: When any logic is downloaded to a communications processor that uses variables from a port database, that database must exist on the specified port. If it does not exist, then downloading the settings (Logic, Math, User) will fail. This becomes a problem when logic settings on one port are automatically downloaded by the SEL-5020 before the other port is configured. To prevent this problem, select Double as the auto message pass option. This will prompt the SEL-5020 to download the logic settings again after all the ports are configured. See Auto Message Pass Options on page 6.8 for more details.

Connect Button

The **Connect** button establishes communication with the attached communications processor. When establishing communication, the SEL-5020 verifies that the attached device is a communications processor and sets the communications processor to the appropriate access level. During this connection process, the **Terminal** window will appear and you will see the commands issued to the communications processor. An example of the **Terminal** window is shown in Figure 6.6.

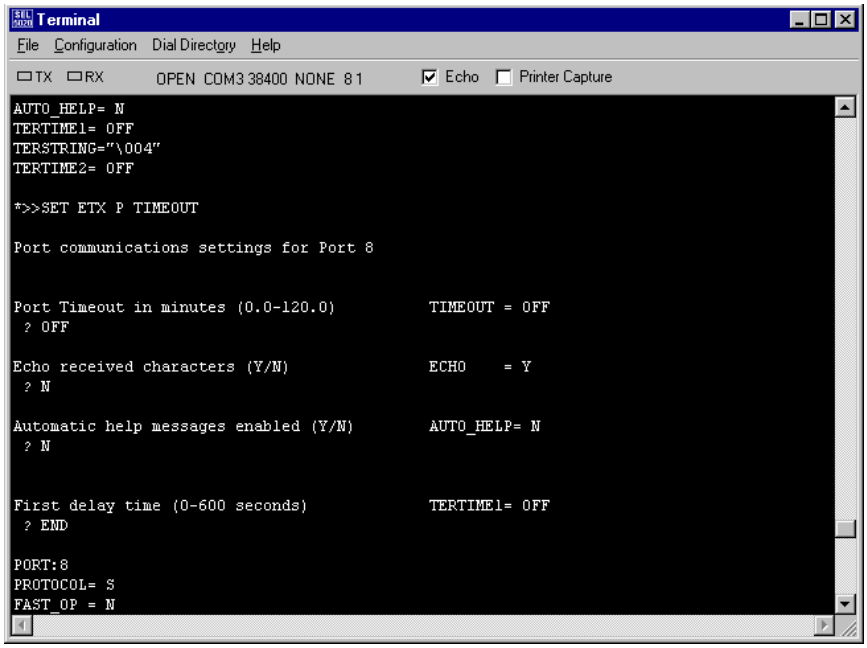

Figure 6.6: Terminal Window

The **Terminal** window allows manual communications with the connected communications processor. If the connection uses multitier communications processor units, use the appropriate communications processor port commands to connect with the target communications processor (refer to the communications processor instruction manual for a command reference).

Disconnect Button

The **Disconnect** button breaks communication with the attached communications processor. Use the **Disconnect** button of the main form to log off from the connected communications processor. The **Terminal** window displays the progress of the log off process.

Read Button

When you are connected, clicking the **Read** button causes the SEL-5020 to read the communications processor settings and store them in the computer memory. Use the **Read** button of the main form to automatically read the settings of the target communications processor. The read process takes several minutes, depending on the communications rate. The **Terminal** window remains open, indicating the progress of the read.

Before reading settings, you are given the option to select which setting you want to read. This window is shown in Figure 6.7.

Figure 6.7: Read Options

Send Button

When you are connected, clicking the **Send** button causes the SEL-5020 to send the settings to the communications processor. The settings sent to the communications processor are specified with an **X** on the **Update Map**.

Communications Processor Auto Configuration

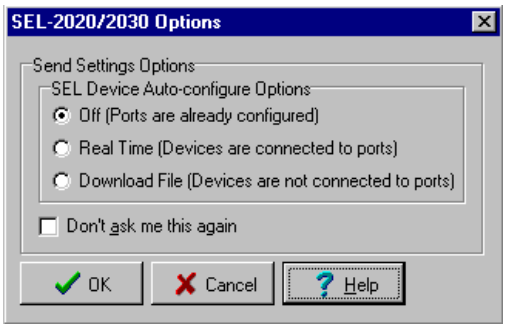

Figure 6.8: SEL-5020 Options During Download

The communications processor maintains specific autoconfiguration information about each connected SEL relay. It is critical that the autoconfiguration stored in the communications processor accurately specify the type of relay, and firmware identification (FID) string of each relay connected to the communications processor. The SEL-5020 offers several options for loading the autoconfiguration information into the communications processor:

- **Off (ports are already configured)**: Send settings to the SEL-5020 without any relay autoconfiguration information. Choose this option only if the communications processor is already configured with autoconfiguration information for each connected relay.
- **Real Time (devices are connected to ports)**: As the settings are sent from the SEL-5020 to the communications processor, retrieve autoconfiguration information from each connected relay. This is the suggested setting for the first time settings are sent to the communications processor (associated relays must be connected to a communications processor). This option ensures that the — communications processor retrieves correct autoconfiguration information for each connected relay. The SEL-5020 automatically updates its available autoconfiguration files when it finds new autoconfiguration information during a setting read process.
- **Download File (devices are not connected to ports)**: Download autoconfiguration information to the communications processor from files available within the SEL-5020. Choose **Download File** only if the relays are not connected to the communications processor. Additionally, verify that the autoconfiguration information in the SEL-5020 port settings matches the firmware version of the connected SEL relay. If a matching firmware version is not available in the SEL-5020 port settings, a **Real Time** autoconfiguration must be performed.

Auto Message Pass Options

The **Double Auto Message Pass Option** uses a two-pass process when sending settings. On the first pass, the ISSUE condition is set to SUN. This is done to ensure that the communications processor does not raise an error when setting another port. Consider an example where Port 2 collects TARGET information from its relay. Port 1 uses the 51P target element from the relay on Port 2 in its

ISSUE condition. The SEL-5020 sends settings for Port 1, then Port 2. When setting ISSUE1 = 2:TARGET:51P, a setting error would occur because the communications processor does not know that Port 2 will have 51P in its target database (it has not been set yet). To avoid this issue, the SEL-5020 initially sets all ISSUE conditions to ISSUE = SUN, so that the communications processor will not raise an error. During the second pass, the SEL-5020 sets the ISSUE condition to the correct port-specific value.

Use the **Single Auto Message Pass Option** only if there are no port-specific settings used in the communications processor settings. The **Single** setting provides slightly faster settings download. Figure 6.8 shows the screen that appears after the **Download** button is clicked.

Abort Button

The **Abort** button terminates the current communication action. If the SEL-5020 is in the middle of a critical process, it may need to finish the process before aborting the action. Also, at any time during the setting upload process you may click the **Abort** button of the main form if you wish to interrupt the setting upload or download.

Terminal Button

The **Terminal** button opens the **Terminal** window. The terminal form can remain open at any time the SEL-5020 is running.

View Log Button

The **View Log** button displays the **Log** window. This displays the status and errors encountered while trying to connect or when connected to the communications processor.

Port Sum Button

The **Port Sum** button displays a summary of the port settings (**Port**, **Device**, **Device FID**, **Port ID** and **Baud**). This form may be left open while you are accessing other SEL-5020 forms.

Exit Button

Click the **Exit** button to exit the Settings Assistant. If you changed any settings and did not save them, you will be prompted to save the changes. This button will automatically disconnect you from a communications processor and close the SEL-5020.

Port Settings

Figure 6.9 shows the communication settings available at each port of the communications processor. Several different serial protocols, baud rates, and other serial port settings are selectable. The **SEL Device File** is the autoconfiguration file described under *Communications Processor Auto Configuration on page 6.8*. See the communications processor instruction manual for further information on specific port settings.

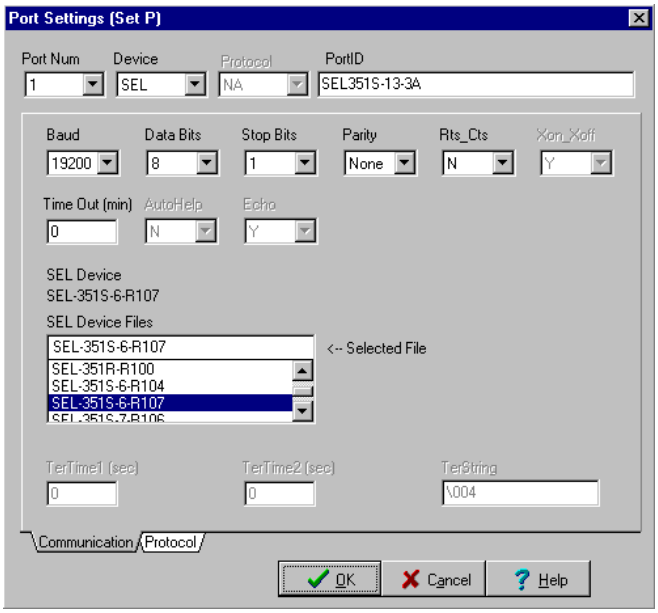

Figure 6.9: Port Settings Window

Auto Message Settings

Figure 6.10 shows the **Auto Message Settings** window. Most commonly, the SET A settings are used to create solicited polls to IEDs. The IEDs respond to these polls with messages containing target status, metering values, etc. Additionally, the **SET A** commands are also used to set the communications processor to perform the following operations:

- Automatically buffer unsolicited messages the communications processor receives.
- Automatically print those unsolicited messages, and clear the buffer after printing, if you desire.

- Issues Fast Operate messages based on operating elements.
- Automatically collect Sequential Events Recorder (SER) data.
- Define startup strings for connected devices so the communications processor can automatically communicate with those devices.
- Create messages to send to other devices and define conditions that trigger those messages (messages are commands, data, or both).
- Define data parsing methods you want used on responses received.
- Define conditions where data is archived in optional nonvolatile memory.

Auto message settings can also be configured to solicit information from non-SEL IEDs.

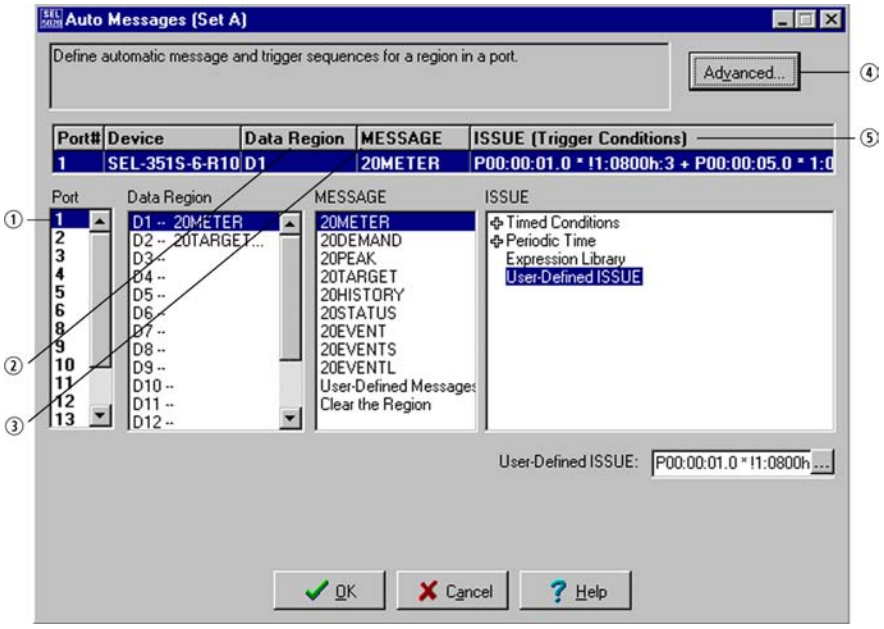

Figure 6.10: Set A Settings

① Port: In this field you can select P1 through P16. This figure shows Port 1 selected.

② Data Region: Each communications processor port can create up to 12 automatic messages. Eight of these messages (D1–D8) have an associated data region and the other four (D9–D12) are for messages only. The message the communications processor sends to the attached device is displayed in this column.

③ MESSAGE: Displays the preconfigured messages each data region can issue out of the port. These are a mix of binary messages (Fast Meter) and ASCII messages. Messages displayed in this column are those supported by the relay you have selected. This information is stored in the configuration file for the particular relay. You can also create user-defined messages for SEL and non-SEL relays.

④ Advanced: Opens the screen shown in Figure 6.11.

⑤ ISSUE: In this field, you can select between periodic time (i.e., every 5 seconds), timed conditions (i.e., 3:00 a.m. every day), or a user-defined ISSUE (i.e., only when a certain bit is set).

Figure 6.11 shows the **Advanced Auto Messages** settings. Access this screen by clicking the **Advanced** button shown in Figure 6.10. Each column represents a port number and each row represents a parameter. See the communications processor instruction manual for further details on each of these settings.

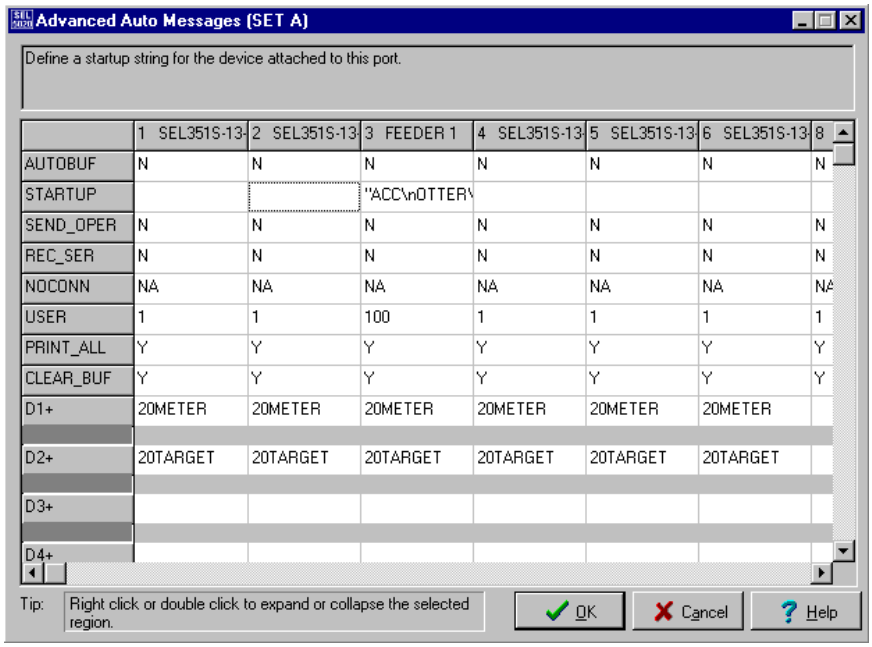

Figure 6.11: Advanced SET A Messages

User Settings

Figure 6.12 is the **User-Defined Commands** settings window for the SEL-5020. Access this screen by selecting the **User** settings for any port configured for an SEL relay (this is item ③ of Figure 6.1). Each column represents a port number and each row represents a setting.

The SET U settings are most commonly used for handling unsolicited messages from an IED. See the communications processor instruction manual for further information on SET U commands.

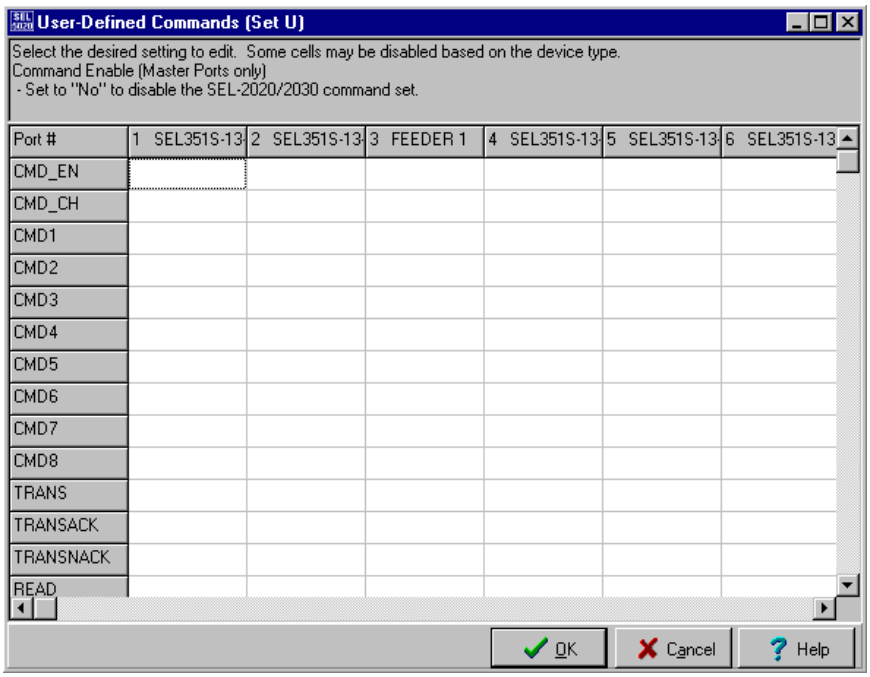

Figure 6.12: User-Defined Commands

Math Settings

Figure 6.13 is the **Move/Math** settings window in the SEL-5020. Access this screen by selecting the **Math** settings for any port (this is item ④ of Figure 6.1).

SET M settings are typically used to perform mathematical manipulations or to consolidate data from the port data regions for use by a SCADA system. See the communications processor instruction manual for further information on the SET M settings.

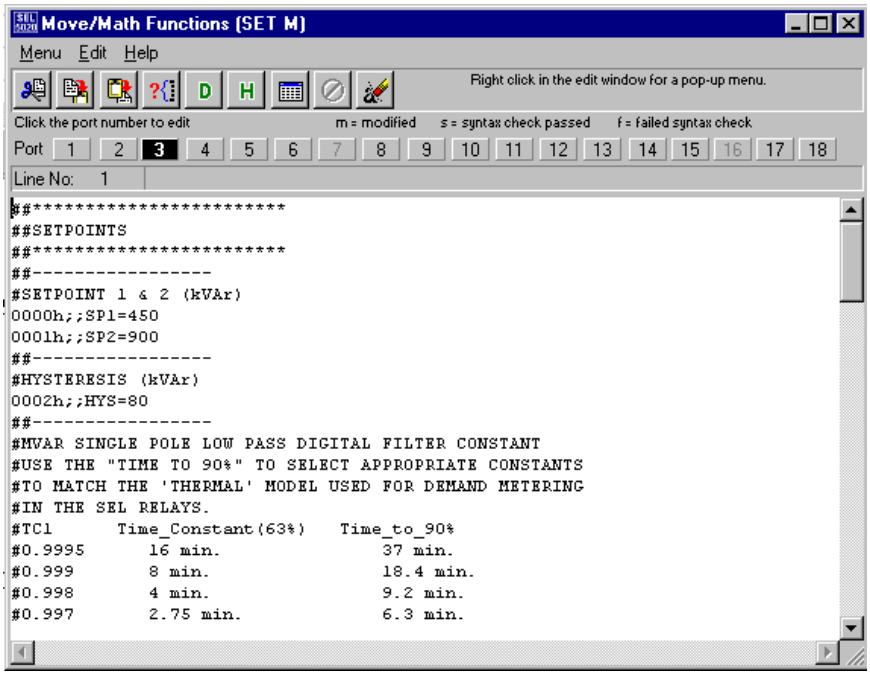

Figure 6.13: Move/Math Settings

Logic Settings

Figure 6.14 is the window used in the SEL-5020 to program logic settings in the communications processor. Each port has 16 breaker bits (BR) and 16 remote bits (RB) for which to write logic. All logic for these bits is written using "set bit" (SBR*x*) and "clear bit" (CBR*x*, where *x* = breaker bit number 1 through 16).

BR1 is reserved for breaker trip and close operations in the SEL-351S, leaving the rest of the breaker and remote bits for intermediate and ancillary logic. Different relays use different numbers of breaker bits. For example, the SEL-487B uses BR1, BR2, BR3, BR4, BR5, BR6, BR7, and BR8 to control 8 different breakers.

See the communications processor instruction manual for further information on SET L and SELOGIC control equations.

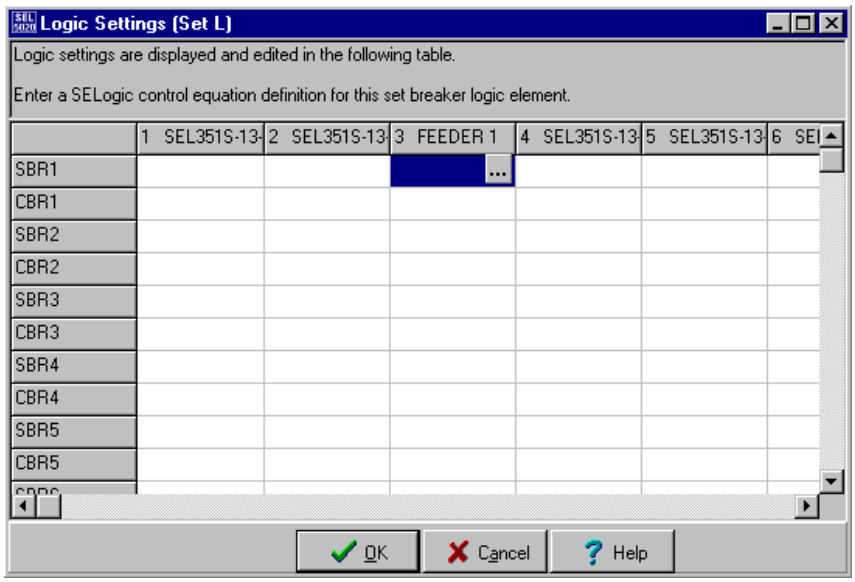

Figure 6.14: Logic Settings

Global Settings

Figure 6.15 is the window used in the SEL-5020 to set global settings in the communications processor. This is where the five timers (**V**, **W**, **X**, **Y**, **Z**) and their associated pickup and dropout times are configured. It is also where the logic for Output 1 through 4 is programmed if the communications processor has the optional I/O board. See the communications processor instruction manual for further information.

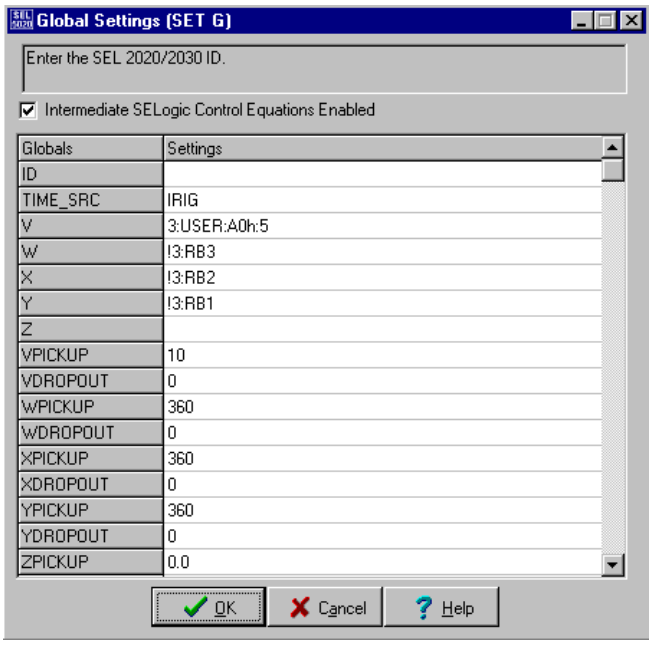

Figure 6.15: Global Settings

SER Settings

Figure 6.16 is the window used to create SER records from inputs on the I/O board on the communications processor. The SER records are automatically transmitted out of all SEL master ports via the SEL binary Fast Message protocol. See the communications processor instruction manual for further information.

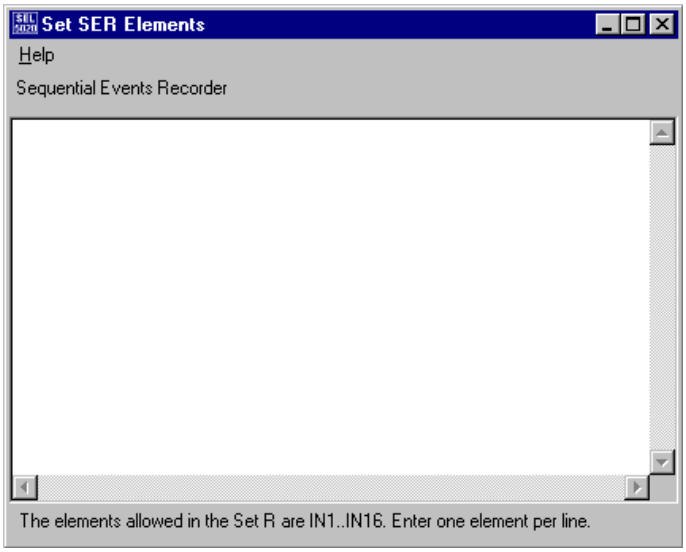

Figure 6.16: Sequential Event Recorder Report Elements

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Figures

Section 7: ACSELERATOR SEL-5030 Software

Introduction

The ACSELERATOR® SEL-5030 Software is used to create, manage, copy, merge, read, and analyze relay settings. It also keeps relay settings organized in one location with the **Database Manager**. Figure 7.1 shows ACSELERATOR. Two major advantages of using ACSELERATOR are:

- It downloads relay settings much faster than previous technology.
- It has a very user-friendly graphical user interface to aid in creating relay settings.

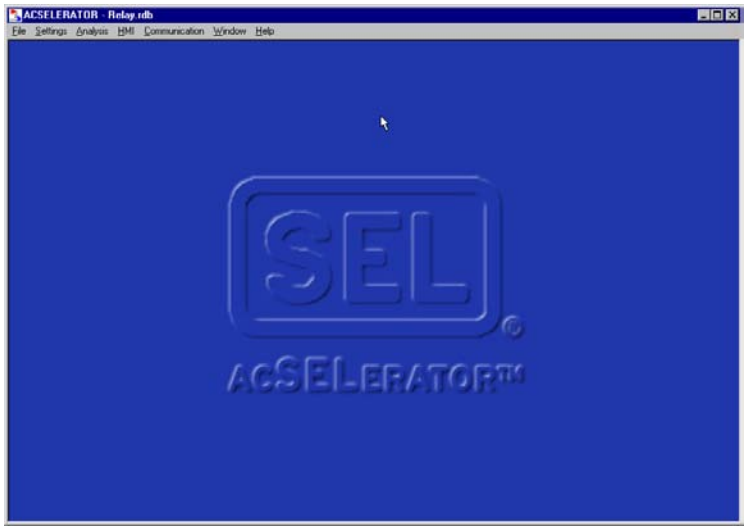

Figure 7.1: ACSELERATOR

ACSELERATOR quickly builds setting files for supported relays. The editor hides settings that you do not need for your application, and the program highlights out-of-range settings. The graphical logic editor allows you to build powerful SELOGIC control equations in an intuitive drag-and-drop environment. Once your settings are finished, use the onboard logic simulator to validate your control equations.

Not all relays can be used with ACSELERATOR. Refer to your version of ACSELERATOR for a list of currently supported relays.

In the SEL-7000, ACSELERATOR is provided to help in making relay settings; all relay settings are by default, provided in the SEL-5010 database format.

File Menu

Figure 7.2 shows the **File** drop-down menu options. These two options allow you to manage and select the active database.

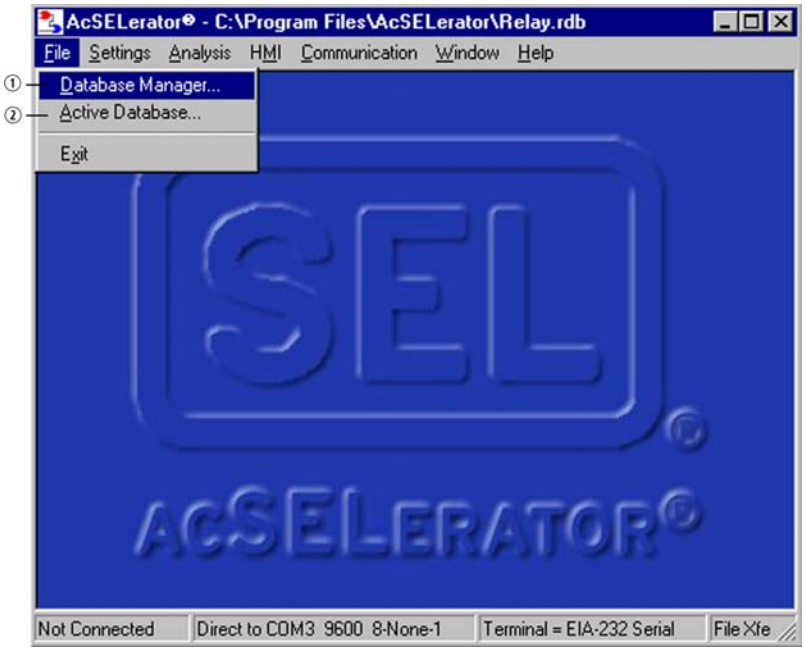

Figure 7.2: File Menu Options

① Database Manager: Allows you to copy and move relay setting files between databases.

② Active Database: Selects the active relay database. For example, it is sometimes useful to keep different databases for different substations.

Settings Menu

The **Settings** drop-down menu is shown in Figure 7.3. These items are used to manage individual relay setting files within the database.

Figure 7.3: ACSELERATOR Settings Menu Options

① New: Creates a new setting file in the database.

② Open: Opens a relay setting file from the database.

③ Read: Uploads relay settings from a connected relay.

④ Convert: Changes the Z number of a relay setting file.

Creating a New Setting File

Perform the following steps to create a new setting file:

Step 1. Select **Settings > New** on the main drop-down menu.

This will open the **Relay Editor Selection** screen shown in Figure 7.4.

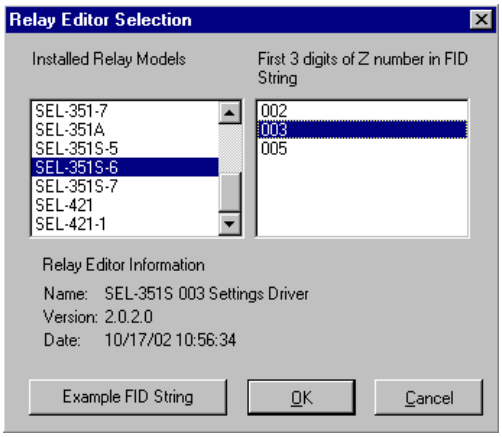

Figure 7.4: Selecting a Relay Model

Step 2. Select the Z number for the relay from the **Installed Relay Models** menu. If you click the **Example FID String** button shown in Figure 7.4, an example FID string for the selected device will appear.

The Z number is in the relay firmware identification (FID) string held in relay memory. Typing **STATUS** at the terminal prompt of the relay will provide you with the relay FID string. The Z number is also available via the front-panel controls.

The Z number is used to identify the ACSELERATOR driver necessary to create an appropriate setting file for the relay. For example, the Z number of the following FID string is 002:

FID = SEL-351S-7-R104-V0-Z**002**001-D20000430

Step 3. After selecting the relay model, enter the proper part number. The relay part number is on the back sticker of the SEL relay or can be displayed by typing **Part** at an Access Level 2 prompt.

An example of this is shown in Figure 7.5. Note that the **x**'s in some SEL part numbers are place holders.

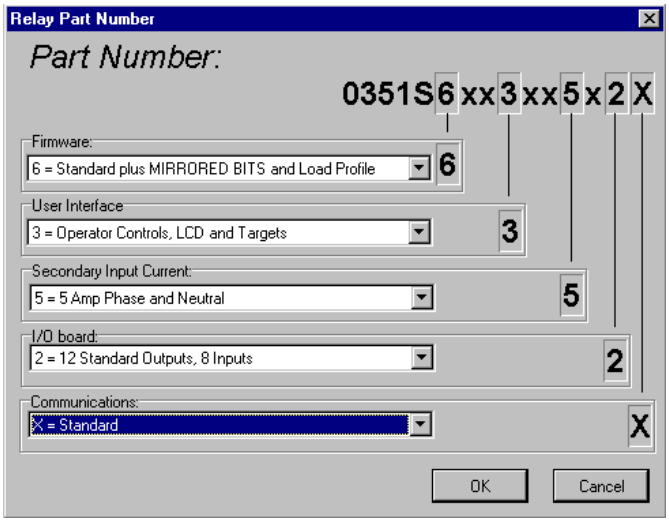

Figure 7.5: Selecting a Part Number

After you select the proper relay, the **Relay Editor** screen will appear, as shown in Figure 7.6. This is where you enter the logic and settings values. It is also where graphical logic can be written, simulated, and debugged.

Figure 7.6: Relay Editor Screen

① Compare: Compares the current setting file with another.

② Search: Searches for a setting name.

③ Import: Imports a previously exported setting file.

④ Export: Exports the current settings to several text files.

⑤ Copy: Copies group settings from one group to another.

⑥ Merge: Merges settings from one relay into the current relay. For example, this would allow SEL-311A settings to be merged with an SEL-311L setting file. Settings that fail to merge are displayed.

Some settings are enabled by other settings. The boxes turn white when the setting is available for editing. Incorrect settings are flagged in red, as shown in Figure 7.7.

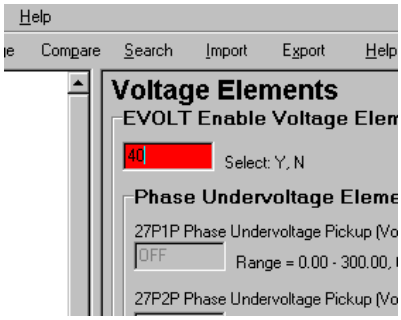

Figure 7.7: Incorrect Setting Flagged In Red

Creating SELOGIC Control Equations

The Graphical Logic Editor in ACSELERATOR can decompile SELOGIC control equations into graphical form, or allow you to create new logic using graphical design tools and then compile them into SELOGIC Control equations. An example of the **Graphical Logic Editor** is shown in Figure 7.8.

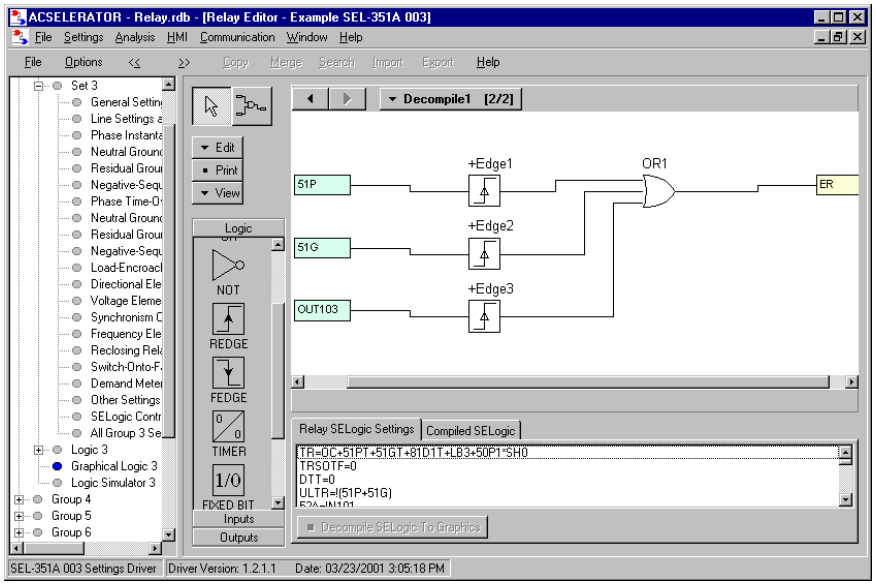

Figure 7.8: ACSELERATOR Graphical Editor

Figure 7.8 shows a graphical representation of the SELOGIC control equation setting, ER = /51P+/51G+/OUT103.

Logic Simulator

The ACSELERATOR Logic Simulator is used to test SEL relay logic settings. You can force inputs high or low at any time in the simulation. You can then monitor the results (outputs) on the same timeline. Alternatively, you can import a relay event record into the logic simulator to test logic under a very specific scenario.

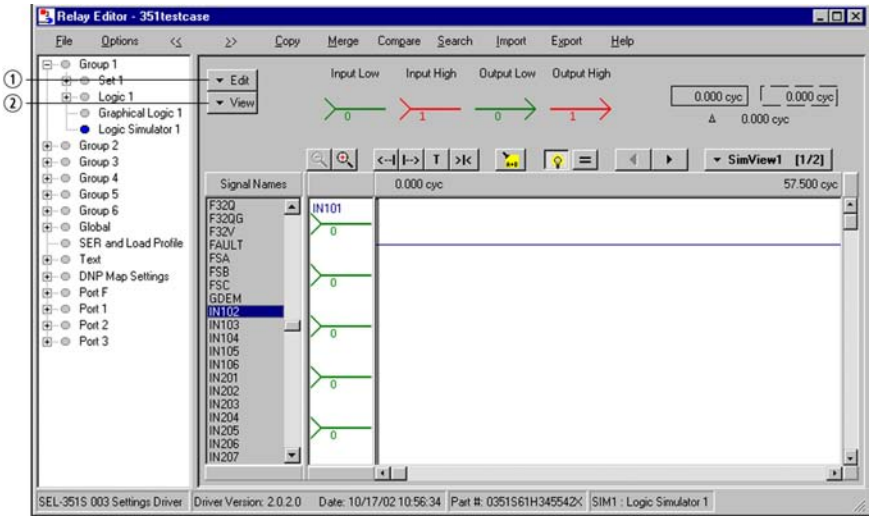

Figure 7.9: Relay Logic Simulator

① Edit: Imports/exports simulation files and imports historical event files.

② View: Creates, renames, or deletes simulations. To select between each loaded simulation file, click the SimView1 drop-down menu.

Use the following steps to create a simulation of SEL relay logic:

Step 1. Drag the inputs to your logic from the **Signal Names** column to the next column to the right (I/O column).

As shown in Figure 7.9, IN101 has been dragged into the I/O column.

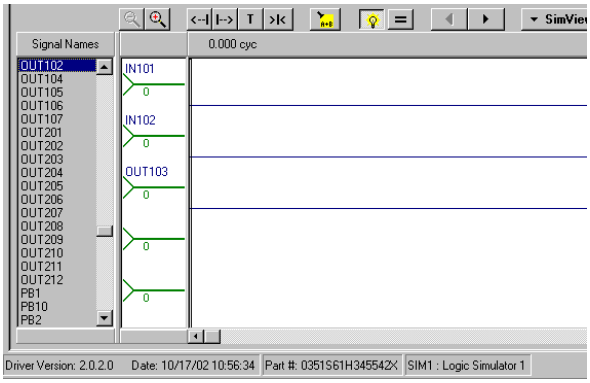

Figure 7.10: Signals in I/O Column

Step 2. Figure 7.10 shows that IN101, IN102, and OUT103 have been dragged into the I/O column. The next step is to change OUT103 from an input to an output.

a. Right-click the signal, as shown in Figure 7.11.

b. Select **Change Signal Type** and change OUT103 to an output.

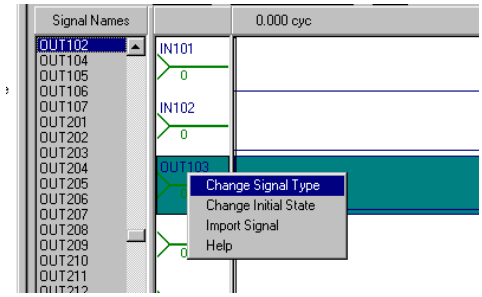

Figure 7.11: Changing to a Logical Output

Step 3. To toggle inputs, drag the cursor to a time and right-click the input trace. Select **Invert Remaining Trace**, as shown in Figure 7.12. The output logic automatically updates, as shown in Figure 7.13.

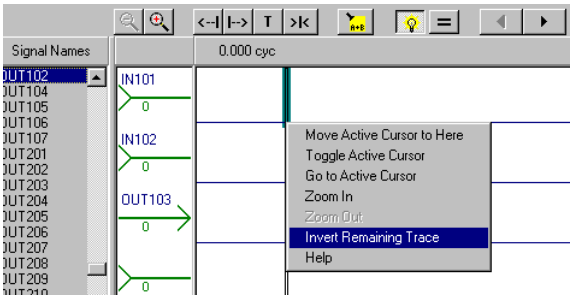

Figure 7.12: Toggling Input State

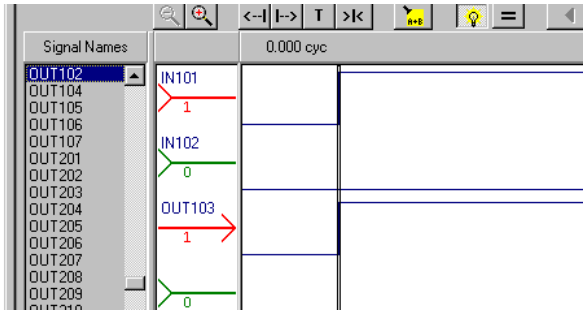

Figure 7.13: Simulated Logic Results

Analysis Menu

The **Analysis** drop-down menu (shown in Figure 7.14) is used to read historical event files from an SEL relay and then analyze the events.

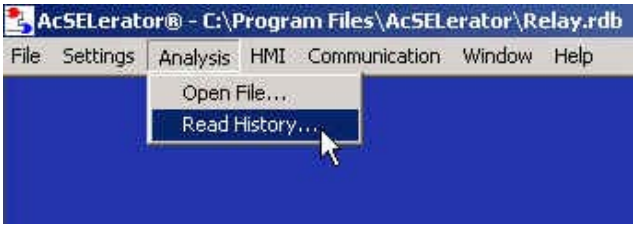

Figure 7.14: Reading SEL Relay Historical Event Reports

Saving Event Reports and Terminal Sessions

ACSELERATOR can read and save relay event reports. To do this, select **Analysis > Read History** from the drop-down menu, as shown in Figure 7.14. Clicking this item will send the **HIS** command to the relay, and the screen shown in Figure 7.15 will display all the recorded events in the relay.

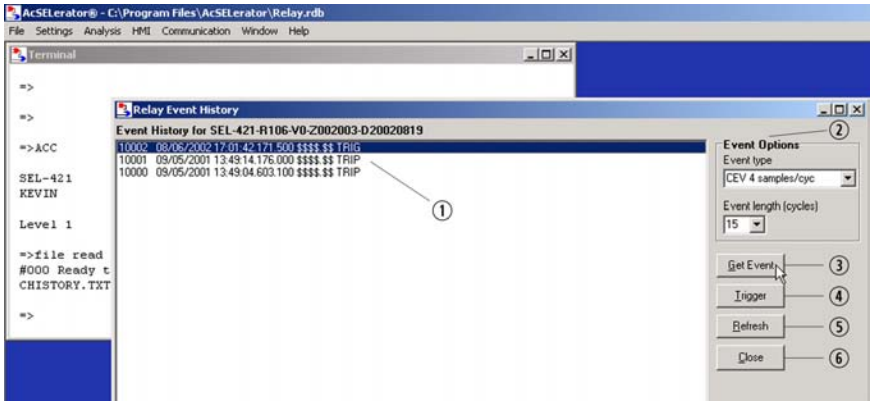

Figure 7.15: History Events

① Event History: Lists the event history files that have been uploaded from the relays.

② Event Options: Specifies the sample rate and length of data to be uploaded to the PC.

③ Get Event: Displays an event. You can then examine the event or save it as a file.

④ Trigger: Sends the TRIG command to the SEL relay. This creates a historical event without a trip.

⑤ Refresh: Resolicits the SEL relay for the event history summary.

⑥ Close: Closes this window.

Analyze Power System Events

After saving an event report, ACSELERATOR can analyze the event report with the **Event Waveform** screen shown in Figure 7.16. Access this screen by selecting the **Analysis > Open File** drop-down menu item shown in Figure 7.14.

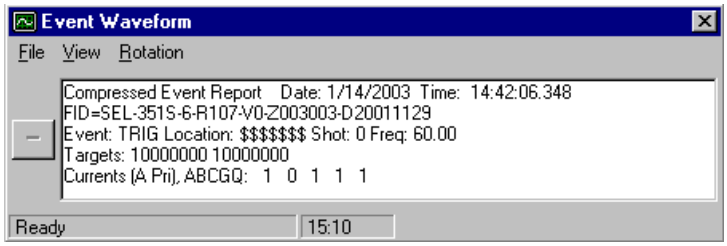

Figure 7.16: Event Waveform Screen

There are a number of ways to display event report data, as shown in the drop-down menu of Figure 7.17.

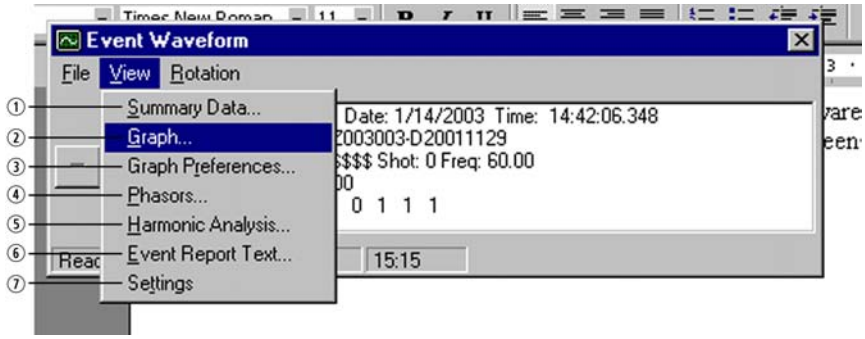

Figure 7.17: Event Viewing Options

① Summary Data: Displays historical summary data for the event. Similar to data retrieved by typing the HIS command in the Terminal window.

② Graph: Displays the oscillogram, as shown in Figure 7.18.

③ Graph Preferences: Modifies what is plotted on the oscillogram.

④ Phasors: Displays the phase and sequence component in phasor diagrams, as shown in Figure 7.20.

⑤ Harmonic Analysis: Performs a harmonic analysis on the data between any two points in time, as you select. See Figure 7.19 for an example.

⑥ Event Report Text: Displays the text from the event report.

⑦ Settings: Displays the SEL relay settings saved with the event report.

The **Graph** function displays the data in an oscillogram like that shown in Figure 7.18. This sample oscillogram shows just a few of the digitals that are available for display. The event report can be up to 30 cycles long, depending on the relay.

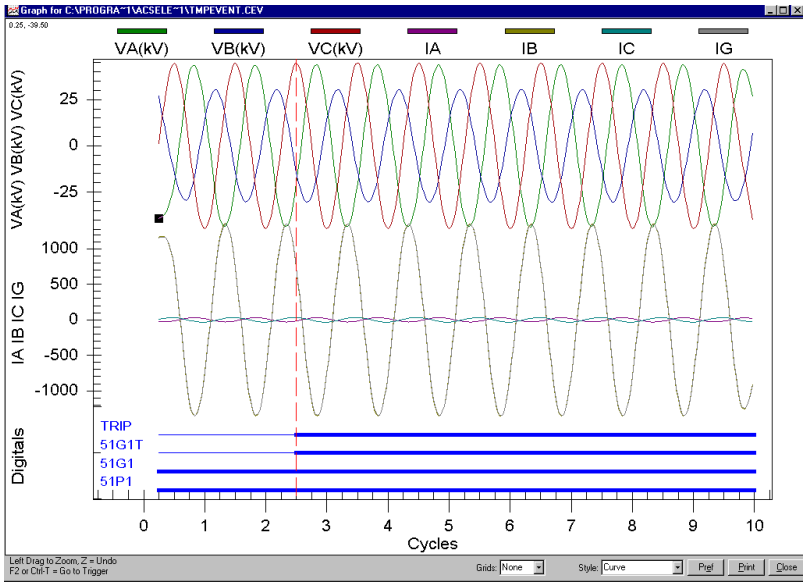

Figure 7.18: Sample Oscillogram

A sample **Harmonic Analysis** is shown in Figure 7.19. This **Harmonic Analysis** screen can display harmonics up to the seventh order.

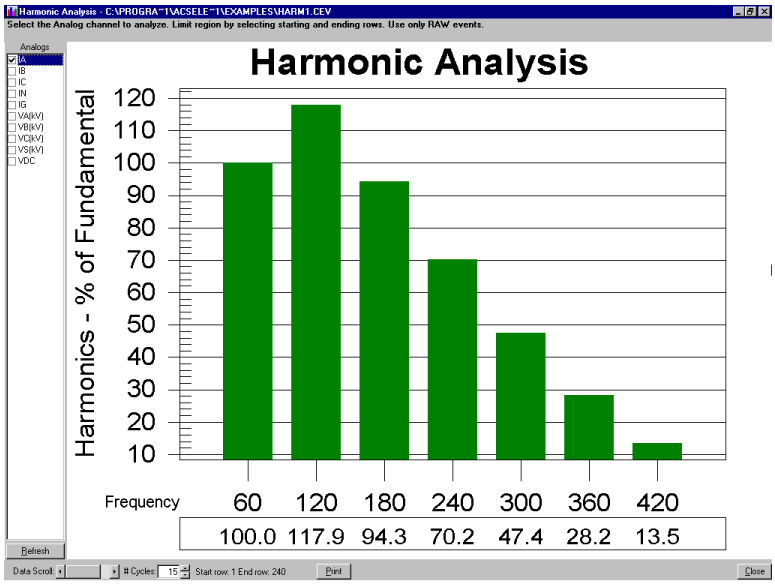

Figure 7.19: Sample Harmonic Analysis

A sample **Phasor Diagram** is shown in Figure 7.20. The **Auto Increment** feature displays the event in chronological order.

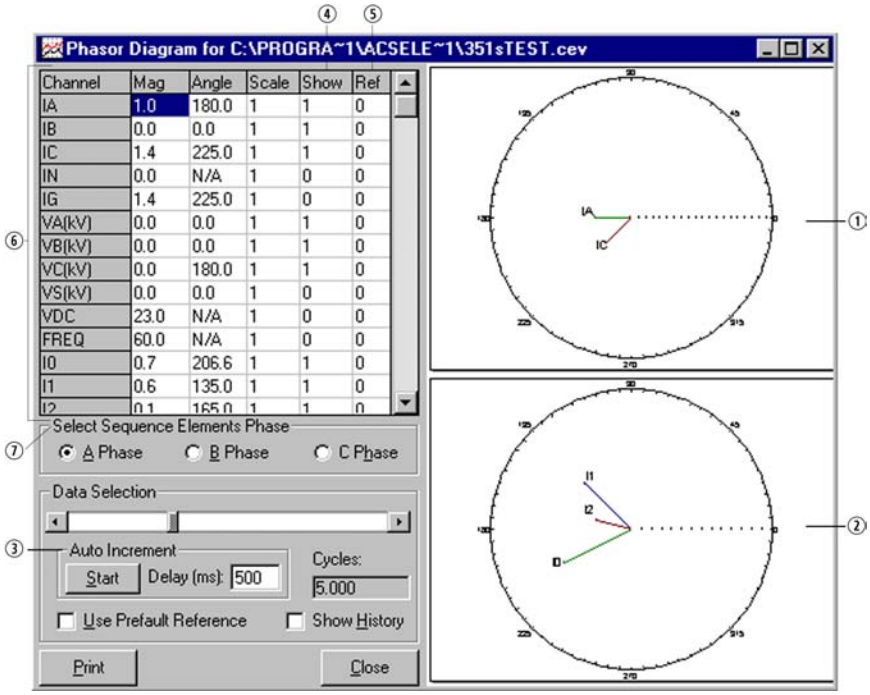

Figure 7.20: Sample Phasor Analysis

① Phase Component Graph: The top-right phasor diagram shows each of the phase currents and voltages.

② Sequence Components Graph: The bottom-right phasor diagram shows the positive-, negative-, and zero-sequence voltages and current for whichever phase (A, B, or C) is selected.

③ Auto Increment: Automatically advances the data by one sample of data, giving a "slower-than-life" simulation of events.

④ Show: Entering a 1 in this column will make the selected channel display on the phase and sequence component graphs.

⑤ Reference: Entering a 1 in this column will make the selected channel the reference on the graphs.

⑥ Channel Data: Details the magnitude and phase data stored in the event report.

⑦ Select Sequence Elements Phase: These radio buttons allow you to display A, B, or C phase positive and negative sequence quantities on the graph at the right.

Metering and Target Information

You can view metering and target information by selecting **HMI > Meter & Control** from the main drop-down menu. When ACSELERATOR is connected to a relay, you can monitor live meter, target, demand, energy, and other data. Figure 7.21 displays a screen capture of the live phasor screen, which updates approximately every second.

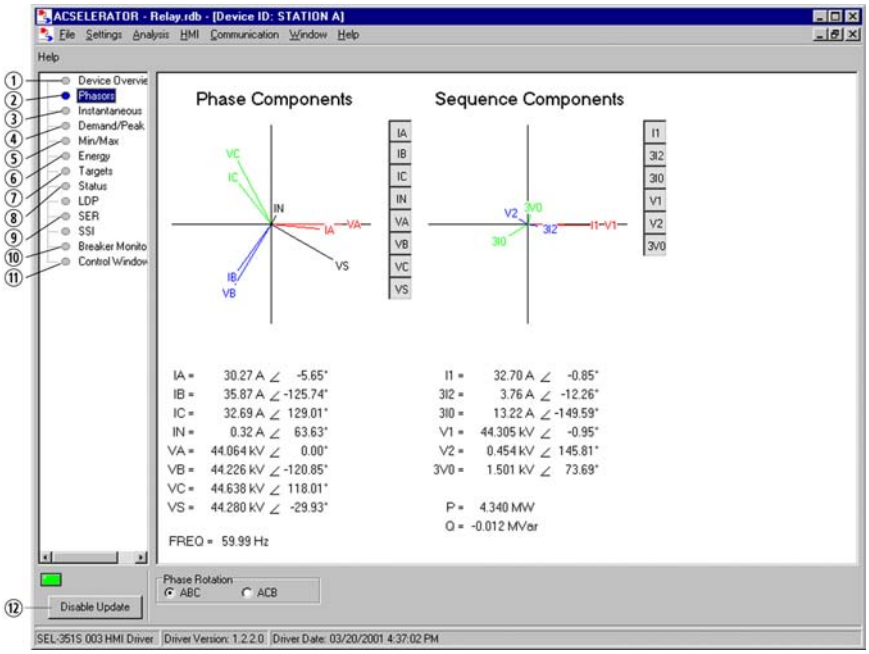

Figure 7.21: Online Metering Data

① Device Overview: Displays front-panel LED status, basic metering quantities, and I/O states.

② Phasors: Displays live phase and sequence components, as shown in this figure.

③ Instantaneous: These are the meter values in the relay. Selecting this option is the same as entering the MET command.

④ Demand/Peak: These are the demand/peak values in the relay. Selecting this option is the same as entering the MET D command.

⑤ Min/Max: These are the minimum/maximum values in the relay. Selecting this option is the same as entering the MET M command.

⑥ Energy: These are the energy values in the relay. Selecting this option is the same as entering the MET E command.

⑦ Targets: These are the target status of the relay. Selecting this option is the same as entering the TAR command.

⑧ Status: Selecting this option is the same as typing STATUS on the relay terminal.

⑨ SER: Selecting this option is the same as typing SER on the relay terminal.

⑩ Breaker Monitor: Selecting this option is the same as typing BRE on the relay terminal.

⑪ Control Window: Makes many of the controls available to you without going to the terminal window. Controls such as trip, close, energy reset, and target reset are available here.

⑫ Disable Update: Disables the update.

Communication Parameters

Select **Communication > Parameters**, as shown in Figure 7.22. Communication can be either serial or Ethernet.

Figure 7.22: ACSELERATOR Communication Parameters

① Parameters: This is the window shown in this figure. Use it to configure communication parameters in the PC.

② Network Address Book: Creates an address book of IP addresses for all of your relays.

③ Disconnect: ACSELERATOR connects whenever ACSELERATOR performs metering, sends commands, or reads commands.

④ Dial: Dials a modem.

⑤ Terminal: Opens a terminal for communication with the relay.

⑥ Terminal Logging: ACSELERATOR saves a terminal communication log file called ACSELERATOR.txt in the root ACSELERATOR directory. This option is enabled or disabled as shown by the check mark next to Terminal Logging. This is particularly useful in troubleshooting a dial-up sequence.

⑦ Connection Log: Keeps track of all the connections made to relays.

⑧ Clear Connection Log: Clears the Connection Log.

Table of Contents

Tables

Figures

Section 8: SEL-5040 Power System Report Manager

Introduction

This section is a reprinted version of the SEL Application Guide 2000-08, *Applying the SEL-5040 Power System Report Manager*. The full version of this application guide is available on the SEL website at www.selinc.com. It also comes with the SEL-5040 Power System Report Manager Software installation.

For the SEL-7000 System, the SEL-5040 starts automatically upon start of the PC. You need only to click the **Run** button for this program to begin polling the relays once daily. The SEL-7000 is set up in direct polling mode. The SEL-5040 can be configured to automatically start in Run mode. To enable this, ensure that the **Auto start…** box is checked in the **Event Collection Options**.

The SEL-5040 retrieves historical data reports from SEL relays. Use the SEL-2020, SEL-2030, or SEL-2032 Communications Processors to apply the SEL-5040, or connect the software directly to SEL relays, either locally or via modem. The configuration of the program varies with the connection used.

This section describes the configuration and settings for the SEL-5040 Connection Directory and for five possible connection methods:

1. Direct polling of SEL relays
2. Automatic notification via a communications processor
3. Automatic notification via multitiered communications processors
4. Direct polling of SEL relays via communications processors
5. Modem connections for automatic notification

You must first modify settings in the SEL-5040, communications processor, and SEL relays for the event notification process to operate correctly. To apply the SEL-5040, you must be familiar with communications and settings for the communications processor and SEL relays. Refer to the communications and settings sections of the communications processor and SEL relay instruction manuals, as necessary.

The SEL-5040 is compatible with existing SEL-5010 databases. You may use an existing SEL-5010 Connection Directory, or use the SEL-5040 to create a new connection directory.

Performance and Capacity

When a power system condition causes an accumulation of event reports on multiple relays, several factors affect the event report collection rate and the overall capacity of the SEL-5040. The data communications speed, types of monitored SEL relays (event report length), and communications processor burden directly influence the event report collection rate. Additionally, the SEL-5040 does not process new event notifications until after the completion of previous collection tasks. When configured for Direct Polling mode, the SEL-5040 scans for new event notifications in the order of the relay ID listing in the SEL-5040 Connection Directory. In Automatic Notification mode, the remote communications processor units notify the SEL-5040 as new events occur and as the SEL-5040 communications link becomes available for new event notification.

Table 8.1 illustrates example collection times for retrieving two 1/4-cycle resolution event reports from relays connected to a two-tiered communications processor system. These times reflect the duration in seconds between when the SEL-5040 receives new event notification and when the software collects and stores the second event report.

Table 8.1 Collection Times for Retrieving Two 1/4-Cycle Resolution Event Reports

Model	# Cycles	2400 Baud	19200 Baud
SEL-351S-7	11	339 sec.	210 sec.
SEL-311C	11	260 sec.	160 sec.
SEL-351	11	259 sec.	180 sec.
SEL-321-1	11	263 sec.	165 sec.
SEL-351R	11	395 sec.	244 sec.
SEL-251	11	138 sec.	122 sec.
SEL-221F/221G/267	11	104 sec.	85 sec.

Configuring the Connection Directory

The SEL-5040 Connection Directory must have entries for each communications processor and SEL relay. Follow the instructions in the **Initial Setup** topic in the help file of the SEL-5040 to correctly configure your communications processor and SEL relay connections.

Connection Directory Required Settings

The first setting necessary for correct operation of the SEL-5040 is the Dial Directory ID. This is the first setting available on the **Required** tab of the **Connection Directory Edit** form within the **SEL-5040 Connection Directory** form (Figure 8.1). At the SEL-5040 ID prompt, you must enter an ID that matches exactly the communications processor version ID. The SEL-5040 uses this ID to match a Connection Directory entry with the connected communications processor.

You must also check the **Relay In Service** box for all SEL IEDs that provide report retrieval with the SEL-5040. Ensure that this box is not checked for relays that are out of service. This prevents the SEL-5040 from attempting connections with an out-of-service relay.

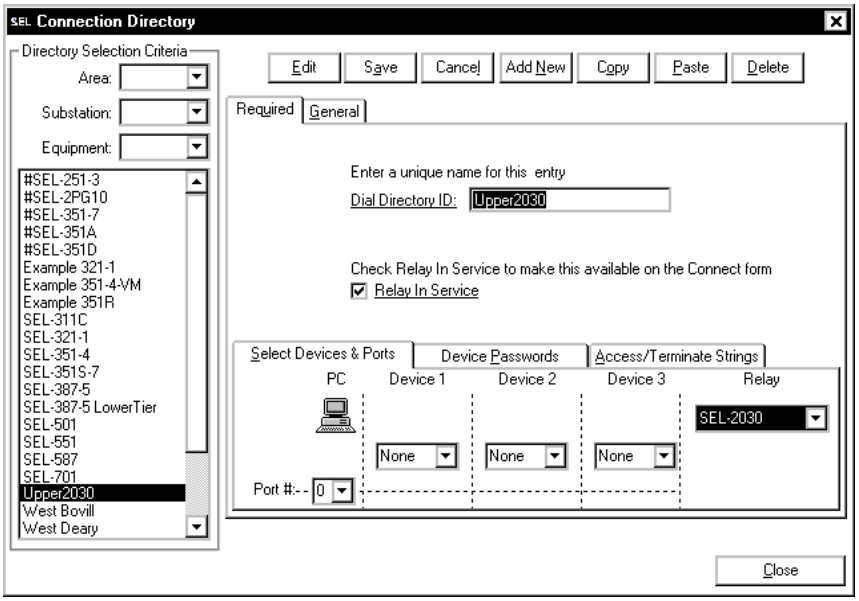

Figure 8.1: SEL-5040 Connection Directory Edit Form—Required Settings

Connection Directory General Settings

One setting under the **General** tab of the **Connection Directory Edit** form (Figure 8.2) is required: you must enter a substation name for the **Substation** setting. You may use the **Area** and **Equipment** settings for additional selection criteria, but these settings are not required. Each SEL IED within a substation must have the same **Substation** setting. The SEL-5040 uses these settings to sort the devices within a substation to identify connection sequence and passwords of individual SEL relays and communications processors.

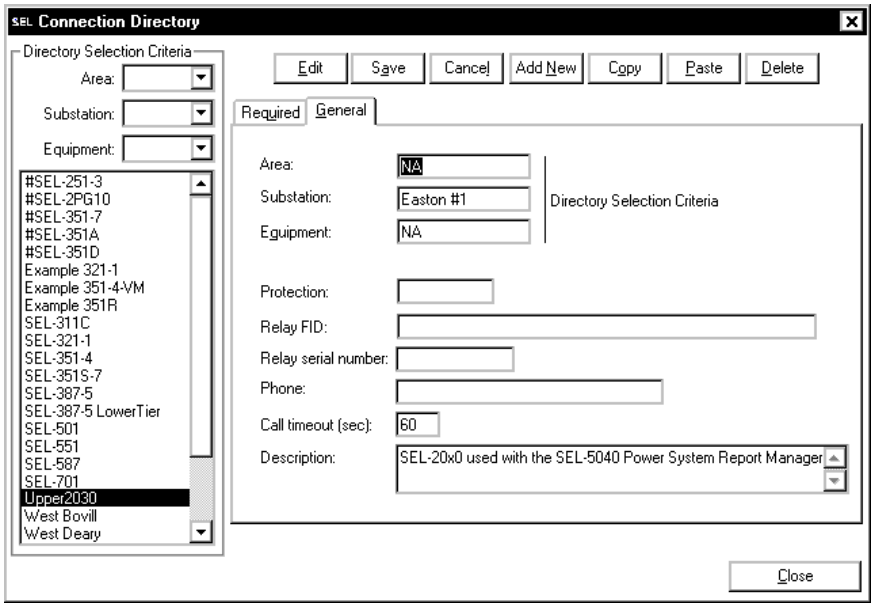

Figure 8.2: SEL-5040 Connection Directory Edit Form—General Settings

Setting the Communications Processor to Match

When you use the SEL-5040 with the communications processor, settings within the SEL-5040 Connection Directory and the communications processor must match exactly. This is necessary for the SEL-5040 to correctly identify connections and passwords for the communications processor and relays.

Direct Polling of SEL Relays

Use direct polling of relays to retrieve event report data when the substation involved has a limited number of relays and no communications processor is present to notify the SEL-5040 automatically that new event data are available.

Begin by using the **SEL-5040 Connection Directory Edit** form to set up the **Connection Directory**. Then select the **SEL-5040 Configure Devices to Poll** form (Figure 8.3).

Select the relays that you want polled, and save the selections by clicking the **Save Selections** button. With the same relay selections still in the **Selected Entries** window, click **OK**. Select the **Configure Polling and Listening** form (Figure 8.4) to configure the relay polling properties.

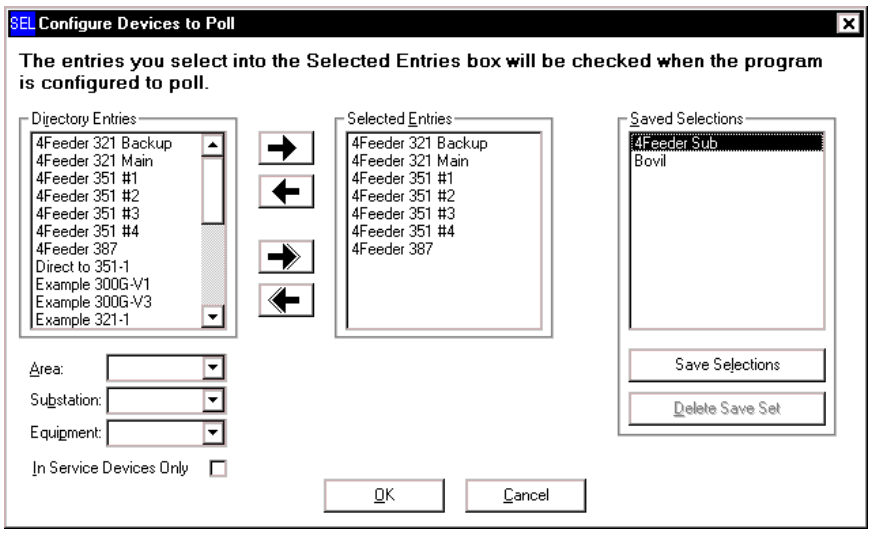

Figure 8.3: Configure Devices to Poll Form

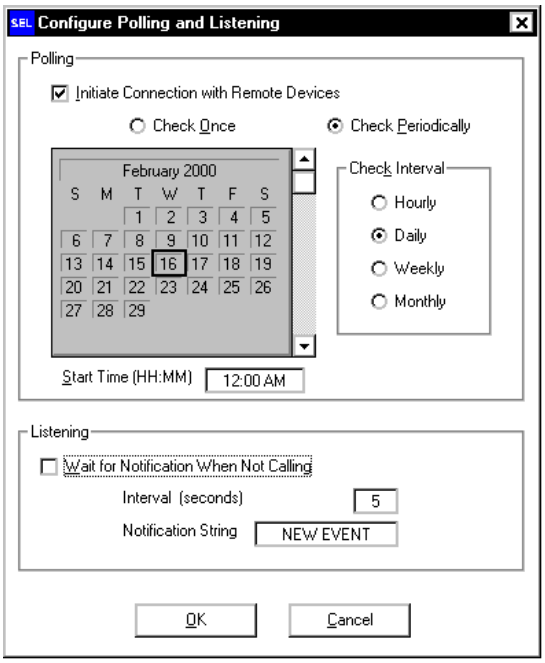

Figure 8.4: Configure Polling and Listening Form

To enable direct polling, check the box for **Initiate Connection with Remote Devices**. Then choose the interval of the poll with either the single or periodic selections. Set the **Start Time** to indicate when polling is to begin, then click **OK**. From the main form (Figure 8.5), click **Run**; the SEL-5040 polls the selected relays at the set period or selected date.

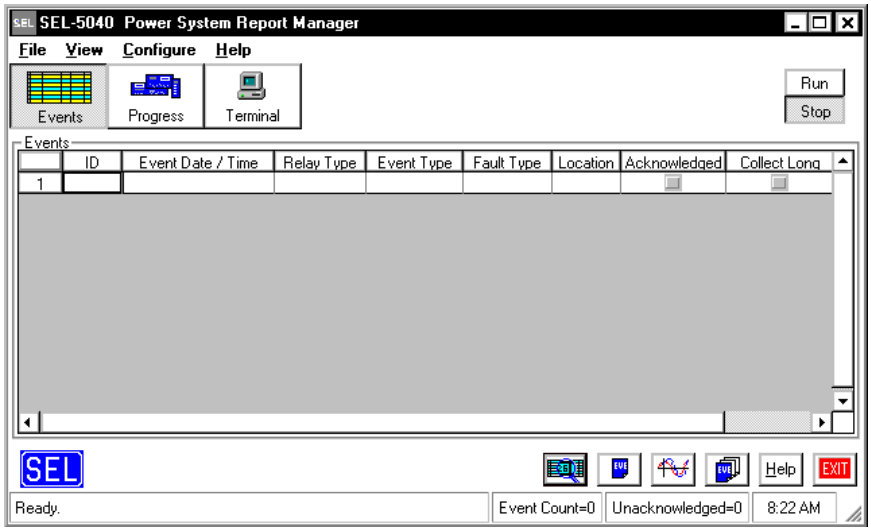

Figure 8.5: Main Form

Automatic Notification Via a Single Communications Processor

Automatic notification of new event data optimizes communications connections to relays in a substation by limiting event report data communications to periods when data are available.

Logic and Data Flow

Figure 8.6 shows the data and logic flow within the communications processor for the automatic notification and event retrieval process. The process begins at the SEL relay with the generation and transmission of an automatic event summary. The communications processor recognizes the event summary message and sets a logic bit to indicate the presence of the new message on the relay connected to the serial port. The communications processor assembles the logic bits from all monitored relays into a single new event status register for ease of retrieval by the SEL-5040. Once the communications processor sets a new event logic bit, it sends an indication to the SEL-5040 that new event data are available.

The SEL-5040 determines the connected device by issuing the **ID** command to the communications processor and matching the response with the **Dial Directory ID**. Additionally, the SEL-5040 scans the contents of the FAULT status register to determine which connected devices contain new event data. Following this identification process, the SEL-5040 uses the information in the **Connection Directory** to connect transparently to the relay, access the relay, and retrieve the new event data. Once the SEL-5040 retrieves the new event data, it terminates the transparent communication connection, resets the logic bit, waits for the communications processor to collect an event history from the relay, and then terminates the communications processor connection.

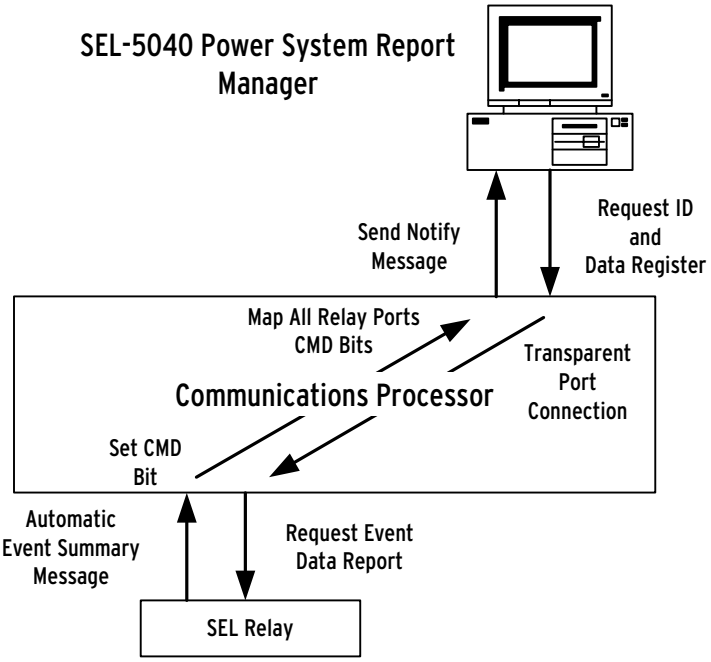

Figure 8.6: Logic and Data Flow for Automatic Notification and Event Retrieval

Connection Directory Settings

To enable automatic notification, you must modify settings in the communications processor and, in some cases, in the SEL relay. Create entries in the **Connection Directory** for the communications processor in addition to configuring the relays. Create entries in two ways:

- Use the database provided with the SEL-5040 to import the necessary **Connection Directory** entries from the SEL-5010 database.
- Add the communications processor device types to the SEL-5010 database **Connection Directory**.

Perform the following steps to add communications processor device types to the SEL-5010 database:

Step 1. Select the **Edit Relay Groups** form from the **Administration > Edit Relay Tables** menu of the SEL-5010 main form.

Step 2. From the **Edit Relay Groups** form, click the **Add** button and enter **2020**, **2030**, or **2032** following the **SEL-** in the **Relay Type** window.

Step 3. Set the Access Level 0 prompt to **STX***, the Access Level 1 prompt to **STX*>**, and the Access Level 2 prompt to **STX*>>**.

Step 4. Click the **Update** button to update the database and close the **Edit Relay Groups** form.

Step 5. If you choose to use a SEL-5010 database, select it in the SEL-5040 from the **File/Select Connection Database** menu.

Step 6. After configuring the **Connection Directory**, select **Communications** from the **Configure** menu on the SEL-5040 main form.

The **Configure Communications** form appears (Figure 8.7). Use this form to set up the PC communications port. This setup includes the messages the SEL-5040 uses to retrieve the Dial Directory ID from the communications processor (**ID Command**), the label of the register indicating which device has event data records to retrieve (**Data Label**), and the **Logic Bit** of the communications processor.

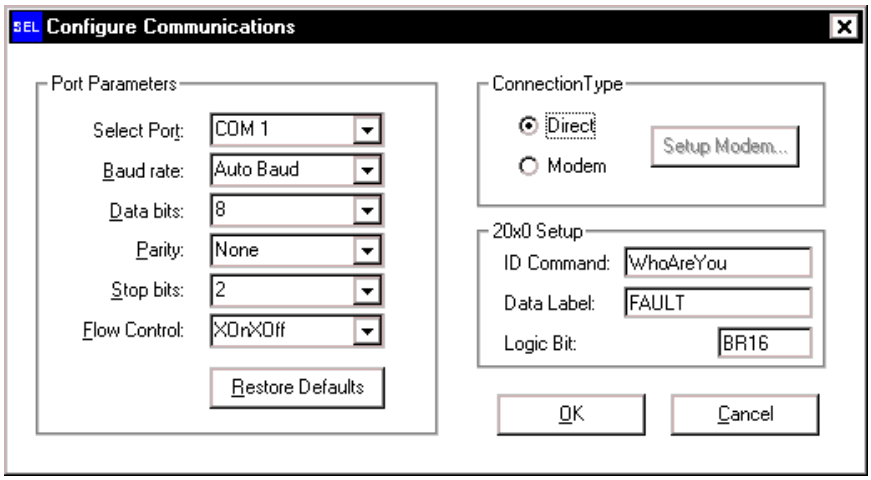

Figure 8.7: Configure Communications Form

Device Settings

Use settings in the SEL relay connected to the communications processor to enable it to transmit automatic event summary messages when the relay triggers new event data. Each SEL relay has an AUTO setting that enables transmission of these automatic messages. You must set AUTO to **Yes** for the automatic notification sequence to function.

Step 1. Set the communications processor to listen for automatic event summary messages from the SEL relay. Use the communications processor user-defined settings (SET U) for this purpose.

```
SET U n        [where n is the communications processor port number]

CMD_CNT = 1
CMD1 = 20EVENTQ
```

The 20EVENTQ option is only available following autoconfiguration of the communications processor relay port. This configuration pulses the communications processor command bit (CMD1) when the communications processor receives an automatic event summary message. The communications processor then uses the CMD1 bit to latch a logic bit to indicate that new event data are available from the connected relay.

Step 2. The SEL-5040 requires the communications processor to request an event history from a relay after breaking a transparent connection. Use the automatic message settings on the communications processor relay port (**SET A**) to create this message.

```
SET A n        [where n is the communications processor port number]

MSG_CNT = 1

ISSUE1 = !n:0800h:3
MESG1 = 20HISTORY

ARCH_EN = N
USER = 0
```

Step 3. Use the logic settings (**SET L**) to create the new event logic bit. These example settings use Breaker Bit 16. Use the CMD1 bit to set Breaker Bit 16. SBR16 is the set equation for Breaker Bit 16 (BR16).

```
SET L n SBR16  [where n is the communications processor port number]

SBR16 = n:CMD1
```

Step 4. Assemble all new event logic bits into a single register on the communications processor port connected to the PC running the SEL-5040. Use the communications processor Math/Data Movement settings (**SET M**) to perform this concentration.

These example settings concentrate Breaker Bit 16 (BR16) from all ports on the communications processor into one register. This maintains a logical mapping order of bit location to port number within the register. Map all bits, even if some communications processor ports are not connected to SEL relays or are not part of the event data collection system.

```
SET M n        [where n is the communications processor port number]

1 000h:0;B = 1:BR16
2 000h:1;B = 2:BR16
3 000h:2;B = 3:BR16
4 000h:3;B = 4:BR16
5 000h:4;B = 5:BR16
6 000h:5;B = 6:BR16
7 000h:6;B = 7:BR16
8 000h:7;B = 8:BR16
9 000h:8;B = 9:BR16
10 000h:9;B = 10:BR16
11 000h:10;B = 11:BR16
12 000h:11;B = 12:BR16
13 000h:12;B = 13:BR16
14 000h:13;B = 14:BR16
15 000h:14;B = 15:BR16
16 000h:15;B;FAULT = 16:BR16
```

These settings concentrate the new event logic bits into the first register of the USER data region of the communications processor Port n and assign the label FAULT to the register. FAULT is the Data Label set in the **Configure Communications** form of the SEL-5040 (Figure 8.7). This label must match exactly for the automatic event notification and retrieval process to function correctly.

Step 5. Use the logic settings (**SET L**) to create a logic bit on the master port that asserts when the communications processor recognizes an event report from any of the 16 EIA-232 ports. These example settings use Breaker Bit 15. Equation SBR15 is the set equation for Breaker Bit 15. Program the bit to clear (n:CBR15) on the reset of any new event status bit (!n:BR16).

```
SET L n         [where n is the master port number]

SBR15 = 1:BR16 + 2:BR16 + 3:BR16 + 4:BR16 + 5:BR16 + 6:BR16 + 7:BR16 +
8:BR16 + 9:BR16 + 10:BR16 + 11:BR16 + 12:BR16 + 13:BR16 + 14:BR16 + 15:BR16
+ 16:BR16

CBR15 = !1:BR16 + !2:BR16 + !3:BR16 + !4:BR16 + !5:BR16 + !6:BR16 + !7:BR16
+ !8:BR16 + !9:BR16 + !10:BR16 + !11:BR16 + !12:BR16 + !13:BR16 + !14:BR16
+ !15:BR16 + !16:BR16
```

Step 6. To notify the SEL-5040 that new event data are available, the communications processor sends an automatic message to the SEL-5040. Use the automatic message settings on the master port (**SET A**) to create this message.

```
SET A n         [where n is the master port number]

MSG_CNT = 1

ISSUE1 = 1:SBR16 + 2:SBR16 + 3:SBR16 + 4:SBR16 + 5:SBR16 + 6:SBR16 +
7:SBR16 + 8:SBR16 + 9:SBR16 + 10:SBR16 + 11:SBR16 + 12:SBR16 + 13:SBR16 +
14:SBR16 + 15:SBR16 + 16:SBR16 + n:BR15 * P00:00:30.0 [where n is the
master port number]

MESG1 = "NEW EVENT\n"

ARCH_EN = N
USER = 1
```

The MESG1 string must match exactly the **Notification String** setting in the **Configure Polling and Listening** form (Figure 8.8). To enable the listening mode, check the **Wait for Notification When Not Calling** box in the **Listening** section. Set **Interval** to a value between 1 and 60 seconds, and set the **Notification String** to match MESG1 in the communications processor.

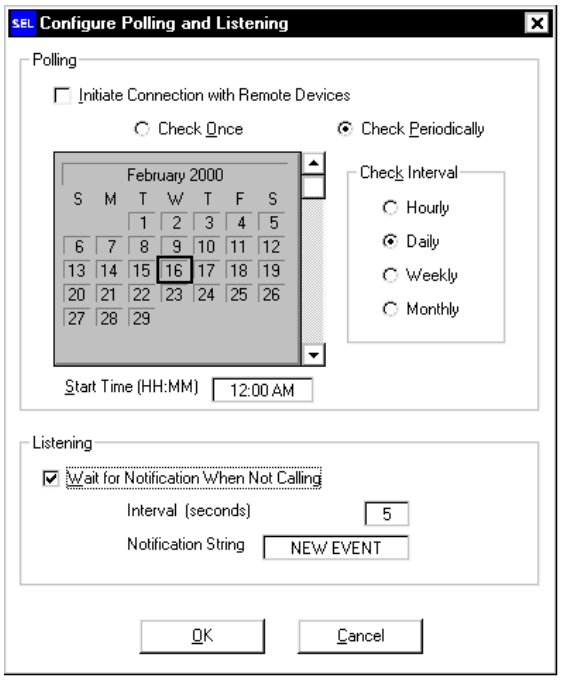

Figure 8.8: Configure Polling and Listening Form

Step 7. Configure the communications processor to respond to the **ID Command** from the SEL-5040. Use the **User Defined Commands** and **Automatic Message** settings of the communications processor. The **User Defined Command** recognizes the **ID Command**, and the automatic message sends the response.

```
SET U n        [where n is the communications processor master port number]

CMD_CNT = 1
CMD1  = WhoAreYou
```

Step 8. Set CMD1 to match exactly the **ID Command** setting from the option on the **Configure Communications** form that Figure 8.9 illustrates.

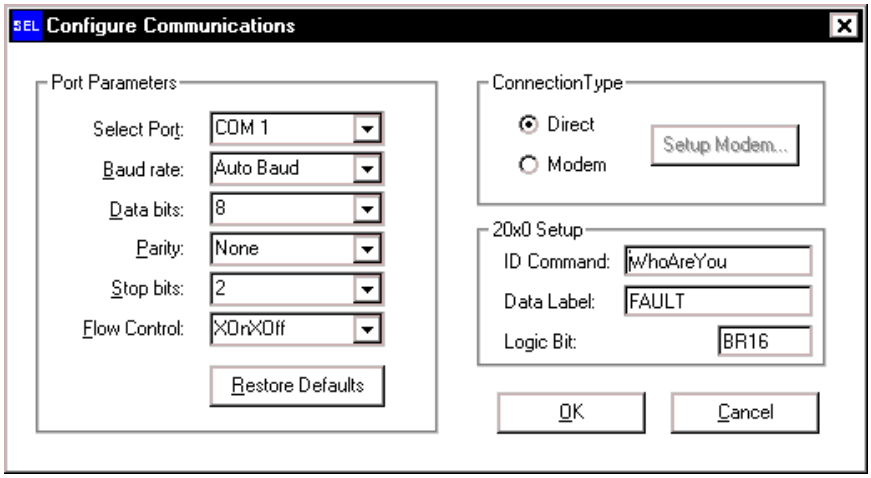

Figure 8.9: Configure Communications Form

Step 9. Add an Automatic Message setting (MESG2) in the communications processor to respond to the **ID Command** from the SEL-5040. Increment the message count and set the new issue condition and message.

```
SET A n         [where n is the master port number]

MSG_CNT = 2

ISSUE1 = 1:SBR16 + 2:SBR16 + 3:SBR16 + 4:SBR16 + 5:SBR16 + 6:SBR16 +
7:SBR16 + 8:SBR16 + 9:SBR16 + 10:SBR16 + 11:SBR16 + 12:SBR16 + 13:SBR16 +
14:SBR16 + 15:SBR16 + 16:SBR16 + n:BR15 * P00:00:30.0 [where n is the
master port number]

MESG1  = "NEW EVENT\n"

ISSUE2 = n:CMD1
MESG2  = "%%Upper2032%%\n"

ARCH_EN = N
USER  = 1
```

You must enclose the MESG2 setting in double percent characters and match exactly the **Dial Directory ID** setting in the **Connection Directory**, as the example settings show. Refer to the **Connection Directory Edit** form (Figure 8.10) to verify the **Dial Directory ID** setting. Note that the **Dial Directory ID** in the **Connection Directory** does not include the double percent characters.

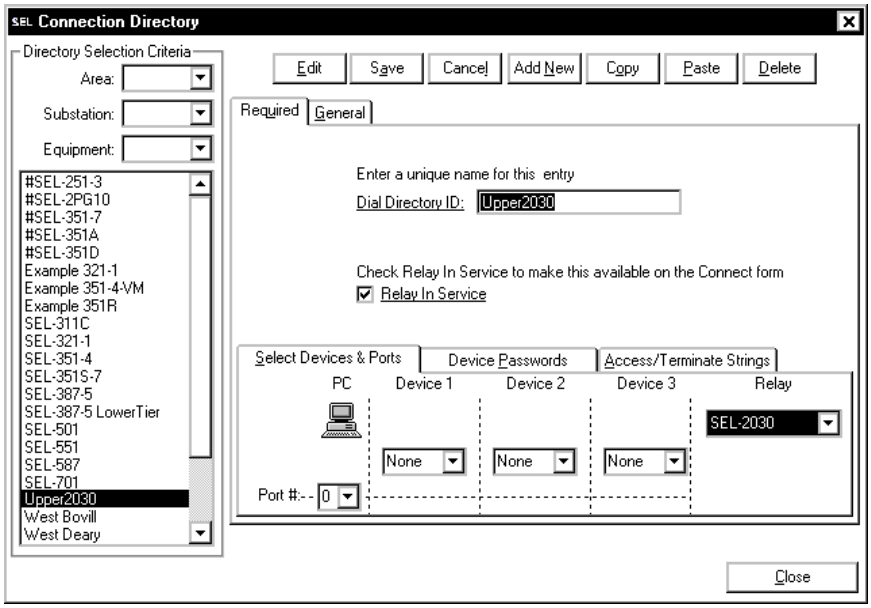

Figure 8.10: SEL-5040 Connection Directory Edit Form

The configuration is now complete. Return to the main form of the SEL-5040 and click **Run**. Relay event summary messages notify the SEL-5040 to connect and retrieve new event reports, as they are available.

Automatic Notification Via Multitiered Communications Processors

In some applications, automatic notification of new event data requires connections through multiple tiers of communications processors. This connection architecture requires modifications to the single-level communications processor application described previously. As with direct polling and single-tier communications processor automatic notification, if you choose to use an SEL-5010 database, you must use the SEL-5010 Relay Assistant to configure **Connection Directory** entries for the communications processors.

This section addresses only the configuration of the upper-tier communications processors. Follow the instructions in *Automatic Notification Via a Single Communications Processor on page 8.6* to configure the SEL relays and each lower-tier communications processor.

Logic and Data Flow

Figure 8.11 shows the logic and data flow for the multitiered connection. The process begins at the SEL relay with the generation and transmission of an automatic event summary message. The communications processor recognizes the event summary message and sets a logic bit. The communications processor then assembles the logic bits from all monitored relays into a single new event status register.

Once the communications processor sets a logic bit, the lower-tier communications processor sends an indication to the upper-tier communications processor. The upper-tier communications processor sets a logic bit based on this indication from the lower-tier, assembles the logic bits into a new event status register, and sends an indication to the SEL-5040 that new event data are available.

The SEL-5040 determines the connected device by issuing the **ID Command** to the communications processor and matching the response with the **Dial Directory ID**. Additionally, the SEL-5040 scans the contents of the new event status register to determine which connected devices contain new event data. Following this identification process, the SEL-5040 uses the information in the **Connection Directory** to connect transparently to the relay, access the relay, and retrieve the new event data. Once the SEL-5040 retrieves the new event data, it resets the logic bits and terminates all connections.

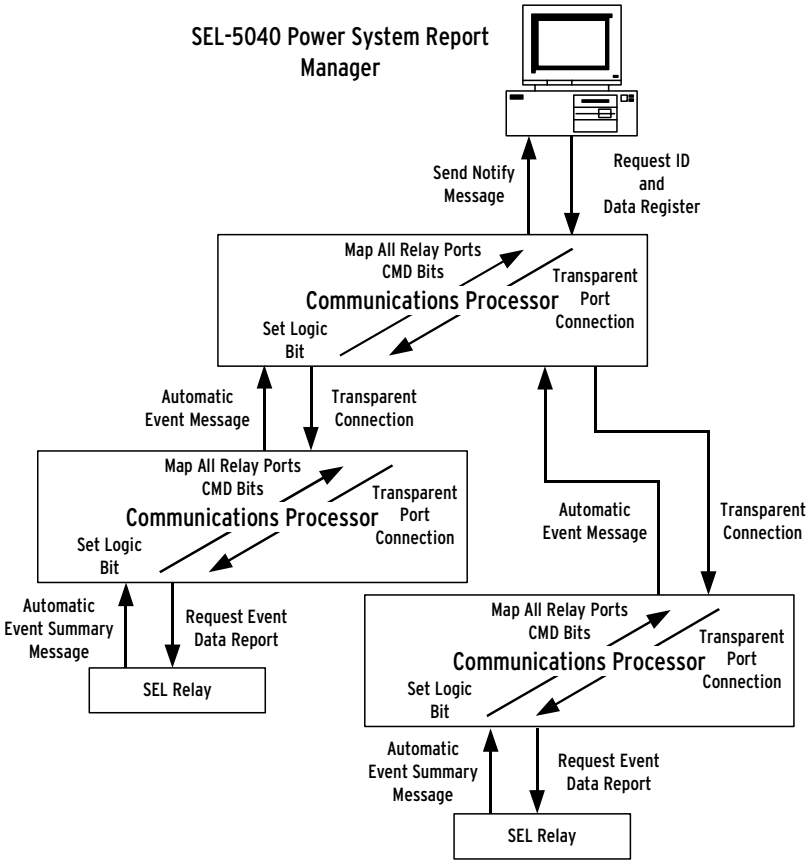

Figure 8.11: Multitiered Logic and Data Flow for Automatic Notification and Event Retrieval

The SEL-5040 uses the passwords and identification information in the Connection Directory to connect transparently to each lower-tier communications processor and request from each the Dial Directory ID and new event status register. The SEL-5040 then identifies relays with new event data, connects transparently to them, and retrieves the new event data. Once the SEL-5040 retrieves the new event data, it resets the logic bits and terminates all connections.

We assume in the following settings instructions that you have configured the lower-tier communications processor and SEL relays according to the procedure we outlined in *Automatic Notification Via a Single Communications Processor on page 8.6*.

Device Settings

Step 1. Set the upper-tier communications processor to watch for the Notification String (NEW EVENT) from each lower-tier communications processor. Use the User Defined settings (SET U) of each upper-tier communications processor for this purpose. Apply this setting on the port connected to each lower-tier communications processor.

```
SET U n        [where n is the communications processor port number]

CMD_CNT = 1
CMD1 = NEW EVENT
```

This configuration pulses the communications processor command bit (CMD1) when the upper-tier communications processor receives the Notification String message. The communications processor then uses the CMD1 bit to latch a logic bit to indicate that new event data are available from the connected communications processor and SEL relays.

Step 2. Use the logic settings (SET L) to create the new event logic bit. These example settings use Breaker Bit 16. Use the CMD1 bit to set Breaker Bit 16. SBR16 is the set equation for Breaker Bit 16 (BR16).

```
SET L n SBR16  [where n is the communications processor port number]

SBR16 = n:CMD1
```

Step 3. The SEL-5040 requires the communications processor to request an event history from a relay after breaking a transparent connection. Use the automatic message settings on the communications processor relay port (SET A) to create this message.

```
SET A n        [where n is the communications processor port number]

MSG_CNT = 1

ISSUE1 = !n:0800h:3
MESG1 = 20HISTORY

ARCH_EN = N
USER = 0
```

Step 4. Assemble all new event logic bits into the new event status register on the communications processor port connected to the PC running the SEL-5040. Use the communications processor Math/Data Movement settings (**SET M**) to perform this concentration. These example settings concentrate Breaker Bit 16 (BR16) from all ports on the communications processor into the new event status register. This maintains a logical mapping order of bit location to port number within the register. Map all bits, even when some communications processor ports are not connected to SEL relays or are not part of the event data collection system.

```
SET M n        [where n is the communications processor port number]

1 000h:0;B = 1:BR16
2 000h:1;B = 2:BR16
3 000h:2;B = 3:BR16
4 000h:3;B = 4:BR16
5 000h:4;B = 5:BR16
6 000h:5;B = 6:BR16
7 000h:6;B = 7:BR16
8 000h:7;B = 8:BR16
9 000h:8;B = 9:BR16
10 000h:9;B = 10:BR16
11 000h:10;B = 11:BR16
12 000h:11;B = 12:BR16
13 000h:12;B = 13:BR16
14 000h:13;B = 14:BR16
15 000h:14;B = 15:BR16
16 000h:15;B;FAULT = 16:BR16
```

These settings concentrate the new event logic bits into the first register of the USER data region of the communications processor Port n and

assign the label FAULT to the register. FAULT is the Data Label set in the **Configure Communications** form of the SEL-5040. The SEL-5040 Data Label and the label associated with the new event status register (SET M line 16) must match exactly for the automatic event notification and retrieval process to function correctly.

Use the logic settings (**SET L**) to create a logic bit on the master port that asserts when the communications processor recognizes an event report from any of the 16 EIA-232 ports. These example settings use Breaker Bit 15. Equation SBR15 is the set equation for Breaker Bit 15. Program the bit to clear (n:CBR15) on the reset of any new event status bit (!n:BR16).

```
SET L n        [where n is the master port number]

SBR15 = 1:BR16 + 2:BR16 + 3:BR16 + 4:BR16 + 5:BR16 + 6:BR16 + 7:BR16 +
8:BR16 + 9:BR16 + 10:BR16 + 11:BR16 + 12:BR16 + 13:BR16 + 14:BR16 + 15:BR16
+ 16:BR16

CBR15 = !1:BR16 + !2:BR16 + !3:BR16 + !4:BR16 + !5:BR16 + !6:BR16 + !7:BR16
+ !8:BR16 + !9:BR16 + !10:BR16 + !11:BR16 + !12:BR16 + !13:BR16 + !14:BR16
+ !15:BR16 + !16:BR16
```

Step 5. To notify the SEL-5040 that new event data are available, the communications processor sends an automatic message to the SEL-5040. Use the automatic message settings on the master port (**SET A**) to create this message.

```
SET A n        [where n is the master port number]

MSG_CNT = 1

ISSUE1 = 1:SBR16 + 2:SBR16 + 3:SBR16 + 4:SBR16 + 5:SBR16 + 6:SBR16 +
7:SBR16 + 8:SBR16 + 9:SBR16 + 10:SBR16 + 11:SBR16 + 12:SBR16 + 13:SBR16 +
14:SBR16 + 15:SBR16 + 16:SBR16 + n:BR15 * P00:00:30.0 [where n is the
master port number]

MESG1 = "NEW EVENT\n"

ARCH_EN = N
USER = 1
```

The MESG1 string must match exactly the **Notification String** setting in the SEL-5040 **Configure Polling and Listening** form (Figure 8.12). To enable the listening mode, check the **Wait for Notification When Not Calling** box in the **Listening** section. Set **Interval** to a value between 1 and 60 seconds, and set the **Notification String** to match MESG1 in the communications processor.

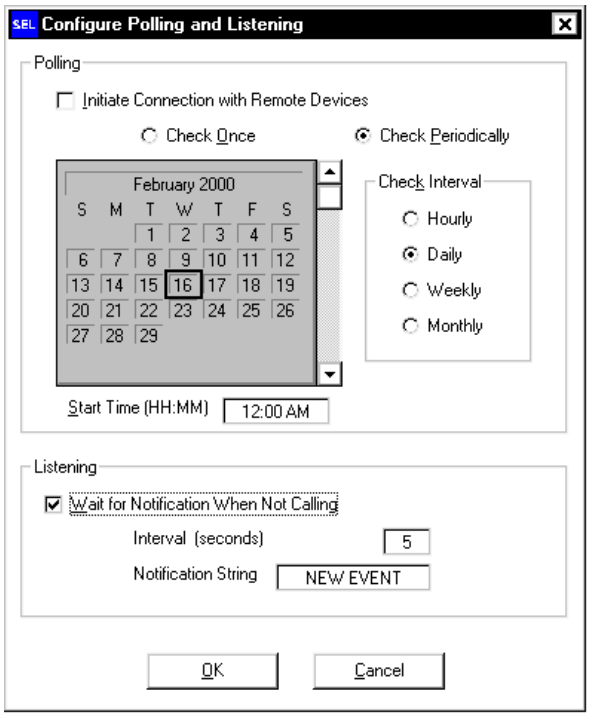

Figure 8.12: Configure Polling and Listening Form

Step 6. Configure the communications processor to respond to the **ID Command** from the SEL-5040. Use the **User Defined Commands** and **Automatic Message** settings of the communications processor. The **User Defined Command** recognizes the **ID Command**, and the automatic message sends the response.

```
SET U n        [where n is the communications processor master port number]

CMD_CNT = 1
CMD1  = WhoAreYou
```

Set CMD1 to match exactly the **ID Command** setting in the **Configure Communications** form that Figure 8.13 illustrates.

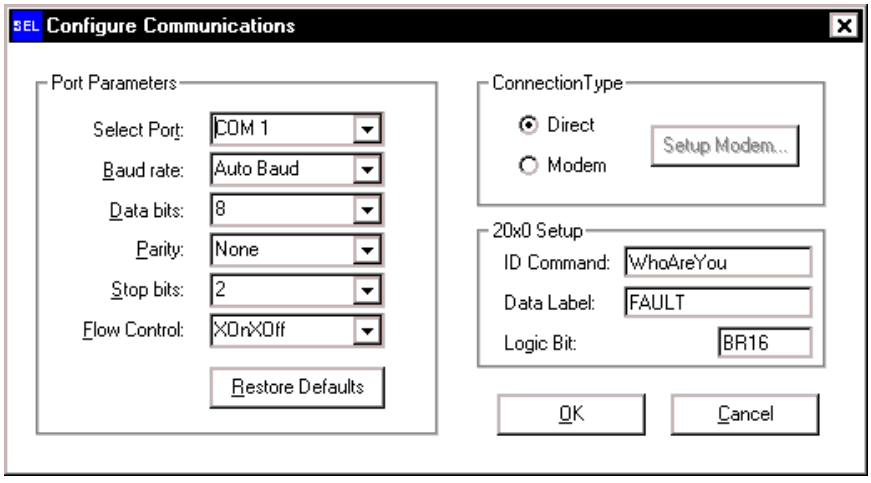

Figure 8.13: Configure Communications Form

Step 7. Add an Automatic Message setting to the communications processor to respond to the **ID Command** from the SEL-5040. Increment the message count and set the new issue condition and message.

```
SET A n        [where n is the master port number]

MSG_CNT = 2

ISSUE1 = 1:SBR16 + 2:SBR16 + 3:SBR16 + 4:SBR16 + 5:SBR16 + 6:SBR16 +
7:SBR16 + 8:SBR16 + 9:SBR16 + 10:SBR16 + 11:SBR16 + 12:SBR16 + 13:SBR16 +
14:SBR16 + 15:SBR16 + 16:SBR16 + n:BR15 * P00:00:30.0 [where n is the
master port number]

MESG1 = "NEW EVENT\n"

ISSUE2 = n:CMD1
MESG2 = "%%Upper2032%%\n"

ARCH_EN = N
USER = 1
```

You must enclose the MESG2 setting in double percent characters and match exactly the **Dial Directory ID** setting in the **Connection Directory**, as the example settings show. Refer to the **Connection Directory Edit** form to verify the **Dial Directory ID** setting that Figure 8.14 illustrates. Note that the **Dial Directory ID** in the **Connection Directory** does not include the double percent characters.

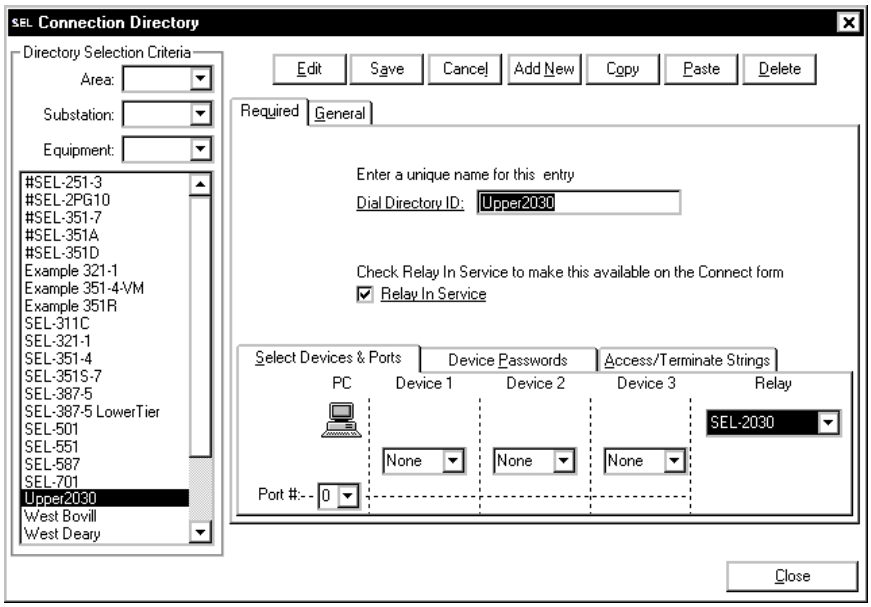

Figure 8.14: SEL-5040 Connection Directory Edit Form

The configuration is now complete. Return to the main form of the SEL-5040 and click **Run**. Relay event summary messages notify the SEL-5040 to connect and retrieve new event reports.

Direct Polling of SEL Relays Via a Communications Processor

When you connect relays to the communications processor but do not want automatic notification, you can identify and retrieve event reports easily with the SEL-5040 direct polling method. Follow the configuration and setup steps that the automatic notification sections describe, ensuring that you add communications processors to the **Connection Directory**. On the **Configure Devices to Poll** form (Figure 8.3), select either the communications processor or the upper-tier communications processor (in the case of a multitiered application) as the device to poll. Enable automatic polling by checking the box for **Initiate Connection with Remote Devices** on the **Configure Polling and Listening** form (Figure 8.12). Then choose the interval of the poll with either the single or periodic selections. From the main form, click **Run** to cause the SEL-5040 to check for events via the communications processor at the set period or selected date.

Modem Connections for Automatic Notification

Use automatic notification mode for modems to dial into the computer running the SEL-5040. You must enter additional settings in the SEL-5040 and the communications processor to support this mode. The communications processor notification message must initiate a dial out to the computer running the SEL-5040, and the SEL-5040 must disconnect the phone connection following the completion of event report retrieval.

SEL-5040 Settings

Use the **Connection Type** option on the **Configure Communications** form (Figure 8.15) to configure the SEL-5040 for modem use. Check the **Modem** option and click the **Setup Modem** button to configure the modem for your PC.

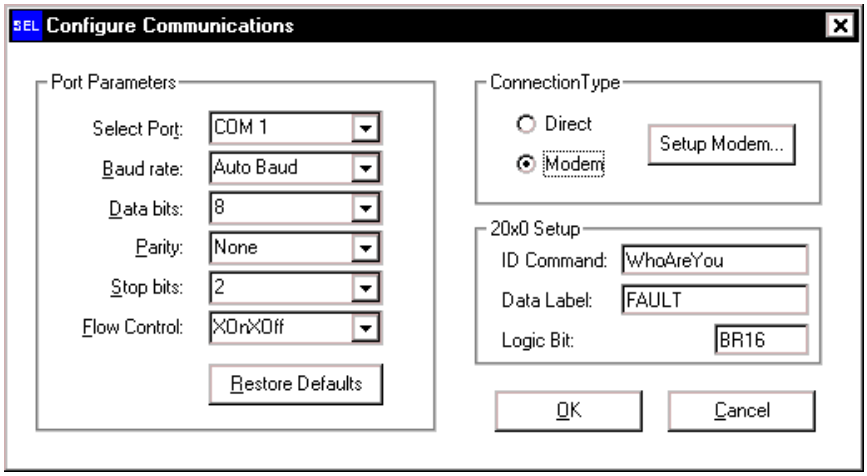

Figure 8.15: Configure Communications Form

Communications Processor Settings

Modify the communications processor SET M equations to provide a new event status bit. Recall from the previous SET M equation description that lines 1–16 build a bitmapped status word to indicate that new event data are available on associated communications processor ports. Create additional SET M equations (lines 17–34) to build a status bit that triggers automatic modem dial out. The additional SET M equations logically OR the 16 bits from Register 0, and store the result in Bit 0 of Register 1. Assertion of this status bit indicates that new event data are available on at least 1 of the 16 communications processor ports.

The following setting example illustrates proper SET M configuration for a modem connected to Port 8.

```
SET M 8
1 000h:0;B = 1:BR16
2 000h:1;B = 2:BR16
3 000h:2;B = 3:BR16
4 000h:3;B = 4:BR16
5 000h:4;B = 5:BR16
6 000h:5;B = 6:BR16
7 000h:6;B = 7:BR16
8 000h:7;B = 8:BR16
9 000h:8;B = 9:BR16
10 000h:9;B = 10:BR16
11 000h:10;B = 11:BR16
12 000h:11;B = 12:BR16
13 000h:12;B = 13:BR16
14 000h:13;B = 14:BR16
15 000h:14;B = 15:BR16
16 000h:15;B;FAULT = 16:BR16
17 001h:0;B = 0
18 001h:0;B += 8:F800h:0
19 001h:0;B += 8:F800h:1
20 001h:0;B += 8:F800h:2
21 001h:0;B += 8:F800h:3
22 001h:0;B += 8:F800h:4
23 001h:0;B += 8:F800h:5
24 001h:0;B += 8:F800h:6
25 001h:0;B += 8:F800h:7
26 001h:0;B += 8:F800h:8
27 001h:0;B += 8:F800h:9
28 001h:0;B += 8:F800h:10
29 001h:0;B += 8:F800h:11
30 001h:0;B += 8:F800h:12
31 001h:0;B += 8:F800h:13
32 001h:0;B += 8:F800h:14
33 001h:0;B += 8:F800h:15
```

Next, modify the notification message to dial out and connect to the remote PC before sending the NEW EVENT message. The port settings of the communications processor include a selection for modem control. You must enable this setting to have modem dial-out capability. The following settings show the NEW EVENT message that you created in the previous automatic notification example modified to include automatic dial out to 5551212. The settings indicate proper configuration for a modem connected to Port 8.

```
SET A 8

MSG_CNT = 4
ISSUE1 = 8:F801h:0
MESG1 = "\IATDT5551212:N/NEW EVENT\n"
ISSUE2 = !8:D1 * P00:30:00.0 * !8:0800h:7 * 8:F801h:0
MESG2 = "\IATDT5551212:N/NEW EVENT\n"
ISSUE3 = 8:CMD1
MESG3 = "%%Upper2032%%\n"
ISSUE4 = !XT * !8:BR16 * !8:D1 * !8:D2
MESG4 = "\Math\n"
ARCH_EN = N
USER = 2
```

If Bit 0, Register 1 of the Port 8 USER region data indicates that a new event is present, MESG1 dials the remote modem. Upon establishment of a successful connection, the communications processor transmits the NEW EVENT string to the remote modem. The :N option within the dial string leaves the modem connected following the message.

MESG2 repeats the dial-out process if MESG1 fails. In the example above, MESG2 triggers a redial sequence every 30 minutes. MESG2 repeats the dial-out process until the SEL-5040 retrieves the new event report data successfully. This setting ensures continual redial attempts until the SEL-5040 database stores the new event report successfully.

After successful modem connection, MESG3 transmits the Dial Directory ID in response to the SEL-5040 **ID Command**. After retrieving all event data from the calling communications processor, the SEL-5040 disconnects the modem connection.

MESG4 disconnects the modem automatically if a connection is established, and the SEL-5040 does not receive the **ID Command** after a specified time interval. This setting limits the connection duration if the remote modem is configured for auto answer and the SEL-5040 is not operational.

Next, enter SET L settings to latch a logic bit at the successful establishment of an SEL-5040 connection. The following example illustrates SET L settings if the modem is connected to Port 8.

```
SET L 8

SBR16  = 8:CMD1
CBR16  = !8:0800h:7
```

When the SEL-5040 receives the **ID Command**, 8:BR16 latches, indicating establishment of a connection with the SEL-5040. When the connection terminates, the modem connection status bit clears the breaker bit.

The final step is to set the modem disconnect timer in the SET G settings. The following example illustrates SET G settings for a modem connected to Port 8. We chose the X variable timer for this example, but you may use the Y or Z timer if you adjust the SET A settings. For this example, we chose a two-minute disconnect time.

```
SET G

ID   =""
LOG_EN = Y
V    = NA
W    = NA
X    = 8:D1 * 8:0800h:7 + 8:D2 * 8:0800h:7
Y    = NA
Z    = NA
XPICKUP = OFF
XDROPOUT= 120.0
YPICKUP = OFF
YDROPOUT= OFF
ZPICKUP = OFF
ZDROPOUT= OFF
```

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Section 9: SEL-5601 Analytic Assistant

Introduction

The SEL-5601 Analytic Assistant is very similar to the analysis program available in the ACSELERATOR® SEL-5030 Software. The SEL-5601 is used to display event reports as oscillography, phasors, or by harmonic content. The SEL-5601 can read ASCII COMTRADE, SEL Compressed ASCII, and some SEL ASCII events. The preferred format is SEL Compressed ASCII.

The SEL-5040 Power System Report Manager, ACSELERATOR, or SEL-5010 Relay Assistant all capture historical files from SEL relays. Additionally, you can view event reports and the text captured in a terminal emulator by typing **EVE *n* C** at the command prompt (where ***n*** = event number).

Figure 9.1 shows the main form of the SEL-5601. After opening an event report, you can also select a saved preferences file. Graphing preferences are saved under **View > Graph Preferences**, as shown in Figure 9.2.

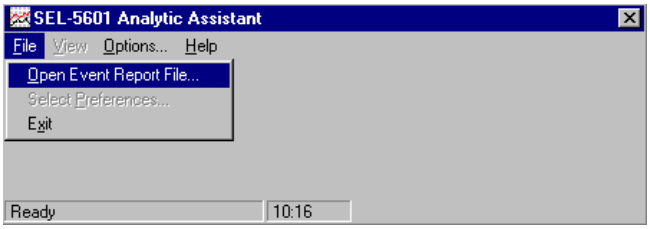

Figure 9.1: SEL-5601 Analytic Assistant Main Form

Analysis of Event Reports

Figure 9.2 shows the various viewing options available in the SEL-5601. Each of the viewing options is detailed in the following subsections.

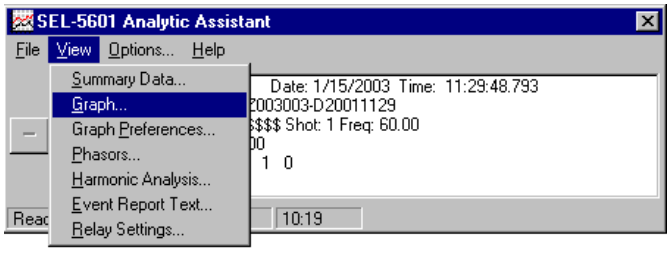

Figure 9.2: View Options

Table 9.1: View Options in the SEL-5601 Analytic Assistant

Option	Description
Summary Data	Displays historical summary data for the event. This is similar to the data retrieved by typing the **HIS** command in the terminal window (see *Summary Data on page 9.1* for more details).
Graph	Displays the oscillogram as shown in Figure 9.4 (see *Graph on page 9.3* for more details).
Graph Preferences	Allows you to modify what is plotted on the oscillogram (see *Graph Preferences on page 9.1* for more details).
Phasors	Displays the phase and sequence component in phasor diagrams as shown in Figure 9.5 (see *Phasors on page 9.4* for more details).
Harmonic Analysis	Performs a harmonic analysis on the data between any two points in time, as selected by the user (see Figure 9.6 for an example).
Event Report Text	Displays the text from the event report (see *Harmonic Analysis on page 9.5* for more details).
Relay Settings	Displays the settings in the relay when the event report was saved (see *Relay Settings on page 9.1* for more details).

Summary Data

Choosing the **View > Summary Data** option opens an **Event Report Summary**, which displays general information about the event report.

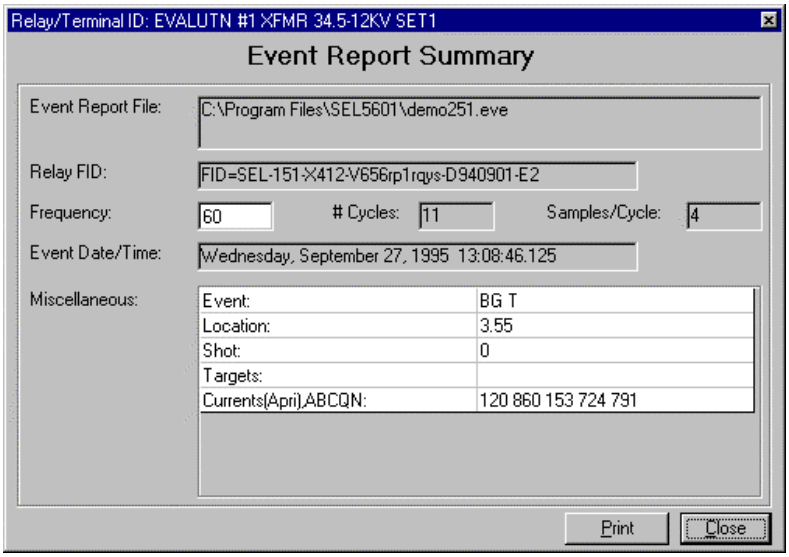

Figure 9.3: Event Report Summary

Table 9.2: Options on the Event Report Summary

Option	Description
Event Report File	Displays the full path and filename of the event report file.
Relay FID	Displays the relay FID (Firmware Identification) for the relay that collected the event.

Frequency	The frequency is displayed in an editable field on the **Event Report Summary** form. This should be verified for correctness. It is not always possible to determine the frequency from an event report (usually extracted from the relay FID). In the case where the frequency is not specified in the FID, the SEL-5601 will use the default frequency specified in the **Options** form. It is up to the user to ensure that the frequency is correct. This is essential for correct calculation of the phasor and sequence elements. When closing the **Event Report Summary** form, the SEL-5601 will verify that the frequency is between 30 Hz and 90 Hz.
# Cycles	Displays the number of cycles in the event report.
Samples/Cycle	Displays the number of samples per cycle in the event report. This value is 4 for SEL-100 and SEL-200 series relays and varies for SEL-300 and SEL-500 series relays.
Event Date/Time	Displays the date and time of the event report.
Miscellaneous	Displays other information taken from the event report. Items may include summary information, such as event, location, and fault current. Information displayed depends on the relay type. Some relays will not include any data in this field.
Print	Click this button to print the data displayed on the **Summary** form, plus the analog and digital channel names and descriptions.

Graph

Choosing **View > Graph** displays an oscillogram like the sample shown in Figure 9.4, which shows just a few of the digitals that are available for display. The event report can be up to 30 cycles long, depending on the relay. The items displayed on the graphs are selected under **View > Graph Preferences**.

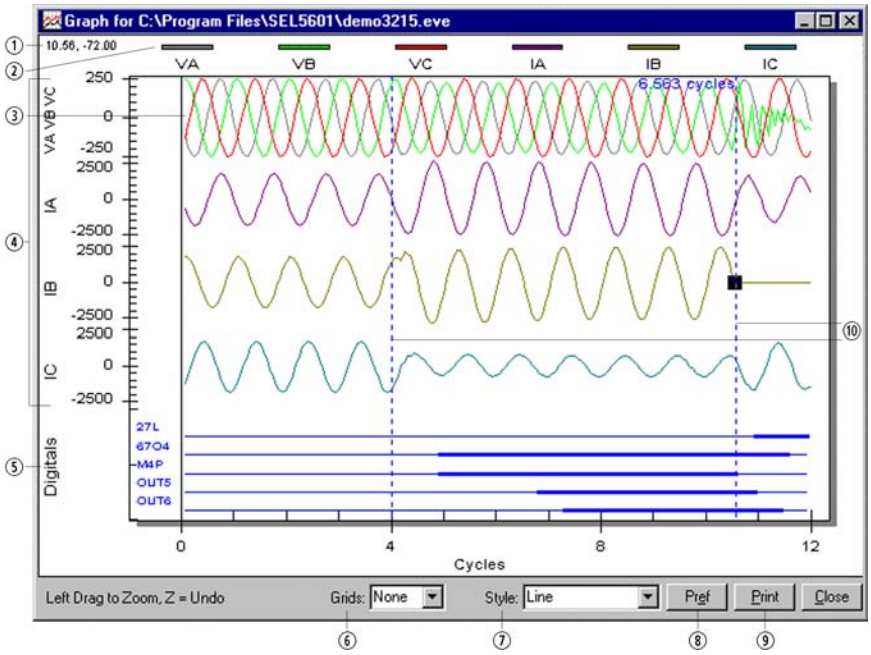

Figure 9.4: Graph of Event Data

① Time/Magnitude Values: The first value indicates the time reference associated with the data cursor location. The time units are determined by a setting in the Graph Preferences screen. The second value is the analog magnitude (volts/amps peak) of the waveform at the data cursor location.

② Color Bars: Color bars at the top of the form indicate the graph line color representations. Colors are defined in the Advanced Preferences form (accessed by choosing View > Graph Preferences; see Advanced Preferences Tab on page 9.9).

③ Data Cursor: Move the data cursor by using the left mouse button or the arrow keys. For event reports with a trigger flag, pressing <F2> or <Ctrl+T> moves the cursor to the trigger point.

④ Oscillographic Display: Displays the selected analog and digital channels. If the Show Trigger on Graph option is selected in the Options form, and the event report includes a trigger mark, the trigger point is indicated on the graph by a dashed vertical line.

⑤ Digital Data: The digital data is displayed with a thin line for logical 0 and a thick line for logical 1. Because the event reports may use one column for multiple elements, a label will be placed above the start of the thick line, indicating that the element asserted. For example, a column for 51Q may display a period character for logical 0, a p for pickup and T for timed pickup. The digital display will have a thin line for the period and a thick line with a p above it for the pickup condition. If the column changes to T, then a label will be placed above the line at the assertion point.

NOTE: When a digital element changes above a line that is already thick, the left side of the element label corresponds to where the element asserted. Zoom in for better resolution.

⑥ Grids: Select the grid line style displayed on the graph. Choices include X only, Y only, X and Y, or None.

⑦ Style: Select the style of the data lines displayed on the graph. For best performance during scrolling, use the line style. Four choices are available for line style:

Line: Draws straight lines between the data points.

Line + Points: Displays the data points and draws straight lines between the points.

Curve: Draws a best-fit curve between the data points.

Curve + Points: Displays the data points and draws a best-fit curve between the points.

⑧ Pref: Opens the Graph Preferences form.

⑨ Print: Prints the graph as displayed, including any zooming (see the Options form for printing options)

⑩ F3 and F4 Markers: Select a data point of interest, then press <F3> to mark a vertical line. Move the cursor to the next point of interest, and then press <F4> to mark a second vertical line. The SEL-5601 will display the row/cycle/time difference between the two lines. This is useful for determining the delta time between two data points.

Phasors

A sample Phasor Analysis is shown in Figure 9.5. The **Auto Increment** feature displays the event in chronological order. The **Channel** column with the **1** in the **Ref** column is the reference for the phasor diagram (in Figure 9.5 it is **V1**). Clicking the **Show** column toggles the selected item on or off. Clicking the **Scale** column toggles the scale from **1**, to **10**, to **100**.

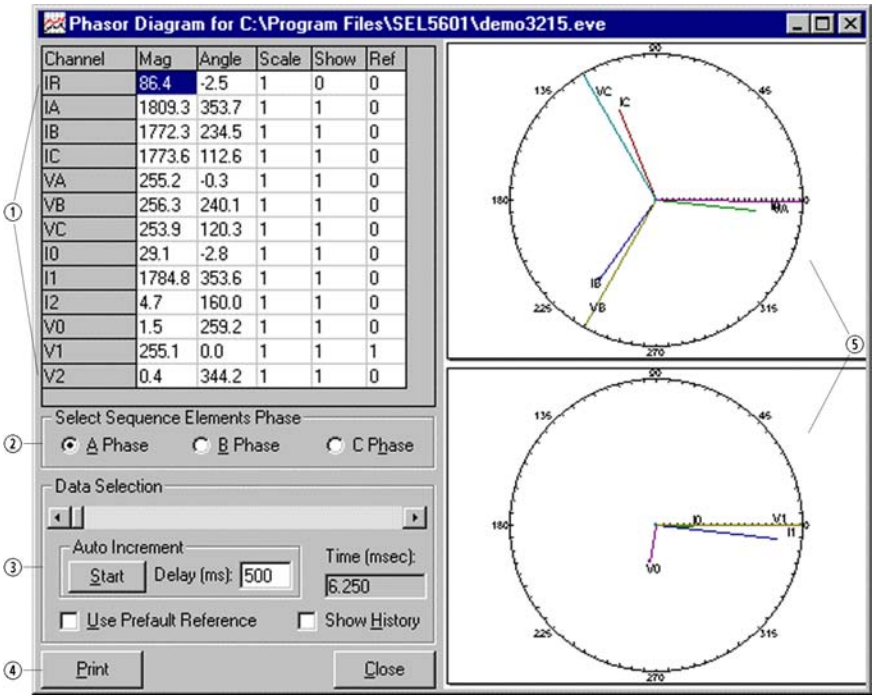

Figure 9.5: Phasor Diagrams of Event Data

① Data Grid: This area displays channel data for an event report in a data grid as the SEL-5601 scrolls through the report. The Magnitude and Angle calculations indicate instantaneous values for the given location of the event report. Use the Scale field to rescale analog values displayed in an event report (the default Scale value is 1). Use the Show field to select or deselect channels for display on the phasor graph display (1 = select, 0 = deselect). Use the Ref field to designate a channel as the reference phasor. The reference phasor is placed at 0 degrees on the phasor graph display.

② Select Sequence Elements Phase: Select whether to display A-Phase, B-Phase, or C-Phase sequence elements on the graph.

③ Data Selection: These control the scrolling, or animation, of the phasor diagram. Drag the scroll bar right or left to move up or down through the event report. Click the Start button to begin automatic scrolling through the event report. The Delay field specifies the duration between steps. The Time (msec) field displays the time-tag of the displayed values. Select the Use Prefault Reference box to reference the phasor display to prefault values. Selecting the Show History box causes the phasor graph to record historical traces as the phasor display evolves.

④ Print: Prints the phasor diagram as it is currently displayed, including any zooming.

⑤ Phasor Graph Display: Very small magnitudes are not displayed unless the scale factor is used to force them to be significant. The actual data values are also seen in the data grid. The current channels are scaled together and the voltage channels are scaled together so that voltages displayed in kV will not appear small relative to current values. The data on the display starts after the first quarter cycle. This is done so the first data points contain accurate data. To zoom in, click and drag with the left mouse button. To zoom out, press <Z>. The right mouse button opens the graph context menu. The context menu allows you to maximize the graph and export the data, as well as use many other graph display options.

Harmonic Analysis

The **Harmonic Analysis** screen shown in Figure 9.6 displays harmonics up to the seventh order. The harmonics can be displayed as percentages or in engineering units. Select **Refresh** after changing any of the options selectable on this screen.

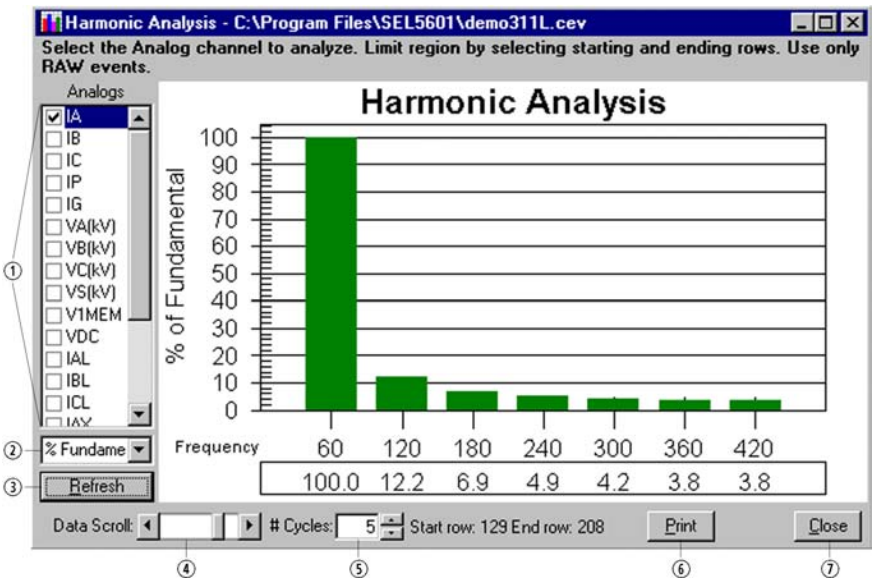

Figure 9.6: Harmonic Analysis of Event Data

① Analogs: Place a check in the box next to the analog signal for which you want a harmonic analysis.

② Display Type: Select either % Fundamental or % Engineering units.

③ Refresh: Click this button after changing either the # Cycles or Data Scroll setting.

④ Data Scroll: Selects the group of data you wish to analyze. The # Cycles must be less than the total cycles in the event report to have this option enabled.

⑤ # Cycles: Selects the number of cycles you wish to analyze.

⑥ Print: Prints the Harmonic Analysis to your default printer.

⑦ Close: Closes the Harmonic Analysis window.

Event Report Text

The **Event Report** text form displays the text from the event report file. Nonprintable control characters are displayed in this screen as small squares. If a file contains multiple event reports, only the selected event report will be displayed. Resize the form by clicking the maximize button or by dragging the application border with the left mouse button. Click the **Close** button to close the form. Refer to the SEL relay instruction manual for specific details on how to read your textual event report.

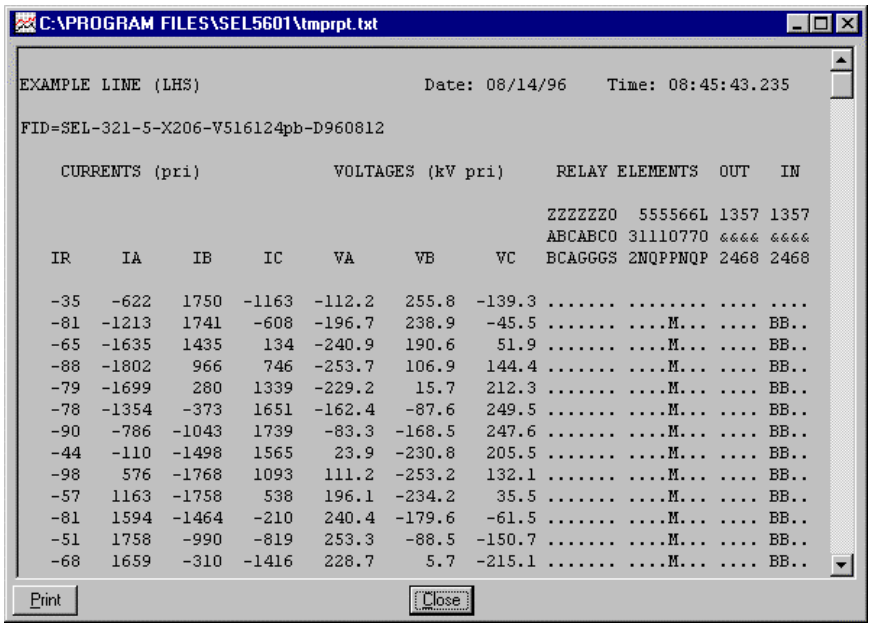

Figure 9.7: Event Report Text Form

Relay Settings

The **Relay Settings** form displays the settings saved in the event report file. The settings saved in the event report file are those in the relay when the file was uploaded from the relay. They are not necessarily the settings in the relay when the event occurred.

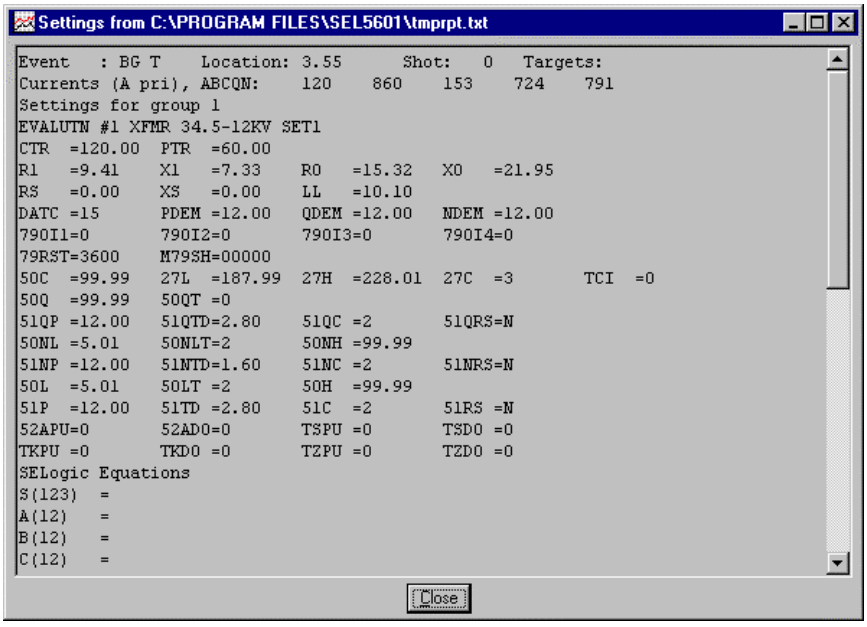

Figure 9.8: Relay Settings Form

Graph Preferences

Once an event report is loaded into the SEL-5601, use the menu at the top of the main form to select viewing options. Selecting **View > Graph Preferences** gives you access to the **Graph Preferences** form.

Use the **Graph Preferences** form to configure the SEL-5601 graph display settings for the selected event report. After selecting the preferences, you may save them to a preference file. Once you save preferences for a given event report, the **Graph Preferences** form is not displayed when you are selecting **View > Graph** for the event report. Instead, the graph displays using the saved preferences. This also happens if you select **View > Graph** after already setting preferences, even if they have not been saved to a file.

To view the **Graph Preferences** form again after preferences have been saved, select **View > Graph Preferences** from the main form menu or click the **Pref** button on the **Graph** form.

When preferences are saved, not only is the preference file created (or updated), but the preference file path is also appended to the event report file.

Preferences Tab

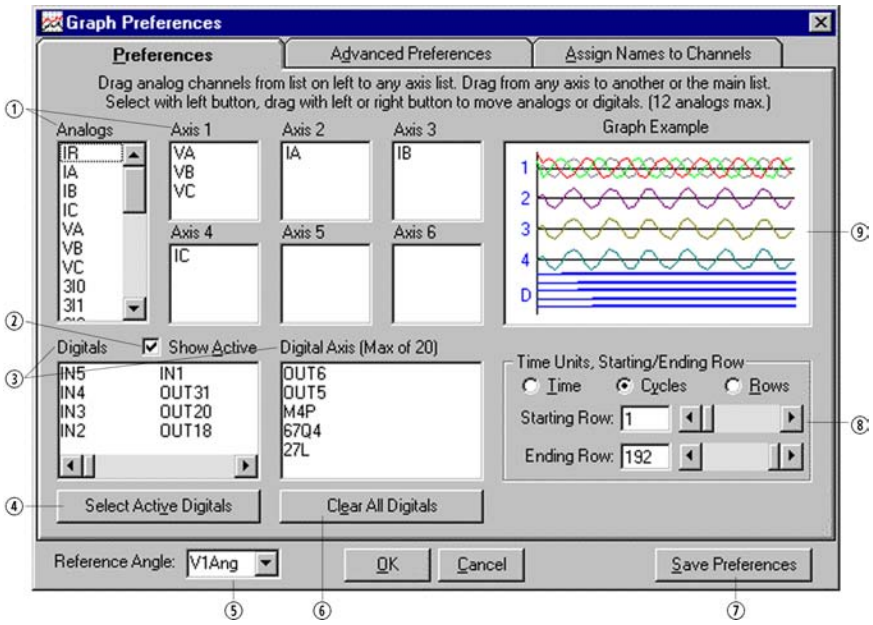

Figure 9.9: Graph Preferences

① Analogs/Axis 1-6: The Analogs box lists the analog waveform channels available in the selected event report. Select individual analog channels or drag the mouse pointer across several channel assignments. Drag the selected channel assignments to the desired graph axis. Use the select and drag method to move channels between axis boxes. Only axes with assigned analog channels are plotted on the Graph form. A maximum of 12 analog channels may be displayed on up to 6 axes.

② Show Active: If this option is checked, the list of digital channels displayed in the Digitals box is restricted to signals that are active in the event report. If this box is left blank, the Digitals box displays all available digital signals found in the event report. Click the Show Active box to select or deselect this option.

③ Digitals/Digital Axis: The Digitals box lists the digital signals available for display. Select individual digital channels or drag the mouse pointer across several

channel assignments. Drag the selected channel assignments to the Digital Axis box. Only digital signals placed in the Digital Axis box are displayed on the Graph form. A maximum of 20 digital values may be displayed. The digitals are placed on the last axis. If all six analog axes are used, the last axis will share both analog and digital values.

④ Select Active Digitals: Automatically selects the first 20 digital channels that are active during the event. The selected digital signal names are placed in the Digital Axis box.

⑤ Reference Angle: Use this option when displaying sequence element angles (V1Ang, VOAng, etc.). Select the sequence angle to use as the reference. The reference angle is subtracted from all displayed angles. The reference angle uses prefault data if that option is selected in the Options.

⑥ Clear All Digitals: Quickly clears the list of digital channels from the Digital Axis display.

⑦ Save Preferences: Saves your preferences to a file. These preferences can be used later when viewing data from other event reports. When preferences are saved, not only is the preference file created (or updated), but the preference file path is also appended to the event report file. Once you save preferences, the Graph Preferences form does not display when you are selecting View > Graph for that event report. Instead, the graph displays according to the saved preferences. This also happens if you select View > Graph after already setting preferences, even if they have not been saved to a file. To view the Graph Preferences form again after preferences have been set, select View > Graph Preferences from the main form menu or click the Pref button on the Graph form.

⑧ Time Units, Starting/Ending Row:

Time: Displays and labels the x-axis in time. The Time parameters apply to both the Graph display and the Phasors display.

Cycles: Displays and labels the x-axis in cycles.

Rows: Displays and labels the x-axis based on event report row numbers.

Starting Row: Determines the row from the event report that will be used as the first row in the graph.

Ending Row: Determines the row from the event report that will be used as the last row in the graph.

⑨ Graph Example: Illustrates an example graph based on the current Preference settings. The display automatically updates as you adjust settings.

Advanced Preferences Tab

This tab of the **Graph Preferences** form is used to customize the graphical displays. Use the **Advanced Preferences** tab to customize the graph styles and colors.

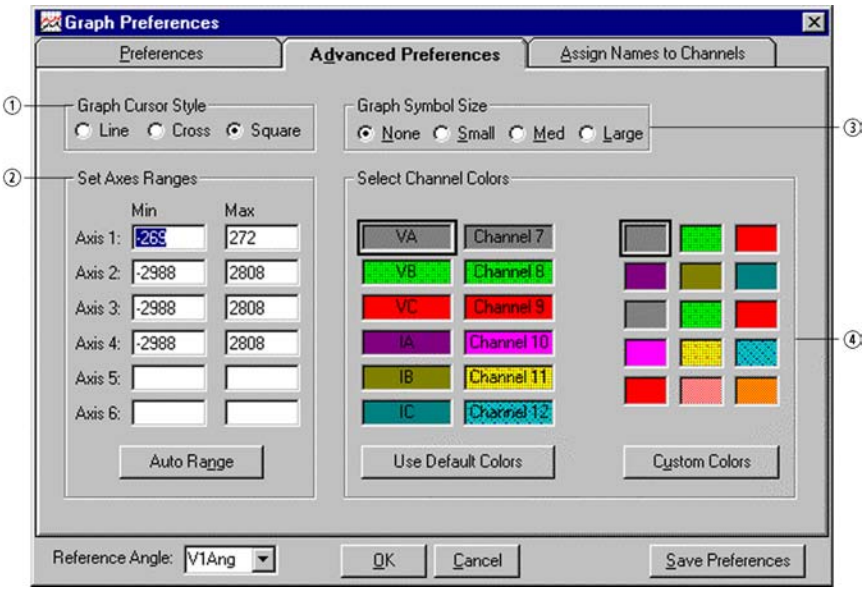

Figure 9.10: Advanced Preferences

① Graph Cursor Style: Specifies the type of cursor that displays when clicking on a data point within a graph.

Line: Displays the cursor as a vertical line on the graph.

Cross: Displays the cursor as a cross on the graph.

Square: Displays the cursor as a small square on the graph.

② Set Axes Ranges: Sets the minimum and maximum magnitude values for each axis of the graph.

Min: Sets the minimum value for the graph. If data values fall below the minimum range, the graph may not display accurately.

Max: Sets the maximum value for the graph. If data values go above the maximum range, the graph may not display accurately.

Auto Range: Auto ranges each axis. Axes with current channels will be scaled to the min/max current. Similarly, axes with voltages will be scaled to the min/max voltage. Auto Range is the default setting on the Options form.

③ Graph Symbol Size: Specifies the symbols used within a graph to indicate data points. Each data point from the event report can be displayed on the graph.

None: Displays the graph with no data point symbols.

Small: Displays the data points as small-size symbols on the graph.

Medium: Displays the data points as medium-size symbols on the graph.

Large: Displays the data points as large size symbols on the graph.

④ Select Channel Colors: Selects the color for each channel of the graph. Select one of the 12 channels from the group on the left. Assign a new color to that channel by selecting one of the color boxes from the group at the right.

Use Default Color: Assigns the default colors to each channel.

Custom Color: Opens a form that allows you to create custom colors for the currently selected channel.

Assign Names to Channels Tab

Use the **Assign Names to Channels** tab of the **Graph Preferences** form to customize names and descriptions of the analog and digital channels.

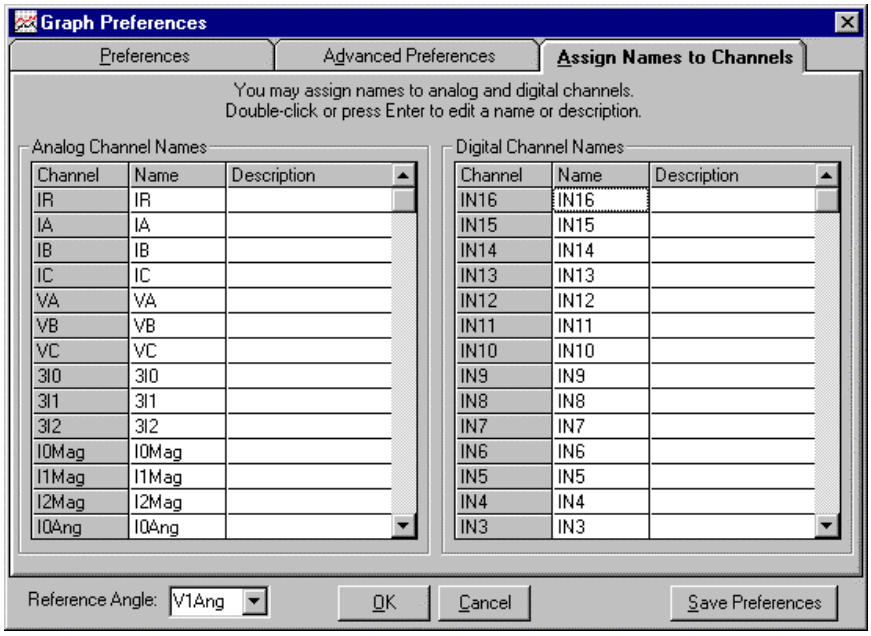

Figure 9.11: Assigning Names to Channels

Table 9.3: Options on the Graph Preferences Form—Assigning Names to Channels Tab

Option	Description
Channel	Lists the channels available in the current event report.
Name	Lists the channel name text assigned to each channel name. By default, these names match the **Channel** names.
Description	Associates additional text to a channel name.
Save Preferences	Saves the names in the preferences files.

Name Suggestions

Use short names, especially for the digital channels. Using short names will keep the name text from covering part of the graph.

Editing the Fields

To enable editing, click a field and press the **<Enter>** key or double-click a field.

To enable editing in append mode, click a field and press the **<Spacebar>**.

To enable editing in replace mode, double-click a field and drag the mouse pointer across the selected text. Type a character to replace the selected text in the field.

Moving Around the Grid

When not in the edit mode, use the arrow keys to move the cursor between cells. From the edit mode, the arrow keys move the cursor within the text field.

SEL-5601 Options

Before opening an event report file, select your graphing options shown in Figure 9.12.

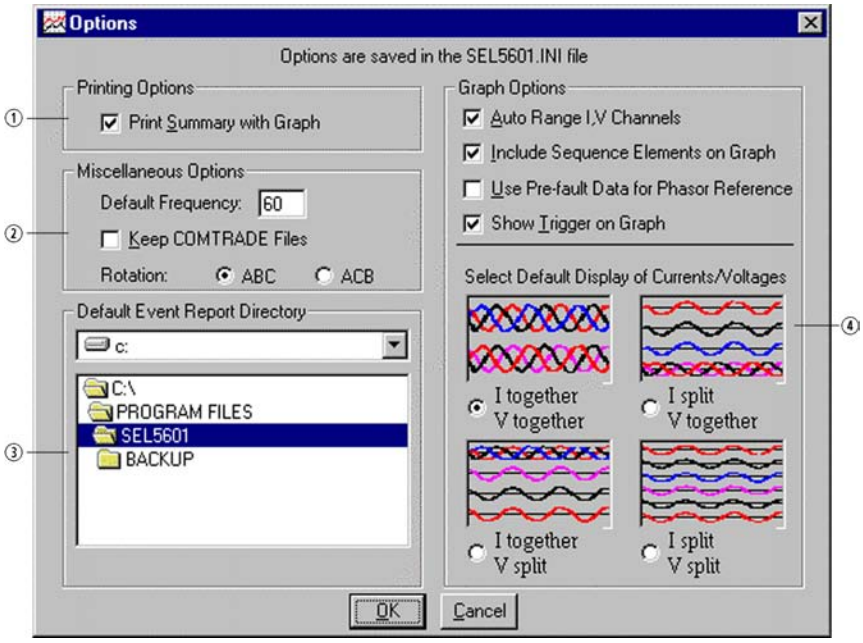

Figure 9.12: SEL-5601 Options

① Print Summary with Graph: Prints the summary information (as seen on the Event Report Summary form) with the print of the graph.

② Miscellaneous Options:

Default Frequency: Enter the default system frequency. This value is displayed in the Frequency field when an event report is opened and the SEL-5601 cannot determine the frequency from the event report.

Keep COMTRADE Files: Saves the COMTRADE files generated when converting an event report.

Rotation: Select either ABC or ACB phase rotation, as applicable to your installation.

③ Default Event Report Directory: Select the default directory where event report files are stored. When you are selecting the Open Event Report from the main form menu, the default directory will be the one defined on this form.

④ Graph Options:

Auto Range I, V Channels: Auto ranges each axis on the graph form. To manually enter graph axis ranges, use the Advanced Preferences tab of the Graph form.

Include Sequence Elements on Graph: Includes sequence elements with the analog channels.

Use Pre-fault Data for Phasor Reference: Uses the prefault data from the second cycle of the event report for the reference angle. All graphed angle channels will be referenced to this prefault data angle. Use this feature so you can use nominal data as the reference for fault conditions.

Show Trigger on Graph: Shows the trigger point as a dashed vertical line. This option has no effect for event reports that do not have a trigger flag.

Default Displays: Select the appropriate default display option. The SEL-5601 uses the channel names from the event report to determine whether a channel is voltage or current. If the channel names are changed, the SEL-5601 may not be able to correctly group currents and voltages. Voltage channels are expected to start with a V and current channels start with an I.

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Appendix A: SEL-7000 Product Documentation

Maintenance

The PC is the only item of the HMI requiring maintenance, as described below:

- Check monthly to ensure there is ample disk space on your PC. Relay event reports stored by the SEL-5040 and the InTouch alarm logger use up disk space as time passes. Consider archiving such data if disk space becomes a problem.
- Defragment the hard drive as needed.
- Verify that the PC power supply fan is still operating. No other equipment in the SEL-7000 has a fan.
- Do not upgrade your version of Wonderware Intouch. Not all versions are backwards compatible.

Upgrades

SEL may occasionally offer upgrades to improve the performance of this HMI. To install these upgrades, follow the instructions supplied with the upgrade.

Product Support

Please contact your local SEL application engineer (AE) or integration application engineer (IAE) for support with this product. Your local AE/IAE can be found at: http://www.selinc.com/techsvc.htm.

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 USA 99163-5603
Telephone: (509) 332-1890
Fax: (509) 332-7990
Internet: www.selinc.com

Further Documentation

The following is a listing of manuals and drawings for the SEL-7000:

- SEL-7000 User's Guide
- SEL-7000 Application Guide
- SEL-7000 Drawing Package, including:
  - AC schematics
  - DC schematics
  - Communication cabling diagram
  - Wiring diagrams
  - Panel layouts
  - Logic diagrams
- SEL-2032 Instruction Manual
- SEL Relay Reference Manuals and User's Guides for the relays used in the SEL-7000
- SEL-2100 Instruction Manual
- SEL Application Guide AG2002-05 "Securing SEL Ethernet Products with VPN Technology"
- SEL Application Guide AG2002-01 "TrafficWerks SEL Fast Message I/O Server Configuration"
- SEL Application Guide AG2001-12 "Implementing MIRRORED BITS™ Technology Over Various Communication Media"
- SEL Application Guide AG2001-06 "Avoiding Magnetic Induction Issues in Communications Cabling"
- SEL Application Guide AG2000-08 "Applying the SEL-5040 Power System Report Manager"
- SEL Application Guide AG99-01 "Using Contact Inputs to Detect DC Grounds"
- Operation Manual. Model 1084 A/B/C Satellite Controlled Clock. Arbiter Systems, Inc.
- Owner's Manual, Davis WeatherMonitor II
- Installation Manual, Standard and Industrial Anemometer
- Specification Sheet, Davis WeatherMonitor II
- Teltone Product Manual, Substation Line Sharing Switch (SLSS)
- User's Guide, WonderWare FactorySuite InTouch
- Reference Guide, WonderWare FactorySuite InTouch

ANSI/IEEE Device Numbers and Functions

The devices in switching equipment are referred to by numbers, according to the functions they perform. These numbers are based on a system that has been adopted as standard for automatic switchgear by IEEE.

1	Master Element	49	Machine or Transformer Thermal Relay
2	Time-Delay Starting or Closing Relay	50	Instantaneous Overcurrent or Rate-of-Rise Relay
3	Checking or Interlocking Relay	51	AC Time Overcurrent Relay
4	Master Contactor	52	AC Circuit Breaker
5	Stopping Device	53	Exciter or DC Generator Relay
6	Starting Circuit Breaker	54	High-Speed DC Circuit Breaker
7	Anode Circuit Breaker	55	Power-Factor Relay
8	Control Power Disconnecting Device	56	Field Application Relay
9	Reversing Device	57	Short-Circuiting or Grounding Device
10	Unit Sequence Switch	58	Power Rectifier Misfire Relay
11	(Reserved For Future Application)	59	Overvoltage Relay
12	Overspeed Device	60	Voltage Balance Relay
13	Synchronous-Speed Device	61	Current Balance Relay
14	Underspeed Device	62	Time Delay Stopping or Opening Relay
15	Speed, or Frequency Matching Device	63	Liquid or Gas Pressure Level or Flow Relay
16	(Reserved For Future Application)	64	Ground Protective Relay
17	Shunting or Discharge-Switch	65	Governor
18	Accelerating or Decelerating Device	66	Notching or Jogging Device
19	Starting-To-Running Transition Contactor	67	AC Directional Overcurrent Relay
20	Electrically Operated Valve	68	Blocking Relay
21	Distance Relay	69	Permissive Control Device
22	Equalizer Circuit Breaker	70	Electrically Operated Rheostat
23	Temperature Control Device	71	(Reserved For Future Application)
24	(Reserved For Future Application)	72	DC Circuit Breaker
25	Synchronizing or Synchronism Check	73	Load Resistor Contactor
26	Apparatus Thermal Device	74	Alarm Relay
27	Undervoltage Relay	75	Position-Changing Mechanism
28	(Reserved For Future Application	76	DC Overcurrent Relay
29	Isolating Contactor	77	Pulse Transmitter
30	Annunciator Relay	78	Phase-Angle Measuring or Out-of-Step Protective Relay
31	Separate Excitation Device	79	AC Reclosing Relay
32	Directional Power Relay	80	(Reserved For Future Application)
33	Position Switch	81	Frequency Relay
34	Motor-Operated Sequence Switch	82	DC Reclosing Relay

35	Brush-Operating or Slip-Ring Short-Circuiting Device	83	Automatic Selective Control or Transfer Relay
36	Polarity Device	84	Operating Mechanism
37	Undercurrent or Underpower Relay	85	Carrier or Pilot-Wire Receiver Relay
38	Bearing Protective Device	86	Locking-Out Relay
39	(Reserved For Future Application)	87	Differential Protective Relay
40	Field Relay	88	Auxiliary Motor or Motor Generator
41	Field Circuit Breaker	89	Line Switch
42	Running Circuit Breaker	90	Regulating Device
43	Manual Transfer or Selector Device	91	Voltage Directional Relay
44	Unit Sequence Starting Relay	92	Voltage And Power Directional Relay
45	(Reserved For Future Application)	93	Field-Changing Contactor
46	Reverse-Phase-Balance Current Relay	94	Tripping or Trip-Free Relay
47	Phase-Sequence Voltage Relay	95	(Device Numbers 95–99 Reserved For Special Application)
48	Incomplete Sequence Relay		