SEL-351R-4 Recloser Control

Instruction Manual

20160715

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM351R-06

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Preface

Manual Overview

NOTE: SEL-351R-4 REFERRED TO AS JUST SEL-351R
Throughout the other sections of this Instruction Manual, the SEL-351R-4 is referred to as just the SEL-351R.

The SEL-351R-4 Recloser Control Instruction Manual and QuickStart Installation and User's Guide describe common aspects of recloser control application and use. They include the necessary information to install, set, test, and operate the control and more detailed information about settings and commands.

An overview of each manual section and topics follows:

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

Section 1: Factory-Set Logic. Describes the factory-set logic (SELOGIC® control equations) that makes the SEL-351R-4 operate as a recloser control.

Section 2: Additional Installation Details. Describes additional SEL-351R-4 installation details not covered in Section 1 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements. Describes the operation of the instantaneous/definite-time overcurrent elements (phase, neutral-ground, residual-ground, and negative-sequence); time-overcurrent elements (phase, neutral-ground, residual-ground, and negative-sequence); voltage elements (single-phase, phase-to-phase, etc.; synchronism-check elements; and frequency elements.

Section 4: Loss-of-Potential, Load-Encroachment, and Directional Element Logic. Describes the operation of loss-of-potential logic and its effect on directional elements; load-encroachment logic and its application to phase overcurrent elements; voltage-polarized and current-polarized directional elements, including directional control for Best Choice Ground Directional Element® logic and automatic settings.

Section 5: Trip and Target Logic. Describes the trip logic of the SEL-351R-4 and the settings to effect flexible tripping using SELOGIC control equations.

Section 6: Close and Reclose Logic. Includes descriptions of close logic, reclose supervision logic, and reclose logic in the SEL-351R-4.

Section 7: Inputs, Outputs, Timers, and Other Control Logic. Describes the elements of the logic input/output of the recloser control. These elements are combined with overcurrent, voltage, frequency, and reclosing elements in SELOGIC control equation settings to realize numerous protection and control schemes.

Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions. Describes the monitoring and metering functions of the SEL-351R-4.

Section 9: Setting the SEL-351R Recloser Control. Explains how to enter settings and also contains the following setting reference information:

- Time-overcurrent curves (5 US and 5 IEC curves)
- Recloser control response curves (38)
- Relay Word bit table and definitions (Relay Word bits are used in SELOGIC control equation settings)
- Settings Sheets for general recloser control, SELOGIC control equation, global, SER, text label, and serial port settings

The *SEL-351R Recloser Control Settings Sheets* can be photocopied and filled out to set the SEL-351R-4. Note that these sheets correspond to the serial port **SET** commands listed in *Table 9.1*.

Section 10: Serial Port Communications and Commands. Describes serial port connector pinout/terminal functions, communications cables, communications protocol, and serial port commands.

Section 11: Additional Front-Panel Interface Details. Describes SEL-351R-4 front-panel interface details not covered in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Section 12: Standard Event Reports and SER. Describes standard 15- and 30-cycle event reports and Sequential Events Recorder (SER) report.

Section 13: Testing and Troubleshooting. Describes general testing philosophy, methods, and tools and control self-tests and troubleshooting.

Section 14: Appendices. Contains the following appendices:

- *Appendix A: Firmware and Manual Versions*
- *Appendix B: Firmware Upgrade Instructions*
- *Appendix C: SEL Distributed Port Switch Protocol*
- *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*
- *Appendix E: Compressed ASCII Commands*
- *Appendix F: Setting Negative-Sequence Overcurrent Elements*
- *Appendix G: Setting SELOGIC Control Equations*
- *Appendix H: Distributed Network Protocol*
- *Appendix I: MIRRORED BITS*
- *Appendix J: PC Software*
- *Appendix K: Fast SER Protocol*

SEL-351R Recloser Control Command Summary. Briefly describes the serial port commands that are described in detail in *Section 10: Serial Port Communications and Commands*.

Safety Information

Dangers, Warnings, and Cautions

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

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

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

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

Safety Symbols

The following symbols are often marked on SEL products.

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

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer’s instructions. Keep battery out of reach of children.	**⚠ATTENTION** Une pile remplacée incorrectement pose des risques d’explosion. Remplacez seulement avec un Ray-O-Vac® no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d’utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d’incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.

Other Safety Marks

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	⚠DANGER Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	⚠AVERTISSEMENT Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠AVERTISSEMENT L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠CAUTION The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.	⚠ATTENTION Le relais contient des pièces sensibles aux décharges électrostatiques. Quand on travaille sur le relais avec les panneaux avant ou du dessus enlevés, toutes les surfaces et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

Conventions

Typographic Conventions

There are three ways to communicate with the SEL-351R-4:

- ➤ Using a command line interface on a PC terminal emulation window
- ➤ Using the front-panel menus and pushbuttons
- ➤ Using ACSELERATOR QuickSet® SEL-5030 Software

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

Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
CLOSE	Control front-panel pushbuttons.
ENABLE	Control front- or rear-panel labels.

Example	Description
`MAIN > METER`	Control front-panel LCD menus and control responses visible on the PC screen. The > character indicates submenus.
SELOGIC control equations	SEL trademarks and registered trademarks contain the appropriate symbol on first reference in a section. In the *SEL-351R-4 Instruction Manual*, certain SEL trademarks appear in small caps. These include SELOGIC control equations.
Modbus®	Registered trademarks of other companies include the registered trademark symbol with the first occurrence of the term in a section.

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-351R-4. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-351R-4.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890
Fax: +1.509.332.7990
Internet: selinc.com
E-mail: info@selinc.com

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Section 1
Factory-Set Logic

Overview

IMPORTANT: Use this manual in conjunction with the SEL-351R-4 Quick-Start Installation and User's Guide.

This section describes the factory-set logic (SELOGIC® control equations, set with the **SET L *n*** command) that makes the SEL-351R Recloser Control operate as a recloser control. *Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements* through *Section 9: Setting the SEL-351R Recloser Control* provide more settings information and settings variation details.

Factory-Default Settings

Factory-default settings are listed under *SHO Command (Show/View Settings) on page 10.25*.

Installation Variations and Logic Changes

For traditional recloser control installations (see *Figure 1.31*), none of the factory-set logic has to be changed. However, for other recloser control installation variations (see *Figure 1.32–Figure 1.34*), some changes might be made to the factory-set logic, as detailed in the text accompanying these figures. Also, if the SEL-351R were applied in "nonstandard" applications (e.g., at a cogeneration interconnection point), changes would probably be made to the factory-set logic. *Section 9: Setting the SEL-351R Recloser Control* provides details on making settings changes.

EZ Settings vs. "Regular" Settings

Section 4 in the *SEL-351R-4 Quick-Start Installation and User's Guide* describes:

- EZ recloser control settings (set with **SET EZ *n*** command)
- EZ Global settings (set with **SET FZ** command)

Section 9: Setting the SEL-351R Recloser Control describes:

- "regular" settings (set with **SET *n*** command)
- "regular" Global settings (set with **SET G** command)

"Regular" Global setting EZGRPS (# of EZ settings groups enabled) determines if EZ recloser control settings are enabled for a particular setting group. When EZGRPS = 0, EZ recloser settings are not enabled, and the control is set with "regular" group and Global settings.

The EZ recloser control settings are a subset of the "regular" settings, but if the EZ recloser control settings are enabled for a specific settings group *n* (*n* = 1–6), then the corresponding EZ recloser control settings override and change certain "regular" settings for that settings group. Also, the Group

Enable Settings associated with the EZ group settings are set to default values and cannot be changed. The group enable settings associated with the EZ group settings include the following:

- E50P
- E50N
- E50G
- E51P
- E51N
- E51G
- E81
- E79
- ESV

The correlation between EZ recloser control settings and "regular" settings is given in *Table 1.1*. The EZ recloser control settings listed in *Table 1.1* override the "regular" group settings listed in *Table 1.1*.

The EZ Global settings override certain "regular" Global settings if EZ recloser control settings are enabled for at least settings group 1. The correlation between EZ Global settings and "regular" Global settings is also given at the end of *Table 1.1*. The EZ Global recloser control settings listed in *Table 1.1* override the "regular" Global settings listed in *Table 1.1*.

Example

If Global setting EZGRPS = 1, then EZ recloser control setting CT Ratio overrides the "regular" Group 1 setting CTR. If the EZ recloser control setting CT Ratio is set to 500, then Group 1 setting CTR changes to 500 also.

While the EZ recloser control settings are enabled, the "regular" group settings listed in *Table 1.1* cannot be changed with the **SET** command. When trying to change a group or Global setting, while EZ Settings are enabled, the control responds with the following message:

```
Warning: EZ settings may override some of these settings
```

Table 1.1 Correspondence Between EZ Settings and "Regular" Settings (Sheet 1 of 3)

EZ Recloser Control Settings (SHO EZ n Command; SET EZ n Command)	Corresponding "Regular" Settings (SHO n Command; SET n Command)
Control Identifier (30 characters)	RID
Circuit Identifier (30 characters)	TID
CT Ratio	CTR
PT Ratio	PTR, PTRS
Min. trip–phase	51P1P, 51P2P, 50P4P, 50P6P
Min. trip–ground	51G1P, 51G2P, 50G6P, 51N1P, 51N2P, 50N6P
Min. trip–SEF	50N3P, 50N4P
Fast curve–phase	51P1C
Time dial–phase fast curve	51P1TD
EM reset–phase fast curve	51P1RS

Table 1.1 Correspondence Between EZ Settings and "Regular" Settings (Sheet 2 of 3)

EZ Recloser Control Settings (SHO EZ n Command; SET EZ n Command)	Corresponding "Regular" Settings (SHO n Command; SET n Command)
Fast curve–ground	51G1C, 51N1C
Time dial–ground fast curve	51G1TD, 51N1TD
EM reset–ground fast curve	51G1RS, 51N1RS
Delay curve–phase	51P2C
Time dial–phase delay curve	51P2TD
EM reset–phase delay curve	51P2RS
Delay curve–ground	51G2C, 51N2C
Time dial–ground delay curve	51G2TD, 51N2TD
EM reset–ground delay curve	51G2RS, 51N2RS
Time delay–SEF	67N3D
Operations–phase fast curve	OPPH
Operations–ground fast curve	OPGR
Operations to lockout–phase	OPLKPH
Operations to lockout–ground	OPLKGR
Operations to lockout–SEF	OPLKSF
Reclose interval 1	790I1
Reclose interval 2	790I2
Reclose interval 3	790I3
Reclose interval 4	790I4
Reset time for auto reclose	79RSD
Reset time from lockout	79RSLD
Close power wait time	79CLSD
Complex fast curve–phase (Y/N)	
Const. time adder–phase fast curve	51P1CT
Vert. multiplier–phase fast curve	51P1TD
Min. response–phase fast curve	51P1MR
Complex fast curve–ground (Y/N)	
Const. time adder–ground fast curve	51G1CT, 51N1CT
Vert. multiplier–ground fast curve	51G1TD, 51N1TD
Min. response–ground fast curve	51G1MR, 51N1MR
Complex Delay curve–phase (Y/N)	
Const. time adder–phase delay curve	51P2CT
Vert. multiplier–phase delay curve	51P2TD
Min. response–phase delay curve	51P2MR
Complex Delay curve–ground (Y/N)	
Const. time adder–ground delay curve	51G2CT, 51N2CT
Vert. multiplier–ground delay curve	51G2TD, 51N2TD
Min. response–ground delay curve	51G2MR, 51N2MR
High-current trip–phase (Y/N)	
High-current trip–phase	50P2P
Time delay–phase high-current trip	67P2D
Activate high-current trip–phase	HITRPH
High-current trip–ground (Y/N)	
High-current trip–ground	50G2P, 50N2P
Time delay–ground high-current trip	67G2D, 67N2D
Activate high-current trip–ground	HITRGR

Table 1.1 Correspondence Between EZ Settings and "Regular" Settings (Sheet 3 of 3)

EZ Recloser Control Settings (SHO EZ n Command; SET EZ n Command)	Corresponding "Regular" Settings (SHO n Command; SET n Command)
High-current lockout–phase (Y/N)	
High-current lockout–phase	50P1P
Activate high-current lockout–phase	HILKPH
High-current lockout–ground (Y/N)	
High-current lockout–ground	50G1P, 50N1P
Activate high-current lockout–ground	HILKGR
Cold load pickup scheme (Y/N)	
Cold load pickup–phase	50P5P, ECOLDP
Cold load pickup–ground	50G5P, ECOLDG, 50N5P
Loss of load diversity time	SV6PU
Restore min. trips–time limit	SV5PU
Restore Min. trip–phase	RPPH
Restore Min. trip–ground	RPGR
Restore Min. trip–SEF	RPSEF
Sequence coordination (Y/N)	ESEQ
Ground trip precedence (Y/N)	PRECED
Underfrequency load shedding (Y/N)	
Underfrequency pickup	81D1P
Underfrequency time delay	81D1D
Demand meter time constant	DMTC

Table 1.2 Correspondence Between EZ Global Settings and "Regular" Settings (Sheet 1 of 2)

EZ Global Settings (SHO FZ Command; SET FZ Command)	Corresponding "Regular" Settings (SHO G Command; SET G Command)
System Frequency	NFREQ
Phase Rotation	PHROT
Recloser Wear Monitor (AUTO, Y, N)	EBMON
Recloser type (OIL, VAC1, VAC2)	COSP1, COSP2, COSP3
Interrupt rating	KASP1, KASP2, KASP3
Reset trip-latched LEDs on close (Y, Y1, N, N1)	RSTLED
True three-phase voltage connected (Y/N)	3PVOLT
Phantom voltages from (VA, VB, VC, VAB, VBC, VCA, OFF)	PHANTV
V123 Terminal Conn. (A, B, C, AB, BC, CA, OFF) Setting range used if 3PVOLT = N, or PHANTV = OFF or	VPCONN
V123 Terminal Conn. (ABC, ACB, BAC, BCA, CAB, CBA) Setting range used if 3PVOLT = Y	VPCONN
I123 Terminal Conn. (ABC, ACB, BAC, BCA, CAB, CBA)	IPCONN
CT Polarity (POS, NEG)	CTPOL

Table 1.2 Correspondence Between EZ Global Settings and "Regular" Settings (Sheet 2 of 2)

EZ Global Settings (SHO FZ Command; SET FZ Command)	Corresponding "Regular" Settings (SHO G Command; SET G Command)
Battery Amp-hours	AMPHR
Power-off Delay After AC Loss (OFF,1–1440 min)	PWR_AC
Power-off Delay After Wake Up (OFF,1–1440 min)	PWR_WU
Power-off Voltage Level 1 (19.2–24 Vdc)	V_LOW1

Overcurrent Element Functions Overview

When the factory-default EZ settings are active for a particular settings group, many of the overcurrent elements in that settings group have specific functions, as explained in *Table 1.3*.

Table 1.3 Overcurrent Element Functions With EZ Settings Operative

Overcurrent Element	Function With EZ Settings Operative	Associated Settings
51P1T	Fast curve–phase	51P1P, 51P1C, 51P1TD, 51P1RS, 51P1CT, 51P1MR
51G1T, 51N1T	Fast curve–ground	51G1P, 51G1C, 51G1TD, 51G1RS, 51G1CT, 51G1MR 51N1P, 51N1C, 51N1TD, 51N1RS, 51N1CT, 51N1MR
51P2T	Delay curve–phase	51P2P, 51P2C, 51P2TD, 51P2RS, 51P2CT, 51P2MR
51G2T, 51N2T	Delay curve–ground	51G2P, 51G2C, 51G2TD, 51G2RS, 51G2CT, 51G2MR 51N2P, 51N2C, 51N2TD, 51N2RS, 51N2CT, 51N2MR
67N3T	SEF element	50N3P, 67N3D
67P2T	High-current trip–phase	50P2P, 67P2D
67G2T, 67N2T	High-current trip–ground	50G2P, 67G2D, 50N2P, 67N2D
67P1	High-current lockout–phase	50P1P
67G1, 67N1	High-current lockout–ground	50G1P, 50N1P
50P5	Effective min. trip for "Delay curve–phase" when cold load pickup scheme is active.	50P5P
50G5, 50N5	Effective min. trip for "Delay curve–ground" and "SEF element" when cold load pickup scheme is active.	50G5P, 50N5P
50P6	Threshold (set equal to "Min. trip–phase") to detect phase current returning below the normal "Min. trip–phase" level when cold load pickup scheme is active.	50P6P
50G6, 50N6	Threshold (set equal to "Min. trip–ground") to detect ground current returning below the normal "Min. trip–ground" level when cold load pickup scheme is active.	50G6P, 50N6P
50N4	Threshold (set equal to "Min. trip–SEF") to detect ground current returning below the normal "Min. trip–SEF" level when cold load pickup scheme is active.	50N4P
50A4, 50B4, 50C4	Threshold (set equal to "Min. trip–phase") to detect faulted phases for trip operation counters.	50P4P

The overcurrent elements are available for use in SELOGIC control equations as “Relay Word bits” (see *Table 9.6* and *Table 9.7*). The associated overcurrent element settings listed in *Table 1.3* and SELOGIC control equations settings are found in the settings sheets at the end of *Section 9: Setting the SEL-351R Recloser Control*. The factory-default SELOGIC control equations settings are explained in the remainder of this section.

Residual Ground vs. Neutral Ground

In the following logic explanations, reference is made to residual ground and neutral ground overcurrent elements. The residual ground overcurrent elements (e.g., 51G1T) are derived from phase current input channels I1, I2, and I3. The neutral ground overcurrent elements (e.g., 51N1T) are derived from current input channel IN. Current channel IN is internally wired residually with phase current input channels I1, I2, and I3, so the residual ground and neutral ground overcurrent elements see the same magnitude zero-sequence current (see terminals Z02–Z05 in *Figure 2.1*).

Phase current input channels I1, I2, and I3 are rated 1 A nominal. Current input channel IN is rated 0.05 A nominal. The neutral ground overcurrent elements (derived from current input channel IN) can be more sensitively set than the residual ground overcurrent elements (derived from phase current input channels I1, I2, and I3).

For example, for the Fast curve–ground element, a neutral ground overcurrent element (51N1T) is used when a more sensitive setting is needed, as opposed to the complementary residual ground overcurrent element (51G1T). This is taken care of automatically when EZ settings are made. See *Figure 1.15* and *Figure 1.19* for more details on the operation of the Fast curve–ground element.

Cold Load Pickup Scheme

The cold load pickup scheme activates to prevent tripping on cold load pickup current. Both the following occur when the cold load pickup scheme activates:

- ➤ Fast curves are disabled
- ➤ Delay curves and SEF (Sensitive Earth Fault) element are desensitized

The delay curves and SEF element are not shifted in the desensitization process—coordination is maintained.

Enable Cold Load Pickup Scheme

The cold load pickup scheme begins in *Figure 1.1* (top). The logic at the top of this figure is enabled when *either* of the following EZ settings is made (enabling the loss-of-load diversity timer, SV6PU):

- ➤ Cold load pickup–phase ≠ OFF (Relay Word bit CLP = logical 1)
- ➤ Cold load pickup–ground ≠ OFF (Relay Word bit CLG = logical 1)

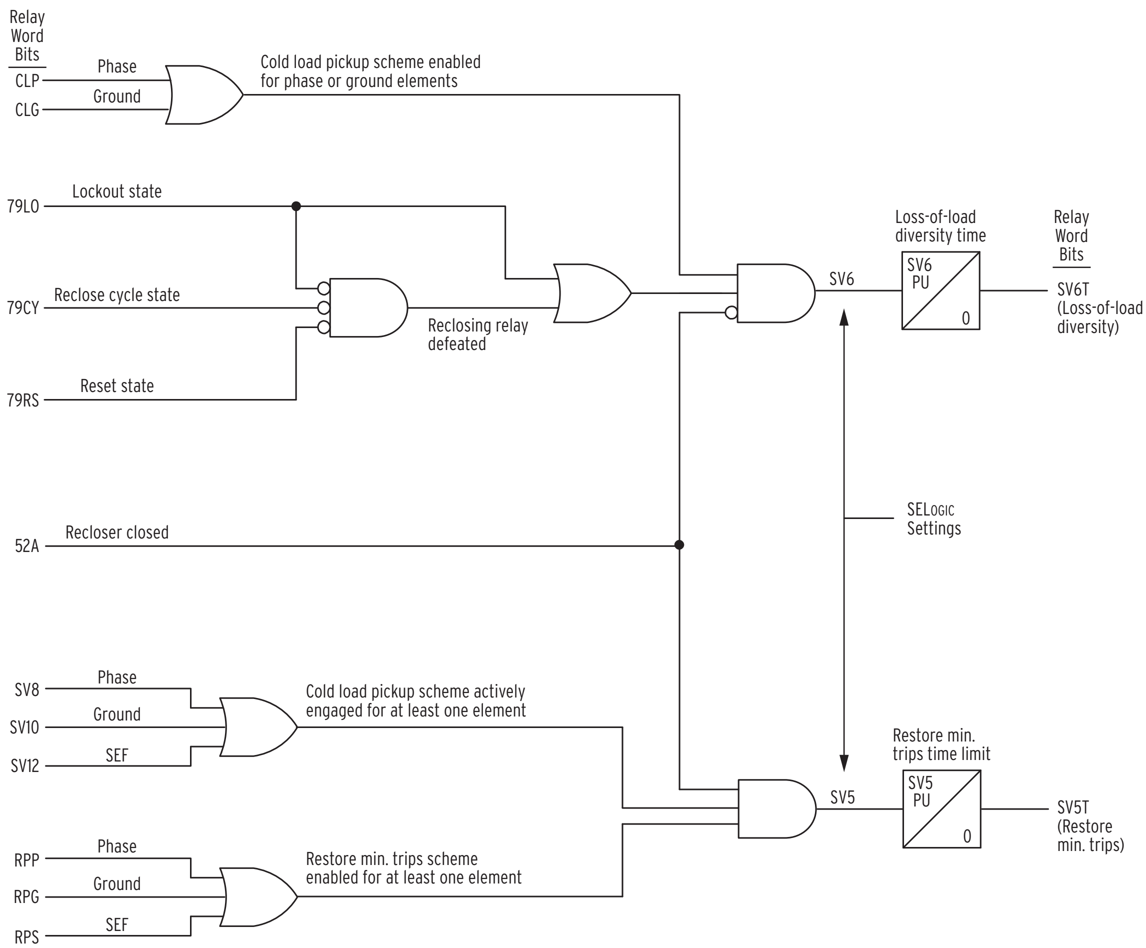


Figure 1.1 Loss-of-Load Diversity (Top) and Restore Minimum Trips (Bottom) Logic for Cold Load Pickup Scheme

Start Loss-of-Load Diversity Timer

Loss-of-load diversity timer SV6PU in *Figure 1.1* starts timing when *both* the following conditions are true:

- ➤ Recloser is open (Relay Word bit 52A = logical 0)
- ➤ SEL-351R is in the lockout state (Relay Word bit 79LO = logical 1) or the reclosing relay is defeated

EZ setting Reclose interval 1 = 0 (**SET EZ** command) or enable setting E79 = N (**SET *n*** command) defeats the reclosing relay (it is effectively nonexistent; Relay Word bits 79RS = 79CY = 79LO = logical 0).

When SV6PU times out, Relay Word bit SV6T asserts to logical 1, indicating a loss-of-load diversity condition. SV6T propagates to the logic in *Figure 1.2–Figure 1.4* for phase, ground, and SEF overcurrent elements, respectively. The logic in these three figures operates similarly—examine the operation of *Figure 1.2* (phase).

Actively Engage Cold Load Pickup Scheme (Phase Elements Example)

SV6T propagates into *Figure 1.2* and seals in with SELOGIC setting/Relay Word bit SV8, if Relay Word bit CLP = logical 1 (EZ setting Cold load pickup–phase ≠ OFF). This actively engages the cold load pickup scheme for the phase overcurrent elements (Relay Word bit SV8 = logical 1).

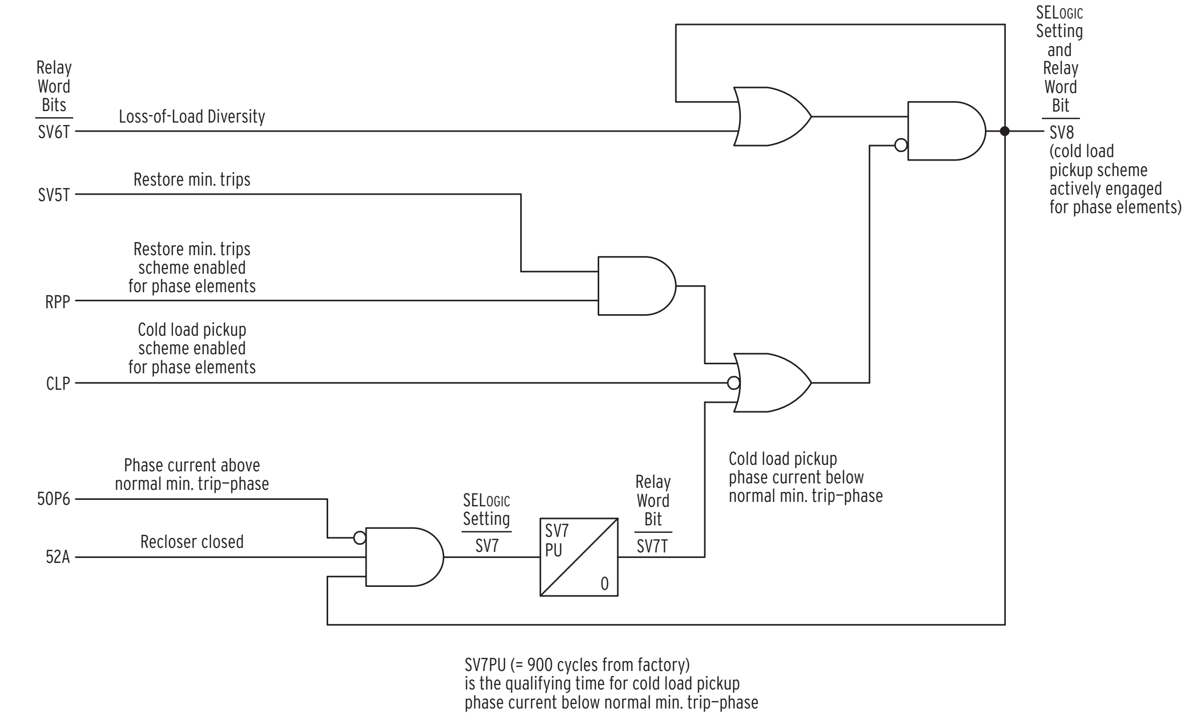


Figure 1.2 Cold Load Pickup Scheme Seal-In Logic for Phase Overcurrent Elements

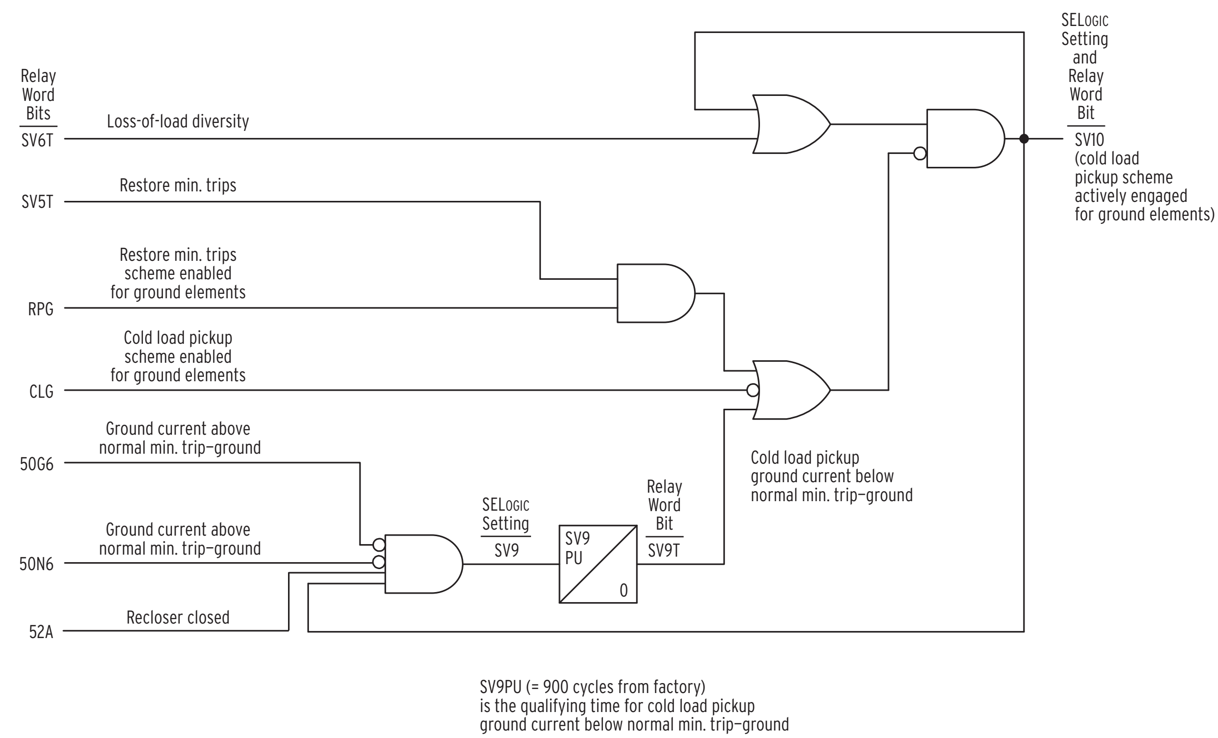


Figure 1.3 Cold Load Pickup Scheme Seal-In Logic for Ground Overcurrent Elements

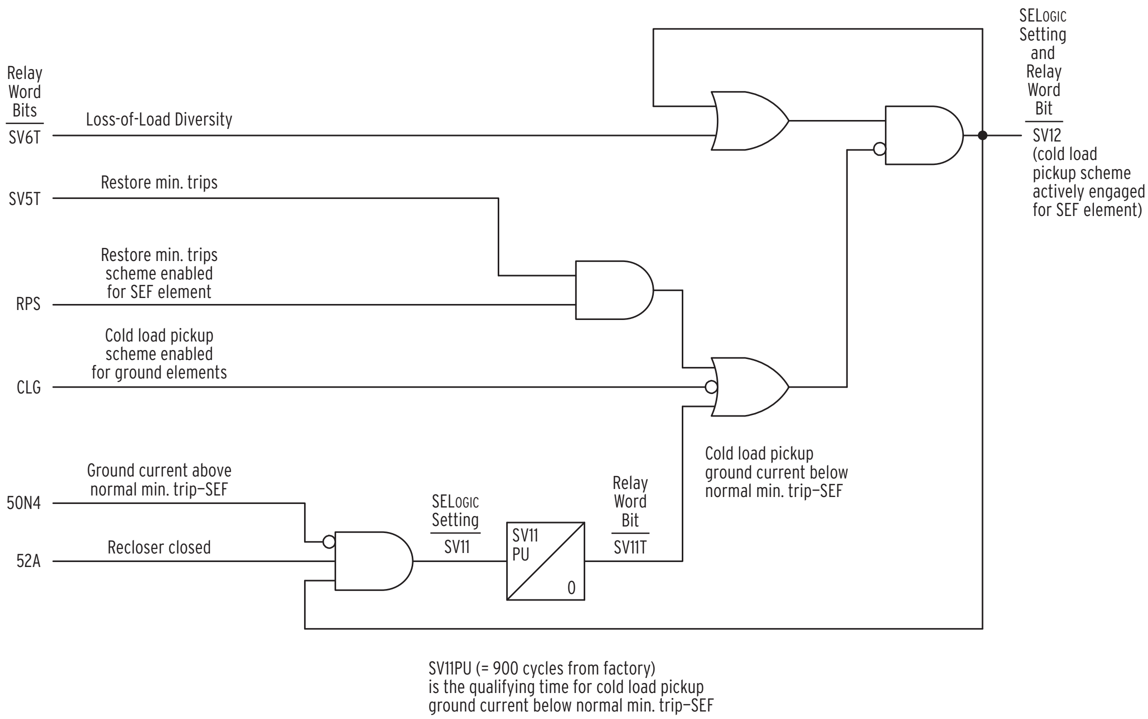


Figure 1.4 Cold Load Pickup Scheme Seal-in Logic for SEF Overcurrent Elements

Use Overcurrent Element Torque Control Logic to Enable/Disable or Desensitize Elements (Phase Elements Example)

With Relay Word bit SV8 = logical 1 (cold load pickup scheme actively engaged for the phase overcurrent elements), both the following occur:

- ➤ Fast curve–phase (51P1T) is disabled (see top of *Figure 1.15*)
- ➤ Delay curve–phase (51P2T) is desensitized (see top of *Figure 1.16*)

With Relay Word bit SV8 = logical 1, SELOGIC setting 51P1TC = logical 0 in top of *Figure 1.15*. This disables Fast curve–phase (51P1T).

With Relay Word bit SV8 = logical 1, SELOGIC setting 51P2TC in top of *Figure 1.16* is controlled by phase instantaneous element 50P5. Element 50P5 asserts to logical 1 when phase current exceeds its pickup setting, 50P5P (see *Figure 3.2*). Pickup setting 50P5P corresponds to EZ setting Cold load pickup–phase. With Relay Word bit SV8 = logical 1, SELOGIC setting 51P2TC enables Delay curve–phase (51P2T) when phase current exceeds pickup setting 50P5P.

Desensitize Delay Curve—Maintain Coordination (Phase Elements Example)

In *Figure 1.5*, the normal Min. trip–phase for Delay curve–phase (51P2T) is 51P2P.

When the cold load pickup scheme is actively engaged for phase elements, the effective Min. trip–phase for Delay curve–phase is 50P5P. This effective Min. trip–phase is derived as follows:

50P5P = 51P2P • [Cold load pickup–phase (multiples of Min. trip–phase)]

When the cold load pickup scheme is actively engaged for the phase elements, the lower portion of the 51P2T phase overcurrent element (below pickup 50P5P) is effectively disabled. Note that the 51P2T phase overcurrent element is not shifted-coordination is maintained.

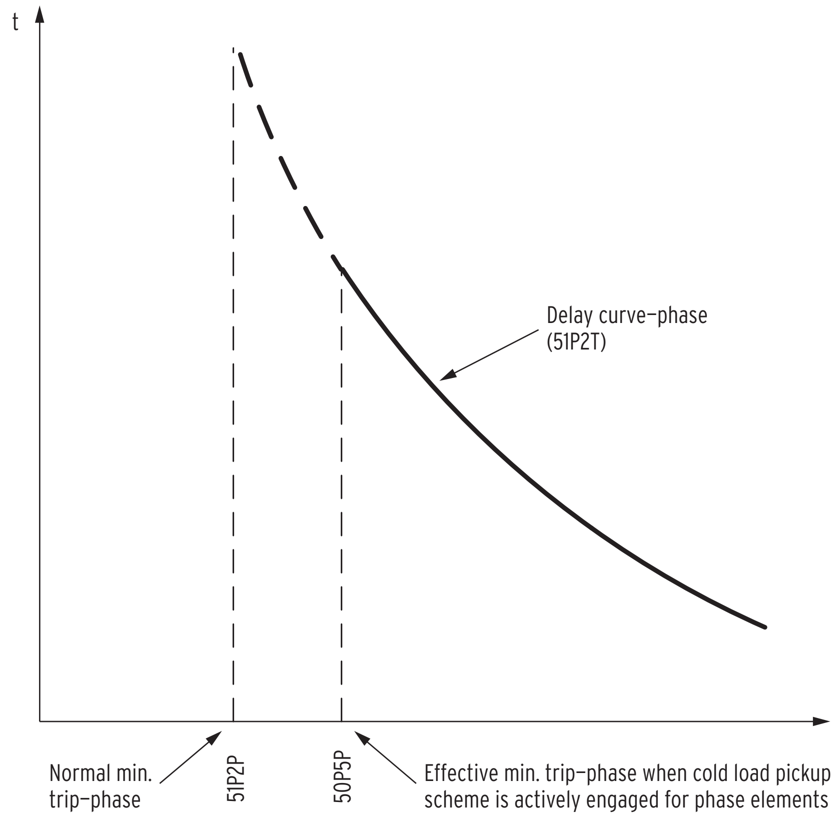


Figure 1.5 Disable Lower Portion of Delay Curve—Phase for Cold Load Pickup

Disengage Cold Load Pickup Scheme (Phase Elements Example)

SV8 in *Figure 1.2* remains sealed in (and the cold load pickup scheme remains actively engaged for the phase overcurrent elements) until one of the following occurs:

- ➤ A *natural* return is made to normal Min. trip–phase
- ➤ A *forced* return is made to normal Min. trip–phase

A *natural* return to normal Min. trip–phase occurs with the logic in *Figure 1.2* (bottom). The recloser closes and cold load pickup phase current goes below the normal Min. trip–phase setting value (monitored by phase instantaneous element 50P6—see *Figure 3.2*; corresponding pickup setting 50P6P is set the same as the normal Min. trip–phase). All this is time-qualified with timer SV7PU. Relay Word bit output SV7T unlatches SV8, disengaging the cold load pickup scheme for the phase elements.

A *forced* return to normal Min. trip–phase occurs with the logic in *Figure 1.1* (bottom). The recloser closes and the Restore min. trips scheme is enabled for at least one element. This is time qualified with timer SV5PU. Relay Word bit output SV5T then propagates to *Figure 1.2* and unlatches SV8 if setting Restore Min. trip–phase = Y (Relay Word bit RPP = logical 1). This disengages the cold load pickup scheme for the phase elements.

Other Cold Load Pickup Scheme Details Involving Ground and SEF Elements

The logic in *Figure 1.3* and *Figure 1.4* operates similarly to the logic operating in *Figure 1.2*, which has just been examined. A few details need to be explained concerning the operation of the cold load pickup scheme for the ground and SEF elements:

➤ See *Figure 1.3* (bottom). If setting Min. trip–ground is set below 0.1 Amp secondary, 50N6 provides the indication that cold load pickup ground current is above the normal Min. trip–ground setting value (50G6 is turned off automatically). Otherwise, 50G6 provides the indication (50N6 is turned off automatically).

➤ See *Figure 1.3* and *Figure 1.4*. The Cold load pickup–ground setting enables the cold load pickup scheme for both the ground and SEF elements (Relay Word bit CLG = logical 1). Ground and SEF elements both see the same zero-sequence current.

Fast Curve Operation Logic

Note the symmetry between *Figure 1.6* and *Figure 1.7*. Relay Word bits SH0–SH4 assert during different periods of a reclose cycle as the shot (reclose) counter increments. The shot counter increments just before each reclose.

NOTE: Table 1.4 presumes that five trip operations are set (four reclosures in between them). If the SEL-351R is set for fewer trip operations, the shot counter does not increment to the higher shots (e.g., the shot counter does not increment to shot = 4 if only four trip operations are set). Thus, the corresponding higher shot bits (e.g., SH4) never assert for lesser numbers of trip operations.

Table 1.4 Conditions for Assertion of Relay Word Bits SH0–SH4

Relay Word Bit	Asserted to Logical 1 From:
SH0	reset state to just before 1st reclose
SH1	just before 1st reclose to just before 2nd reclose
SH2	just before 2nd reclose to just before 3rd reclose
SH3	just before 3rd reclose to just before 4th reclose
SH4	just before 4th reclose, and following (through lockout state)

An example reclose cycle (from reset to lockout) appears as:

(reset) 1st trip—1st reclose—2nd trip—2nd reclose—3rd trip—3rd reclose—4th trip (lockout)

Per *Table 1.4*, SH0 = logical 1 during the first trip, SH1 = logical 1 during the second trip, and so forth. Therefore, to enable Fast curve–phase for the first and second trip operations, make EZ setting Operations–phase fast curve = 2 (OPGR = 2) see *Figure 1.6*. This causes Relay Word bit OCG to assert to logical 1 for both the following conditions:

➤ shot = 0 (SH0 = logical 1)

➤ shot = 1 (SH1 = logical 1)

The note in *Figure 1.6* refers to *Figure 1.15*—the logic that controls the Fast curve–phase (phase time-overcurrent element 51P1T). In this example, Fast curve–phase is enabled for the first two trip operations.

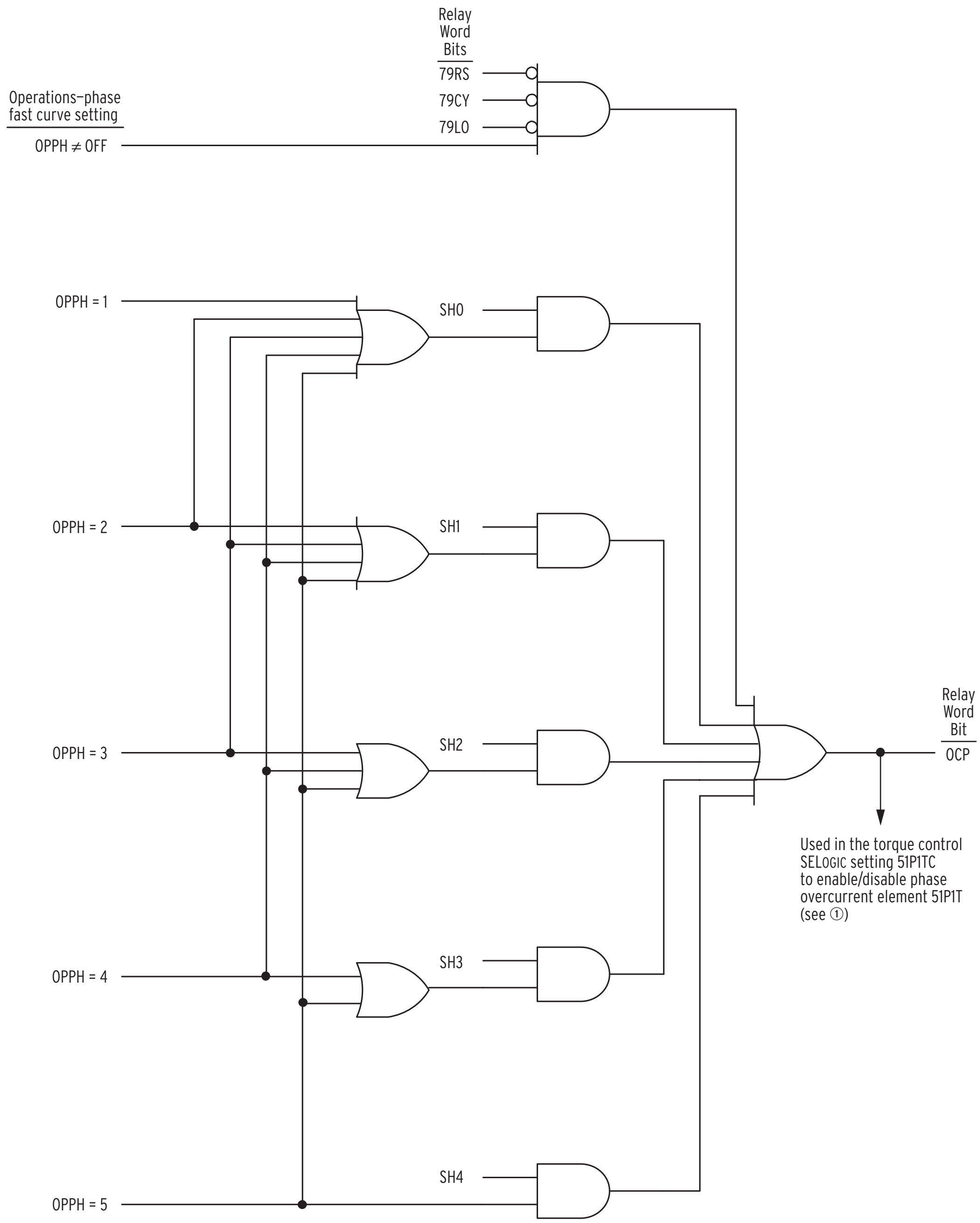
Fast curve–ground (*Figure 1.7*) operates similarly to the Fast curve–phase just discussed (*Figure 1.6*).

Fast Curve Operation When Reclosing Is Defeated

If reclosing is defeated via setting (e.g., all Operations to lockout ≤ 1), then all the following reclosing-related Relay Word bits default to logical 0 (the reclosing relay is nonexistent):

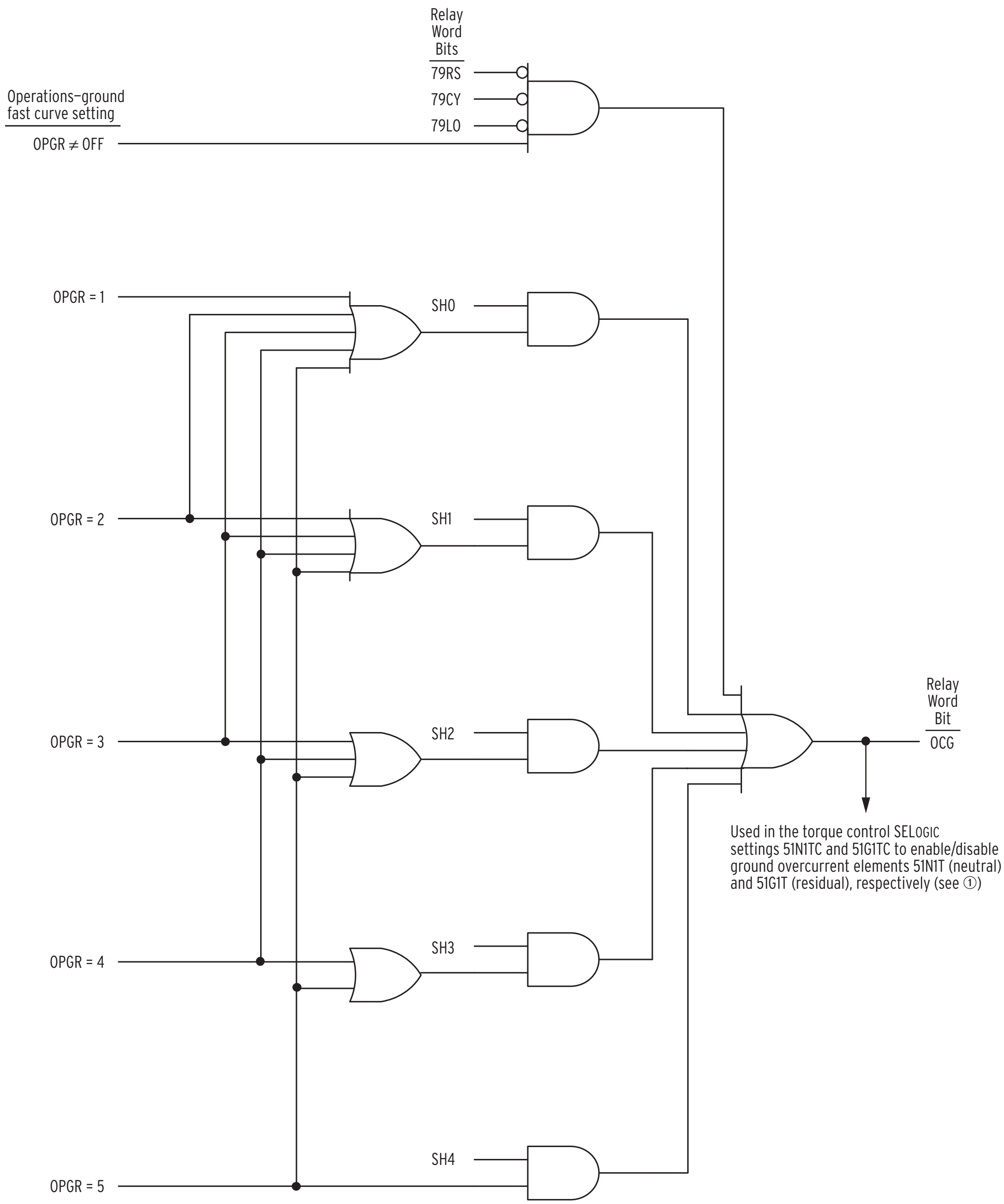
- SH0, SH1, SH2, SH3, SH4 (shot counter states)
- 79RS, 79CY, 79LO (reclosing relay states)

The logic at the top of *Figure 1.6* and *Figure 1.7* enables set phase and ground fast curves, respectively, when reclosing is defeated.



① Figure 1.15.

Figure 1.6 Operations—Phase Fast Curve Logic



① Figure 1.15.

Figure 1.7 Operations–Ground Fast Curve Logic

Operations to Lockout, Activate High-Current Trip, and Activate High-Current Lockout Logic

Note the symmetry amongst *Figure 1.8–Figure 1.14*. Relay Word bits SH0–SH4 assert during different periods of a reclose cycle as the shot (reclose) counter increments. The shot counter increments just before each reclose. See *Table 1.4* and accompanying note.

An example reclose cycle (from reset to lockout) appears as:

> (reset) 1st trip—1st reclose—2nd trip—2nd reclose—3rd trip—3rd reclose—4th trip (lockout)

Per *Table 1.4*, SH0 = logical 1 during the first trip, SH1 = logical 1 during the second trip and so forth. To enable the High-current trip–phase for the third and fourth trip operations, make setting Activate High-current trip–phase = 3 (HITRPH = 3). As shown in *Figure 1.11*, this causes Relay Word bit HTP to be asserted to logical 1 for all the following conditions:

- ➤ shot = 2 (SH2 = logical 1)
- ➤ shot = 3 (SH3 = logical 1)
- ➤ shot = 4 (SH4 = logical 1)

The note in *Figure 1.11* refers to *Figure 1.17*—the logic that controls the High-current trip–phase (phase definite-time element 67P2T). In this example, High-current trip–phase is enabled for the third trip operation and every following trip operation.

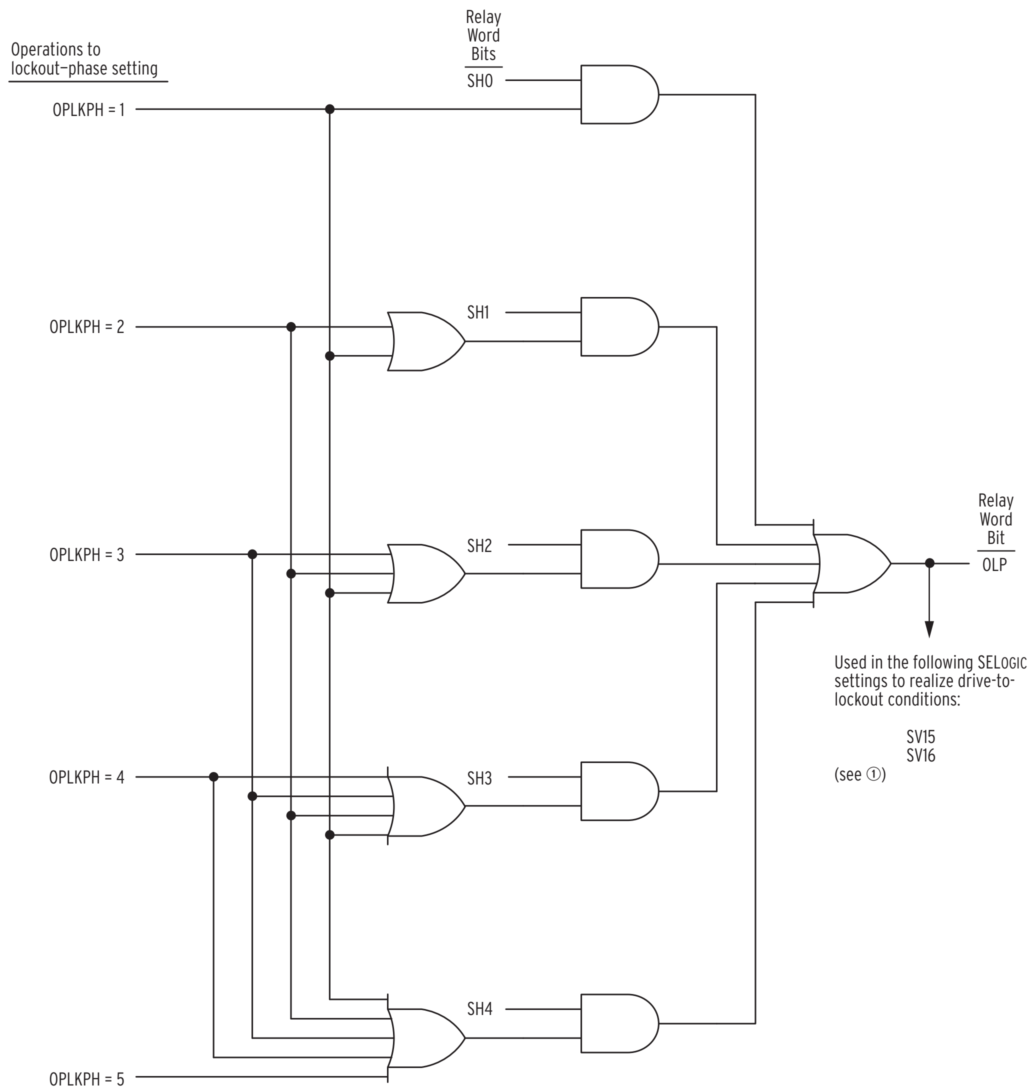
The logic in *Figure 1.8–Figure 1.10* and *Figure 1.12–Figure 1.14* operates similarly to the High-current trip–phase just discussed (*Figure 1.11*).

High-Current Trip Operation When Reclosing Is Defeated

If reclosing is defeated via setting (e.g., all Operations to lockout ≤ 1), then all the following reclosing-related Relay Word bits default to logical 0 (the reclosing relay is nonexistent):

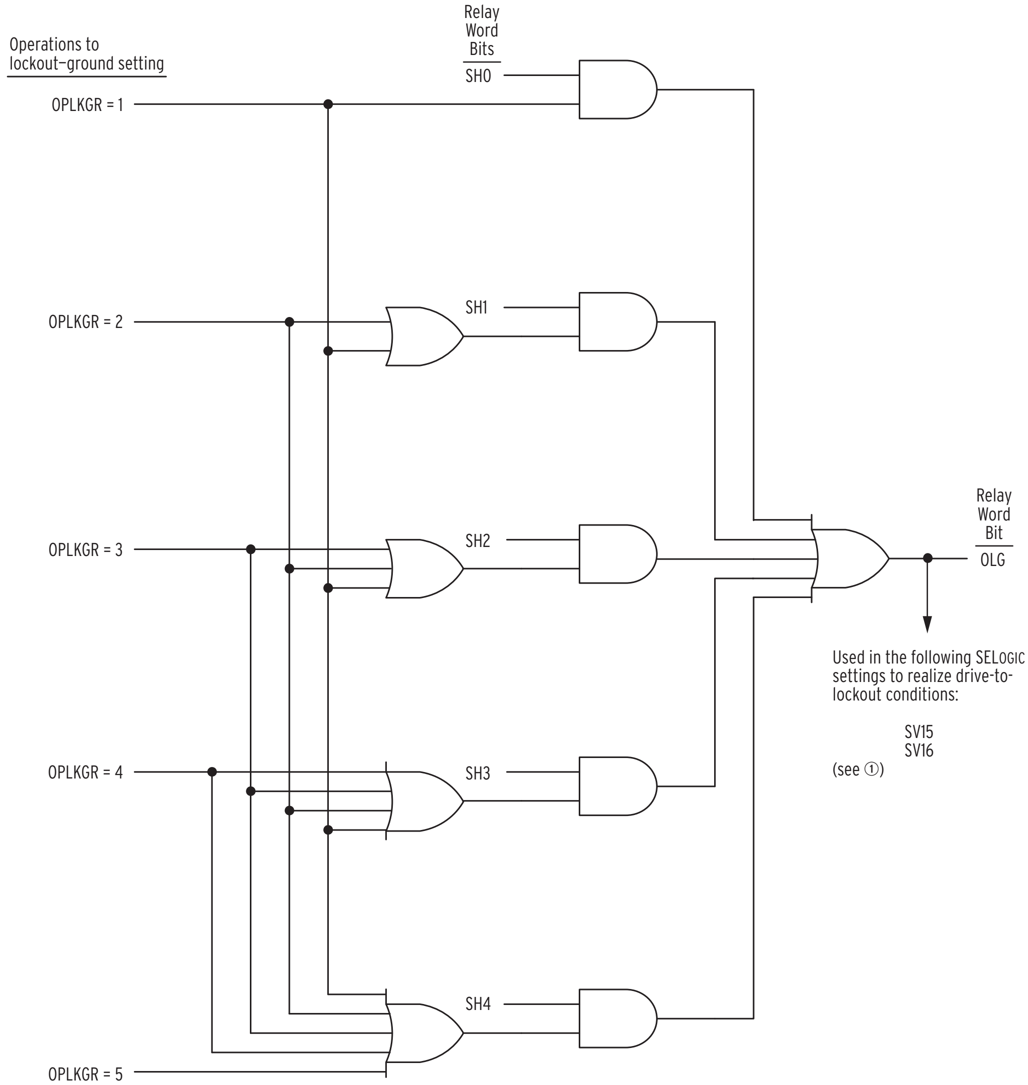
- ➤ SH0, SH1, SH2, SH3, SH4 (shot counter states)
- ➤ 79RS, 79CY, 79LO (reclosing relay states)

The logic at the top of *Figure 1.11* and *Figure 1.12* enables set phase and ground High-current trips, respectively, when reclosing is defeated.



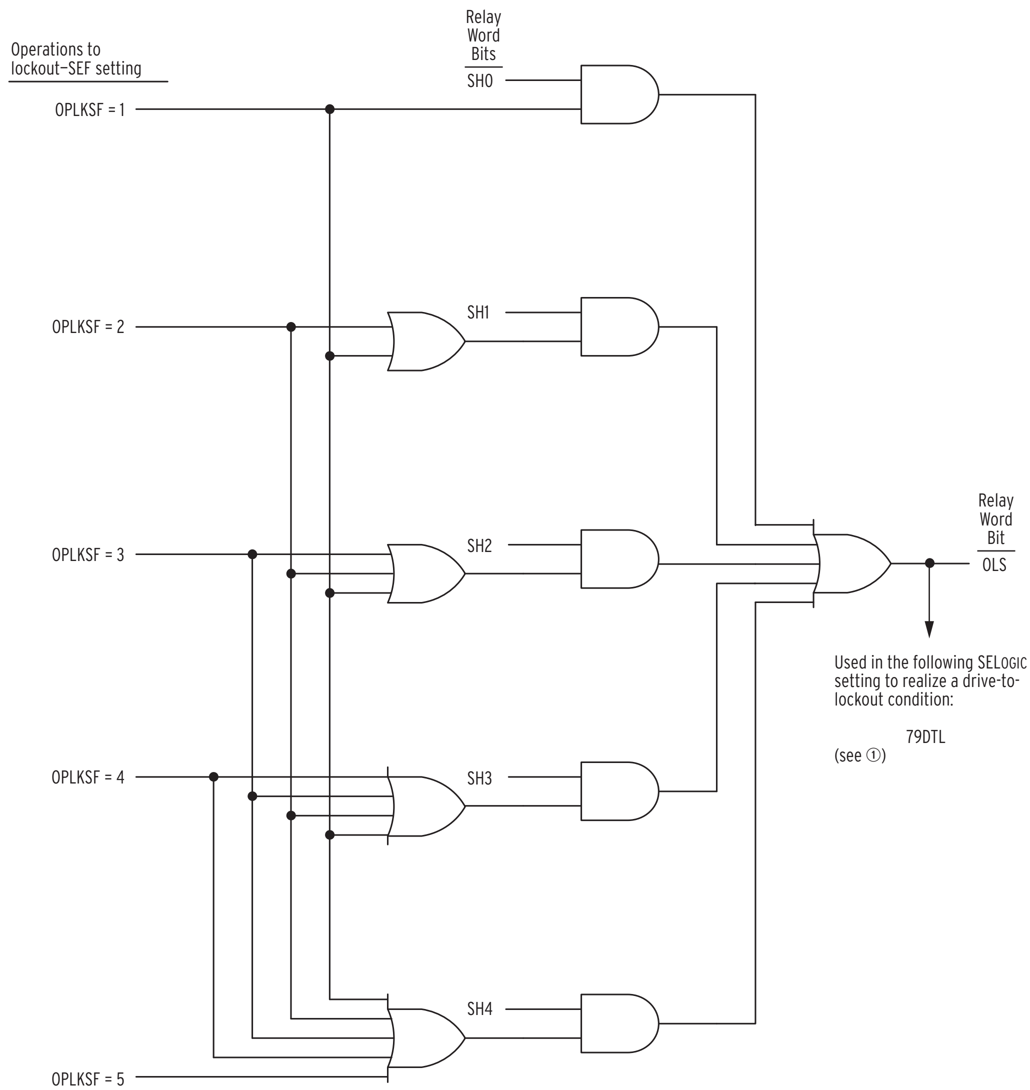
① Figure 1.24.

Figure 1.8 Operations to Lockout—Phase Logic



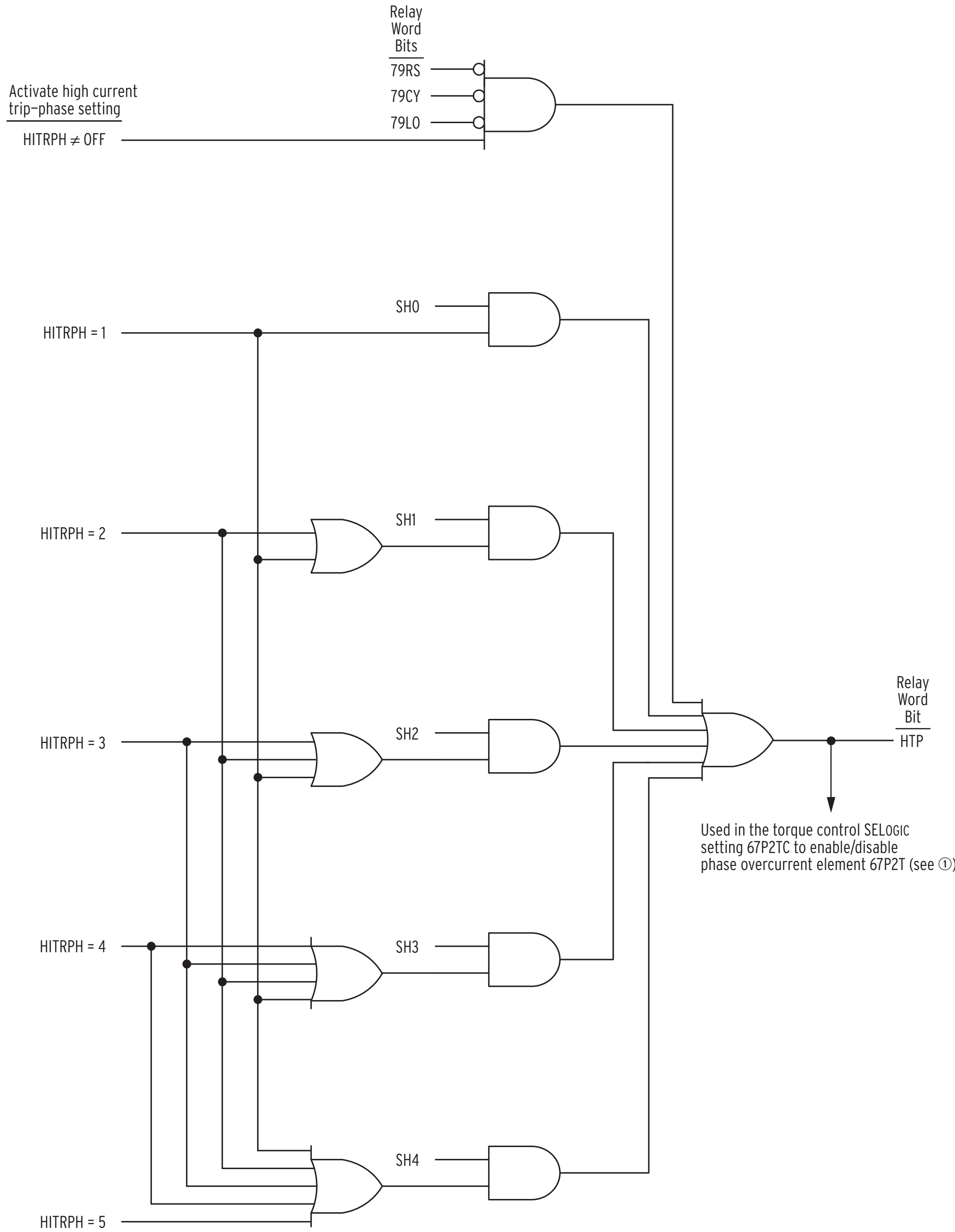
① Figure 1.24.

Figure 1.9 Operations to Lockout—Ground Logic



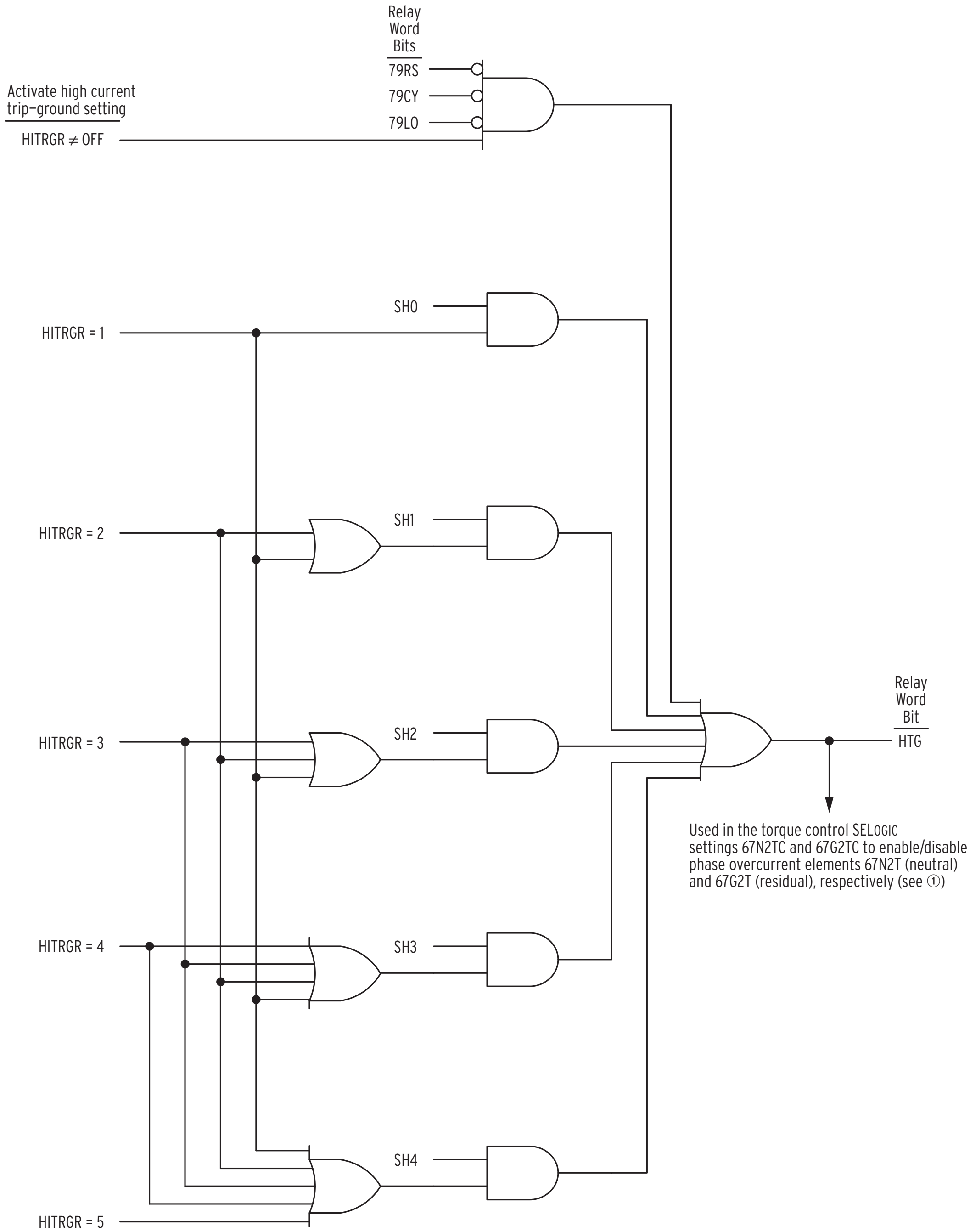
① Figure 1.25.

Figure 1.10 Operations to Lockout—SEF Logic



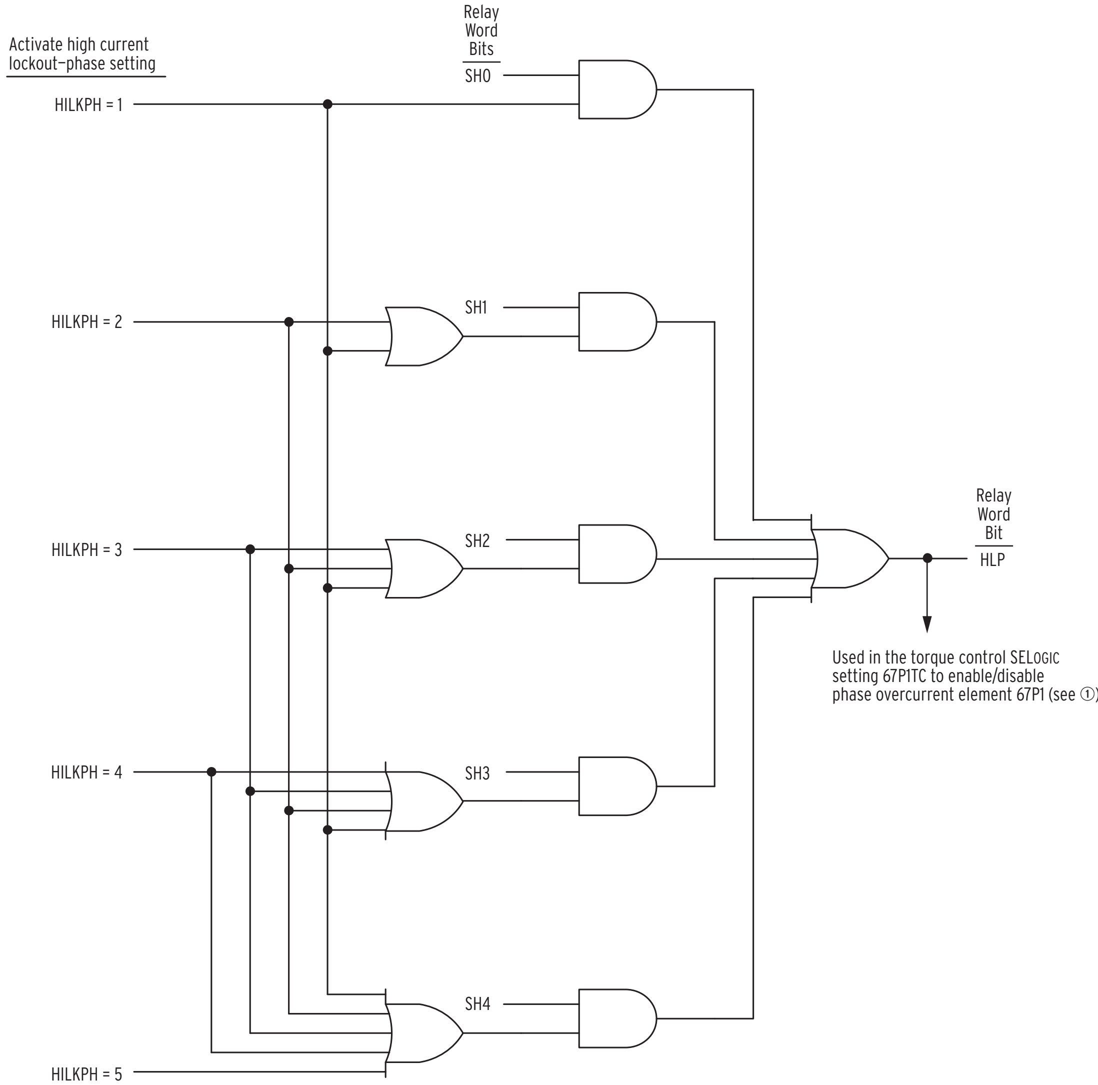
① Figure 1.17.

Figure 1.11 Activate High-Current Trip–Phase Logic



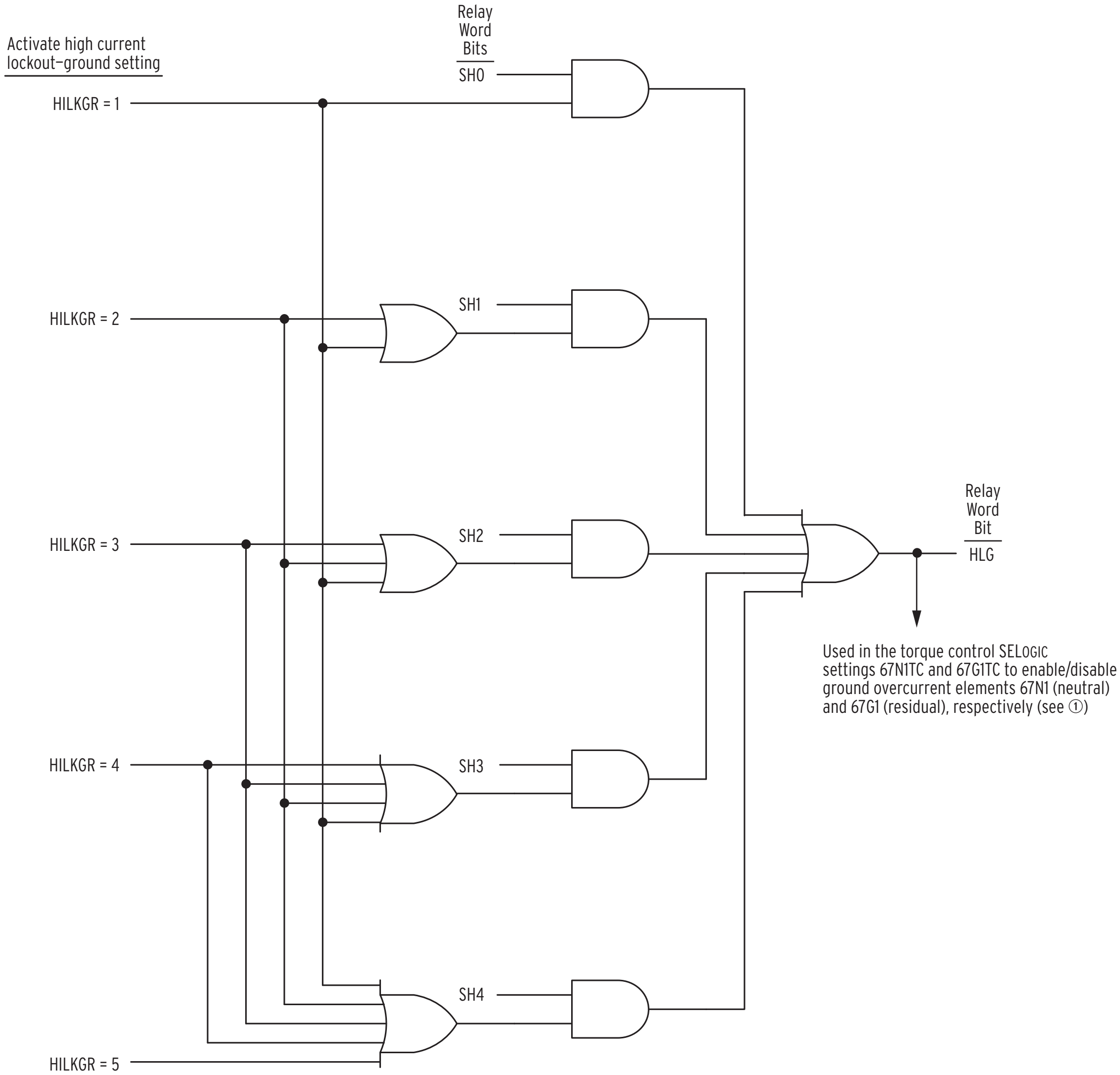
① Figure 1.17.

Figure 1.12 Activate High-Current Trip—Ground Logic



① Figure 1.17.

Figure 1.13 Activate High-Current Lockout—Phase Logic



① Figure 1.17.

Figure 1.14 Activate High-Current Lockout—Ground Logic

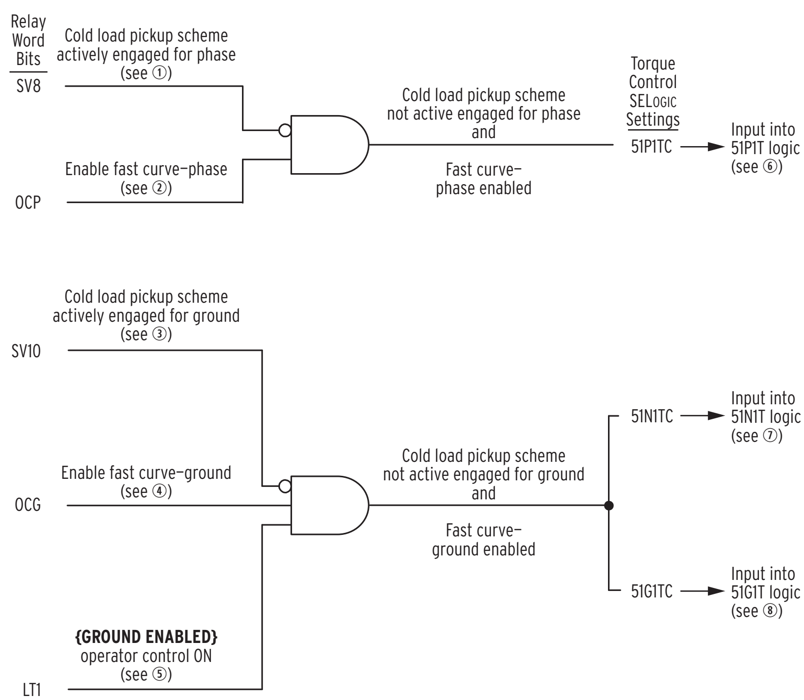
Overcurrent Element Enable/Disable Logic

The logic in *Figure 1.15–Figure 1.18* is a compilation of cold load pickup scheme outputs (Relay Word bits SV8, SV10, and SV12) and other enabling logic (Relay Word bits OCP, OCG, HTP, HTG, HLP, and HLG) discussed in preceding subsections. The torque control settings set with this logic propagate to their respective overcurrent elements to enable/disable the elements.

Note that all the ground and SEF overcurrent elements are *controlled* by the GROUND ENABLED operator control (via Relay Word bit LT1).

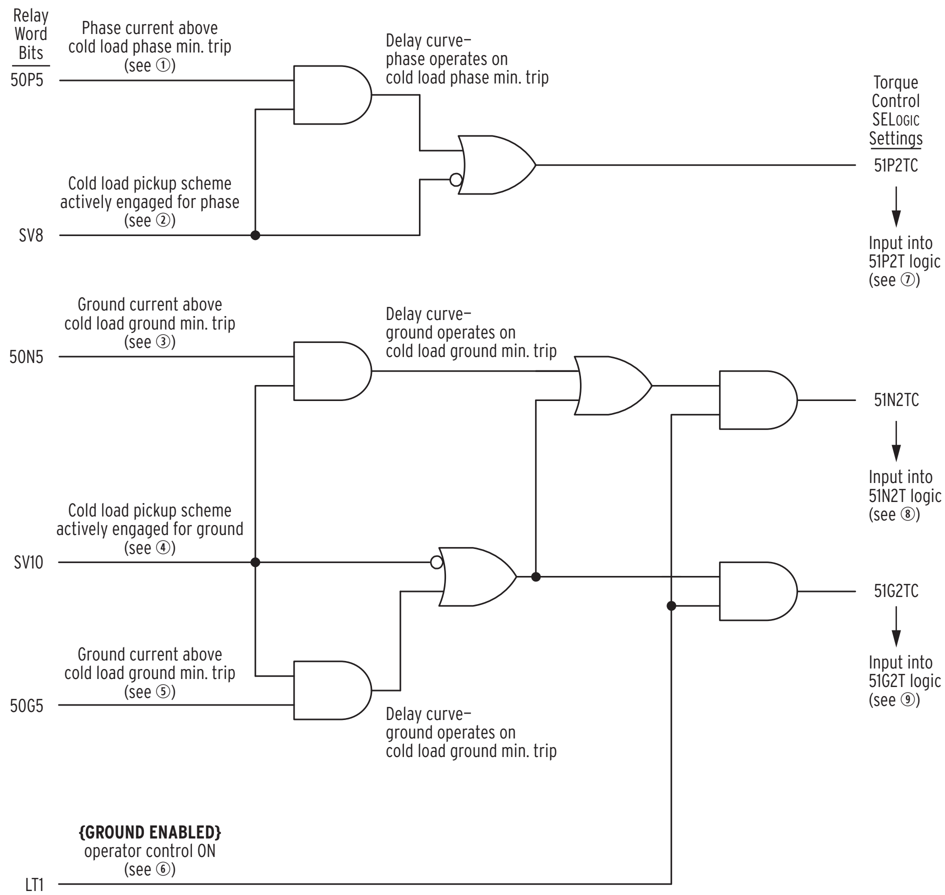
Other overcurrent element enable/disable details involving ground and SEF elements:

- See *Figure 1.16* (bottom) and *Figure 1.18*. If setting Cold load pickup–ground is set effectively below 0.05 Amp secondary, 50N5 is set to this Cold load pickup–ground value (50G5 is turned off automatically). 50N5 provides the effective Min. trip–ground for Delay curve–ground when the cold load pickup scheme is actively engaged (similar to *Figure 1.5*). Otherwise, 50G5 provides the effective Min. trip–ground for Delay curve–ground when the cold load pickup scheme is actively engaged (50N5 is turned off automatically).
- See *Figure 1.18*. The SEF element is enabled only if none of the Fast curve and Delay curve elements are picked up and timing. If the SEF element is used, it is traditionally set to be more sensitive than any other overcurrent elements.



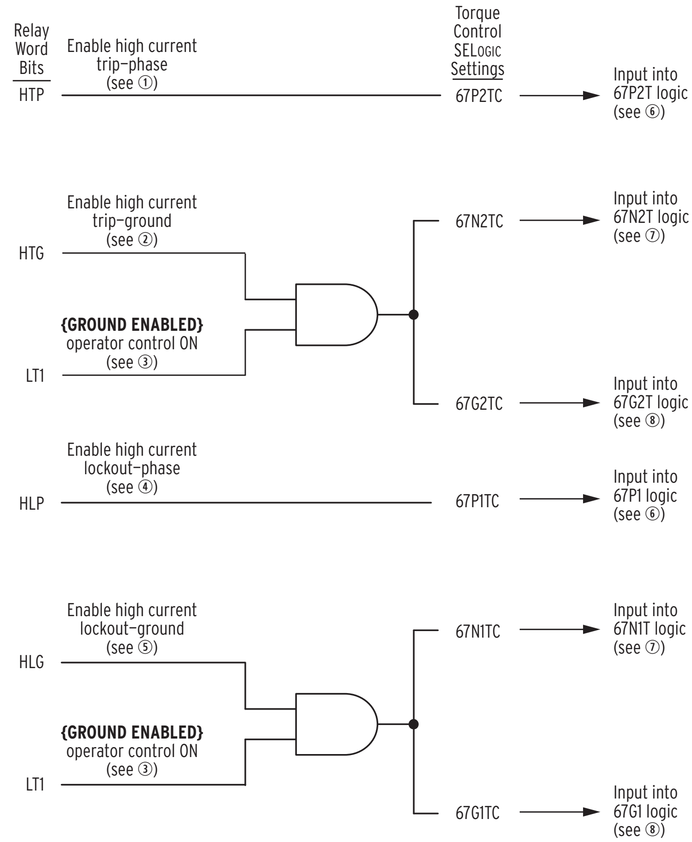
① Figure 1.2; ② Figure 1.6; ③ Figure 1.3; ④ Figure 1.7; ⑤ Figure 1.41;
⑥ Figure 3.14; ⑦ Figure 3.16; ⑧ Figure 3.18.

Figure 1.15 Fast Curve—Phase (Top) and Fast Curve—Ground (Bottom) Enable/Disable Logic



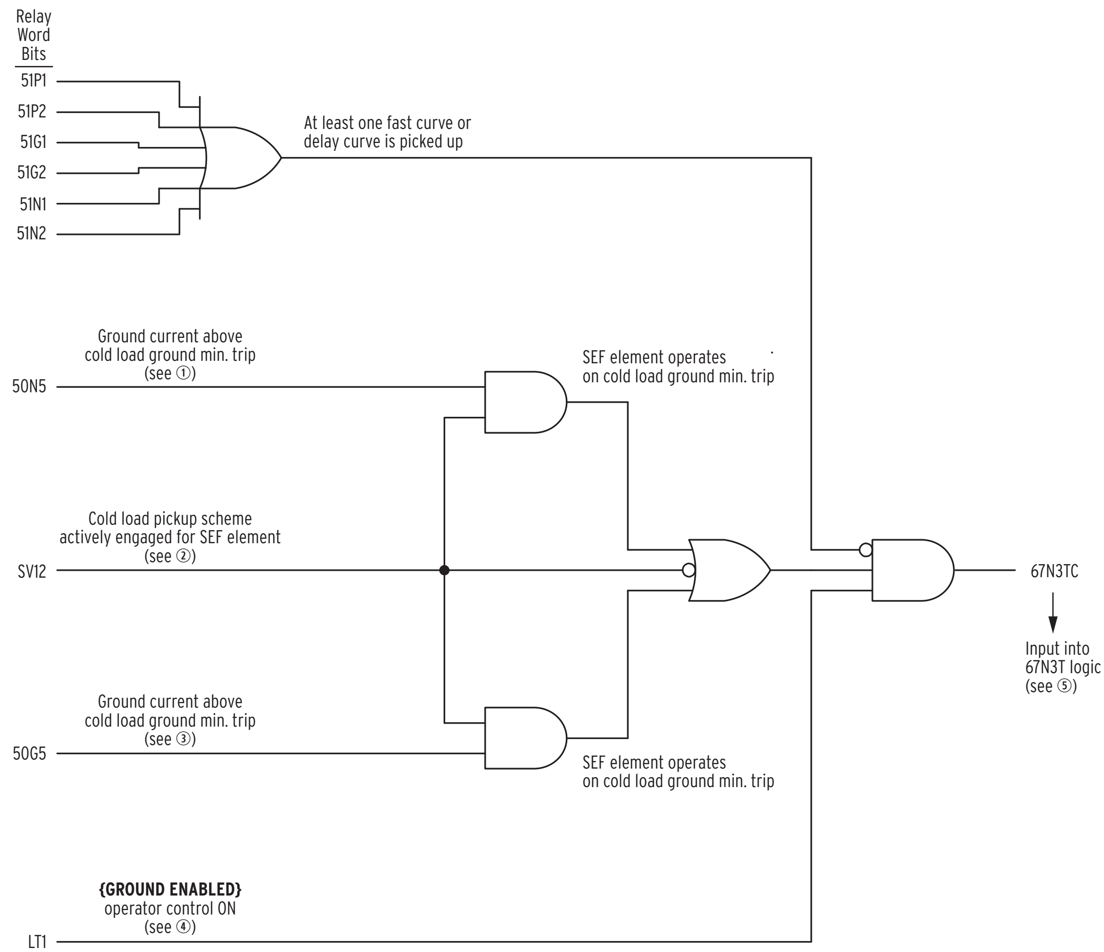
① Figure 3.2; ② Figure 1.2; ③ Figure 3.9; ④ Figure 1.3; ⑤ Figure 3.11; ⑥ Figure 1.41; ⑦ Figure 3.15; ⑧ Figure 3.17; ⑨ Figure 3.19.

Figure 1.16 Delay Curve—Phase (Top) and Delay Curve—Ground (Bottom) Enable/Disable Logic



① Figure 1.11; ② Figure 1.12; ③ Figure 1.41; ④ Figure 1.13; ⑤ Figure 1.14; ⑥ Figure 3.3; ⑦ Figure 3.8; ⑧ Figure 3.10.

Figure 1.17 High-Current Trip (Top) and High-Current Lockout (Bottom) Enable/Disable Logic



① Figure 3.9; ② Figure 1.4; ③ Figure 3.11; ④ Figure 1.41; ⑤ Figure 3.8.

Figure 1.18 SEF Element Enable/Disable Logic

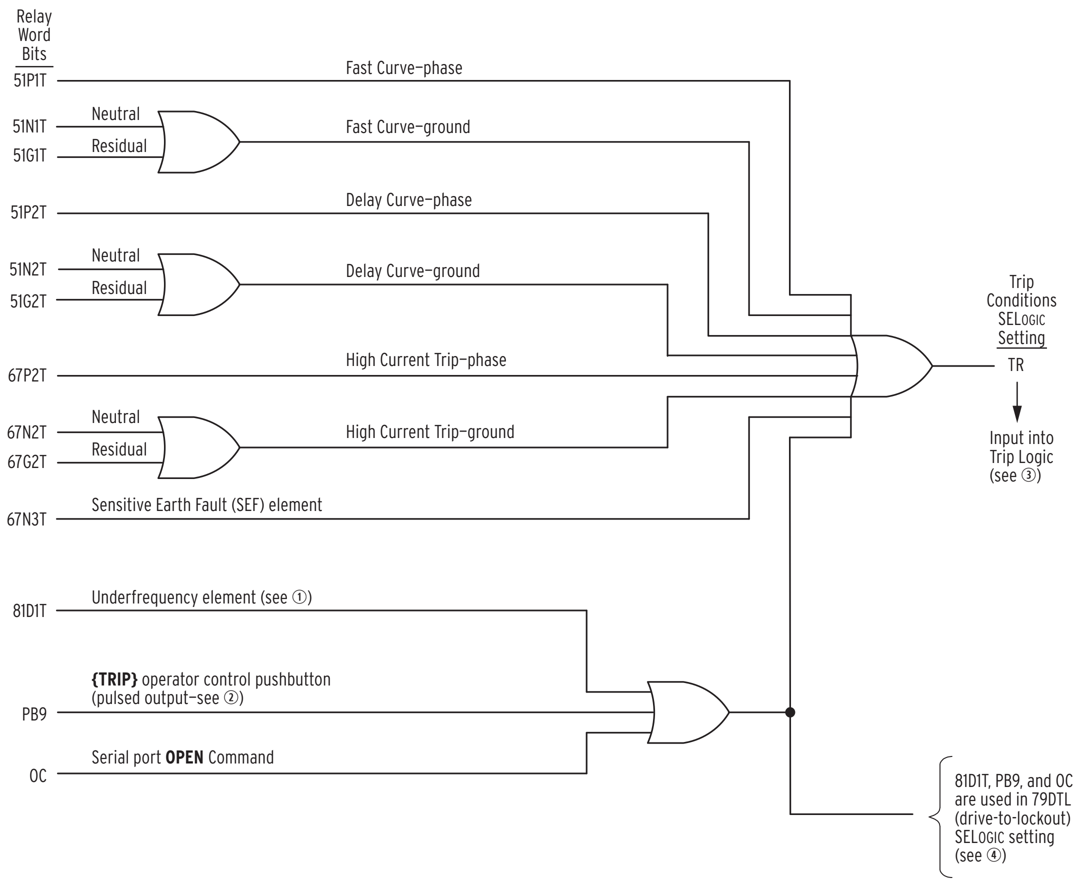
Trip Logic

See *Figure 1.19*. The overcurrent elements in *Figure 1.19* are controlled by the logic in *Figure 1.15–Figure 1.18*. Other trip logic details:

- ➤ If setting Min. trip–ground is set below 0.1 Amp secondary, 51N1T and 51N2T operate as Fast curve–ground and Delay curve–ground, respectively (51G1T and 51G2T are turned off automatically). Otherwise, 51G1T and 51G2T operate as Fast curve–ground and Delay curve–ground, respectively (51N1T and 51N2T are turned off automatically).
- ➤ If setting High-current trip–ground is set effectively below 0.05 Amp secondary, 67N2T operates as High-current trip–ground (67G2T is turned off automatically). Otherwise, 67G2T operates as High-current trip–ground (67N2T is turned off automatically).

Figure 1.19 propagates into the trip logic (see *Figure 5.1*). The trip signal output (Relay Word bit TRIP) is then assigned to the HV FET trip output with SELOGIC recloser control trip setting (see *Figure 7.29*):

RCTR = **TRIP**



① Figure 3.28; ② Figure 1.40; ③ Figure 5.1; ④ Figure 1.25.

Figure 1.19 Trip Conditions

Close Logic

Close Conditions—Other Than Auto-Reclosing

Figure 1.20 shows the two additional ways to issue a close signal to a recloser, other than with auto-reclosing:

- CLOSE operator control (local)
- Serial port **CLOSE** command (remote)

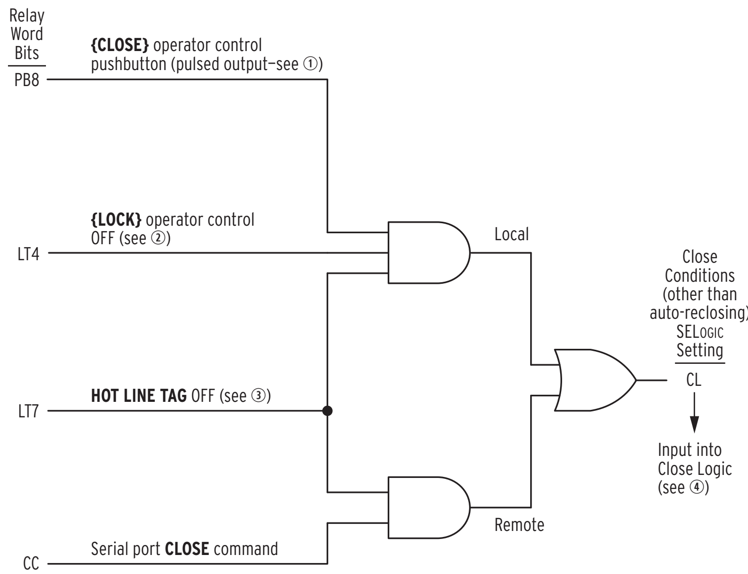
Supervision of these local and remote close signals is provided by:

- LOCK operator control—supervises CLOSE operator control only
- Hot-line tag—supervises CLOSE operator control and serial port **CLOSE** command

Other close logic details in *Figure 1.20* are listed below:

- The LOCK operator control also supervises other front-panel operator controls (see *Figure 1.41–Figure 1.43* and *Figure 1.45–Figure 1.49*).
- Hot-line tag also supervises auto-reclosing (see *Figure 1.25*).
- No standing close is possible with this logic. The CLOSE operator control (Relay Word bit PB8) and serial port **CLOSE** command (Relay Word bit CC) pulse for only one processing interval (one quarter cycle) when activated. Also, in referenced

Figure 6.1, SELOGIC control equation setting CL is rising edge triggered. Thus, if the LOCK operator control (Relay Word bit LT4) or hot-line tag (Relay Word bit LT7) are turned ON or OFF, no surprise close takes place—there is no standing close condition waiting to get through.



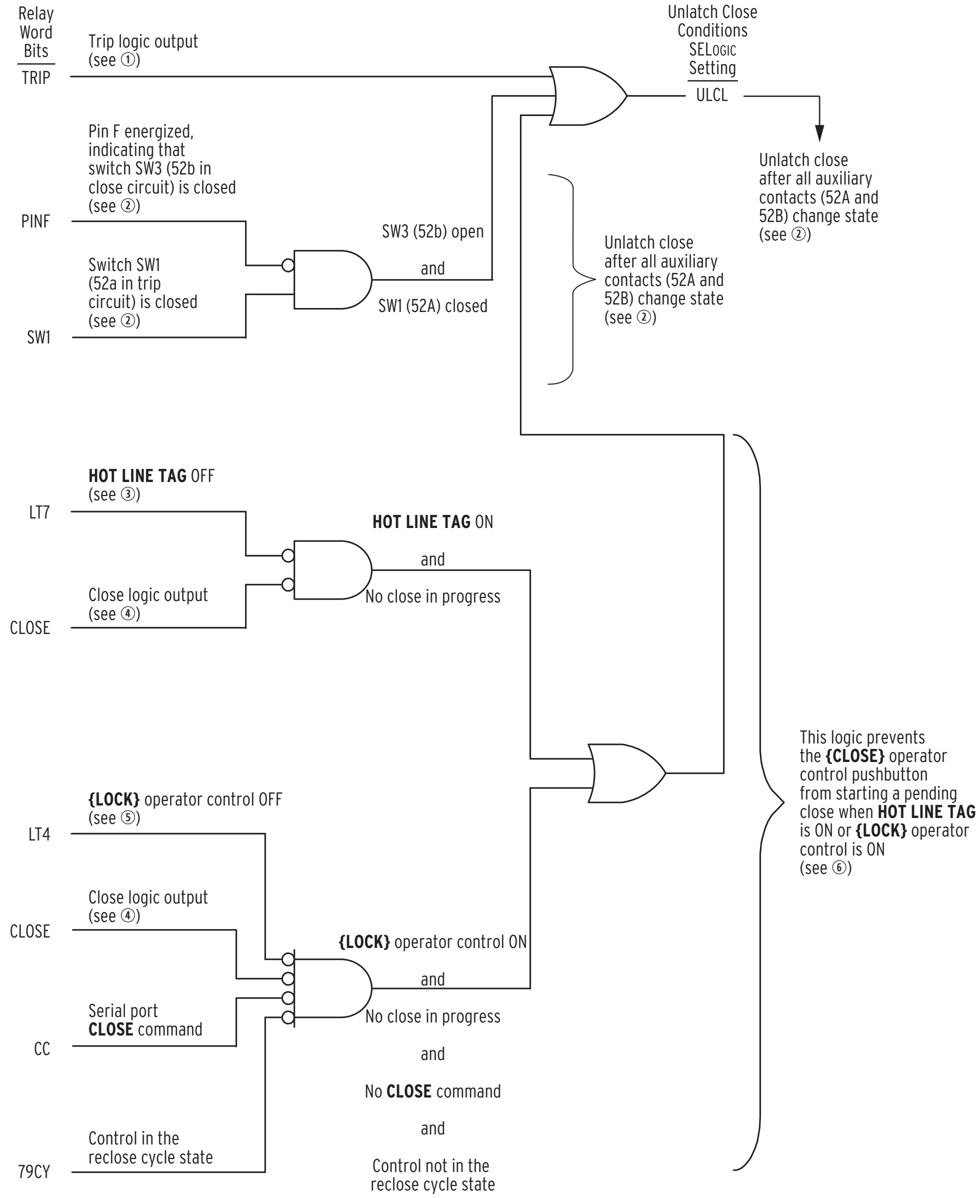
① Figure 1.39; ② Figure 1.50; ③ Figure 1.47; ④ Figure 6.1.

Figure 1.20 Close Conditions—Other Than Auto-Reclosing

Unlatch Close Conditions

Figure 1.21 shows the means to unlatch the close signal output. Other unlatch close logic details in *Figure 1.21* are listed below:

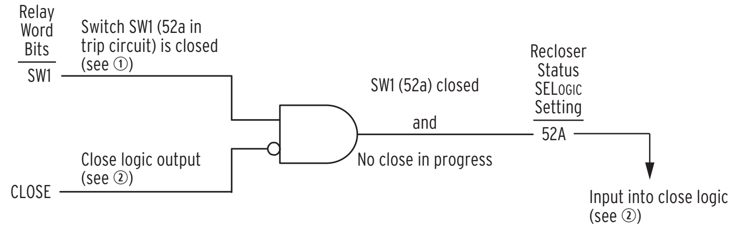
- When the CLOSE operator control is set with a time delay (PB8D > 0; see *Figure 1.39*) and is timing to a pending close, the corresponding RECLOSER CLOSED LED flashes as a timing indication. Besides unlatching the close signal output, the unlatch close SELOGIC setting (ULCL) also prevents the CLOSE operator control from starting to time to a pending close. The logic in the bottom-half of *Figure 1.21* is set primarily with the task in mind of keeping the RECLOSER CLOSED LED from flashing, by preventing the CLOSE operator control from starting to time for a hot-line tag ON or a LOCK operator control ON. The logic allows the **CLOSE** command and auto-reclosing to still proceed, with the LOCK operator control ON.
- The logic in the top-half of *Figure 1.21* is set to unlatch the close signal output when the 52b contact in the close circuit is open and the 52a in the trip circuit is closed (see *Figure 7.29*)—the recloser has made a complete mechanical changeover to the close position.



① Figure 5.1; ② Figure 7.29; ③ Figure 1.47; ④ Figure 6.1; ⑤ Figure 1.50; ⑥ Figure 1.39.

Figure 1.21 Unlatch Close Conditions

Figure 1.22 shows the logic for recloser status determination. SELOGIC setting 52A includes the CLOSE Relay Word bit to hold off the change of state of 52A until the unlatch close logic (see *Figure 1.21*) unlatches the close signal output. This assures that the 52b in the close circuit is open (as indicated by Relay Word bit PINF = logical 0 in *Figure 7.29*) before the close signal output is unlatched (CLOSE = logical 0).



① Figure 7.29; ② Figure 6.1.

Figure 1.22 Recloser Status Determination

Figure 1.20–Figure 1.22 all propagate into the close logic (see *Figure 6.1*). The close signal output (Relay Word bit CLOSE) is then assigned to the HV FET close output with SELOGIC recloser control close setting (see *Figure 7.29*):

RCCL = **CLOSE**

Drive-to-Lockout Logic

SELOGIC Variables SV13, SV14, SV15, and SV16 are used as intermediate steps in realizing the entire drive-to-lockout logic (see *Figure 1.23–Figure 1.25*). Other details in *Figure 1.23*:

- If setting Min. trip–ground is set below 0.1 Amp secondary, 51N1T and 51N2T operate as Fast curve–ground and Delay curve–ground, respectively (51G1T and 51G2T are turned off automatically). Otherwise, 51G1T and 51G2T operate as Fast curve–ground and Delay curve–ground, respectively (51N1T and 51N2T are turned off automatically).
- If setting High-current trip–ground is set effectively below 0.05 Amp secondary, 67N2T operates as High-current trip–ground (67G2T is turned off automatically). Otherwise, 67G2T operates as High-current trip–ground (67N2T is turned off automatically).
- If setting Min. trip–ground is set below 0.1 Amp secondary, 50N6 provides the indication that ground current is above the Min. trip–ground setting value (50G6 is turned off automatically). Otherwise, 50G6 provides the indication (50N6 is turned off automatically).

Operations to Lockout

The logic for the operations to lockout settings for phase, ground and SEF elements is found in preceding *Figure 1.8–Figure 1.10*. The output of this logic (Relay Word bits OLP, OLG, and OLS) is used in the drive-to-lockout logic in *Figure 1.24* and top of *Figure 1.25*.

The SEL-351R is driven to lockout if all the following are true:

- The number of trip operations is greater than or equal to setting Operations to lockout–ground (Relay Word bit OLG asserted to logical 1)
- An overcurrent trip is in progress (except SEF element trip)

- *Either* of the following two scenarios is true:
  - Ground trip precedence enabled and ground fault current above Min. trip–ground level
  - Ground trip precedence disabled, ground fault current above Min. trip–ground level, and phase fault current below Min. trip–phase level

The SEL-351R is driven to lockout if *all* the following are true:

- The number of trip operations is greater than or equal to setting Operations to lockout–phase (Relay Word bit OLP asserted to logical 1)
- An overcurrent trip is in progress (except SEF element trip)
- *Either* of the following two scenarios is true:
  - Ground trip precedence enabled, ground fault current below Min. trip–ground level, and phase fault current above Min. trip–phase level
  - Ground trip precedence disabled and phase fault current above Min. trip–phase level

The SEL-351R is driven to lockout (regardless of the Ground trip precedence setting) if *all* the following are true:

- An overcurrent trip is in progress (except SEF element trip)
- The number of trip operations is greater than or equal to setting Operations to lockout–ground (Relay Word bit OLG asserted to logical 1)
- The number of trip operations is greater than or equal to setting Operations to lockout–phase (Relay Word bit OLP asserted to logical 1)

The SEL-351R is driven to lockout if *both* the following are true:

- The SEF element trips
- The number of trip operations is greater than or equal to setting Operations to lockout–SEF (Relay Word bit OLS asserted to logical 1)

High-Current Lockout

The controlling logic for the High-current lockout–phase and ground elements is found in preceding *Figure 1.17*. The resultant High-current lockout–phase and High-current lockout–ground elements are used in the drive-to-lockout logic in *Figure 1.25*. If phase or ground fault current exceeds the pickups of either of these respective High-current lockout–phase and High-current lockout ground elements when the SEL-351R trips, the SEL-351R is driven to lockout.

- If setting High-current lockout–ground is set effectively below 0.05 Amp secondary, 67N1 operates as the High-current lockout–ground element (67G1 is turned off automatically). Otherwise, 67G1 operates as the High-current lockout–ground element (67N1 is turned off automatically).

Other Drive-to-Lockout Conditions

The SEL-351R is driven to lockout if a trip operation occurs or the recloser opens while either one of the following is true:

➤ RECLOSE ENABLED operator control OFF

➤ Hot-line tag ON

The SEL-351R is driven to lockout if any of the following occur:

➤ Underfrequency element operates

➤ TRIP operator control pressed

➤ Serial port **OPEN** command executed

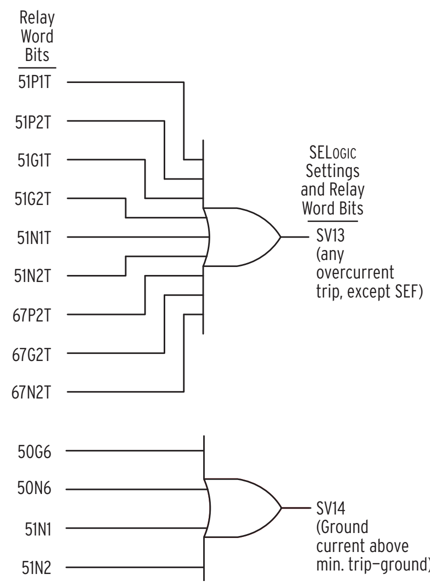
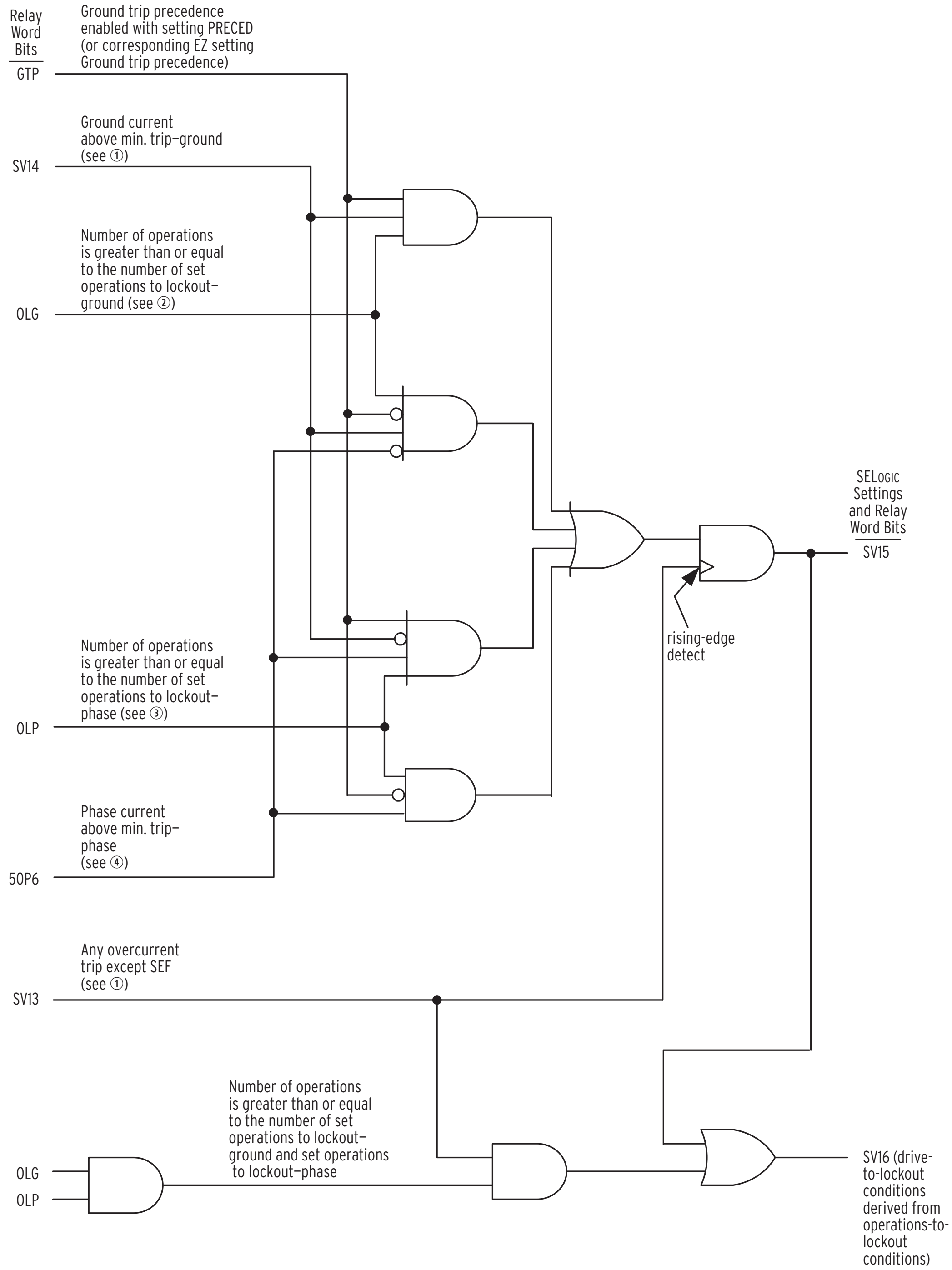
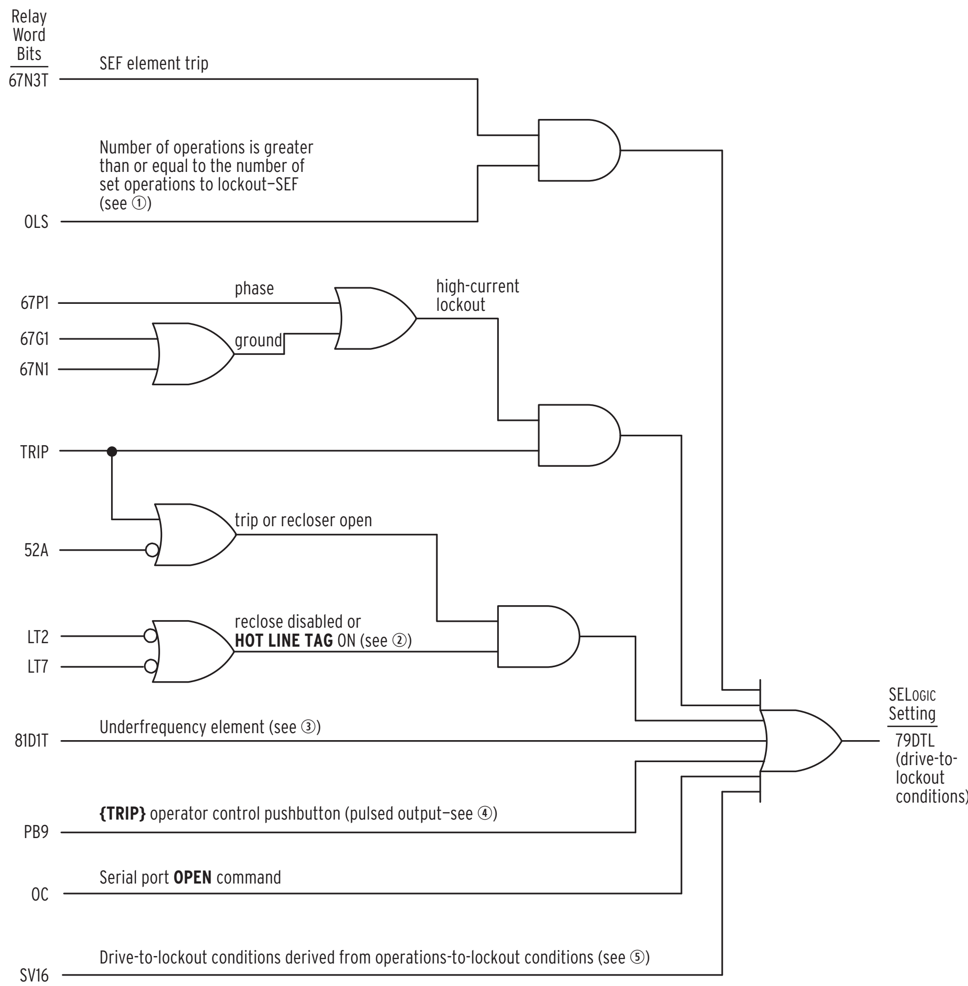


Figure 1.23 Drive-to-Lockout Logic—Part 1 of 3



① Figure 1.23; ② Figure 1.9; ③ Figure 1.8; ④ Figure 3.2.

Figure 1.24 Drive-to-Lockout Logic—Part 2 of 3



① Figure 1.10; ② Figure 1.42 and Figure 1.47; ③ Figure 3.28; ④ Figure 1.40; ⑤ Figure 1.24.

Figure 1.25 Drive-to-Lockout Logic—Part 3 of 3

Block Reset Timing

See *Figure 1.26*. If any of the fast curves, delay curves, or SEF elements are picked up and timing, reset timing is blocked. Reset timing is also blocked if tripping is in progress. After block reset conditions are gone, the reset timer fully loads up again and then begins timing if the recloser is closed.

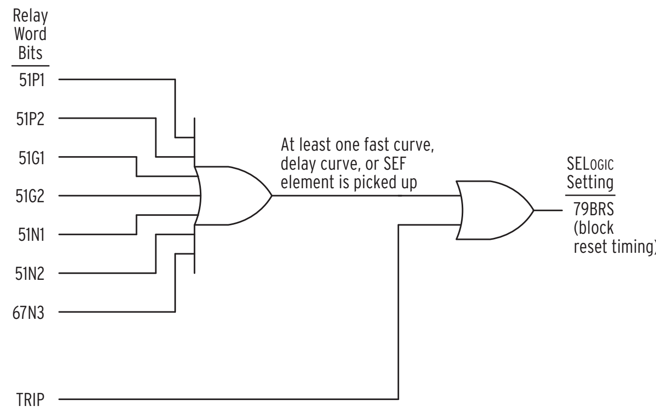


Figure 1.26 Block Reset Timing Logic

Sequence Coordination

Refer to *Sequence Coordination Setting (79SEQ) on page 6.21* for background on the operation of the 79SEQ setting.

See *Figure 1.27*. Enable sequence coordination with EZ setting:

Sequence coordination = **Y** (asserts Relay Word bit SEQC to logical 1)

Besides the Sequence coordination EZ setting, the factory-set sequence coordination logic requires *both* the following be true:

- SEL-351R is in the Reset state (Relay Word bit 79RS = logical 1)
- Fast curve–phase or Fast curve–ground is picked up (Relay Word bit pickup indicator 51P1 = logical 1, 51G1 = logical 1, or 51N1 = logical 1, respectively)

Then the sequence coordination SELOGIC setting 79SEQ asserts to logical 1.

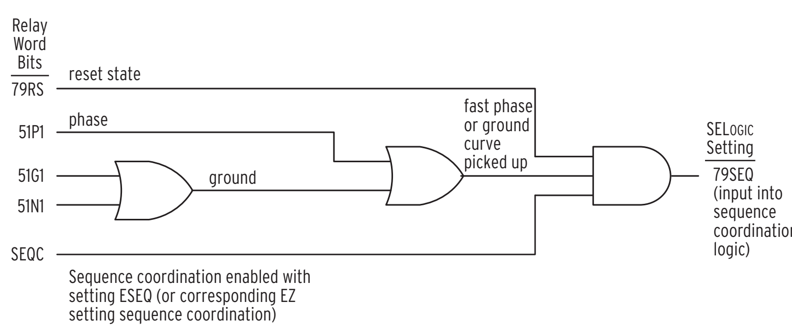


Figure 1.27 Sequence Coordination Logic

Refer to the example in *Figure 1.28*. The sequence coordination logic in *Figure 1.27* keeps SEL-351R(1) from overtripping for a fault beyond SEL-351R(2).

Refer to *Figure 1.29*. The following are factory settings for SEL-351R(1):

79SEQ = **79RS * (51P1 + 51G1 + 51N1) * SEQC** (see *Figure 1.27*)

51P1TC = **!SV8 * OCP** (see *Figure 1.2* and *Figure 1.15*)

Presuming the cold load pickup scheme is not active, !SV8 = NOT(SV8) = NOT (logical 0) = logical 1. Setting 51P1TC is then controlled only by Relay Word bit OCP. With factory EZ setting Operations–phase fast curve = 2, Relay Word bit OCP = logical 1 for shot counter = 0 and shot counter = 1. Fast curve–phase (51P1T) is then enabled for shot counter = 0 and shot counter = 1.

Figure 1.29 gives a time-line of the operation of SEL-351R(1) sequence coordination logic for a fault beyond downstream SEL-351R(2). Each time SEL-351R(2) interrupts the phase fault, the SEL-351R(1) shot counter increments to the next shot. The shot counter in turn controls Fast curve–phase (51P1T) via torque control setting 51P1TC.

Once shot counter = 2, Fast curve–phase is disabled. Then when downstream SEL-351R(2) is operating on Delay curve–phase, the SEL-351R(1) Fast curves are out of the way—the SEL-351R(1) does not overtrip for a fault beyond SEL-351R(2).

As stated in *Sequence Coordination Setting (79SEQ) on page 6.21*, the reset timer setting 79RSD (corresponding EZ setting Reset time for auto reclose) takes the shot counter back to shot counter = 0 after a sequence coordination operation increments the shot counter. Make sure that reset timer setting 79RSD is set long enough to maintain the shot counter at shot = 2 as shown in *Figure 1.29*.

Other sequence coordination details involving ground elements:

If setting Min. trip–ground is set below 0.1 Amp secondary, 51N1 provides the indication that the ground fault current is above the normal Min. trip–ground setting value and the Fast curve–ground is picked up (51G1 is turned off automatically). Otherwise, 51G1 provides the indication (51N1 is turned off automatically).

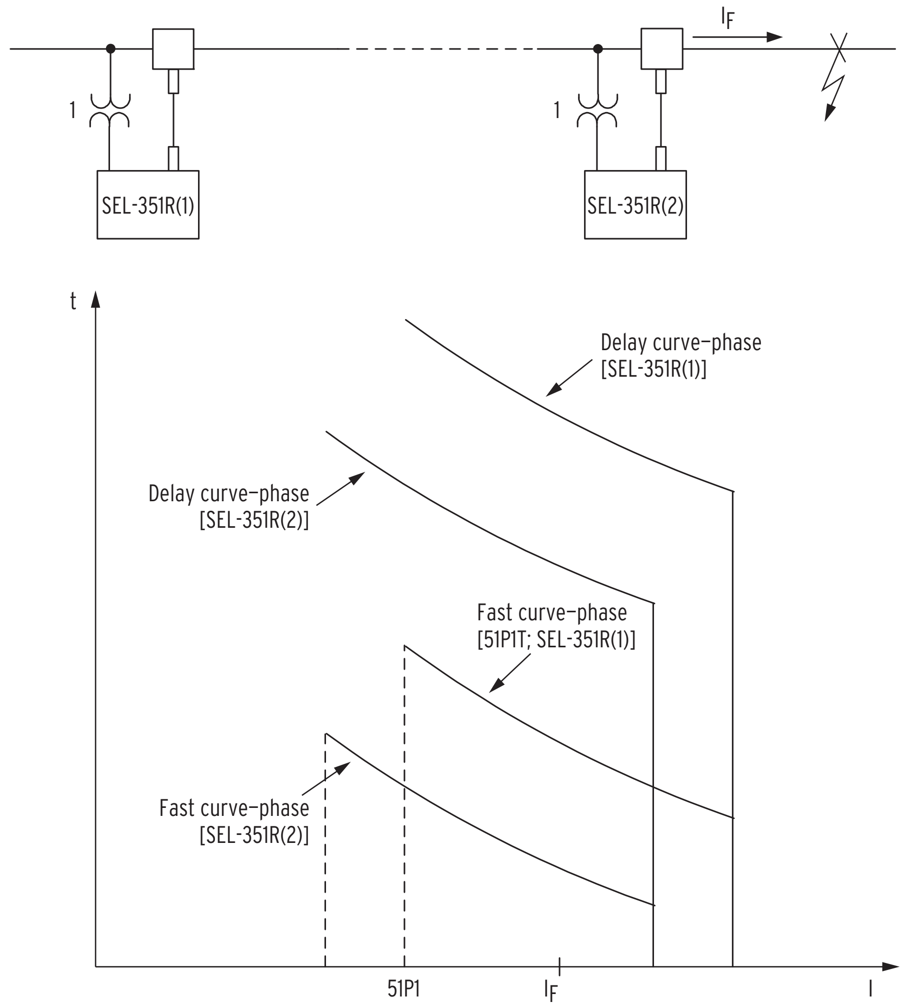
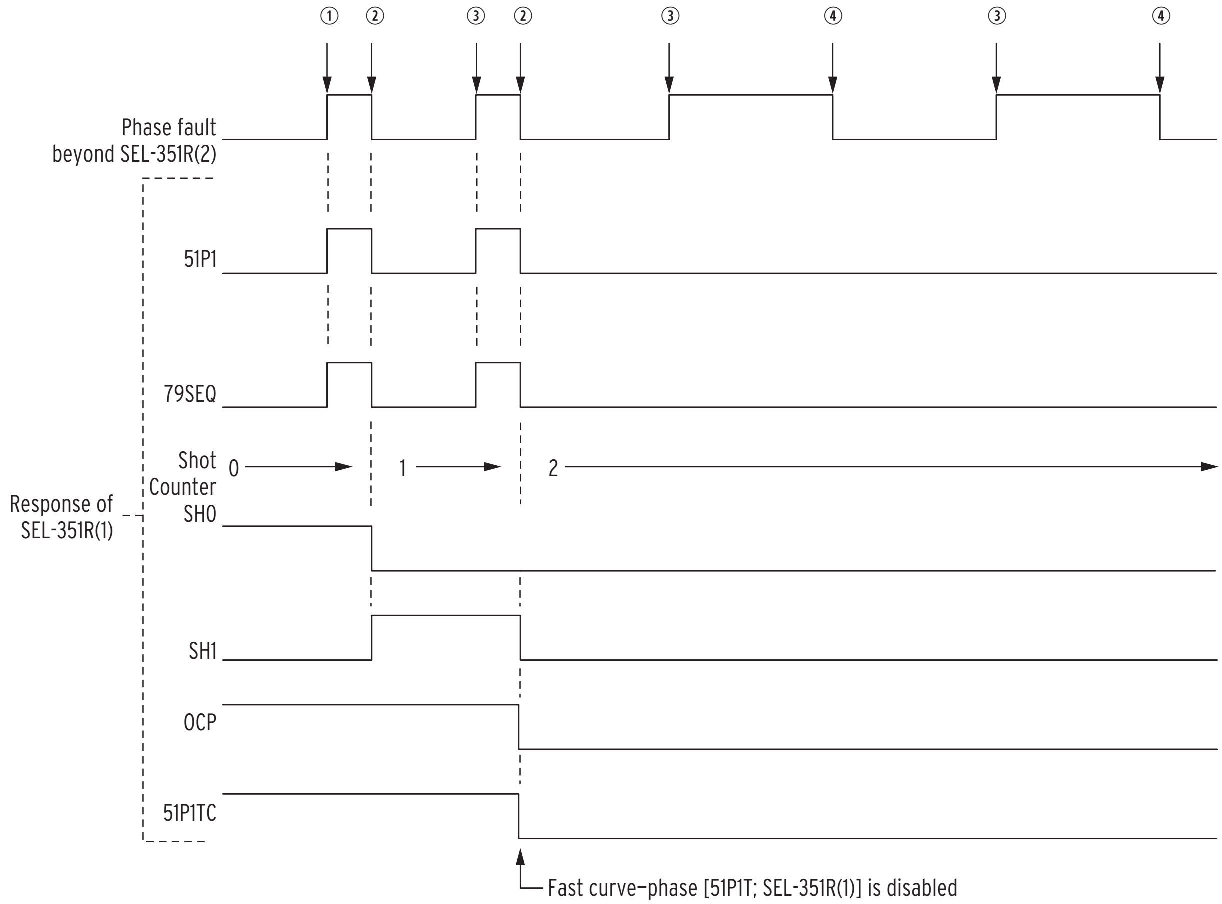


Figure 1.28 Phase Coordination of SEL-351R Recloser Controls in Series



① Fault occurs beyond SEL-351R(2); ② fault cleared by SEL-351R(2) Fast curve–phase; ③ SEL-351R(2) recloses into fault; ④ fault cleared by SEL-351R(2) Delay curve–phase.

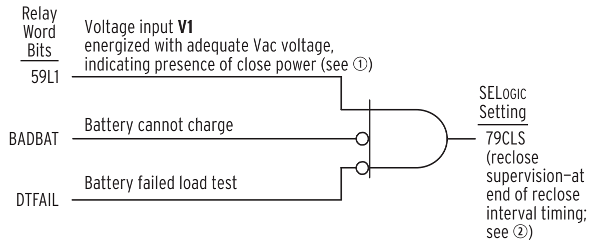
Figure 1.29 Operation of SEL-351R(1) Sequence Coordination Logic for Phase Fault Beyond Downstream SEL-351R(2)

Reclose Supervision Logic

See *Figure 1.30*. After a reclose interval times out, a final check is made of the reclose supervision logic before the SEL-351R auto-recloses the recloser. For auto-reclosing to proceed, *both* following conditions must be met:

- ➤ Healthy battery
- ➤ Present close power

After a reclose interval times out, the logic in *Figure 1.30* is final checked for a time period equivalent to EZ setting Close power wait time (corresponding setting 79CLSD—see *Figure 6.2*). If SELOGIC setting 79CLS (reclose supervision) asserts to logical 1 any time during this time period, auto-reclosing proceeds.



① Figure 3.21; ② Figure 6.2.

Figure 1.30 Reclose Supervision Logic

Healthy Battery

Relay Word bits BADBAT and DTFAIL (used in *Figure 1.30* logic) indicate that the battery is unhealthy. If the battery fails the load test, Relay Word bit DTFAIL remains asserted to logical 1 until the next load test is successfully passed. See Section 6 in the *SEL-351R-4 Quick-Start Installation and User's Guide* and subsection *Battery System Monitor on page 8.15* of this manual for more information.

Any reclose consideration always has to presume a trip may soon follow. If the adequate ac power source is lost after the recloser is reclosed, any trip will be dependent on the battery providing 24 Vdc energy. Therefore, if the battery is not healthy (e.g., it cannot take a charge or failed the battery discharge test), the control should not issue a reclose because there might not be enough battery energy to trip at a later time.

Present Close Power

The power to close the main contacts and compress the tripping springs in the recloser is usually either of the following:

- Secondary voltage
- Primary voltage

depending on recloser design. If this close power is secondary voltage (e.g.,120 Vac), it is usually paralleled off the SEL-351R power terminals for convenience (see Figure 1.7 in the *SEL-351R-4 Quick-Start Installation and User's Guide*).

Figure 1.31–Figure 1.34 detail various scenarios for connecting the SEL-351R to the recloser, ac power (120 Vac power in these examples), and power system voltages. The installation in each figure is discussed from the point of view of both close power scenarios (120 Vac or primary voltage). In each of these figures, note the following voltage connections are always made:

- Source power bus (to power the SEL-351R; 120 Vac power in these examples)
- Voltage input **V1** (for frequency monitoring)

Suggested settings changes are given for:

- Close power monitoring in the reclose supervision logic (SELOGIC setting 79CLS in *Figure 1.30*)
- Undervoltage block for frequency elements (setting 27B81P in *Figure 3.27*)

These settings change, depending on the installation connections.

Front-Panel AC SUPPLY LED

Refer to Figure 1.7 in the *SEL-351R-4 Quick-Start Installation and User's Guide*. Note that the power supply inside the SEL-351R Recloser Control module is fused internally. If the fuse blew, adequate source power could still be hot up to the power terminals, (bused-together Terminals Z25 and Z26) and to paralleled voltage input **V1** (if factory-installed jumpers are still in place). Thus, an energized voltage input **V1** is not necessarily an indication that the SEL-351R relay module is energized. Thus, the SELOGIC setting for the **AC SUPPLY** LED is:

LED11 = **!DISCHG** [= NOT(DISCHG); the battery is not discharging]

If the battery is not discharging, it is either charging, disconnected, or otherwise damaged. The SEL-351R relay module gets its power to run from either:

- ➤ Incoming adequate source power (120 Vac power in the following examples)
- ➤ 24 Vdc battery

If neither one of these power sources is available, then the SEL-351R relay module is dead and the **AC SUPPLY** LED is extinguished anyway. The **AC SUPPLY** LED may flicker at times when tripping or closing, because of momentary battery discharge.

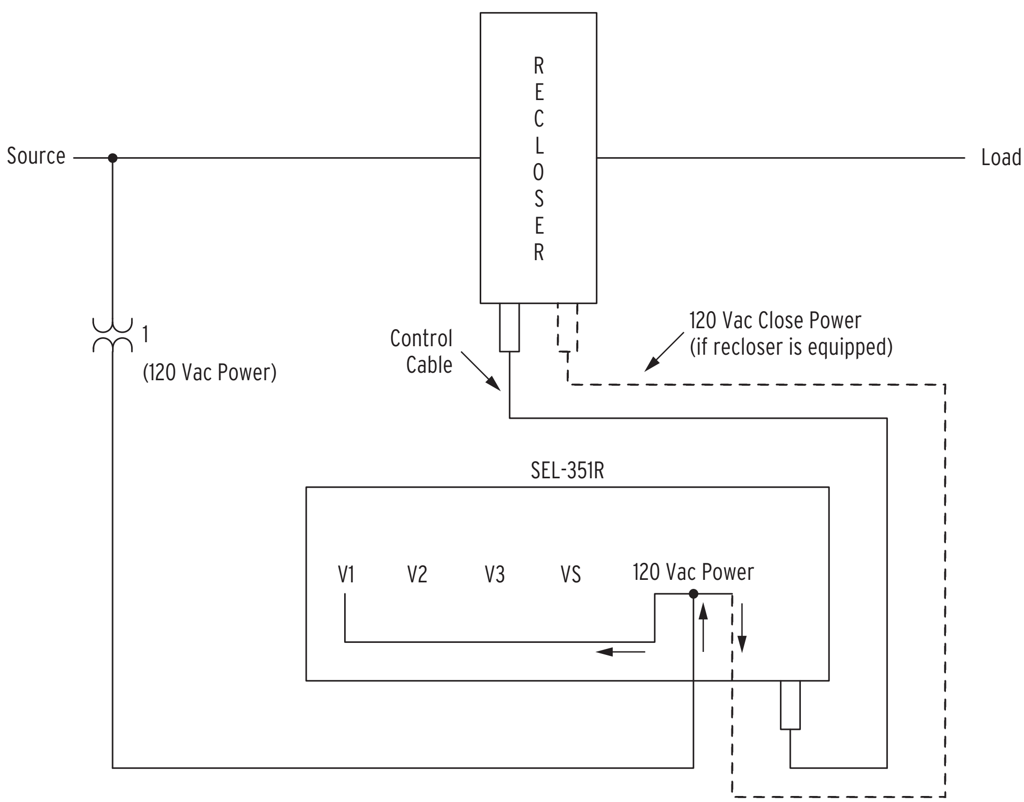


Figure 1.31 Installation With Only AC Power (Traditional Installation; 120 Vac Power Example)

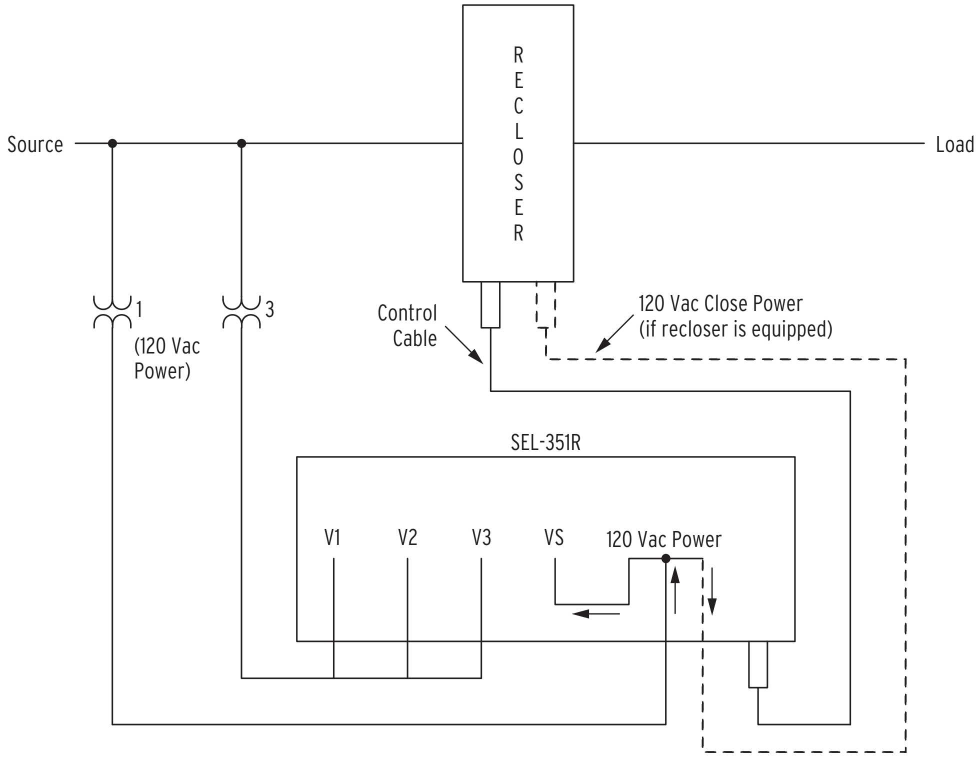


Figure 1.32 Installation With Separate AC Power and Three-Phase Voltage (120 Vac Power Example)

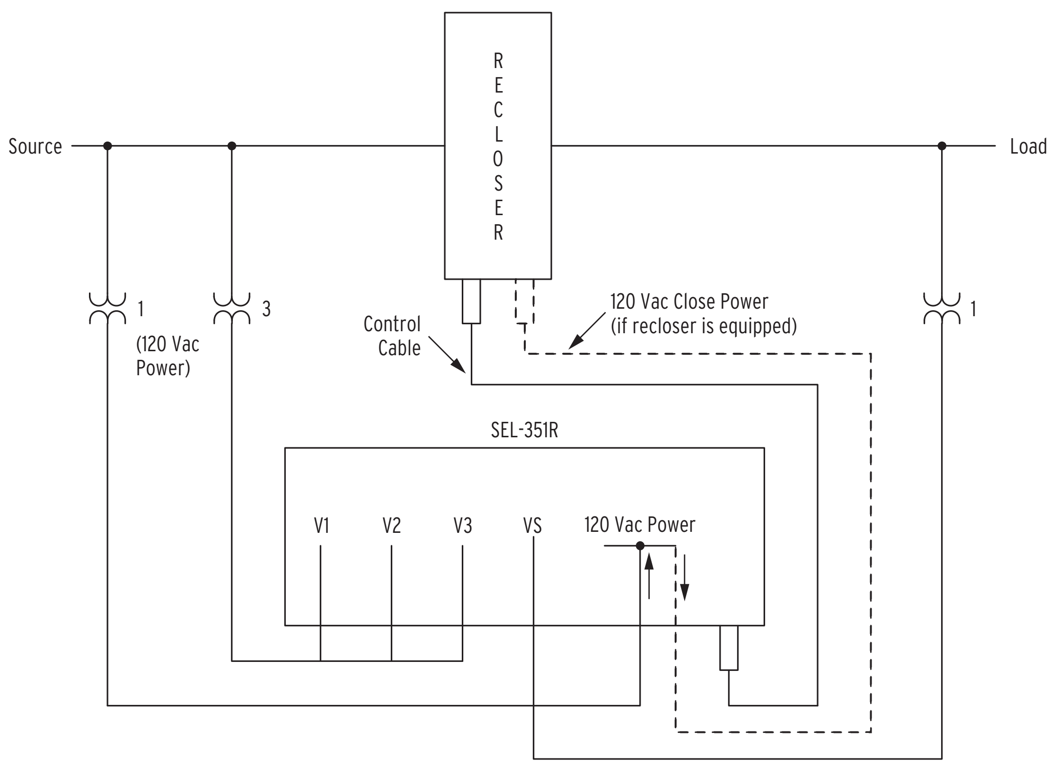


Figure 1.33 Installation With Separate AC Power, Three-Phase, and Synchronism-Check Voltage (120 Vac Power Example)

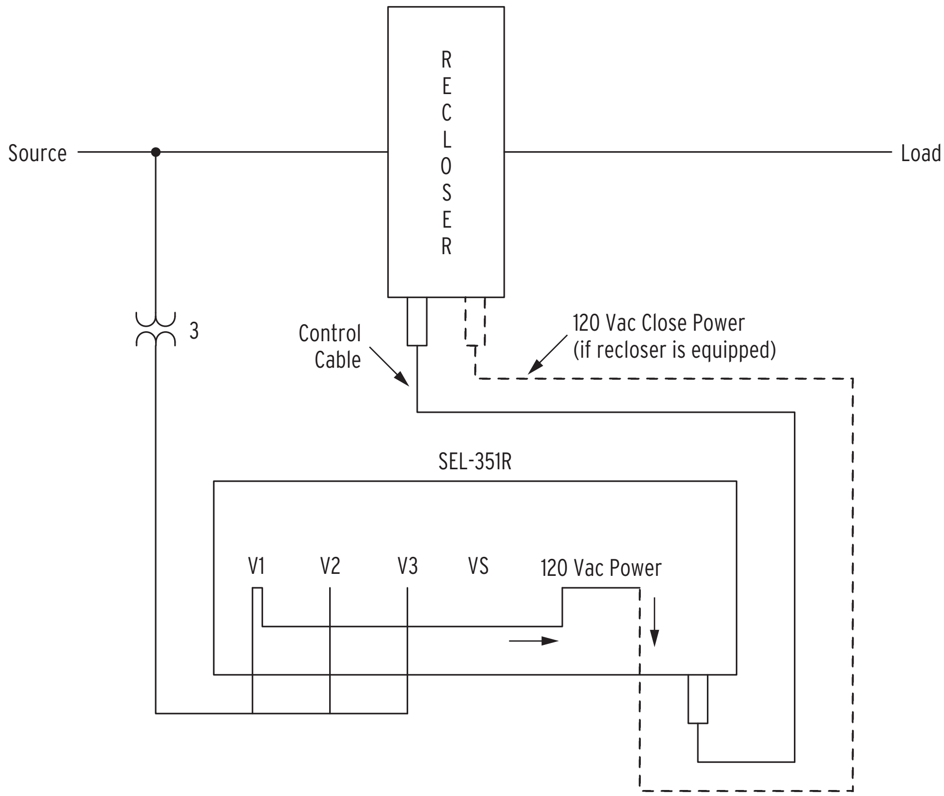


Figure 1.34 Installation With Only Three-Phase Voltage (AC Power Provided by Three-Phase Voltage; 120 Vac Power Example)

Installation With Only AC Power (Traditional Installation; 120 Vac Power Example)

See *Figure 1.31*. This is the traditional recloser control installation—only single-phase 120 Vac power is brought to the SEL-351R. The jumper from the 120 Vac power bus to voltage input V1 is factory-installed (see also Figure 1.7 and Figure 1.11 in the *SEL-351R-4 Quick-Start Installation and User's Guide*).

120 Vac Close Power

Voltage input V1 provides direct 120 Vac close power monitoring—the input is in parallel with the incoming 120 Vac power. The close power part of the factory-set logic in *Figure 1.30* (79CLS = 59L1 * …) works regardless of the VPCONN setting. Voltage element 59L1 picks up when nominal 120 Vac is applied to voltage input V1. If the factory-default wiring is modified such that the 120 Vac close power is not supplied by the voltage connected to voltage input V1, the 79CLS logic should be modified to include the correct voltage element (e.g., 59A1, 59B1, or 59C1).

Primary Voltage Close Power

Voltage input V1 provides only indirect primary voltage close power monitoring.

Installation With Separate AC Power and Three-Phase Voltage (120 Vac Power Example)

See *Figure 1.32*. The factory-installed jumper from the 120 Vac power bus to voltage input **V1** is moved to voltage input **VS** (see also Figure 1.7 and Figure 1.11 in the *SEL-351R-4 Quick-Start Installation and User's Guide*). Voltage input **VS** is then in parallel with the incoming 120 Vac power.

120 Vac Close Power

Voltage input **VS** provides direct 120 Vac close power monitoring.

Change the close power part of factory-set logic in *Figure 1.30* from 79CLS = 59L1 * … (for voltage input **V1**) *to* 79CLS = 59S1 * … (for voltage input **VS**) with the **SET L *n*** command (*n* = setting group number).

Make pickup setting 59S1P = 104 (for voltage element 59S1; 87 percent of 120 V) with the **SET *n*** command (*n* = setting group number). Voltage element 59S1 picks up when nominal 120 Vac is applied to voltage input **VS**.

Primary Voltage Close Power

All three voltage inputs **V1**, **V2**, and **V3** are connected and can provide indirect, but phase-specific primary voltage close power monitoring.

For example, if primary voltage close power for the recloser comes from phases B and C (phase-to-phase), change the close power part of the factory-set logic in *Figure 1.30* from 79CLS = 59L1 * … (for voltage input **V1**) *to* 79CLS = 59BC * … (for voltage channels VB and VC, per Global setting VPCONN), with the **SET L *n*** command (*n* = setting group number). Set pickup setting 59PP (for voltage element 59BC) to some percentage (e.g., 87 percent) of the nominal phase-to-phase voltage secondary value of the three-phase voltage with the **SET *n*** command (*n* = setting group number). Voltage element 59BC picks up when nominal voltage is applied to voltage channels VB and VC.

Undervoltage Block for Frequency Elements

If the three-phase voltage is not 120 Vac nominal (phase-to-neutral), then the factory-set pickup setting 27B81P = 80 may have to be changed. 27B81P is the pickup setting for the undervoltage block for frequency elements (see *Figure 3.27*).

Installation With Separate AC Power, Three-Phase, and Synchronism-Check Voltage (120 Vac Power Example)

See *Figure 1.33*. This installation is similar to *Installation With Separate AC Power and Three-Phase Voltage (120 Vac Power Example) on page 1.42* (*Figure 1.32*), with the addition of a load-side voltage to the synchronism-check voltage input **VS**. The factory-installed jumper from the 120 Vac power bus to voltage input **V1** is removed (see also Figure 1.7 and Figure 1.11 in the *SEL-351R-4 Quick-Start Installation and User's Guide*). No voltage input is in parallel with the incoming 120 Vac power (no extra voltage input is available).

120 Vac Close Power

No voltage input provides direct 120 Vac close power monitoring. All three voltage inputs **V1**, **V2**, and **V3** are connected and can provide indirect, but phase-specific monitoring of 120 Vac close power. If the 120 Vac close power comes from the phase corresponding to voltage input **V1**, keep the close power part of factory-set logic in *Figure 1.30* (79CLS = 59L1 * …). If the 120 Vac power comes from another phase (e.g., phase B), change the close power part of factory-set logic in *Figure 1.30* to 79CLS = 59B1 * … , with the **SET L *n*** command (*n* = setting group number).

If the three-phase voltage is not 120 Vac nominal (phase-to-neutral), then change factory-set pickup setting 59P1P =104 (for voltage elements 59A1, 59B1, and 59C1; 87 percent of 120 V) to some percentage (e.g., 87 percent) of the nominal phase-to-neutral voltage secondary value of the three-phase voltage, with the **SET *n*** command (*n* = setting group number). Voltage elements 59A1, 59B1, and 59C1 pick up when nominal voltage is applied to voltage inputs V1, V2, and V3 set to VA, VB, and VC (per Global setting VPCONN).

Primary Voltage Close Power

All three voltage inputs V1, V2, and V3 are connected to power system VA, VB, and VC and can provide indirect, but phase-specific, primary voltage close power monitoring.

For example, if primary voltage close power for the recloser comes from phases B and C (phase-to-phase), change the close power part of the factory-set logic in *Figure 1.30* from 79CLS = 59L1 * … (for voltage input V1) to 79CLS = 59BC * … (for voltage channels VB and VC, per Global setting VPCONN), with the **SET L *n*** command (*n* = setting group number). Set pickup setting 59PP (for voltage element 59BC) to some percentage (e.g., 87 percent) of the nominal phase-to-phase voltage secondary value of the three-phase voltage with the **SET *n*** command (*n* = setting group number). Voltage element 59BC picks up when nominal voltage is applied to voltage channels VB and VC.

Undervoltage Block for Frequency Elements

If the three-phase voltage is not 120 Vac nominal (phase-to-neutral), then the factory-set pickup setting 27B81P = 80 may have to be changed. Setting 27B81P is the pickup setting for the undervoltage block for frequency elements (see *Figure 3.27*).

Installation With Only Three-Phase Voltage (AC Power Provided by Three-Phase Voltage; 120 Vac Power Example)

See *Figure 1.34*. Only three-phase voltage is brought to the SEL-351R. The jumper from the 120 Vac power bus to voltage input V1 is factory-installed (see also Figure 1.7 and Figure 1.11 in the *SEL-351R-4 Quick-Start Installation and User's Guide*). The three-phase voltage must be 120 Vac nominal (phase-to-neutral) for this example.

120 Vac Close Power

Voltage input V1 provides direct 120 Vac close power monitoring—the input is in parallel with the incoming 120 Vac power. The close power part of the factory-set logic in *Figure 1.30* (79CLS = 59L1 * …) works best in a configuration such as that in *Figure 1.34*. Voltage element 59L1 picks up when nominal 120 Vac is applied to voltage input V1.

Primary Voltage Close Power

All three voltage inputs V1, V2, and V3 are set to VA, VB, and VC (per Global setting VPCONN) and can provide indirect, but phase-specific, primary voltage close power monitoring.

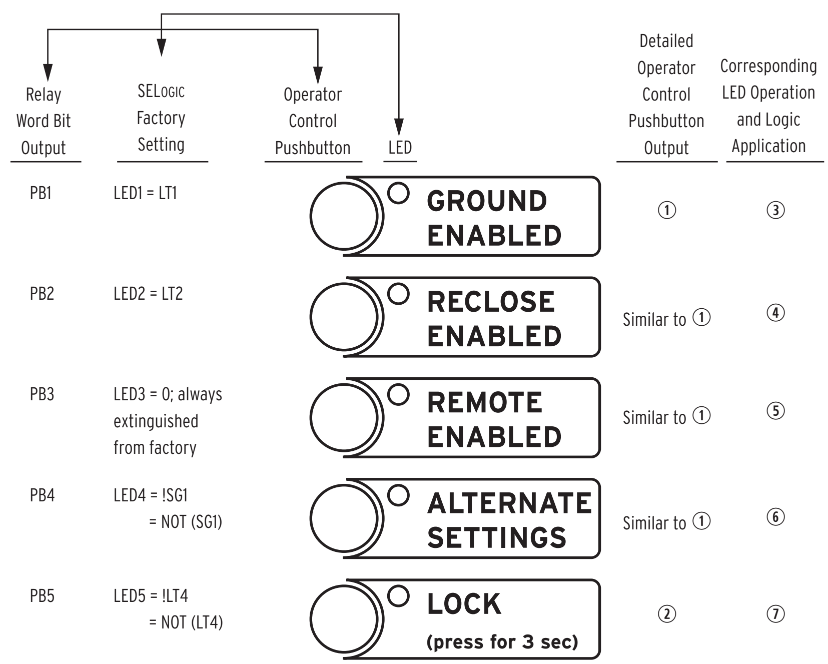
For example, if primary voltage close power for the recloser comes from phases B and C (phase-to-phase), change the close power part of the factory-set logic in *Figure 1.34* from 79CLS = 59L1 * … to 79CLS = 59BC * … (for voltage channels VB and VC), with the **SET L *n*** command (*n* = setting group number). Set pickup setting 59PP (for voltage element 59BC) to some percentage (e.g., 87 percent) of the nominal phase-to-phase voltage secondary value of the three-phase voltage with the **SET *n*** command (*n* = setting group number). Voltage element 59BC picks up when nominal voltage is applied to voltage channels VB and VC.

Operator Control Logic

See Operator Controls in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide* for an explanation of the factory-set operation for the operator controls.

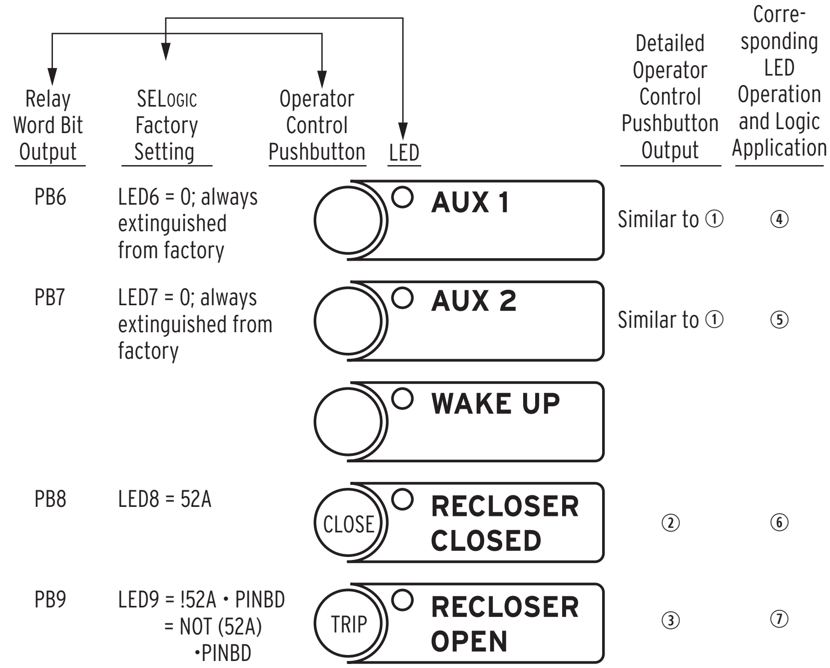
See *Figure 1.35* and *Figure 1.36*. The operator controls (except WAKE UP) are programmable. Relay Word bits PB1–PB9 are the outputs of operator control pushbuttons GROUND ENABLED through TRIP, respectively.

The corresponding LEDs (LED1–LED9, respectively) are programmed independently. This allows great flexibility, especially in indicating status for a function that is controlled both locally and remotely.



① Figure 1.37; ② Figure 1.38; ③ Figure 1.41; ④ Figure 1.42; ⑤ Figure 1.43;
⑥ Figure 1.49; ⑦ Figure 1.50.

Figure 1.35 Operator Controls—GROUND ENABLED Through LOCK



① Figure 1.37; ② Figure 1.39; ③ Figure 1.40; ④ Figure 1.45; ⑤ Figure 1.46;
⑥ Figure 1.20; ⑦ Figure 1.19.

Time Delays are available for the **TRIP** and **CLOSE** operator control pushbuttons (Global settings PB8D and PB9D, respectively; settable up to 3600 cycles). These time delay settings are set to zero from the factory (no time delay; PB8D = 0; PB9D = 0).

Figure 1.36 Operator Controls—AUX 1 Through TRIP

Detailed Operator Control Pushbutton Output

Figure 1.35 and *Figure 1.36* list corresponding figures that detail operator control pushbutton output and corresponding LED operation and logic operation. Note that the pushbutton output (e.g., Relay Word bit PB1 for the **GROUND ENABLED** operator control pushbutton) corresponds number-wise to the LED setting (e.g., SELOGIC setting LED1 for the **GROUND ENABLED** LED).

GROUND ENABLED Operator Control Pushbutton Output

Figure 1.37 describes the **GROUND ENABLED** operator control pushbutton output. Every time the **GROUND ENABLED** operator control pushbutton is pressed momentarily, Relay Word bit PB1 asserts to logical 1 immediately for one processing interval.

The corresponding **GROUND ENABLED** LED (controlled by SELOGIC setting LED1) is independent of the **GROUND ENABLED** operator control pushbutton.

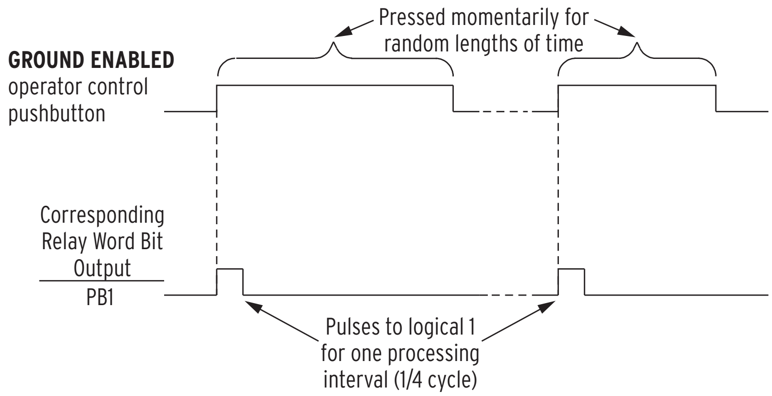


Figure 1.35 and Figure 1.36 list other operator control pushbuttons that operate similarly to the above detailed **GROUND ENABLED** operator control pushbutton and corresponding Relay Word bit PB1.

Figure 1.37 GROUND ENABLED Operator Control Pushbutton Output

Other Operator Control Pushbutton Outputs Operate Similarly to GROUND ENABLED

The following operator control pushbutton outputs operate similarly to the GROUND ENABLED operator control pushbutton output described in *Figure 1.37* (corresponding Relay Word bits PB2, PB3, PB4, PB6, and PB7 assert to logical 1 immediately for one processing interval when the operator control pushbutton is pressed momentarily):

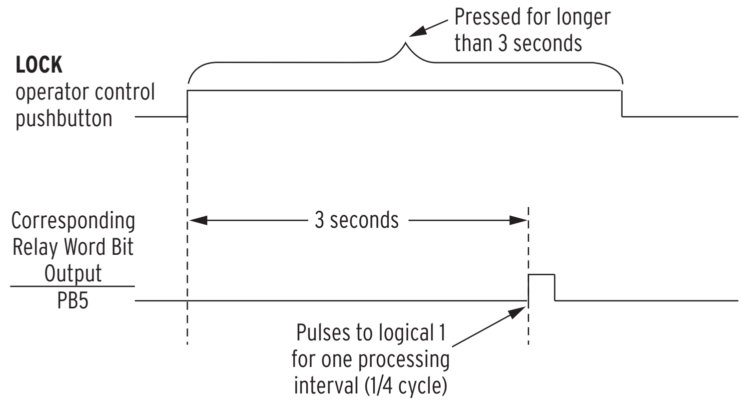
- RECLOSE ENABLED (PB2)
- REMOTE ENABLED (PB3)
- ALTERNATE SETTINGS (PB4)
- AUX 1 (PB6)
- AUX 2 (PB7)

LOCK Operator Control Pushbutton Output

NOTE: The three-second delay described in Figure 1.38 can be defeated via setting (see Global setting RSTLED and corresponding Global EZ setting "Reset trip-latched LEDs on close"). If the three-second delay is defeated, the LOCK operator control operates as in Figure 1.37.

Figure 1.38 describes the output of the unique LOCK operator control pushbutton. Note the need to press the LOCK operator control pushbutton continually for three seconds until Relay Word bit PB5 asserts to logical 1 for one processing interval.

The corresponding LOCK LED (controlled by SELOGIC setting LED5) is independent of the LOCK operator control pushbutton, unless the LOCK operator control pushbutton is pressed for the three seconds (and the LED flashes), as described in *Figure 1.38*.



The corresponding LOCK LED flashes during this three-second timing period while the LOCK operator control pushbutton is pressed. This flashing indicates a pending pulsing of Relay Word bit PB5, regardless of the setting of corresponding SELOGIC control equation setting LED5.

If the LOCK operator control pushbutton is released before three seconds, the corresponding LED stops flashing and Relay Word bit PB5 is not pulsed. The LED returns to its regular operation, per SELOGIC control equation setting LED5 (see Figure 1.50).

Figure 1.38 LOCK Operator Control Pushbutton Output

TRIP and CLOSE Operator Control Pushbutton Outputs

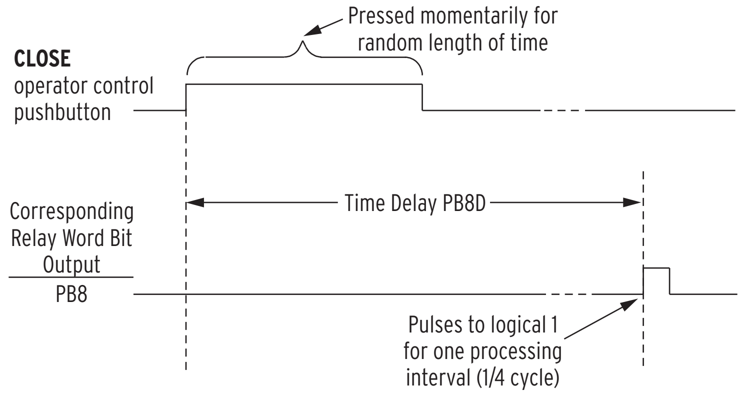
Figure 1.39 and *Figure 1.40* describe the operation of the CLOSE and TRIP operator control pushbutton outputs, respectively. On the Configurable Label model, the words CLOSE and TRIP do not appear on the pushbuttons (see Operator Controls in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*). However, the discussion that follows refers to the pushbuttons by these names, because the factory logic settings are the same as those for the default settings.

Note the programmable time delays (PB8D and PB9D, respectively), whereby the operator control can be pressed momentarily and the corresponding Relay Word bit (PB8 or PB9) asserts to logical 1 for one processing interval after the time delay. Also note the interlocking between the CLOSE and TRIP pushbuttons as described in *Figure 1.39* and *Figure 1.40*, whereby a pending close can be turned off by pressing the TRIP pushbutton and a pending trip can be turned off by pressing the CLOSE pushbutton.

The corresponding RECLOSER CLOSED and RECLOSER OPEN LEDs (controlled by SELOGIC settings LED8 and LED9, respectively) are independent of the CLOSE and TRIP operator control pushbuttons, unless the CLOSE or TRIP operator control pushbutton is pressed and a pending close or trip results (and LED flashes), as described in *Figure 1.39* and *Figure 1.40*.

If the control cable is removed from the bottom of the SEL-351R, both RECLOSER CLOSED and RECLOSER OPEN LEDs extinguish, even if the recloser is open. This occurs even for the RECLOSER OPEN LED because of SELOGIC setting LED9 = !52A * PINBD. See *Figure 7.29*—monitored trip circuit point PINBD should always be energized by the 24 Vdc anytime the recloser is open [SW1(52a) is open]. If PINBD is not energized (PINBD = logical 0) and the recloser is open, the control cable must be removed, or some other defect is in the 24 Vdc trip circuit/control cable.

CLOSE and TRIP operator control pushbuttons (Relay Word bits PB8 and PB9) are routed into close logic (see *Figure 1.20*) and trip logic (see *Figure 1.19*), respectively.



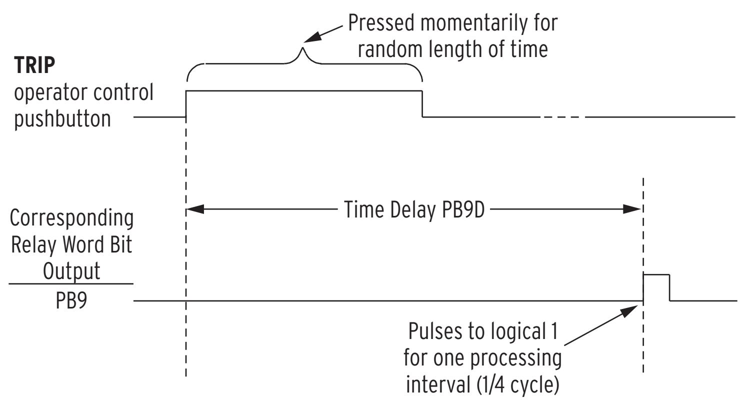
The corresponding **RECLOSER CLOSED** LED flashes during the timing of time delay PB8D. This flashing indicates a pending pulsing of Relay Word Bit PB8, regardless of the setting of corresponding SELOGIC control equation setting LED8.

If the **CLOSE** operator control pushbutton is pressed again (or the **TRIP** operator control pushbutton is pressed) while PB8D is timing, the **RECLOSER CLOSED** LED stops flashing, PB8D stops timing, and Relay Word bit PB8 is not pulsed. The pending close operation is aborted. The **RECLOSER CLOSED** LED returns to its regular operation, per SELOGIC control equation setting LED8 (see Figure 1.36).

If time delay setting PB8D is set PB8D > 0, then the assertion of SELOGIC setting ULCL (unlatch close) to logical 1 also aborts pending closes and prevents the **CLOSE** operator control pushbutton from starting a pending close in the first place. Furthermore, Relay Word bit PB8 is defeated and will not assert for any PB8 SELOGIC control equation setting. See Figure 1.21.

If time delay setting PB8D is set PB8D = 0 (no time delay), Relay Word bit PB8 functions in a manner similar to Figure 1.37.

Figure 1.39 CLOSE Operator Control Pushbutton Output



The corresponding **RECLOSER OPEN** LED flashes during the timing of time delay PB9D. This flashing indicates a pending pulsing of Relay Word bit PB9, regardless of the setting of corresponding SELOGIC control equation setting LED9.

If the **TRIP** operator control pushbutton is pressed again (or the **CLOSE** operator control pushbutton is pressed) while PB9D is timing, the **RECLOSER OPEN** LED stops flashing, PB9D stops timing, and Relay Word bit PB9 is not pulsed. The pending trip operation is aborted. The **RECLOSER OPEN** LED returns to its regular operation, per SELOGIC control equation setting LED9 (see Figure 1.36).

If time delay setting PB9D is set PB9D = 0 (no time delay), then Relay Word bit PB9 functions in a manner similar to Figure 1.37.

Figure 1.40 TRIP Operator Control Pushbutton Output

Corresponding Operator Control LEDs and Logic Applications

Figure 1.35 and *Figure 1.36* list corresponding figures that detail operator control LED operation and logic applications. Note that the pushbutton output corresponds number-wise to the LED setting—for example:

- **GROUND ENABLED** operator control pushbutton output: PB*1*
- **GROUND ENABLED** LED SELOGIC control equations setting: LED*1*

GROUND ENABLED Operator Control

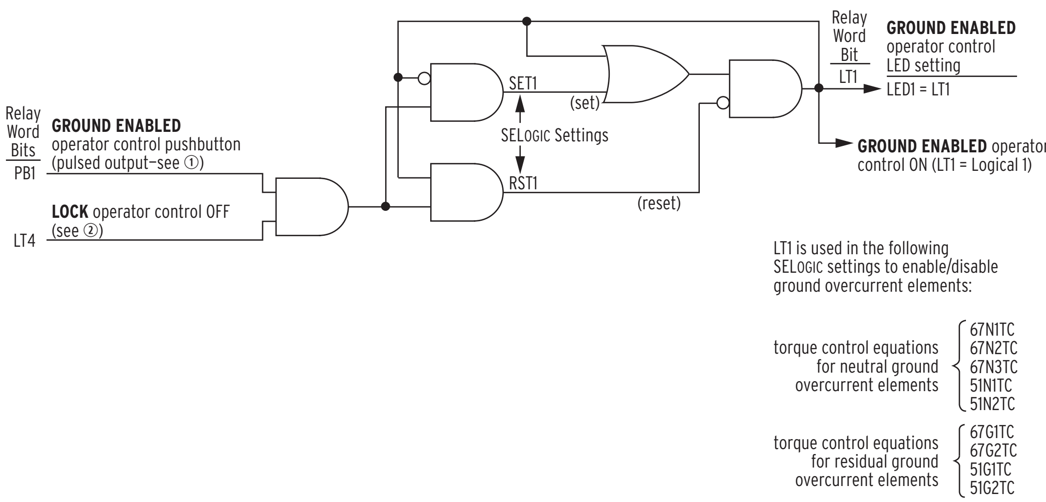
Figure 1.41 describes the logic driven by the **GROUND ENABLED** operator control pushbutton (pulsed output PB1) and operation of the corresponding LED. Note that the **LOCK** operator control logic supervises the **GROUND ENABLED** operator control. The **LOCK** operator control has to be OFF (LT4 = logical 1) in order for the **GROUND ENABLED** operator control to effectively function—so that Relay Word bit PB1 can propagate on to latch LT1.

Latch LT1 is set up as a flip-flop with one effective logic input:

- Momentarily press the **GROUND ENABLED** operator control pushbutton and LT1 sets to logical 1
- Momentarily press the **GROUND ENABLED** operator control pushbutton again and LT1 resets to logical 0

All latches (LT1–LT8) are nonvolatile (retain their state if the SEL-351R is powered down and then powered up again). The latch output (Relay Word bit LT1) propagates to the following logic:

- Drives the corresponding **GROUND ENABLED** operator control LED (SELOGIC setting LED1 = LT1) to indicate that ground overcurrent tripping is enabled (LED is illuminated) or disabled (LED is extinguished).
- Drives the ground overcurrent element torque control equations to enable or disable ground overcurrent elements.



① Figure 1.37; ② Figure 1.50.

Figure 1.41 GROUND ENABLED Operator Control LED and Logic Application

Other Operator Controls

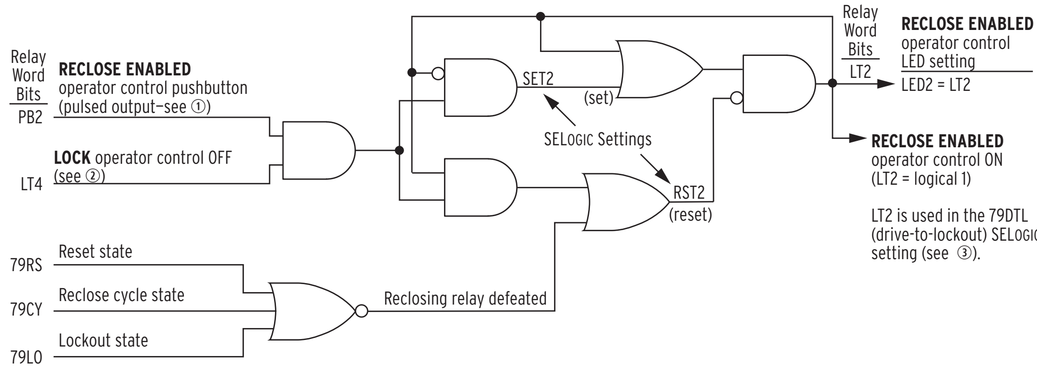
The following figures:

- ➤ *Figure 1.42* RECLOSE ENABLED
- ➤ *Figure 1.43* REMOTE ENABLED
- ➤ *Figure 1.45* AUX 1
- ➤ *Figure 1.46* AUX 2

operate similarly to *Figure 1.41*. Note that the LOCK operator control logic supervises the operator controls in these figures, too.

RECLOSE ENABLED Operator Control

Figure 1.42 (RECLOSE ENABLED) has additional logic that resets latch LT2 (LT2 = logical 0) if the reclosing relay is defeated. If the reclosing relay is defeated, the RECLOSE ENABLED operator control is effectively disabled—the corresponding LED (LED2 = LT2) is always extinguished. Make setting Reclose interval 1 = 0 to defeat reclosing and all three reclosing relay state Relay Word bits (79RS, 79CY, and 79LO) deassert to logical 0.

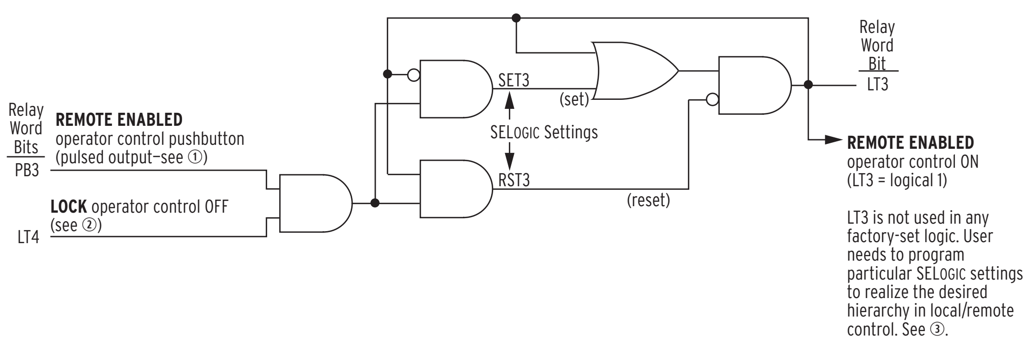


① Figure 1.37; ② Figure 1.50; ③ Figure 1.25.

Figure 1.42 RECLOSE ENABLED Operator Control LED and Logic Application

REMOTE ENABLED Operator Control

As stated in *Figure 1.43* (REMOTE ENABLED), latch LT3 is not used in any of the factory-set logic. Each press of the REMOTE ENABLED operator control pushbutton toggles latch LT3 from LT3 = logical 0 to LT3 = logical 1 and vice versa, but LT3 is not used in any of the factory-set logic. Thus, the REMOTE ENABLED operator control is not functional from the factory (corresponding LED is extinguished all the time, too; SELOGIC setting LED3 = 0, see *Figure 1.35*).

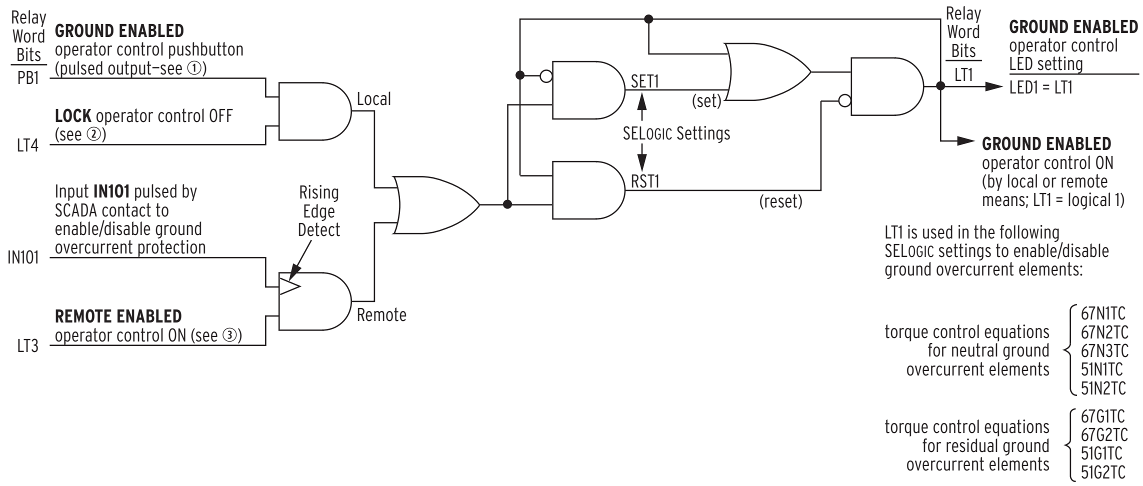


① Figure 1.37; ② Figure 1.50; ③ Figure 1.44.

Figure 1.43 REMOTE ENABLED Operator Control Logic Application

Example Application for the REMOTE ENABLED Operator Control

To use the **REMOTE ENABLED** operator control, change the corresponding LED setting to LED3 = LT3 (to monitor the output of latch LT3) and assign LT3 to a supervising role in logic. For example, *Figure 1.44* is a logic modification to *Figure 1.41* (**GROUND ENABLED** operator control). Latch LT1 can be set/reset locally (with **GROUND ENABLED** operator control pushbutton) or remotely (with input **IN101**). Note that the remote control (**IN101**) is supervised by Relay Word bit LT3 (**REMOTE ENABLED** operator control). Likewise, the local control (**GROUND ENABLED** operator control) is supervised by Relay Word bit LT4 (**LOCK** operator control). This is just one example—many variations are possible.

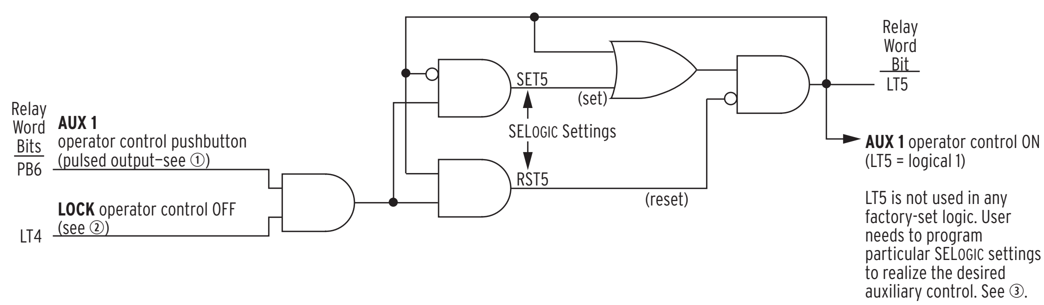


① Figure 1.37; ② Figure 1.50; ③ Figure 1.43.

Figure 1.44 Example REMOTE ENABLED Operator Control Application (Supervising Remote Control of Ground Overcurrent Elements)

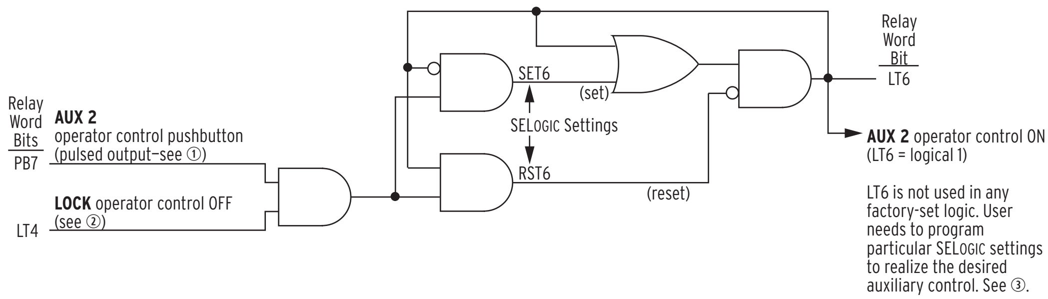
AUX 1 and AUX 2 Operator Controls

As stated in *Figure 1.45* (**AUX 1**) and *Figure 1.46* (**AUX 2**), latches LT5 and LT6 are not used in any of the factory-set logic. Each press of the **AUX 1** operator control pushbutton toggles latch LT5 from LT5 = logical 0 to LT5 = logical 1 and vice versa, but LT5 is not used in any of the factory-set logic. Thus, the **AUX 1** operator control is not functional from the factory (corresponding LED is extinguished all the time, too; SELOGIC setting LED6 = 0, see *Figure 1.36*). The **AUX 2** operator control operates similarly.



① Figure 1.37; ② Figure 1.50; ③ Figure 1.48.

Figure 1.45 AUX 1 Operator Control Logic Application



① Figure 1.37; ② Figure 1.50; ③ Figure 1.48.

Figure 1.46 AUX 2 Operator Control Logic Application

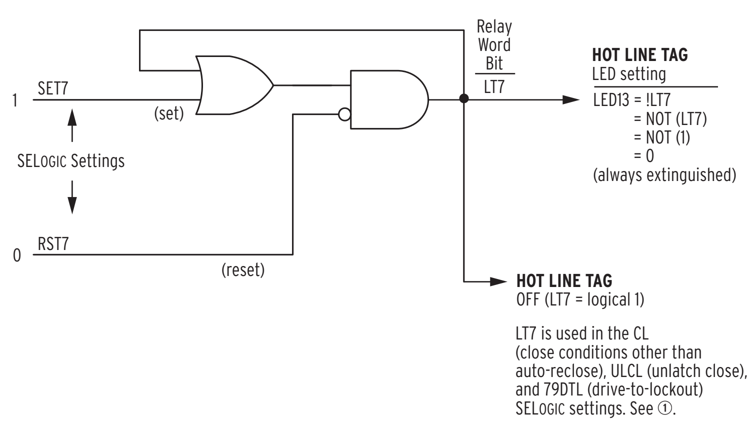
Example Application for the AUX 1 Operator Control (Hot-Line Tag)

The following figures show that latches are reserved for the corresponding operator controls in the factory settings:

- *Figure 1.41* GROUND ENABLED
- *Figure 1.42* RECLOSE ENABLED
- *Figure 1.43* REMOTE ENABLED
- *Figure 1.45* AUX 1
- *Figure 1.46* AUX 2
- *Figure 1.50* LOCK

However, these operator control pushbuttons can be used without the reserved latches if desired. For example, the AUX 1 operator control pushbutton output is embedded into latch LT5 in the factory settings. However, the AUX 1 operator control pushbutton output (PB6) can be used independent of latch LT5 (latch LT5 can reprogrammed for another function). The following describes applying the AUX 1 operator control pushbutton output to hot-line tag logic. A set hot-line tag disables all closing or auto-reclosing from the SEL-351R.

Figure 1.47 shows the factory-set hot-line tag logic. From the factory, latch LT7 is set such that latch output LT7 is always asserted (Relay Word bit LT7 = logical 1)—the hot-line tag is reset (disabled). The front-panel HOT LINE TAG LED is always extinguished. Relay Word bit LT7 is also embedded in close logic (CL and ULCL) and drive-to-lockout (79DTL) SELOGIC factory settings.



① Figure 1.20, Figure 1.21, and Figure 1.25.

Figure 1.47 Hot-Line Tag Logic

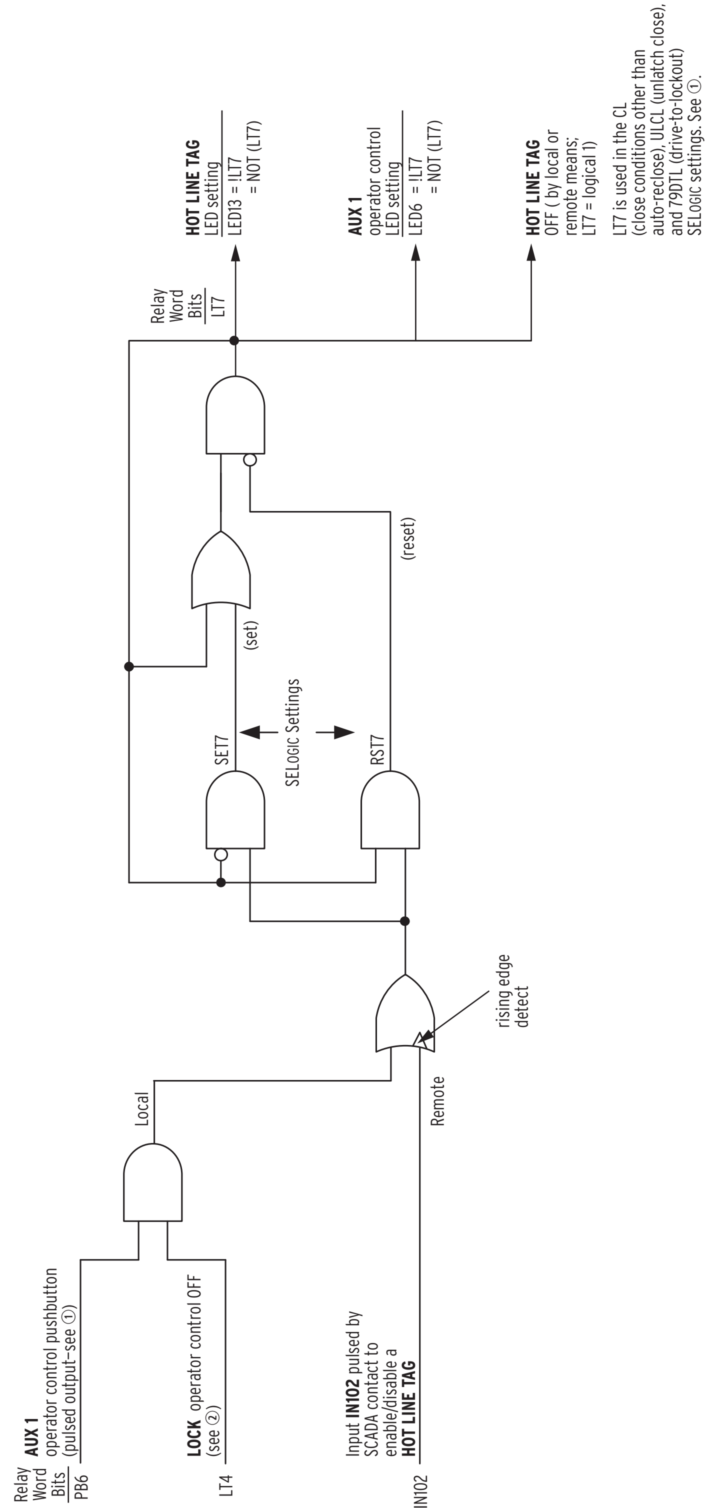
Figure 1.48 shows modified hot-line tag logic, where the hot-line tag can be set/reset in either of two ways:

- Locally (with the AUX 1 operator control pushbutton output)
- Remotely (with input IN102 wired to a SCADA contact)

Note that the LOCK operator control logic supervises the AUX 1 operator control. The LOCK operator control has to be OFF (LT4 = logical 1) in order for the AUX 1 operator control to effectively function, and so that Relay Word bit PB6 can propagate on to latch LT7.

The corresponding AUX 1 LED (SELOGIC setting LED6 = !LT7) is programmed to follow the front-panel HOT LINE TAG LED (SELOGIC setting LED13 = !LT7). Thus, the AUX 1 LED displays the status of the hot-line tag—not of a latch reserved specifically for the AUX 1 operator control.

Input IN102 is not supervised in this example. A SCADA contact pulses input IN102 to set/reset hot-line tag remotely.



① Figure 1.37; ② Figure 1.50; ③ Figure 1.20, Figure 1.21, and Figure 1.25.

Figure 1.48 Example AUX 1 Operator Control Application (Local Control of HOT LINE TAG)

ALTERNATE SETTINGS Operator Control

Figure 1.49 describes the logic driven by the **ALTERNATE SETTINGS** operator control pushbutton (pulsed output PB4) and operation of the corresponding LED. Note that the **LOCK** operator control logic supervises the **ALTERNATE**

SETTINGS operator control. The **LOCK** operator control has to be OFF (LT4 = logical 1) in order for the **ALTERNATE SETTINGS** operator control to effectively function, and so that Relay Word bit PB4 can propagate on to:

- “select setting group” SELOGIC settings SS1 and SS2
- **ALTERNATE SETTINGS** operator control LED setting LED4

Relay Word bit SG1 = logical 1 indicates that Setting Group 1 is the active setting group. Relay Word bit SG1 routes the **ALTERNATE SETTINGS** operator control pushbutton output PB4 to:

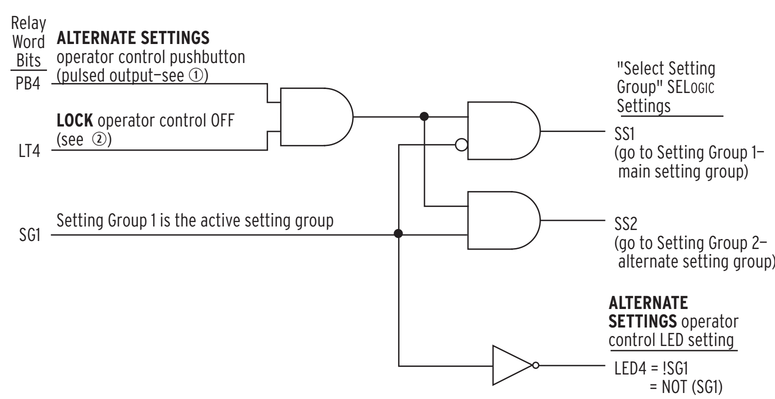
- SELOGIC setting SS1 (go to Setting Group 1) when SG1 = logical 0 (Setting Group 1 is *not* presently the active setting group)
- SELOGIC setting SS2 (go to Setting Group 2) when SG1 = logical 1 (Setting Group 1 is presently the active setting group)

Each time the **ALTERNATE SETTINGS** operator control pushbutton is momentarily pressed, the active setting group switches between:

- Setting Group 2 as the active setting group (**ALTERNATE SETTINGS** operator control LED illuminates)
- And Setting Group 1 as the active setting group (**ALTERNATE SETTINGS** operator control LED extinguishes)

Neither SELOGIC setting SS1 nor SS2 has to be maintained at logical 1 in order for the active setting group to remain at Setting Group 1 or Setting Group 2, respectively. See *Multiple Setting Groups on page 7.15*.

The active setting group designation is nonvolatile (retained if the SEL-351R is powered down and then powered up again, i.e., returns to the same active setting group).



① Figure 1.37; ② Figure 1.50.

Figure 1.49 ALTERNATE SETTINGS Operator Control LED and Logic Application

LOCK Operator Control

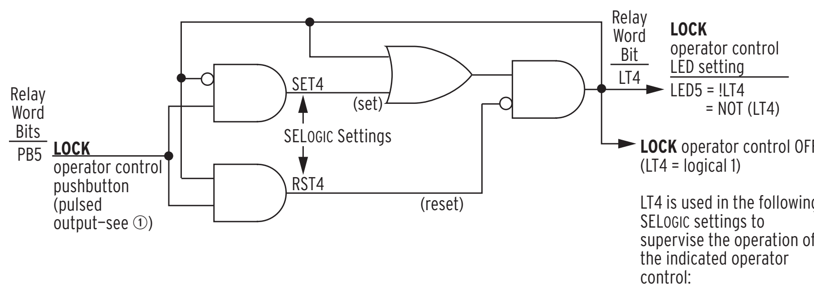
Figure 1.50 describes the logic driven by the **LOCK** operator control pushbutton (pulsed output PB5) and operation of the corresponding LED. Relay Word bit PB5 propagates to latch LT4.

Latch LT4 is set up as a flip-flop:

- ➤ Press the **LOCK** operator control pushbutton (for three seconds as described in *Figure 1.38*) and LT4 sets to logical 1
- ➤ Press the **LOCK** operator control pushbutton (for three seconds as described in *Figure 1.38*) again and LT4 resets to logical 0

All latches (LT1–LT8) are nonvolatile (retain their state if the SEL-351R is powered down and then powered up again). The latch output (Relay Word bit LT4) propagates to the following logic:

- ➤ Drives the corresponding **LOCK** operator control LED [SELOGIC setting LED5 = !LT4 = NOT(LT4)] to indicate that **LOCK** is ON (LED is illuminated; LT4 = logical 0) or OFF (LED is extinguished; LT4 = logical 1).
- ➤ Supervises most of the other operator controls as listed at the bottom of *Figure 1.50*.



Operator Control	SELOGIC Settings	Logic Application
GROUND ENABLED	SET1, RST1	②
RECLOSE ENABLED	SET2, RST2	③
REMOTE ENABLED	SET3, RST3	④
ALTERNATE SETTINGS	SS1, SS2	⑤
AUX 1	SET5, RST5	⑥
AUX 2	SET6, RST6	⑦
CLOSE	CL	⑧

① Figure 1.38; ② Figure 1.41; ③ Figure 1.42; ④ Figure 1.43; ⑤ Figure 1.49;
⑥ Figure 1.45; ⑦ Figure 1.46; ⑧ Figure 1.20.

Figure 1.50 LOCK Operator Control LED and Logic Application

Front-Panel Status and Trip Target LEDS

See Figure 3.3 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for an explanation of the factory-set operation for the front-panel status and trip target LEDs.

See *Figure 1.51–Figure 1.54*. The front-panel status and trip target LEDs (except the **CONTROL ENABLED** status LED and the **A**, **B**, and **C** fault-type trip target LEDs) are programmable. Two settings are made for each of these programmable target LEDs:

- ➤ SELOGIC setting
- ➤ LED*n*L Global setting (where *n* = 11–20, 24, or 25)

The SELOGIC setting lists the conditions to illuminate the specified LED (e.g., LED11 = !DISCHG; the **AC SUPPLY** LED illuminates when Relay Word bit DISCHG deasserts to logical 0; see the font-panel **AC SUPPLY** LED discussion in *Reclose Supervision Logic on page 1.37*).

The LED*n*L Global setting determines if the specified LED illuminates in one of two ways:

➤ LED*n*L (Y/N) = N (LED operates as a *status* LED):

For example, when LED11L (Y/N) = N and LED11 = !DISCHG

The **AC SUPPLY** LED illuminates when Relay Word bit DISCHG deasserts to logical 0, regardless of any trip condition.

➤ If LED*n*L (Y/N) = Y (LED operates as a trip target LED):

For example, when LED17L (Y/N) = Y and LED17 = 81D1T.

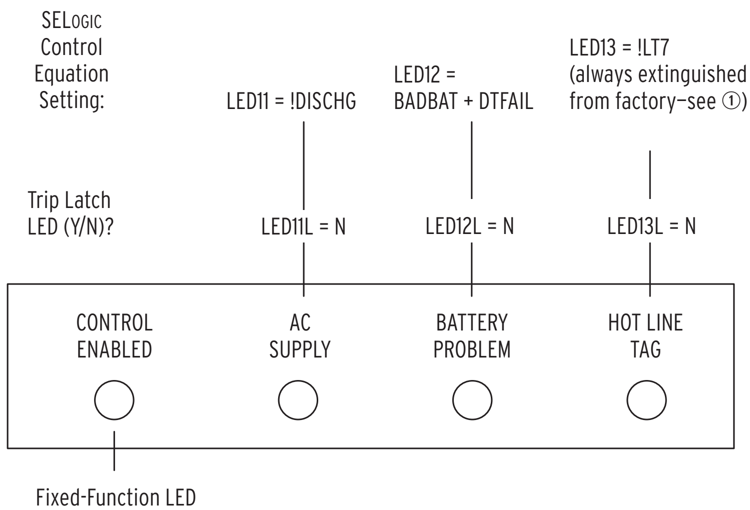
The **81** (underfrequency trip) LED illuminates when Relay Word bit 81D1T is asserted to logical 1 *and* a rising-edge of TRIP occurs.

Trip-latched LEDs [e.g., the 81 (underfrequency trip) LED] remain latched in and illuminated until one of the following occur:

➤ Next trip occurs

➤ **TARGET RESET** pushbutton is pressed

➤ Recloser closes [if Global setting "Reset trip–latched LEDs on close (Y,Y1,N,N1)" = Y or Y1]



① Figure 1.47.

Figure 1.51 Front-Panel Status LEDs

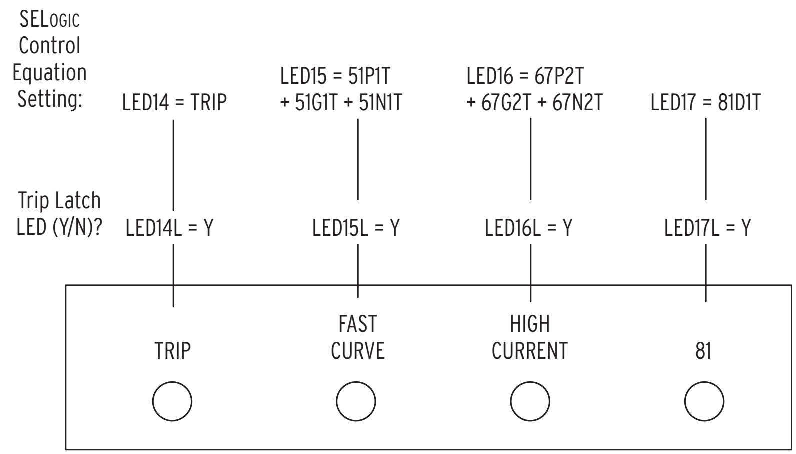


Figure 1.52 Front-Panel Trip Target LEDs

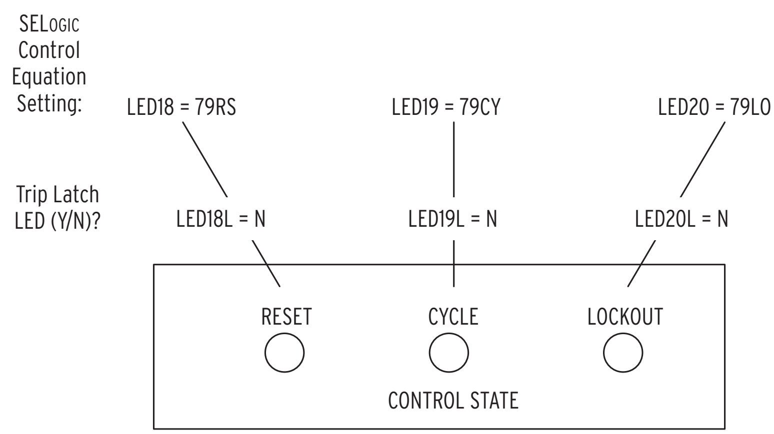


Figure 1.53 Front-Panel Reclosing Relay Status LEDs

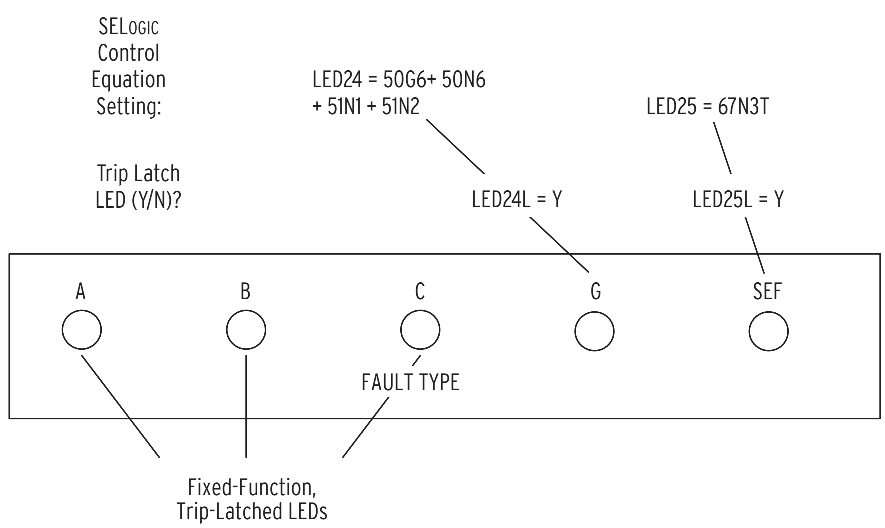


Figure 1.54 Front-Panel Fault-Type Trip Target LEDs

Section 2
Additional Installation Details

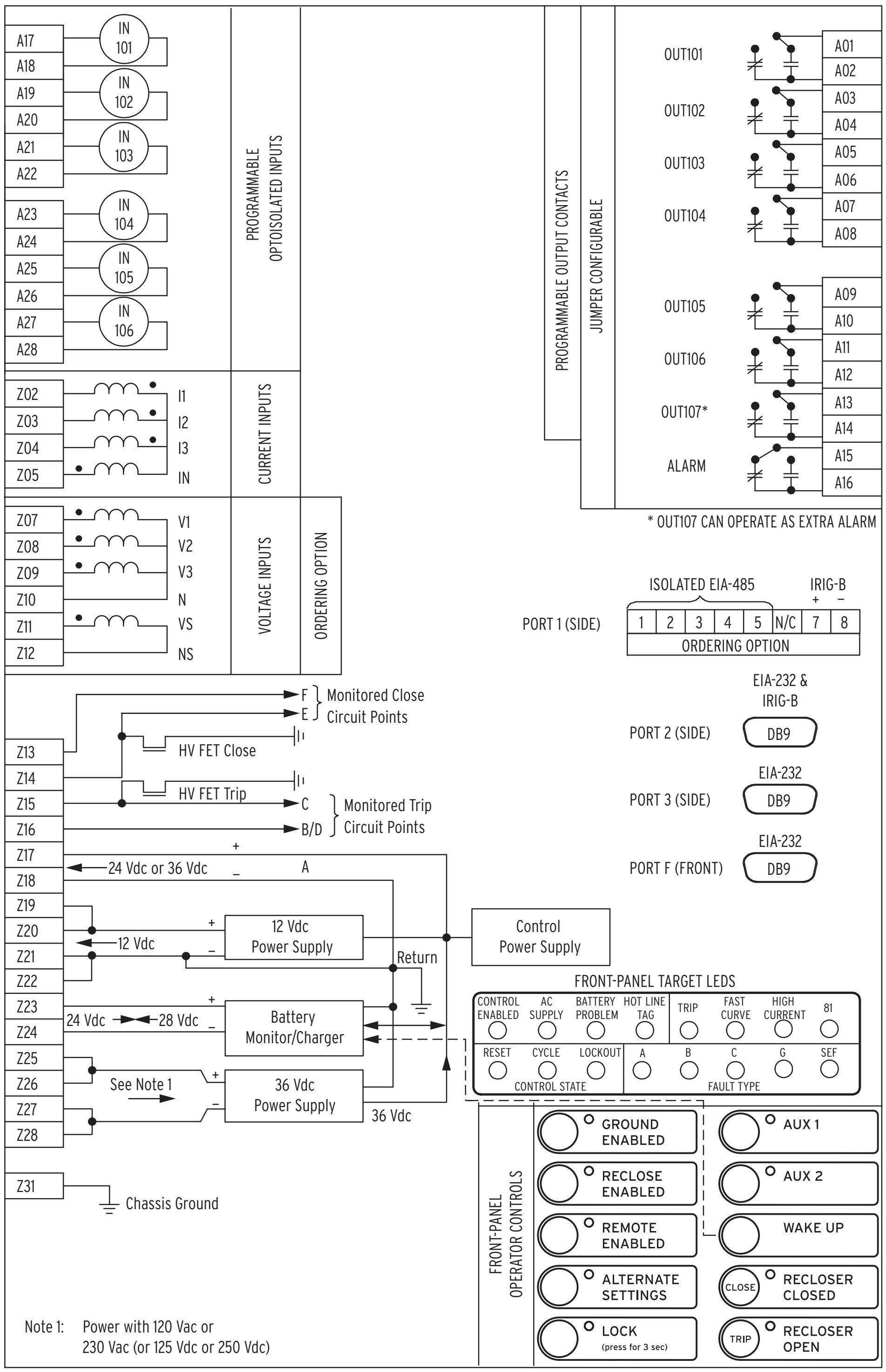


Figure 2.1 SEL-351R Recloser Control Module Inputs, Outputs, and Communications Ports

Overview

This section describes additional SEL-351R Recloser Control installation details not covered in Section 1 of the *SEL-351R-4 Quick-Start Installation and User's Guide*. Refer also to Figure 2.8 in the guide.

Output Contact Jumpers

Table 2.1 shows the correspondence between output contact jumpers and the output contacts they control. Figure 2.8 in the *SEL-351R-4 Quick-Start Installation and User's Guide* shows the exact location and correspondence. With a jumper in the A position, the corresponding output contact is an a-type output contact. An a-type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. With a jumper in the B position, the corresponding output contact is a b-type output contact. A b-type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized. These jumpers are soldered in place.

In *Figure 2.1*, note that the ALARM output contact is a b-type output contact and the other output contacts are all a-type output contacts. This is how these jumpers are configured in a standard SEL-351R Recloser Control shipment. Refer to corresponding *Figure 7.26* for examples of output contact operation for different output contact types.

Table 2.1 Output Contact Jumpers and Corresponding Output Contacts

Output Contact Jumpers	Corresponding Output Contacts
JMP21–JMP29 (but not JMP23)	ALARM–OUT101

"Extra Alarm" Output Contact Control Jumper

The SEL-351R has a dedicated alarm output contact (labeled ALARM—see *Figure 2.1*). Often more than one alarm output contact is needed for such applications as local or remote annunciation, backup schemes, etc. An extra alarm output contact can be had without the addition of any external hardware.

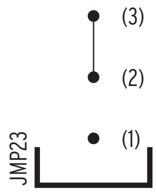
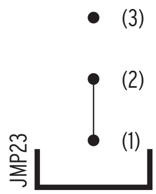
The output contact next to the dedicated ALARM output contact can be converted to operate as an "extra alarm" output contact by moving a jumper on the main board (see *Table 2.2*).

Table 2.2 "Extra Alarm" Output Contact and Corresponding Controlling Jumper

"Extra Alarm" Output Contact	Controlling Jumper
OUT107	JMP23

The position of the jumper controls the operation of the output contact next to the dedicated ALARM output contact. With the jumper in one position, the output contact operates regularly. With the jumper in the other position, the output contact is driven by the same signal that operates the dedicated ALARM output contact (see *Table 2.3*).

Table 2.3 Required Position of Jumper JMP23 for Desired Output Contact OUT107 Operation

Position	Output Contact OUT107 Operation
	Regular output contact OUT107 (operated by Relay Word bit OUT107). Jumper JMP23 comes in this position in a *standard* SEL-351R shipment (see *Figure 7.26*)
	"Extra Alarm" output contact (operated by alarm logic/circuitry). Relay Word bit OUT107 does not have any effect on output contact OUT107 when jumper JMP23 is in this position (see *Figure 7.26*)

If an output contact is operating as an "extra alarm" (driven by the same signal that operates the dedicated ALARM output contact), it will be in the *opposite state* of the dedicated ALARM output contact in a *standard recloser control shipment*. In a standard SEL-351R shipment, the dedicated ALARM output contact comes as a b-type output contact and all the other output contacts (including the "extra alarm") come as a-type output contacts.

The output contact type for any output contact can be changed (see *Output Contact Jumpers on page 2.2*). Thus, the dedicated ALARM output contact and the "extra alarm" output contact can be configured as the same output contact type if desired (e.g., both can be configured as b-type output contacts).

Password and Breaker Jumpers

Table 2.4 Password and Breaker Jumper Positions for Standard Recloser Control Shipments

Password Jumper/Position (for standard recloser control shipments)	Breaker Jumper/Position (for standard recloser control shipments)
JMP6-A = OFF	JMP6-B = ON

Table 2.5 Password and Breaker Jumper Operation

Jumper Type	Jumper Position	Function
Password	ON (in place)	disable password protection[a] for serial ports and front panel
	OFF (removed/not in place)	enable password protection[a] for serial ports and front panel
Breaker	ON (in place)	enable serial port commands **OPEN**, **CLOSE**, and **PULSE**[b]
	OFF (removed/not in place)	disable serial port commands **OPEN**, **CLOSE**, and **PULSE2**

[a] Set the passwords with the PASSWORD command (see Section 10: Serial Port Communications and Commands).
[b] The OPEN, CLOSE, and PULSE commands are used primarily to assert output contacts for circuit breaker control or testing purposes (see Section 10: Serial Port Communications and Commands).

Note that JMP6 in Figure 2.8 in the *SEL-351R-4 Quick-Start Installation and User's Guide* has multiple jumpers A–D. Jumpers A and B are used (see *Table 2.4* and *Table 2.5*). Jumpers C and D are not used. Therefore, the positions (ON or OFF) of jumpers C and D are of no consequence.

EIA-232 Serial Port Voltage Jumpers

The jumpers listed in *Table 2.6* connect or disconnect +5 Vdc to Pin 1 on the corresponding EIA-232 serial ports. The +5 Vdc is rated at 0.5 A maximum for each port. Refer to *Table 2.6* for the placement of jumpers in a standard SEL-351R shipment.

When the jumper is "OFF" (removed/not in place), the +5 Vdc is not connected to Pin 1 on the corresponding EIA-232 serial port. Put the jumper "ON" (in place) so that the +5 Vdc is connected to Pin 1 on the corresponding EIA-232 serial port. See *Table 10.1* for EIA-232 serial port pin functions.

NOTE: Table 2.6 refers to units that come with a yellow label indicating +5 Vdc enabled on Pin 1.

Table 2.6 EIA-232 Serial Port Voltage Jumper Positions for Standard Recloser Control Shipments

EIA-232 Serial Port 2 (rear panel)	EIA-232 Serial Port 3 (rear panel)
JMP2 = OFF	JMP1 = ON

Clock Battery

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer's instructions.

Refer to Figure 2.8 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for clock battery location (front of main board). A lithium battery powers the control clock (date and time) if power source is lost or removed. The battery is a 3 V lithium coin cell, Ray-O-Vac No. BR2335 or equivalent. At room temperature (25°C), the battery will nominally operate for 10 years at rated load.

If power is lost or disconnected, the battery discharges to power the clock. When the SEL-351R is powered from an external source, the battery only experiences a low self-discharge rate. Thus, battery life can extend well beyond the nominal 10 years because the battery rarely has to discharge after the control is installed. The battery cannot be recharged.

If the control does not maintain the date and time after power loss, replace the battery. Follow the instructions in Password Jumper in Section 2 of the *SEL-351R-4 Quick-Start Installation and User's Guide* to remove the control main board.

Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up. Reassemble the control as described in the same subsection. Set the control date and time via serial communications port or front panel (see Section 2 or Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*, respectively).

Voltage Connections

See *Figure 1.31–Figure 1.34* and accompanying text in *Section 1: Factory-Set Logic*.

Section 3

Overcurrent, Voltage, Synchronism Check, and Frequency Elements

Overview

Many of the elements described in this section are used in the factory-set logic for the SEL-351R Recloser Control. Refer to *Table 1.1* for the correlation between the EZ settings that drive this factory-set logic and the "regular" settings that set many of the elements in this section. Refer to *Table 1.3* for the functions of the overcurrent elements when the factory-default EZ settings are active for a particular setting group.

Instantaneous/Definite-Time Overcurrent Elements

Phase Instantaneous/ Definite-Time Overcurrent Elements

Four levels of phase instantaneous/definite-time overcurrent elements are available. Two additional levels of phase instantaneous overcurrent elements (Levels 5 and 6) are also available. The different levels are enabled with the E50P enable setting, as shown in *Figure 3.1–Figure 3.3*.

Level 2 element 67P2S in *Figure 3.3* is used in directional comparison blocking schemes (see *Directional Comparison Blocking (DCB) Logic on page 5.21*). All the other phase instantaneous/definite-time overcurrent elements are available for use in any tripping or control scheme.

Settings Ranges

Setting range for pickup settings 50P1P–50P6P:

0.05–20.00 A secondary (1 A nominal phase currents, IA, IB, IC)

Setting range for definite-time settings 67P1D–67P4D:

0.00–16000.00 cycles, in 0.25-cycle steps

Setting range for definite-time setting 67P2SD (used in the DCB logic):

0.00–60.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Timer: ±0.25 cycles and ±0.1% of setting

Transient Overreach: ±5% of setting

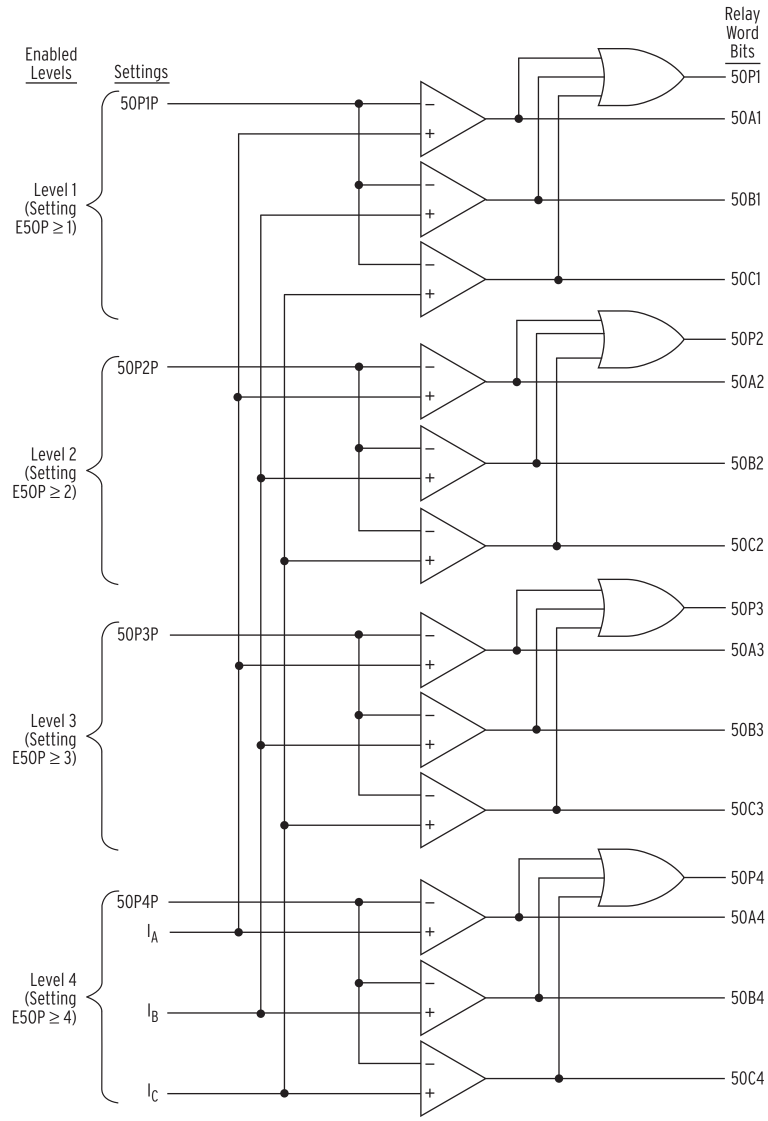


Figure 3.1 Levels 1–4 Phase Instantaneous Overcurrent Elements

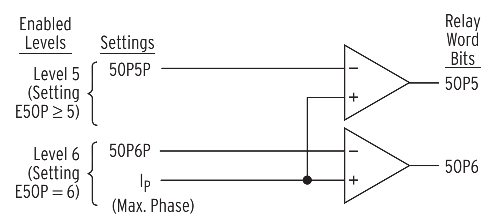


Figure 3.2 Levels 5–6 Phase Instantaneous Overcurrent Elements

Pickup Operation

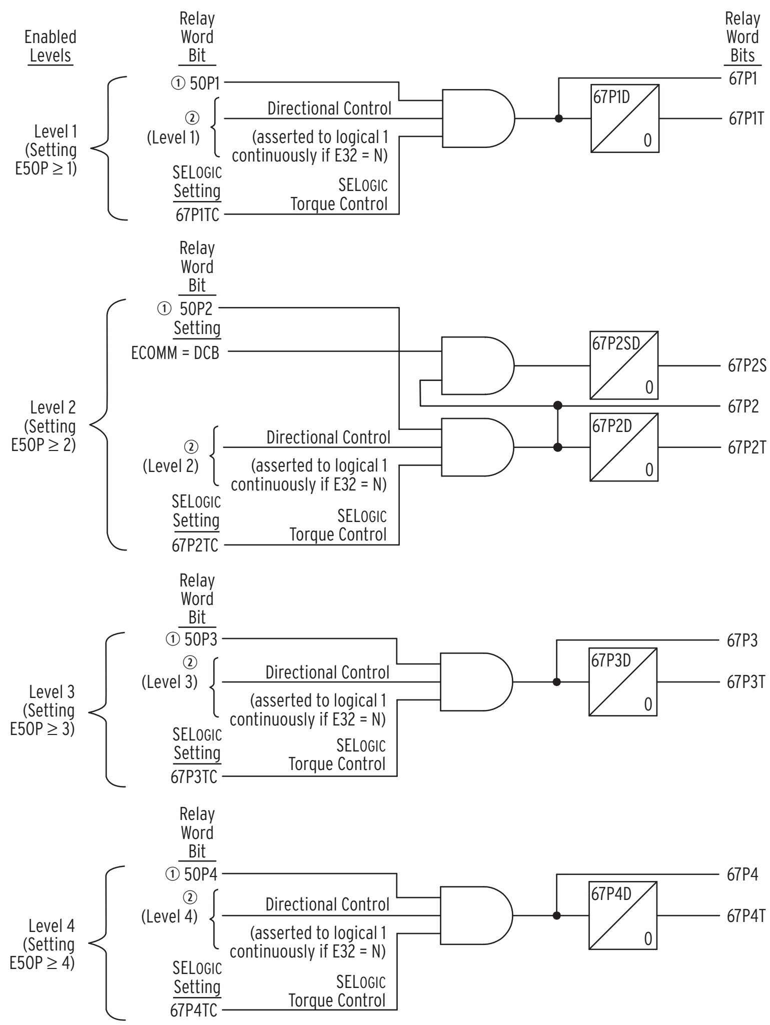
The phase instantaneous/definite-time overcurrent element logic begins with *Figure 3.1* and *Figure 3.2*. The pickup settings for each level (50P1P–50P6P) are compared to the magnitudes of the individual phase currents I_A, I_B, and I_C. The logic outputs in *Figure 3.1* and *Figure 3.2* are Relay Word bits and operate as follows (Level 1 example shown below).

50A1 = 1 (logical 1), if I_A > pickup setting 50P1P
= 0 (logical 0), if $I_A \le$ pickup setting 50P1P
50B1 = 1 (logical 1), if I_B > pickup setting 50P1P
= 0 (logical 0), if $I_B \le$ pickup setting 50P1P

50C1 = 1 (logical 1), if I_C > pickup setting 50P1P
= 0 (logical 0), if $I_C \leq$ pickup setting 50P1P
50P1 = 1 (logical 1), if at least one of the Relay Word bits 50A1, 50B1, or 50C1 is asserted (e.g., 50B1 = 1)
= 0 (logical 0), if all three Relay Word bits 50A1, 50B1, and 50C1 are deasserted (50A1 = 0, 50B1 = 0, and 50C1 = 0)

Note that single-phase overcurrent elements are not available in Levels 5 and 6 (see *Figure 3.2*).

Ideally, set 50P1P > 50P2P > 50P3P > 50P4P so that instantaneous overcurrent elements 67P1–67P4 will display in an organized fashion in event reports (see *Figure 3.3* and *Table 12.3*).



① From Figure 3.1; ② from Figure 4.21.

Figure 3.3 Levels 1–4 Phase Instantaneous/Definite-Time Overcurrent Elements (With Directional Control Option)

Directional Control Option

The phase instantaneous overcurrent element Relay Word bit outputs in *Figure 3.1* (50P1, 50P2, 50P3, and 50P4) are inputs into the phase instantaneous/definite-time overcurrent element logic in *Figure 3.3*.

Levels 1–4 in *Figure 3.3* have corresponding directional control options. See *Figure 4.21* for more information on this optional directional control. If the directional control enable setting E32 is set:

E32 = **N**

then directional control is defeated, and the directional control inputs into all four phase instantaneous/definite-time overcurrent element levels in *Figure 3.3* are asserted to logical 1 continuously. Then only the corresponding SELOGIC® control equation torque control settings have to be considered in the control of the phase instantaneous/definite-time overcurrent elements.

For example, consider the Level 1 phase instantaneous/definite-time overcurrent elements 67P1/67P1T in *Figure 3.3*. If the directional control enable setting E32 is set:

E32 = **N**

then the directional control input from *Figure 4.21* (Level 1) is asserted to logical 1 continuously. Then only the corresponding SELOGIC control equation torque control setting 67P1TC has to be considered in the control of the phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

SELOGIC control equation torque control settings are discussed next.

Torque Control

NOTE: Some of the SELOGIC control equation torque control settings are set directly to logical 1 (e.g., 67P3TC = 1) for the factory-default settings. See SHO Command (Show/View Settings) on page 10.25 for a list of the factory-default settings.

Levels 1–4 in *Figure 3.3* have corresponding SELogic control equation torque control settings 67P1TC–67P4TC. SELogic control equation torque control settings cannot be set directly to logical 0. The following are torque control setting examples for Level 1 phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

67P1TC = **1** Setting 67P1TC set directly to logical 1:

Then only the corresponding directional control input from *Figure 4.21* has to be considered in the control of phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

If directional control enable setting E32 = N, then phase instantaneous/definite-time overcurrent elements 67P1/67P1T are enabled and nondirectional.

67P1TC = **IN105** Input **IN105** deasserted (67P1TC = IN105 = logical 0):

Then phase instantaneous/definite-time overcurrent elements 67P1/67P1T are defeated and nonoperational, regardless of any other setting.

Input **IN105** asserted (67P1TC = IN105 = logical 1):

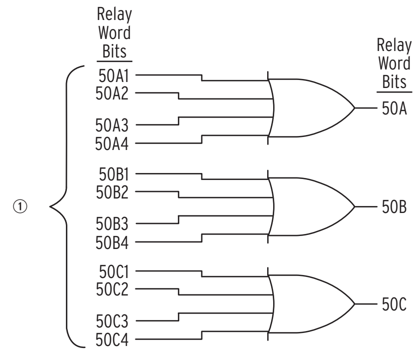
Then only the corresponding directional control input from *Figure 4.21* has to be considered in the control of phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

If directional control enable setting E32 = N, then phase instantaneous/definite-time overcurrent elements 67P1/67P1T are enabled and nondirectional.

Combined Single-Phase Instantaneous Overcurrent Elements

The single-phase instantaneous overcurrent element Relay Word bit outputs in *Figure 3.1* are combined together in *Figure 3.4* on a per phase basis, producing Relay Word bit outputs 50A, 50B, and 50C.

Relay Word bits 50A, 50B, and 50C can be used to indicate the presence or absence of current in a particular phase.



① From Figure 3.1.

Figure 3.4 Combined Single-Phase Instantaneous Overcurrent Elements

Pickup and Reset Time Curves

Figure 3.5 and *Figure 3.6* show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-351R (60 Hz or 50 Hz controls). These times do *not* include output contact operating time and, thus, are accurate for determining element operation time for use in internal SELOGIC control equations. Output contact pickup/dropout time is 4 ms (0.25 cycle for a 60 Hz control; 0.20 cycle for a 50 Hz control).

If instantaneous overcurrent elements are made directional, the pickup time curve in *Figure 3.5* is adjusted as follows:

multiples of pickup setting ≤ 4: add 0.25 cycle

multiples of pickup setting > 4: add 0.50 cycle

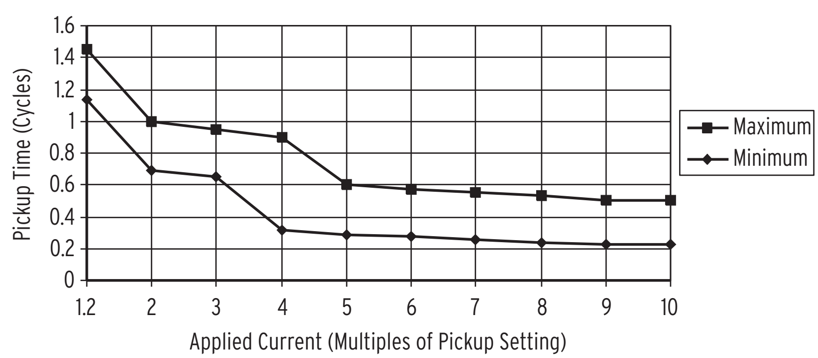


Figure 3.5 SEL-351R Recloser Control Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

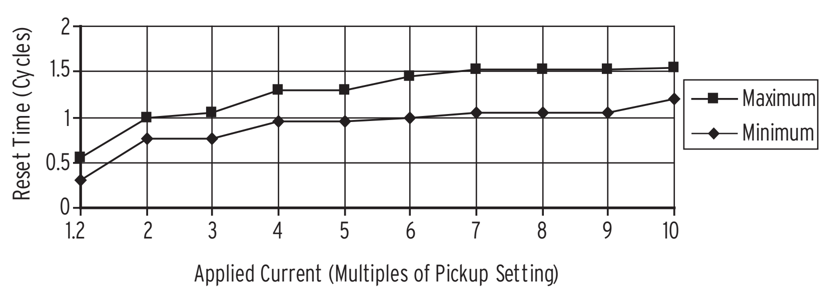


Figure 3.6 SEL-351R Recloser Control Nondirectional Instantaneous Overcurrent Element Reset Time Curve

Phase-to-Phase Instantaneous Overcurrent Elements

Four levels of phase-to-phase instantaneous overcurrent elements are available. The different levels are enabled with the E50P enable setting, as shown in *Figure 3.7*.

Setting Range

Setting range for pickup settings 50PP1P–50PP4P:

0.20–34.00 A secondary (1 A nominal phase currents, IA, IB, IC)

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Pickup Operation

The pickup settings for each level (50PP1P–50PP4P) are compared to the magnitudes of the individual phase-to-phase difference currents I_{AB}, I_{BC}, and I_{CA}. The logic outputs in *Figure 3.7* are the following Relay Word bits (Level 1 example shown):

50AB1	=	1 (logical 1), if I_{AB} > pickup setting 50PP1P
	=	0 (logical 0), if $I_{AB} \leq$ pickup setting 50PP1P
50BC1	=	1 (logical 1), if I_{BC} > pickup setting 50PP1P
	=	0 (logical 0), if $I_{BC} \leq$ pickup setting 50PP1P
50CA1	=	1 (logical 1), if I_{CA} > pickup setting 50PP1P
	=	0 (logical 0), if $I_{CA} \leq$ pickup setting 50PP1P

Pickup and Reset Time Curves

See *Figure 3.5* and *Figure 3.6*.

Neutral Ground Instantaneous/ Definite-Time Overcurrent Elements

Four levels of neutral ground instantaneous/definite-time overcurrent elements are available. Two additional levels of neutral ground instantaneous overcurrent elements (Levels 5 and 6) are also available. The different levels are enabled with the E50N enable setting, as shown in *Figure 3.8* and *Figure 3.9*.

Level 2 element 67N2S in *Figure 3.8* is used in directional comparison blocking schemes (see *Directional Comparison Blocking (DCB) Logic on page 5.21*). All the other neutral ground instantaneous/definite-time overcurrent elements are available for use in any tripping or control scheme.

To understand the operation of *Figure 3.8* and *Figure 3.9*, follow the explanation given for *Figure 3.1–Figure 3.3* in *Phase Instantaneous/ Definite-Time Overcurrent Elements on page 3.1*, substituting current I_N (channel **IN** current) for phase currents and substituting like settings and Relay Word bits.

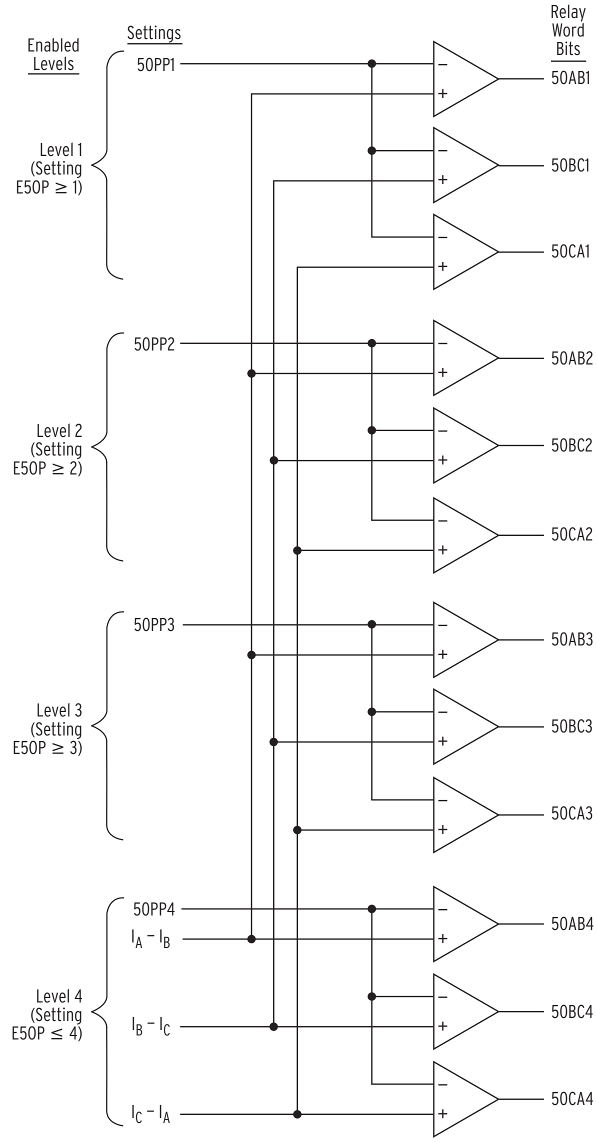
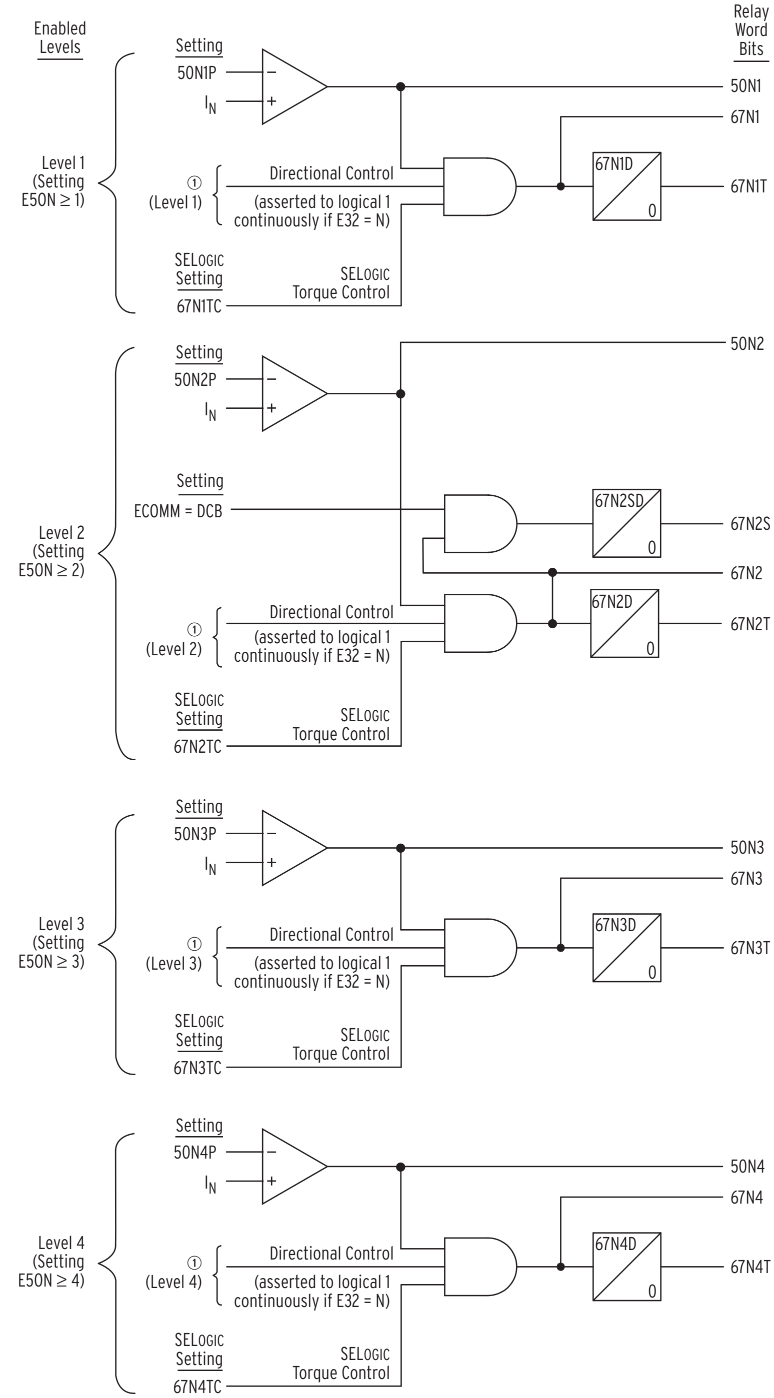


Figure 3.7 Levels 1—4 Phase-to-Phase Instantaneous Overcurrent Elements



① From Figure 4.15.

Figure 3.8 Levels 1–4 Neutral Ground Instantaneous/Definite-Time Overcurrent Elements (With Directional Control Option)

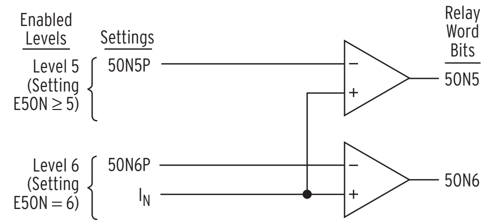


Figure 3.9 Levels 5–6 Neutral Ground Instantaneous Overcurrent Elements

Settings Ranges

NOTE: Because channel IN is rated 0.05 A nominal, there is an additional 2-cycle time delay on all the neutral ground instantaneous (50N1–50N6, 67N1–67N4) and definite-time (67N1T–67N4T) elements. Any time delay provided by the definite-time settings (67N1D–67N4D) is in **addition** to this 2-cycle time delay.

Setting range for pickup settings 50N1P–50N6P:

0.005–1.500 A secondary (0.05 A nominal channel IN current input)

Setting range for definite-time settings 67N1D–67N4D:

0.00–16000.00 cycles, in 0.25-cycle steps

Setting range for definite-time setting 67N2SD (used in DCB logic):

0.00–60.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ±1 mA secondary and ±5% of setting
(0.05 A nominal channel IN current input)

Timer: ±0.25 cycles and ±0.1% of setting

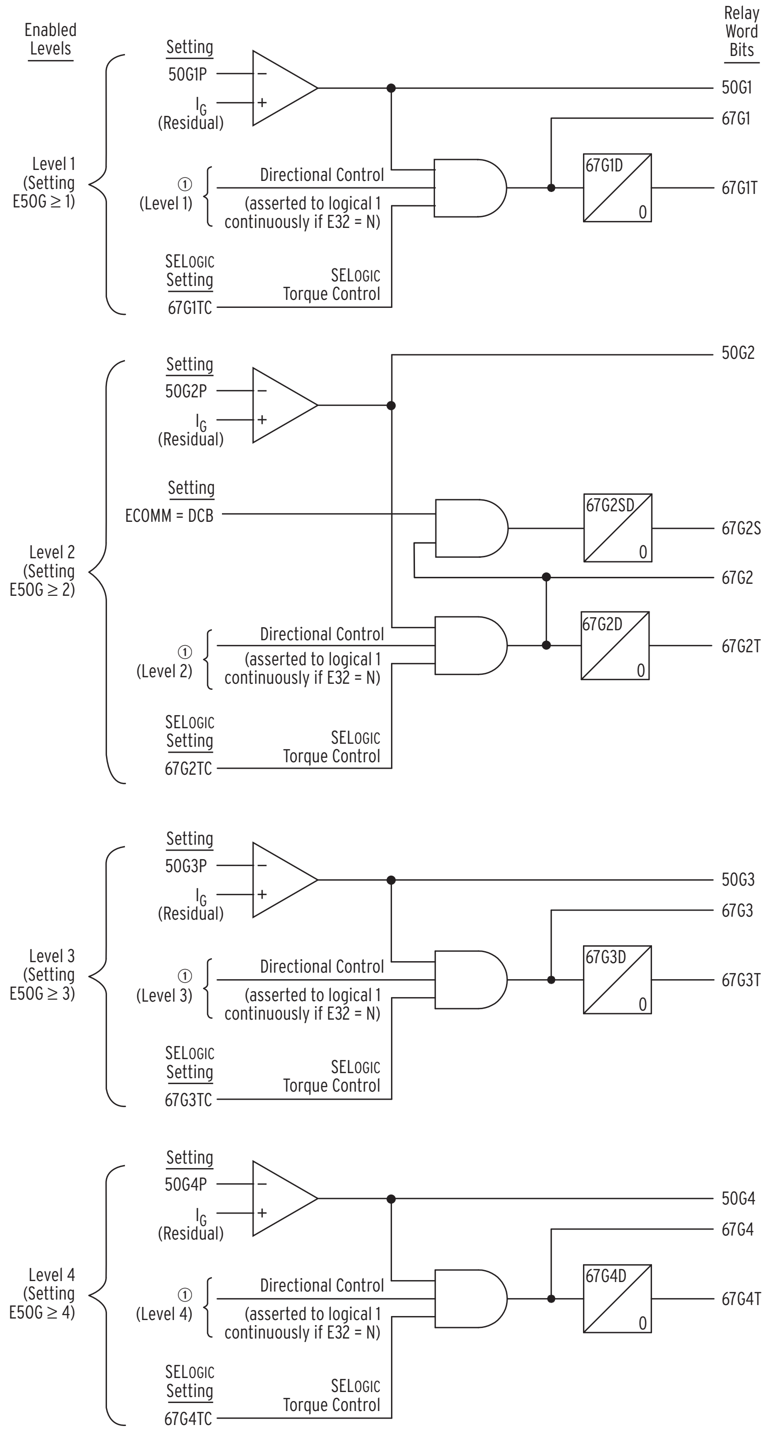
Transient Overreach: ±5% of setting

Pickup and Reset Time Curves

See *Figure 3.5* and *Figure 3.6*.

Residual Ground Instantaneous/ Definite-Time Overcurrent Elements

Four levels of residual ground instantaneous/definite-time overcurrent elements are available. Two additional levels of residual ground instantaneous overcurrent elements (Levels 5 and 6) are also available. The different levels are enabled with the E50G enable setting, as shown in *Figure 3.10* and *Figure 3.11*.



① From Figure 4.14.

Figure 3.10 Levels 1—4 Residual Ground Instantaneous/Definite-Time Overcurrent Elements (With Directional Control Option)

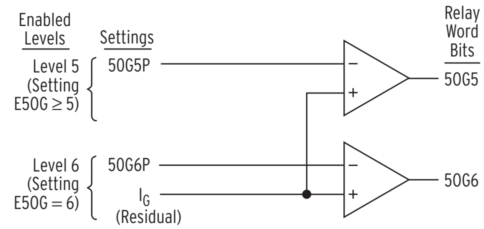


Figure 3.11 Levels 5–6 Residual Ground Instantaneous Overcurrent Elements

Level 2 element 67G2S in *Figure 3.10* is used in directional comparison blocking schemes (see *Directional Comparison Blocking (DCB) Logic on page 5.21*). All the other residual ground instantaneous/definite-time overcurrent elements are available for use in any tripping or control scheme.

To understand the operation of *Figure 3.10* and *Figure 3.11*, follow the explanation given for *Figure 3.1–Figure 3.3* in *Phase Instantaneous/ Definite-Time Overcurrent Elements on page 3.1*, substituting residual ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for phase currents and substituting like settings and Relay Word bits.

Settings Ranges

Setting range for pickup settings 50G1P–50G6P:

0.05–20.00 A secondary (1 A nominal phase currents, IA, IB, IC)

Setting range for definite-time settings 67G1D–67G4D:

0.00–16000.00 cycles, in 0.25-cycle steps

Setting range for definite-time setting 67G2SD (used in DCB logic):

0.00–60.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Timer: ±0.25 cycles and ±0.1% of setting

Transient Overreach: ±5% of setting

Pickup and Reset Time Curves

See *Figure 3.5* and *Figure 3.6*.

Negative-Sequence Instantaneous/ Definite-Time Overcurrent Elements

IMPORTANT: See Appendix F: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.

Four levels of negative-sequence instantaneous/definite-time overcurrent elements are available. Two additional levels of negative-sequence instantaneous overcurrent elements (Levels 5 and 6) are also available. The different levels are enabled with the E50Q enable setting, as shown in *Figure 3.12* and *Figure 3.13*.

Level 2 element 67Q2S in *Figure 3.12* is used in directional comparison blocking schemes (see *Directional Comparison Blocking (DCB) Logic on page 5.21*). All the other negative-sequence instantaneous/definite-time overcurrent elements are available for use in any tripping or control scheme.

To understand the operation of *Figure 3.12* and *Figure 3.13*, follow the explanation given for *Figure 3.1–Figure 3.3* in *Phase Instantaneous/ Definite-Time Overcurrent Elements on page 3.1*, substituting negative-sequence current $3I_2$ [$3I_2 = I_A + a^2 \cdot I_B + a \cdot I_C$ (ABC rotation), $3I_2 = I_A + a^2 \cdot I_C + a \cdot I_B$ (ACB rotation), where $a = 1 \angle 120°$ and $a^2 = 1 \angle -120°$] for phase currents and substituting like settings and Relay Word bits.

Settings Ranges

Setting range for pickup settings 50Q1P–50Q6P:

0.05–20.00 A secondary (1 A nominal phase currents, IA, IB, IC)

Setting range for definite-time settings 67Q1D–67Q4D:

0.00–16000.00 cycles, in 0.25-cycle steps

Setting range for definite-time setting 67Q2SD (used in DCB logic):

0.00–60.00 cycles, in 0.25-cycle steps

Accuracy

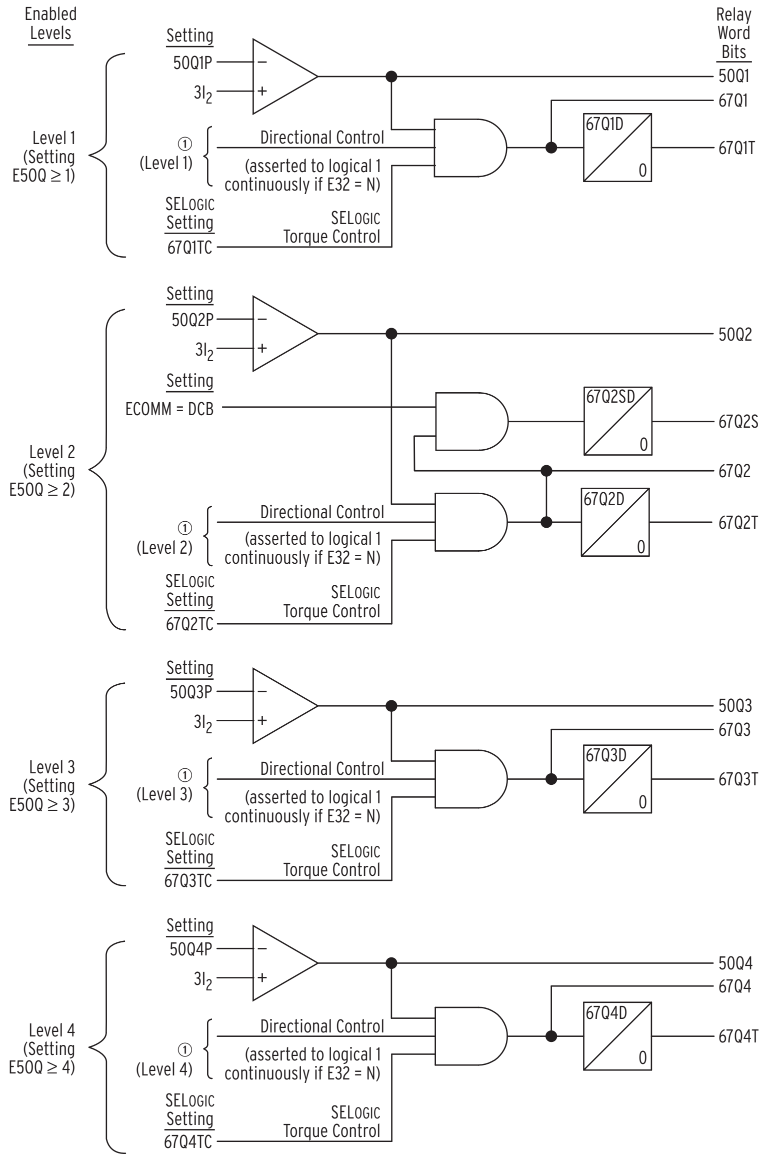
Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Timer: ±0.25 cycles and ±0.1% of setting

Transient Overreach: ±5% of setting

Pickup and Reset Time Curves

See *Figure 3.5* and *Figure 3.6*.



① From Figure 4.20.

Figure 3.12 Levels 1–4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements (With Directional Control Option)

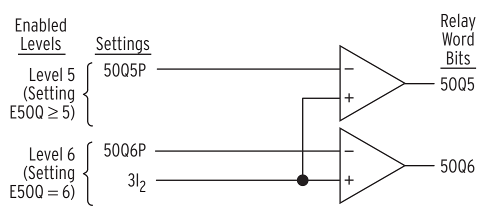


Figure 3.13 Levels 5–6 Negative-Sequence Instantaneous Overcurrent Elements

Time-Overcurrent Elements

Phase Time-Overcurrent Elements

Two phase time-overcurrent elements, 51P1T and 51P2T, are available. The elements are enabled with the E51P enable setting as shown in *Table 3.1*.

Table 3.1 Available Phase Time-Overcurrent Elements

Time-Overcurrent Element	Enabled With Setting	Operating Current	See Figure
51P1T 51P2T	E51P = 1 or 2 E51P = 2	I_P, maximum of A-, B-, and C-phase currents	*Figure 3.14*

The following is an example of 51P1T element operation. 51P2T is similar.

Settings Ranges

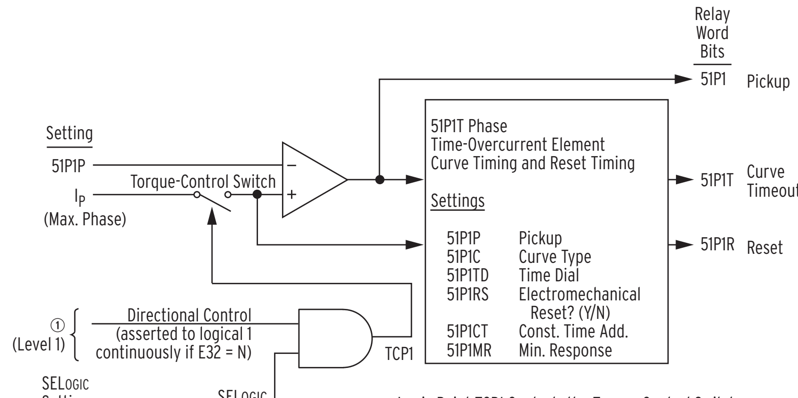
Besides the settings involved with the torque-control switch operation in *Figure 3.14* and *Figure 3.15*, the 51P1T and 51P2T phase time-overcurrent elements have the settings shown in *Table 3.2*.

Table 3.2 Phase Time-Overcurrent Elements Settings

Setting	Definition	Range
51P1P 51P2P	pickup	0.05–3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51P1C 51P2C	curve type	U1–U5 (U.S. curves), C1–C5 (IEC curves), recloser or user curves see *Figure 9.1–Figure 9.20*
51P1TD 51P2TD	time dial (has no multiplying effect on constant time adder or minimum response time)	0.50–15.00 (U.S. curves), 0.05–1.00 (IEC curves), 0.10–2.00 (recloser or user curves) see *Figure 9.1–Figure 9.20*
51P1RS 51P2RS	electromechanical reset timing	Y, N
51P1CT 51P2CT	constant time adder—adds additional time to curve	0.00–60.00 cycles (no effect if set = 0.00)
51P1MR 51P2MR	minimum response time—flattens curve at set time; curve can operate no faster than this set time	0.00–60.00 cycles (no effect if set = 0.00)
51P1TC 51P2TC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table 9.3* or set directly to logical 1 (=1)[a]

[a] SELOGIC control equation torque-control settings (e.g., 51P1TC) cannot be set directly to logical 0.

See *Section 9: Setting the SEL-351R Recloser Control* for additional time-overcurrent element setting information.

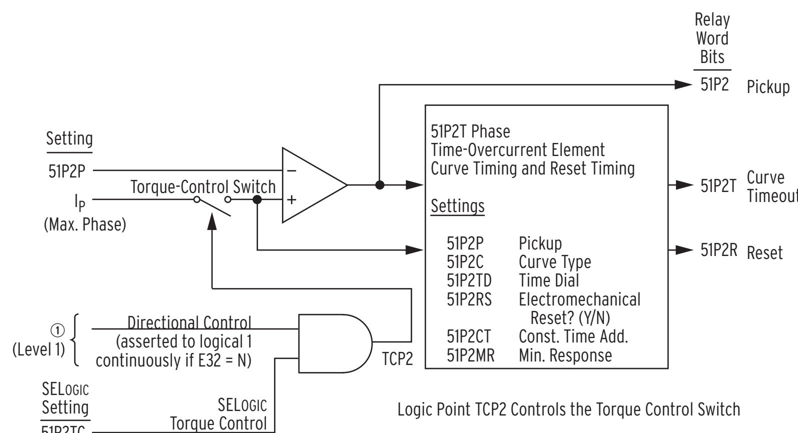


TCP1 State	Torque-Control Switch Position
logical 1	Closed
logical 0	Open

Setting 51P1RS =	Reset Timing
Y	Electromechanical
N	1 Cycle

① From Figure 4.21.

Figure 3.14 Phase Time-Overcurrent Element 51P1T (With Directional Control Option)



TCP2 State	Torque-Control Switch Position
logical 1	Closed
logical 0	Open

Setting 51P2RS =	Reset Timing
Y	Electromechanical
N	1 Cycle

① From Figure 4.21.

Figure 3.15 Phase Time-Overcurrent Element 51P2T (With Directional Control Option)

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Curve Timing: ±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

Logic Outputs (51P1T Element Example)

The resultant logic outputs in *Figure 3.14* are the Relay Word bits shown in *Table 3.3*.

Table 3.3 Phase Time-Overcurrent Element (Maximum Phase) Logic Outputs

Relay Word Bit	Definition/Indication	Application
51P1	Maximum phase current, I_P, is greater than phase time-overcurrent element pickup setting 51P1P.	Element pickup testing or other control applications. See *Trip Logic on page 5.1*.
51P1T	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See *Trip Logic on page 5.1*.
51P1R	Phase time-overcurrent element is fully reset.	Element reset testing or other control applications.

Torque-Control Switch Operation (51P1T Element Example)

Torque-Control Switch Closed

The pickup comparator in *Figure 3.14* compares the pickup setting (51P1P) to the maximum phase current, I_P, if the torque-control switch is closed. I_P is also routed to the curve timing/reset timing functions. The Relay Word bits logic outputs operate as follows with the torque-control switch closed:

51P1 = 1 (logical 1), if I_P > pickup setting 51P1P and the phase time-overcurrent element is timing or is timed out on its curve

= 0 (logical 0), if $I_P \le$ pickup setting 51P1P

51P1T = 1 (logical 1), if I_P > pickup setting 51P1P and the phase time-overcurrent element is timed out on its curve

= 0 (logical 0), if I_P > pickup setting 51P1P and the phase time-overcurrent element is timing, but not yet timed out on its curve

= 0 (logical 0), if $I_P \le$ pickup setting 51P1P

51P1R = 1 (logical 1), if $I_P \le$ pickup setting 51P1P and the phase time-overcurrent element is fully reset

= 0 (logical 0), if $I_P \le$ pickup setting 51P1P and the phase time-overcurrent element is timing to reset (not yet fully reset)

= 0 (logical 0), if I_P > pickup setting 51P1P and the phase time-overcurrent element is timing or is timed out on its curve

Torque-Control Switch Open

If the torque-control switch in *Figure 3.14* is open, maximum phase current, I_P, *cannot* get through to the pickup comparator (setting 51P1P) and the curve timing/reset timing functions. For example, suppose that the torque-control switch is closed, I_P is:

I_P > pickup setting 51P1P

and the phase time-overcurrent element is timing or is timed out on its curve. If the torque-control switch is then opened, I_P effectively appears as a magnitude of zero (0) to the pickup comparator:

I_P = 0 A (effective) < pickup setting 51P1P

resulting in Relay Word bit 51P deasserting to logical 0. I_P also effectively appears as a magnitude of zero (0) to the curve timing/reset timing functions, resulting in Relay Word bit 51P1T also deasserting to logical 0. The phase time-overcurrent element then starts to time to reset. Relay Word bit 51P1R asserts to logical 1 when the phase time-overcurrent element is fully reset.

Control of Logic Point TCP1

Refer to *Figure 3.14*.

The torque-control switch is controlled by logic point TCP1. Logic point TCP1 is controlled by directional control (optional) and SELOGIC control equation torque control setting 51P1TC.

If logic point TCP1 = logical 1, the torque-control switch is closed and maximum phase current, I_P, is routed to the pickup comparator (setting 51P1P) and the curve timing/reset timing functions.

If logic point TCP1 = logical 0, the torque-control switch is open and maximum phase current, I_P, *cannot* get through to the pickup comparator and the curve timing/reset timing functions. The maximum phase current, I_P, effectively appears as a magnitude of zero (0) to the pickup comparator and the curve timing/reset timing function.

Directional Control Option

Refer to *Figure 3.14*.

See *Figure 4.21* for more information on the optional directional control. If the directional control enable setting E32 is set:

E32 = **N**

then directional control is defeated, and the directional control input into logic point TCP1 in *Figure 3.14* is asserted to logical 1 continuously. Then, only the corresponding SELOGIC control equation torque control setting 51P1TC has to be considered in the control of logic point TCP1 (and, thus, in the control of the torque-control switch and phase time-overcurrent element 51P1T).

Torque Control

Refer to *Figure 3.14*.

NOTE: Some of the overcurrent element SELOGIC control equation torque-control settings are set directly to logical 1 (e.g., 51QTC = 1) for the factory-default settings. See SHO Command (Show/View Settings) on page 10.25 for a list of the factory-default settings.

SELOGIC control equation torque-control settings (e.g., 51P1TC) cannot be set directly to logical 0. The following are setting examples of SELOGIC control equation torque control setting 51P1TC for phase time-overcurrent element 51P1T.

51P1TC = **1** Setting 51P1TC set directly to logical 1:

Then only the corresponding directional control input from *Figure 4.21* has to be considered in the control of logic point TCP1 (and, thus, in the control of the torque-control switch and phase time-overcurrent element 51P1TC).

If directional control enable setting E32 = N, then logic point TCP1 = logical 1 and, thus, the torque-control switch closes and phase time-overcurrent element 51P1TC is enabled and nondirectional.

51P1TC = **IN105** Input **IN105** deasserted (51P1TC = IN105 = logical 0):

Then logic point TCP1 = logical 0 and, thus, the torque-control switch opens and phase time-overcurrent element 51P1T is defeated and nonoperational, regardless of any other setting.

Input **IN105** asserted (51P1TC = IN105 = logical 1):

Then only the corresponding directional control input from *Figure 4.21* has to be considered in the control of logic point TCP1 (and, thus, in the control of the torque-control switch and phase time-overcurrent element 51P1T).

If directional control enable setting E32 = N, then logic point TCP1 = logical 1 and, thus, the torque-control switch closes and phase time-overcurrent element 51P1T is enabled and nondirectional.

Sometimes SELOGIC control equation torque control settings are set to provide directional control. See *Directional Control Provided by Torque-Control Settings on page 4.33*.

Reset Timing Details (51P1T Element Example)

Refer to *Figure 3.14*.

Any time current I_P goes above pickup setting 51P1P and the phase time-overcurrent element starts timing, Relay Word bit 51P1R (reset indication) = logical 0. If the phase time-overcurrent element times out on its curve, Relay Word bit 51P1T (curve time-out indication) = logical 1.

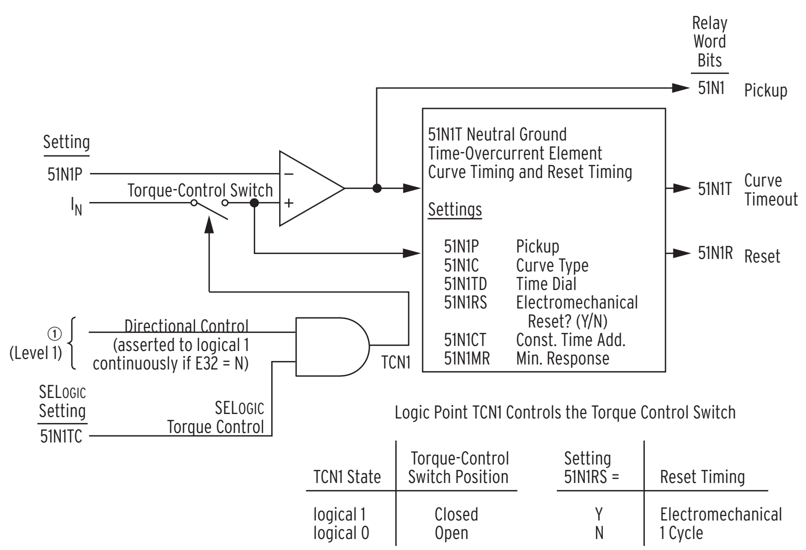
Setting 51P1RS = Y

If electromechanical reset timing setting 51P1RS = Y, the phase time-overcurrent element reset timing emulates electromechanical reset timing. If maximum phase current, I_P, goes above pickup setting 51P1P (element is timing or already timed out) and then current I_P goes below 51P1P, the element starts to time to reset, emulating electromechanical reset timing. Relay Word bit 51P1R (resetting indication) = logical 1 when the element is fully reset.

Setting 51P1RS = N

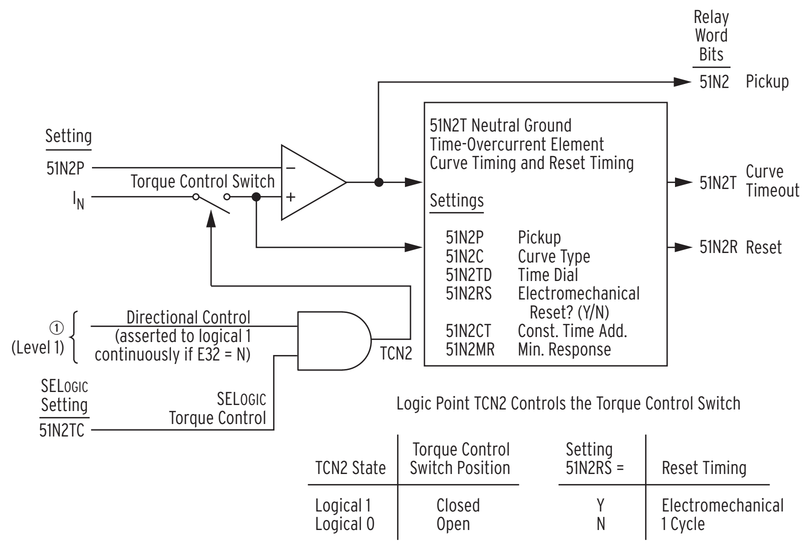
If reset timing setting 51P1RS = N, element 51P1T reset timing is a one-cycle dropout. If current I_P goes above pickup setting 51P1P (element is timing or already timed out) and then current I_P goes below pickup setting 51P1P, there is a one-cycle delay before the element fully resets. Relay Word bit 51P1R (reset indication) = logical 1 when the element is fully reset.

Neutral Ground Time-Overcurrent Elements



① From Figure 4.15.

Figure 3.16 Neutral Ground Time-Overcurrent Element 51N1T (With Directional Control Option)



① From Figure 4.15.

Figure 3.17 Neutral Ground Time-Overcurrent Element 51N2T (With Directional Control Option)

To understand the operation of *Figure 3.16* and *Figure 3.17*, follow the explanation given for *Figure 3.14* in *Phase Time-Overcurrent Elements on page 3.14*, substituting current I_N (channel IN current) for maximum phase current I_P and substituting like settings and Relay Word bits.

Settings Ranges

Table 3.4 Neutral Ground Time-Overcurrent Elements Settings

Setting	Definition	Range
51N1P 51N2P	pickup	0.005–0.160 A secondary (0.05 A nominal channel IN current input)
51N1C 51N2C	curve type	U1–U5 (U.S. curves), C1–C5 (IEC curves), recloser or user curves see *Figure 9.1–Figure 9.20*
51N1TD 51N2TD	time dial (has no multiplying effect on constant time adder or minimum response time)	0.50–15.00 (U.S. curves), 0.05–1.00 (IEC curves), 0.10–2.00 (recloser or user curves) see *Figure 9.1–Figure 9.20*
51N1RS 51N2RS	electromechanical reset timing	Y, N
51N1CT 51N2CT	constant time adder—adds additional time to curve	0.00–60.00 cycles (no effect if set = 0.00)
51N1MR 51N2MR	minimum response time—flattens curve at set time; curve can operate no faster than this set time	0.00–60.00 cycles (no effect if set = 0.00)
51N1TC 51N2TC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table 9.6* or set directly to logical 1 (= 1) or logical 0 (= 0)[a]

[a] If SELOGIC control equation torque control setting 51N1TC is set directly to logical 0 (i.e., 51N1TC = 0), then corresponding neutral ground time-overcurrent element 51N1T is **defeated** and **nonoperational**, regardless of any other setting. Setting 51N2TC = 0 affects 51N2T similarly.

See *Section 9: Setting the SEL-351R Recloser Control* for additional time-overcurrent element setting information.

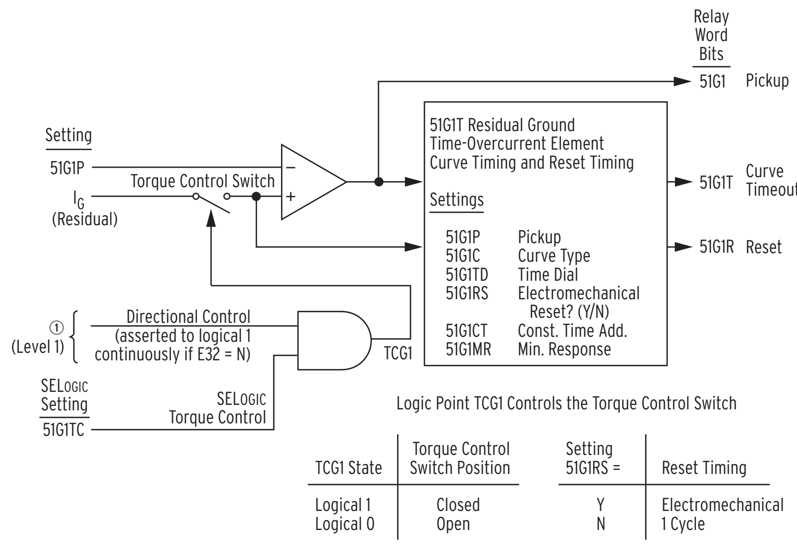
Accuracy

Pickup: ±1 mA secondary and ±5% of setting (0.05 A nominal channel **IN** current input)

Curve Timing: ±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

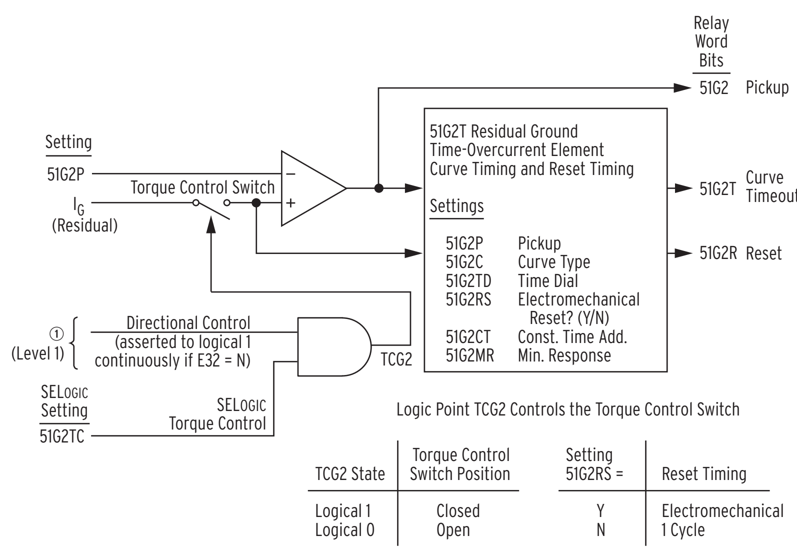
Residual Ground Time-Overcurrent Elements

To understand the operation of *Figure 3.16* and *Figure 3.17*, follow the explanation given for *Figure 3.14* in *Phase Time-Overcurrent Elements on page 3.14*, substituting residual ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for maximum phase current I_P and substituting like settings and Relay Word bits.



① From Figure 4.14.

Figure 3.18 Residual Ground Time-Overcurrent Element 51G1T (With Directional Control Option)



① From Figure 4.14.

Figure 3.19 Residual Ground Time-Overcurrent Element 51G2T (With Directional Control Option)

Settings Ranges

Table 3.5 Residual Ground Time-Overcurrent Element Settings

Setting	Definition	Range
51G1P 51G2P	pickup	0.05–3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51G1C 51G2C	curve type	U1–U5 (U.S. curves), C1–C5 (IEC curves), recloser or user curves see *Figure 9.1–Figure 9.20*
51G1RS 51G2RS	electromechanical reset timing	Y, N
51G1TD 51G2TD	time dial (has no multiplying effect on constant time adder or minimum response time)	0.50–15.00 (U.S. curves), 0.05–1.00 (IEC curves), 0.10–2.00 (recloser or user curves) see *Figure 9.1–Figure 9.20*
51G1CT 51G2CT	constant time adder—adds additional time to curve	0.00–60.00 cycles (no effect if set = 0.00)
51G1MR 51G2MR	minimum response time—flattens curve at set time; curve can operate no faster than this set time	0.00–60.00 cycles (no effect if set = 0.00)
51G1TC 51G2TC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table 9.6* or set directly to logical 1 (= 1) or logical 0 (= 0)[a]

[a] If SELOGIC control equation torque control setting 51G1TC is set directly to logical 0 (i.e., 51G1TC = 0), then corresponding residual ground time-overcurrent element 51G1T is **defeated** and **nonoperational**, regardless of any other setting. Setting 51G2T is similar.

See *Section 9: Setting the SEL-351R Recloser Control* for additional time-overcurrent element setting information.

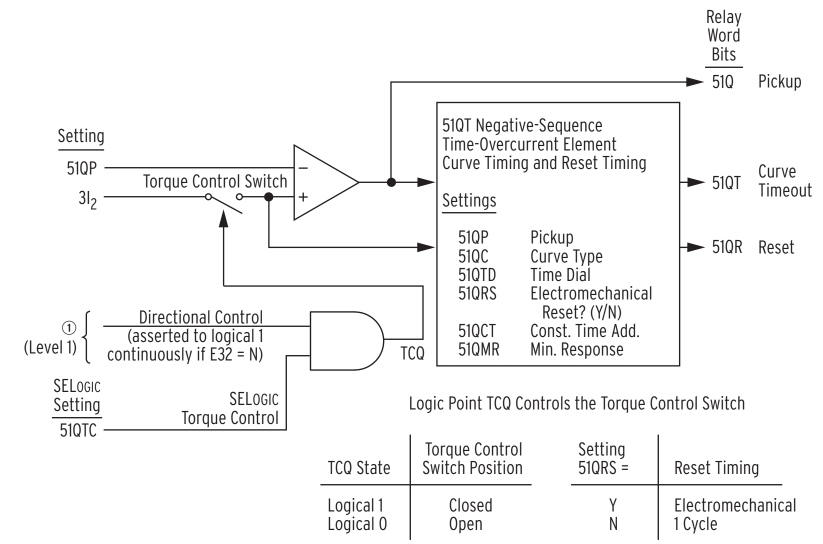
Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Curve Timing: ±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

Negative-Sequence Time-Overcurrent Element

IMPORTANT: See Appendix F: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.



① From Figure 4.20.

Figure 3.20 Negative-Sequence Time-Overcurrent Element 51QT (With Directional Control Option)

To understand the operation of *Figure 3.20*, follow the explanation given for *Figure 3.14* in *Phase Time-Overcurrent Elements on page 3.14*, substituting negative-sequence current $3I_2$ [$3I_2 = I_A + a^2 \bullet I_B + a \bullet I_C$ (ABC rotation), $3I_2 = I_A + a^2 \bullet I_C + a \bullet I_B$ (ACB rotation), where $a = 1 \angle 120°$ and $a^2 = 1 \angle -120°$] for maximum phase current I_P and like settings and Relay Word bits.

Settings Ranges

Table 3.6 Negative-Sequence Time-Overcurrent Elements Settings

Setting	Definition	Range
51QP	pickup	0.05–3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51QC	curve type	U1–U5 (U.S. curves), C1–C5 (IEC curves), recloser or user curves see *Figure 9.1–Figure 9.20*
51QTD	time dial (has no multiplying effect on constant time adder or minimum response time)	0.50–15.00 (U.S. curves), 0.05–1.00 (IEC curves), 0.10–2.00 (recloser or user curves) see *Figure 9.1–Figure 9.20*
51QRS	electromechanical reset timing	Y, N
51QCT	constant time adder—adds additional time to curve	0.00–60.00 cycles (no effect if set = 0.00)
51QMR	minimum response time—flattens curve at set time; curve can operate no faster than this set time	0.00–60.00 cycles (no effect if set = 0.00)
51QTC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table 9.6* or set directly to logical 1 (= 1) or logical 0 (= 0)[a]

[a] If SELOGIC control equation torque control setting 51QTC is set directly to logical 0 (i.e., 51QTC = 0), then corresponding negative-sequence time-overcurrent element 51QT is **defeated** and **nonoperational**, regardless of any other setting.

See *Section 9: Setting the SEL-351R Recloser Control* for additional time-overcurrent element setting information.

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting
(1 A nominal phase currents, IA, IB, IC)

Curve Timing: ±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

Voltage Elements

Enable numerous voltage elements by making the enable setting:

EVOLT = **Y**

Voltage Values

The voltage elements operate off of various voltage values shown in *Table 3.7*.

NOTE: Global settings 3PVOLT, PHANTV, and VPCONN determine the assignments of voltage inputs **V1**, **V2**, and **V3** to phases A, B, and C, thus allowing voltages V_A, V_B, and V_C to be derived (see Table 9.7).

Table 3.7 Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage
V_B	B-phase voltage
V_C	C-phase voltage
V_{AB}	Phase-to-phase voltage
V_{BC}	Phase-to-phase voltage
V_{CA}	Phase-to-phase voltage
$3V_0$	Zero-sequence voltage
V_2	Negative-sequence voltage
V_1	Positive-sequence voltage
V_S	Synchronism-check voltage, from SEL-351R rear-panel voltage input **V_S**[a]

[a] Voltage V_S is used in the synchronism-check elements described in Synchronism-Check Elements on page 3.28. Voltage V_S is also used in the three voltage elements described at the end of Table 3.8 and Figure 3.26. These voltage elements are independent of the synchronism-check elements, even though voltage V_S is used in both.

Voltage Element Settings

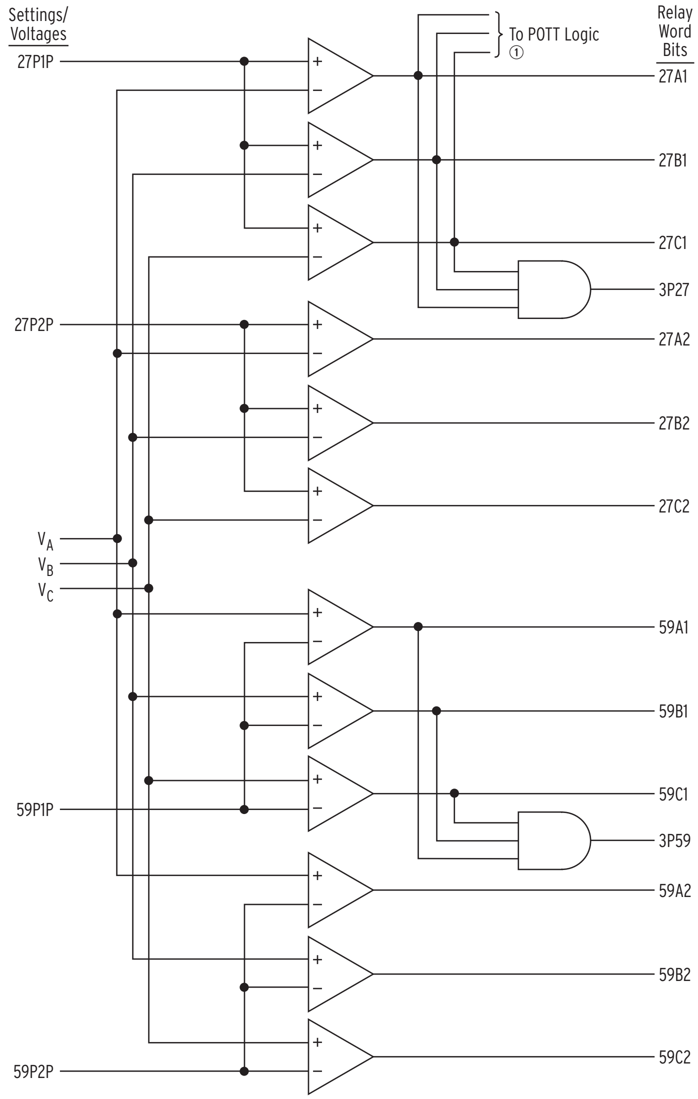
Table 3.8 lists available voltage elements and the corresponding voltage inputs and settings ranges.

Table 3.8 Voltage Elements Settings and Settings Ranges (Sheet 1 of 2)

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A1	V_A	27P1P	*Figure 3.21*
27B1	V_B	0.0–300.0 V secondary	
27C1	V_C		
3P27 = 27A1 * 27B1 * 27C1			
27A2	V_A	27P2P	
27B2	V_B	0.0–300.0 V secondary	
27C2	V_C		

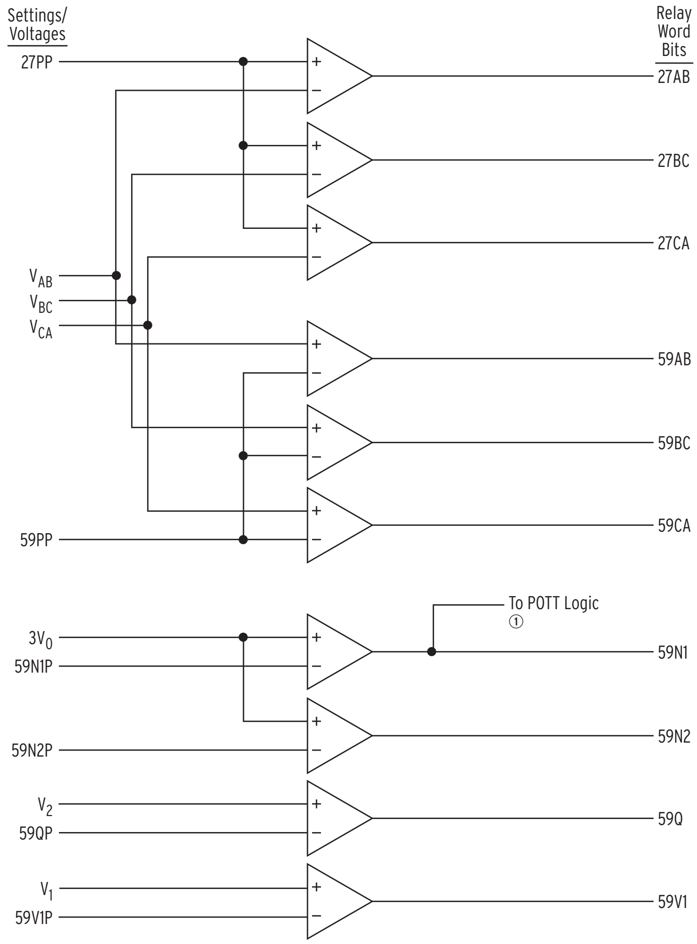
Table 3.8 Voltage Elements Settings and Settings Ranges (Sheet 2 of 2)

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
59A1 59B1 59C1 3P59 = 59A1 * 59B1 * 59C1 59L1	V_A V_B V_C Input V1	59P1P 0.0–300.0 V secondary	Figure 3.22
59A2 59B2 59C2	V_A V_B V_C	59P2P 0.0–300.0 V secondary	
27AB 27BC 27CA	V_{AB} V_{BC} V_{CA}	27PP 0.0–520.0 V secondary	
59AB 59BC 59CA	V_{AB} V_{BC} V_{CA}	59PP 0.0–520.0 V secondary	
59N1	$3V_0$	59N1P, 0.0–300.0 V secondary	
59N2	$3V_0$	59N2P, 0.0–300.0 V secondary	
59Q	V_2	59QP, 0.0–200.0 V secondary	
59V1	V_1	59V1P, 0.0–300.0 V secondary	
27S	V_S	27SP, 0.0–300.0 V secondary	Figure 3.23
59S1	V_S	59S1P, 0.0–300.0 V secondary	
59S2	V_S	59S2P, 0.0–300.0 V secondary	



① Figure 5.6.

Figure 3.21 Single-Phase and Three-Phase Voltage Elements



① Figure 5.6.

Figure 3.22 Phase-to-Phase and Sequence Voltage Elements

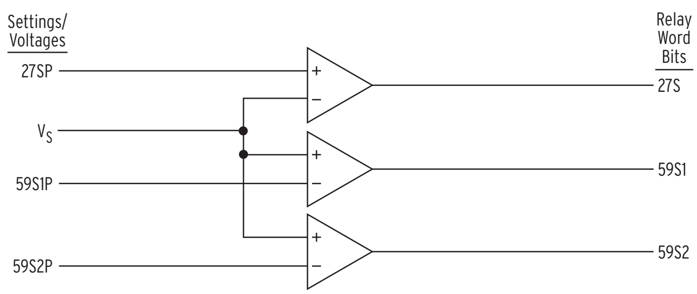


Figure 3.23 Channel VS Voltage Elements

Accuracy

Pickup: ±1 V and ±5% of setting

Transient Overreach: ±5% of setting

Voltage Element Operation

Note that the voltage elements in *Table 3.8*, *Figure 3.21*, and *Figure 3.22* are a combination of “undervoltage” (Device 27) and “overvoltage” (Device 59) type elements. Undervoltage elements (Device 27) assert when the operating voltage goes below the corresponding pickup setting. Overvoltage elements (Device 59) assert when the operating voltage goes above the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to *Figure 3.21* (top of the figure).

Pickup setting 27P1P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 3.21* are the following Relay Word bits:

27A1	=	1 (logical 1), if V_A < pickup setting 27P1P
	=	0 (logical 0), if $V_A \geq$ pickup setting 27P1P
27B1	=	1 (logical 1), if V_B < pickup setting 27P1P
	=	0 (logical 0), if $V_B \geq$ pickup setting 27P1P
27C1	=	1 (logical 1), if V_C < pickup setting 27P1P
	=	0 (logical 0), if $V_C \geq$ pickup setting 27P1P
3P27	=	1 (logical 1), if all three Relay Word bits 27A1, 27B1, and 27C1 are asserted (27A1 = 1, 27B1 = 1, and 27C1 = 1)
	=	0 (logical 0), if at least one of the Relay Word bits 27A1, 27B1, or 27C1 is deasserted (e.g., 27A1 = 0)

Overvoltage Element Operation Example

Refer to *Figure 3.21* (bottom of the figure).

Pickup setting 59P1P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 3.21* are the following Relay Word bits:

59A1	=	1 (logical 1), if V_A > pickup setting 59P1P
	=	0 (logical 0), if $V_A \leq$ pickup setting 59P1P
59B1	=	1 (logical 1), if V_B > pickup setting 59P1P
	=	0 (logical 0), if $V_B \leq$ pickup setting 59P1P
59C1	=	1 (logical 1), if V_C > pickup setting 59P1P
	=	0 (logical 0), if $V_C \leq$ pickup setting 59P1P
3P59	=	1 (logical 1), if all three Relay Word bits 59A1, 59B1, and 59C1 are asserted (59A1 = 1, 59B1 = 1, and 59C1 = 1)
	=	0 (logical 0), if at least one of the Relay Word bits 59A1, 59B1, or 59C1 is deasserted (e.g., 59A1 = 0)

Voltage Elements Used in POTT Logic

Refer to *Figure 3.21* and *Figure 3.22*. Note that voltage elements 27A1, 27B1, 27C1, and 59N1 are also used in the weak-infeed portion of the POTT logic, if the weak-infeed logic is enabled (see *Figure 5.6*).

If the weak-infeed portion of the POTT logic is enabled (setting EWFC = Y) and these voltage elements are used in the logic, they can still be used in other applications (if the settings are applicable). If the weak-infeed portion of the POTT logic is not enabled, these voltage elements can be used in any desired application.

Synchronism-Check Elements

Enable the two single-phase synchronism-check elements by making the enable setting:

E25 = **Y**

Synchronism-check voltage input **VS** is connected to one side of the circuit breaker, on any desired phase. The other synchronizing phase (V_A, V_B, or V_C voltages) on the other side of the circuit breaker is setting selected.

The two synchronism-check elements use the same voltage window (to ensure healthy voltage) and slip frequency settings (see *Figure 3.24*). They have separate angle settings (see *Figure 3.25*).

If the voltages are static (voltages *not* slipping with respect to one another), the two synchronism-check elements operate as shown in the top of *Figure 3.25*. The angle settings are checked for synchronism-check closing.

If the voltages are *not* static (voltages slipping with respect to one another), the two synchronism-check elements operate as shown in the bottom of *Figure 3.25*. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero degree phase angle difference, to minimize system shock.

These synchronism-check elements are explained in detail in the following text.

Voltage Input VS Connected Phase-to-Phase or Beyond Delta-Wye Transformer

Sometimes synchronism-check voltage V_S cannot be in phase with voltage V_A, V_B, or V_C. This happens in applications where voltage input **VS** is connected phase-to-phase or beyond a delta-wye transformer. For such applications requiring V_S to be at a constant phase angle difference from any of the possible synchronizing voltages (V_A, V_B, or V_C), an angle setting is made with the SYNCP setting (see *Table 3.9* and the SYNCP setting discussion that follows).

Synchronism-Check Elements Settings

Table 3.9 Synchronism-Check Elements Settings and Settings Ranges

Setting	Definition	Range
25VLO	low voltage threshold for “healthy voltage” window	0.0–300.0 V secondary
25VHI	high voltage threshold for “healthy voltage” window	0.0–300.0 V secondary
25SF	maximum slip frequency	0.005–0.500 Hz
25ANG1	synchronism-check element 25A1 maximum angle	0°–80°
25ANG2	synchronism-check element 25A2 maximum angle	0°–80°
SYNCP	synchronizing phase	VA, VB, or VC
	or	
	the number of degrees that synchronism-check voltage V_S constantly lags voltage V_A	0°–330°, in 30-degree steps
TCLOSD	breaker close time for angle compensation	0.00–60.00 cycles
BSYNCH	SELOGIC control equation block synchronism-check setting	Relay Word bits referenced in *Table 9.6*

Setting SYNCP

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCP are referenced to V_A, and they indicate the number of degrees by which V_S constantly lags V_A. In situations where V_S cannot be in phase with V_A, V_B, or V_C, it is simplest to use the angle setting choices (0, 30, …, 300, or 330 degrees).

NOTE ON SETTING SYNCP = 0:
Settings SYNCP = 0 and SYNCP = VA are effectively the same (voltage V_S is directly synchronism checked with voltage V_A; V_S does not lag V_A). The control will display the setting entered (SYNCP = VA or SYNCP = 0).

In any synchronism-check application, voltage input **V1** must always be connected to determine system frequency on one side of the circuit breaker. Input **V1** must always meet the “healthy voltage” criteria (settings 25VHI and 25VLO; see *Figure 3.24*). See SEL Application Guide AG2002-02 entitled *Compensate for Constant Phase Angle Difference in Synchronism Check With the* SEL-*351 Relay Family* for more information on setting SYNCP with an angle setting.

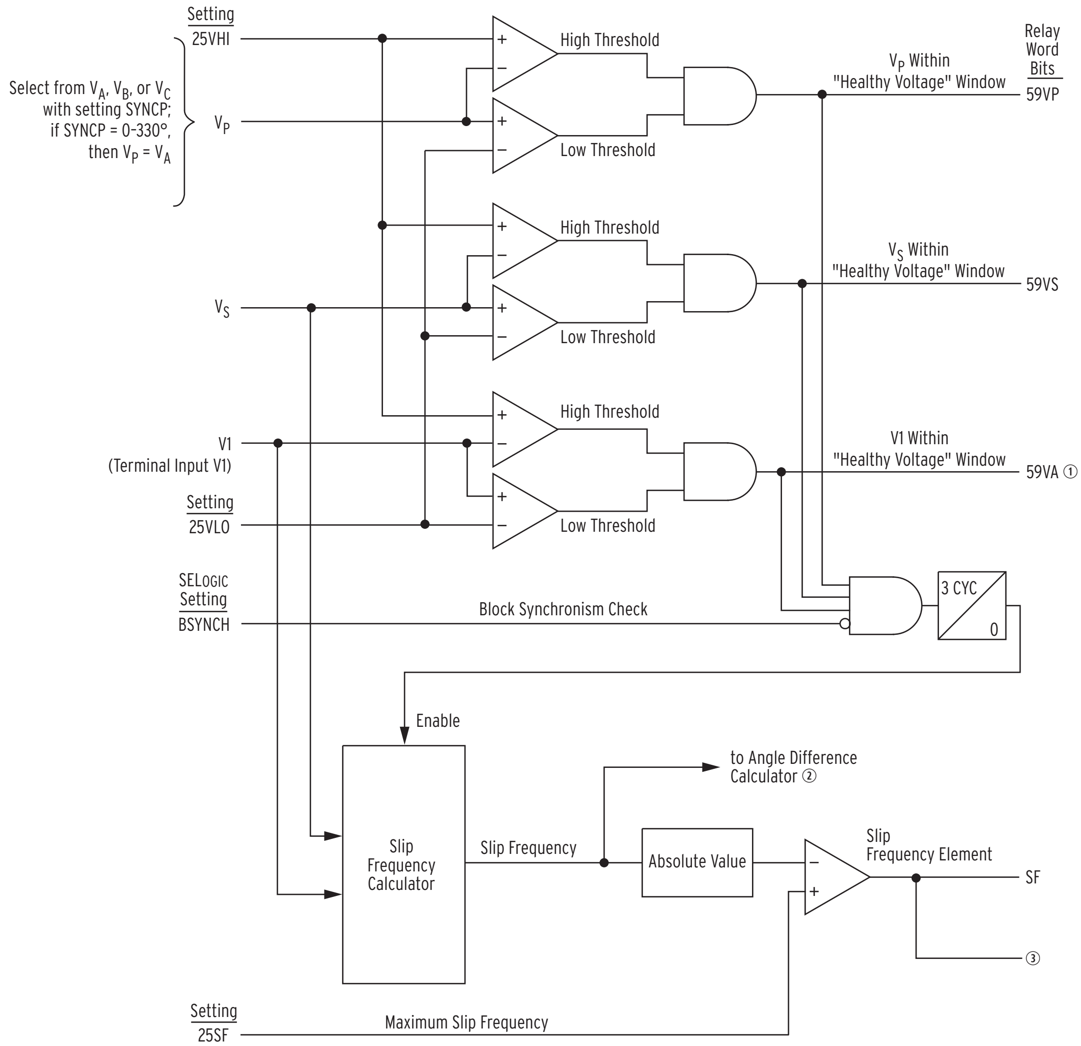
Accuracy

Voltage Pickup: ±1 V and ±5% of setting

Voltage Transient Overreach: ±5% of setting

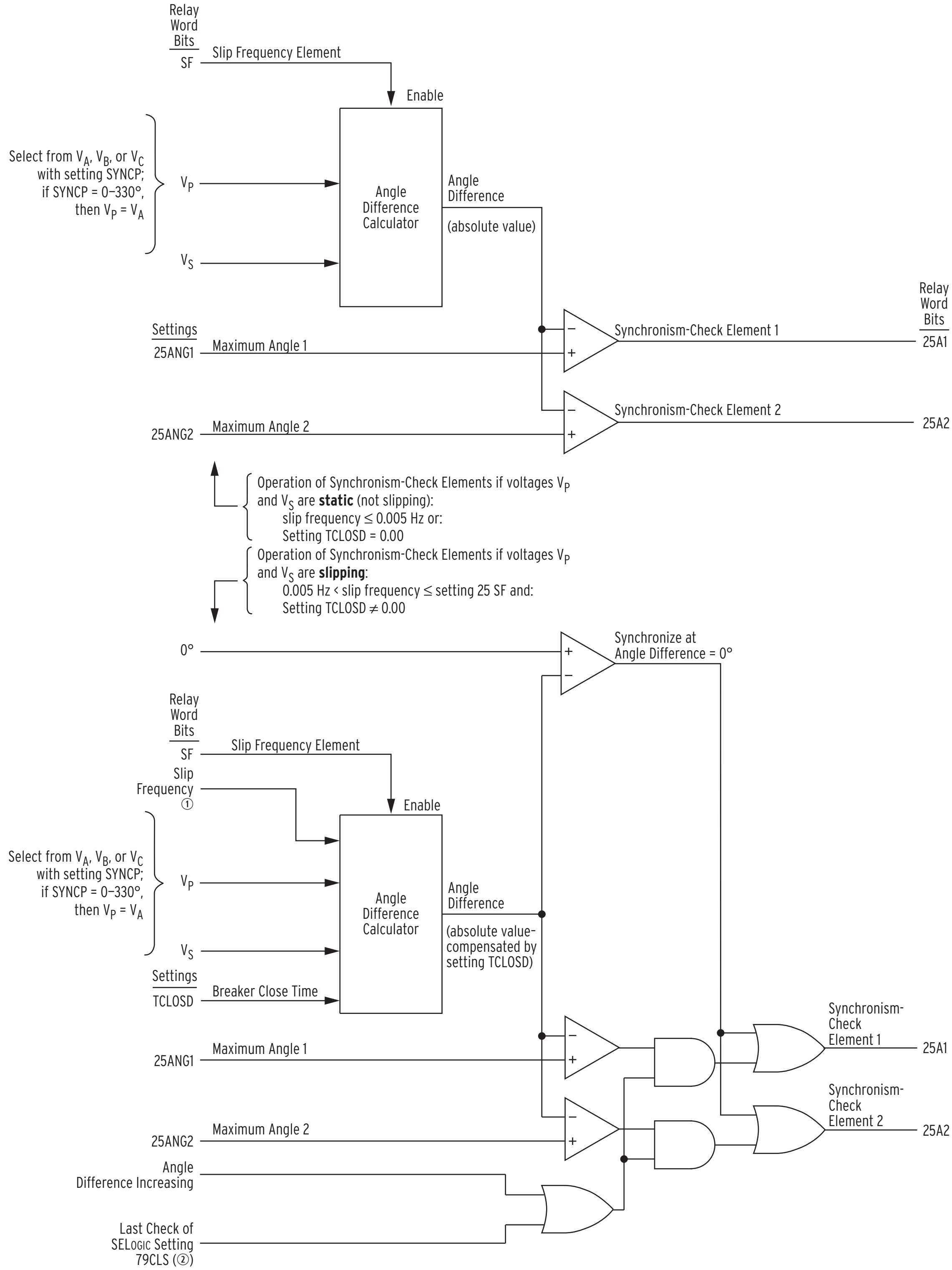
Slip Pickup: 0.003 Hz

Angle Pickup: ±4°



① Relay Word bit 59VA was labeled prior to phase rolling when V1 input terminal was VA; ② see bottom of Figure 3.25; ③ to Figure 3.25.

Figure 3.24 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 3.24; ② see Figure 6.2.

Figure 3.25 Synchronism-Check Elements

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements are single-phase elements, with single-phase voltage inputs V_P and V_S used for both elements:

V_P Phase input voltage (V_A, V_B, or V_C), designated by setting SYNCP (e.g., if SYNCP = VB, then $V_P = V_B$)

V_S Synchronism-check voltage, from SEL-351R rear-panel voltage input **VS**

For example, if V_P is designated as phase input voltage V_B (setting SYNCP = VB), then rear-panel voltage input **VS** is connected to B-phase on the other side of the circuit breaker. The voltage across **VB** is synchronism checked with the voltage across **VS** (see *Figure 2.1*).

System Frequencies Determined from Voltages V_1 and V_S

To determine slip frequency, you must first determine the system frequencies on both sides of the circuit breaker. Voltage V_S determines the frequency on one side. Voltage **V1** determines the frequency on the other side. Thus, voltage input **V1** has to be connected.

In most applications, all three system voltages, VA, VB, and VC, are connected to the three-phase power system, and there are no additional connection concerns regarding voltage connection **V1-N**. The presumption is that the frequency determined for the phase connected to **V1** is also valid for the other two phases in a three-phase power system.

However, for example, if you want to synchronize voltage V_B with voltage V_S and connect only system voltage Phase B and **VS** to Phase B on both sides of the circuit breaker, then connect V_B to input **V1** and set VPCONN = B.

Another possible solution to this example (synchronism-check voltage input **VS** connected to Phase B) is to make setting SYNCP = 120 (the number of degrees that synchronism-check voltage V_S constantly lags voltage V_A) and connect voltage input **V1** to Phase A. Voltage input **VB** does not have to be connected.

System Rotation Can Affect Setting SYNCP

The solution in the preceding paragraph:

- Voltage input **V1** connected to Phase A
- Voltage input **VS** connected to Phase B
- Setting SYNCP = 120 degrees (V_S constantly lags V_A by 120 degrees)

presumes ABC system rotation. If voltage input connections are the same, but system rotation is ACB, then setting SYNCP = 240 degrees (V_S constantly lags V_A by 240 degrees). See Application Guide AG2002-02, entitled *Compensate for Constant Phase Angle Difference in Synchronism Check With the* SEL-*351 Relay Family* for more information on setting SYNCP with an angle setting.

Synchronism-Check Elements Operation

Refer to *Figure 3.24* and *Figure 3.25*.

Voltage Window

Refer to *Figure 3.24*.

Single-phase voltage inputs V_P and V_S are compared to a voltage window, to verify that the voltages are “healthy” and lie within settable voltage limits 25VLO and 25VHI. If both voltages are within the voltage window, the following Relay Word bits assert:

NOTE: Relay Word bit 59VA was labeled prior to phase rolling when **V1** terminal input was VA.

59VP indicates that voltage V_P is within voltage window setting limits 25VLO and 25VHI

59VS indicates that voltage V_S is within voltage window setting limits 25VLO and 25VHI

As discussed previously, voltage **V1** determines the frequency on the voltage V_P side of the circuit breaker. Voltage **V1** is also run through voltage limits 25VLO and 25VHI to ensure “healthy voltage” for frequency determination, with corresponding Relay Word bit output 59VA.

Other Uses for Voltage Window Elements

If voltage limits 25VLO and 25VHI are applicable to other control schemes, Relay Word bits 59VP, 59VS, and 59VA can be used in other logic at the same time they are used in the synchronism-check logic.

If synchronism check is not being used, Relay Word bits 59VP, 59VS, and 59VA can still be used in other logic, with voltage limit settings 25VLO and 25VHI set as desired. Enable the synchronism-check logic (setting E25 = Y) and make settings 25VLO and 25VHI. Apply Relay Word bits 59VP, 59VS, and 59VA in desired logic scheme, using SELOGIC control equations. Even though synchronism-check logic is enabled, the synchronism-check logic outputs (Relay Word bits SF, 25A1, and 25A2) do not need to be used.

Block Synchronism Check Conditions

Refer to *Figure 3.24*.

The synchronism-check element slip frequency calculator runs if voltages V_P, V_S, and input **V1** are healthy (59VP, 59VS, and 59VA asserted to logical 1) *and* the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCH is most commonly set to block synchronism-check operation when the circuit breaker is closed (synchronism check is only needed when the circuit breaker is open):

BSYNCH = **52A** (see *Figure 1.22*)

In addition, synchronism-check operation can be blocked when the control is tripping:

BSYNCH = **... + TRIP**

Slip Frequency Calculator

Refer to *Figure 3.24*.

The synchronism-check element Slip Frequency Calculator in *Figure 3.24* runs if voltages V_P, V_S, and input **V1** are healthy (59VP, 59VS, and 59VA asserted to logical 1) *and* the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is:

Slip Frequency = $f_P - f_S$ (in units of Hz = slip cycles/second)

f_P = frequency of voltage V_P (determined from input **V1**) (in units of Hz = cycles/second)

f_S = frequency of voltage V_S (in units of Hz = cycles/second)

A complete slip cycle is one single 360-degree revolution of one voltage (e.g., V_S) by another voltage (e.g., V_P). Both voltages are thought of as revolving phasor-wise, so the "slipping" of V_S past V_P is the *relative* revolving of V_S past V_P.

For example, in *Figure 3.24*, if voltage V_P has a frequency of 59.95 Hz and voltage V_S has a frequency of 60.05 Hz, the difference between them is the slip frequency:

Slip Frequency = 59.95 Hz – 60.05 Hz = –0.10 Hz = –0.10 slip cycles/second

The slip frequency in this example is negative, indicating that voltage V_S is not "slipping" *behind* voltage V_P, but in fact "slipping" *ahead* of voltage V_P. In a time period of one second, the angular distance between voltage V_P and voltage V_S changes by 0.10 slip cycles, which translates into:

0.10 slip cycles/second • (360°/slip cycle) • 1 second = 36°

Thus, in a time period of one second, the angular distance between voltage V_P and voltage V_S changes by 36 degrees.

The absolute value of the Slip Frequency output is run through a comparator and if the slip frequency is less than the maximum slip frequency setting, 25SF, Relay Word bit SF asserts to logical 1.

Angle Difference Calculator

The synchronism-check element Angle Difference Calculator in *Figure 3.25* runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

If SYNCP = 0, 30, …, 300, or 330 degrees (indicating how many degrees V_S constantly lags $V_P = V_A$), the Angle Difference Calculator automatically accounts for this angular difference.

Voltages V_P and V_S Are "Static"

Refer to top of *Figure 3.25*.

If the slip frequency is less than or equal to 0.005 Hz, the Angle Difference Calculator does *not* take into account breaker close time—it presumes voltages V_P and V_S are "static" (not "slipping" with respect to one another). This would usually be the case for an open breaker with voltages V_P and V_S that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages V_P and V_S:

Angle Difference = $|(\angle V_P - \angle V_S)|$

For example, if SYNCP = 90 (indicating V_S constantly lags $V_P = V_A$ by 90 degrees), but V_S actually lags V_A by 100 angular degrees on the power system at a given instant, the Angle Difference Calculator automatically accounts for the 90 degrees and:

$$\text{Angle Difference} = |(\angle V_P - \angle V_S)| = 10°$$

Also, if breaker close time setting TCLOSD = 0.00, the Angle Difference Calculator does not take into account breaker close time, even if the voltages V_P and V_S are "slipping" with respect to one another.

Voltages V_P and V_S Are "Slipping"

Refer to bottom of *Figure 3.25*.

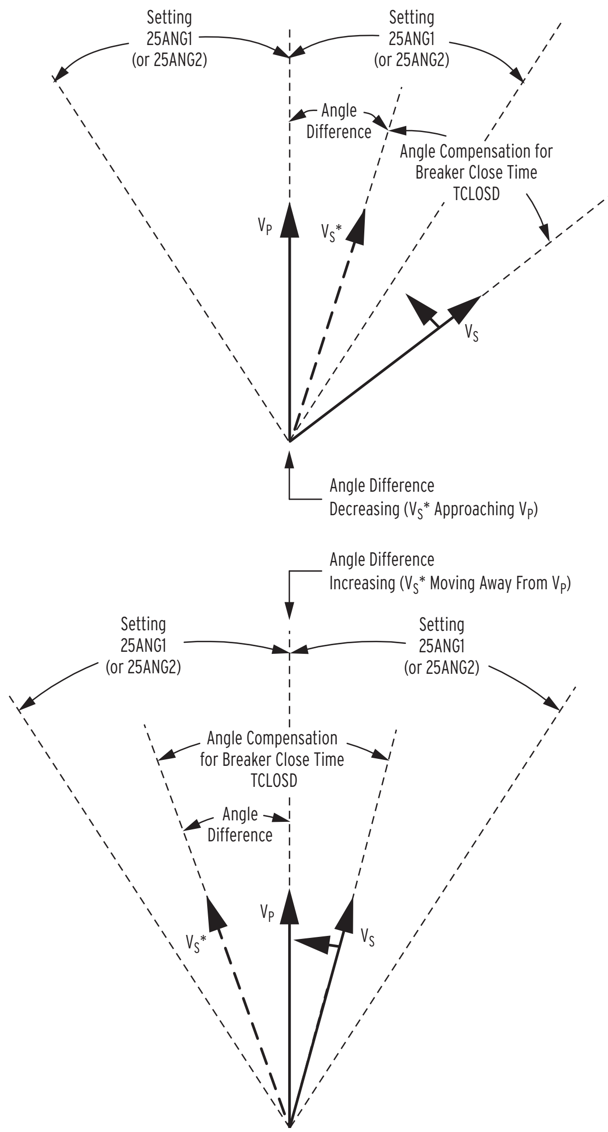


Figure 3.26 Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$; V_P Shown as Reference in This Example)

If the slip frequency is greater than 0.005 Hz *and* breaker close time TCLOSD $\neq$ 0.00, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in cycles; see *Figure 3.26*). The Angle Difference Calculator calculates the Angle Difference between voltages V_P and V_S, compensated with the breaker close time:

Angle Difference = $|(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot \text{TCLOSD} \cdot (1\ \text{second}/60\ \text{cycles}) \cdot (360°/\text{slip cycle})]|$

Angle Difference Example (Voltages V_p and V_S Are "Slipping")

Refer to bottom of *Figure 3.25*.

For example, if the breaker close time is 10 cycles, set TCLOSD = 10. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages V_P and V_S, compensated with the breaker close time:

Angle Difference = $|(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot \text{TCLOSD} \cdot (1\ \text{second}/60\ \text{cycles}) \cdot (360°/\text{slip cycle})]|$

Intermediate calculations:

$(f_P - f_S) = (59.95\ \text{Hz} - 60.05\ \text{Hz}) = -0.10\ \text{Hz} = -0.10$ slip cycles/second

TCLOSD • (1 second/60 cycles) = 10 cycles • (1 second/60 cycles) = 0.167 second

Resulting in:

Angle Difference = $|(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot \text{TCLOSD} \cdot (1\ \text{second}/60\ \text{cycles}) \cdot (360°/\text{slip cycle})]|$

$= |(\angle V_P - \angle V_S) + [-0.10 \cdot 0.167 \cdot 360°]|$

$= |(\angle V_P - \angle V_S) - 6°|$

NOTE: The angle compensation in Figure 3.26 appears much greater than 6 degrees. Figure 3.26 is for general illustrative purposes only.

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6 degrees. This 6-degree angle compensation is applied to voltage V_S, resulting in derived voltage V_S*, as shown in *Figure 3.26*.

The top of *Figure 3.26* shows the Angle Difference *decreasing*—V_S* is approaching V_P. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0°). Then when the circuit breaker main contacts finally close, V_S is in-phase with V_P, minimizing system shock.

The bottom of *Figure 3.26* shows the Angle Difference *increasing*—V_S* is moving away from V_P. Ideally, circuit breaker closing is initiated when V_S* is in-phase with V_P (Angle Difference = 0°). Then when the circuit breaker main contacts finally close, V_S is in-phase with V_P. But in this case, V_S* has already moved past V_P. In order to initiate circuit breaker closing when V_S* is in phase with V_P (Angle Difference = 0°), V_S* has to slip around another revolution, relative to V_P.

Synchronism-Check Element Outputs

Synchronism-check element outputs (Relay Word bits 25A1 and 25A2 in *Figure 3.25*) assert to logical 1 for the conditions explained in the following text.

Voltages V_P and V_S Are "Static" or Setting TCLOSD = 0.00

Refer to top of *Figure 3.25*.

If V_P and V_S are "static" (not "slipping" with respect to one another), the Angle Difference between them remains constant—it is not possible to close the circuit breaker at an ideal zero degree phase angle difference. Thus, synchronism-check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Also, if breaker close time setting TCLOSD = 0.00, the Angle Difference Calculator does not take into account breaker close time, even if the voltages V_P and V_S are "slipping" with respect to one another. Thus, synchronism-check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Voltages V_P and V_S Are "Slipping" and Setting TCLOSD $\neq$ 0.00

Refer to bottom of *Figure 3.25*. If V_P and V_S are "slipping" with respect to one another and breaker close time setting TCLOSD $\neq$ 0.00, the Angle Difference (compensated by breaker close time TCLOSD) changes through time. Synchronism-check element 25A1 or 25A2 asserts to logical 1 for any one of the following three scenarios.

1. The top of *Figure 3.26* shows the Angle Difference *decreasing*—V_S* is approaching V_P. When V_S* is in-phase with V_P (Angle Difference = 0°), synchronism-check elements 25A1 and 25A2 assert to logical 1.
2. The bottom of *Figure 3.26* shows the Angle Difference *increasing*—V_S* is moving away from V_P. V_S* was in-phase with V_P (Angle Difference = 0°), but has now moved past V_P. If the Angle Difference is *increasing*, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism-check elements 25A1 or 25A2 assert to logical 1.

   In this scenario of the Angle Difference increasing, but still being less than maximum angle settings 25ANG1 or 25ANG2, the operation of corresponding synchronism-check elements 25A1 and 25A2 becomes *less restrictive*. Synchronism-check breaker closing does not have to wait for voltage V_S* to slip around again in-phase with V_P (Angle Difference = 0°). There might not be enough time to wait for this to happen. Thus, the "Angle Difference = 0°" restriction is eased for this scenario.
3. Refer to *Reclose Supervision Logic on page 6.4*.

   Refer to the bottom of *Figure 6.2*. If timer 79CLSD is set greater than zero (e.g., 79CLSD = 60.00 cycles) and it times out without SELOGIC control equation setting 79CLS (Reclose Supervision) asserting to logical 1, the relay goes to the Lockout State (see top of *Figure 6.3*).

   Refer to the top of *Figure 6.2*. If timer 79CLSD is set to zero (79CLSD = 0.00), SELOGIC control equation setting 79CLS (Reclose Supervision) is checked only once to see if it is asserted to logical 1. If it is not asserted to logical 1, the relay goes to the Lockout State.

   Refer to the top of *Figure 3.26*. Ideally, circuit breaker closing is initiated when V_S* is in-phase with V_P (Angle Difference =

0°). Then when the circuit breaker main contacts finally close, V_S is in-phase with V_P, minimizing system shock. But with time limitations imposed by timer 79CLSD, this may not be possible. To try to avoid going to the Lockout State, employ the following logic:

If 79CLS has not asserted to logical 1 while timer 79CLSD is timing (or timer 79CLSD is set to zero and only one check of 79CLS is made), the synchronism-check logic at the bottom of *Figure 3.25* becomes *less restrictive* at the "instant" timer 79CLSD is going to time out (or make the single check). It drops the requirement of waiting until the *decreasing* Angle Difference (V_S* approaching V_P) brings V_S* in-phase with V_P (Angle Difference = 0°). Instead, it just checks to see that the Angle Difference is less than angle settings 25ANG1 or 25ANG2.

If the Angle Difference is less than angle setting 25ANG1 or 25ANG2, then the corresponding Relay Word bit, 25A1 or 25A2, asserts to logical 1 for that "instant" (asserts for 1/4 cycle).

For example, if SELOGIC control equation setting 79CLS (Reclose Supervision) is set as follows:

79CLS = **25A1 + ...**

and the angle difference is less than angle setting 25ANG1 at that "instant," setting 79CLS asserts to logical 1 for 1/4 cycle, allowing the sealed-in open interval time out to propagate on to the close logic in *Figure 6.1*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Close Logic on page 6.1* and *Reclose Supervision Logic on page 6.4*.

For example, set 25ANG1 = 15° and use the resultant synchronism-check element in the reclosing relay logic to supervise automatic reclosing, e.g.:

79CLS = **25A1 + ...** (see *Figure 6.2*)

Set 25ANG2 = 25° and use the resultant synchronism-check element in manual close logic to supervise manual closing (for example, assert **IN106** to initiate manual close), e.g.:

CL = **IN106 * (25A2 + ...)** (see *Figure 6.1*)

In this example, the angular difference across the circuit breaker can be greater for a manual close (25 degrees) than for an automatic reclose (15 degrees).

A single output contact (e.g., OUT102 = CLOSE) can provide the close function for both automatic reclosing and manual closing (see *Figure 6.1* logic output).

Frequency Elements

Six frequency elements are available. The desired number of frequency elements are enabled with the E81 enable setting:

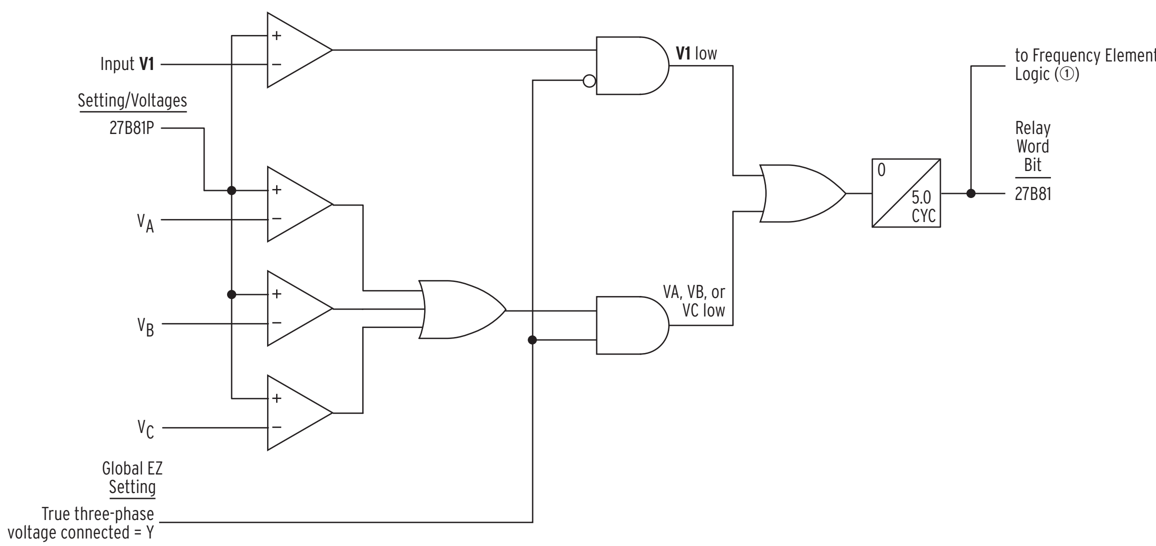
E81 = **N** (none), 1–6

as shown in *Figure 3.28*. Frequency is determined from the voltage connected to voltage input **V1**.

Frequency element 1 at the top of *Figure 3.28* is the frequency element used in the factory-default EZ settings (see *Figure 1.19* and the underfrequency load shedding setting in Table 4.3 and subsection Settings Descriptions in Section 4 in the *SEL-351R-4 Quick-Start Installation and User's Guide*).

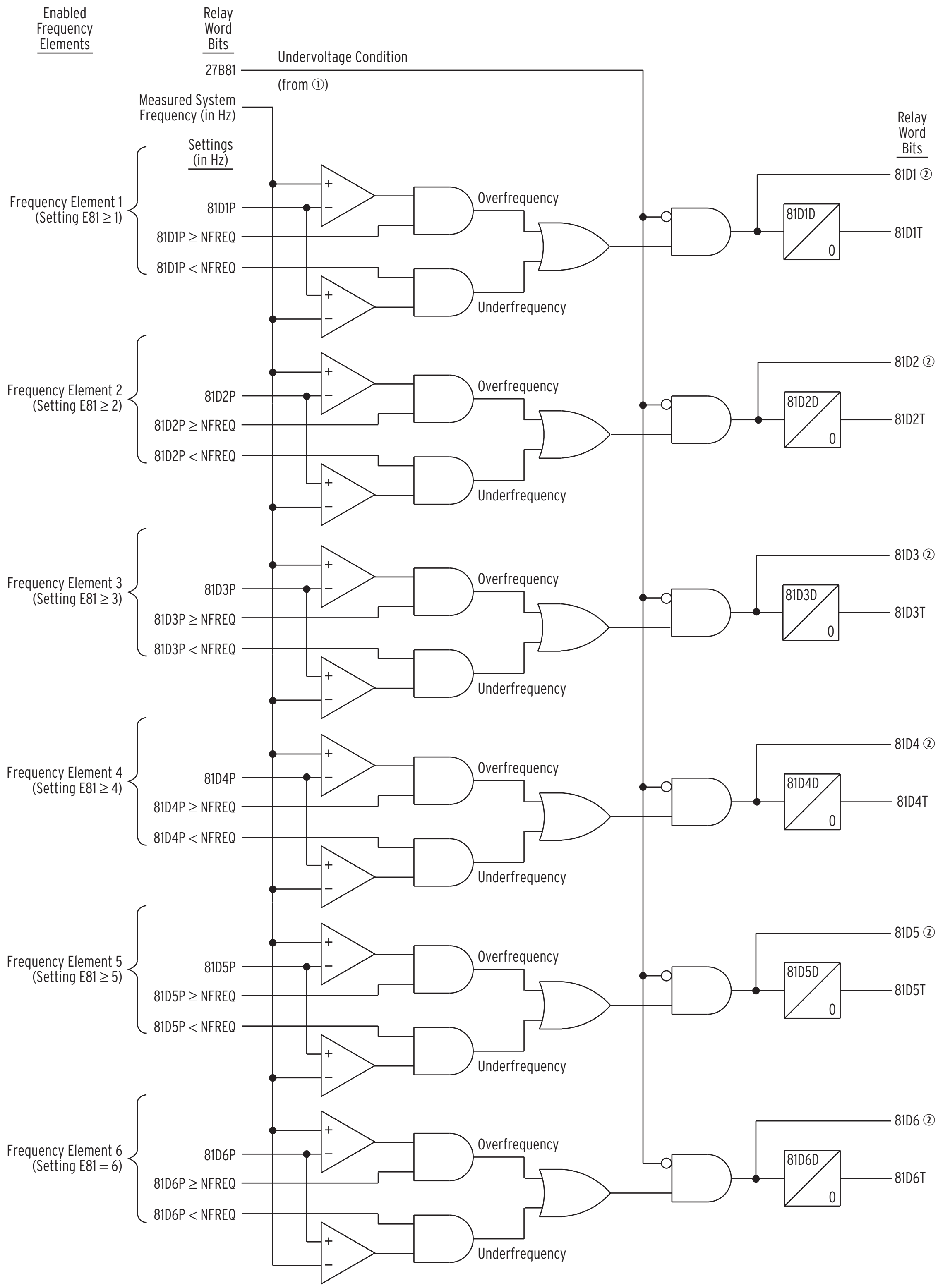
For various connections, *Figure 1.31–Figure 1.34* and associated text in *Reclose Supervision Logic on page 1.37* discuss possible changes necessary to the factory-default undervoltage block setting 27B81P (see *Figure 3.27* and *Table 3.10*).

Frequency Element Settings



① Figure 3.28.

Figure 3.27 Undervoltage Block for Frequency Elements



① From Figure 3.27; ② 81D1–81D6 are for testing purposes only.

Figure 3.28 Levels 1–6 Frequency Elements

Table 3.10 Frequency Elements Settings and Settings Ranges

Setting	Definition	Range
27B81P	Undervoltage frequency element block	20.0–300.0 V secondary
81D1P	Frequency Element 1 pickup	40.10–65.00 Hz
81D1D	Frequency Element 1 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D2P	Frequency Element 2 pickup	40.10–65.00 Hz
81D2D	Frequency Element 2 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D3P	Frequency Element 3 pickup	40.10–65.00 Hz
81D3D	Frequency Element 3 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D4P	Frequency Element 4 pickup	40.10–65.00 Hz
81D4D	Frequency Element 4 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D5P	Frequency Element 5 pickup	40.10–65.00 Hz
81D5D	Frequency Element 5 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D6P	Frequency Element 6 pickup	40.10–65.00 Hz
81D6D	Frequency Element 6 time delay	2.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ±0.01 Hz

Timer: ±0.25 cycles and ±0.1% of setting

Create Over- and Underfrequency Elements

Refer to *Figure 3.28*.

Note that pickup settings 81D1P–81D6P are compared to setting NFREQ. NFREQ is the nominal frequency setting (a Global setting), set to 50 or 60 Hz.

Overfrequency Element

For example, make settings:

NFREQ = **60 Hz** (nominal system frequency is 60 Hz)

E81 ≥ **1** (enable frequency element 1)

81D1P = **61.25 Hz** (frequency element 1 pickup)

With these settings:

81D1P ≥ **NFREQ**

the overfrequency part of frequency element 1 logic is enabled. 81D1 and 81D1T operate as overfrequency elements. 81D1 is used in *testing only*.

Underfrequency Element

For example, make settings:

NFREQ = **60 Hz** (nominal system frequency is 60 Hz)

E81 ≥ **2** (enable frequency element 2)

81D2P = **59.65 Hz** (frequency element 2 pickup)

With these settings:

81D2P < **NFREQ**

the underfrequency part of frequency element 2 logic is enabled. 81D2 and 81D2T operate as underfrequency elements. 81D2 is used in *testing only*.

Frequency Element Operation

Refer to *Figure 3.28*.

Overfrequency Element Operation

With the previous overfrequency element example settings, if system frequency is *less than or equal to* 61.25 Hz (81D1P = 61.25 Hz), frequency element 1 outputs:

81D1 = logical 0 (instantaneous element)

81D1T = logical 0 (time delayed element)

If system frequency is *greater than* 61.25 Hz (81D1P = 61.25 Hz), frequency element 1 outputs:

81D1 = logical 1 (instantaneous element)

81D1T = logical 1 (time delayed element)

Relay Word bit 81D1T asserts to logical 1 only after time delay 81D1D.

Underfrequency Element Operation

With the previous underfrequency element example settings, if system frequency is *less than or equal to* 59.65 Hz (81D2P = 59.65 Hz), frequency element 2 outputs:

81D2 = logical 1 (instantaneous element)

81D2T = logical 1 (time delayed element)

Relay Word bit 81D2T asserts to logical 1 only after time delay 81D2D.

If system frequency is *greater than* 59.65 Hz (81D2P = 59.65 Hz), frequency element 2 outputs:

81D2 = logical 0 (instantaneous element)

81D2T = logical 0 (time delayed element)

Frequency Element Voltage Control

Refer to *Figure 3.27* and *Figure 3.28*.

Note that all six frequency elements are controlled by the same undervoltage element (Relay Word bit 27B81). Relay Word bit 27B81 asserts to logical 1 and blocks the frequency element operation if any voltage (V_A, V_B, or V_C) goes below voltage pickup 27B81P. This control prevents erroneous frequency element operation following fault inception.

- Any voltage (V_A, V_B, or V_C) goes below voltage pickup 27B81P (EZ Global setting "True three-phase voltage connected" = Y)
- Voltage input **V1** goes below voltage pickup 27B81P (EZ Global setting "True three-phase voltage connected" = N)

This control prevents erroneous frequency element operation following fault inception.

Other Uses for Undervoltage Element 27B81

If voltage pickup setting 27B81P is applicable to other control schemes, Relay Word bit 27B81 can be used in other logic at the same time it is used in the frequency element logic.

If frequency elements are not being used, Relay Word bit 27B81 can still be used in other logic, with voltage setting 27B81P set as desired. Enable the frequency elements (setting E81 ≥ 1) and make setting 27B81P. Apply Relay Word bit 27B81 in desired logic scheme, using SELOGIC control equations. Even though frequency elements are enabled, the frequency element outputs (Relay Word bits 81D1T–81D6T) do not have to be used.

Frequency Element Uses

The instantaneous frequency elements (81D1–81D6) are used in *testing only.*

The time-delayed frequency elements (81D1T–81D6T) are used for underfrequency load shedding, frequency restoration, and other schemes.

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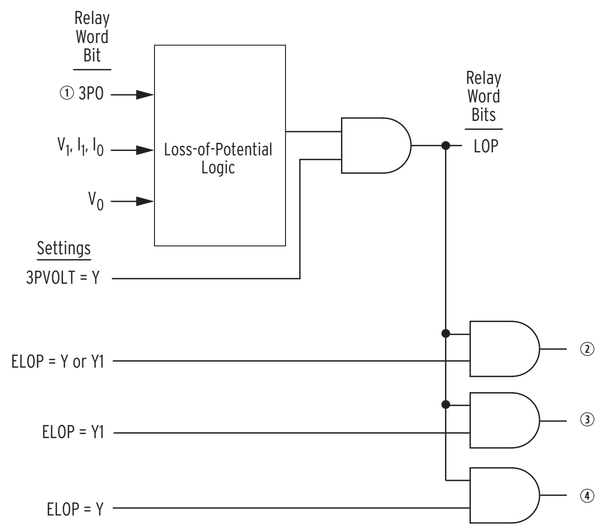
Section 4
Loss-of-Potential, Load-Encroachment, and Directional Element Logic

Loss-of-Potential Logic

The loss-of-potential (LOP) logic operates as shown in *Figure 4.1*.



① From Figure 5.3; ② to Figure 4.9, Figure 4.10, Figure 4.11, Figure 4.17, and Figure 4.18; ③ to Figure 5.6; ④ to Figure 4.12, Figure 4.13, and Figure 4.19.

Figure 4.1 Loss-of-Potential Logic

Inputs into the LOP logic are:

- 3PO three-pole open condition (indicates circuit breaker open condition see *Figure 5.3*)
- V_1 positive-sequence voltage (V secondary)
- I_1 positive-sequence current (A secondary)
- V_0 zero-sequence voltage (V secondary)
- I_0 zero-sequence current (A secondary)
- V_2 negative-sequence voltage (V secondary)

The circuit breaker has to be closed (Relay Word bit 3PO = logical 0) for the LOP logic to operate. The EZ Global setting “True three-phase voltage connected (Y/N)” = Y also has to be made in order for the LOP logic to operate (corresponding “regular” Global setting 3PVOLT = Y). Even if the LOP logic is not used (i.e., no directional overcurrent elements are used), setting 3PVOLT = Y should still be made (**SET G** command) if true three-phase voltage is connected to the SEL-351R Recloser Controller.

Loss-of-potential is declared (Relay Word bit LOP = logical 1) when a 10 percent drop in V_1 is detected, with no corresponding change in I_1 or I_0. If the LOP condition persists for 60 cycles, it latches in. LOP resets (Relay Word bit LOP = logical 0) when V_1 returns above 50 V secondary and V_0 is less than 5 V secondary.

The loss-of-potential enable setting, ELOP, does not enable or disable the LOP logic. It just routes the LOP Relay Word bit to different logic, as is shown in *Figure 4.1* and explained in the remainder of this subsection.

Setting ELOP = Y or Y1

If setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), negative-sequence voltage-polarized, zero-sequence voltage-polarized, and positive-sequence voltage-polarized directional elements are disabled (see *Figure 4.9*, *Figure 4.10*, *Figure 4.11*, *Figure 4.17*, and *Figure 4.18*). The loss-of-potential condition makes these voltage-polarized directional elements unreliable. Thus, they are disabled. The overcurrent elements controlled by these voltage-polarized directional elements are also disabled (unless overridden by conditions explained in *Setting ELOP = Y*).

In *Figure 5.6*, if setting ELOP = Y1 and LOP asserts, keying and echo keying in the permissive overreaching transfer trip (POTT) logic are blocked.

Setting ELOP = Y

Additionally, if setting ELOP = Y and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), overcurrent elements set direction forward are enabled (see *Figure 4.12*, *Figure 4.13*, and *Figure 4.19*). These direction-forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

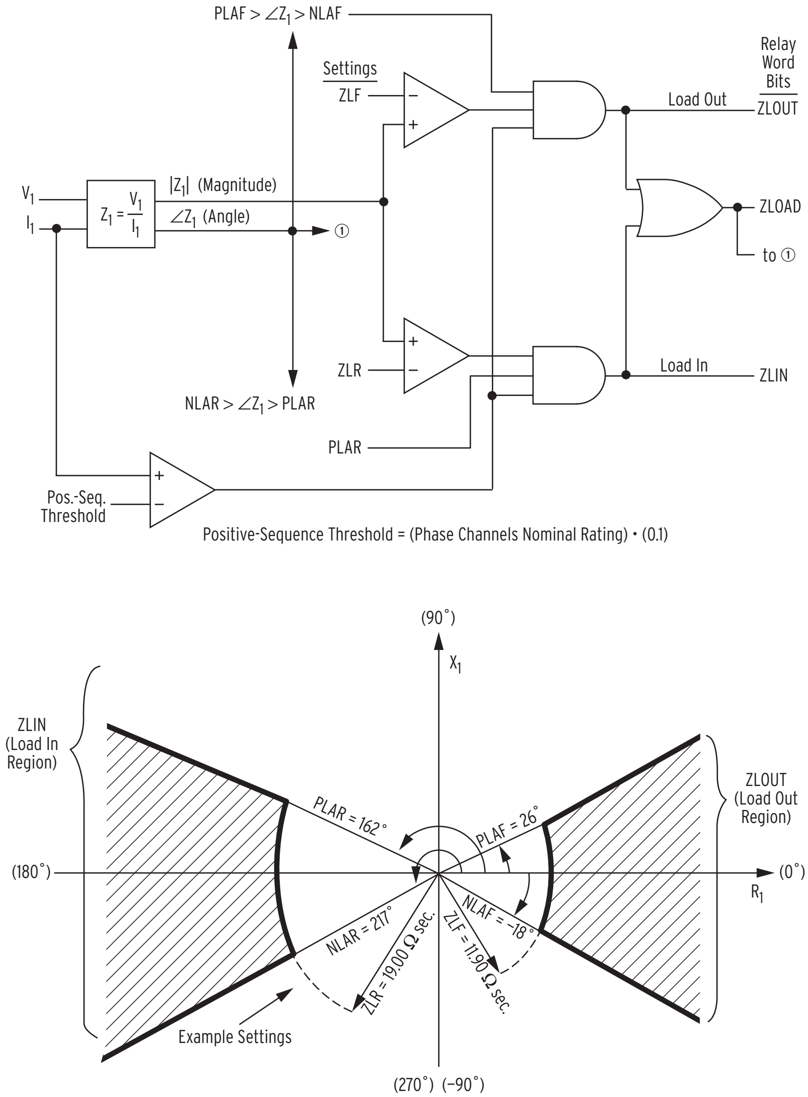
As detailed previously, voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are also disabled. But this disable condition is overridden for the overcurrent elements set direction forward if setting ELOP = Y.

Setting ELOP = N

If setting ELOP = N, the loss-of-potential logic still operates (Relay Word bit LOP asserts to logical 1 for a loss-of-potential condition) but does not disable any voltage-based directional elements (as occurs with ELOP = Y or Y1) or enable overcurrent elements set direction forward (as occurs with ELOP = Y).

Load-Encroachment Logic

The load-encroachment logic (see *Figure 4.2*) and settings are enabled/disabled with setting ELOAD (= Y or N).The load-encroachment feature allows phase overcurrent elements to be set independent of load levels. This is especially helpful in bus overcurrent applications. A bus relay sees the cumulative currents of all the feeders, but still has to provide overcurrent backup protection for all these feeders. If the phase elements in the bus relay are set to provide adequate backup, they often are set close to maximum bus load current levels. This runs the risk of tripping on bus load current. The load-encroachment feature prevents this from happening, as shown in the example that follows in this subsection.



① Figure 4.18.

Figure 4.2 Load-Encroachment Logic

Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.2*. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic only operates if the positive-sequence current (I_1) is greater than the Positive-Sequence Threshold defined in *Figure 4.2*. For a balanced load condition, I_1 = phase current magnitude.

Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

Reverse load (load flowing in) lies within the hatched region labeled ZLIN. Relay Word bit ZLIN asserts to logical 1 when the load lies within this hatched region.

Relay Word bit ZLOAD is the OR-combination of ZLOUT and ZLIN:

ZLOAD = ZLOUT + ZLIN

Settings Ranges

Refer to *Figure 4.2*.

Setting	Description and Range
ZLF	Forward minimum load impedance—corresponding to maximum load flowing out
ZLR	Reverse minimum load impedance—corresponding to maximum load flowing in
	0.5 to 640.00 Ω secondary (1 A nominal phase currents, IA, IB, IC)
PLAF	Maximum positive load angle forward (–90° to +90°)
NLAF	Maximum negative load angle forward (–90° to +90°)
PLAR	Maximum positive load angle reverse (+90° to +270°)
NLAR	Maximum negative load angle reverse (+90° to +270°)

Load-Encroachment Setting Example

Example system conditions:

Condition	Value
Nominal line-to-line voltage	230 kV
Maximum forward load	800 MVA
Maximum reverse load	500 MVA
Power factor (forward load)	0.90 lag to 0.95 lead
Power factor (reverse load)	0.80 lag to 0.95 lead
CT ratio	2000/5 = 400
PT ratio	134000/67 = 2000

The PTs are connected line-to-neutral.

Convert Maximum Loads to Equivalent Secondary Impedances

Start with maximum forward load:

$$800\text{ MVA} \bullet \left(\frac{1}{3}\right) = 267\text{ MVA per phase}$$

$$230\text{ kV} \bullet \frac{1}{\sqrt{3}} = 132.8\text{ kv line-to-neutral}$$

$$267\text{ MVA} \bullet \left(\frac{1}{132.8\text{ kV}}\right) \bullet \left(\frac{1000\text{ kV}}{\text{MV}}\right) = 2010\text{ A primary}$$

$$2010\text{ A primary} \bullet \left(\frac{1}{\text{CT Ratio}}\right) = 2010\text{ A primary} \bullet \left(\frac{1\text{ A secondary}}{400\text{ A primary}}\right)$$
$$= 5.03\text{ A secondary}$$

$$132.8\text{ kV} \bullet \left(\frac{1000\text{ V}}{\text{kV}}\right) = 132800\text{ V primary}$$

$$132800\text{ V primary} \bullet \left(\frac{1}{\text{PT Ratio}}\right) = 132800\text{ V primary} \bullet \left(\frac{1\text{ V secondary}}{2000\text{ V primary}}\right)$$
$$= 66.4\text{ V secondary}$$

Now, calculate the equivalent secondary impedance:

$$\frac{66.4\text{ V secondary}}{5.03\text{ A secondary}} = 13.2\ \Omega\text{ secondary}$$

This Ω secondary value can be calculated more expediently with the following equation:

$$\frac{[(\text{line-to-line voltage in kV}^2) \bullet (\text{CT ratio})]}{[(\text{3-phase load in MVA}) \bullet (\text{PT ratio})]}$$

Again, for the maximum forward load:

$$\frac{[(230)^2 \bullet (400)]}{[(800) \bullet (2000)]} = 13.2\ \Omega\text{ secondary}$$

To provide a margin for setting ZLF, multiply by a factor of 0.9:

$$\text{ZLF} = 13.2\ \Omega\text{ secondary} \bullet 0.9 = 11.90\ \Omega\text{ secondary}$$

For the maximum reverse load:

$$\frac{[(230)^2 \bullet (400)]}{[(500) \bullet (2000)]} = 21.1\ \Omega\text{ secondary}$$

Again, to provide a margin for setting ZLR:

$$\text{ZLR} = 21.1\Omega\text{ secondary} \bullet 0.9 = 19.00\ \Omega\text{ secondary}$$

Convert Power Factors to Equivalent Load Angles

The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

Setting PLAF = $\cos^{-1}$ (0.90) = 26°

Setting NLAF = $\cos^{-1}$ (0.95) = –18°

The power factor (reverse load) can vary from 0.80 lag to 0.95 lead.

Setting PLAR = 180° – $\cos^{-1}$ (0.95) = 180° – 18° = 162°

Setting NLAR = 180° + $\cos^{-1}$ (0.80) = 180° + 37° = 217°

Apply Load-Encroachment Logic to a Phase Time-Overcurrent

Again, from *Figure 4.2*:

ZLOAD = ZLOUT + ZLIN

Refer to *Figure 4.3*. In a load condition, the apparent positive-sequence impedance is *within* the ZLOUT area, resulting in:

ZLOAD = ZLOUT + ZLIN = logical 1 + ZLIN = logical 1

If a fault occurs, the apparent positive-sequence impedance moves *outside* the ZLOUT area (and stays outside the ZLIN area, too), resulting in:

ZLOAD = ZLOUT + ZLIN = logical 0 + logical 0 = logical 0

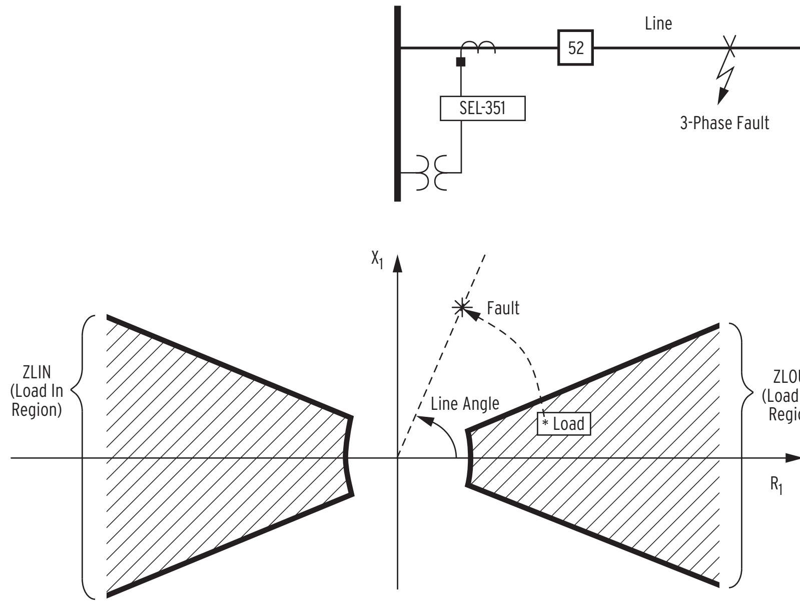


Figure 4.3 Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to *Figure 3.14*. To prevent phase time-overcurrent element 51P1T from operating for high-load conditions, make the following SELOGIC® control equation torque control setting:

51P1TC = **!ZLOAD * !LOP + 50P6** (= NOT[ZLOAD] * NOT[LOP] + 50P6)

As shown in *Figure 4.2*, load-encroachment logic is a positive-sequence calculation. During LOP conditions (loss-of-potential; see *Figure 4.1*), positive-sequence voltage (V_1) can be substantially depressed in magnitude or changed in angle. This change in V_1 can possibly cause ZLOAD to deassert (= logical 0), erroneously indicating that a “fault condition” exists. Thus, !ZLOAD should be supervised by !LOP in a torque control setting. This also effectively happens in the directional element in *Figure 4.18*, where ZLOAD and LOP are part of the logic.

In the above setting example, phase instantaneous overcurrent element 50P6 is set above any maximum load current level—if 50P6 picks up, there is assuredly a fault. For faults below the pickup level of 50P6, but above the pickup of phase time-overcurrent element 51PT, the !ZLOAD * !LOP logic discriminates between high load and fault current. If an LOP condition occurs (LOP = logical 1), the pickup level of 50P6 becomes the effective pickup of phase time-overcurrent element 51P1T (51P1T loses its sensitivity when an LOP condition occurs):

51P1TC = **!ZLOAD * !LOP + 50P6** = !ZLOAD * NOT[LOP] + 50P6
= !ZLOAD * NOT[logical 1] + 50P6 = 50P6

Use SEL-321 Relay Application Guide for the SEL-351R Recloser Control

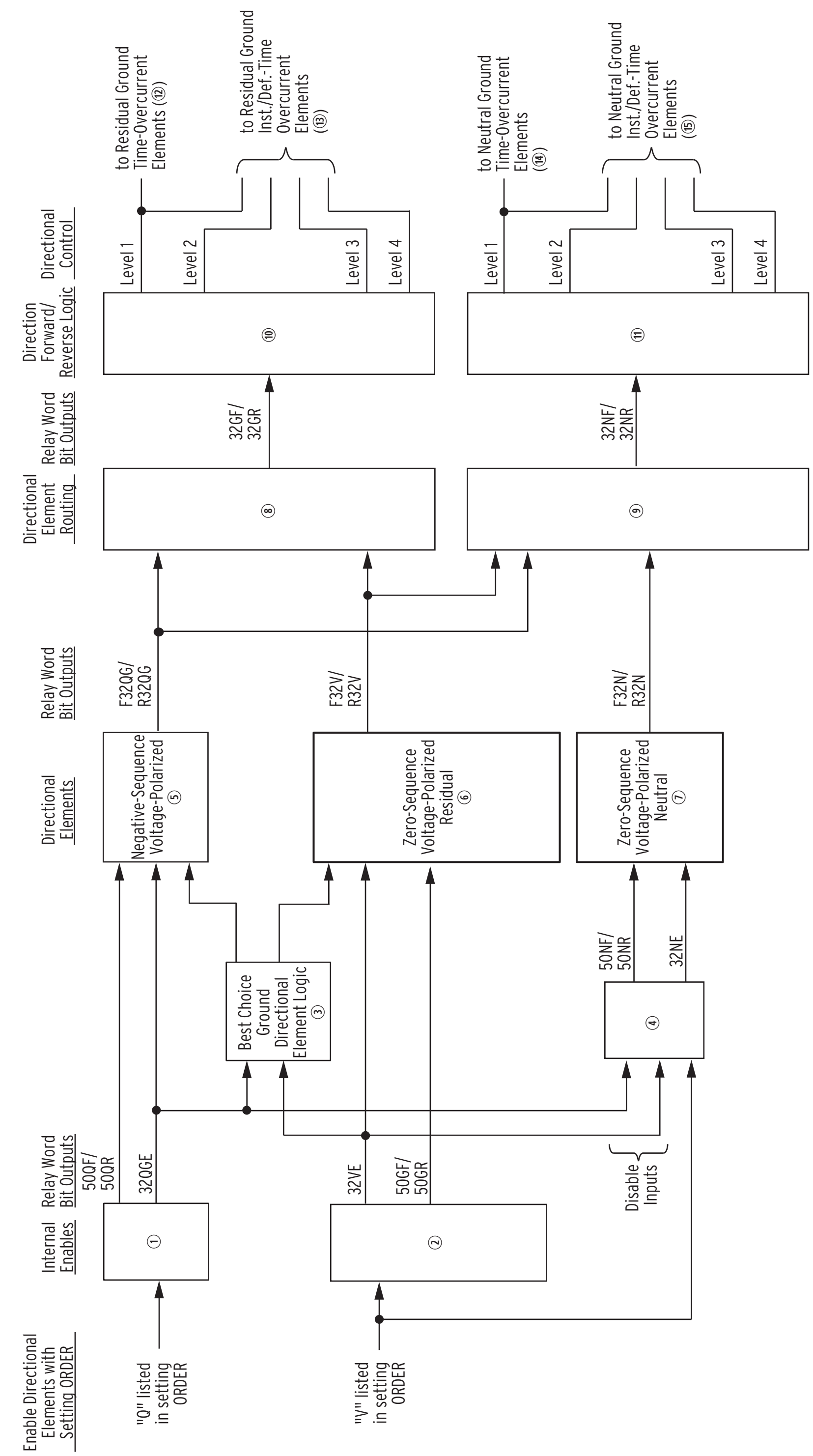
The load-encroachment logic and settings in the SEL-351R Recloser Control are the same as those in the SEL-321 Relay. Refer to Application Guide AG93-10 (SEL-*321 Relay Load-Encroachment Function Setting Guidelines*) for applying the load-encroachment logic in the SEL-351R. Note that Application Guide AG93-10 discusses applying the load-encroachment feature to phase distance elements in the SEL-321 Relay. Although the SEL-351R does not have phase distance elements, the principles and settings example in this guide are still applicable.

Directional Control for Neutral Ground and Residual Ground Overcurrent Elements

The directional control for overcurrent elements is enabled by making directional control enable setting E32. Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.25*.

Three directional elements are available to control the neutral ground and two directional elements are available to control residual ground overcurrent elements. These directional elements are:

- ➤ Negative-sequence voltage-polarized directional element (residual and neutral)
- ➤ Zero-sequence voltage-polarized, residual-current directional element (residual and neutral)
- ➤ Zero-sequence voltage-polarized, neutral-current directional element (neutral only)



① Figure 4.5; ② Figure 4.6; ③ Figure 4.8; ④ Figure 4.7; ⑤ Figure 4.9; ⑥ Figure 4.10; ⑦ Figure 4.11; ⑧ Figure 4.12; ⑨ Figure 4.13; ⑩ Figure 4.14; ⑪ Figure 4.15; ⑫ Figure 3.18 and Figure 3.19; ⑬ Figure 3.10; ⑭ Figure 3.16 and Figure 3.17; ⑮ Figure 3.8.

Figure 4.4 General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements

Figure 4.4 gives an overview of how these directional elements are enabled and routed to control the neutral ground and residual ground overcurrent elements.

Note in *Figure 4.4* that setting ORDER enables the directional elements. Setting ORDER can be set with any combination of Q and V. They have the following correspondence to the directional elements:

Q	Negative-sequence voltage-polarized directional element
V	Zero-sequence voltage-polarized, residual-current directional element and zero-sequence voltage-polarized, neutral-current directional element

The *order* in which these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional Element® logic control. See discussion on setting ORDER in *Directional Control Settings on page 4.25*.

Internal Enables

Refer to *Figure 4.4–Figure 4.7*.

The internal enables 32QGE and 32VE have the following correspondence to the directional elements:

32QGE	Negative-sequence voltage-polarized directional element
32VE	Zero-sequence voltage-polarized, residual-current directional element and zero-sequence voltage-polarized, neutral-current directional element

Note that *Figure 4.5* has extra internal enable 32QE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.17*).

The settings involved with internal enables 32QGE and 32VE in *Figure 4.5* and *Figure 4.6* (e.g., settings a2, k2, a0) are explained in *Directional Control Settings*.

The zero-sequence voltage-polarized, neutral-current directional element is a sensitive-earth-fault (SEF) directional element. If V is in the setting ORDER, and no other internal enable is asserted, 32NE may be asserted as shown in *Figure 4.7*. Neutral current will then be used in determining fault direction.

Best Choice Ground Directional Element Logic

Refer to *Figure 4.4* and *Figure 4.8*.

The internal enables 32QGE and 32VE and setting ORDER are used in the Best Choice Ground Directional Element logic in *Figure 4.8*. The Best Choice Ground Directional logic determines which directional element should be enabled to operate. The neutral ground and residual ground overcurrent elements set for directional control are then controlled by this enabled directional element. If V is in the setting ORDER, and no other internal enable is asserted, 32NE may be asserted as shown in *Figure 4.7*. Neutral current will then be used in determining fault direction.

Directional Elements

Refer to *Figure 4.4* and *Figure 4.9–Figure 4.11*.

The enable output of Best Choice Ground Directional Element logic in *Figure 4.8,* and the internal enables in *Figure 4.5–Figure 4.7* determine which directional element will run.

Additionally, note that if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized and zero-sequence voltage-polarized directional elements are disabled (see *Figure 4.9–Figure 4.11*).

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

Directional Element Routing

Refer to *Figure 4.4*, *Figure 4.12*, and *Figure 4.13*.

The negative-sequence and zero-sequence polarized, residual-current directional element outputs are routed to the forward (Relay Word bit 32GF) and reverse (Relay Word bit 32GR) logic points and then on to the direction forward/reverse logic in *Figure 4.14*.

Neutral overcurrent directional logic, shown in *Figure 4.13*, uses the quantities listed above along with zero-sequence polarized, neutral-current directional element outputs from *Figure 4.11*.

Loss-of-Potential

Note that if *both* the following are true:

➤ Enable setting ELOP = Y

➤ A loss-of-potential condition occurs (Relay Word bit LOP asserts)

then the forward logic point (Relay Word bit 32GF) asserts to logical 1, thus enabling the neutral ground and residual ground overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F, etc.). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously (in *Figure 4.9*–*Figure 4.11*), voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are disabled also. But this disable condition is overridden for the overcurrent elements set direction forward if setting ELOP = Y.

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

Direction Forward/ Reverse Logic

Refer to *Figure 4.4*, *Figure 4.14*, and *Figure 4.15*.

The forward (Relay Word bits 32GF and 32NF) and reverse (Relay Word bits 32GR and 32NR) logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1–DIR4.

Table 4.2 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.2* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

In most communications-assisted trip schemes, the levels are set as follows (see *Figure 5.4*):

Level 1 overcurrent elements set direction forward (DIR1 = F)

Level 2 overcurrent elements set direction forward (DIR2 = F)

Level 3 overcurrent elements set direction reverse (DIR3 = R)

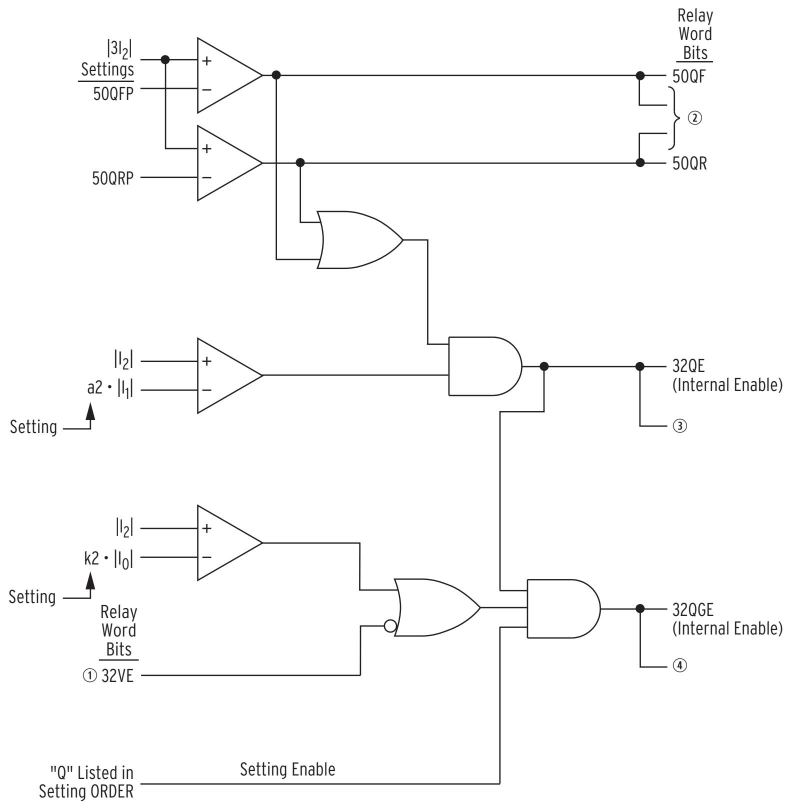
If a level direction setting (e.g., DIR1) is set:

DIR1 = **N** (nondirectional)

then the corresponding Level 1 directional control output in *Figure 4.14* asserts to logical 1. The Level 1 overcurrent elements referenced in *Figure 4.14* and *Figure 4.15* are then not controlled by the directional control logic.

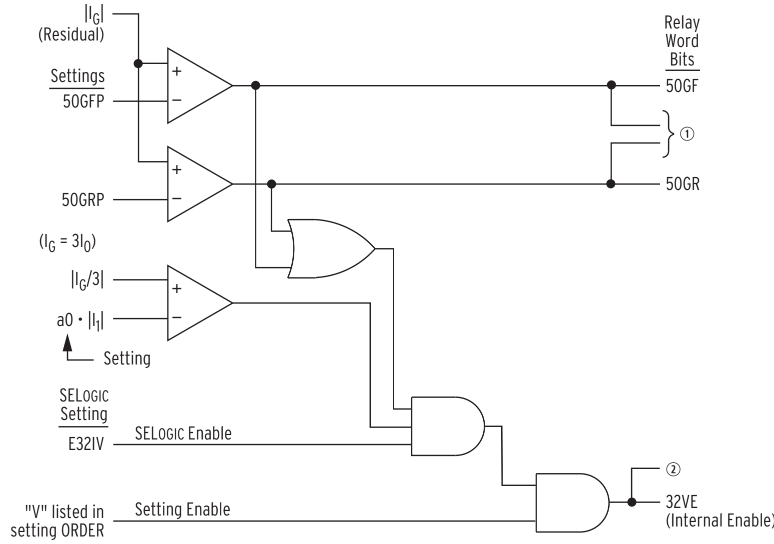
See the beginning of *Directional Control Settings on page 4.25* for discussion of the operation of level direction settings DIR1–DIR4 when the directional control enable setting E32 is set to E32 = N.

In some applications, level direction settings DIR1–DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque-Control Settings on page 4.33* describes how to avoid this limitation for special cases.



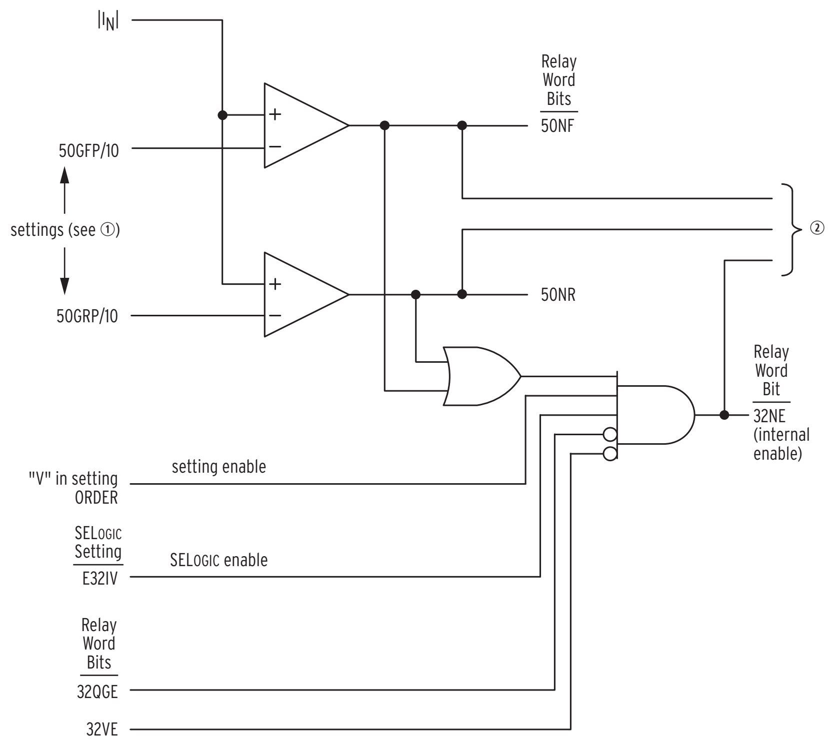
① From Figure 4.6; ② to Figure 4.9 and Figure 4.17; ③ to Figure 4.17 and Figure 4.18; ④ to Figure 4.7, Figure 4.8 and Figure 4.9.

Figure 4.5 Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



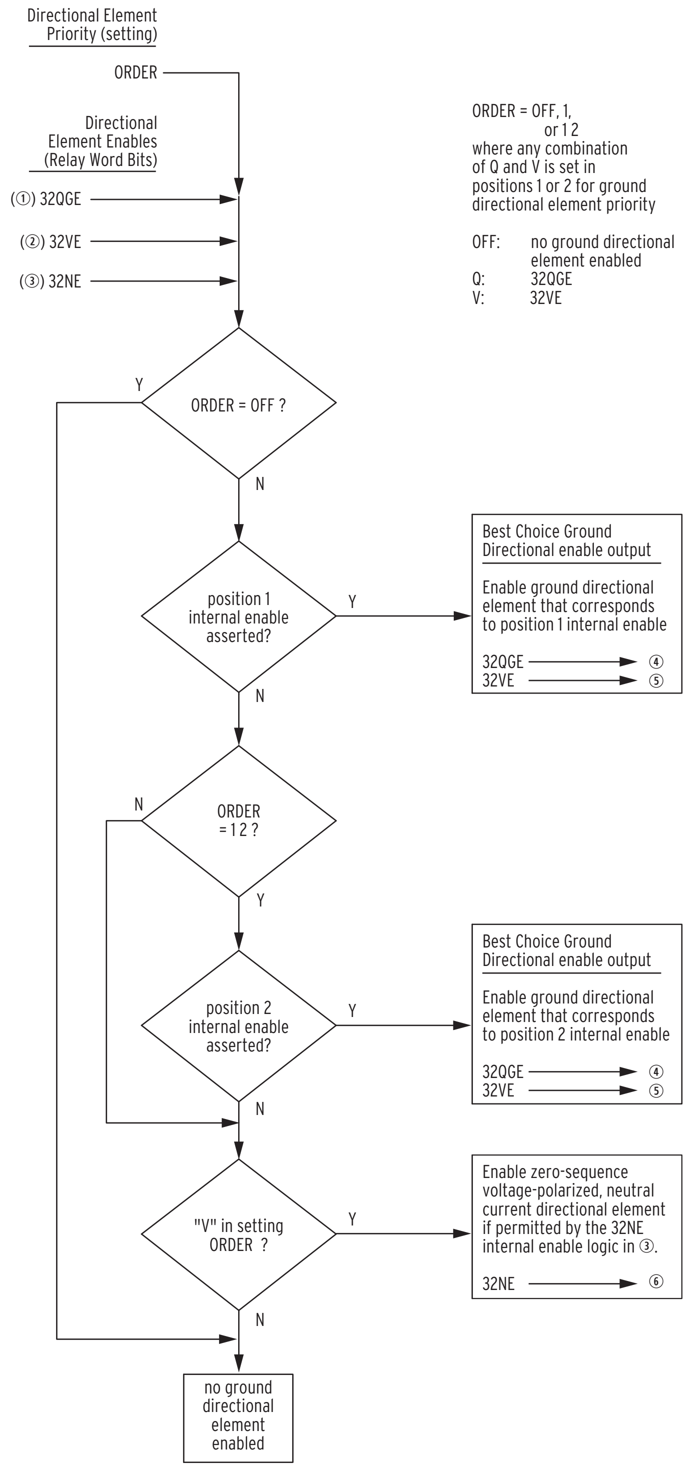
① To Figure 4.10; ② to Figure 4.5, Figure 4.7, Figure 4.8, and Figure 4.10.

Figure 4.6 Internal Enable (32VE) Logic for Zero-Sequence Voltage-Polarized, Residual-Current Directional Element



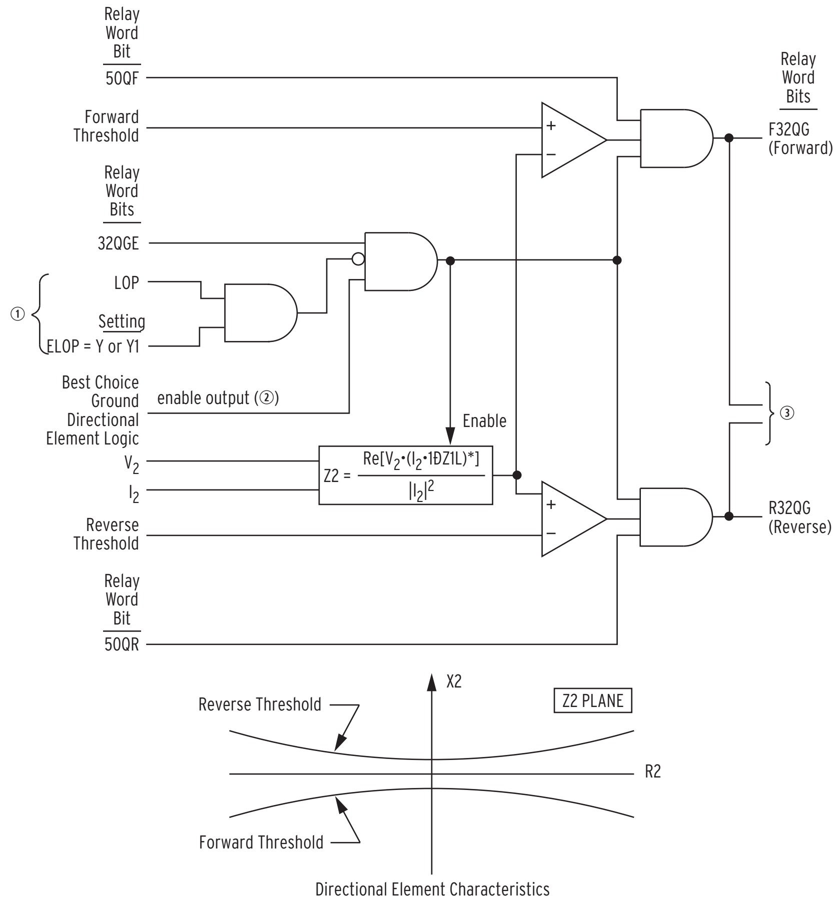
① Figure 4.6; ② to Figure 4.11.

Figure 4.7 Internal Enable (32NE) for Zero-Sequence Voltage-Polarized, Neutral-Current Directional Element



① From Figure 4.5; ② from Figure 4.6; ③ from Figure 4.7; ④ Figure 4.9; ⑤ Figure 4.10; ⑥ Figure 4.11.

Figure 4.8 Best Choice Ground Directional Element Logic



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Reverse Threshold:

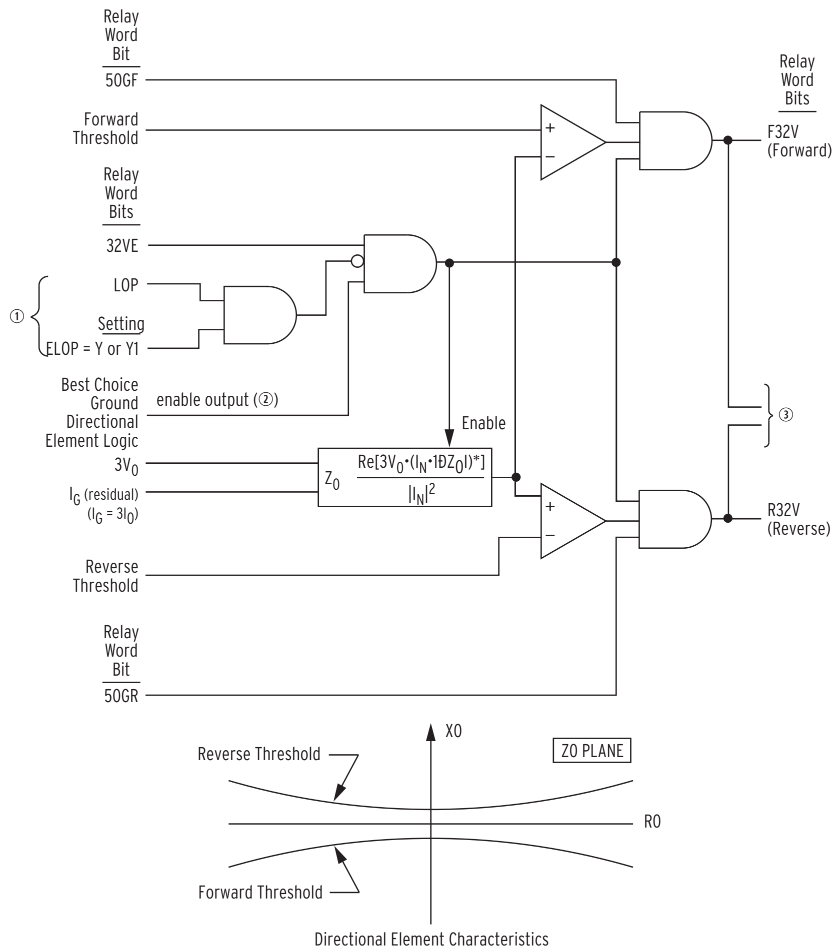
If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Note: 1ÐZ1L = One Ohm at the Positive-Sequence Line Angle

① From Figure 4.1; ② from Figure 4.8; ③ to Figure 4.12 and Figure 4.13.

Figure 4.9 Negative-Sequence Voltage-Polarized Directional Element for Neutral and Residual Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold = $1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Reverse Threshold:

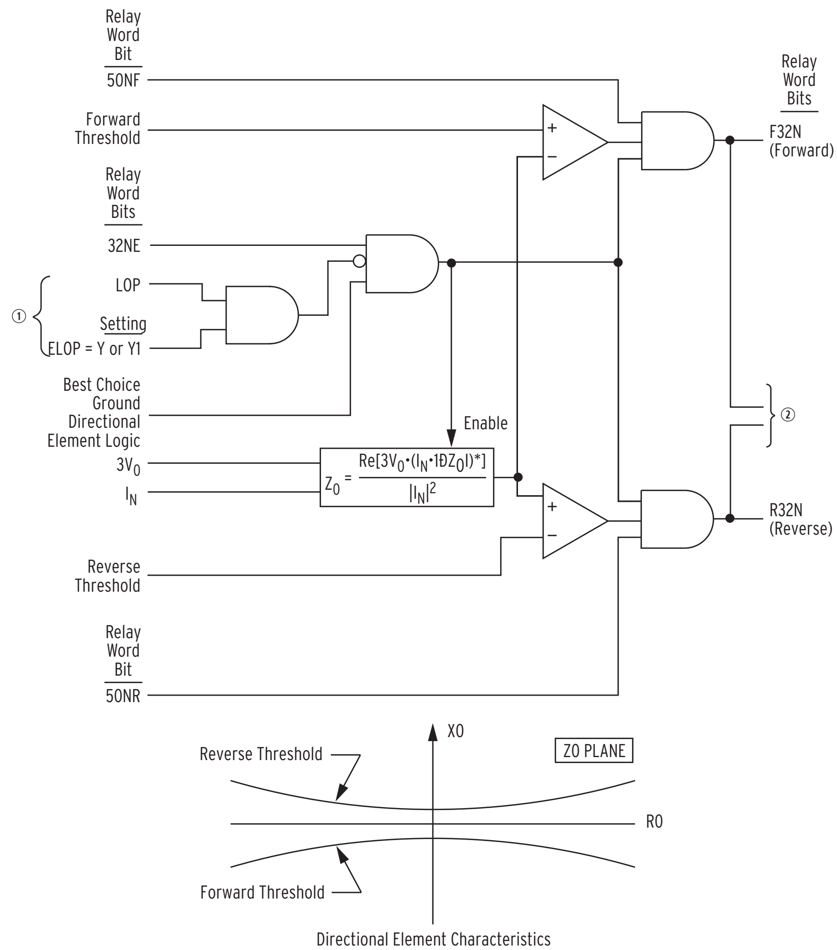
If Z0R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0R Setting < 0, Reverse Threshold = $1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Note: 1ÐZ0L = One Ohm at the Zero-Sequence Line Angle

① From Figure 4.1; ② from Figure 4.8; ③ to Figure 4.12 and Figure 4.13.

Figure 4.10 Zero-Sequence Voltage-Polarized, Residual-Current Directional Element for Neutral and Residual Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold = $1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Reverse Threshold:

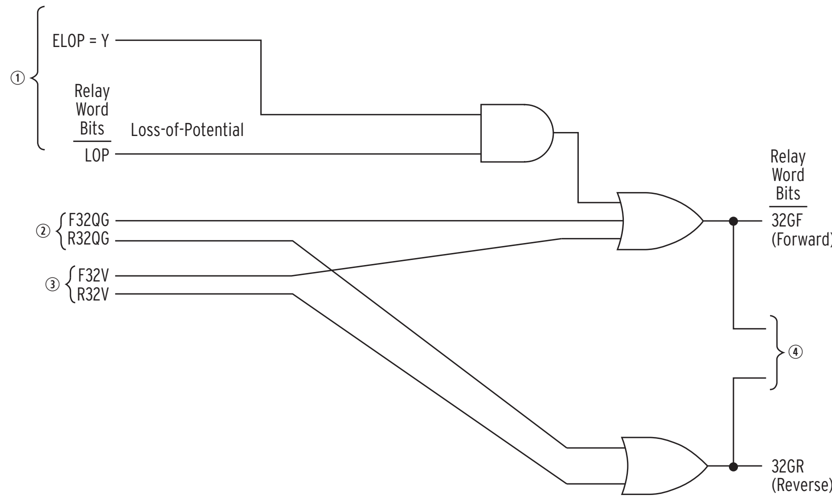
If Z0R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0R Setting < 0, Reverse Threshold = $1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Note: 1ÐZ0L = One Ohm at the Zero-Sequence Line Angle

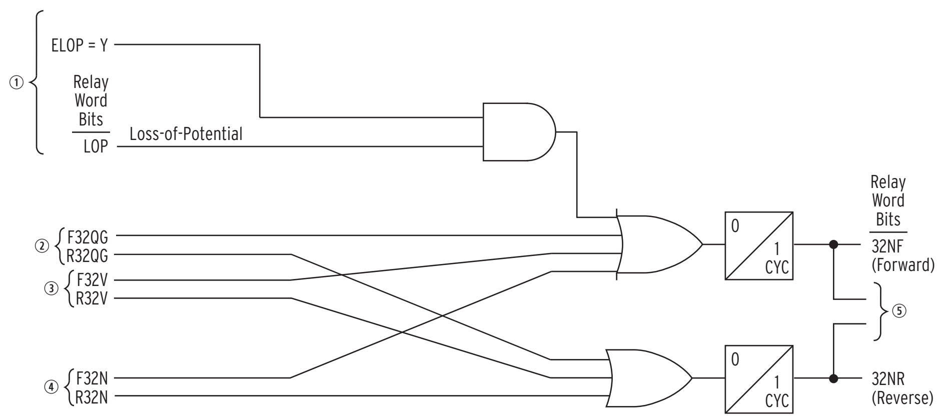
① From Figure 4.1; ② to Figure 4.13.

Figure 4.11 Zero-Sequence Voltage-Polarized, Neutral-Current Directional Elements for Neutral Ground Overcurrent Elements



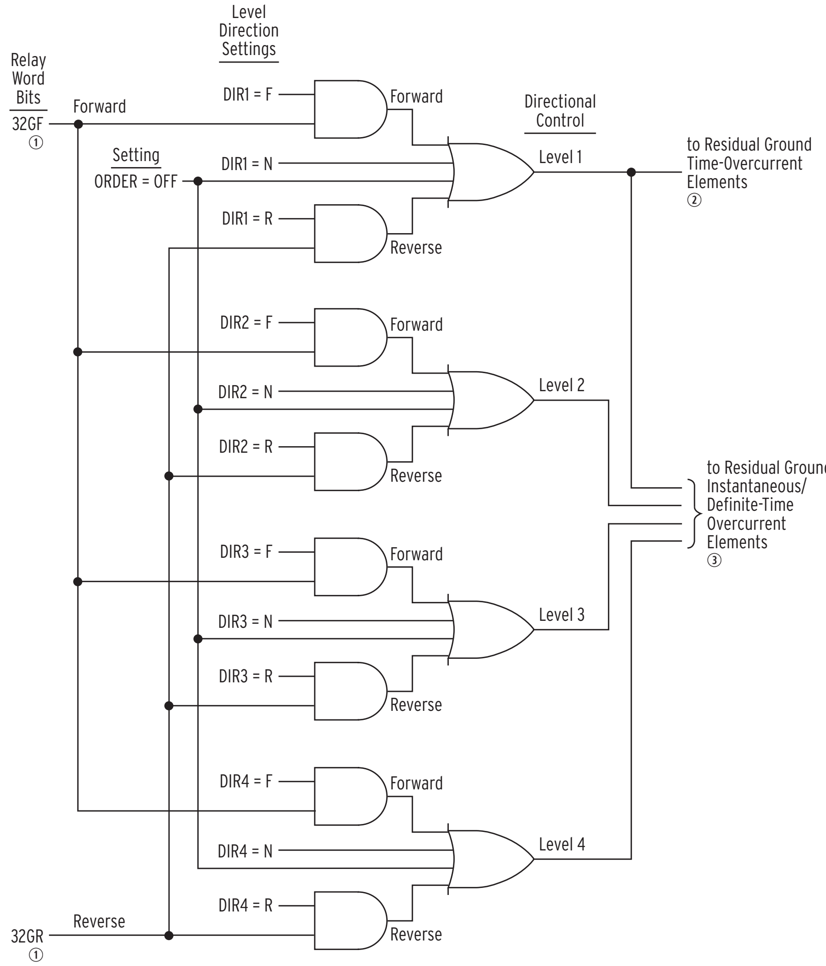
① From Figure 4.1; ② from Figure 4.9; ③ from Figure 4.10; ④ to Figure 4.14.

Figure 4.12 Routing of Directional Elements to Residual Ground Overcurrent Elements



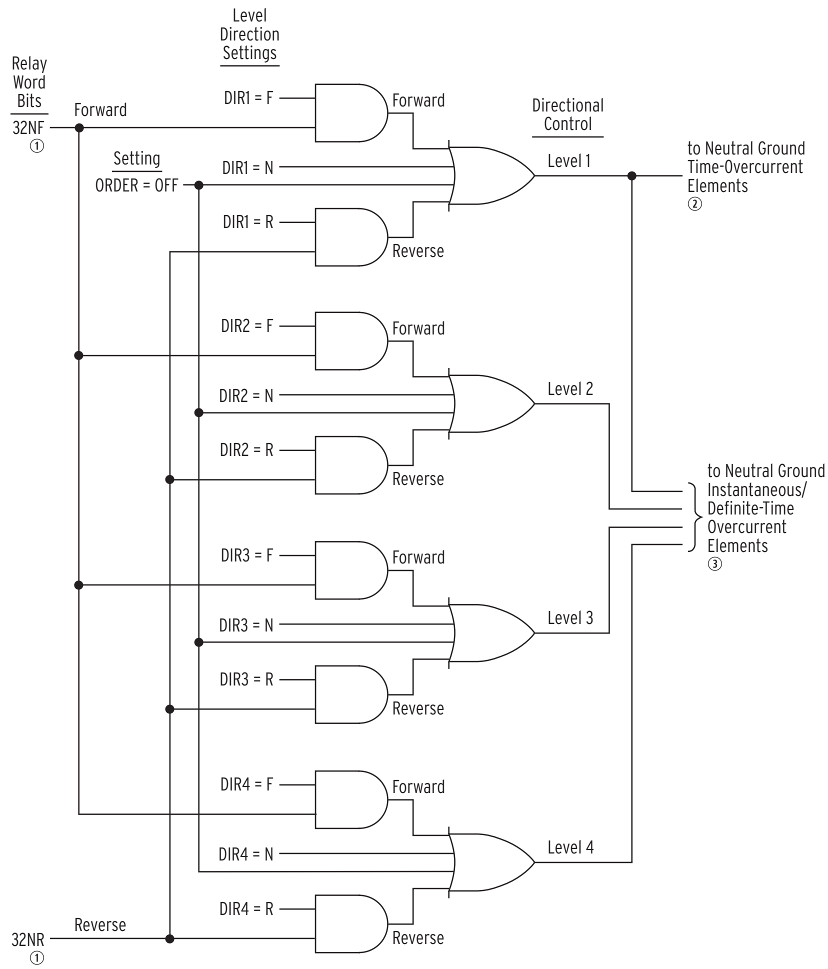
① From Figure 4.1; ② from Figure 4.9; ③ from Figure 4.10; ④ from Figure 4.11; ⑤ to Figure 4.15.

Figure 4.13 Routing of Directional Elements to Neutral Ground Overcurrent Elements



① From Figure 4.12; ② Figure 3.18 and Figure 3.19; ③ Figure 3.10.

Figure 4.14 Direction Forward/Reverse Logic for Residual Ground Overcurrent Elements



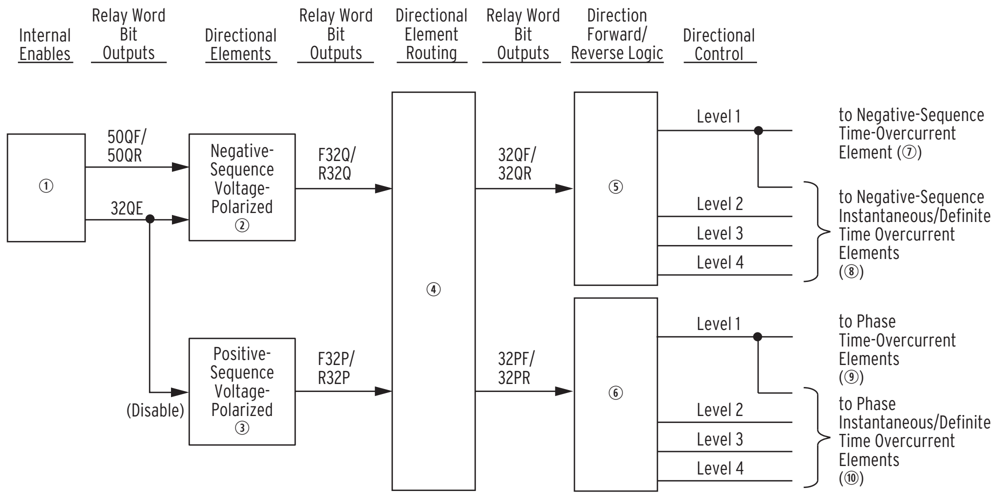
① From Figure 4.13; ② Figure 3.16 and Figure 3.17; ③ Figure 3.8.

Figure 4.15 Direction Forward/Reverse Logic for Neutral Ground Overcurrent Elements

Directional Control for Negative-Sequence and Phase Overcurrent Elements

The directional control for overcurrent elements is enabled by making directional control enable setting E32. Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.25*.

The negative-sequence voltage-polarized directional element controls the negative-sequence overcurrent elements. Negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements control the phase overcurrent elements. *Figure 4.17* gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed to control the negative-sequence and phase overcurrent elements.



① Figure 4.5; ② Figure 4.17; ③ Figure 4.18; ④ Figure 4.19; ⑤ Figure 4.20; ⑥ Figure 4.21; ⑦ Figure 3.20; ⑧ Figure 3.12; ⑨ Figure 3.14; ⑩ Figure 3.3.

Figure 4.16 General Logic Flow of Directional Control for Negative-Sequence and Phase Overcurrent Elements

The negative-sequence voltage-polarized directional element has priority over the positive-sequence voltage-polarized directional elements in controlling the phase overcurrent elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults, while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Internal Enables

Refer to *Figure 4.5* and *Figure 4.16*.

The internal enable 32QE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.5* has extra internal enable 32QGE, which is used in the directional element logic that controls the neutral ground and residual ground overcurrent elements (see *Figure 4.4*).

The settings involved with internal enable 32QE in *Figure 4.5* (e.g., settings a2, k2) are explained in *Directional Control Settings on page 4.25*.

Directional Elements

Refer to *Figure 4.16–Figure 4.18*.

If enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are disabled (see *Figure 4.17* and *Figure 4.18*).

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

Note in *Figure 4.16* and *Figure 4.18*, that the assertion of internal enable 32QE (for the negative-sequence voltage-polarized directional element) disables the positive-sequence voltage-polarized directional element. The negative-sequence voltage-polarized directional element has priority over the positive-sequence voltage-polarized directional elements in controlling the phase overcurrent elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Note also in *Figure 4.18* that the assertion of ZLOAD disables the positive-sequence voltage-polarized directional element. ZLOAD asserts when the relay is operating in a user-defined load region (see *Figure 4.2*).

Directional Element Routing

Refer to *Figure 4.16* and *Figure 4.19*.

The directional element outputs are routed to the forward (Relay Word bits 32QF and 32PF) and reverse (Relay Word bits 32QR and 32PR) logic points and then on to the direction forward/reverse logic in *Figure 4.20* and *Figure 4.21*.

Loss-of-Potential

Note if *both* the following are true:

- Enable setting ELOP = Y,
- A loss-of-potential condition occurs (Relay Word bit LOP asserts),

then the forward logic points (Relay Word bits 32QF and 32PF) assert to logical 1, thus, enabling the negative-sequence and phase overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F, etc.). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously (in *Figure 4.17* and *Figure 4.18*), voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are also disabled. But this disable condition is overridden for the overcurrent elements set direction forward if setting ELOP = Y.

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

Direction Forward/ Reverse Logic

Refer to *Figure 4.16*, *Figure 4.20*, and *Figure 4.21*.

The forward (Relay Word bits 32QF and 32PF) and reverse (Relay Word bits 32QR and 32PR) logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1–DIR4.

Table 4.2 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.2* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

In most communications-assisted trip schemes, the levels are set as follows (see *Figure 5.4*):

Level 1 overcurrent elements set direction forward (DIR1 = F)

Level 2 overcurrent elements set direction forward (DIR2 = F)

Level 3 overcurrent elements set direction reverse (DIR3 = R)

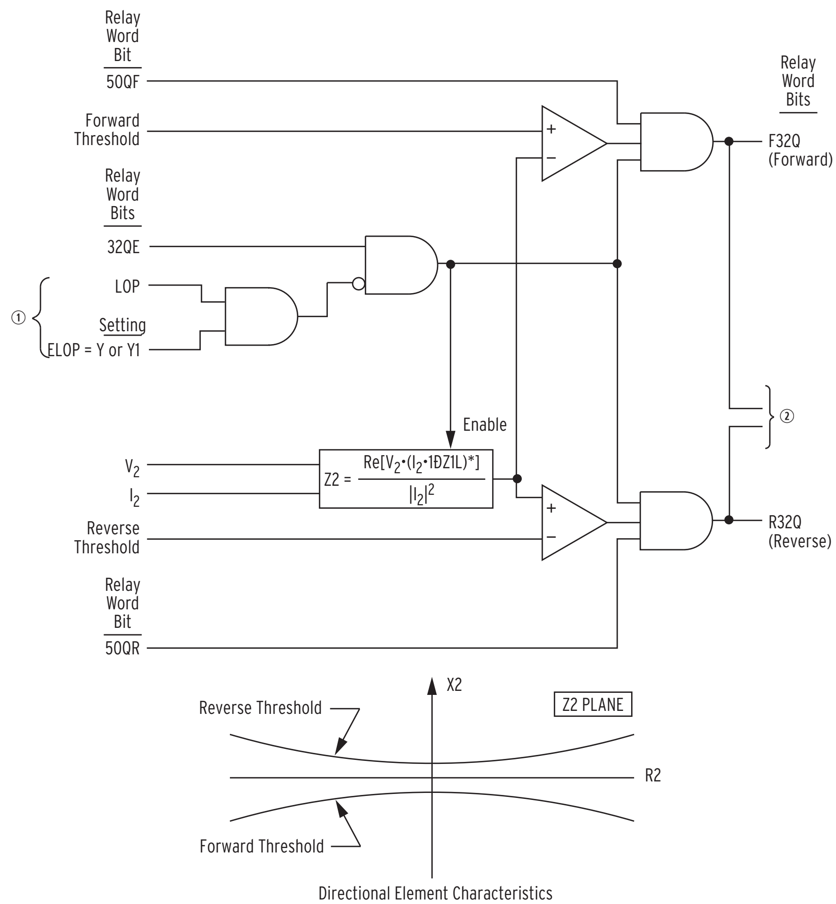
If a level direction setting (e.g., DIR1) is set:

DIR1 = **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.20* and *Figure 4.21* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.20* and *Figure 4.21* are then not controlled by the directional control logic.

See the beginning of *Directional Control Settings on page 4.25* for discussion of the operation of level direction settings DIR1–DIR4 when the directional control enable setting E32 is set to E32 = N.

In some applications, level direction settings DIR1–DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque-Control Settings on page 4.33* describes how to avoid this limitation for special cases.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Reverse Threshold:

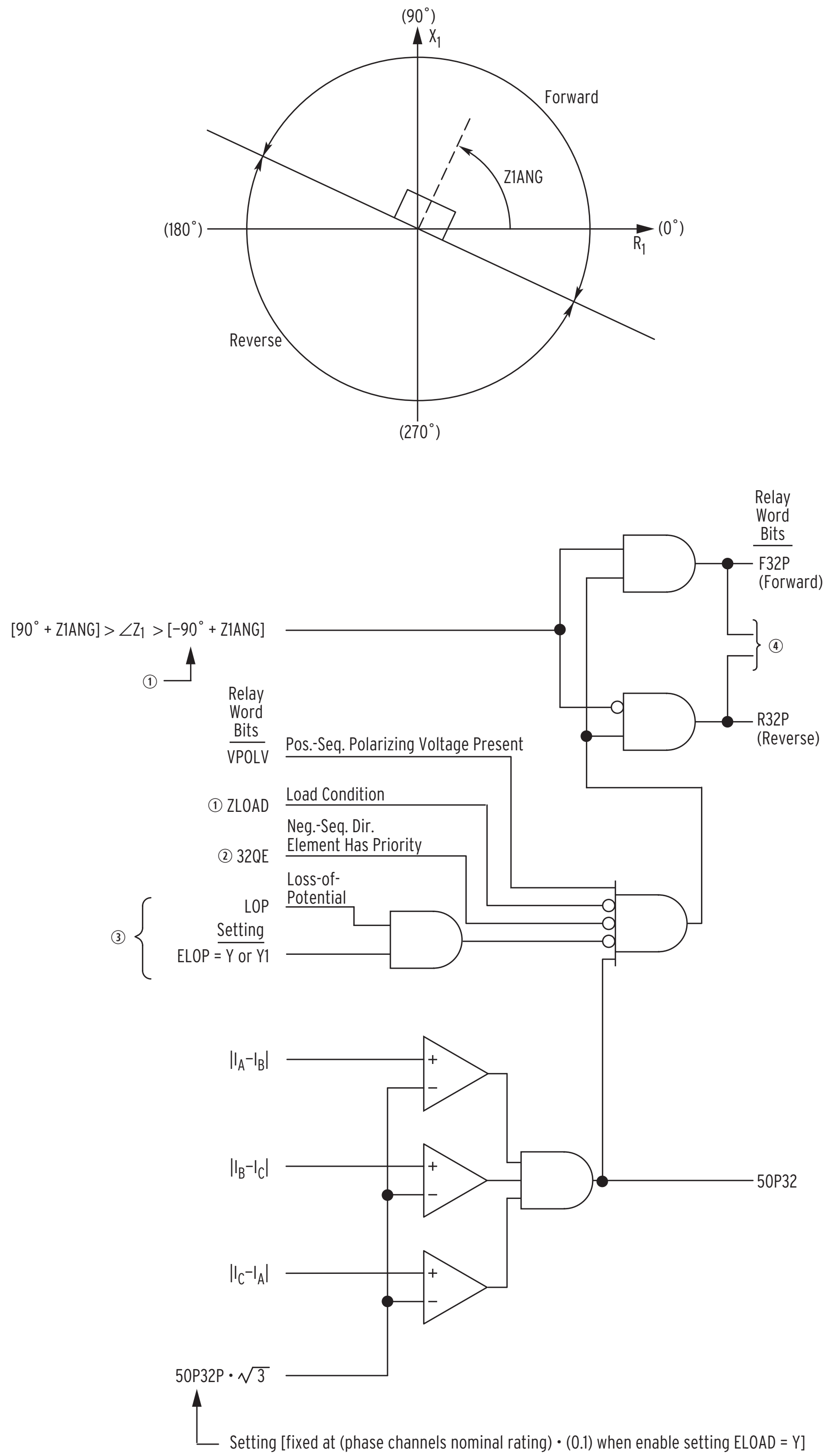
If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Note: 1ÐZ1L = One Ohm at the Positive-Sequence Line Angle

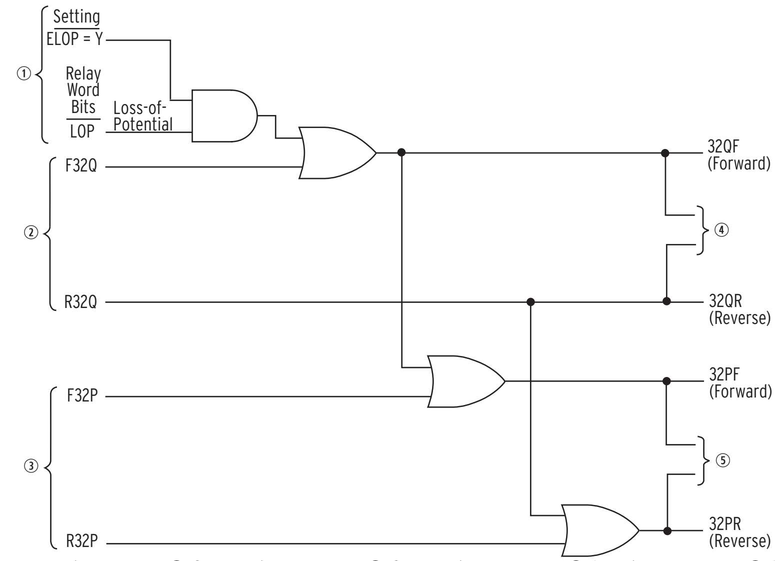
① From Figure 4.1; ② to Figure 4.19.

Figure 4.17 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements



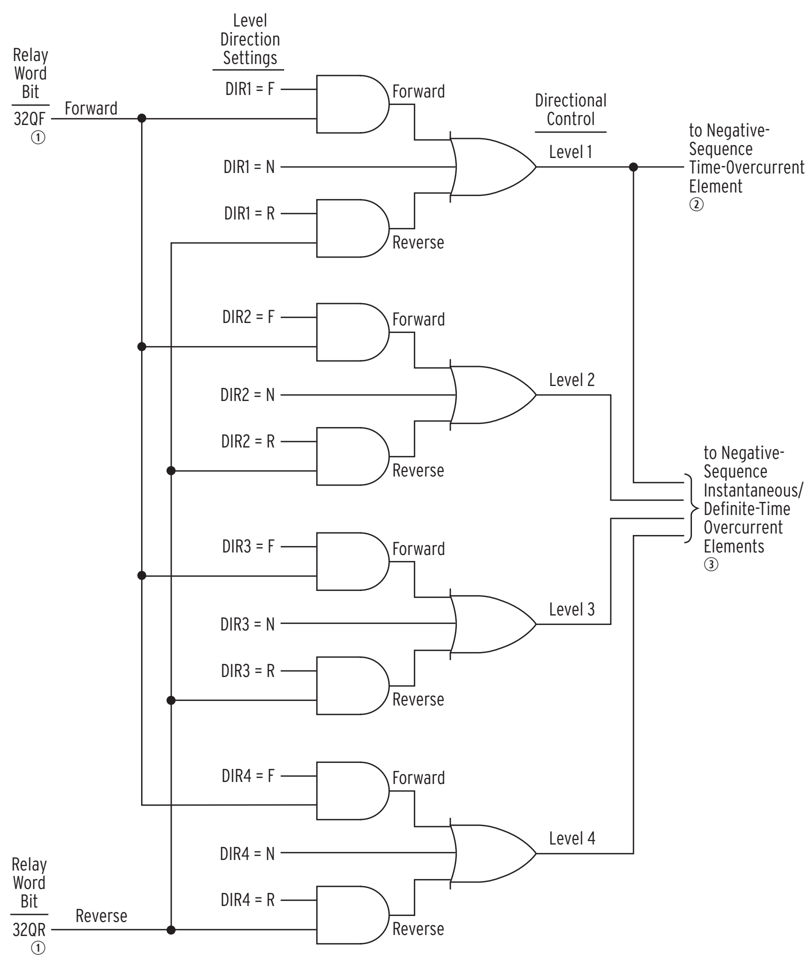
① From Figure 4.2; ② from Figure 4.5; ③ from Figure 4.1; ④ to Figure 4.19.

Figure 4.18 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



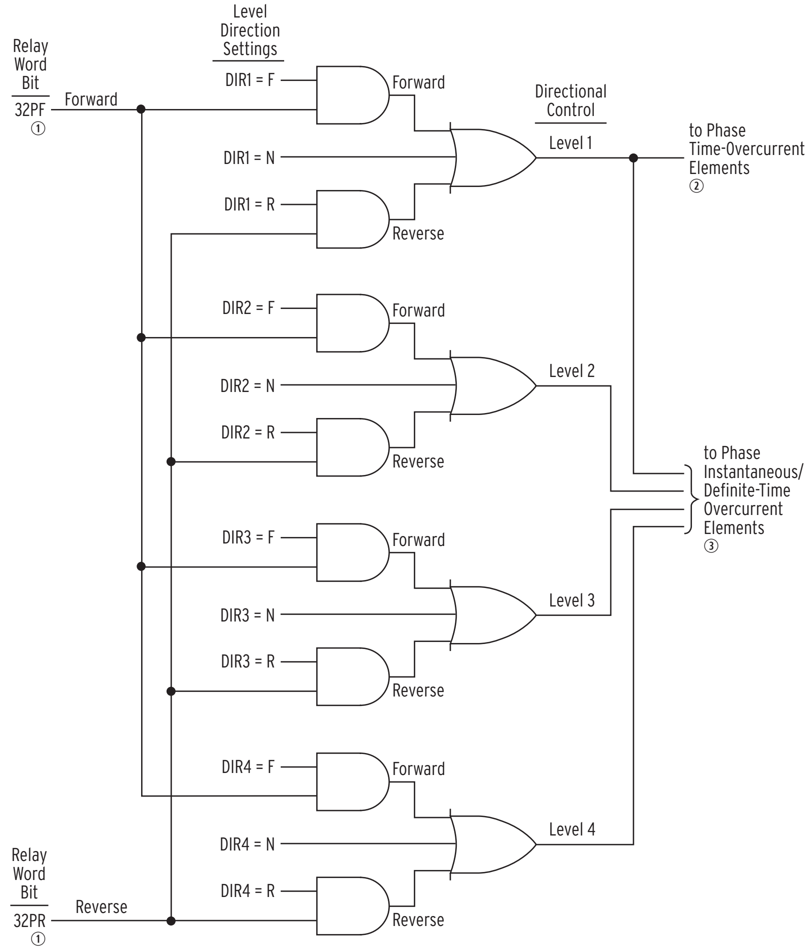
① From Figure 4.1; ② from Figure 4.17; ③ from Figure 4.18; ④ to Figure 4.20; ⑤ to Figure 4.21.

Figure 4.19 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.19; ② Figure 3.20; ③ Figure 3.12.

Figure 4.20 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements



① From Figure 4.19; ② Figure 3.14 and Figure 3.15; ③ Figure 3.3.

Figure 4.21 Direction Forward/Reverse Logic for Phase Overcurrent Elements

Directional Control Settings

The directional control for overcurrent elements is enabled by making directional control enable setting E32. Setting E32 has setting choices:

Y	enable directional control
N	disable directional control
AUTO	enable directional control and set a number of the directional element settings automatically

If directional control enable setting E32 = N, directional control is disabled and no directional control settings are made. All level direction settings are set internally as:

DIR1 = **N** (no directional control for Level 1 overcurrent elements)

DIR2 = **N** (no directional control for Level 2 overcurrent elements)

DIR3 = **N** (no directional control for Level 3 overcurrent elements)

DIR4 = **N** (no directional control for Level 4 overcurrent elements)

With the above settings, the directional control outputs in *Figure 4.14*, *Figure 4.20*, and *Figure 4.21* assert to logical 1. The referenced overcurrent elements in *Figure 4.14*, *Figure 4.20*, and *Figure 4.21* are then not controlled by the directional control logic.

Settings Made Automatically

If the directional control enable setting E32 is set:

E32 = **AUTO**

then the following directional control settings are calculated and set automatically:

Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GFP, 50GRP, a0, Z0F, and Z0R

Once these settings are calculated automatically, they can only be modified if the user goes back and changes the directional control enable setting to E32 = Y.

Use caution when you set E32 = AUTO. It is not appropriate for all applications. Systems with a strong negative-sequence source (e.g., equivalent negative-sequence impedance of less than $2.5/I_{NOM}$ in ohms) can use E32 = AUTO. It is best to use the settings in *Table 4.1* if any of the following apply:

- the negative-sequence impedance of the source is greater than $2.5/I_{NOM}$ in ohms
- the line impedance is unknown
- a non-fault condition occurs, such as a switching transformer energization causing the negative-sequence voltage to be approximately zero

Table 4.1 Ground Directional Element Preferred Settings

Name	5 A nominal	1 A nominal
E32	Y	Y
Z2F	–0.30	–1.5
Z2R	0.30	1.5
Z0F	–0.30	–1.5
Z0R	0.30	1.5
Z0MTA	Set equal to Z0ANG	Set equal to Z0ANG
50QFP /50GFP	0. 50 A	0.10 A
50QRP /50GRP	0. 25 A	0.05 A
a2	0.10	0.10
k2	0.20	0.20
a0	0.10	0.10

The preferred settings in *Table 4.1* will provide equal or better protection than E32 = AUTO for most systems.

The remaining directional control settings are *not* set automatically if setting E32 = AUTO. They have to be set by the user, whether setting E32 = AUTO or Y. These settings are:

DIR1, DIR2, DIR3, DIR4, ORDER, 50P32P, and E32IV

All these settings are explained in detail in the remainder of this subsection.

Settings

DIR1—Level 1 Overcurrent Element Direction Setting
DIR2—Level 2 Overcurrent Element Direction Setting
DIR3—Level 3 Overcurrent Element Direction Setting
DIR4—Level 4 Overcurrent Element Direction Setting

Setting Range:

- ➤ F = Direction Forward
- ➤ R = Direction Reverse
- ➤ N = Nondirectional

Table 4.2 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.2* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. *Figure 4.14*, *Figure 4.20*, and *Figure 4.21* show the logic implementation of the control listed in *Table 4.2*.

Table 4.2 Overcurrent Elements Controlled by Level Direction Settings DIR1–DIR4 (Corresponding Overcurrent Element Figure Numbers in Parentheses)

Level Direction Settings	Phase	Neutral Ground	Residual Ground	Negative-Sequence
DIR1	67P1 (*Figure 3.3*) 67P1T (*Figure 3.3*) 51P1T (*Figure 3.14*) 51P2T (*Figure 3.15*)	67N1 (*Figure 3.8*) 67N1T (*Figure 3.8*) 51N1T (*Figure 3.16*) 51N2T (*Figure 3.17*)	67G1 (*Figure 3.10*) 67G1T (*Figure 3.10*) 51G1T (*Figure 3.18*) 51G2T (*Figure 3.19*)	67Q1 (*Figure 3.12*) 67Q1T (*Figure 3.12*) 51QT (*Figure 3.20*)
DIR2	67P2 (*Figure 3.3*) 67P2T (*Figure 3.3*) 67P2S (*Figure 3.3*)	67N2 (*Figure 3.8*) 67N2T (*Figure 3.8*) 67N2S (*Figure 3.8*)	67G2 (*Figure 3.10*) 67G2T (*Figure 3.10*) 67G2S (*Figure 3.10*)	67Q2 (*Figure 3.12*) 67Q2T (*Figure 3.12*) 67Q2S (*Figure 3.12*)
DIR3	67P3 (*Figure 3.3*) 67P3T (*Figure 3.3*)	67N3 (*Figure 3.8*) 67N3T (*Figure 3.8*)	67G3 (*Figure 3.10*) 67G3T (*Figure 3.10*)	67Q3 (*Figure 3.12*) 67Q3T (*Figure 3.12*)
DIR4	67P4 (*Figure 3.3*) 67P4T (*Figure 3.3*)	67N4 (*Figure 3.8*) 67N4T (*Figure 3.8*)	67G4 (*Figure 3.10*) 67G4T (*Figure 3.10*)	67Q4 (*Figure 3.12*) 67Q4T (*Figure 3.12*)

In most communications-assisted trip schemes, the levels are set as follows (see *Figure 5.4*):

Level 1 overcurrent elements set direction forward (DIR1 = F)

Level 2 overcurrent elements set direction forward (DIR2 = F)

Level 3 overcurrent elements set direction reverse (DIR3 = R)

In some applications, level direction settings DIR1–DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque-Control Settings on page 4.33* describes how to avoid this limitation for special cases.

ORDER—Ground Directional Element Priority Setting

Setting Range:

Q Negative-sequence voltage-polarized directional element

V	Zero-sequence voltage-polarized, residual-current directional element and zero-sequence voltage-polarized, neutral-current directional element
OFF	No ground directional control

Setting ORDER can be set with any combination of Q and V. The order in which these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional Element logic control. See *Figure 4.8*.

For example, if setting:

ORDER = **QV**

then the first listed directional element (Q = negative-sequence voltage-polarized, residual-current directional element; see *Figure 4.9*) is the first priority directional element to provide directional control for the neutral ground and residual ground overcurrent elements.

If the zero-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32QGE, not being asserted), then the second listed directional element (V = zero-sequence voltage-polarized, residual-current directional element; see *Figure 4.10*) provides directional control for the neutral ground and residual ground overcurrent elements.

If the zero-sequence voltage-polarized, residual-current directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32VE, not being asserted), then 32NE asserts according to *Figure 4.7*. In this case, directional control will be provided for neutral ground overcurrent elements only.

Another example, if setting:

ORDER = **V**

then the zero-sequence voltage-polarized, residual-current directional element (see *Figure 4.10*) provides directional control for the neutral ground and residual ground overcurrent elements. If the zero-sequence voltage-polarized, residual-current directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32VE, not being asserted), then 32NE asserts according to *Figure 4.7*. In this case, directional control will be provided for neutral ground overcurrent elements only.

Setting ORDER can be set with any element combination (e.g., ORDER = VQ, ORDER = Q).

If setting:

ORDER = **OFF**

then the two directional elements (Q and V) are inoperable. Note in *Figure 4.14* and *Figure 4.15* that setting ORDER = OFF effectively makes the neutral ground and residual ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.14* and *Figure 4.15* are continuously asserted to logical 1).

50P32P—Phase Directional Element Three-Phase Current Pickup

Setting Range:

0.1 to 2.00 A secondary (1 A nominal phase currents, IA, IB, IC)

The 50P32P setting is set to pick up for all three-phase faults that need to be covered by the phase overcurrent elements. It supervises the positive-sequence voltage-polarized directional elements F32P and R32P (see *Figure 4.18*).

If the load-encroachment logic is enabled (enable setting ELOAD = Y), then setting 50P32P is not made or displayed, but is fixed internally at:

0.1 A secondary (1 A nominal phase currents, IA, IB, IC)

Z2F—Forward Directional Z2 Threshold Z2R—Reverse Directional Z2 Threshold

Setting Range:

–640.00 to +640.00 Ω secondary (1 A nominal phase currents, IA, IB, IC)

Z2F and Z2R are used to calculate the Forward and Reverse Thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see *Figure 4.9* and *Figure 4.17*).

Z2F and Z2R Set Automatically

If enable setting E32 = AUTO, settings Z2F and Z2R (negative-sequence impedance values) are calculated automatically, using the positive-sequence line impedance magnitude setting Z1MAG as follows:

Z2F = **Z1MAG/2** (Ω secondary)

Z2R = **Z1MAG/2 + 1.0** (Ω secondary)

If enable setting E32 = Y, settings Z2F and Z2R (negative-sequence impedance values) are calculated by the user and entered by the user, but setting Z2R must be at least 1.0 Ω secondary greater in value than setting Z2F.

50QFP—Forward Directional Negative-Sequence Current Pickup 50QRP—Reverse Directional Negative-Sequence Current Pickup

Setting Range:

0.05 to 1.00 A secondary (1 A nominal phase currents, IA, IB, IC)

The 50QFP setting ($3I_2$ current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see *Figure 4.5*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting ($3I_2$ current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see *Figure 4.5*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced reverse faults.

50QFP and 50QRP Set Automatically

If enable setting E32 = AUTO, settings 50QFP and 50QRP are set automatically at:

50QFP = 0.10 A secondary (1 A nominal phase currents, IA, IB, IC)

50QRP = 0.05 A secondary (1 A nominal phase currents, IA, IB, IC)

a2—Positive-Sequence Current Restraint Factor, I_2/I_1

Setting Range:

0.02 to 0.50 (unitless)

Refer to *Figure 4.5*.

The a2 factor increases the security of the negative-sequence voltage-polarized directional elements. It keeps the elements from operating for negative-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

a2 Set Automatically

If enable setting E32 = AUTO, setting a2 is set automatically at:

a2 =. **0.1**

For setting a2 = 0.1, the negative-sequence current (I_2) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled:

$$(|I_2| > 0.1 \bullet |I_1|)$$

k2—Zero-Sequence Current Restraint Factor, I_2/I_0

Setting Range:

0.10 to 1.20 (unitless)

Note the internal enable logic outputs in *Figure 4.5*:

32QE internal enable for the negative-sequence voltage-polarized directional element that controls the negative-sequence and phase overcurrent elements

32QGE internal enable for the negative-sequence voltage-polarized directional element that controls the neutral ground and residual ground overcurrent elements

The k2 factor is applied to internal enable 32QGE. The negative-sequence current (I_2) magnitude has to be greater than the zero-sequence current (I_0) magnitude multiplied by k2 in order for the 32QGE internal enable (and following negative-sequence voltage-polarized directional element in *Figure 4.9*) to be enabled:

$$(|I_2| > k2 \bullet |I_0|)$$

This check ensures that the control uses the most robust analog quantities in making directional decisions for the neutral ground and residual ground overcurrent elements.

If the internal enable:

32VE internal enable for the zero-sequence voltage-polarized, residual-current directional element that controls the neutral ground and residual ground overcurrent elements

is deasserted, then factor k2 is ignored as a logic enable for the 32QGE internal enable. If the zero-sequence voltage-polarized directional elements are not operable, less restrictions (i.e., factor k2) are put on the operation of the negative-sequence voltage-polarized directional element.

k2 Set Automatically

If enable setting E32 = AUTO, setting k2 is set automatically at:

k2 = **0.2**

For setting k2 = 0.2, the negative-sequence current (I_2) magnitude has to be greater than 1/5 of the zero-sequence current (I_0) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled

$$(|I_2| > 0.2 \bullet |I_0|)$$

Again, this presumes internal enable 32VE is asserted.

50GFP—Forward Directional Residual Ground Current Pickup
50GRP—Reverse Directional Residual Ground Current Pickup

Setting Range:

0.05 to 1.00 A secondary (1 A nominal phase currents, IA, IB, IC)

If preceding setting ORDER does not contain V (zero-sequence voltage-polarized directional element is not enabled), then settings 50GFP and 50GRP are not made or displayed.

The 50GFP setting ($3I_0$ current value) is the pickup for the forward fault detector 50GF of the zero-sequence voltage-polarized, residual-current directional element (see *Figure 4.6*). Ideally, the setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting ($3I_0$ current value) is the pickup for the reverse fault detector 50GR of the zero-sequence voltage-polarized, residual-current directional element (see *Figure 4.6*). Ideally, the setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

The 50GFP/10 setting (I_N current value) is the pickup for the forward fault detector 50NF of the zero-sequence voltage-polarized, neutral-current directional element (see *Figure 4.7*). This setting is always automatic and used for SEF applications.

The 50GRP/10 setting (I_N current value) is the pickup for the reverse fault detector 50NR of the zero-sequence voltage-polarized, neutral-current directional element (see *Figure 4.7*). This setting is always automatic and used for SEF applications.

50GFP and 50GRP Set Automatically

If enable setting E32 = AUTO, settings 50GFP and 50GRP are set automatically at:

50GFP = 0.10 A secondary (1 A nominal phase currents, IA, IB, IC)

50GRP = 0.05 A secondary (1 A nominal phase currents, IA, IB, IC)

a0—Positive-Sequence Current Restraint Factor, I_0/I_1

Setting Range:

0.02 to 0.50 (unitless)

If preceding setting ORDER does not contain V (zero-sequence voltage-polarized directional element is not enabled), then setting a0 is not made or displayed.

Refer to *Figure 4.6*.

The a0 factor increases the security of the zero-sequence voltage-polarized directional element. It keeps the element from operating for zero-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

a0 Set Automatically

If enable setting E32 = AUTO, setting a0 is set automatically at:

a0 =. **0.1**

For setting a0 = 0.1, the zero-sequence current (I_0) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the zero-sequence voltage-polarized directional element to be enabled.

$$(|I_0| > 0.1 \cdot |I_1|)$$

Z0F—Forward Directional Z0 Threshold
Z0R—Reverse Directional Z0 Threshold

Setting Range:

–640.00 to + 640.00 Ω secondary (1 A nominal phase currents, IA, IB, IC)

If preceding setting ORDER does not contain V (no zero-sequence voltage-polarized directional element is enabled), then settings Z0F and Z0R are not made or displayed.

Z0F and Z0R are used to calculate the Forward and Reverse Thresholds, respectively, for all the zero-sequence voltage-polarized directional elements (see *Figure 4.10* and *Figure 4.11*).

Z0F and Z0R Set Automatically

If enable setting E32 = AUTO, settings Z0F and Z0R (zero-sequence impedance values) are calculated automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

Z0F = **Z0MAG/2** (Ω secondary)

Z0R = **Z0MAG/2 + 1.0** (Ω secondary)

If enable setting E32 = Y, settings Z0F and Z0R (zero-sequence impedance values) are calculated by the user and entered by the user, but setting Z0R must be at least 1.0 Ω secondary greater in value than setting Z0F.

E32IV—SELOGIC Control Equation Enable

Refer to *Figure 4.6*.

SELOGIC control equation setting E32IV must be asserted to logical 1 to enable the zero-sequence voltage-polarized directional element for directional control of neutral ground and residual ground overcurrent elements.

Most often, this setting is set directly to logical 1:

E32IV = **1** (numeral 1)

For situations where zero-sequence source isolation can occur (e.g., by the opening of a circuit breaker) and result in possible mutual coupling problems for the zero-sequence voltage-polarized directional elements, SELOGIC control equation setting E32IV should be deasserted to logical 0. In this example, this is accomplished by connecting a circuit breaker auxiliary contact from the identified circuit breaker to the SEL-351R:

E32IV = **IN6** (52a connected to optoisolated input IN6) Almost any desired control can be set in SELOGIC control equation setting E32IV.

Directional Control Provided by Torque-Control Settings

For most applications, the level direction settings DIR1–DIR4 are used to set overcurrent elements direction forward, reverse, or nondirectional. *Table 4.2* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.2* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See *Figure 4.14*, *Figure 4.20*, and *Figure 4.21*.

In most communications-assisted trip schemes, the levels are set as follows (see *Figure 5.4*):

Level 1 overcurrent elements set direction forward (DIR1 = F)

Level 2 overcurrent elements set direction forward (DIR2 = F)

Level 3 overcurrent elements set direction reverse (DIR3 = R)

Suppose that the Level 1 overcurrent elements should be set as follows:

67P1 direction forward

67G1 direction forward

51P1T direction forward

51P2T direction reverse

51N1T nondirectional

51G1T direction forward

To accomplish this, the DIR1 setting is "turned off," and the corresponding SELOGIC control equation torque control settings for the above overcurrent elements are used to make the elements directional (forward or reverse) or nondirectional. The required settings are:

DIR1 = **N** ("turned off"; see *Figure 4.14*, *Figure 4.20*, and *Figure 4.21*)

67P1TC = **32PF** (direction forward; see *Figure 3.3*)

67G1TC = **32GF** (direction forward; see *Figure 3.10*)

51P1TC = **32PF** (direction forward; see *Figure 3.14*)

51P2TC = **32PR** (direction reverse; see *Figure 3.15*)

51N1TC = **1** (nondirectional; see *Figure 3.16*)

51G1TC = **32GF** (direction forward; see *Figure 3.18*)

This is just one example of using SELOGIC control equation torque control settings to make overcurrent elements directional (forward or reverse) or nondirectional. This example discussed only Level 1 overcurrent elements (controlled by level direction setting DIR1). The same setting principles can apply to the other levels as well. Many variations are possible.

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Section 5
Trip and Target Logic

Trip Logic

The trip logic in *Figure 5.1* provides flexible tripping with SELOGIC® control equation settings:

TRCOMM Communications-Assisted Trip Conditions. Setting TRCOMM is supervised by communications-assisted trip logic. See *Communications-Assisted Trip Logic—General Overview on page 5.7* for more information on communications-assisted tripping.

DTT Direct Transfer Trip Conditions. Note in *Figure 5.1* that setting DTT is unsupervised. Any element that asserts in setting DTT will cause Relay Word bits COMMT and TRIP to assert to logical 1.

A typical setting for DTT is:

DTT = **IN106**

where input **IN106** is connected to the output of direct transfer trip communications equipment.

Setting DTT is also used for Direct Underreaching Transfer Trip (DUTT) schemes.

To illuminate an LED to indicate a communications-assisted trip (via SELOGIC control equation settings TRCOMM or DTT), reprogram an LED with Relay Word bit COMMT. The LED also has to be set as a trip-latch LED (see *Front-Panel Status and Trip Target LEDS on page 1.56*).

TRSOTF Switch-Onto-Fault Trip Conditions. Setting TRSOTF is supervised by the switch-onto-fault logic enable SOTFE. See *Switch-Onto-Fault (SOTF) Trip Logic on page 5.4* for more information on switch-onto-fault logic.

TR Other Trip Conditions. Setting TR is the SELOGIC control equation trip setting *most often used* if tripping does not involve communications-assisted (settings TRCOMM and DTT) or switch-onto-fault (setting TRSOTF) trip logic.

Note in *Figure 5.1* that setting TR is unsupervised. Any element that asserts in setting TR will cause Relay Word bit TRIP to assert to logical 1.

ULTR Unlatch Trip Conditions.

TDURD Minimum Trip Duration Time. This timer establishes the *minimum* time duration for which the TRIP Relay Word bit asserts. This is a rising-edge initiated timer. The settable range for this timer is 4–16,000 cycles (see *Figure 5.2*).

More than one trip setting (or all four trip settings TRCOMM, DTT, TRSOTF, and TR) can be set. For example, in a communications-assisted trip scheme, TRCOMM is set with direction forward overreaching Level 2 overcurrent elements, TR is set with direction forward underreaching Level 1 overcurrent elements and other time delayed elements (e.g., Level 2 definite-time overcurrent elements), and TRSOTF is set with nondirectional overcurrent elements.

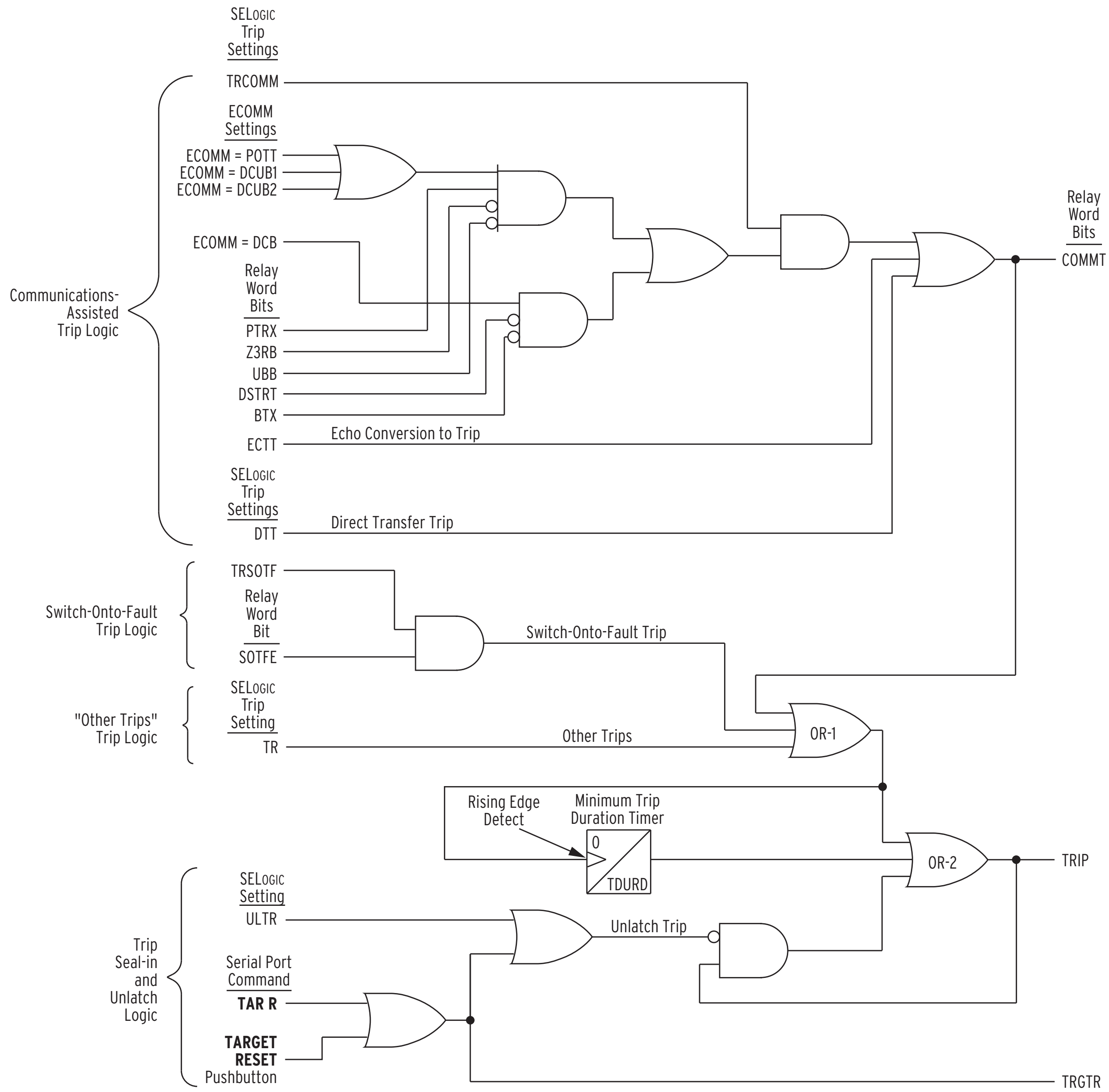


Figure 5.1 Trip Logic

Set Trip

Refer to *Figure 5.1*. All trip conditions:

- Communications-Assisted Trip
- Direct Transfer Trip
- Switch-Onto-Fault Trip
- Other Trips

are combined into OR-1 gate. The output of OR-1 gate asserts Relay Word bit TRIP to logical 1, regardless of other trip logic conditions. It also is routed into the Minimum Trip Duration Timer (setting TDURD).

As shown in the time line example in *Figure 5.2*, the Minimum Trip Duration Timer (with setting TDURD) outputs a logical 1 for a time duration of “TDURD” cycles any time it sees a *rising edge* on its input (logical 0 to logical 1 transition), if it is not already timing (timer is reset). The TDURD timer assures that the TRIP Relay Word bit remains asserted at logical 1 for a *minimum* of “TDURD” cycles. If the output of OR-1 gate is logical 1 beyond the TDURD time, Relay Word bit TRIP remains asserted at logical 1 for as long as the output of OR-1 gate remains at logical 1, regardless of other trip logic conditions.

The Minimum Trip Duration Timer can be set no less than four cycles.

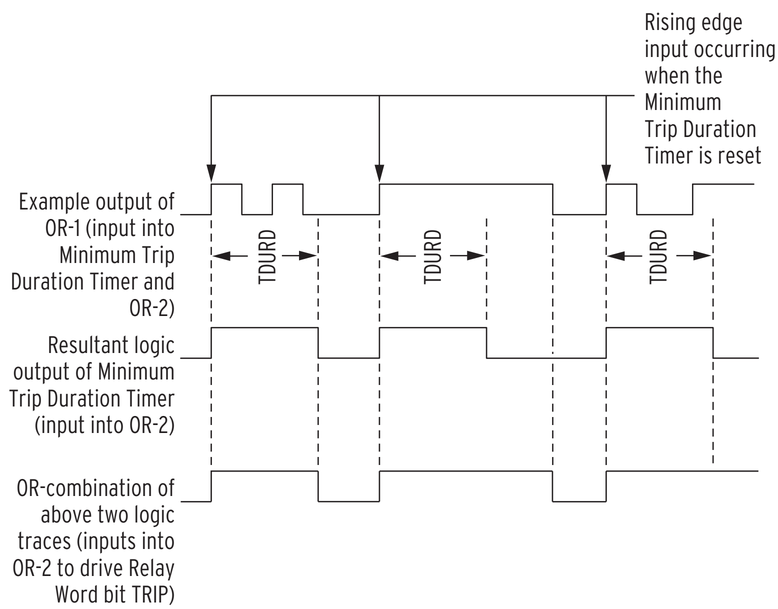


Figure 5.2 Minimum Trip Duration Timer Operation (See Bottom of Figure 5.1)

Unlatch Trip

Once Relay Word bit TRIP is asserted to logical 1, it remains asserted at logical 1 until *all* the following conditions come true:

- Minimum Trip Duration Timer stops timing (logic output of the TDURD timer goes to logical 0)
- Output of OR-1 gate deasserts to logical 0
- One of the following occurs:
  - SELOGIC control equation setting ULTR asserts to logical 1,
  - The front-panel TARGET RESET pushbutton is pressed,
  - Or the **TAR R** (Target Reset) command is executed via the serial port.

The front-panel TARGET RESET pushbutton or the **TAR R** (Target Reset) serial port command is primarily used during testing. Use these to force the TRIP Relay Word bit to logical 0 if test conditions are such that setting ULTR does not assert to logical 1 to automatically deassert the TRIP Relay Word bit instead.

Other Applications for the Target Reset Function

Refer to the bottom of *Figure 5.1*. Note that the combination of the **TARGET RESET** pushbutton and the **TAR R** (Target Reset) serial port command is also available as Relay Word bit TRGTR. See *Figure 5.17* and accompanying text for applications for Relay Word bit TRGTR.

Factory Settings Example (using setting TR)

If the "communications-assisted" and "switch-onto-fault" trip logic at the top of *Figure 5.1* can effectively be ignored, the figure becomes a lot smaller. Then SELOGIC control equation trip setting TR is the only input into OR-1 gate and follows into the "seal-in and unlatch" logic for Relay Word bit TRIP.

The factory settings for the trip logic SELOGIC control equation settings are:

TR = **51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T + PB9 + OC** (trip conditions)

ULTR = **!52A** (unlatch trip conditions)

The factory setting for the Minimum Trip Duration Timer setting is:

TDURD = **12.00 cycles**

With setting TDURD = 12.000 cycles, once the TRIP Relay Word bit asserts via SELOGIC control equation setting TR, it remains asserted at logical 1 for a *minimum* of 12 cycles.

See figures in *Section 1: Factory-Set Logic* for more information on factory-set SELOGIC control equation settings TR and ULTR.

Program an Output for Tripping

In the factory settings, the resultant of the trip logic in *Figure 5.1* is routed to high voltage FET trip output RCTR with the following SELOGIC control equation setting:

RCTR = **TRIP** (see *Figure 7.29*)

If additional TRIP output contacts are needed, program the extra output contacts with the TRIP Relay Word bit (e.g., OUT101 = TRIP). Examples of uses for additional TRIP output contacts:

- Tripping more than one breaker
- Keying an external breaker failure relay
- Keying communication equipment in a Direct Transfer Trip scheme

See *Output Contacts on page 7.27* for more information on programming output contacts.

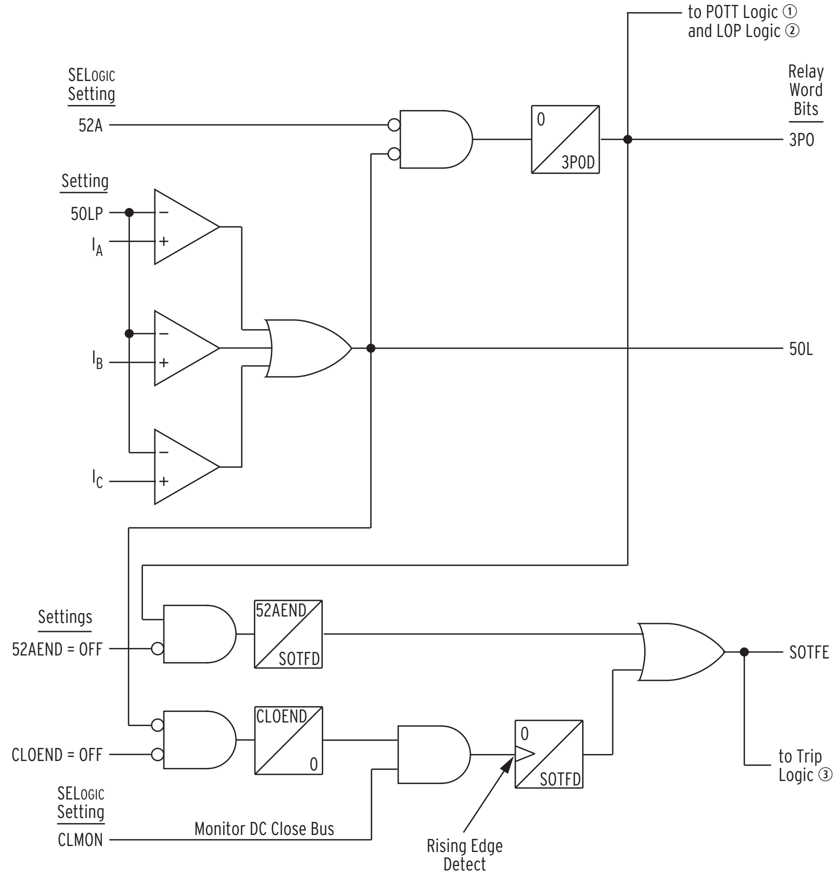
Switch-Onto-Fault (SOTF) Trip Logic

Switch-Onto-Fault (SOTF) trip logic provides a programmable time window for selected elements to trip right after the circuit breaker closes. "Switch-onto-fault" implies that a circuit breaker is closed into an existing fault condition. For example, suppose safety grounds are accidentally left attached to a line after a clearance. If the circuit breaker is closed into such a condition, the resulting fault needs to be cleared right away and reclosing blocked. An instantaneous overcurrent element is usually set to trip in the three-pole open (3PO) logic and the SOTF trip logic.

Refer to the SOTF trip logic in *Figure 5.1* (middle of figure). The SOTF trip logic permits tripping if *both* the following occur:

- ➤ An element asserts in SELOGIC control equation trip setting TRSOTF
- ➤ Relay Word bit SOTFE is asserted to logical 1

Relay Word bit SOTFE (the enable of the SOTF logic) provides the effective time window for an element in trip setting TRSOTF (e.g., TRSOTF = 50P2) to trip after the circuit breaker closes. *Figure 5.3* and the following discussion describe the three-pole open (3PO) logic and the SOTF logic.



① Figure 5.6; ② Figure 4.1; ③ Figure 5.1.

Figure 5.3 Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom)

Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of *Figure 5.3*. It is not affected by enable setting ESOTF (see *Other Enable Settings on page SET.2*).

The open circuit breaker condition is determined from the combination of:

- ➤ Circuit breaker status (52A)
- ➤ Load current condition (50L)

If the circuit breaker is open (52A = logical 0) *and* current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = logical 1 (circuit breaker open)

The 3POD dropout time qualifies circuit breaker closure, whether detected by circuit breaker status (52A) or load current level (50L). When the circuit breaker is closed:

3PO = logical 0 (circuit breaker closed)

Determining Three-Pole Open Condition Without Circuit Breaker Auxiliary Contact

If a circuit breaker auxiliary contact is not connected to the SEL-351R Recloser Control, SELOGIC control equation setting 52A is set:

52A = **0** (numeral 0)

With SELOGIC control equation setting 52A continually at logical 0, 3PO logic is controlled solely by load detection element 50L. Phase pickup 50LP is set below load current levels.

When the circuit breaker is open, Relay Word bit 50L drops out (= logical 0) and the 3PO condition asserts:

3PO = logical 1 (circuit breaker open)

When the circuit breaker is closed, Relay Word bit 50L picks up (= logical 0; current above phase pickup 50LP) and the 3PO condition deasserts after the 3POD dropout time:

3PO = logical 0 (circuit breaker closed)

Note that the 3PO condition is also routed to the permissive overreaching transfer trip (POTT) logic (see *Figure 5.6*) and the loss-of-potential (LOP) logic (see *Figure 4.1*).

Circuit Breaker Operated Switch-Onto-Fault Logic

Circuit breaker operated switch-onto-fault logic is enabled by making time setting 52AEND (52AEND ≠ OFF). Time setting 52AEND qualifies the three-pole open (3PO) condition and then asserts Relay Word bit SOTFE:

SOTFE = logical 1

Note that SOTFE is asserted when the circuit breaker is open. This allows elements set in the SELOGIC control equation trip setting TRSOTF to operate if a fault occurs when the circuit breaker is open (see *Figure 5.1*). In such a scenario (e.g., flashover inside the circuit breaker tank), the tripping via setting TRSOTF cannot help in tripping the circuit breaker (the circuit breaker is already open), but can initiate breaker failure protection, if a breaker failure scheme is implemented in the SEL-351R (see *Figure 7.24*) or externally.

When the circuit breaker is closed, the 3PO condition deasserts (3PO = logical 0) after the 3POD dropout time (setting 3POD is usually set for no more than a cycle). The SOTF logic enable, SOTFE, continues to remain asserted at logical 1 for dropout time SOTFD.

Close Bus Operated Switch-Onto-Fault Logic

Close bus operated switch-onto-fault logic is enabled by making time setting CLOEND (CLOEND ≠ OFF). Time setting CLOEND qualifies the deassertion of the load detection element 50L (indicating that the circuit breaker is open).

Circuit breaker closure is detected by monitoring the dc close bus. This is accomplished by wiring an optoisolated input on the SEL-351R (e.g., IN104) to the dc close bus. When a manual close or automatic reclosure occurs, optoisolated input IN104 is energized. SELOGIC control equation setting CLMON (close bus monitor) monitors the optoisolated input IN104:

CLMON = **IN104**

When optoisolated input IN104 is energized, CLMON asserts to logical 1. At the instant that optoisolated input IN104 is energized (close bus is energized), the circuit breaker is still open so the output of the CLOEND timer continues to be asserted to logical 1, Thus, the ANDed combination of these conditions latches in the SOTFD timer. The SOTFD timer outputs a logical 1 for a time duration of “SOTFD” cycles any time it sees a *rising edge* on its input (logical 0 to logical 1 transition), if it is not already timing. The SOTF logic enable, SOTFE, asserts to logical 1 for SOTFD time.

Switch-Onto-Fault Logic Enable (SOTFE)

Relay Word bit SOTFE is the output of the circuit breaker operated SOTF logic or the close bus operated SOTF logic described previously. Time setting SOTFD in each of these logic paths provides the effective time window for the overcurrent elements in SELOGIC control equation trip setting TRSOTF to trip after the circuit breaker closes (see *Figure 5.1*—middle of figure). Time setting SOTFD is usually set around 30 cycles.

Switch-Onto-Fault Trip Logic Trip Setting (TRSOTF)

An instantaneous overcurrent element is usually set to trip in the SELOGIC control equation trip setting TRSOTF (e.g., TRSOTF = 50P2).

If the voltage potential for the control is from the line-side of the circuit breaker, the instantaneous overcurrent element in the SELOGIC control equation trip setting TRSOTF should be nondirectional. When the circuit breaker is open and the line is reenergized, the control sees zero voltage. If a close-in three-phase fault condition exists on the line (e.g., safety grounds accidentally left attached to the line after a clearance) and then the circuit breaker is closed, the control continues to see zero voltage. The directional elements have no voltage for reference and cannot operate. In this case, the instantaneous overcurrent element in the SOTF trip logic should be nondirectional.

Communications-Assisted Trip Logic—General Overview

The SEL-351R includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

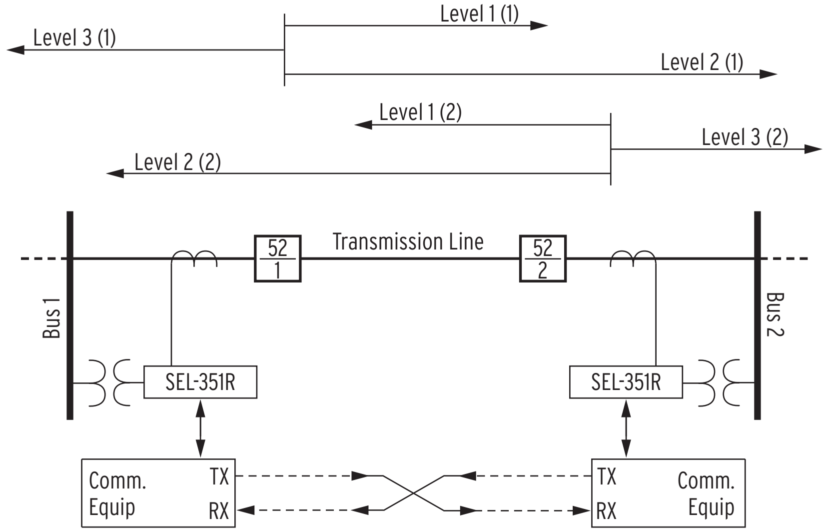


Figure 5.4 Communications-Assisted Tripping Scheme

Refer to *Figure 5.4* and the top half of *Figure 5.1*.

The six available tripping schemes are:

- Direct Transfer Trip (DTT)
- Direct Underreaching Transfer Trip (DUTT)
- Permissive Overreaching Transfer Trip (POTT)
- Permissive Underreaching Transfer Trip (PUTT)
- Directional Comparison Unblocking (DCUB)
- Directional Comparison Blocking (DCB)

Enable Setting ECOMM

The POTT, PUTT, DCUB, and DCB tripping schemes are enabled with enable setting ECOMM. Setting choices are:

ECOMM = **N** (no communications-assisted trip scheme enabled)

ECOMM = **POTT** (POTT or PUTT scheme)

ECOMM = **DCUB1** (DCUB scheme for two-terminal line [communications from *one* remote terminal])

ECOMM = **DCUB2** (DCUB scheme for three-terminal line [communications from *two* remote terminals])

ECOMM = **DCB** (DCB scheme)

These tripping schemes can all work in two-terminal or three-terminal line applications. The DCUB scheme requires separate settings choices for these applications (ECOMM = DCUB1 or DCUB2) because of unique DCUB logic considerations.

NOTE: EZ settings should be turned off for the setting group(s) used in a communications-assisted tripping scheme. The overcurrent element applications for traditional recloser control schemes (addressed with EZ settings) differ from those in a communications-assisted tripping scheme (see following trip settings). See Table 1.1 and Table 1.3 and the EZ settings explanation preceding Table 1.1 for more information on EZ settings and overcurrent element applications for traditional recloser control schemes.

In most cases, these tripping schemes require (see *Figure 5.4*):

- Level 1 underreaching overcurrent elements set direction forward (setting DIR1 = F)
- Level 2 overreaching overcurrent elements set direction forward (setting DIR2 = F)
- Level 3 overcurrent elements set direction reverse (setting DIR3 = R)

See *Settings* in the *Directional Control Settings on page 4.25* for more information on level direction settings DIR1–DIR4.

POTT, PUTT, DCUB, and DCB communications-assisted tripping schemes are explained in subsections that follow.

Trip Setting TRCOMM

The POTT, PUTT, DCUB, and DCB tripping schemes use SELOGIC control equation trip setting TRCOMM for those tripping elements that are supervised by the communications-assisted trip logic (see top half of *Figure 5.1*). Setting TRCOMM is typically set with Level 2 overreaching overcurrent elements (set direction forward):

67P2 Level 2 directional phase instantaneous overcurrent element

67N2 Level 2 directional neutral ground instantaneous overcurrent element

67G2 Level 2 directional residual ground instantaneous overcurrent element

67Q2 Level 2 directional negative-sequence instantaneous overcurrent element

The exception is a DCB scheme, where Level 2 overreaching overcurrent elements (set direction forward) with a short delay are used instead:

67P2S Level 2 directional phase instantaneous overcurrent element (with delay 67P2SD)

67N2S Level 2 directional neutral ground instantaneous overcurrent element (with delay 67N2SD)

67G2S Level 2 directional residual ground instantaneous overcurrent element (with delay 67G2SD)

67Q2S Level 2 directional negative-sequence instantaneous overcurrent element (with delay 67Q2SD)

The short delays provide necessary carrier coordination delays (waiting for the block trip signal).

Trip Settings TRSOTF and TR

In a communications-assisted trip scheme, the SELOGIC control equation trip settings TRSOTF and TR can also be used, in addition to setting TRCOMM.

Setting TRSOTF can be set as described in *Switch-Onto-Fault (SOTF) Trip Logic on page 5.4*.

Setting TR is typically set with unsupervised Level 1 underreaching overcurrent elements (set direction forward):

67P1 Level 1 directional phase instantaneous overcurrent element

67N1 Level 1 directional neutral ground instantaneous overcurrent element

67G1 Level 1 directional residual ground instantaneous overcurrent element

67Q1 Level 1 directional negative-sequence instantaneous overcurrent element

and other time delayed elements (e.g., Level 2 definite-time overcurrent elements).

Trip Setting DTT

The DTT and DUTT tripping schemes are realized with SELOGIC control equation trip setting DTT, discussed at the beginning of this section.

To illuminate an LED to indicate a communications-assisted trip (via SELOGIC control equation settings TRCOMM or DTT), reprogram an LED with Relay Word bit COMMT (see *Figure 5.1*). The LED also has to be set as a trip-latch LED (see *Front-Panel Status and Trip Target LEDS on page 1.56*).

Use Existing SEL-321 Relay Application Guides for the SEL-351R Recloser Control

The communications-assisted tripping schemes settings in the SEL-351R are very similar to those in the SEL-321 Relay. Existing SEL-321 application guides can also be used in setting up these schemes in the SEL-351R. The following application guides are available from SEL.

Application Guide Number	Title
AG93-06	Applying the SEL-321 Relay to Directional Comparison Blocking (DCB) Schemes
AG95-29	Applying the SEL-321 Relay to Permissive Overreaching Transfer Trip (POTT) Schemes
AG96-19	Applying the SEL-321 Relay to Directional Comparison Unblocking (DCUB) Schemes
AG98-06	Using SEL-351 and SEL-351R Relays to Provide Automated Load Restoration for Distribution Feeders

The major differences are in the way optoisolated input settings and the trip settings are made. The following explanations describe these differences.

Optoisolated Input Settings Differences Between the SEL-321 and SEL-351R Recloser Control

The SEL-351R does not have optoisolated input settings like the SEL-321 Relay. Rather, the optoisolated inputs of the SEL-351R are available as Relay Word bits and are used in SELOGIC control equations. The following optoisolated input setting example is for a Permissive Overreaching Transfer Trip (POTT) scheme.

SEL-321 Relay	SEL-351R
IN2 = PT	PT1 = IN102 (received permissive trip)

In the above SEL-351R setting example, Relay Word bit IN102 is set in the PT1 SELOGIC control equation. Optoisolated input **IN102** is wired to a communications equipment receiver output contact. Relay Word bit IN102 can also be used in other SELOGIC control equations in the SEL-351R. See *Optoisolated Inputs on page 7.1* for more information on optoisolated inputs.

Trip Settings Differences Between the SEL-321 and SEL-351R Recloser Control

Some of the SELOGIC control equation trip settings of the SEL-321 and SEL-351R have different labels, yet are operationally the same. The correspondence is:

SEL-321 Relay	SEL-351R
MTCS	TRCOMM (Communications-Assisted Trip Conditions)
MTO	TRSOTF (Switch-Onto-Fault Trip Conditions)
MTU	TR (Unconditional or Other Trip Conditions)

The SEL-321 handles trip unlatching with setting TULO. The SEL-351R handles trip unlatching with SELOGIC control equation setting ULTR.

The SEL-321 has single-pole trip logic. The SEL-351R does not have single-pole trip logic.

Permissive Overreaching Transfer Trip (POTT) Logic

NOTE: With only optoisolated input IN101 and output contact OUT107, the SEL-351R is not equipped for traditionally implemented three-terminal line POTT applications. Three-terminal line applications would have to be realized with MIRRORED BITS as the I/O medium instead. See this same subsection in the standard SEL-351R Instruction Manual for information on three-terminal line POTT applications.

Enable the POTT logic by setting ECOMM = POTT. The POTT logic in *Figure 5.6* is also enabled for directional comparison unblocking schemes (ECOMM = DCUB1 or ECOMM = DCUB2). The POTT logic performs the following tasks:

- ➤ Keys communication equipment to send permissive trip when any element included in the SELOGIC control equation communications-assisted trip equation TRCOMM asserts and the current reversal logic is not asserted.
- ➤ Prevents keying and tripping by the POTT logic following a current reversal.
- ➤ Echoes the received permissive signal to the remote terminal.
- ➤ Prevents channel lockup during echo and test.
- ➤ Provides a secure means of tripping for weak- and/or zero-infeed line terminals.

Use Existing SEL-321 Relay POTT Application Guide for the SEL-351R Recloser Control

Use the existing SEL-321 Relay POTT application guide (AG95-29) to help set up the SEL-351R in a POTT scheme (see *Communications-Assisted Trip Logic—General Overview* for more setting comparison information on the SEL-321/SEL-351R).

External Inputs

See *Optoisolated Inputs on page 7.1* for more information on optoisolated inputs.

PT1—Received Permissive Trip Signal(s)

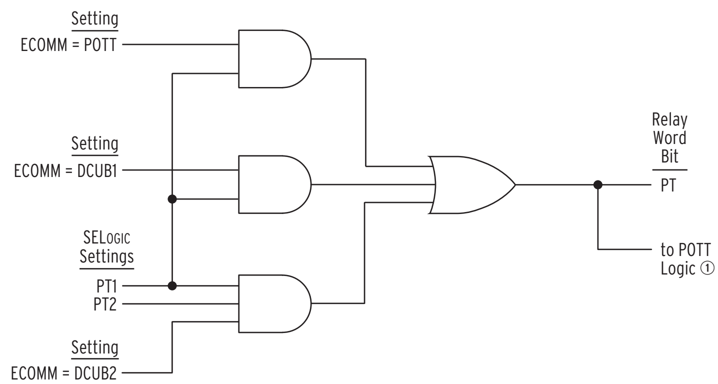
In two-terminal line POTT applications, a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-351R (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.8*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line POTT applications, permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-351R (e.g., input **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.9*). Make SELOGIC control equation setting PT1 as follows:

PT1 = **IN104 * IN106** (three-terminal line application)

SELOGIC control equation setting PT1 in *Figure 5.5* is routed to control Relay Word bit PT if enable setting ECOMM = POTT. Relay Word bit PT is then an input into the POTT logic in *Figure 5.6* (for echo keying).



① Figure 5.6.

Figure 5.5 Permissive Input Logic Routing to POTT Logic

Also note that SELOGIC control equation setting PT1 in *Figure 5.7* is routed to control Relay Word bit PTRX if enable setting ECOMM = POTT. Relay Word bit PTRX is then the permissive trip receive input into the trip logic in *Figure 5.1*.

Timer Settings

See *Section 9: Setting the SEL-351R Recloser Control* for setting ranges.

Z3RBD—Zone (Level) 3 Reverse Block Delay

Current-reversal guard timer—typically set at 5 cycles.

EBLKD—Echo Block Delay

Prevents echoing of received PT for settable delay after dropout of local permissive elements in trip setting TRCOMM—typically set at 10 cycles. Set to OFF to defeat EBLKD.

ETDPU—Echo Time Delay Pickup

Sets minimum time requirement for received PT, before echo begins—typically set at 2 cycles. Set to OFF for no echo.

EDURD—Echo Duration

Limits echo duration, to prevent channel lockup—typically set at 3.5 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.27* for more information on output contacts.

Z3RB—Zone (Level) 3 Reverse Block

Current-reversal guard asserted (operates as an input into the trip logic in *Figure 5.1* and the DCUB logic in *Figure 5.10*).

ECTT—Echo Conversion to Trip

PT received, converted to a trip condition for a Weak-Infeed Condition (operates as an input into the trip logic in *Figure 5.1*).

KEY—Key Permissive Trip

Signals communications equipment to transmit permissive trip. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **KEY**

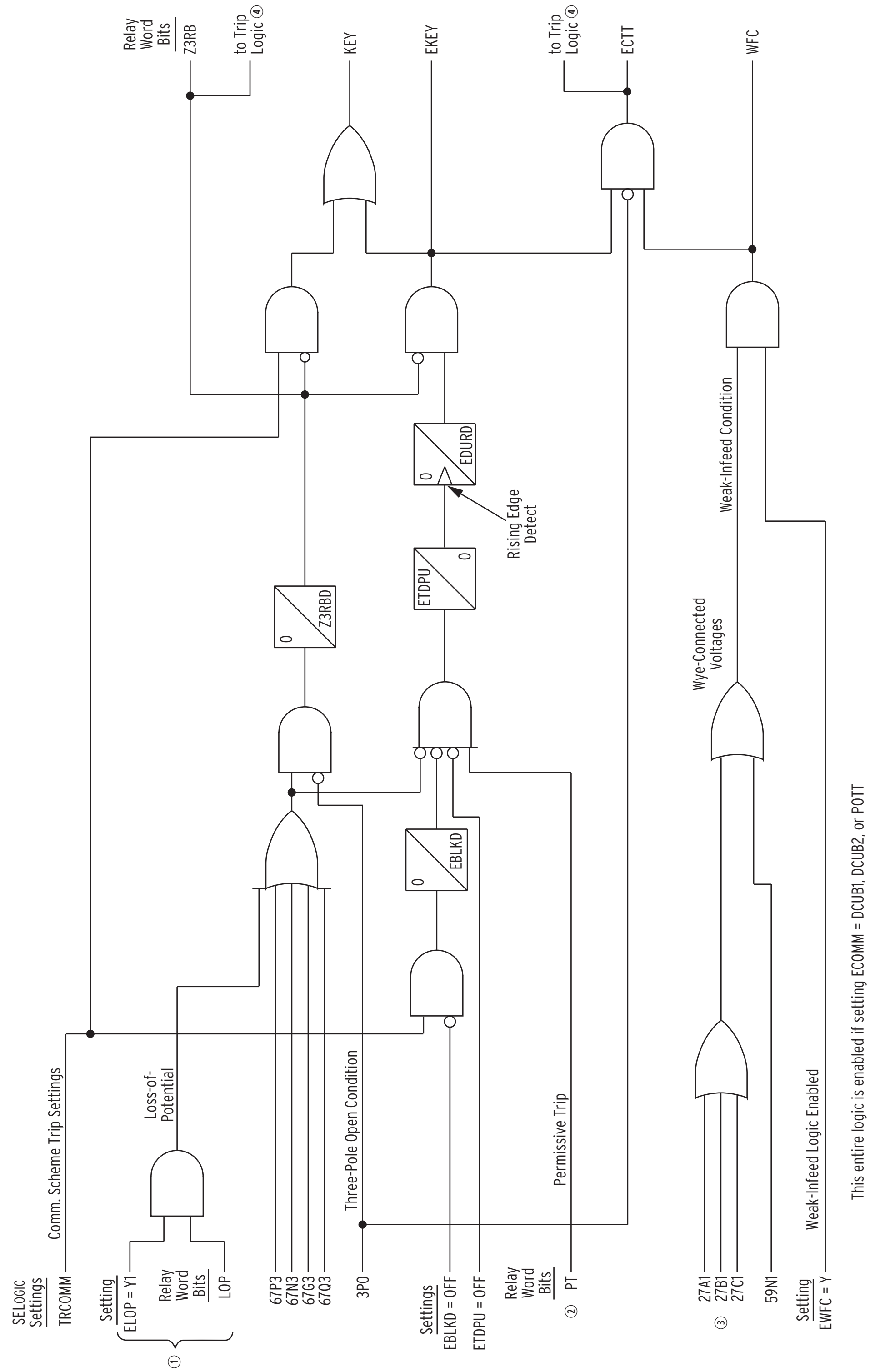
Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.8*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.9*):

OUT107 = **KEY**

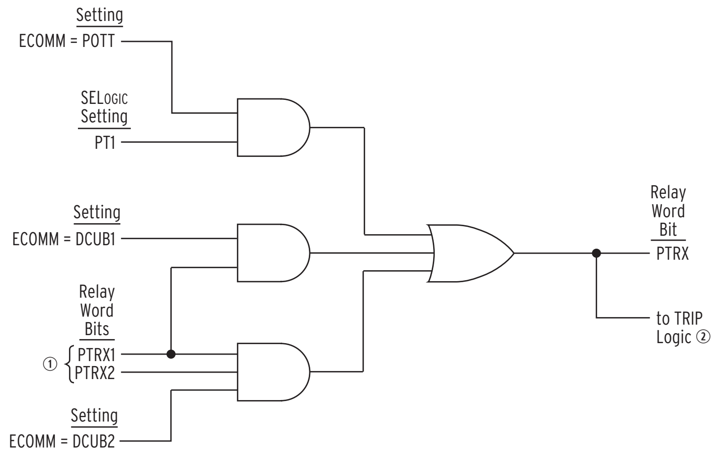
EKEY—Echo Key Permissive Trip

Permissive trip signal keyed by Echo logic (used in testing).



① From Figure 4.1; ② from Figure 5.5; ③ see Table 3.8; ④ Figure 5.1.

Figure 5.6 POTT Logic



① Figure 5.10; ② Figure 5.1.

Figure 5.7 Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to *Figure 5.4* and *Figure 5.6*. In a PUTT scheme, keying is provided by Level 1 underreaching overcurrent elements (set direction forward), instead of with Relay Word bit KEY. This is accomplished by setting output contact **OUT105** with these elements:

67P1 Level 1 directional phase instantaneous overcurrent element

67N1 Level 1 directional neutral ground instantaneous overcurrent element

67G1 Level 1 directional residual ground instantaneous overcurrent element

67Q1 Level 1 directional negative-sequence instantaneous overcurrent element

instead of with element KEY (see *Figure 5.8*):

NOTE: Only use enabled elements.

OUT105 = **67P1 + 67N1 + 67G1 + 67Q1**

If echo keying is desired, add the echo key permissive trip logic output, as follows:

OUT105 = **67P1 + 67N1 + 67G1 + 67Q1 + EKEY**

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.9*).

Installation Variations

Figure 5.9 shows output contacts **OUT105** and **OUT107** connected to separate communications equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (**TX**) on the communications equipment in *Figure 5.9*. Then output contact **OUT107** can be used for another function.

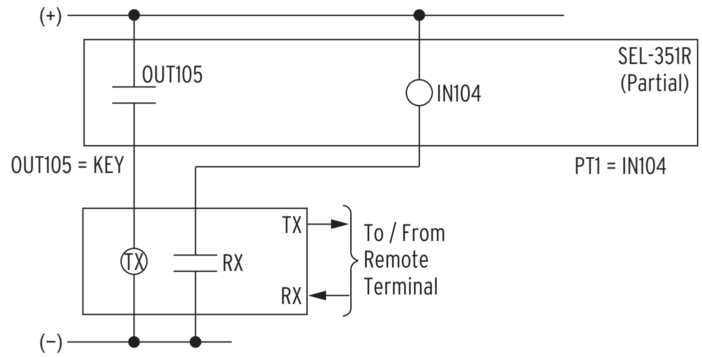


Figure 5.8 SEL-351R Recloser Control Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

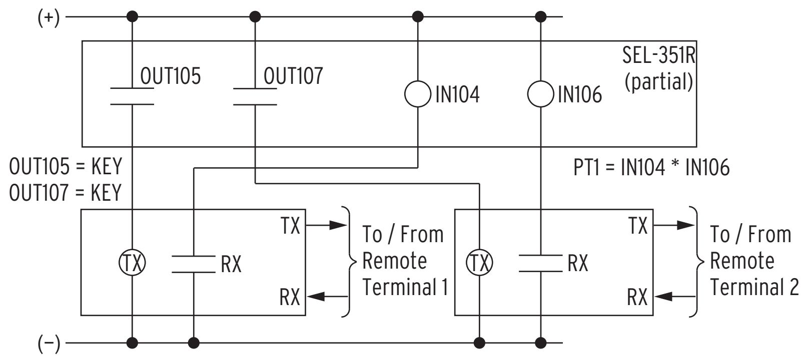


Figure 5.9 SEL-351R Recloser Control Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

Directional Comparison Unblocking (DCUB) Logic

Enable the DCUB logic by setting ECOMM = DCUB1 or ECOMM = DCUB2. The DCUB logic in *Figure 5.10* is an extension of the POTT logic in *Figure 5.6*. Thus, the control requires *all* the POTT settings and logic, *plus* exclusive DCUB settings and logic. The difference between setting choices DCUB1 and DCUB2 is:

DCUB1 directional comparison unblocking scheme for two-terminal line (communications from *one* remote terminal)

DCUB2 directional comparison unblocking scheme for three-terminal line (communications from *two* remote terminals)

The DCUB logic in *Figure 5.10* takes in the loss-of-guard and permissive trip outputs from the communication receivers (see *Figure 5.12* and *Figure 5.13*) and makes permissive (PTRX1/PTRX2) and unblocking block (UBB1/UBB2) logic output decisions.

DCUB schemes are typically implemented with FSK (frequency shift carrier) or analog microwave as the communications medium.

Use Existing SEL-321 Relay DCUB Application Guide for the SEL-351R Recloser Control

Use the existing SEL-321 Relay DCUB application guide (AG96-19) to help set up the SEL-351R in a DCUB scheme (see *Communications-Assisted Trip Logic—General Overview* for more setting comparison information on the SEL-321/SEL-351R).

External Inputs

See *Optoisolated Inputs on page 7.1* for more information on optoisolated inputs.

PT1, PT2—Received Permissive Trip Signal(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a permissive trip signal is received from *one* remote terminal. One optoisolated input on the SEL-351R (e.g., input IN104) is driven by a communications equipment receiver output (see *Figure 5.12*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), permissive trip signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-351R (e.g., inputs IN104 and IN106) are driven by communications equipment receiver outputs (see *Figure 5.13*). Make SELOGIC control equation settings PT1 and PT2 as follows:

PT1 = **IN104** (three-terminal line application)

PT2 = **IN106**

SELOGIC control equation settings PT1 and PT2 are routed into the DCUB logic in *Figure 5.10* for “unblocking block” and “permissive trip receive” logic decisions.

As explained in *Permissive Overreaching Transfer Trip (POTT) Logic*, the SELOGIC control equation settings PT1 and PT2 in *Figure 5.5* are routed in various combinations to control Relay Word bit PT, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit PT is then an input into the POTT logic in *Figure 5.6* (for echo keying).

LOG1, LOG2—Loss-of-Guard Signal(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a loss-of-guard signal is received from *one* remote terminal. One optoisolated input on the SEL-351R (e.g., input IN105) is driven by a communications equipment receiver output (see *Figure 5.12*). Make SELOGIC control equation setting LOG1:

LOG1 = **IN105** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), loss-of-guard signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-351R (e.g., input IN105 and IN107) are driven by communications equipment receiver outputs (see *Figure 5.13*). Make SELOGIC control equation settings LOG1 and LOG2 as follows:

LOG1 = **IN105** (three-terminal line application)

LOG2 = **IN107**

SELOGIC control equation settings LOG1 and LOG2 are routed into the DCUB logic in *Figure 5.10* for “unblocking block” and “permissive trip receive” logic decisions.

Timer Settings

See *Section 9: Setting the SEL-351R Recloser Control* for setting ranges.

GARD1D—Guard-Present Delay

Sets minimum time requirement for reinstating permissive tripping following a loss-of-channel condition—typically set at 10 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

UBDURD—DCUB Disable Delay

Prevents tripping by POTT logic after a settable time following a loss-of-channel condition—typically set at 9 cycles (150 ms). Channel 1 and 2 logic use separate timers but have this same delay setting.

UBEND—DCUB Duration Delay

Sets minimum time required to declare a loss-of-channel condition—typically set at 0.5 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

Logic Outputs

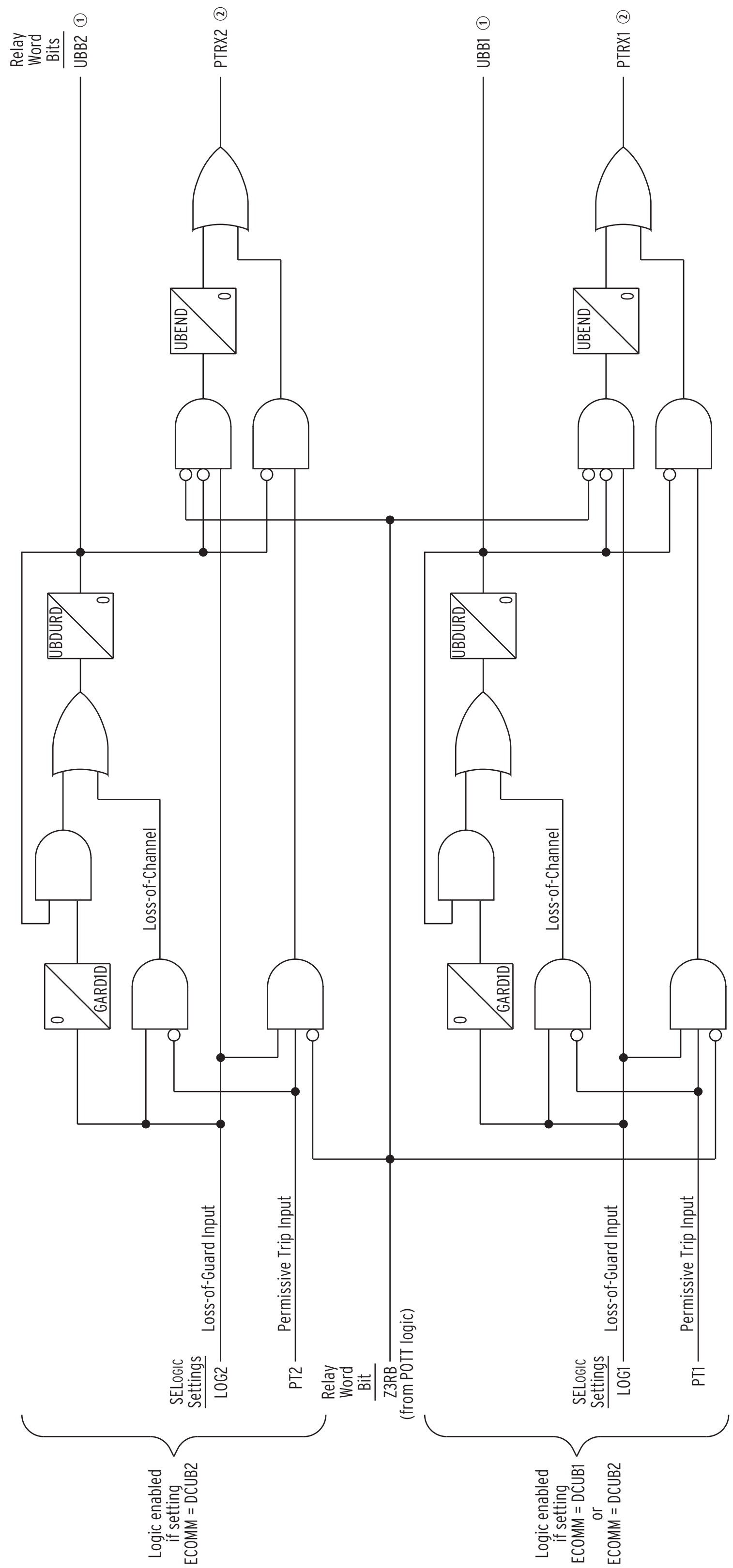
The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.27* for more information on output contacts.

UBB1, UBB2—Unblocking Block Output(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), UBB1 disables tripping if the loss-of-channel condition continues for longer than time UBDURD.

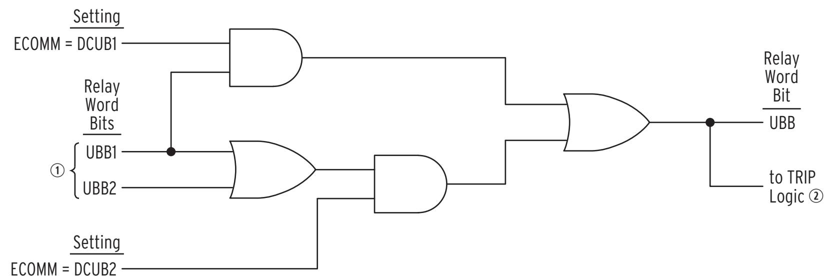
In three-terminal line DCUB applications (setting ECOMM = DCUB2), UBB1 or UBB2 disable tripping if the loss-of-channel condition (for the respective Channel 1 or 2) continues for longer than time UBDURD.

The UBB1 and UBB2 are routed in various combinations in *Figure 5.11* to control Relay Word bit UBB, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit UBB is the unblock block input into the trip logic in *Figure 5.1*. When UBB asserts to logical 1, tripping is blocked.



① To Figure 5.11; ② to Figure 5.7.

Figure 5.10 DCUB Logic



① From Figure 5.10; ② Figure 5.1.

Figure 5.11 Unblocking Block Logic Routing to Trip Logic

PTRX1, PTRX2—Permissive Trip Receive Outputs

In two-terminal line DCUB applications (setting ECOMM = DCUB1), PTRX1 asserts for loss-of-channel or an actual received permissive trip.

In three-terminal line DCUB applications (setting ECOMM = DCUB2), PTRX1 or PTRX2 assert for loss-of-channel or an actual received permissive trip (for the respective Channel 1 or 2).

The PTRX1/PTRX2 Relay Word bits are then routed in various combinations in *Figure 5.7* to control Relay Word bit PTRX, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit PTRX is the permissive trip receive input into the trip logic in *Figure 5.1*.

Installation Variations

Figure 5.13 shows output contacts OUT105 and OUT107 connected to separate communications equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (TX) on the communications equipment in *Figure 5.13*. Then output contact OUT107 can be used for another function.

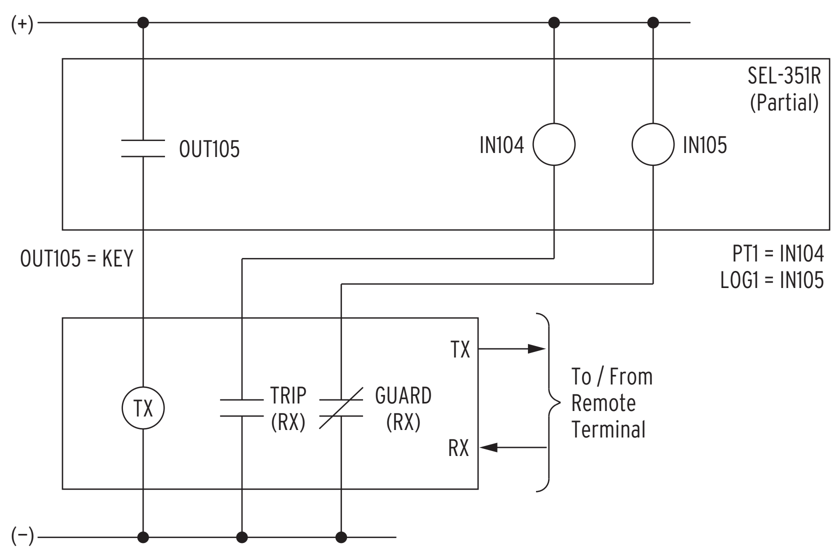


Figure 5.12 SEL-351R Recloser Control Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

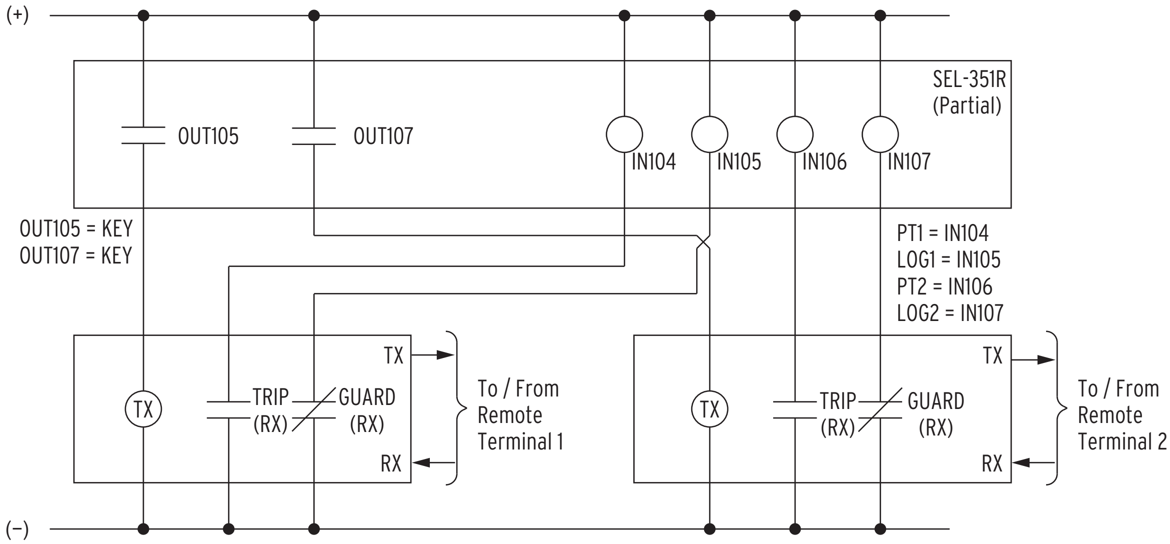


Figure 5.13 SEL-351R Recloser Control Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)

Directional Comparison Blocking (DCB) Logic

Enable the DCB logic by setting ECOMM = DCB. The DCB logic in *Figure 5.14* performs the following tasks:

- Provides the individual carrier coordination timers for the Level 2 directional overcurrent elements 67P2S, 67N2S, 67G2S, and 67Q2S. These delays allow time for the block trip signal to arrive from the remote terminal.
- Instantaneously keys the communications equipment to transmit block trip for reverse faults and extends this signal for a settable time following the dropout of all Level 3 directional overcurrent elements 67P3, 67N3, 67G3, and 67Q3.
- Latches the block trip send condition by the directional overcurrent following a close-in zero-voltage three-phase fault where the polarizing memory expires. Latch is removed when the polarizing memory voltage returns or current is removed.
- Extends the received block signal by a settable time.

Use Existing SEL-321 Relay DCB Application Guide for the SEL-351R Recloser Control

Use the existing SEL-321 Relay DCB application guide (AG93-06) to help set up the SEL-351R in a DCB scheme (see *Communications-Assisted Trip Logic—General Overview on page 5.7* for more setting comparison information on the SEL-321/SEL-351R).

External Inputs

See *Optoisolated Inputs on page 7.1* for more information on optoisolated inputs.

BT—Received Block Trip Signal(s)

In two-terminal line DCB applications, a block trip signal is received from *one* remote terminal. One optoisolated input on the SEL-351R (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.15*). Make SELOGIC control equation setting BT:

BT = **IN104** (two-terminal line application)

In three-terminal line DCB applications, block trip signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-351R (e.g., inputs **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.16*). Make SELOGIC control equation setting BT as follows:

BT = **IN104 + IN106** (three-terminal line application)

SELOGIC control equation setting BT is routed through a dropout timer (BTXD) in the DCB logic in *Figure 5.14*. The timer output, Relay Word bit BTX, is routed to the trip logic in *Figure 5.1*.

Timer Settings

See *Section 9: Setting the SEL-351R Recloser Control* for setting ranges.

Z3XPU—Zone (Level) 3 Reverse Pickup Time Delay

Current-reversal guard pickup timer—typically set at 1 cycle.

Z3XD—Zone (Level) 3 Reverse Dropout Extension

Current-reversal guard dropout timer—typically set at 5 cycles.

BTXD—Block Trip Receive Extension

Sets reset time of block trip received condition (BTX) after the reset of block trip input **BT**.

67P2SD, 67N2SD, 67G2SD, 67Q2SD—Level 2 Short Delay

Carrier coordination delays for the output of Level 2 overreaching overcurrent elements 67P2S, 67N2S, 67G2S, and 67Q2S, respectively—typically set at one cycle.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.27* for more information on output contacts.

DSTRT—Directional Carrier Start

Program an output contact for directional carrier start. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **DSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.16*):

OUT107 = **DSTRT**

DSTART includes current reversal guard logic.

NSTRT—Nondirectional Carrier Start

Program an output contact to include nondirectional carrier start, in addition to directional start. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **DSTRT + NSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.16*):

OUT107 = **DSTRT + NSTRT**

STOP—Stop Carrier

Program to an output contact to stop carrier. For example, SELOGIC control equation setting OUT106 is set:

OUT106 = **STOP**

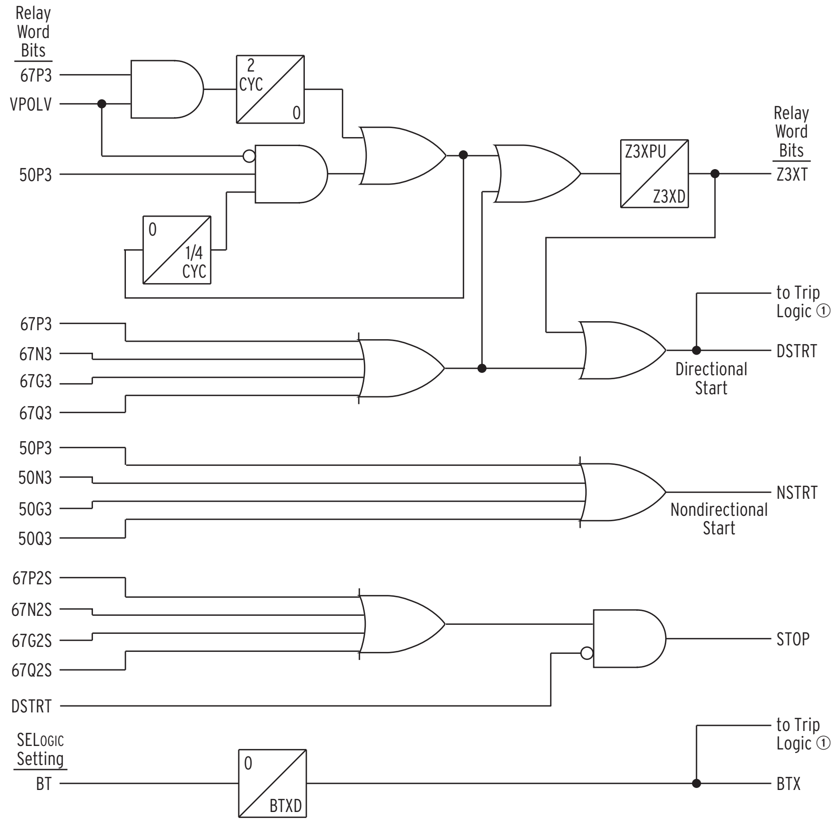
Output contact **OUT106** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT104** is set the same as **OUT106** (see *Figure 5.16*):

OUT104 = **STOP**

BTX—Block Trip Extension

The received block trip input (e.g., BT = IN104) is routed through a dropout timer (BTXD) in the DCB logic in *Figure 5.14*. The timer output (BTX) is routed to the trip logic in *Figure 5.1*.



① Figure 5.1.

Figure 5.14 DCB Logic

Installation Variations

Figure 5.16 shows output contacts OUT104–OUT107 connected to separate communications equipment for the two remote terminals. Both output contact pairs are programmed the same (OUT105 = DSTRT + NSTRT and OUT107 = DSTRT + NSTRT; OUT106 = STOP and OUT104 = STOP).

Depending on the installation, perhaps one output contact (e.g., OUT105 = DSTRT + NSTRT) can be connected in parallel to both START inputs on the communications equipment in *Figure 5.16*. Then output contact OUT107 can be used for another function.

Depending on the installation, perhaps one output contact (e.g., OUT106 = STOP) can be connected in parallel to both STOP inputs on the communications equipment in *Figure 5.16*. Then output contact OUT104 can be used for another function.

Figure 5.16 also shows communication equipment RX (receive) output contacts from each remote terminal connected to separate inputs IN104 and IN106 on the SEL-351R. The inputs operate as block trip receive inputs for the two remote terminals and are used in the SELOGIC control equation setting:

BT = **IN104 + IN106**

Depending on the installation, perhaps one input (e.g., IN104) can be connected in parallel to both communication equipment RX (receive) output contacts in *Figure 5.16*. Then setting BT would be programmed as follows:

BT = **IN104**

and input IN106 can be used for another function.

In *Figure 5.15* and *Figure 5.16*, the carrier scheme cutout switch contact (85CO) should be closed when the communications equipment is taken out of service so that the BT input of the relay remains asserted. An alternative to asserting the BT input is to change to a setting group where the DCB logic is not enabled.

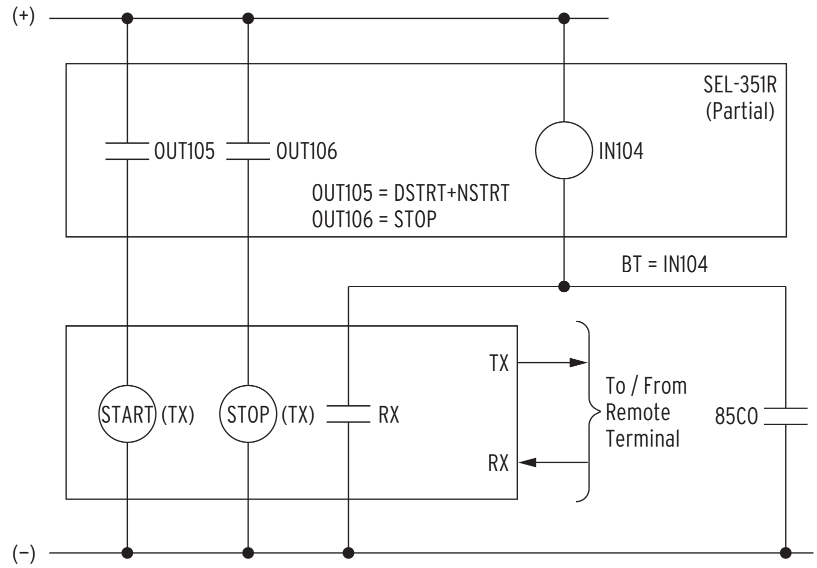


Figure 5.15 SEL-351R Recloser Control Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

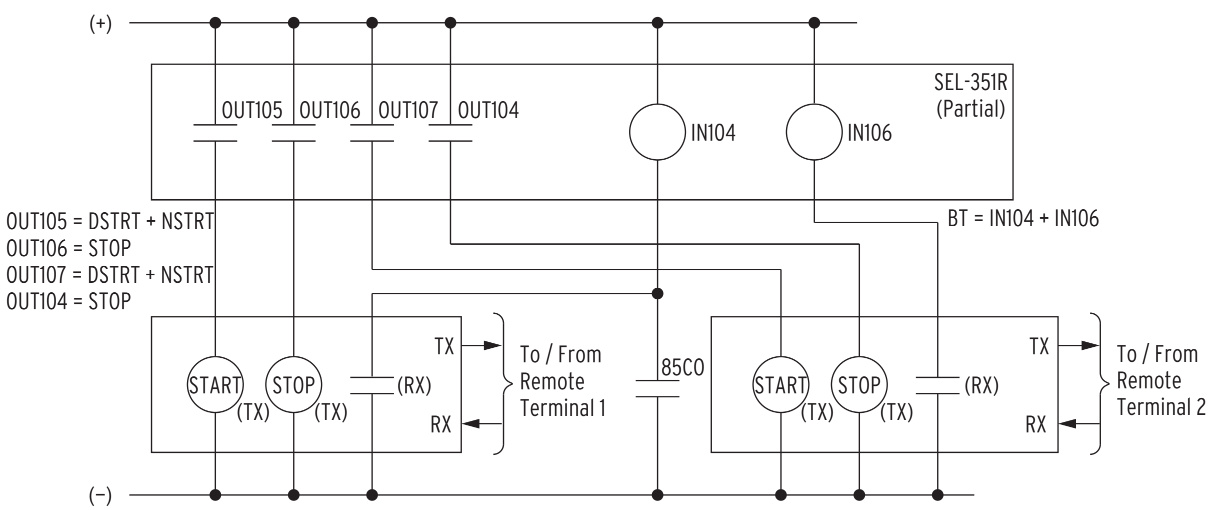


Figure 5.16 SEL-351R Recloser Control Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

Additional Front-Panel Status and Target LED Information

A, B, and C Target LEDs

A (Phase A) target LED is illuminated at the rising edge of trip if an overcurrent element causes the trip and Phase A is involved in the fault [likewise for B (Phase B) and C (Phase C) target LEDs]. SELOGIC control equation FAULT has to be picked up for three-phase fault indication.

A, B, and C phase targeting is more secure if both the following are true:

- True three-phase voltage is connected to the SEL-351R
- Setting 3PVOLT = Y is made (**SET G** command)

TARGET RESET/LAMP TEST Front-Panel Pushbutton

When the TARGET RESET/LAMP TEST front-panel pushbutton is pressed:

- All front-panel LEDs illuminate for 1 second.
- All latched target LEDs are extinguished (unlatched), unless a trip condition is present in which case the latched target LEDs reappear in their previous state.

Other Applications for the Target Reset Function

Refer to the bottom of *Figure 5.1*. The combination of the TARGET RESET pushbutton and the **TAR R** (Target Reset) serial port command is available as Relay Word bit TRGTR. Relay Word bit TRGTR pulses to logical 1 for one processing interval when either the TARGET RESET pushbutton is pushed or the **TAR R** (Target Reset) serial port command is executed.

Relay Word bit TRGTR can be used to unlatch logic. For example, refer to the breaker failure logic in *Figure 7.24*. If a breaker failure trip occurs (SV7T asserts), the occurrence can be displayed on the front panel with seal-in logic and a rotating default display (see *Rotating Default Display on page 7.29* and *Rotating Default Display on page 11.6*; see *Figure 5.17*).

SV8 = **(SV8 + SV7T) * !TRGTR**

DP3 = **SV8**

DP3_1 = **BREAKER FAILURE**

DP3_0 = (blank)

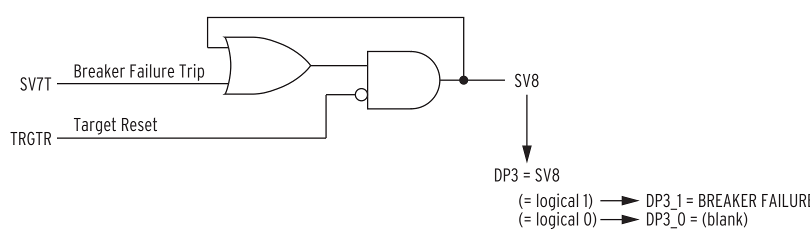


Figure 5.17 Seal-In of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in *Figure 5.17* to seal-in. Asserted SV8 in turn asserts DP3, causing the following message:

```
BREAKER FAILURE
```

to display in the rotating default display.

This message can be removed from the display rotation by pushing the **TARGET RESET** pushbutton (Relay Word bit TRGTR pulses to logical 1, unlatching SV8 and in turn deasserting DP3). Thus, front-panel rotating default displays can be easily reset along with the front-panel targets by pushing the **TARGET RESET** pushbutton.

SELOGIC Control Equation Setting FAULT

SELOGIC control equation setting FAULT has control over or is used in the following:

- Front-panel target LEDs **INST**, **A**, **B**, and **C**. See *A, B, and C Target LEDs on page 5.26*.
- Demand Meter—FAULT is used to suspend demand metering updating and peak recording. See *Demand Metering on page 8.21*.
- Maximum/Minimum Metering—FAULT is used to block Maximum/Minimum metering updating. See *Maximum/ Minimum Metering on page 8.29*.

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Section 6
Close and Reclose Logic

Overview

NOTE: Setting E79 = N defeats the reclosing relay, but does not defeat the ability of the close logic described in the first subsection (Figure 6.1) to close the circuit breaker for other close conditions via SELOGIC control equation setting CL (e.g., manual close initiation via serial port or optoisolated inputs).

This section is made up of three subsections.

Close Logic on page 6.1. This subsection describes the final logic that controls the close output (e.g., RCCL = CLOSE). This output closes the recloser for automatic reclosures and other close conditions (e.g., manual close initiation via serial port or optoisolated inputs).

If automatic reclosing is not needed, but the SEL-351R Recloser Control is to close the circuit breaker for other close conditions (e.g., manual close initiation via serial port or optoisolated inputs), then this subsection is the only subsection that needs to be read in this section (particularly the description of SELOGIC® control equation setting CL).

Reclose Supervision Logic on page 6.4. This subsection describes the logic that supervises automatic reclosing when an open interval time times out—a final condition check right before the close logic asserts the close output contact.

Reclosing Relay on page 6.9. This subsection describes all the reclosing relay settings and logic needed for automatic reclosing (besides the final close logic and reclose supervision logic described in the previous subsections).

The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1–4 are the number of desired automatic reclosures.

Close Logic

The close logic in *Figure 6.1* provides flexible circuit breaker closing/ automatic reclosing with SELOGIC control equation settings:

52A (breaker status)

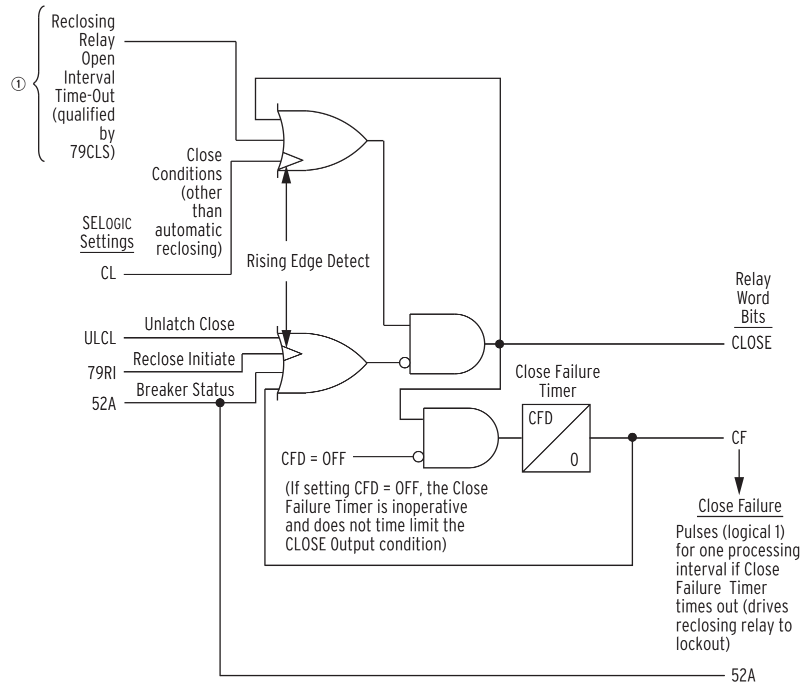
CL (close conditions, other than automatic reclosing)

ULCL (unlatch close conditions, other than circuit breaker status, close failure, or reclose initiation)

and setting:

CFD (Close Failure Time)

See the settings sheets in *Section 9: Setting the SEL-351R Recloser Control* for setting ranges.



① From Figure 6.2.

Figure 6.1 Close Logic

Set Close

If *all* the following are true:

- ➤ The unlatch close condition is not asserted (ULCL = logical 0).
- ➤ The circuit breaker is open (52A = logical 0).
- ➤ The reclose initiation condition (79RI) is not making a rising-edge (logical 0 to logical 1) transition.
- ➤ And a close failure condition does not exist (Relay Word bit CF = 0).

Then the CLOSE Relay Word bit can be asserted to logical 1 if either of the following occurs:

- ➤ A reclosing relay open interval times out (qualified by SELOGIC control equation setting 79CLS—see *Figure 6.2*).
- ➤ Or SELOGIC control equation setting CL goes from logical 0 to logical 1 (rising-edge transition).

Unlatch Close

If the CLOSE Relay Word bit is asserted at logical 1, it stays asserted at logical 1 until one of the following occurs:

- ➤ The unlatch close condition asserts (ULCL = logical 1).
- ➤ The circuit breaker closes (52A = logical 1).
- ➤ The reclose initiation condition (79RI) makes a rising-edge (logical 0 to logical 1) transition.
- ➤ Or the Close Failure Timer times out (Relay Word bit CF = 1).

The Close Failure Timer is inoperative if setting CFD = OFF.

Factory Settings Example

The factory settings for the close logic SELOGIC control equation settings are:

52A = **SW1 * !CLOSE**

CL = **PB8 * LT4 * LT7 + CC * LT7**

ULCL = **TRIP + !PINF * SW1 + ! (LT7 + CLOSE) + ! (LT4 + CLOSE + CC + 79CY)**

The factory setting for the Close Failure Timer setting is:

CFD = **60.00 cycles**

With setting CFD = 60.00 cycles, once the CLOSE Relay Word bit asserts, it remains asserted at logical 1 no longer than a *maximum* of 60 cycles. If the Close Failure Timer times out, Relay Word bit CF asserts to logical 1, forcing the CLOSE Relay Word bit to logical 0.

Defeat the Close Logic

If SELOGIC control equation circuit breaker auxiliary setting 52A is set with numeral 0 (52A = 0), then the close logic is inoperable. Also, the reclosing relay is defeated (see *Reclosing Relay on page 6.9*).

Circuit Breaker Status

Refer to the bottom of *Figure 6.1*. Note that SELOGIC control equation setting 52A (circuit breaker status) is available as Relay Word bit 52A. This makes for convenience in setting other SELOGIC control equations. For example, if the following setting is made:

52A = **IN101** (52a auxiliary contact wired to input **IN101**)

or

52A = **!IN101** (52b auxiliary contact wired to input **IN101**)

then if breaker status is used in other SELOGIC control equations, it can be entered as 52A—the user does not have to enter IN101 (for a 52a) or !IN101 (for a 52b). For example, refer to *Rotating Default Display on page 7.29*. In the factory settings, circuit breaker status indication is controlled by display point setting DP2:

DP2 = **IN101**

This can be entered instead as:

DP2 = **52A**

(presuming SELOGIC control equation setting 52A = IN101 is made).

Program an Output for Closing

In the factory settings, the resultant of the close logic in *Figure 6.1* is routed to high voltage FET CLOSE output with the following SELOGIC control equation:

RCCL = **CLOSE** (see *Figure 7.29*)

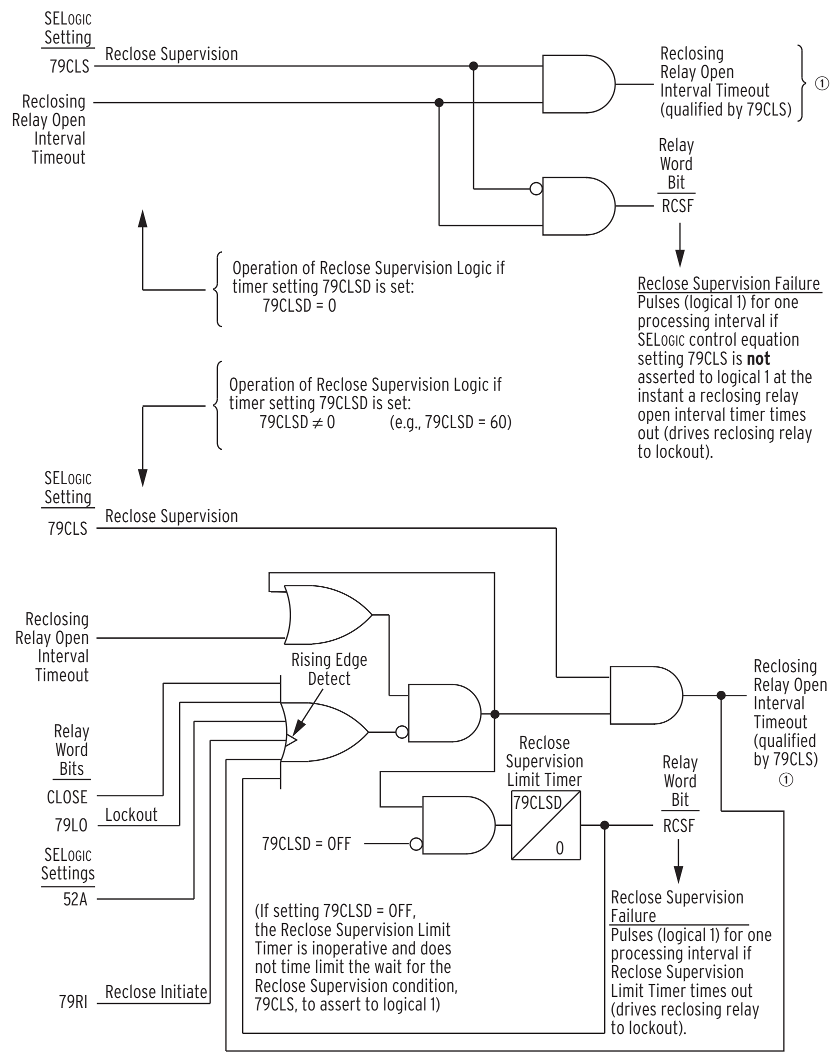
See *Output Contacts on page 7.27* for more information on programming additional output contacts.

Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 6.1* is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input into the close logic in *Figure 6.1* is the indication that a reclosing relay open interval has timed out (see *Figure 6.6*), a qualifying condition (SELOGIC control equation setting 79CLS) has been met, and thus, automatic reclosing of the circuit breaker should proceed by asserting the CLOSE Relay Word bit to logical 1. This input into the close logic in *Figure 6.1* is an output of the reclose supervision logic in the following *Figure 6.2*.



① To Figure 6.1.

Figure 6.2 Reclose Supervision Logic (Following Open Interval Time-Out)

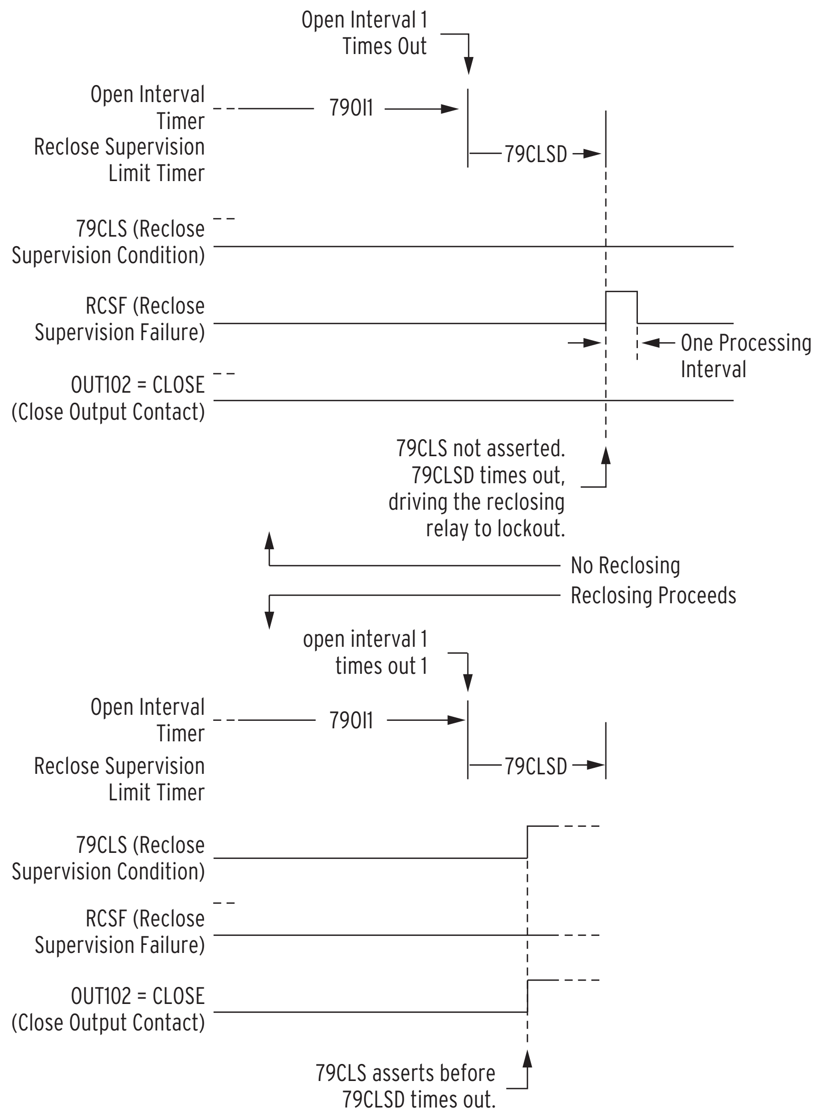


Figure 6.3 Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.2)

Settings and General Operation

Figure 6.2 contains the following SELOGIC control equation setting:

79CLS (reclose supervision conditions—checked after reclosing relay open interval time-out)

and setting:

79CLSD (Reclose Supervision Limit Time)

See the *SEL-351R Recloser Control Settings Sheets* for setting ranges.

Reclose Supervision Limit Time = 0 (Top of Figure 6.2)

79CLSD = **0.00**

With this setting, the logic in the top of *Figure 6.2* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is *checked just once*.

If 79CLS is *asserted* to logical 1 at the instant of an open interval time-out, then the now-qualified open interval time-out will propagate onto the final close logic in *Figure 6.1* to automatically reclose the circuit breaker.

If 79CLS is *deasserted* to logical 0 at the instant of an open interval time-out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to the Lockout State.

See *Factory Settings Example on page 6.3* and *Settings Example 1 on page 6.7*.

Reclose Supervision Limit Time > 0 (Bottom of Figure 6.2 and Figure 6.3)

e.g., 79CLSD = **60.00**

With this setting, the logic in the bottom of *Figure 6.2* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is then *checked for a time window* equal to setting 79CLSD.

If 79CLS *asserts* to logical 1 at any time during this 79CLSD time window, then the now-qualified open interval time-out will propagate onto the final close logic in *Figure 6.1* to automatically reclose the circuit breaker.

If 79CLS remains *deasserted* to logical 0 during this entire 79CLSD time window, when the time window times out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to the Lockout State.

The logic in the bottom of *Figure 6.2* is explained in more detail in the following text.

Set Reclose Supervision Logic (Bottom of Figure 6.2)

Refer to the bottom of *Figure 6.2*. If *all* the following are true:

- The close logic output CLOSE (also see *Figure 6.1*) is *not* asserted (Relay Word bit CLOSE = logical 0)
- The reclosing relay is *not* in the Lockout State (Relay Word bit 79LO = logical 0).
- The circuit breaker is open (52A = logical 0)
- The reclose initiation condition (79RI) is *not* making a rising-edge (logical 0 to logical 1) transition
- The Reclose Supervision Limit Timer is *not* timed out (Relay Word bit RCSF = logical 0)

then a reclosing relay open interval time-out seals. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 6.2* and on to the close logic in *Figure 6.1*.

Unlatch Reclose Supervision Logic (Bottom of Figure 6.2)

Refer to the bottom of *Figure 6.2*. If the reclosing relay open interval time-out condition is sealed-in, it stays sealed-in until *one* of the following occurs:

- ➤ The close logic output CLOSE (also see *Figure 6.1*) asserts (Relay Word bit CLOSE = logical 1).
- ➤ The reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1).
- ➤ The circuit breaker closes (52A = logical 1).
- ➤ The reclose initiation condition (79RI) makes a rising-edge (logical 0 to logical 1) transition.
- ➤ SELOGIC control equation setting 79CLS asserts (79CLS = logical 1).
- ➤ Or the Reclose Supervision Limit Timer times out (Relay Word bit RCSF = logical 1 for one processing interval).

The Reclose Supervision Limit Timer is inoperative if setting 79CLSD = OFF. With 79CLSD = OFF, reclose supervision condition 79CLS is not time limited. When an open interval times out, reclose supervision condition 79CLS is checked indefinitely until one of the other above unlatch conditions comes true.

The unlatching of the sealed-in reclosing relay open interval time-out condition by the assertion of SELOGIC control equation setting 79CLS indicates successful propagation of a reclosing relay open interval time-out condition on to the close logic in *Figure 6.1*.

See *Settings Example 2 on page 6.9*.

Settings Example 1

Refer to the top of *Figure 6.2* and *Figure 6.4*.

SEL-351R recloser controls are installed at both ends of a transmission line in a high-speed reclose scheme. After both circuit breakers open for a transmission line fault, the SEL-351R(1) recloses circuit breaker 52/1 first, followed by the SEL-351R(2) reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

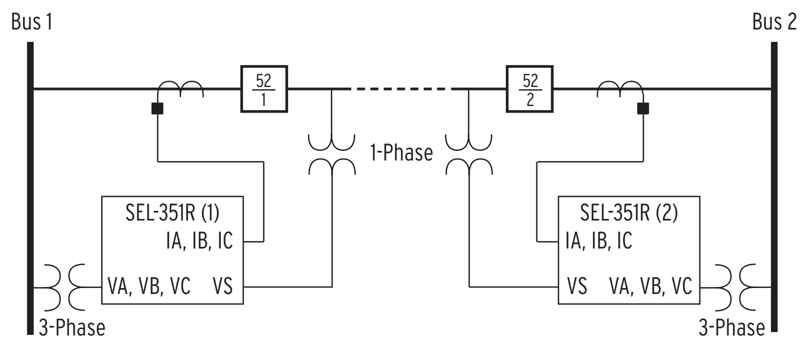


Figure 6.4 SEL-351R Recloser Controls Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-351R(1) Recloser Control

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-351R(1) checks that Bus 1 voltage is hot and the transmission line voltage is dead. This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **3P59 * 27S**

where:

3P59 = all three Bus 1 phase voltages (**VA**, **VB**, and **VC**) are hot

27S = monitored single-phase transmission line voltage (channel **VS**) is dead

SEL-351R(2) Recloser Control

The SEL-351R(2) checks that Bus 2 voltage is hot, the transmission line voltage is hot, and in synchronism after the reclosing relay open interval times out, before allowing circuit breaker 52/2 to be reclosed. This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **25A1**

where:

25A1 = selected Bus 2 phase voltage (**VA**, **VB**, or **VC**) is in synchronism with monitored single-phase transmission line voltage (channel **VS**) and both are hot

Other Setting Considerations for SEL-351R(1) and SEL-351R(2) Recloser Controls

Refer to *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, respectively) on page 6.18.*

SELOGIC control equation setting 79STL stalls open interval timing if it asserts to logical 1. If setting 79STL is deasserted to logical 0, open interval timing can continue.

The SEL-351R(1) has no intentional open interval timing stall condition (circuit breaker 52/1 closes first after a transmission line fault):

79STL = **0** (numeral 0)

The SEL-351R(2) starts open interval timing after circuit breaker 52/1 at the remote end has re-energized the line. The SEL-351R(2) has to see Bus 2 hot, transmission line hot, and in synchronism across open circuit breaker 52/2 for open interval timing to begin. Thus, SEL-351R(2) open interval timing is stalled when the transmission line voltage and Bus 2 voltage are not in synchronism across open circuit breaker 52/2:

79STL = **!25A1** [=NOT(25A1)]

A transient synchronism-check condition across open circuit breaker 52/2 could possibly occur if circuit breaker 52/1 recloses into a fault on one phase of the transmission line. The other two unfaulted phases would be briefly energized until circuit breaker 52/1 is tripped again. If channel **VS** of the SEL-351R(2) Recloser Control is connected to one of these briefly energized phases, synchronism-check element 25A1 could momentarily assert to logical 1.

So that this possible momentary assertion of synchronism-check element 25A1 does not cause any inadvertent reclose of circuit breaker 52/2, make sure the open interval timers in the SEL-351R(2) are set with some appreciable time greater than the momentary energization time of the faulted transmission line. Or, run the synchronism-check element 25A1 through a programmable timer before using it in the preceding 79CLS and 79STL settings for the SEL-351R(2) (see *Figure 7.23* and *Figure 7.24*). Note the built-in three-cycle qualification of the synchronism-check voltages shown in *Figure 3.24*.

Settings Example 2

Refer to *Synchronism-Check Elements on page 3.28*. Also, refer to *Figure 6.3* and *Figure 6.4*.

If the synchronizing voltages across open circuit breaker 52/2 are "slipping" with respect to one another, the Reclose Supervision Limit Timer setting 79CLSD should be set greater than zero so there is time for the slipping voltages to come into synchronism. For example:

79CLSD = **60.00 cycles**

79CLS = **25A1**

The status of synchronism-check element 25A1 is checked continuously during the 60-cycle window. If the slipping voltages come into synchronism while timer 79CLSD is timing, synchronism-check element 25A1 asserts to logical 1 and reclosing proceeds.

In the above referenced *Synchronism-Check Elements on page 3.28*, note item 3 under *Voltages V_P and V_S Are "Slipping" on page 3.35*. Item 3 describes a last attempt for a synchronism-check reclose before timer 79CLSD times out (or setting 79CLSD = 0.00 and only one check is made).

Reclosing Relay

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 6.2* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 6.1* to automatically reclose a circuit breaker. The explanation that follows in this reclosing relay subsection describes all the reclosing relay settings and logic that eventually result in this open interval time-out logic input into *Figure 6.2*. Other aspects of the reclosing relay are also explained. Up to four automatic reclosures (shots) are available.

The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1–4 are the number of desired automatic reclosures (see *Open Interval Timers on page 6.12*).

Reclosing Relay States and General Operation

Figure 6.5 explains in general the different states of the reclosing relay and its operation.

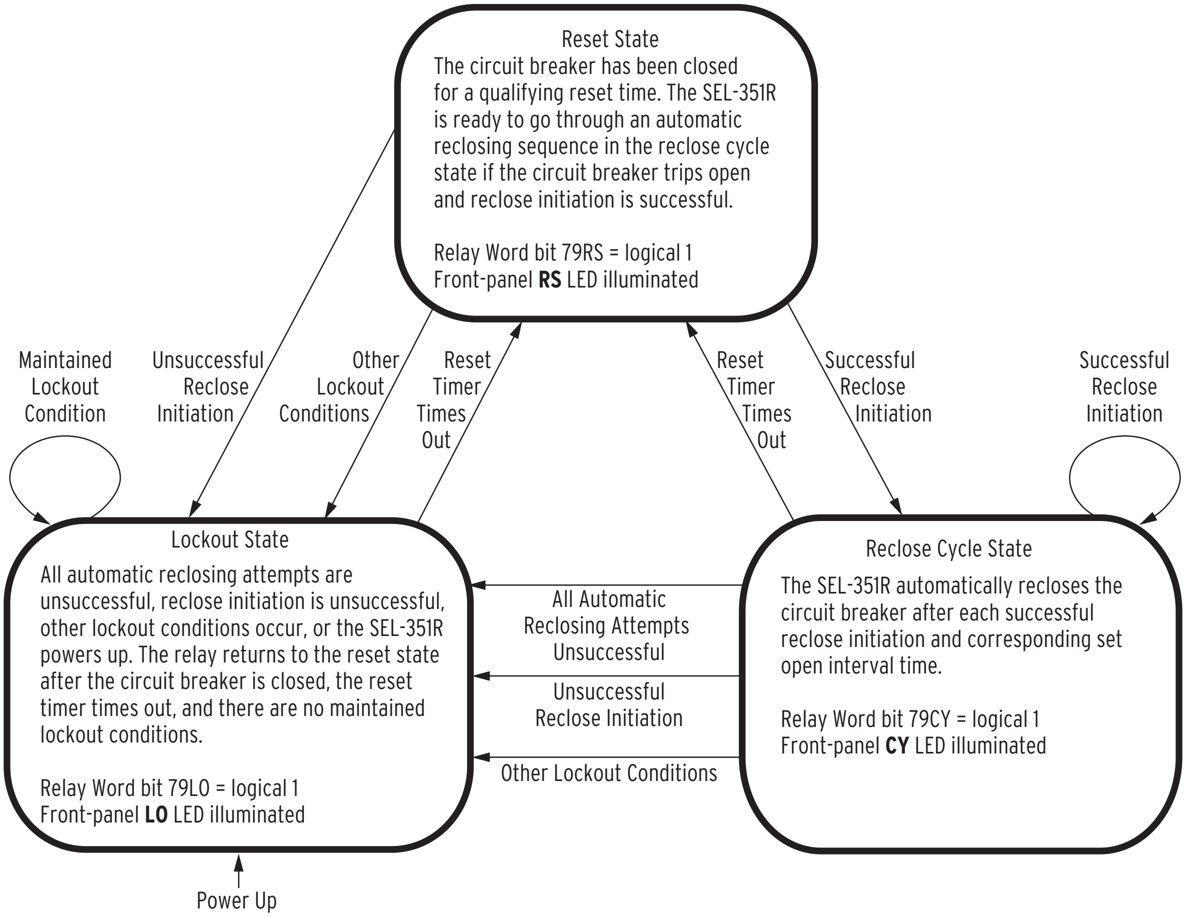


Figure 6.5 Reclosing Relay States and General Operation

Table 6.1 Relay Word Bit and Front-Panel Correspondence to Reclosing Relay States

Reclosing Relay State	Corresponding Relay Word Bit	Corresponding Front-Panel LED
Reset	79RS	RS
Reclose Cycle	79CY	CY
Lockout	79LO	LO

The reclosing relay is in one (and only one) of these states (listed in *Table 6.1*) at any time. When in a given state, the corresponding Relay Word bit asserts to logical 1, and the LED illuminates. Automatic reclosing only takes place when the relay is in the Reclose Cycle State.

Lockout State

The reclosing relay goes to the Lockout State if any *one* of the following occurs:

- The shot counter is equal to or greater than the last shot at time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see *Figure 6.6*).
- Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS [see *Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, respectively) on page 6.15*].

- The circuit breaker opens without reclose initiation (e.g., an external trip).
- The shot counter is equal to or greater than last shot, and the circuit breaker is open (e.g., the shot counter is driven to last shot with SELOGIC control equation setting 79DLS while open interval timing is in progress). See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, respectively) on page 6.17*.
- The close failure timer (setting CFD) times out (see *Figure 6.1*).
- SELOGIC control equation setting 79DTL = logical 1 [see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, respectively)*].
- The Reclose Supervision Limit Timer (setting 79CLSD) times out (see *Figure 6.2* and top of *Figure 6.3*).

Reclosing Relay States and Settings/ Setting Group Changes

If individual settings are changed for the active setting group *or* the active setting group is changed, *all* of the following occur:

- The reclosing relay remains in the state it was in before the settings change.
- The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- The reset timer is loaded with reset time setting 79RSLD (see discussion on reset timing later in this section).

If the relay happened to be in the Reclose Cycle State and was timing on an open interval before the settings change, the relay would be in the Reclose Cycle State after the settings change, but the relay would immediately go to the Lockout State. This is because the breaker is open and the relay is at last shot after the settings change, so no more automatic reclosures are available.

If the circuit breaker remains closed through the settings change, the reset timer times out on reset time setting 79RSLD after the settings change and goes to the Reset State (if it is not already in the Reset State), and the shot counter returns to shot = 0. If the relay happens to trip during this reset timing, the SEL-351R will immediately go to the Lockout State, because shot = last shot.

Defeat the Reclosing Relay

If *any one* of the following reclosing relay settings are made:

- Reclose enable setting E79 = N.
- Open Interval 1 time setting 79OI1 = 0.00.

then the reclosing relay is defeated, and no automatic reclosing can occur. These settings are explained later in this section. See also the *SEL-351R Recloser Control Settings Sheets*.

If the reclosing relay is defeated, the following also occur:

- All three reclosing relay state Relay Word bits (79RS, 79CY, and 79LO) are forced to logical 0 (see *Table 6.1*).
- All shot counter Relay Word bits (SH0, SH1, SH2, SH3, and SH4) are forced to logical 0 (the shot counter is explained later in this section).
- The front-panel LEDs **RS**, **CY**, and **LO** are all extinguished—a ready indication that the recloser is defeated.

Close Logic Can Still Operate When the Reclosing Relay Is Defeated

If the reclosing relay is defeated, the close logic (see *Figure 6.1*) can still operate if SELOGIC control equation circuit breaker status setting 52A is set to something other than numeral 0. Making the setting 52A = 0 defeats the close logic *and* also defeats the reclosing relay.

For example, if 52A = IN101, a 52a circuit breaker auxiliary contact is connected to input **IN101**. If the reclosing relay does not exist, the close logic still operates, allowing closing to take place via SELOGIC control equation setting CL (close conditions, other than automatic reclosing). See *Close Logic on page 6.1* for more discussion on SELOGIC control equation settings 52A and CL. Also see *Optoisolated Inputs on page 7.1* for more discussion on SELOGIC control equation setting 52A.

Reclosing Relay Timer Settings

The open interval and reset timer factory settings are shown in *Table 6.2*:

Table 6.2 Reclosing Relay Timer Settings and Setting Ranges

Timer Setting (range)	Factory Setting (in cycles)	Definition
79OI1 (0.00–999999 cyc)	300.00	open interval 1 time
79OI2 (0.00–999999 cyc)	600.00	open interval 2 time
79OI3 (0.00–999999 cyc)	600.00	open interval 3 time
79OI4 (0.00–999999 cyc)	0.00	open interval 4 time
79RSD (0.00–999999 cyc)	1800.00	reset time from reclose cycle state
79RSLD (0.00–999999 cyc)	600.00	reset time from lockout state

The operation of these timers is affected by SELOGIC control equation settings discussed later in this section. Also, see the *SEL-351R Recloser Control Settings Sheets*.

Open Interval Timers

The reclose enable setting, E79, determines the number of open interval time settings that can be set. For example, if setting E79 = 3, the first three open interval time settings in *Table 6.2*, are made available for setting.

If an open interval time is set to zero, then that open interval time is not operable, and neither are the open interval times that follow it.

In the factory settings in *Table 6.2*, the open interval 4 time setting 79OI4 is the first open interval time setting set equal to zero:

79OI4 = **0.00 cycles**

Thus, open interval time 79OI4 is not operable. In the factory settings, open interval time 79OI4 is set to zero. But if the settings were:

79OI3 = **0.00 cycles**

79OI4 = **900.00 cycles** (set to some value other than zero)

both open interval time 79OI3 and 79OI4 would be inoperative, because a preceding open interval time is set to zero (i.e., 79OI3 = 0.00).

If open interval 1 time setting, 79OI1, is set to zero (79OI1 = 0.00 cycles), no open interval timing takes place, and the reclosing relay is defeated.

The open interval timers time consecutively; they do not have the same beginning time reference point. In the above factory settings, open interval 1 time setting, 79OI1, times first. If the subsequent first reclosure is not successful, then open interval 2 time setting, 79OI2, starts timing. If the subsequent second reclosure is not successful, the relay goes to the Lockout State. See the example time line in *Figure 6.6*.

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing [see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, respectively)*].

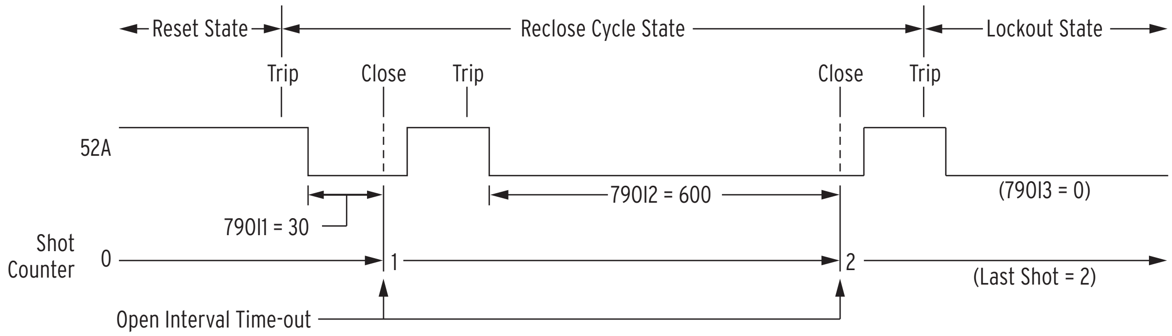


Figure 6.6 Reclosing Sequence From Reset to Lockout With Example Settings

Determination of Number of Reclosures (Last Shot)

The number of reclosures is equal to the number of open interval time settings that precede the first open interval time setting set equal to zero. The "last shot" value is also equal to the number of reclosures.

In the above factory settings, three set open interval times precede open interval 4 time, which is set to zero (79OI4 = 0.00):

79OI1 = **300.00**

79OI2 = **600.00**

79OI3 = **600.00**

79OI4 = **0.00**

For this example:

Number of reclosures (last shot) = 3 = the number of set open interval times that precede the first open interval set to zero.

Observe Shot Counter Operation

Observe the reclosing relay shot counter operation, especially during testing, with the front-panel shot counter screen (accessed via the **OTHER** pushbutton). See *Functions Unique to the Front-Panel Interface on page 11.1*.

Reset Timer

The reset timer qualifies circuit breaker closure before taking the relay to the Reset State from the Reclose Cycle State or the Lockout State. Circuit breaker status is determined by the SELOGIC control equation setting 52A. (See *Close Logic* for more discussion on SELOGIC control equation setting 52A. Also see *Optoisolated Inputs on page 7.1* for more discussion on SELOGIC control equation setting 52A.)

Setting 79RSD:

Qualifies closures when the SEL-351R is in the Reclose Cycle State. These closures are usually automatic reclosures resulting from open interval time-out.

It is also the reset time used in sequence coordination schemes [see *Sequence Coordination Setting (79SEQ)*].

Setting 79RSLD:

Qualifies closures when the relay is in the Lockout State. These closures are usually manual closures. These manual closures can originate external to the SEL-351R, via the **CLOSE** command, or via the SELOGIC control equation setting CL (see *Figure 6.1*).

Setting 79RSLD is also the reset timer used when the SEL-351R powers up, has individual settings changed for the active setting group, or the active setting group is changed (see *Reclosing Relay States and Settings/ Setting Group Changes*).

Typically, setting 79RSLD is set less than setting 79RSD. Setting 79RSLD emulates reclosing relays with motor-driven timers that have a relatively short reset time from the lockout position to the reset position.

The 79RSD and 79RSLD settings are set independently (setting 79RSLD can even be set greater than setting 79RSD, if desired). SELOGIC control equation setting 79BRS (block reset timing) can be set to control reset timing [see *Block Reset Timing Setting (79BRS)*].

Monitoring Open Interval and Reset Timing

Open interval and reset timing can be monitored with the following Relay Word bits:

Relay Word Bits	Definition
OPTMN	Indicates that the open interval timer is *actively* timing
RSTMN	Indicates that the reset timer is *actively* timing

If the open interval timer is actively timing, OPTMN asserts to logical 1. When the SEL-351R is not timing on an open interval (e.g., it is in the Reset State or in the Lockout State), OPTMN deasserts to logical 0. The SEL-351R can only time on an open interval when it is in the Reclose Cycle State, but just because the relay is in the Reclose Cycle State does not necessarily mean the relay is timing on an open interval. The SEL-351R only times on an open interval after successful reclose initiation and if no stall conditions are present [see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, respectively)*].

If the reset timer is actively timing, RSTMN asserts to logical 1. If the reset timer is not timing, RSTMN deasserts to logical 0. See *Block Reset Timing Setting (79BRS)*.

Reclosing Relay Shot Counter

Refer to *Figure 6.6*.

The shot counter increments for each reclose operation. For example, when the SEL-351R is timing on open interval 1, 79OI1, it is at shot = 0. When the open interval times out, the shot counter increments to shot = 1 and so forth for the set open intervals that follow. The shot counter cannot increment beyond the last shot for automatic reclosing [see *Determination of Number of Reclosures (Last Shot)*]. The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 6.3 Shot Counter Correspondence to Relay Word Bits and Open Interval Times

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2
2	SH2	79OI3
3	SH3	79OI4
4	SH4	

When the shot counter is at a particular shot value (e.g., shot = 2), the corresponding Relay Word bit asserts to logical 1 (e.g., SH2 = logical 1).

The shot counter also increments for sequence coordination operation. The shot counter can increment beyond the last shot for sequence coordination [see *Sequence Coordination Setting (79SEQ)*].

Reclosing Relay SELogic Control Equation Settings Overview

Table 6.4 Reclosing Relay SELogic Control Equation Settings

SELogic Control Equation Setting	Factory Setting	Definition
79RI	TRIP	Reclose Initiate
79RIS	52A + 79CY	Reclose Initiate Supervision
79DTL	67N3T * OLS + (67P1 + 67G1 + 67N1) * TRIP + (!LT2 + !LT7) * (TRIP + !52A) + 81D1T + PB9 + OC + SV16	Drive-to-Lockout
79DLS	79LO	Drive-to-Last Shot
79SKP	0	Skip Shot
79STL	TRIP	Stall Open Interval Timing
79BRS	51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2 + 67N3 + TRIP	Block Reset Timing
79SEQ	79RS * (51P1 + 51G1 + 51N1) * SEQC	Sequence Coordination
79CLS	59L1*!BADBAT*!DTFAIL	Reclose Supervision

These settings are discussed in detail in the remainder of this subsection.

The longer factory settings are explained in *Section 1: Factory-Set Logic*.

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS = logical 1) in order for open interval timing to be initiated.

If 79RIS = logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the Lockout State.

Factory Settings Example

With factory settings:

79RI =**TRIP**

79RIS =**52A + 79CY**

the transition of the TRIP Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A or 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1).

The recloser has to be closed (recloser status 52A = logical 1) at the instant of the first trip operation of the auto-reclose cycle in order for the SEL-351R to successfully initiate reclosing and start timing on the first open interval. The SEL-351R is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip operation.

Then for any subsequent trip operations in the auto-reclose cycle, the SEL-351R is in the reclose cycle state (79CY = logical 1) and the SEL-351R successfully initiates reclosing for each trip operation. Because of factory setting 79RIS = 52A + 79CY, successful reclose initiation in the reclose cycle state (79CY = logical 1) is not dependent on the recloser status (52A). This allows successful reclose initiation for the case of a fast curve/instantaneous trip operation, but the recloser status indication is slow—the fast curve/instantaneous trip operation (reclose initiation) occurs before the SEL-351R sees the recloser close.

If a flashover occurs in a recloser tank during an open interval (recloser open and the SEL-351R calls for a trip), the SEL-351R goes immediately to lockout.

Additional Settings Example

The preceding settings example initiates open interval timing on rising edge of the TRIP Relay Word bit. The following is an example of reclose initiation on the opening of a circuit breaker.

Presume input IN101 is connected to a 52a circuit breaker auxiliary contact (52A = IN101).

With setting:

79RI = **!52A**

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) initiates open interval timing. Setting 79RI looks for a logical 0 to logical 1 transition, thus Relay Word bit 52A is inverted in the 79RI setting [!52A = NOT(52A)].

The reclose initiate supervision setting 79RIS supervises setting 79RI. With settings:

79RI = **!52A**

79RIS = **TRIP**

the transition of the 52A Relay Word bit from logical 1 to logical 0 initiates open interval timing only if the TRIP Relay Word bit is at logical 1 (TRIP = logical 1). Thus, the TRIP Relay Word bit has to be asserted when the circuit breaker opens in order to initiate open interval timing. With a long enough setting of the Minimum Trip Duration Timer (TDURD), the TRIP Relay Word bit will still be asserted to logical 1 when the circuit breaker opens (see *Figure 5.1* and *Figure 5.2*).

If the TRIP Relay Word bit is at logical 0 (TRIP = logical 0) when the circuit breaker opens (logical 1 to logical 0 transition), the relay goes to the Lockout State. This helps prevent reclose initiation for circuit breaker openings caused by trips external to the relay.

If circuit breaker status indication (52A) is slow, the TRIP Relay Word bit should be removed from ULCL setting (unlatch close; see *Figure 1.21* and *Figure 6.1* and accompanying explanation) when 79RI = !52A. Making this change to the ULCL setting keeps the SEL-351R from going to lockout prematurely for an instantaneous trip after an auto-reclose; by not turning CLOSE off until the circuit breaker status indication tells the relay that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

1. In the preceding additional setting example, the reclose initiate setting (79RI) includes input **IN101**, that is connected to a 52a breaker auxiliary contact (52A = IN101).

   79RI = **!52A**

   If a 52b breaker auxiliary contact is connected to input **IN101** (52A = !IN101), the reclose initiate setting (79RI) remains the same.

2. If no reclose initiate supervision is desired, make the following setting:

   79RIS = **1** (numeral 1)

   Setting 79RIS = logical 1 at all times. Any time a logical 0 to logical 1 transition is detected by setting 79RI, open interval timing will be initiated (unless prevented by other means).

3. If the following setting is made:

   79RI = **0** (numeral 0)

   reclosing will never take place (reclosing is never initiated). The reclosing relay is effectively inoperative.

4. If the following setting is made:

   79RIS = **0** (numeral 0)

   reclosing will never take place (the reclosing relay goes directly to the lockout state any time reclosing is initiated). The reclosing relay is effectively inoperative.

Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, respectively)

When 79DTL = logical 1, the reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1), and the front-panel Lockout LED illuminates.

79DTL has a 60-cycle dropout time. This keeps the drive-to-lockout condition up 60 more cycles after 79DTL has reverted back to 79DTL = logical 0. This is useful for situations where both the following are true:

- ➤ any of the trip and drive-to-lockout conditions are “pulsed” conditions (e.g., the **OPEN** Command Relay Word bit, OC, asserts for only a one-quarter cycle—see *Figure 1.25*)
- ➤ reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—see *Additional Settings Example* discussion.

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-351R stays in lockout after the breaker trips open.

When 79DLS = logical 1, the reclosing relay goes to the last shot, if the shot counter is not at a shot value greater than or equal to the calculated last shot (see *Reclosing Relay Shot Counter*).

Factory Settings Example

The drive-to-last shot factory setting is:

79DLS = **79LO**

Three open intervals are also set in the factory settings, resulting in last shot = 3. Any time the SEL-351R is in the lockout state (Relay Word bit 79LO = logical 1), the SEL-351R is driven to last shot (if the shot counter is not already at a shot value greater than or equal to shot = 3):

79DLS = **79LO** = logical 1

Other Settings Considerations

If no special drive-to-lockout or drive-to-last shot conditions are desired, make the following settings:

79DTL = **0** (numeral 0)

79DLS = **0** (numeral 0)

With settings 79DTL and 79DLS inoperative, the relay still goes to the Lockout State (and to last shot) if an entire automatic reclose sequence is unsuccessful.

Overall, settings 79DTL or 79DLS are needed to take the relay to the Lockout State (or to last shot) for immediate circumstances.

Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, respectively)

The skip shot setting 79SKP causes a reclose shot to be skipped. Thus, an open interval time is skipped, and the next open interval time is used instead.

If 79SKP = logical 1 at the instant of successful reclose initiation (see preceding discussion on settings 79RI and 79RIS), the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 6.3*). If the new shot is the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State*).

After successful reclose initiation, open interval timing does not start until allowed by the stall open interval timing setting 79STL. If 79STL = logical 1, open interval timing is stalled. If 79STL = logical 0, open interval timing can proceed.

If an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. In such conditions (open interval timing has not yet started timing), if 79SKP = logical 1, the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 6.3*). If the new shot turns out to be the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State*).

If the relay is in the middle of timing on an open interval and 79STL changes state to 79STL = logical 1, open interval timing stops where it is. If 79STL changes state back to 79STL = logical 0, open interval timing resumes where it left off. Use the OPTMN Relay Word bit to monitor open interval timing (see *Monitoring Open Interval and Reset Timing*).

Factory Settings Example

The skip shot function is not enabled in the factory settings:

79SKP = **0** (numeral 0)

The stall open interval timing factory setting is:

79STL = **TRIP**

After successful reclose initiation, open interval timing does not start as long as the trip condition is present (Relay Word bit TRIP = logical 1). As discussed previously, if an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. Once the trip condition goes away (Relay Word bit TRIP = logical 0), open interval timing can proceed.

Additional Settings Example 1

With skip shot setting:

79SKP = **50P2 * SH0**

if shot = 0 (Relay Word bit SH0 = logical 1) *and* phase current is above the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2 = logical 1), at the instant of successful reclose initiation, the shot counter is incremented from shot = 0 to shot = 1. Then, open interval 1 time (setting 79OI1) is skipped, and the relay times on the open interval 2 time (setting 79OI2) instead.

Table 6.5 Open Interval Time Example Settings

Shot	Corresponding Relay Word Bit	Corresponding Open Interval	Open Interval Time Example Setting
0	SH0	79OI1	30 cycles
1	SH1	79OI2	600 cycles

In *Table 6.5*, note that the open interval 1 time (setting 79OI1) is a short time, while the following open interval 2 time (setting 79OI2) is significantly longer. For a high magnitude fault (greater than the phase instantaneous overcurrent element 50P2 threshold), open interval 1 time is skipped, and open interval timing proceeds on the following open interval 2 time.

Once the shot is incremented to shot = 1, Relay Word bit SH0 = logical 0 and then setting 79SKP = logical 0, regardless of Relay Word bit 50P2.

Additional Settings Example 2

If the SEL-351R is used on a feeder with a line-side independent power producer (cogenerator), the utility should not reclose into a line still energized by an islanded generator. To monitor line voltage and block reclosing, connect a line-side single-phase potential transformer to channel **VS** on the SEL-351R as shown in *Figure 6.7*.

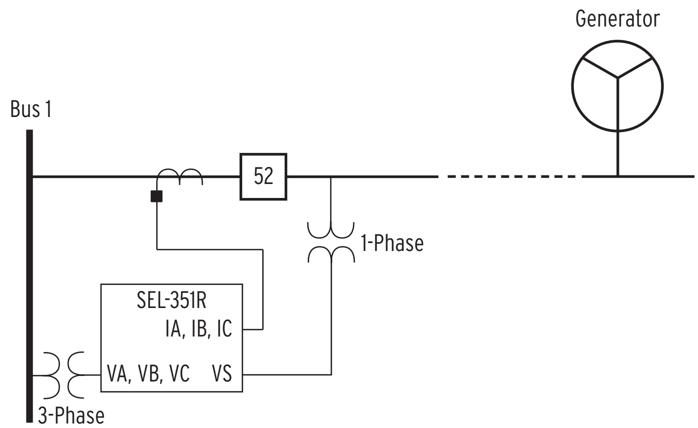


Figure 6.7 Reclose Blocking for Islanded Generator

If the line is energized, channel **VS** overvoltage element 59S1 can be set to assert. Make the following setting:

79STL = **59S1 + ...**

If line voltage is present, Relay Word bit 59S1 asserts, stalling open interval timing (reclose block). If line voltage is not present, Relay Word bit 59S1 deasserts, allowing open interval timing to proceed (unless some other set condition stalls open interval timing).

Additional Settings Example 3

Refer to *Figure 6.4* and accompanying setting example, showing an application for setting 79STL.

Other Settings Considerations

If no special skip shot or stall open interval timing conditions are desired, make the following settings:

79SKP = **0** (numeral 0)

79STL = **0** (numeral 0)

Block Reset Timing Setting (79BRS)

The block reset timing setting 79BRS keeps the reset timer from timing. Depending on the reclosing relay state, the reset timer can be loaded with either reset time:

79RSD (Reset Time from Reclose Cycle)

or

79RSLD (Reset Time from Lockout)

Depending on how setting 79BRS is set, none, one, or both of these reset times can be controlled. If the reset timer is timing and then 79BRS asserts to:

79BRS = logical 1

reset timing is stopped and does not begin timing again until 79BRS deasserts to:

79BRS = logical 0

When reset timing starts again, the reset timer is fully loaded. Thus, successful reset timing has to be continuous. Use the RSTMN Relay Word bit to monitor reset timing (see *Monitoring Open Interval and Reset Timing*).

Example 1

The block reset timing setting is:

79BRS = **(51P + 51G) * 79CY**

Relay Word bit 79CY corresponds to the Reclose Cycle State. The reclosing relay is in one of the three reclosing relay states at any one time (see *Figure 6.5* and *Table 6.1*).

When the relay is in the Reset or Lockout States, Relay Word bit 79CY is deasserted to logical 0. Thus, the 79BRS setting has no effect when the relay is in the Reset or Lockout States. When a circuit breaker is closed from lockout, there could be cold load inrush current that momentarily picks up a time-overcurrent element [e.g., phase time-overcurrent element 51PT pickup (51P) asserts momentarily]. But, this assertion of pickup 51P has no effect on reset timing because the relay is in the Lockout State (79CY = logical 0). The relay will time immediately on reset time 79RSLD and take the relay from the Lockout State to the Reset State with no additional delay because 79BRS is deasserted to logical 0.

When the relay is in the Reclose Cycle State, Relay Word bit 79CY is asserted to logical 1. Thus, the factory 79BRS setting can function to block reset timing if time-overcurrent pickup 51P or 51G is picked up while the relay is in the Reclose Cycle State. This helps prevent repetitive “trip-reclose” cycling.

Sequence Coordination Setting (79SEQ)

Sequence coordination keeps the SEL-351R in step with a downstream recloser control (another SEL-351R or otherwise; see *Figure 6.8*). Sequence coordination prevents overreaching SEL-351R fast curves from tripping for faults beyond the downstream recloser control. This is accomplished by incrementing the shot counter and controlling fast curves with resultant shot counter elements.

Refer to *Figure 6.8*. In order for the sequence coordination logic in SEL-351R(1) to increment the shot counter by one count to keep in step with the operation of downstream SEL-351R(2), *all* the following have to occur in SEL-351R(1):

- No trip present (Relay Word bit TRIP = logical 0)
- Recloser closed (Relay Word bit 52A = logical 1)
- Sequence coordination SELOGIC setting 79SEQ asserts to logical 1 for at least 1.25 cycles and then deasserts to logical 0

Every time the sequence coordination logic increments the shot counter (e.g., from 0 to 1), the reset timer is loaded up with reset time 79RSD (EZ setting Reset time for auto reclose). The reset timer starts timing—when it times out, the shot counter returns back to shot = 0. But if during this reset timer timing, the sequence coordination logic causes the shot counter to increment again (e.g., from 1 to 2), the reset timer is fully loaded up again with reset time 79RSD.

Sequence coordination can increment the shot counter beyond last shot (unless limited by SELOGIC setting 79SEQ), but no further than shot = 4. The reset timer timing is subject to SELOGIC setting 79BRS [see *Block Reset Timing Setting (79BRS)*].

See *Figure 1.27* for the 79SEQ factory settings and accompanying example.

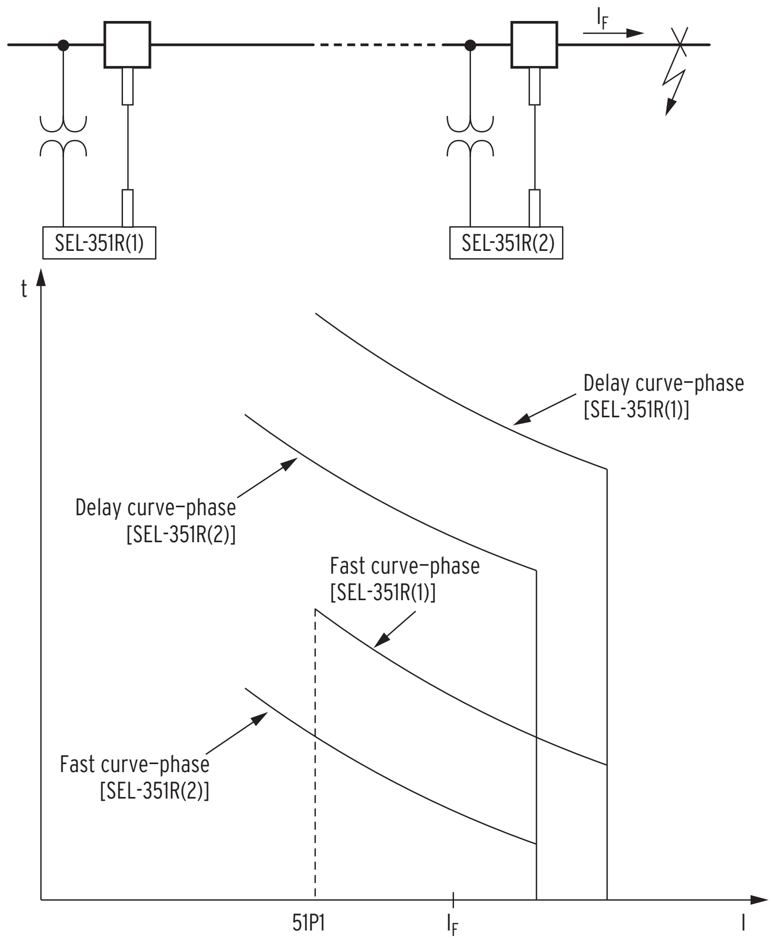


Figure 6.8 SEL-351R Recloser Controls in Series, Requiring Sequence Coordination

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic*.

Section 7

Inputs, Outputs, Timers, and Other Control Logic

Overview

This section explains the settings and operation of:

The above items are all the logic input/output of the control. They are combined with the overcurrent, voltage, frequency, and reclosing elements in SELOGIC® control equation settings to realize numerous protection and control schemes.

Relay Word bits and SELOGIC control equation setting examples are used throughout this section. See *Section 9: Setting the SEL-351R Recloser Control* for more information on Relay Word bits and SELOGIC control equation settings. See *Section 10: Serial Port Communications and Commands* for more information on viewing and making SELOGIC control equation settings (commands **SHO L** and **SET L**).

Optoisolated Inputs

Figure 7.1 shows the resultant Relay Word bits (e.g., Relay Word bits IN101–IN106 in *Figure 7.1*) that follow corresponding optoisolated inputs (e.g., optoisolated inputs IN101–IN106 in *Figure 7.1*) for the different SEL-351R Recloser Control models. The figures show examples of energized and de-energized optoisolated inputs and corresponding Relay Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair (see Figure 2.1 and Figure 1.12 in the *SEL-351R-4 Quick-Start Installation and User's Guide*).

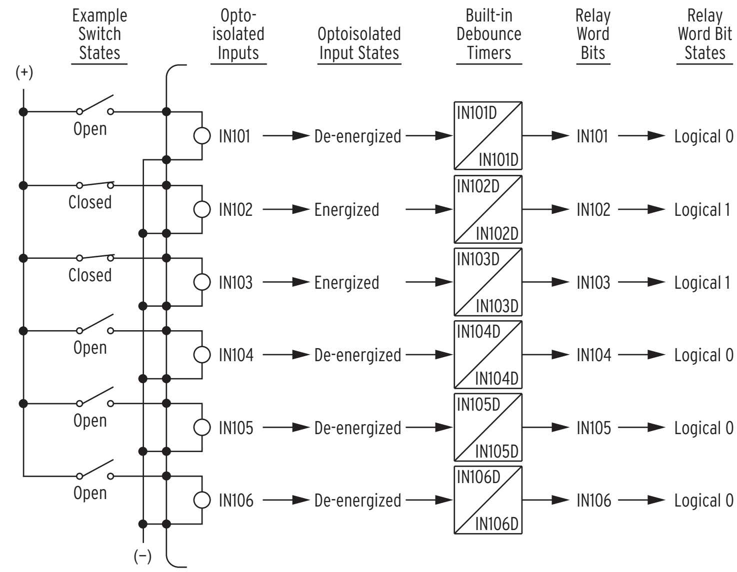


Figure 7.1 Example Operation of Optoisolated Inputs IN101–IN106

Input Debounce Timers

See *Figure 7.1*.

Each input has settable pickup/dropout timers (IN101D–IN106D) for input energization/de-energization debounce. Note that a given time setting (e.g., IN101D = 0.50) is applied to both the pickup and dropout time for the corresponding input.

Time settings IN101D–IN106D are settable from 0.00 to 1.00 cycles (or to “AC”—discussed below). The SEL-351R takes the entered time setting and internally runs the timer at the nearest 1/16 cycle. For example, if setting IN5D = 0.80, internally the timer runs at the nearest 1/16 cycle: 13/16 cycles (13/16 = 0.8125).

The “AC” setting (e.g., IN101D = AC) allows the optoisolated inputs to sense ac voltage correctly. In this “AC” operation mode, an optoisolated input has a maximum pickup time of 0.75 cycles and a maximum dropout time of 1.25 cycles for the application or removal, respectively, of ac voltage on the input.

For ***most** dc applications*, the input pickup/dropout debounce timers should be set in 1/4 cycle increments. For example, in the *factory-default settings*, all the optoisolated input pickup/dropout debounce timers are set at 1/2 cycle (e.g., IN104D = 0.50). See *SHO Command (Show/View Settings) on page 10.25* for a list of the factory-default settings.

Only a ***few** applications* (e.g., communications-assisted tripping schemes) might require input pickup/dropout debounce timers set less than 1/4 cycle [e.g., if setting IN105D = 0.13, internally the timer runs at the nearest 1/16 cycle: 2/16 cycles (2/16 = 0.1250)].

The control processing interval is 1/4 cycle, so Relay Word bits IN101–IN106 are updated every 1/4 cycle. The optoisolated input status may have made it through the pickup/dropout debounce timer (for settings less than 1/4 cycle) because these timers run each 1/16 cycle, but Relay Word bits IN101–IN106 are updated every 1/4 cycle.

If more than one cycle of debounce is needed, run Relay Word bit IN*n* (*n* = 101–106) through a SELOGIC control equation variable timer and use the output of the timer for input functions (see *Figure 7.23* and *Figure 7.24*).

Input Functions

There are *no* optoisolated input settings such as:

IN101 =

IN102 =

Optoisolated inputs **IN101**–**IN106** receive their function by the way their corresponding Relay Word bits IN101–IN106 are used in SELOGIC control equations.

Settings Examples

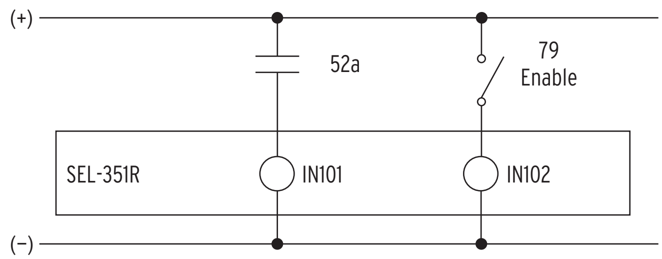


Figure 7.2 Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102

The example functions for inputs **IN101** and **IN102** are described in the following discussions.

Input IN101

In this example, Relay Word bit IN101 is used in the SELOGIC control equation circuit breaker status setting:

52A = **IN101**

Connect input **IN101** to a 52a circuit breaker auxiliary contact.

If a 52b circuit breaker auxiliary contact is connected to input **IN101**, the setting is changed to:

52A = **!IN101** [!IN101 = NOT(IN101)]

See *Close Logic on page 6.1* for more information on SELOGIC control equation setting 52A.

The pickup/dropout timer for input **IN101** (IN101D) is set at:

IN101D = **0.75 cycles**

to provide input energization/de-energization debounce.

Input **IN101** is also used in other example settings [i.e., SELOGIC control equation settings BSYNCH (see *Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements*), 79RIS (see *Section 6: Close and Reclose Logic*), and DP2 (see *Rotating Default Display on page 7.29*)]. Using Relay Word bit IN101 for the circuit breaker status setting 52A does not prevent using Relay Word bit IN101 in other SELOGIC control equation settings.

Input IN102

In this example, Relay Word bit IN102 is used in the SELOGIC control equation drive-to-lockout setting:

79DTL = **!IN102 + ...** [=NOT(IN102) + ...]

Connect input **IN102** to a reclose enable switch.

When the reclose enable switch is open, input **IN102** is de-energized and the reclosing relay is driven to lockout:

79DTL = **!IN102 + ...** = NOT(IN102) + ... = NOT(logical 0) +... = logical 1

When the reclose enable switch is closed, input **IN102** is energized and the reclosing relay is enabled, if no other setting condition is driving the reclosing relay to lockout:

79DTL = **!IN102 + ...** = NOT(IN102) + ... = NOT(logical 1) +... = logical 0 + ...

See *Section 6: Close and Reclose Logic* for more information on SELOGIC control equation setting 79DTL.

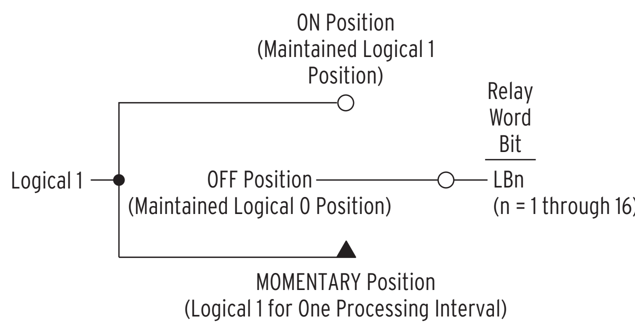
The pickup/dropout timer for input **IN102** (IN102D) is set at:

IN102D = **1.00 cycle**

to provide input energization/de-energization debounce.

Local Control Switches

In addition to the 10 operator control pushbuttons on the bottom half of the front panel, the SEL-351R contains 16 local control switches. Control of these local switches is through the front-panel keyboard/display (see *Section 11: Additional Front-Panel Interface Details*).



The switch representation in this figure is derived from the standard: Graphics symbols for Electrical and Electronics Diagrams IEEE Std 315-1975, CSA Z99-1975, ANSI Y32.2-1975, 4.11 Combination Locking and Nonlocking Switch, Item 4.11.1.

Figure 7.3 Local Control Switches Drive Local Bits LB1–LB16

The output of the local control switch in *Figure 7.3* is a Relay Word bit LB*n* called a local bit, where *n* = 1–16. The local control switch logic in *Figure 7.3* repeats for each local bit LB1–LB16. Use these local bits in SELOGIC control equations. For a given local control switch, the local control switch positions are enabled by making corresponding label settings.

Table 7.1 Correspondence Between Local Control Switch Positions and Label Settings (Sheet 1 of 2)

Switch Position	Label Setting	Setting Definition	Logic State
not applicable	NLB*n*	Name of Local Control Switch	not applicable
ON	SLB*n*	“Set” Local bit LB*n*	logical 1

Table 7.1 Correspondence Between Local Control Switch Positions and Label Settings (Sheet 2 of 2)

Switch Position	Label Setting	Setting Definition	Logic State
OFF	CLB*n*	"Clear" Local bit LB*n*	logical 0
MOMENTARY	PLB*n*	"Pulse" Local bit LB*n*	logical 1 for one processing interval

Note the first setting in *Table 7.1* (NLB*n*) is the overall switch name setting. Make each label setting through the serial port using the command **SET T**. View these settings using the serial port command **SHO T** (see *Section 9: Setting the SEL-351R Recloser Control* and *Section 10: Serial Port Communications and Commands*).

Local Control Switch Types

Configure any local control switch as one of the following three switch types:

ON/OFF Switch

Local bit LB*n* is in either the ON (LB*n* = logical 1) or OFF (LB*n* = logical 0) position.

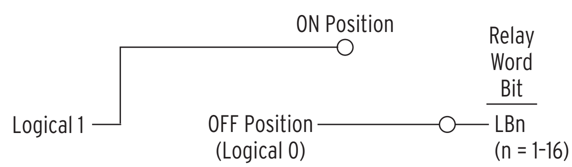


Figure 7.4 Local Control Switch Configured as an ON/OFF Switch

OFF/MOMENTARY Switch

The local bit LB*n* is maintained in the OFF (LB*n* = logical 0) position and pulses to the MOMENTARY (LB*n* = logical 1) position for one processing interval (1/4 cycle).

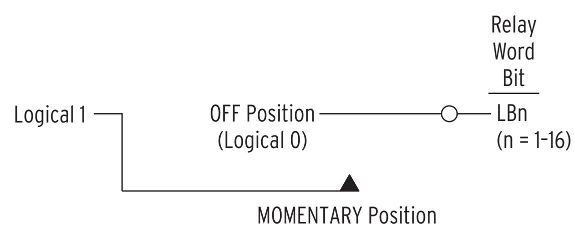


Figure 7.5 Local Control Switch Configured as an OFF/MOMENTARY Switch

ON/OFF/MOMENTARY Switch

The local bit LB*n*:

is in either the ON (LB*n* = logical 1) or OFF (LB*n* = logical 0) position

or

is in the OFF (LB*n* = logical 0) position and pulses to the MOMENTARY (LB*n* = logical 1) position for one processing interval (1/4 cycle).

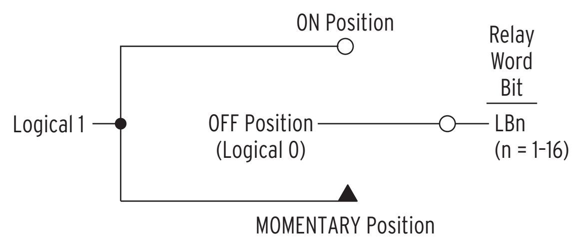


Figure 7.6 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Table 7.2 Correspondence Between Local Control Switch Types and Required Label Settings

Local Switch Type	Label NLBn	Label CLBn	Label SLBn	Label PLBn
ON/OFF	X	X	X	
OFF/MOMENTARY	X	X		X
ON/OFF/MOMENTARY	X	X	X	X

Disable local control switches by "nulling out" all the label settings for that switch (see *Section 9: Setting the SEL-351R Recloser Control*). The local bit associated with this disabled local control switch is then fixed at logical 0.

Settings Examples

Local bits LB3 and LB4 are used in example manual trip and close functions. Their corresponding local control switch position labels are set to configure the switches as OFF/MOMENTARY switches:

Local Bit	Label Settings	Function
LB3	NLB3 = MANUAL TRIP	trips breaker and drives reclosing relay to lockout
	CLB3 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB3 =	ON position—not used (left "blank")
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE	closes breaker, separate from automatic reclosing
	CLB4 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB4 =	ON position—not used (left "blank")
	PLB3 = CLOSE	MOMENTARY position

Figure 7.7 and *Figure 7.8* show local control switches with factory settings.

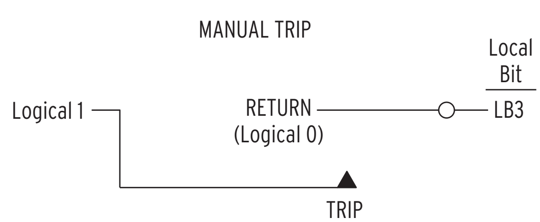


Figure 7.7 Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation trip setting example (see *Figure 5.1*):

TR = **... + LB3 + ...**

To keep reclosing from being initiated for this trip example, set local bit LB3 to drive the reclosing relay to lockout for a manual trip example (see *Section 6: Close and Reclose Logic*):

79DTL = **... + LB3**

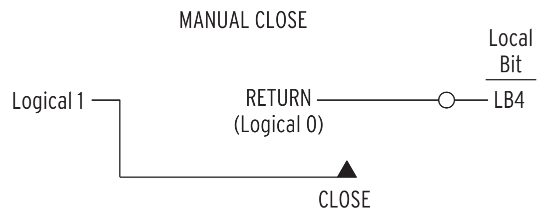


Figure 7.8 Configured Manual Close Switch Drives Local Bit LB4

Local bit LB4 is set to close the circuit breaker in the following SELOGIC control equation setting example:

CL = **LB4**

SELOGIC control equation setting CL is for close conditions, other than automatic reclosing or serial port **CLOSE** command (see *Figure 6.1*).

Additional Local Control Switch Application Ideas

The preceding factory settings examples are OFF/MOMENTARY switches. Local control switches configured as ON/OFF switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable
- Remote control supervision
- Sequence coordination enable/disable

Local control switches can also be configured as ON/OFF/MOMENTARY switches for applications that require such. Local control switches can be applied to almost any control scheme that traditionally requires front-panel switches.

Local Control Switch States Retained

Power Loss

The state of each local bit LB1–LB16 is retained if power to the control is lost and restored. This feature makes the local bit feature behave the same as a traditional installation with panel mounted control switches. If power is lost to the panel, the front-panel control switch positions remain unchanged.

Settings Change or Active Setting Group Change

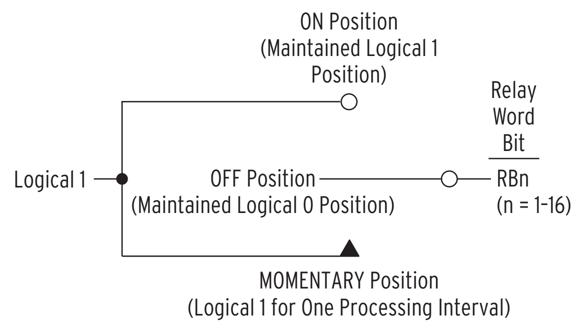
If settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the local bits LB1–LB16 are retained, much like in the preceding *Power Loss* explanation.

If settings are changed for a setting group other than the active setting group, there is no interruption of the local bits (the control is not momentarily disabled).

If a local control switch is made inoperable because of a settings change (i.e., the corresponding label settings are nulled), the corresponding local bit is then fixed at logical 0, regardless of the local bit state before the settings change. If a local control switch is made newly operable because of a settings change (i.e., the corresponding label settings are set), the corresponding local bit starts out at logical 0.

Remote Control Switches

Remote control switches are operated via the serial communications port only (see *CON Command (Control Remote Bit) on page 10.41*).



The switch representation in this figure is derived from the standard: Graphics symbols for Electrical and Electronics Diagrams IEEE Std 315-1975, CSA Z99-1975, ANSI Y32.2-1975, 4.11 Combination Locking and Nonlocking Switch, Item 4.11.1.

Figure 7.9 Remote Control Switches Drive Remote Bits RB1–RB16

The outputs of the remote control switches in *Figure 7.9* are Relay Word bits RB*n* called remote bits, where *n* = 1–16. Use these remote bits in SELOGIC control equations.

Any given remote control switch can be put in one of the following three positions:

- ON (logical 1)
- OFF (logical 0)
- MOMENTARY (logical 1 for one processing interval)

Remote Bit Application Ideas

With SELOGIC control equations, the remote bits can be used in applications similar to those in which local bits are used (see *Local Control Switches on page 7.4*).

Remote bits can be used much as optoisolated inputs are used in operating latch control switches (see discussion following *Figure 7.14*). Pulse (momentarily operate) the remote bits for this application.

Remote Bit States Not Retained When Power Is Lost

The states of the remote bits RB1–RB16 are not retained if power to the control is lost and then restored. The remote control switches always come back in the OFF position (corresponding remote bit is deasserted to logical 0) when power is restored to the control.

Remote Bit States Retained When Settings Changed or Active Setting Group Changed

The state of each remote bit RB1–RB16 is retained if a relay setting within any group is changed. If a remote control switch is in the ON position (remote bit is a logical 1) before a setting change or an active setting group change, it comes back in the ON position after the change. If a remote control switch is in the OFF position (remote bit is a logical 0) before a settings change or an active setting group change, it comes back in the OFF position after the change.

If settings are changed for a setting group other than the active setting group, there is no interruption of the remote bits; the control is not momentarily disabled.

Latch Control Switches

The latch control switch feature of this recloser control replaces latching relays. Traditional latching relays maintain their output contact state when set. The SEL-351R latch bit retains memory even when control power is lost. If the latch bit is set to a programmable output contact and control power is lost, the state of the latch bit is stored in nonvolatile memory but the output contact will go into its de-energized state. When control power is applied back to the control, the programmed output contact will go back to the state of the latch bit.

The state of a traditional latching relay output contact is changed by pulsing the latching relay inputs (see *Figure 7.10*). Pulse the set input to close ("set") the latching relay output contact. Pulse the reset input to open ("reset") the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU).

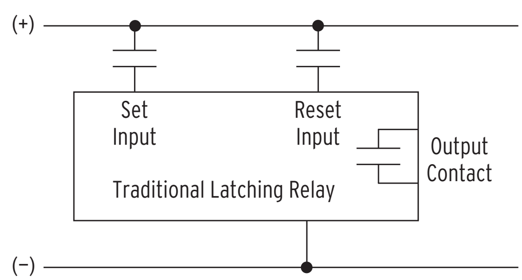


Figure 7.10 Traditional Latching Relay

The 16 latch control switches in the SEL-351R provide latching relay type functions.

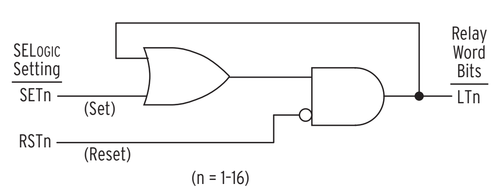


Figure 7.11 Latch Control Switches Drive Latch Bits LT1–LT16

The output of the latch control switch in *Figure 7.11* is a Relay Word bit LT*n* called a latch bit, where *n* = 1–16. The latch control switch logic in *Figure 7.11* repeats for each latch bit LT1–LT16. Use these latch bits in SELOGIC control equations.

These latch control switches each have the following SELOGIC control equation settings:

SET*n* (set latch bit LT*n* to logical 1)

RST*n* (reset latch bit LT*n* to logical 0)

If setting SET*n* asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0.

Latch Control Switch Application Ideas

Latch control switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable
- Sequence coordination enable/disable

Latch control switches can be applied to almost any control scheme. The following is an example of using a latch control switch to enable/disable the reclosing relay in the SEL-351R.

Reclosing Relay Enable/Disable Setting Example

Use a latch control switch to enable/disable the reclosing relay in the SEL-351R. In this example, a SCADA contact is connected to optoisolated input **IN104**. Each pulse of the SCADA contact changes the state of the reclosing relay. The SCADA contact is not maintained, just pulsed to enable/disable the reclosing relay.

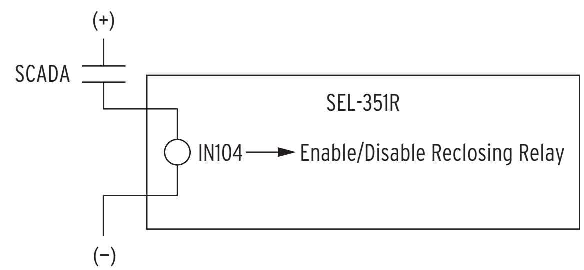


Figure 7.12 SCADA Contact Pulses Input IN104 to Enable/Disable Reclosing Relay

If the reclosing relay is enabled and the SCADA contact is pulsed, the reclosing relay is then disabled. If the SCADA contact is pulsed again, the reclosing relay is enabled again. The control operates in a cyclic manner:

pulse to enable ... pulse to disable ... pulse to enable ... pulse to disable ...

This reclosing relay logic is implemented in the following SELOGIC control equation settings and displayed in *Figure 7.13*.

SET1 = **/IN104 * !LT1** [= (rising edge of input **IN104**) AND NOT(LT1)]

RST1 = **/IN104 * LT1** [= (rising edge of input **IN104**) AND LT1]

79DTL = **!LT1** [= NOT(LT1); drive-to-lockout setting]

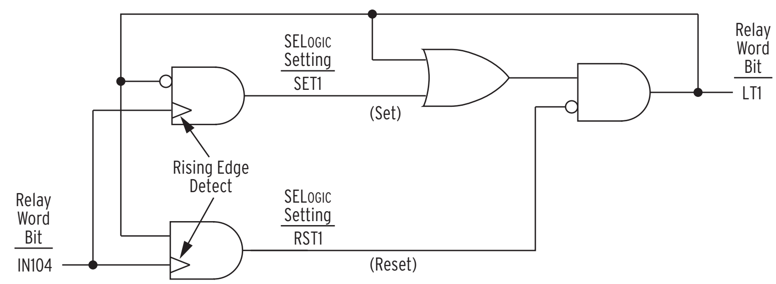


Figure 7.13 Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

Feedback Control

Note in *Figure 7.13* that the latch control switch output (latch bit LT1) is effectively used as feedback for SELOGIC control equation settings SET1 and RST1. The feedback of latch bit LT1 "guides" input IN104 to the correct latch control switch input.

If latch bit LT1 = logical 0, input IN104 is routed to setting SET1 (set latch bit LT1):

SET1 = **/IN104 * !LT1** = /IN104 * NOT(LT1) = /IN104 * NOT(logical 0) = /IN104 = rising edge of input IN104

RST1 = **/IN104 * LT1** = /IN104 * (logical 0) = logical 0

If latch bit LT1 = logical 1, input IN104 is routed to setting RST1 (reset latch bit LT1):

SET1 = **/IN104 * !LT1** = /IN104 * NOT(LT1) = /IN104 * NOT(logical 1) = /IN104 * (logical 0) = logical 0

RST1 = **/IN104 * LT1** = /IN104 * (logical 1) = /IN104 = rising edge of input IN104

Rising-Edge Operators

Refer to *Figure 7.13* and *Figure 7.14*.

The rising-edge operator in front of Relay Word bit IN104 (/IN104) sees a logical 0 to logical 1 transition as a "rising edge," and /IN104 asserts to logical 1 for one processing interval.

The rising-edge operator on input IN104 is necessary because any single assertion of optoisolated input IN104 by the SCADA contact will last for at least a few cycles, and each individual assertion of input IN104 should only change the state of the latch control switch once (e.g., latch bit LT1 changes state from logical 0 to logical 1).

For example in *Figure 7.13*, if:

LT1 = logical 0

input IN104 is routed to setting SET1 (as discussed previously):

SET1 = **/IN104** = rising edge of input IN104

If input IN104 is then asserted for a few cycles by the SCADA contact (see Pulse 1 in *Figure 7.14*), SET1 is asserted to logical 1 for one processing interval. This causes latch bit LT1 to change state to:

LT1 = logical 1

at the next processing interval.

With latch bit LT1 now at logical 1 for the next processing interval, input IN104 is routed to setting RST1 (as discussed previously):

RST1 = **/IN104** = rising edge of input IN104

NOTE: Refer to Optoisolated Inputs on page 7.1 and Figure 7.1. Relay Word bit IN104 shows the state of optoisolated input IN104 after the input pickup/dropout debounce timer IN104D. Thus, when using Relay Word bit IN104 in Figure 7.11 and Figure 7.12 and associated SELOGIC control equations, keep in mind any time delay produced by the input pickup/dropout debounce timer IN104D.

This would then appear to enable the “reset” input (setting RST1), the next processing interval. However, the “rising-edge” condition occurred in the preceding processing interval, causing /IN104 to then deassert to logical 0. So, since /IN104 is now at logical 0, setting RST1 does not assert, even though input IN104 remains asserted for at least a few cycles by the SCADA contact.

If the SCADA contact deasserts and then asserts again (new rising edge—see Pulse 2 in *Figure 7.14*), the “reset” input (setting RST1) asserts and latch bit LT1 deasserts back to logical 0 again. Thus, each individual assertion of input IN104 (Pulse 1, Pulse 2, Pulse 3, and Pulse 4 in *Figure 7.14*) changes the state of latch control switch just once.

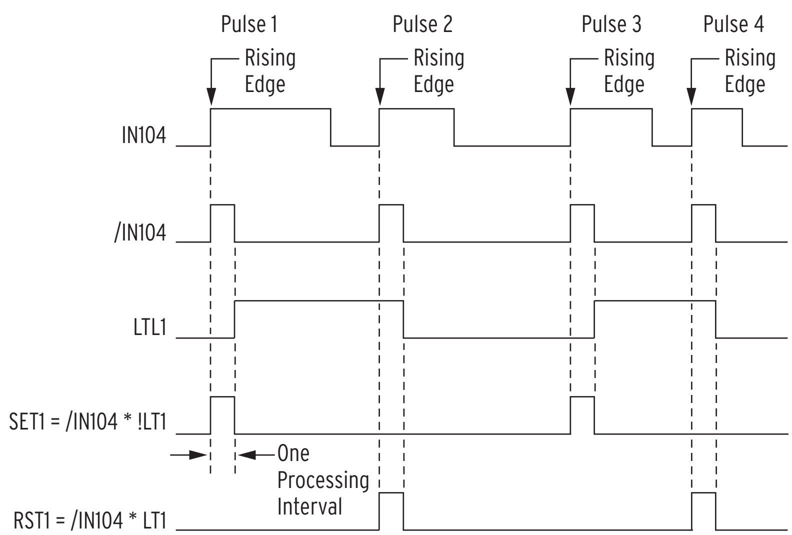


Figure 7.14 Latch Control Switch Operation Time Line

Use a Remote Bit Instead to Enable/Disable the Reclosing Relay

Use a remote bit to enable/disable the reclosing relay, instead of an optoisolated input. For example, substitute remote bit RB1 for optoisolated input IN104 in the settings accompanying *Figure 7.13*:

SET1 = **/RB1 * !LT1** [= (rising edge of remote bit RB1) AND NOT(LT1)]

RST1 = **/RB1 * LT1** [= (rising edge of remote bit RB1) AND LT1]

79DTL = **!LT1** [= NOT(LT1); drive-to-lockout setting]

Pulse remote bit RB1 to enable reclosing, pulse remote bit RB1 to disable reclosing, etc.—much like the operation of optoisolated input IN104 in the previous example. Remote bits RB1–RB16 are operated through the serial port. See *Figure 7.9* and *Section 10: Serial Port Communications and Commands* for more information on remote bits.

These are just a few control logic examples—many variations are possible.

Latch Control Switch States Retained

Power Loss

NOTE: Although the control retains the state of a latched bit when power is cycled, the control cannot hold contact closure when power is removed from the control.

The states of the latch bits LT1–LT16 are retained if power to the control is lost and then restored. If a latch bit is asserted (e.g., LT2 = logical 1) when power is lost, it comes back asserted when power is restored. If a latch bit is deasserted (e.g., LT3 = logical 0) when power is lost, it comes back deasserted when power is restored. This feature makes the latch bit feature behave the same as traditional latching relays. In a traditional installation, if power is lost to the panel, the latching relay output contact position remains unchanged.

Settings Change or Active Setting Group Change

If individual settings are changed (for the active setting group or for one of the other setting groups) or the active setting group is changed, then the states of the latch bits LT1–LT16 are retained, much like in the preceding *Power Loss* explanation.

If individual settings are changed for a setting group other than the active setting group, there is no interruption of the latch bits (the control is not momentarily disabled).

If the individual settings change or an active setting group change causes a change in SELOGIC control equation settings SET*n* or RST*n*, where *n* = 1–16, then the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Reset Latch Bits for Active Setting Group Change

If desired, the latch bits can be reset to logical 0 right after a settings group change, using SELOGIC control equation setting RST*n*, where *n* = 1–16. Relay Word bits SG1–SG6 indicate the active Setting Group 1–6, respectively (see *Table 7.3*).

For example, when Setting Group 4 becomes the active setting group, latch bit LT2 should be reset. Make the following SELOGIC control equation settings in Setting Group 4:

SV7 = **SG4**

RST2 = **!SV7T + ...** [= NOT(SV7T) + ...]

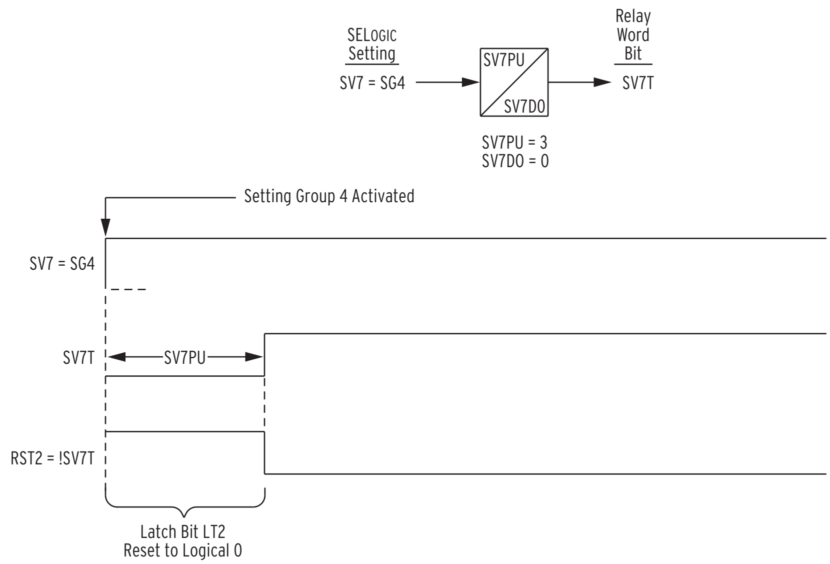


Figure 7.15 Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

In *Figure 7.15*, latch bit LT2 is reset (deasserted to logical 0) when reset setting RST2 asserts to logical 1 for the short time right after Setting Group 4 is activated. This logic can be repeated for other latch bits.

Make Latch Control Switch Settings With Care

The latch bit states are stored in nonvolatile memory so they can be retained during power loss, settings change, or active setting group change. The nonvolatile memory is rated for a finite number of "writes" for all cumulative latch bit state changes. Exceeding this limit can result in an EEPROM self-test failure. *This limit translates to an average of 70 cumulative latch bit state changes per day for a 25-year recloser control service life.* Therefore, set equations SET*n* and RST*n* with care so continuous cyclical operation of latch bit LT*n* does not occur. Use timers to qualify conditions set in settings SET*n* and RST*n*. If any optoisolated inputs IN101–IN106 are used in settings SET*n* and RST*n*, the inputs have their own debounce timer that can help in providing the necessary time qualification (see *Figure 7.1*).

In the preceding reclosing relay enable/disable example application (*Figure 7.13* and *Figure 7.14*), the SCADA contact cannot be asserting/deasserting continuously, thus causing latch bit LT1 to change state continuously. Note that the rising-edge operators in the SET1 and RST1 settings keep latch bit LT1 from cyclically operating for any single assertion of the SCADA contact.

Another variation to the example application in *Figure 7.13* and *Figure 7.14* that adds more security is a timer with pickup/dropout times set the same (see *Figure 7.16* and *Figure 7.17*). Suppose that SV6PU and SV6DO are both set to 300 cycles. Then the SV6T timer keeps the state of latch bit LT1 from being able to be changed at a rate faster than once every 300 cycles (5 seconds).

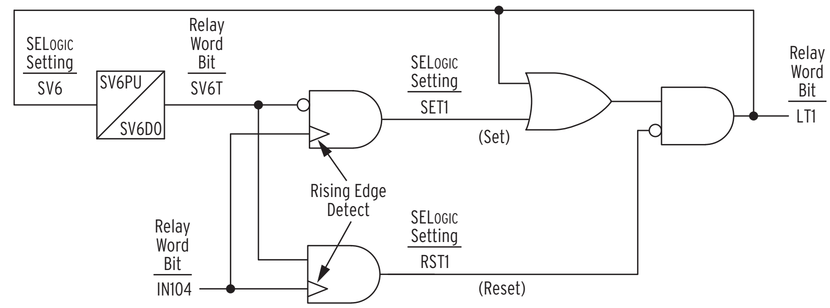


Figure 7.16 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

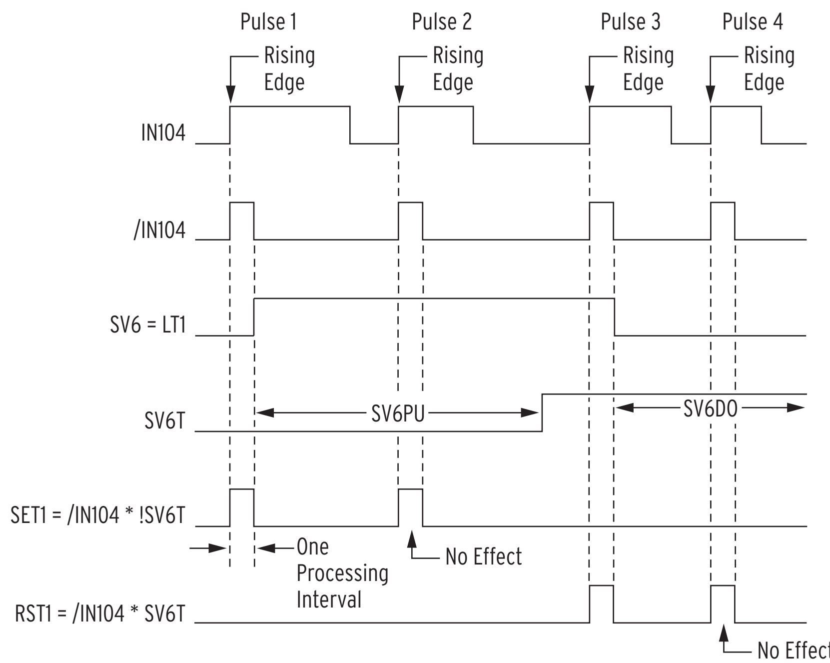


Figure 7.17 Latch Control Switch (With Time Delay Feedback) Operation Time Line

Multiple Setting Groups

The recloser control has six independent setting groups. Each setting group has complete control (overcurrent, reclosing, frequency, etc.) and SELOGIC control equation settings.

Active Setting Group Indication

Only one setting group can be active at a time. Relay Word bits SG1–SG6 indicate the active setting group:

Table 7.3 Definitions for Active Setting Group Indication Relay Word Bits SG1–SG6 (Sheet 1 of 2)

Relay Word Bit	Definition
SG1	Indication that Setting Group 1 is the active setting group
SG2	Indication that Setting Group 2 is the active setting group
SG3	Indication that Setting Group 3 is the active setting group

Table 7.3 Definitions for Active Setting Group Indication Relay Word Bits SG1–SG6 (Sheet 2 of 2)

Relay Word Bit	Definition
SG4	Indication that Setting Group 4 is the active setting group
SG5	Indication that Setting Group 5 is the active setting group
SG6	Indication that Setting Group 6 is the active setting group

For example, if Setting Group 4 is the active setting group, Relay Word bit SG4 asserts to logical 1, and the other Relay Word bits SG1, SG2, SG3, SG5, and SG6 are all deasserted to logical 0.

Selecting the Active Setting Group

The active setting group is selected with:

- SELOGIC control equation settings SS1–SS6.
- The serial port **GROUP** command (see *Section 10: Serial Port Communications and Commands*).
- Or the front-panel **GROUP** pushbutton (see *Section 11: Additional Front-Panel Interface Details*).

SELOGIC control equation settings SS1–SS6 have priority over the serial port **GROUP** command and the front-panel **GROUP** pushbutton in selecting the active setting group.

Operation of SELOGIC Control Equation Settings SS1–SS6

Each setting group has its own set of SELOGIC control equation settings SS1–SS6.

Table 7.4 Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 Through SS6

Setting	Definition
SS1	go to (or remain in) Setting Group 1
SS2	go to (or remain in) Setting Group 2
SS3	go to (or remain in) Setting Group 3
SS4	go to (or remain in) Setting Group 4
SS5	go to (or remain in) Setting Group 5
SS6	go to (or remain in) Setting Group 6

The operation of these settings is explained with the following example:

Assume the active setting group starts out as Setting Group 3. Corresponding Relay Word bit SG3 is asserted to logical 1 as an indication that Setting Group 3 is the active setting group (see *Table 7.3*).

With Setting Group 3 as the active setting group, setting SS3 has priority. If setting SS3 is asserted to logical 1, Setting Group 3 remains the active setting group, regardless of the activity of settings SS1, SS2, SS4, SS5, and SS6. With settings SS1–SS6 all deasserted to logical 0, Setting Group 3 still remains the active setting group.

With Setting Group 3 as the active setting group, if setting SS3 is deasserted to logical 0 and one of the other settings (e.g., setting SS5) asserts to logical 1, the control switches from Setting Group 3 as the active setting group to another setting group (e.g., Setting Group 5) as the active setting group, after qualifying time setting TGR:

TGR Group Change Delay Setting (settable from 0.00 to 16000.00 cycles)

In this example, TGR qualifies the assertion of setting SS5 before it can change the active setting group.

Operation of Serial Port GROUP Command and Front-Panel GROUP Pushbutton

SELOGIC control equation settings SS1–SS6 have priority over the serial port **GROUP** command and the front-panel **GROUP** pushbutton in selecting the active setting group. If any *one* of SS1–SS6 asserts to logical 1, neither the serial port **GROUP** command nor the front-panel **GROUP** pushbutton can be used to switch the active setting group. But if SS1–SS6 *all* deassert to logical 0, the serial port **GROUP** command or the front-panel **GROUP** pushbutton can be used to switch the active setting group.

See *Section 10: Serial Port Communications and Commands* for more information on the serial port **GROUP** command. See *Section 11: Additional Front-Panel Interface Details* for more information on the front-panel **GROUP** pushbutton.

SEL-351R Disabled Momentarily During Active Setting Group Change

The SEL-351R is disabled for a *few seconds* while in the process of changing active setting groups. SEL-351R elements, timers, and logic are reset, unless indicated otherwise in the specific logic description. For example, during an active setting group change, the SEL-351R retains states for local bits LB1–LB16 and latch bits LT1–LT16. The output contacts do not change state until the control enables in the new setting group and the SELOGIC control equations are processed to determine the output contact status for the new group. For instance, if setting OUT105 = logical 1 in Group 2, and setting OUT105 = logical 1 in Group 3, and the control is switched from Group 2 to Group 3, **OUT105** stays energized before, during, and after the group change. However, if the Group 3 setting was OUT105 = logical 0 instead, then **OUT105** remains energized until the control enables in Group 3, solves the SELOGIC control equations, and causes **OUT105** to de-energize. See *Figure 7.26* for examples of output contacts in the de-energized state (i.e., corresponding output contact coils de-energized).

Active Setting Group Switching Example 1

Use a single optoisolated input to switch between two setting groups in the SEL-351R. In this example, optoisolated input **IN105** on the control is connected to a SCADA contact in *Figure 7.18*. Each pulse of the SCADA contact changes the active setting group from one setting group (e.g., Setting Group 1) to another (e.g., Setting Group 4). The SCADA contact is not maintained, just pulsed to switch from one active setting group to another.

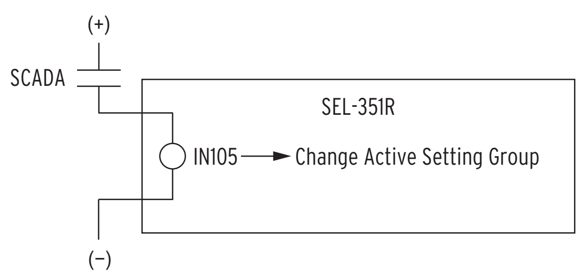


Figure 7.18 SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

If Setting Group 1 is the active setting group and the SCADA contact is pulsed, Setting Group 4 becomes the active setting group. If the SCADA contact is pulsed again, Setting Group 1 becomes the active setting group again. The setting group control operates in a cyclical manner:

pulse to activate Setting Group 4 ... pulse to activate Setting Group 1 ...
pulse to activate Setting Group 4 ... pulse to activate Setting Group 1 ...

This logic is implemented in the SELOGIC control equation settings in *Table 7.5*.

Table 7.5 SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

Setting Group 1	Setting Group 4
SV8 = SG1	SV8 = SG4
SS1 = 0	SS1 = IN5 * SV8T
SS2 = 0	SS2 = 0
SS3 = 0	SS3 = 0
SS4 = IN5 * SV8T	SS4 = 0
SS5 = 0	SS5 = 0
SS6 = 0	SS6 = 0

SELOGIC control equation timer input setting SV8 in *Table 7.5* has logic output SV8T, shown in operation in *Figure 7.19* for both Setting Groups 1 and 4.

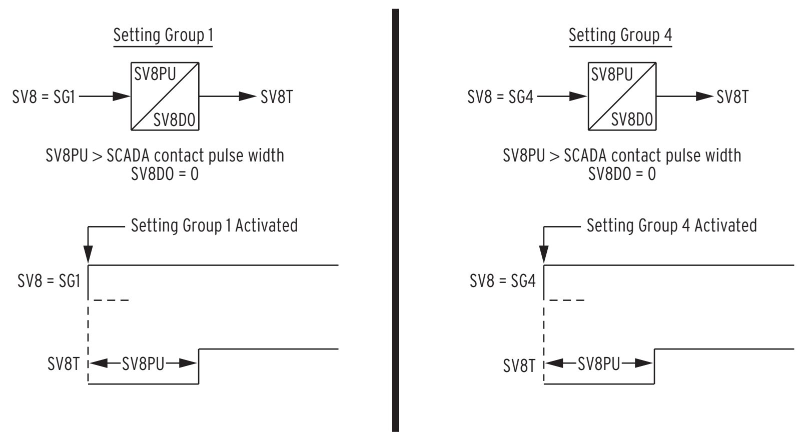


Figure 7.19 SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

In this example, timer SV8T is used in both setting groups—different timers could have been used with the same operational result. The timers reset during the setting group change, allowing the same timer to be used in both setting groups.

Timer pickup setting SV8PU is set greater than the pulse width of the SCADA contact (*Figure 7.18*). This allows only one active setting group change (e.g., from Setting Group 1 to 4) for each pulse of the SCADA contact (and subsequent assertion of input **IN105**). The function of the SELOGIC control equations in *Table 7.5* becomes more apparent in the following example scenario.

Start Out in Setting Group 1

Refer to *Figure 7.20*.

The control has been in Setting Group 1 for some time, with timer logic output SV8T asserted to logical 1, thus enabling SELOGIC control equation setting SS4 for the assertion of input **IN105**.

Switch to Setting Group 4

Refer to *Figure 7.20*.

The SCADA contact pulses input **IN105**, and the active setting group changes to Setting Group 4 after qualifying time setting TGR (perhaps set at a cycle or so to qualify the assertion of setting SS4). Optoisolated input **IN105** also has its own built-in debounce timer (IN105D) available (see *Figure 7.1*).

Note that *Figure 7.20* shows both Setting Group 1 and Setting Group 4 settings. The Setting Group 1 settings (top of *Figure 7.20*) are enabled only when Setting Group 1 is the active setting group and likewise for the Setting Group 4 settings at the bottom of the figure.

Setting Group 4 is now the active setting group, and Relay Word bit SG4 asserts to logical 1. After the control has been in Setting Group 4 for a time period equal to SV8PU, the timer logic output SV8T asserts to logical 1, thus enabling SELOGIC control equation setting SS1 for a new assertion of input **IN105**.

Note that input **IN105** is still asserted as Setting Group 4 is activated. Pickup time SV8PU keeps the continued assertion of input **IN105** from causing the active setting group to revert back again to Setting Group 1 for a single assertion of input **IN105**. This keeps the active setting group from being changed at a time interval less than time SV8PU.

Switch Back to Setting Group 1

Refer to *Figure 7.20*.

The SCADA contact pulses input **IN105** a second time, and the active setting group changes back to Setting Group 1 after qualifying time setting TGR (perhaps set at a cycle or so to qualify the assertion of setting SS1). Optoisolated input **IN105** also has its own built-in debounce timer (IN105D) available (see *Figure 7.1*).

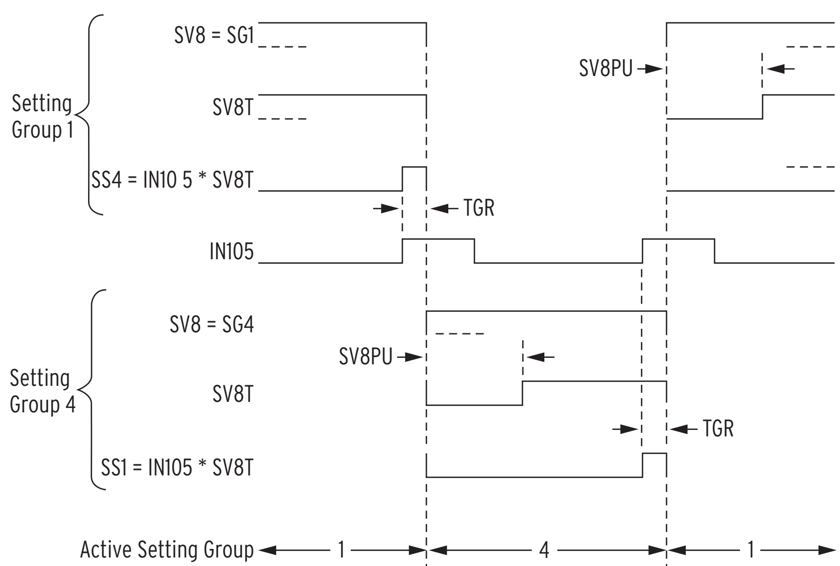


Figure 7.20 Active Setting Group Switching (With Single Input) Time Line

Active Setting Group Switching Example 2

Previous SEL relays (e.g., SEL-321 and SEL-251 Relays) have multiple settings groups controlled by the assertion of three optoisolated inputs (e.g., IN101, IN102, and IN103) in different combinations as shown in *Table 7.6*.

Table 7.6 Active Setting Group Switching Input Logic

Input States			Active Setting Group
IN103	IN102	IN103	
0	0	0	Remote
0	0	1	Group 1
0	1	0	Group 2
0	1	1	Group 3
1	0	0	Group 4
1	0	1	Group 5
1	1	0	Group 6

The SEL-351R can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-351R. In this example, optoisolated inputs IN101, IN102, and IN103 on the control are connected to a rotating selector switch in *Figure 7.21*.

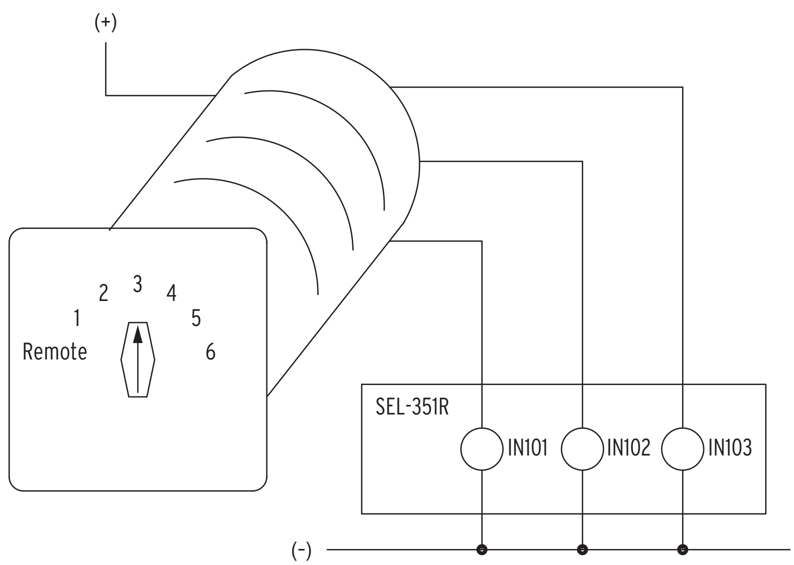


Figure 7.21 Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

The selector switch has multiple internal contacts arranged to assert inputs IN101, IN102, and IN103, dependent on the switch position. As shown in *Table 7.7*, when the selector switch is moved from one position to another, a different setting group is activated. The logic in *Table 7.6* is implemented in the SELOGIC control equation settings in *Table 7.7*.

Table 7.7 SELOGIC Control Equation Settings for Rotating Selector Switch Active Setting Group Switching

Setting	Description
SS1 = !IN103 * !IN102 * IN101	= NOT(IN103) * NOT(IN102) * IN101
SS2 = !IN103 * IN102 * !IN101	= NOT(IN103) * IN102 * NOT(IN101)
SS3 = !IN103 * IN102 * IN101	= NOT(IN103) * IN102 * IN101
SS4 = IN103 * !IN102 * !IN101	= IN103 * NOT(IN102) * NOT(IN101)
SS5 = IN103 * !IN102 * IN101	= IN103 * NOT(IN102) * IN101
SS6 = IN103 * IN102 * !IN101	= IN103 * IN102 * NOT(IN101)

The settings in *Table 7.7* are made in each Setting Group 1–6.

Selector Switch Starts Out in Position 3

Refer to *Table 7.7* and *Figure 7.22*.

If the selector switch is in position 3 in *Figure 7.21*, Setting Group 3 is the active setting group (Relay Word bit SG3 = logical 1). Inputs **IN101** and **IN102** are energized and **IN103** is de-energized:

SS3 = **!IN103 * IN102 * IN101** = NOT(IN103) * IN102 * IN101 = NOT(logical 0) * logical 1 * logical 1 = logical 1

To get from position 3 to position 5 on the selector switch, the switch passes through position 4. The switch is only briefly in position 4:

SS4 = **IN103 * !IN102 * !IN101** = IN103 * NOT(IN102) * NOT(IN101) = logical 1 * NOT(logical 0) * NOT(logical 0) = logical 1

but not long enough to be qualified by time setting TGR in order to change the active setting group to Setting Group 4. For such a rotating selector switch application, qualifying time setting TGR is typically set at 180 to 300 cycles. Set TGR long enough to allow the selector switch to pass through intermediate positions without changing the active setting group, until the switch rests on the desired setting group position.

Selector Switch Switched to Position 5

Refer to *Figure 7.22*.

If the selector switch is rested on position 5 in *Figure 7.21*, Setting Group 5 becomes the active setting group (after qualifying time setting TGR; Relay Word bit SG5 = logical 1). Inputs **IN101** and **IN103** are energized and **IN102** is de-energized:

SS5 = **IN103 * !IN102 * IN101** = IN103 * NOT(IN102) * IN101 = logical 1 * NOT(logical 0) * logical 1 = logical 1

To get from position 5 to position REMOTE on the selector switch, the switch passes through positions 4, 3, 2, and 1. The switch is only briefly in the these positions, but not long enough to be qualified by time setting TGR in order to change the active setting group to any one of these setting groups.

Selector Switch Now Rests on Position REMOTE

Refer to *Figure 7.22*.

If the selector switch is rested on position REMOTE in *Figure 7.21*, all inputs IN101, IN102, and IN103 are de-energized and all settings SS1–SS6 in *Table 7.7* are at logical 0. The last active setting group (Group 5 in this example) remains the active setting group (Relay Word bit SG5 = logical 1).

With settings SS1–SS6 all at logical 0, the serial port **GROUP** command or the front-panel GROUP pushbutton can be used to switch the active setting group from Group 5, in this example, to another desired setting group.

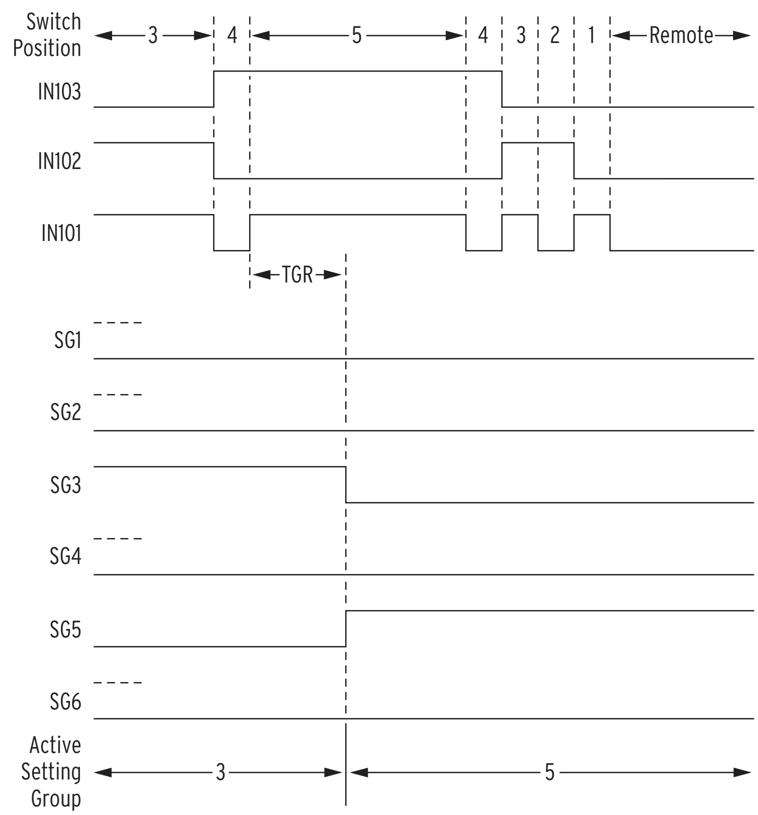


Figure 7.22 Active Setting Group Switching (With Rotating Selector Switch) Time Line

Active Setting Group Retained

Power Loss

The active setting group is retained if power to the control is lost and then restored. If a particular setting group is active (e.g., Setting Group 5) when power is lost, it comes back with the same setting group active when power is restored.

Settings Change

If individual settings are changed (for the active setting group or one of the other setting groups), the active setting group is retained, much like in the *Power Loss* explanation.

If individual settings are changed for a setting group other than the active setting group, there is no interruption of the active setting group (the control is not momentarily disabled).

If the individual settings change causes a change in one or more SELOGIC control equation settings SS1–SS6, the active setting group can be changed, subject to the newly enabled SS1–SS6 settings.

Make Active Setting Group Switching Settings With Care

The active setting group is stored in nonvolatile memory so it can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of “writes” for all setting group changes. Exceeding this limit can result in an EEPROM self-test failure. *This limit translates to an average of 1 setting group change per day for a 25-year recloser control service life.* Therefore, set equations SS1–SS6 with care so continuous cyclical changing of the active setting group does not occur. Time setting TGR qualifies settings SS1–SS6 before changing the active setting group. If optoisolated inputs **IN101**–**IN106** are used in settings SS1–SS6, the inputs have their own built-in debounce timer that can help in providing the necessary time qualification (see *Figure 7.1*).

SELOGIC Control Equation Variables/Timers

Sixteen (16) SELOGIC control equation variables/timers are available. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 7.23* and *Figure 7.24*.

Timers SV1T–SV16T in *Figure 7.23* have a setting range of a little over 4.5 hours:

0.00–999999.00 cycles in 0.25-cycle increments

These timer setting ranges apply to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1–16).

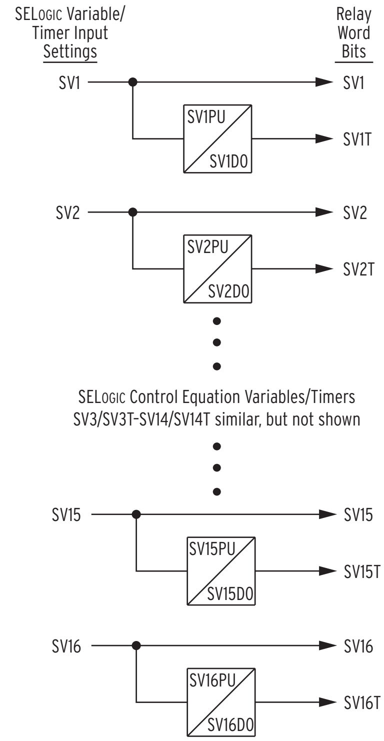


Figure 7.23 SELOGIC Control Equation Variables/Timers SV1/SV1T–SV16/SV16T

Settings Example 1

A SELOGIC control equation timer can be used for a simple breaker failure scheme:

SV1 = **TRIP**

The TRIP Relay Word bit is run through a timer for breaker failure timing. Timer pickup setting SV1PU is set to the breaker failure time (SV1PU = 12 cycles). Timer dropout setting SV1DO is set for a two-cycle dropout (SV1DO = 2 cycles). The output of the timer (Relay Word bit SV1T) operates output contact **OUT103**.

OUT103 = **SV1T**

Settings Example 2

Another application idea is dedicated breaker failure protection (see *Figure 7.24*):

SV6 = **IN101** (breaker failure initiate)

SV7 = **(SV7 + IN101) * (50P1 + 50N1)**

OUT101 = **SV6T** (retrip)

OUT102 = **SV7T** (breaker failure trip)

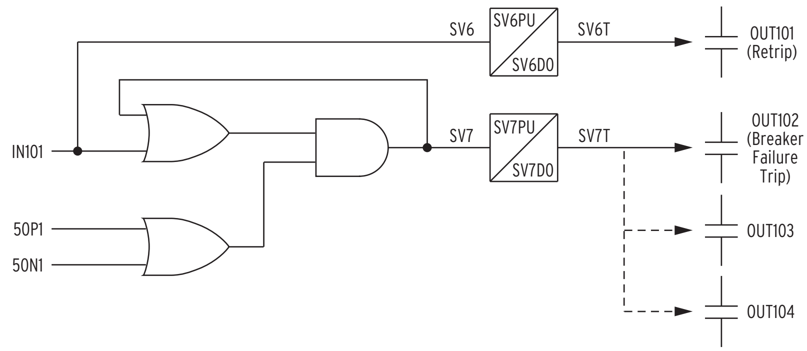


Figure 7.24 Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in *Figure 7.24*) by virtue of SELOGIC control equation setting SV7 being set equal to Relay Word bit SV7 (SELOGIC control equation variable SV7):

SV7 = **(SV7 + IN101) * (50P1 + 50N1)**

Optoisolated input **IN101** functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 and neutral ground instantaneous overcurrent element 50N1 function as fault detectors.

Timer pickup setting SV6PU provides retrip delay, if desired (can be set to zero). Timer dropout setting SV6DO holds the retrip output (output contact **OUT101**) closed for extra time if needed after the breaker failure initiate signal (IN101) goes away.

Timer pickup setting SV7PU provides breaker failure timing. Timer dropout setting SV7DO holds the breaker failure trip output (output contact **OUT102**) closed for extra time if needed after the breaker failure logic unlatches (fault detectors 50P1 and 50N1 drop out).

Note that *Figure 7.24* suggests the option of having output contacts **OUT103** and **OUT104** operate as additional breaker failure trip outputs. This is done by making the following SELOGIC control equation settings:

OUT103 = **SV7T** (breaker failure trip)

OUT104 = **SV7T** (breaker failure trip)

Settings Example 3

The seal-in logic circuit in the dedicated breaker failure scheme in *Figure 7.24* can be removed by changing the SELOGIC control equation setting SV7 to:

SV7 = **IN101 * (50P1 + 50N1)**

If the seal-in logic circuit is removed, optoisolated input **IN101** (breaker failure initiate) has to be continually asserted for a breaker failure time-out.

Timers Reset When Power Is Lost, Settings Are Changed, or Active Setting Group Is Changed

If power is lost to the control, settings are changed (for the active setting group), or the active setting group is changed, then the SELOGIC control equation variables/timers are reset. Relay Word bits SV*n* and SV*n*T (*n* = 1–16) are reset to logical 0 and corresponding timer settings SV*n*PU and SV*n*DO load up again after power restoration, settings change, or active setting group switch.

Preceding *Figure 7.24* shows an effective seal-in logic circuit, created by use of Relay Word bit SV7 (SELOGIC control equation variable SV7) in SELOGIC control equation SV7:

SV7 = **(SV7 + IN101) * (50P1 + 50N1)**

If power is lost to the control, settings are changed (for the active setting group), or the active setting group is changed, then the seal-in logic circuit is “broken” by virtue of Relay Word bit SV7 being reset to logical 0 (assuming input IN101 is not asserted). Relay Word bit SV7T is also reset to logical 0, and timer settings SV7PU and SV7DO load up again.

SELOGIC Counters

NOTE: The SELOGIC counters also reset to zero if power is lost to the control. The values are maintained if a setting or the active setting group is changed. If it is necessary to reset the counter after a setting group change, include the rising edge of the target group in the reset equation. For example, if SC1 in Group 1 must be reset when going to Group 2, then OR /SG2 into the SC1R equation.

Eight (8) SELOGIC counters are available. Three SELOGIC control equations per counter define when the counter increments, decrements, or resets to zero, see *Figure 7.25*. Each rising edge of SC*n*I increments the counter as long as SC*n*D (decrement equation) and SC*n*R (reset equation) are not asserted, and the counter has not reached 999,999 counts. Similarly, the counter decrements on each rising edge of SC*n*D as long as SC*n*I and SC*n*R are not asserted, and the counter has not reached –999,999 counts. If SC*n*R asserts, the counter resets to zero.

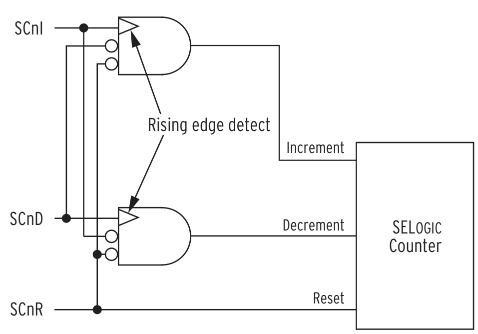


Figure 7.25 SELOGIC Counter

The value of each SELOGIC counter is accessible through a comparison statement within a SELOGIC control equation; see *SELOGIC Control Equation Analog Compares on page G.7*.

Output Contacts

Figure 7.26 shows an example operation of output contact Relay Word bits (e.g., Relay Word bits OUT101–OUT107 in *Figure 7.26*) resulting from:

- SELOGIC control equation operation (e.g., SELOGIC control equation settings OUT101–OUT107 in *Figure 7.26*)

  or

- **PULSE** command execution

The output contact Relay Word bits in turn control the output contacts (e.g., output contacts **OUT101**–**OUT107** in *Figure 7.26*).

Alarm logic/circuitry controls the **ALARM** output contact (see *Figure 7.26*)

Figure 7.26 is used for the following discussion/examples.

Settings Example

Three output contacts can be used for the following functions:

OUT101 = **TRIP** (overcurrent tripping/manual tripping; see *Section 5: Trip and Target Logic*)

OUT102 = **CLOSE** (automatic reclosing/manual closing; see *Section 6: Close and Reclose Logic*)

OUT103 = **SV1T** (breaker failure trip; see *SELOGIC Control Equation Variables/Timers on page 7.23*)

OUT104 = **0** (output contact **OUT104** not used—set equal to zero)

.

.

.

OUT107 = **0** (output contact **OUT107** not used—set equal to zero)

Operation of Output Contacts for Different Output Contact Types

Output Contacts OUT101–OUT107

Refer to *Figure 7.26*.

The execution of the serial port command **PULSE *n*** (*n* = OUT101–OUT107) asserts the corresponding Relay Word bit (OUT101–OUT107) to logical 1. The assertion of SELOGIC control equation setting OUT*m* (*m* = 101–107) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 101–107) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 101–107) to logical 1 causes the energization of the corresponding output contact OUT*m* coil. Depending on the contact type (a or b), the output contact closes or opens as demonstrated in *Figure 7.26*. An a-type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. A b-type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized.

Notice in *Figure 7.26* that all four possible combinations of output contact coil states (energized or de-energized) and output contact types (a or b) are demonstrated. See *Output Contact Jumpers on page 2.2* for output contact type options.

Output contact pickup/dropout time is 4 ms.

ALARM Output Contact

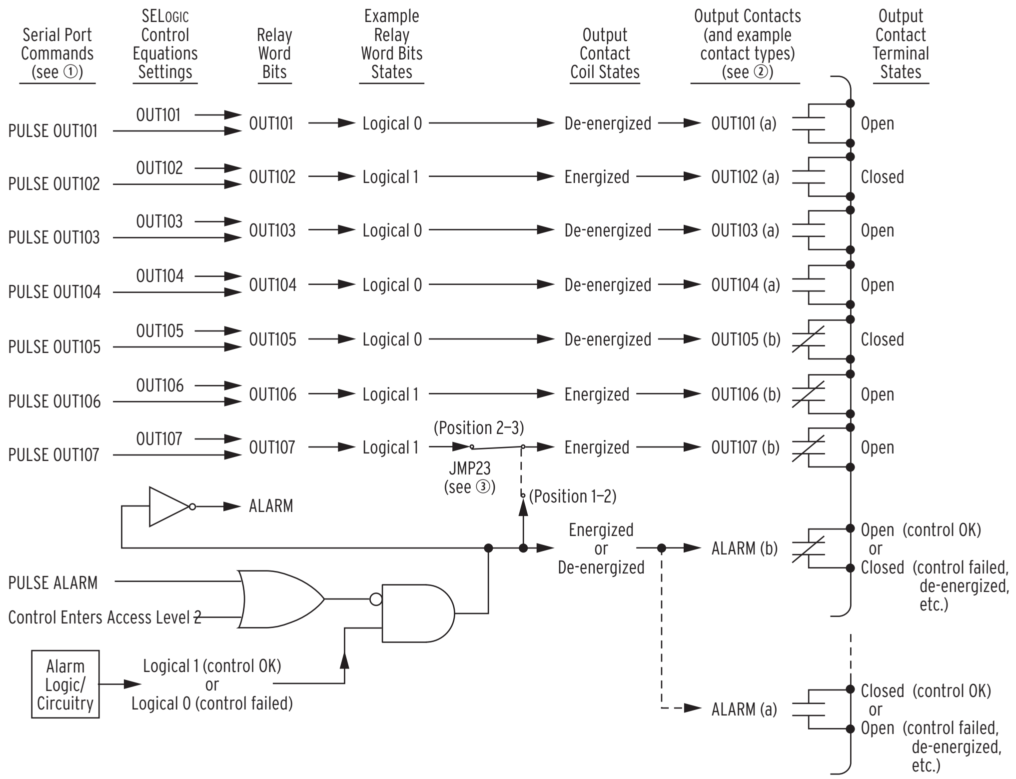
Refer to *Figure 7.26* and *SEL-351R Self-Tests on page 13.5*.

When the control is operational, the ALARM output contact coil is energized. The alarm logic/circuitry keeps the ALARM output contact coil energized. Depending on the ALARM output contact type (a or b), the ALARM output contact closes or opens as demonstrated in *Figure 7.26*. An a-type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. A b-type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized.

To verify ALARM output contact mechanical integrity, execute the serial port command **PULSE ALARM**. Execution of this command momentarily de-energizes the ALARM output contact coil.

The Relay Word bit ALARM is deasserted to logical 0 when the control is operational. When the serial port command **PULSE ALARM** is executed, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the control enters Access Level 2, the ALARM Relay Word bit momentarily asserts to logical 1 (and the ALARM output contact coil is de-energized momentarily).

Notice in *Figure 7.26* that all possible combinations of ALARM output contact coil states (energized or de-energized) and output contact types (a or b) are demonstrated. See *Output Contact Jumpers on page 2.2* for output contact type options.



① The **PULSE** command is also available via the front panel (**CNTRL** pushbutton, `Output Contact Testing` option). Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

② Output contacts **OUT101** through **ALARM** are configurable as a- or b-type output contacts. See Table 2.1 and accompanying text for more information on selecting output contact type.

③ Main board jumper JMP23 allows output contact **OUT107** to operate as: regular output contact **OUT107** (JMP23 in position 2–3); an extra Alarm output contact (JMP23 in position 1–2). See Table 2.3 for more information on jumper JMP23.

Figure 7.26 Logic Flow for Example Output Contact Operation

Rotating Default Display

The rotating default display on the recloser control front panel replaces indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as:

- circuit breaker open/closed
- reclosing relay enabled/disabled

Traditional Indicating Panel Lights

Figure 7.27 shows traditional indicating panel lights wired in parallel with SEL-351R optoisolated inputs. Input **IN101** provides circuit breaker status to the control, and input **IN102** enables/disables reclosing in the control via the following SELOGIC control equation settings:

52A = **IN101**

79DTL = **!IN102** [= NOT(IN102); drive-to-lockout setting]

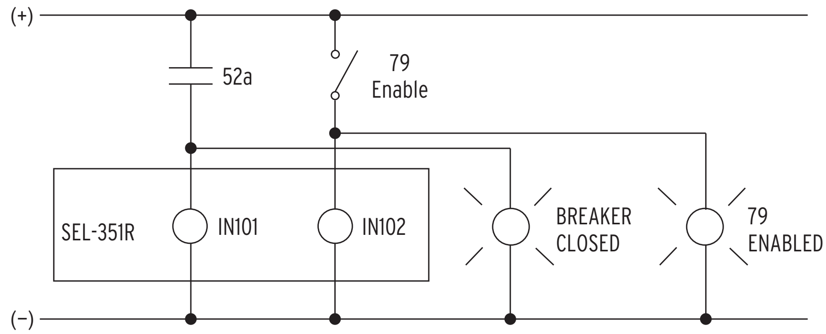


Figure 7.27 Traditional Panel Light Installations

Note that *Figure 7.27* corresponds to *Figure 7.3* (settings example).

Reclosing Relay Status Indication

In *Figure 7.27*, the **79 ENABLED** panel light illuminates when the "79 Enable" switch is closed. When the "79 Enable" switch is open, the **79 ENABLED** panel light extinguishes, and it is understood that the reclosing relay is disabled.

Circuit Breaker Status Indication

In *Figure 7.27*, the **BREAKER CLOSED** panel light illuminates when the 52a circuit breaker auxiliary contact is closed. When the 52a circuit breaker auxiliary contact is open, the **BREAKER CLOSED** panel light extinguishes, and it is understood that the breaker is open.

Traditional Indicating Panel Lights Replaced With Rotating Default Display

The indicating panel lights are not needed if the rotating default display feature in the SEL-351R is used. *Figure 7.28* shows the elimination of the indicating panel lights by using the rotating default display.

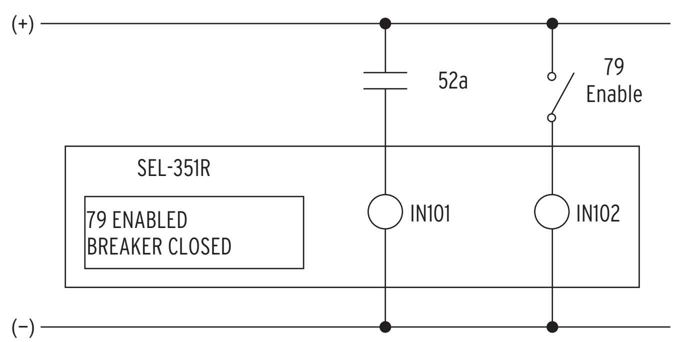


Figure 7.28 Rotating Default Display Replaces Traditional Panel Light Installations

There are 16 default displays available in the SEL-351R. Each default display has two complementary screens (e.g., `BREAKER CLOSED` and `BREAKER OPEN`) available.

General Operation of Rotating Default Display Settings

SELOGIC control equation display point setting DP*n*, where *n* = 1–16 controls the display of corresponding, complementary text settings:

DP*n*_1 (displayed when DP*n* = logical 1)

DP*n*_0 (displayed when DP*n* = logical 0)

Make each text setting through the serial port using the command **SET T**. View these text settings using the serial port command **SHO T** (see *Section 9: Setting the SEL-351R Recloser Control* and *Section 10: Serial Port Communications and Commands*). These text settings are displayed on the SEL-351R front-panel display on a two-second rotation (see *Rotating Default Display on page 11.6* for more specific operation information).

The following factory settings examples use optoisolated inputs IN101 and IN102 in the display points settings. Local bits LB1–LB4, latch bits LT1–LT4, remote bits RB1–RB16, setting group indicators SG1–SG6, and any other combination of Relay Word bits in a SELOGIC control equation setting can also be used in display point setting DP*n*.

Settings Examples

The following example settings provide the replacement solution shown in *Figure 7.28* for the traditional indicating panel lights in *Figure 7.27*.

Reclosing Relay Status Indication

Make SELOGIC control equation display point setting DP1:

DP1 = **IN102**

Make corresponding, complementary text settings:

DP1_1 = **79 ENABLED**

DP1_0 = **79 DISABLED**

Display point setting DP1 controls the display of the text settings.

Reclosing Relay Enabled

In *Figure 7.28*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

```
79 ENABLED
```

Reclosing Relay Disabled

In *Figure 7.28*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:

```
79 DISABLED
```

Circuit Breaker Status Indication

Make SELOGIC control equation display point setting DP2:

DP2 = **IN101**

Make corresponding, complementary text settings:

DP2_1 =. **BREAKER CLOSED**

DP2_0 = **BREAKER OPEN**

Display point setting DP2 controls the display of the text settings.

Circuit Breaker Closed

In *Figure 7.28*, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

DP2 = **IN101** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display:

```
BREAKER CLOSED
```

Circuit Breaker Open

In *Figure 7.28*, optoisolated input IN101 is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = **IN101** = logical 0

This results in the display of corresponding text setting DP2_0 on the front-panel display:

```
BREAKER OPEN
```

Additional Settings Examples

Display Only One Message

To display just one screen, but not its complement, set only one of the text settings. For example, to display just the “breaker closed” condition, but not the “breaker open” condition, make the following settings:

DP2 = **IN101** (52a circuit breaker auxiliary contact connected to input IN101—see *Figure 7.28*)

DP2_1 = **BREAKER CLOSED** (displays when DP2 = logical 1)

DP2_0 = (blank)

Circuit Breaker Closed

In *Figure 7.28*, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

DP2 = **IN101** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display:

```
BREAKER CLOSED
```

Circuit Breaker Open

In *Figure 7.28*, optoisolated input **IN101** is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = **IN101** = logical 0

Corresponding text setting DP2_0 is not set (it is “blank”), so no message is displayed on the front-panel display.

Continually Display a Message

To continually display a message in the rotation, set the SELOGIC control equation display point setting directly to 0 (logical 0) or 1 (logical 1) and the corresponding text setting. For example, if an SEL-351R is protecting a 12 kV distribution feeder, labeled “Feeder 1204,” the feeder name can be continually displayed with the following settings

DP5 = **1** (set directly to logical 1)

DP5_1 = **FEEDER 1204** (displays when DP5 = logical 1)

DP5_0 = (“blank”)

This results in the continual display of text setting DP5_1 on the front-panel display:

```
FEEDER 1204
```

This can also be realized with the following settings:

DP5 = **0** (set directly to logical 0)

DP5_1 = (“blank”)

DP5_0 = **FEEDER 1204** (displays when DP5 = logical 0)

This results in the continual display of text setting DP5_0 on the front-panel display:

```
FEEDER 1204
```

Active Setting Group Switching Considerations

The SELOGIC control equation display point setting DP*n*, where *n* = 1–16 are available separately in each setting group. The corresponding text settings DP*n*_1 and DP*n*_0 are made only once and used in all setting groups.

Refer to *Figure 7.28* and the following example setting group switching discussion.

Setting Group 1 Is the Active Setting Group

When Setting Group 1 is the active setting group, optoisolated input **IN102** operates as a reclose enable/disable switch with the following settings:

SELOGIC control equation settings:

79DTL = **!IN102 + ...** [= NOT(IN102) + ...; drive-to-lockout setting]

DP1 = **IN102**

Text settings:

DP1_1 =. **79 ENABLED** (displayed when DP1 = logical 1)

DP1_0 = **79 DISABLED** (displayed when DP1 = logical 0)

Reclosing Relay Enabled

In *Figure 7.28*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

```
79 ENABLED
```

Reclosing Relay Disabled

In *Figure 7.28*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:

```
79 DISABLED
```

Now the active setting group is switched from Setting Group 1 to 4.

Switch to Setting Group 4 as the Active Setting Group

When Setting Group 4 is the active setting group, the reclosing relay is always disabled and optoisolated input IN102 has no control over the reclosing relay. The text settings cannot be changed (they are used in all setting groups), but the SELOGIC control equation settings can be changed:

SELOGIC control equation settings:

79DTL = **1** (set directly to logical 1—reclosing relay permanently "driven-to-lockout")

DP1 = **0** (set directly to logical 0)

Text settings (remain the same for all setting groups):

DP1_1 = **79 ENABLED** (displayed when DP1 = logical 1)

DP1_0 = **79 DISABLED** displayed when DP1 = logical 0)

Because SELOGIC control equation display point setting DP1 is always at logical 0, the corresponding text setting DP1_0 continually displays in the rotating default displays:

```
79 DISABLED
```

Additional Rotating Default Display Example

See *Figure 5.17* and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the TARGET RESET pushbutton.

Displaying Values (Other Than User-Entered Text) on the Rotating Default Display

Table 7.8–Table 7.11 list the values available for the rotating default display. These available values cover metering (*Table 7.8*), self-check status (*Table 7.9*), breaker wear/counters (*Table 7.10*), and time-overcurrent element pickups (*Table 7.11*). In general, any of these values can be selected for the rotating default display by entering a double colon followed by the mnemonic. For example, to display peak demand currents (*Table 7.8*) for currents IA, IB, IC, and IN, make the following text (**SET T** command) and logic (**SET L** command) settings:

SET T	SET L
DP1_0 = ::IAPK	DP1 = 0
DP2_0 = ::IBPK	DP2 = 0
DP3_0 = ::ICPK	DP3 = 0
DP4_0 = ::INPK	DP4 = 0

Logic settings DP1–DP4 above are permanently set to logical 0 in this example. This causes the corresponding DP*n*_0 value to permanently rotate in the display (the mnemonics in the DP*n*_0 settings indicate the value displayed, per *Table 7.8*):

```
IA  PEAK = 603.5
IB  PEAK = 598.7
```

then,

```
IC  PEAK = 605.1
IN  PEAK = 88.2
```

The *Rotating Default Display on page 11.6* explains pictorially which display setting gets displayed (DP*n*_0 or DP*n*_1), depending on the logic state (logical 0 or 1) of corresponding logic setting DP*n*.

Values Displayed for Incorrect Settings

If the display point setting does not match the format correctly, the control displays the setting text string as it was actually entered, without substituting the display value. For example:

SET T		SET L
DP1_0 = :IAPK	(missing ":")	DP1 = 0
DP2_0 = ::IBPJ	(misspelled mnemonic)	DP2 = 0

Again, logic settings DP1 and DP2 are permanently set to logical 0. This causes the corresponding DP*n*_0 value to permanently rotate in the display. With the above DP*n*_0 setting problems, the control displays the setting text string as it was actually entered, without substituting the intended display value from *Table 7.8*:

```
:IAPK
::IBPJ
```

Metering Values on the Rotating Default Display

Table 7.8 lists the metering values available for the rotating default display. These values correspond to the primary metering values available via the **METER** command (**MET** [Instantaneous], **MET X** [Extended Instantaneous], **MET D** [Demand], and **MET E** [Energy]; see *Section 10: Serial Port Communications and Commands* for serial port commands).

Note in *Table 7.8* that many of the magnitude values are listed with three digits behind the decimal point. For example, the first value in *Table 7.8* is shown generically as below:

```
IA= x.xxxA  yyy°
```

If the magnitude is less than 10, it displays with three digits behind the decimal point:

```
IA= 8.325A    0°
```

(three digits behind the decimal point)

If the magnitude is greater than or equal to 10, it displays with two or fewer digits behind the decimal point:

```
IA= 52.37A    0°
IB= 635.8A -120°
```

(two digits behind the decimal point)
(one digit behind the decimal point)

```
IC= 1173A   120°
```

(no digits behind the decimal point)

The previous IA, IB, IC example is perhaps absurd in magnitude difference, but it demonstrates the automatic decimal point shifting in the rotating default display for these values.

Self-Check Status Values on the Rotating Default Display

Table 7.9 lists the self-check status values available for the rotating default display. These values correspond to the self-check status values available via the **STATUS** command (**STA**; see *Section 10: Serial Port Communications and Commands* for serial port commands).

Breaker Wear/Counter Values on the Rotating Default Display

Table 7.10 lists the breaker wear/counter values available for the rotating default display. These values correspond to the breaker wear/counter values available via the **BREAKER A** command (**BRE A**; see *Section 10* for serial port commands).

Same Display Values/Different Settings

In *Table 7.10*, the following display pair (shown with example values):

```
EF/G TRIPS=  845
GND CNTR=    845
```

(corresponding mnemonic EFGTR)
(corresponding mnemonic GNDCNTR)

display the same value—the number of trips, involving ground, issued by the SEL-351R Recloser Control.

Combined Display Values

Note that the following display choices from *Table 7.10* (shown with example values):

```
A-OPS= 752  72%
B-OPS= 829  78%
```

(corresponding mnemonic ATRWR)
(corresponding mnemonic BTRWR)

```
C-OPS= 861  81%
```

(corresponding mnemonic CTRWR)

are a combination of the information available through respective, individual display choices:

```
A-PH TRIPS=  752
WEAR A=      72%
```

(corresponding mnemonic APHTR)
(corresponding mnemonic WEARA)

```
B-PH TRIPS=  829
WEAR B=      78%
```

(corresponding mnemonic BPHTR)
(corresponding mnemonic WEARB)

```
B-PH TRIPS=  861
WEAR B=      81%
```

(corresponding mnemonic CPHTR)
(corresponding mnemonic WEARC)

Time-Overcurrent Element Pickup Values on the Rotating Default Display

Table 7.11 lists the time-overcurrent element pickup values available for the rotating default display. The mnemonics in *Table 7.11* correspond exactly to the time-overcurrent element pickup settings, set with the **SET** command (see *Section 9: Setting the SEL-351R Recloser Control* for serial port **SET** commands explanation).

The time-overcurrent element pickup settings are made in Amps secondary (e.g., 51P1P = 0.5 A secondary). What gets displayed on the screen is the pickup in terms of Amps primary—the difference factor being the current transformer ratio setting. If phase time-overcurrent element pickup 51P1P is set for display:

SET	SET T	SET L
CTR = 1000 51P1P = 0.50	DP2_0 = ::51P1P	DP2 = 0

then the following gets displayed:

```
500.00 A pri
```

The `A pri` is automatically added at the end. The `500.00` is computed from:

setting CTR • setting 51P1P = 1000 • 0.50 = 500.00

Precede Pickup Display With Explanatory Text

To have some text precede the time-overcurrent element pickup in the rotating default display (to define what the displayed pickup is), make settings as follows (again, the phase time-overcurrent element pickup example):

SET	SET T	SET L
CTR = 1000	DP1_0 = PHASE TRIPS AT	DP1 = 0
51P1P = 0.5	DP2_0 = ::51P1P	DP2 = 0

then the following gets displayed:

```
PHASE TRIPS AT
500.00 A pri
```

With the text strings displaying on "odd" settings:

DP1_0 = **PHASE TRIPS AT** DP1 = 0

and the pickup settings displaying on the "even" settings:

DP2_0 = **::51P1P** DP2 = 0

the two lines will always display together in the rotation, as shown above.

Element Turned OFF

If the time-overcurrent pickup is set off (e.g., 51P1P = OFF):

SET	SET T	SET L
CTR = 1000	DP1_0 = PHASE TRIPS AT	DP1 = 0
51P1P = OFF	DP2_0 = ::51P1P	DP2 = 0

then the following gets displayed:

```
PHASE TRIPS AT
OFF
```

Channel IN Elements Use CTR Multiplier

Again, current transformer ratio setting CTR is the multiplier applied to the 51N1P and 51N2P pickups for the neutral-ground time-overcurrent elements (operating off of channel IN). If neutral-ground time-overcurrent element pickup 51N1P is set for display (note the preceding text in setting DP3_0):

SET	SET T	SET L
CTR = 1000	DP3_0 = NEUTRAL TRIPS AT	DP3 = 0
51N1P = 0.05	DP4_0 = ::51N1P	DP4 = 0

then the following gets displayed:

```
NEUTRAL TRIPS AT
50.00 A pri
```

The `A pri` is automatically added at the end. The `50.00` is computed from:

setting CTR • setting 51N1P = 1000 • 0.05 = 50.00

Table 7.8 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 1 of 3)

Mnemonic	Display																Description
IA		I	A	=		x	.	x	x	x	A		y	y	y	°	IA phase current
IB		I	B	=		x	.	x	x	x	A		y	y	y	°	IB phase current
IC		I	C	=		x	.	x	x	x	A		y	y	y	°	IC phase current
IN		I	N	=		x	.	x	x	x	A		y	y	y	°	IN neutral current
VA		V	A	=	x	.	x	x	x	K	V		y	y	y	°	VA phase voltage
VB		V	B	=	x	.	x	x	x	K	V		y	y	y	°	VB phase voltage
VC		V	C	=	x	.	x	x	x	K	V		y	y	y	°	VC phase voltage
VS		V	S	=	x	.	x	x	x	K	V		y	y	y	°	VS input voltage
IG		I	G	=		x	.	x	x	x	A		y	y	y	°	IG = IA + IB + IC (residual)
3IO	3	I	0	=		x	.	x	x	x	A		y	y	y	°	3IO = IG (zero-sequence)
I1		I	1	=		x	.	x	x	x	A		y	y	y	°	positive-sequence current
3I2	3	I	2	=		x	.	x	x	x	A		y	y	y	°	negative-sequence current
3V0	3	V	0	=	x	.	x	x	x	K	V		y	y	y	°	zero-sequence voltage
V1		V	1	=	x	.	x	x	x	K	V		y	y	y	°	positive-sequence voltage
V2		V	2	=	x	.	x	x	x	K	V		y	y	y	°	negative-sequence voltage
MWA				M	W			A	=		x	x	.	x	x	x	A megawatts
MWB				M	W			B	=		x	x	.	x	x	x	B megawatts
MWC				M	W			C	=		x	x	.	x	x	x	C megawatts
MW3				M	W		3	P	=		x	x	.	x	x	x	three-phase megawatts
MVARA		M	V	A	R			A	=		x	x	.	x	x	x	A megavars
MVARB		M	V	A	R			B	=		x	x	.	x	x	x	B megavars
MVARC		M	V	A	R			C	=		x	x	.	x	x	x	C megavars
MVAR3		M	V	A	R		3	P	=		x	x	.	x	x	x	three-phase megavars
PFA	P	F			A	=		x	.	x	x		L	E	A	D	A power factor
PFB	P	F			B	=		x	.	x	x			L	A	G	B power factor
PFC	P	F			C	=		x	.	x	x			L	A	G	C power factor
PF3	P	F		3	P	=		x	.	x	x		L	E	A	D	three-phase power factor
FREQ	F	R	Q	=	x	x	.	x									system frequency from V1
VAB	V	A	B	=	x	.	x	x	x	K	V		y	y	y	°	AB voltage
VBC	V	B	C	=	x	.	x	x	x	K	V		y	y	y	°	BC voltage
VCA	V	C	A	=	x	.	x	x	x	K	V		y	y	y	°	CA voltage
IADEM	I	A			D	E	M			=		x	.	x	x	x	IA demand current
IAPK	I	A			P	E	A	K		=		x	.	x	x	x	IA peak current
IBDEM	I	B			D	E	M			=		x	.	x	x	x	IB demand current
IBPK	I	B			P	E	A	K		=		x	.	x	x	x	IB peak current
ICDEM	I	C			D	E	M			=		x	.	x	x	x	IC demand current

Table 7.8 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 2 of 3)

Mnemonic	Display																Description
ICPK	I	C			P	E	A	K		=		x	.	x	x	x	IC peak current
INDEM	I	N			D	E	M			=		x	.	x	x	x	IN demand current
INPK	I	N			P	E	A	K		=		x	.	x	x	x	IN peak current
IGDEM	I	G			D	E	M			=		x	.	x	x	x	IG demand current
IGPK	I	G			P	E	A	K		=		x	.	x	x	x	IG peak current
3I2DEM	3	I	2		D	E	M			=		x	.	x	x	x	3I2 demand current
3I2PK	3	I	2		P	E	A	K		=		x	.	x	x	x	3I2 peak current
MWADI	M	W	A		I	N		D	E	M	=	x	.	x	x	x	A demand megawatts in
MWAPI	M	W	A		I	N		P	K		=	x	.	x	x	x	A peak megawatts in
MWBDI	M	W	B		I	N		D	E	M	=	x	.	x	x	x	B demand megawatts in
MWBPI	M	W	B		I	N		P	K		=	x	.	x	x	x	B peak megawatts in
MWCDI	M	W	C		I	N		D	E	M	=	x	.	x	x	x	C demand megawatts in
MWCPI	M	W	C		I	N		P	K		=	x	.	x	x	x	C peak megawatts in
MW3DI	M	W	3		I	N		D	E	M	=	x	.	x	x	x	three-phase demand megawatts in
MW3PI	M	W	3		I	N		P	K		=	x	.	x	x	x	three-phase peak megawatts in
MVRADI	M	V	R	A		I		D	E	M	=	x	.	x	x	x	A demand megavars in
MVRAPI	M	V	R	A		I		P	K		=	x	.	x	x	x	A peak megavars in
MVRBDI	M	V	R	B		I		D	E	M	=	x	.	x	x	x	B demand megavars in
MVRBPI	M	V	R	B		I		P	K		=	x	.	x	x	x	B peak megavars in
MVRCDI	M	V	R	C		I		D	E	M	=	x	.	x	x	x	C demand megavars in
MVRCPI	M	V	R	C		I		P	K		=	x	.	x	x	x	C peak megavars in
MVR3DI	M	V	R	3		I		D	E	M	=	x	.	x	x	x	three-phase demand megavars in
MVR3PI	M	V	R	3		I		P	K		=	x	.	x	x	x	three-phase peak megavars in
MWADO	M	W	A			O		D	E	M	=	x	.	x	x	x	A demand megawatts out
MWAPO	M	W	A			O		P	K		=	x	.	x	x	x	A peak megawatts out
MWBDO	M	W	B			O		D	E	M	=	x	.	x	x	x	B demand megawatts out
MWBPO	M	W	B			O		P	K		=	x	.	x	x	x	B peak megawatts out
MWCDO	M	W	C			O		D	E	M	=	x	.	x	x	x	C demand megawatts out
MWCPO	M	W	C			O		P	K		=	x	.	x	x	x	C peak megawatts out
MW3DO	M	W	3			O		D	E	M	=	x	.	x	x	x	three-phase demand megawatts out
MW3PO	M	W	3			O		P	K		=	x	.	x	x	x	three-phase peak megawatts out
MVRADO	M	V	R	A		O		D	E	M	=	x	.	x	x	x	A demand megavars out
MVRAPO	M	V	R	A		O		P	K		=	x	.	x	x	x	A peak megavars out
MVRBDO	M	V	R	B		O		D	E	M	=	x	.	x	x	x	B demand megavars out
MVRBPO	M	V	R	B		O		P	K		=	x	.	x	x	x	B peak megavars out
MVRCDO	M	V	R	C		O		D	E	M	=	x	.	x	x	x	C demand megavars out

Table 7.8 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 3 of 3)

Mnemonic	Display																Description
MVRCPO	M	V	R	C		O		P	K		=	x	.	x	x	x	C peak megavars out
MVR3DO	M	V	R	3		O		D	E	M	=	x	.	x	x	x	three-phase demand megavars out
MVR3PO	M	V	R	3		O		P	K		=	x	.	x	x	x	three-phase peak megavars out
MWHAI	M	W	h		A		I	N	=		x	x	.	x	x	x	A megawatt-hours in
MWHAO	M	W	h		A		O	U	T	=	x	x	.	x	x	x	A megawatt-hours out
MWHBI	M	W	h		B		I	N	=		x	x	.	x	x	x	B megawatt-hours in
MWHBO	M	W	h		B		O	U	T	=	x	x	.	x	x	x	B megawatt-hours out
MWHCI	M	W	h		C		I	N	=		x	x	.	x	x	x	C megawatt-hours in
MWHCO	M	W	h		C		O	U	T	=	x	x	.	x	x	x	C megawatt-hours out
MWH3I	M	W	h		3		I	N	=		x	x	.	x	x	x	three-phase megawatt-hours in
MWH3O	M	W	h		3		O	U	T	=	x	x	.	x	x	x	three-phase megawatt-hours out
MVRHAI	M	V	A	R	h		A		I	=	x	x	.	x	x	x	A megavar-hours in
MVRHAO	M	V	A	R	h		A		O	=	x	x	.	x	x	x	A megavar-hours out
MVRHBI	M	V	A	R	h		B		I	=	x	x	.	x	x	x	B megavar-hours in
MVRHBO	M	V	A	R	h		B		O	=	x	x	.	x	x	x	B megavar-hours out
MVRHCI	M	V	A	R	h		C		I	=	x	x	.	x	x	x	C megavar-hours in
MVRHCO	M	V	A	R	h		C		O	=	x	x	.	x	x	x	C megavar-hours out
MVRH3I	M	V	A	R	h		3		I	=	x	x	.	x	x	x	three-phase megavar-hours in
MVRH3O	M	V	A	R	h		3		O	=	x	x	.	x	x	x	three-phase megavar-hours out

Table 7.9 Mnemonic Settings for Self-Check Status on the Rotating Default Display

Mnemonic	Display																Description
5VPS	+	5	V	_	P	S	=				x	.	x	x			5 V supply
5VREG	+	5	V	_	R	E	G	=			x	.	x	x			A/D 5 V supply
–5VREG	–	5	V	_	R	E	G	=		–	x	.	x	x			A/D –5 V supply
12VPS	+	1	2	V	_	P	S	=		x	x	.	x	x			12 V supply
–12VPS	–	1	2	V	_	P	S	=	–	x	x	.	x	x			–12 V supply
15VPS	+	1	5	V	_	P	S	=		x	x	.	x	x			15 V supply
–15VPS	–	1	5	V	_	P	S	=	–	x	x	.	x	x			–15 V supply
TEMP	T	E	M	P	=						x	x	.	x			main board temperature
MODE	M	O	D	E	=				C	H	A	R	G	E			battery charger mode
HOURS	H	R	S	_	L	F	T	=		h	h	:	m	m			hours:min left until go to sleep
12VAUX	1	2	_	A	U	X	=			x	x	.	x	x			battery charger 12 V aux. supply
BATTV	V	B	A	T	=					x	x	.	x	x			battery voltage
CHARGE	I	B	A	T	=					–	x	x	x	x			(dis)charge current

Table 7.10 Mnemonic Settings for Breaker Wear/Counters on the Rotating Default Display

Mnemonic	Display																Description
BRKDATE	R	S	T		D	A	T	:	m	m	/	d	d	/	y	y	last reset date
BRKTIME	R	S	T		T	I	M	:	h	h	:	m	m	:	s	s	last reset time
CTRLTR	C	T	R	L		T	R	I	P	S	=	x	x	x	x	x	internal trip count
OPSCNTR	O	P	S		C	N	T	R	=			x	x	x	x	x	internal plus external trip count
CTRLIA	C	T	R	L		I	A	=	x	x	x	x	x		k	A	internal trip S IA
CTRLIB	C	T	R	L		I	B	=	x	x	x	x	x		k	A	internal trip S IB
CTRLIC	C	T	R	L		I	C	=	x	x	x	x	x		k	A	internal trip S IC
EXTTR	E	X	T		T	R	I	P	S	=		x	x	x	x	x	external trip count
EXTIA	E	X	T		I	A	=		x	x	x	x	x		k	A	external trip S IA
EXTIB	E	X	T		I	B	=		x	x	x	x	x		k	A	external trip S IB
EXTIC	E	X	T		I	C	=		x	x	x	x	x		k	A	external trip S IC
APHTR	A	–	P	H		T	R	I	P	S	=	x	x	x	x	x	A phase trip count
BPHTR	B	–	P	H		T	R	I	P	S	=	x	x	x	x	x	B phase trip count
CPHTR	C	–	P	H		T	R	I	P	S	=	x	x	x	x	x	C phase trip count
EFGTR	E	F	/	G		T	R	I	P	S	=	x	x	x	x	x	Ground trip count
GNDCNTR	G	N	D		C	N	T	R	=			x	x	x	x	x	Ground trip count
SEFTR	S	E	F		T	R	I	P	S	=		x	x	x	x	x	SEF trip count
WEARA	W	E	A	R		A	=						y	y	y	%	A phase wear monitor
WEARB	W	E	A	R		B	=						y	y	y	%	B phase wear monitor
WEARC	W	E	A	R		C	=						y	y	y	%	C phase wear monitor
ATRWR	A	–	O	P	S	=	x	x	x	x	x		y	y	y	%	A phase trip & wear
BTRWR	B	–	O	P	S	=	x	x	x	x	x		y	y	y	%	B phase trip & wear
CTRWR	C	–	O	P	S	=	x	x	x	x	x		y	y	y	%	C phase trip & wear

Table 7.11 Mnemonic Settings for Time-Overcurrent (TOC) Element Pickups on the Rotating Default Display (Sheet 1 of 2)

Mnemonic	Display																Description
51P1P	x	x	x	.	x	x		A		p	r	i					pickup for phase TOC element 51P1T
51P2P	x	x	x	.	x	x		A		p	r	i					pickup for phase TOC element 51P2T
51N1P	x	x	x	.	x	x		A		p	r	i					pickup for neutral ground TOC element 51N1T
51N2P	x	x	x	.	x	x		A		p	r						pickup for neutral ground TOC element 51N2T
51G1P	x	x	x	.	x	x		A		p	r	i					pickup for residual ground TOC element 51G1T

Table 7.11 Mnemonic Settings for Time-Overcurrent (TOC) Element Pickups on the Rotating Default Display (Sheet 2 of 2)

Mnemonic	Display																Description
51G2P	x	x	x	.	x	x		A		p	r	i					pickup for residual ground TOC element 51G2T
51QP	x	x	x	.	x	x		A		p	r	I					pickup for negative-sequence TOC element 51QT

Recloser Trip and Close Circuits

Figure 7.29 is similar to Figure 1.17 in the *SEL-351R-4 Quick-Start Installation and User's Guide*, with additional detail:

- Relay Word Bits: PINBD, PINC, PINE, and PINF (all debounced for three quarter cycles)
- SELOGIC control equations: RCTR and RCCL

When a monitored trip or close circuit point is energized, the corresponding Relay Word bit asserts to logical 1 (e.g., PINBD = logical 1). When de-energized, they deassert to logical 0.

NOTE: The recloser trip and close circuit in Figure 7.29 is unique to Cooper reclosers. To trip and close a conventional circuit breaker, use programmable output contacts (e.g., OUT101 = TRIP, OUT102 = CLOSE). See Output Contacts on page 7.27.

When a high-voltage FET is turned “on” to

- trip (RCTR = TRIP = logical 1)
- or close (RCCL = CLOSE = logical 1)

the recloser, the FET makes an effective short circuit to ground to energize the corresponding trip or close coil. Otherwise, the FETs are an effective open circuit.

Also, the trip circuit differs for motor-operated Cooper reclosers (as compared to *Figure 7.29*), requiring a few SEL-351R settings to be modified. Refer to SEL Application Guide AG99-10, *Change Logic in SEL-351R Recloser Control for Motor-Operated Reclosers*.

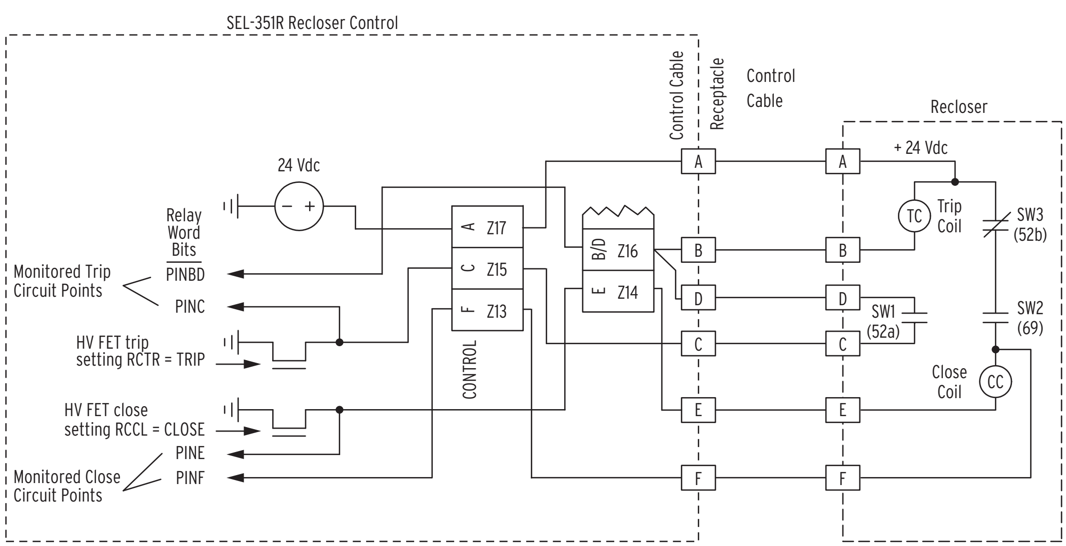


Figure 7.29 Recloser Trip and Close Circuit Connections

Section 8

Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions

Overview

The SEL-351R Recloser Control monitoring functions include:

- ➤ Breaker/Recloser Contact Wear Monitor
- ➤ Battery System Monitor

In addition to instantaneous metering, the SEL-351R metering functions include:

- ➤ Demand Metering
- ➤ Energy Metering
- ➤ Maximum/Minimum Metering

This section explains these functions in detail.

Breaker/Recloser Contact Wear Monitor

The breaker/recloser contact wear monitor in the SEL-351R provides information that helps in scheduling circuit breaker or recloser maintenance. This monitoring function accumulates the number of internal and external trip operations and integrates the number of close-open operations and the per-phase current during each opening operation. The SEL-351R compares the integrated close-open information to a pre-defined breaker or recloser maintenance curve to calculate the percent contact wear on a per-pole basis. The SEL-351R updates and stores the contact wear information, and the number of trip operations, in nonvolatile memory. You can view this information through the front-panel display and by communicating with the SEL-351R through any serial communication port with a computer.

Individual phase Breaker Contact Wear bits, BCWA, BCWB, and BCWC, assert when the contact wear percentage on their respective phases reaches 100 percent. You can use these individual phase elements or the combined result of these elements, BCW (asserts when BCWA or BCWB or BCWC assert), in a SELOGIC® control equation to alarm or control other functions, such as block reclosing.

Enable the breaker/recloser contact wear monitor with the Global EZ setting Recloser Wear Monitor (AUTO, Y, N). Access this setting with the **SET FZ** (Global EZ settings) command from Access Level E (EZ) or Access Level 2. The contact wear monitor is configured as follows:

NOTE: The Access Level E (EZ) Global settings override the corresponding Access Level 2 Global settings when the Access Level E (EZ) Global setting "Recloser Wear Monitor (AUTO, Y, N)" is set to "AUTO" or "N."

- Recloser Wear Monitor (AUTO, Y, N) = N disables the contact wear monitor. Setting EBMON in *Table 8.1* is automatically set EBMON = N and the rest of the settings in *Table 8.1* are hidden.
- Recloser Wear Monitor (AUTO, Y, N) = Y enables the contact wear monitor. Setting EBMON in *Table 8.1* and *Table 8.4* is automatically set EBMON = Y, but you must then use the **SET G** command (Global settings) in Access Level 2 to enter the rest of the settings in *Table 8.1* (or *Table 8.4* if using a G&W Viper-S recloser) that define the maintenance curve (see *Figure 8.2*).
- Recloser Wear Monitor (AUTO, Y, N) = AUTO presents you with subsequent Global EZ settings:
  - Recloser type (OIL, VAC1, VAC2)
  - Interrupt rating (500–20000 A pri.)

  Use *Table 8.2* to make these two settings. The settings in *Table 8.1* are then made automatically, in accordance with the parameters in *Table 8.3*.

Table 8.1 Access Level 2 Global Settings for Contact Wear Monitor

Setting	Definition	Range
EBMON	Enable Breaker/Recloser Monitor	Y (Yes) or N (No)
COSP1	Close/Open set point 1—maximum	0–65000 close/open operations
COSP2	Close/Open set point 2—middle	0–65000 close/open operations
COSP3	Close/Open set point 3—minimum	0–65000 close/open operations
KASP1[a]	kA Interrupted set point 1—minimum	0.10–999.00 kA in 0.01 kA steps
KASP2	kA Interrupted set point 2—middle	0.10–999.00 kA in 0.01 kA steps
KASP3[a]	kA Interrupted set point 3—maximum	0.10–999.00 kA in 0.01 kA steps

[a] The ratio of settings KASP3/KASP1 must be: $5 \leq$ KASP3/KASP1 ≤ 100.

Table 8.2 Access Level E (EZ) Global Settings for Contact Wear Monitor (Sheet 1 of 2)

Recloser Model	Setting: Recloser Type	Setting: Interrupt Rating (Amps primary)
RXE	OIL	6000
RVE	OIL	6000
WE	OIL	12000 (@ 4.8 kV)
WE	OIL	10000 (@ 14.4 kV)
VWE	VAC2	12000
VWVE27	VAC2	12000
VWVE38X	VAC2	12000
WVE27	OIL	8000
WVE38X	OIL	8000
VSA12	VAC2	12000

Table 8.2 Access Level E (EZ) Global Settings for Contact Wear Monitor (Sheet 2 of 2)

Recloser Model	Setting: Recloser Type	Setting: Interrupt Rating (Amps primary)
VSA16	VAC2	16000
VSA20	VAC2	20000
VSA20A	VAC2	20000
VSA20B	VAC2	20000
VSO12	VAC2	12000
VSO16	VAC2	16000

Table 8.3 Parameters Used to Automatically Set Contact Wear Monitor

Table 8.1 Settings	Recloser Type = OIL	Recloser Type = VAC1	Recloser Type = VAC2
EBMON =	Y	Y	Y
COSP1 =	10000	10000	10000
COSP2 =	20	40	80
COSP3 =	20	40	80
KASP1 =	Interrupt Rating/63	Interrupt Rating/40	Interrupt Rating/25
KASP2 =	Interrupt Rating	Interrupt Rating	Interrupt Rating
KASP3 =	Interrupt Rating	Interrupt Rating	Interrupt Rating

Table 8.4 Recommended Contact Wear Monitor Settings for G&W Viper-S Reclosers

Ratings	Table 8.1 Settings				
	EBMON	COSP1	COSP2 COSP3	KASP1	KASP2 KASP3
15.5 or 27 kV, 12500 A interrupt	Y	10000	2510 64	1.25	2.00 12.50
38 kV, 12000 A interrupt	Y	10000	100	1.25	12.00

The parameters in *Table 8.3* are derived from ANSI C37.61-1973/IEEE Standard 321-1973, IEEE Standard Guide for the Application, Operation, and Maintenance of Automatic Circuit Reclosers. These parameters are used in automatically making the settings in *Table 8.1*, when Global EZ setting Recloser Wear Monitor (AUTO, Y, N) = AUTO is made, as described previously.

For example, if the SEL-351R is connected to a type WVE27 Oil Circuit Recloser, use the **SET FZ** command to enter and save the following Access Level E (EZ) Global settings for the contact wear monitor:

- ➤ Recloser Wear Monitor (AUTO, Y, N) = AUTO
- ➤ Recloser Type (OIL, VAC1, VAC2) = OIL
- ➤ Interrupt Rating (500–20000 A pri.) = 8000

When you enter and save the above Global EZ settings, the SEL-351R automatically sets the following set points in the Access Level 2 Global settings:

EBMON =. **Y**

COSP1 = **10000**

COSP2 = **20**

COSP3 = **20**

KASP1 = **0.10**

KASP2 = **8.00**

KASP3 = **8.00**

The SEL-351R integrates current and increments the trip counters for the contact wear monitor each time the logical function BKMON asserts. Set the logic for this function using the Access Level 2 **SET L** command. The default setting is BKMON = TRIP, which causes the contact wear monitor to integrate and increment each time the SEL-351R trip logic asserts.

For more information on the **SET G** and **SET L** commands, see *Table 9.1*. Also, refer to *BRE and BRE A Commands (Breaker Monitor Data) on page 10.15* and *BRE R (Reset Breaker Wear) on page 10.39*.

Breaker Monitor Setting Example

If your recloser is not included in *Table 8.2*, or you adapt the SEL-351R to operate a breaker, you can create a contact wear monitor curve for your specific breaker or recloser. The breaker/recloser contact wear monitor is set with breaker or recloser maintenance information provided by circuit breaker and recloser manufacturers. This maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for a 25 kV circuit breaker.

Table 8.5 Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
0.0–1.2	10,000
2.0	3,700
3.0	1,500
5.0	400
8.0	150
10.0	85
20.0	12

[a] The action of a circuit breaker closing and then later opening is counted as one close/open operation.

The breaker maintenance information in *Table 8.5* is plotted in *Figure 8.1*.

Connect the plotted points in *Figure 8.1* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-351R contact wear monitor, three set points are entered:

➤ Set Point 1—*maximum* number of close/open operations with corresponding current interruption level.

➤ Set Point 2—number of close/open operations that correspond to some *midpoint* current interruption level.

➤ Set Point 3—number of close/open operations that correspond to the *maximum* current interruption level.

These three set points are entered with the settings in *Table 8.1*.

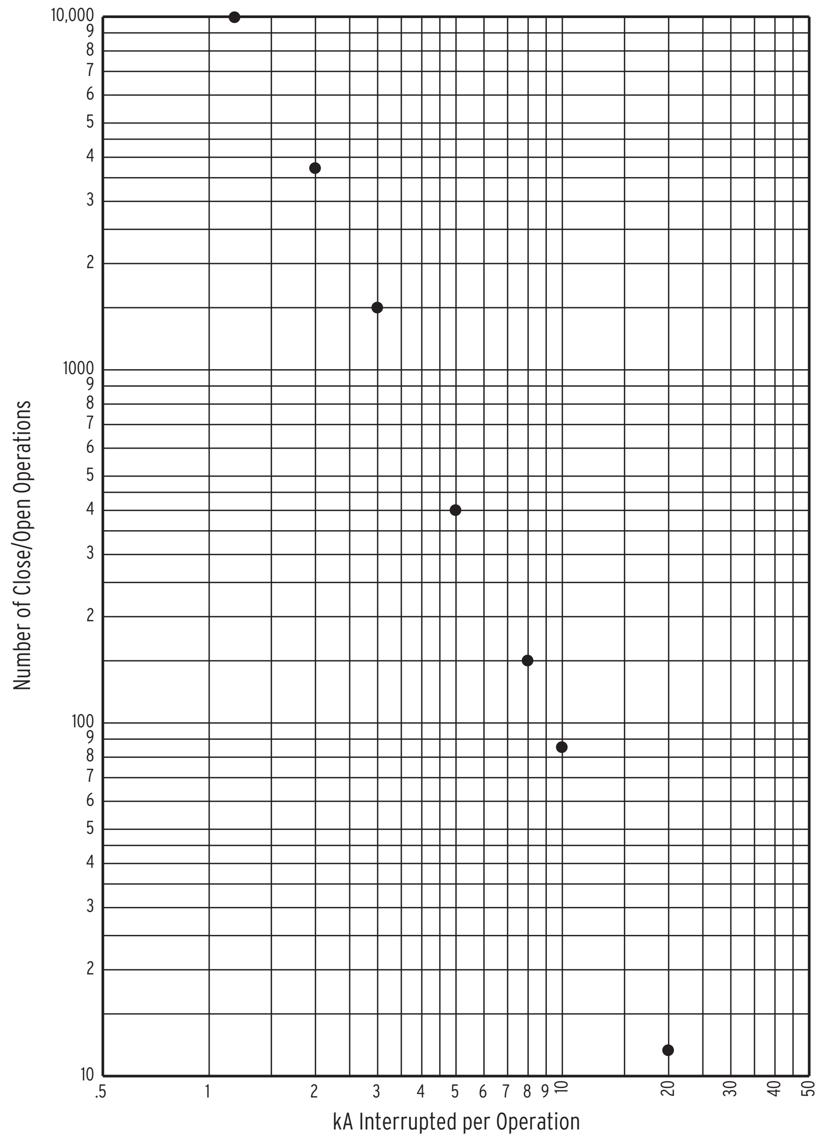


Figure 8.1 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

First, use the **SET FZ** (Global EZ settings) command in Access Level E (EZ) or Access Level 2 to make setting Recloser Wear Monitor (AUTO, Y, N) = Y. Then, in Access Level 2, use the **SET G** (Global settings) command to make the following SEL-351R contact wear monitor settings:

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

Figure 8.2 shows the resultant breaker maintenance curve.

Breaker Maintenance Curve Details

In *Figure 8.2*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 8.5* and *Figure 8.1*.

In this example, set point KASP2, COSP2 provides an intermediate breaker maintenance point in the breaker maintenance information in *Table 8.5* and *Figure 8.1*. Set point KASP2, COSP2 should be set to provide the best "curve-fit" with the plotted breaker maintenance points in *Figure 8.1*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 8.2*), because the separate circuit breaker interrupting contacts for Phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

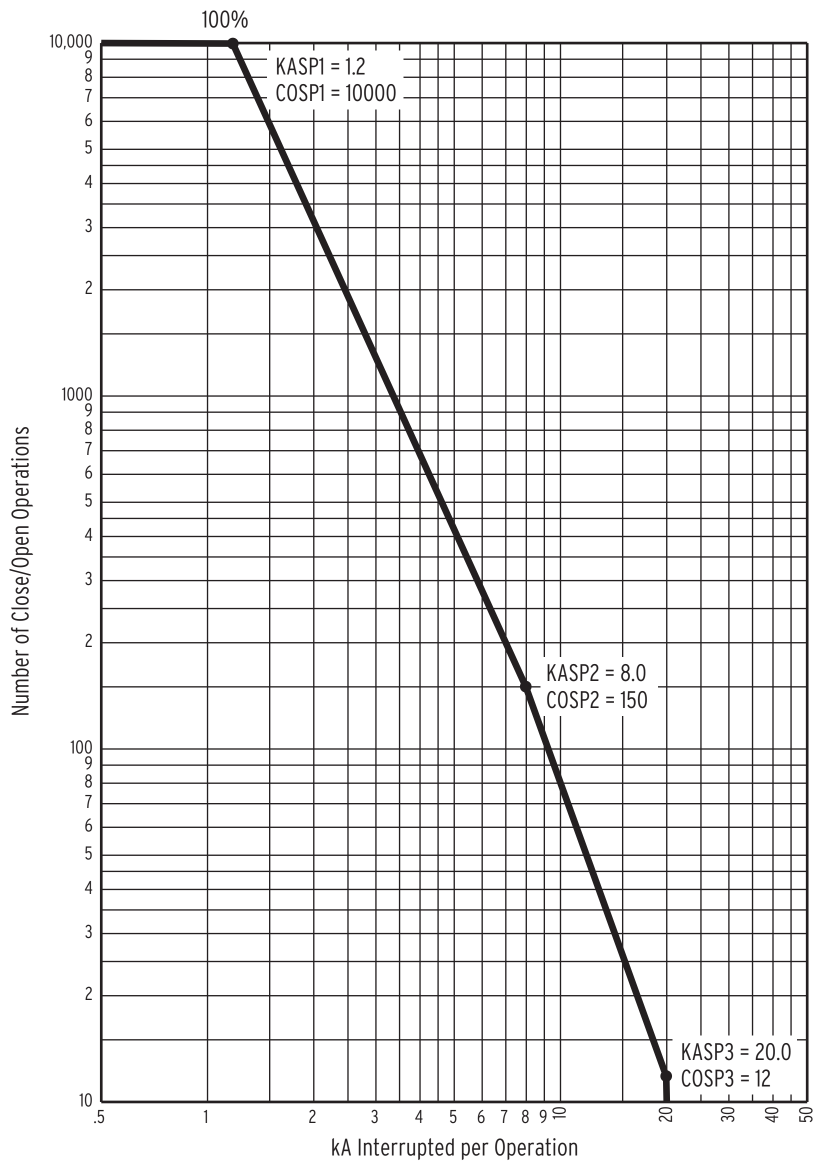


Figure 8.2 SEL-351R Recloser Control Breaker Maintenance Curve for a 25 kV Circuit Breaker

In *Figure 8.2*, note that the breaker maintenance curve levels off horizontally below set point KASP1, COSP1. This is the close/open operation limit of the circuit breaker (COSP1 = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically above set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting BKMON

The SELOGIC control equation breaker monitor initiation setting BKMON determines when the breaker/recloser monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 8.2*) and the breaker monitor accumulated currents/trips [see *BRE and BRE A Commands (Breaker Monitor Data) on page 10.15*].

The BKMON setting looks for a rising edge (logical 0 to logical 1 transition) in its associated logic equation as the trigger to read in current values. The acquired current values are then applied to the breaker maintenance curve and the breaker monitor accumulated currents/trips (see references in previous paragraph).

In the factory-default settings, the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **TRIP** (TRIP is the logic output of *Figure 5.1*)

Refer to *Figure 8.3*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 8.3*, the breaker/recloser monitor actually reads in the current values 1.5 cycles after BKMON asserts. This delay ensures that the current has reached its peak value, especially for an instantaneous trip operation. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be “climbing” to its full value and then will level off. The 1.5-cycle delay allows time for the fault current to level off before the current values are recorded by the contact wear monitor.

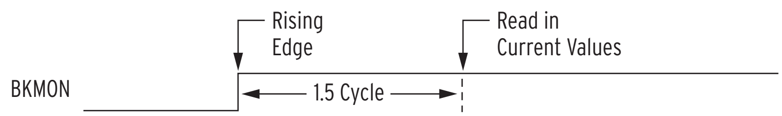


Figure 8.3 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 8.8* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 8.4–Figure 8.7*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in each of the following four figures (*Figure 8.4–Figure 8.7*) that the interrupted current is the same magnitude for all the interruptions (e.g., in *Figure 8.5*, 2.5 kA is interrupted 290 times). This is not realistic but helps to demonstrate the operation of the breaker maintenance curve and how it integrates for various current levels.

0 Percent to 10 Percent Breaker Wear

Refer to *Figure 8.4*. 7.0 kA is interrupted 20 times (20 close/open operations = 20–0), integrating the contact wear curve from 0 percent to the 10 percent wear level.

Compare the 100 percent and 10 percent curves and note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 8.5*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480–190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves and note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 8.6*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24–13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves and note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 8.7*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000–3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted) until reset by the **BRE R** command (see *View or Reset Breaker Monitor Information on page 8.13*). However, the current and trip counts continue to be accumulated until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

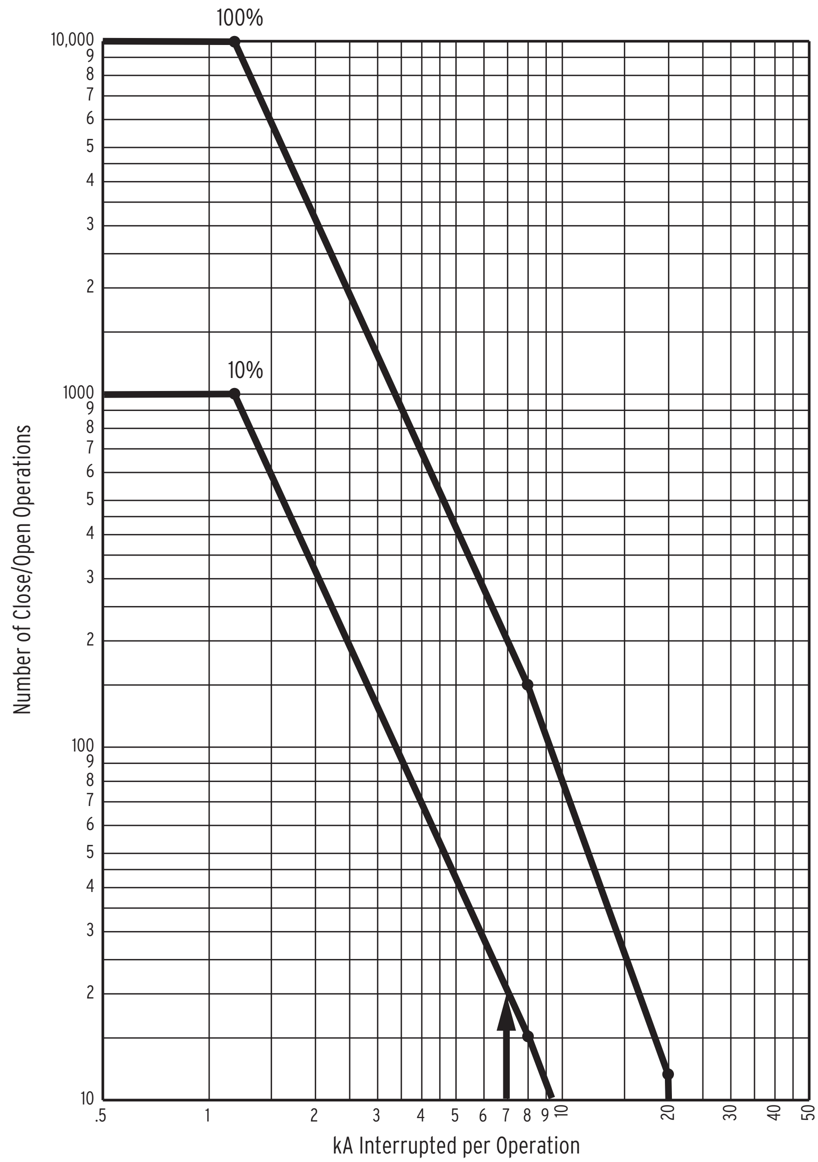


Figure 8.4 Breaker Monitor Accumulates 10 Percent Wear

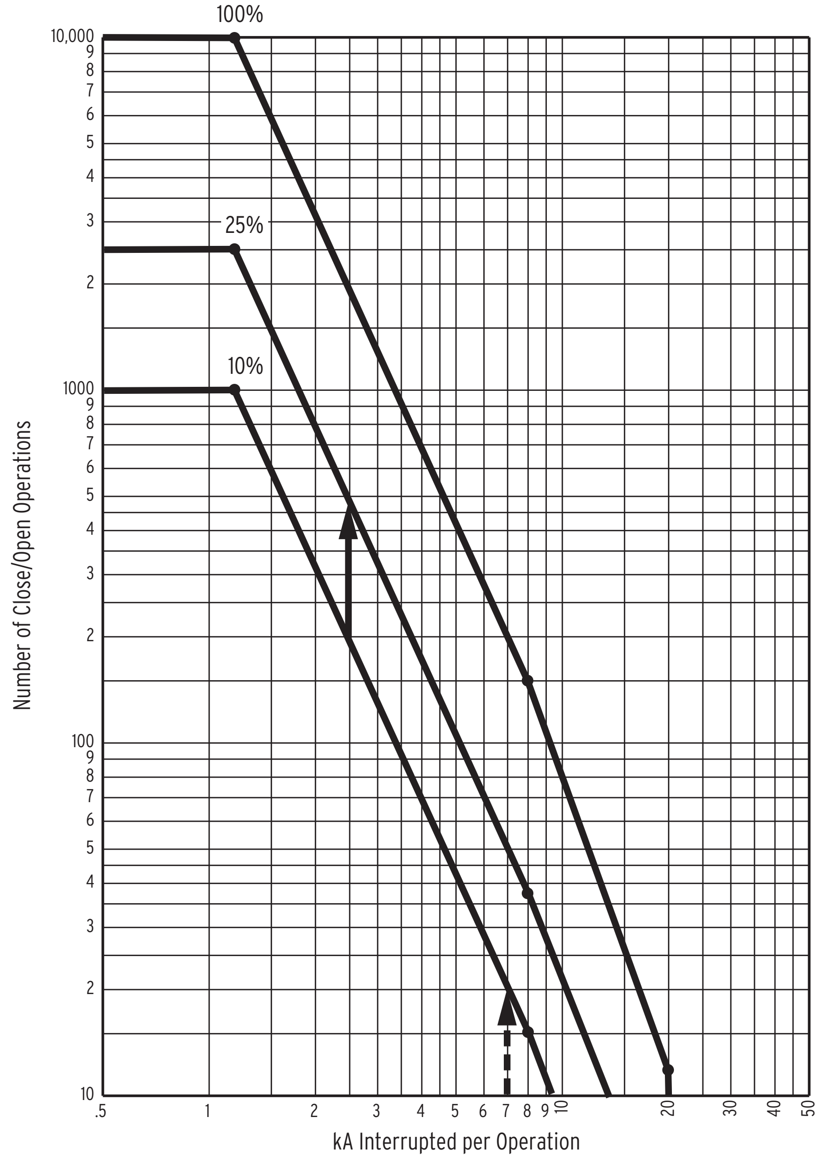


Figure 8.5 Breaker Monitor Accumulates 25 Percent Wear

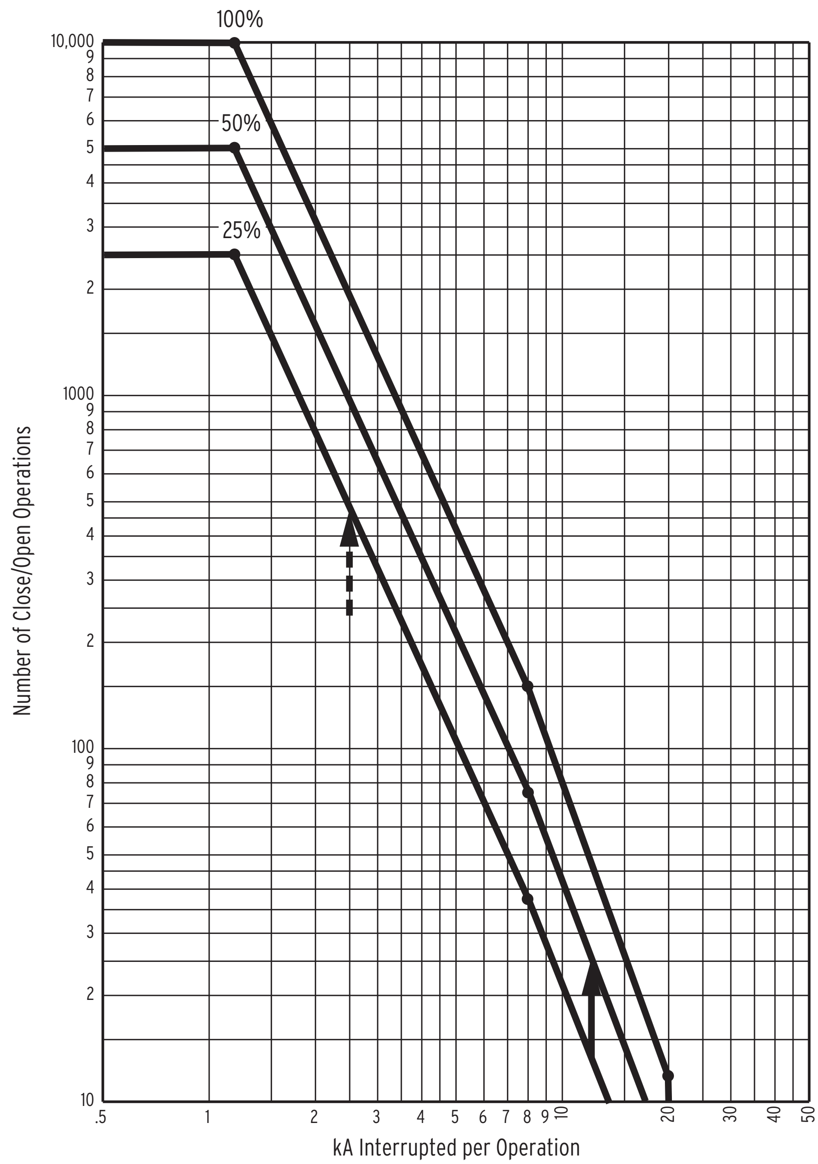


Figure 8.6 Breaker Monitor Accumulates 50 Percent Wear

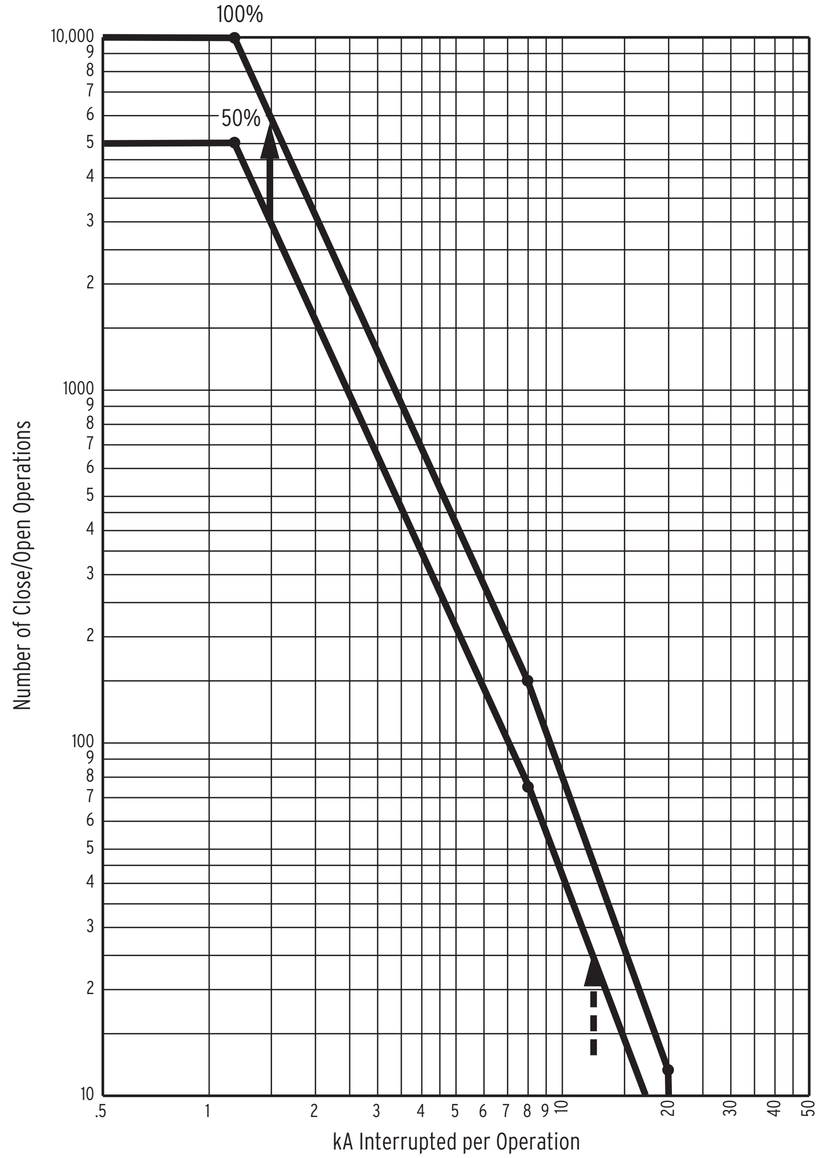


Figure 8.7 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 8.7*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bit	Definition
BCWA	Phase A breaker contact wear has reached the 100% wear level
BCWB	Phase B breaker contact wear has reached the 100% wear level
BCWC	Phase C breaker contact wear has reached the 100% wear level
BCW	BCWA + BCWB + BCWC

Example Applications

These logic outputs can be used to alarm:

OUT105 = **BCW**

or drive the control to lockout the next time the control trips:

79DTL = **... + TRIP * BCW**

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the control loses power or the breaker monitor is disabled (setting EBMON = N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *BRE and BRE A Commands (Breaker Monitor Data) on page 10.15*. The **BRE** command displays the following information:

- Accumulated number of control-initiated trips
- Accumulated interrupted current from control-initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent contact wear for each phase
- Date when the preceding items were last reset via the **BRE R** command

The **BRE A** command displays the above-listed information and the following additional information:

- Accumulated number of trips involving A-phase
- Accumulated number of trips involving B-phase
- Accumulated number of trips involving C-phase
- Accumulated number of trips involving ground (G)
- Accumulated number of trips involving SEF element

A-phase, B-phase, or C-phase involvement is determined by checking if respective elements 50A4, 50B4, or 50C4 are picked up when setting BKMON asserts for a trip.

Ground involvement is determined by checking if elements 50G6, 50N6, 51N1, or 51N2 are picked up when setting BKMON asserts for a trip (this corresponds to the operation of the **G** LED).

SEF involvement is determined by checking if SEF element 67N3T is picked up when setting BKMON asserts for a trip (this corresponds to the operation of the **SEF** LED).

See *BRE R (Reset Breaker Wear) on page 10.39*. The **BRE W** command allows the percent breaker wear to be preloaded for each individual phase. The **BRE W A** command allows the percent breaker wear and trip operation counters to be preloaded for each individual phase/value.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts

(BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE A** and **BRE R** are also available via the front-panel OTHER pushbutton. See the OTHER pushbutton in Pushbutton Primary Functions in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Determination of Control Initiated Trips and Externally Initiated Trips

See *BRE and BRE A Commands (Breaker Monitor Data) on page 10.15*. Note in the **BRE** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by *recloser control initiated trips* (Cntrl Trips) and that generated by *externally initiated trips* (Ext Trips). The categorization of the data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 8.3* and accompanying explanation. When BKMON asserts (logical 0 to logical 1 transition), the control reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Is it under *control initiated trips* or *externally initiated trips?*

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON asserts (TRIP is the logic output of *Figure 5.1*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under *recloser control initiated trips* (Cntrl Trips). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under *externally initiated trips* (Ext Trips).

Regardless of whether the current and trip count information is accumulated under control initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see *Figure 8.3–Figure 8.7*).

Factory-Default Setting Example

Previously as discussed, the SELOGIC control equation breaker monitor initiation factory-default setting is:

BKMON = **TRIP**

Thus, any new assertion of BKMON is classified as a recloser control trip, and the current and trip count information is accumulated under *recloser control initiated trips* (Cntrl Trip).

Additional Example

Refer to *Figure 8.8*. Output contact OUT101 is set to provide tripping:

OUT101 = **TRIP**

Note that optoisolated input IN102 monitors the trip bus. If the trip bus is energized by output contact OUT101, an external control switch, or some other external trip, then IN102 is asserted.

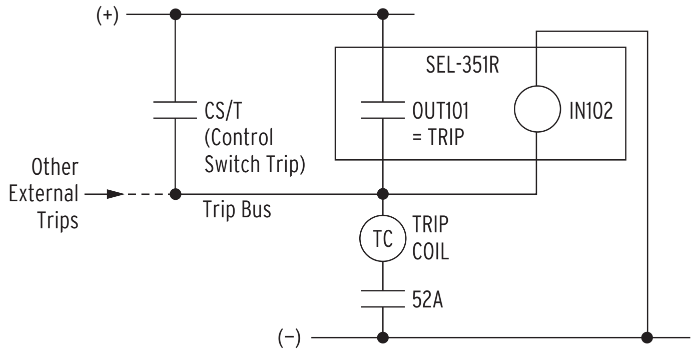


Figure 8.8 Input IN102 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **IN102**

then the SEL-351R monitor sees all trips.

If output contact OUT101 asserts, energizing the trip bus, the contact wear monitor classifies it as a *recloser control initiated trip*. This is because when BKMON is newly asserted (input IN102 energized), the TRIP Relay Word bit is asserted. Thus, the current and trip count information is accumulated under *recloser control initiated trip* (Cntrl Trips).

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor classifies it as an *externally initiated trip* because the TRIP Relay Word bit is not asserted when BKMON asserts (input IN102 energized). Thus, the current and trip count information is accumulated under *externally initiated trips* (Ext Trips).

Battery System Monitor

DC POWER INSTEAD
The SEL-351R can be energized with dc power, instead of ac power. Nothing changes as far as battery operation.

First, see Section 1 and Section 6 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for battery and battery charger/monitor information. The information in the following subsection of this instruction manual will not necessarily repeat information already contained in the *SEL-351R-4 Quick-Start Installation and User's Guide.*

Table 8.6 Battery Charger/Monitor-Related Settings

Global EZ Settings	Corresponding "Regular" Global Settings
Battery Amp-hours (6.5–20)	AMPHR
Power-off Delay After AC Loss (OFF, 1–1440 min)	PWR_AC
Power-off Delay After Wake Up (OFF, 1–1440 min)	PWR_WU
Power-off Voltage Level 1 (19.2–24 Vdc)	V_LOW1

These settings are available via the **SET FZ** (Global EZ settings) or the **SET G** ("regular" Global settings) commands. See Table 1.2 and Section 4 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for more information on Global EZ settings.

Battery Charging

If adequate source power (e.g., 120 Vac power) is present, the constant-voltage battery charger/monitor charges the nominal 24 Vdc battery and Relay Word bit CHRGG asserts. The battery charger/monitor aims for a constant voltage output for a given temperature:

- around 26.5 Vdc for high temperatures
- around 27.5 Vdc for room temperature
- increasingly higher voltages for lower temperatures (e.g., around 29 Vdc for 0ºC; around 30.5 Vdc for –20ºC)

The battery charger is current-limited to 150 mA. Normally, battery charging current gradually declines over time and eventually reaches zero when the battery is fully charged. Then, the control remains in the charging state, with Relay Word bit CHRGG continuing to be asserted.

If the battery is charging at too high of rate (> 100 mA; indicated by Relay Word bit HICHRG asserting) for too long a period of time, then the battery must not be able to take a charge and the following occurs:

- The battery charger turns off
(Relay Word bit CHRGG deasserts)
- The "bad battery" state is entered
(Relay Word bit BADBAT asserts)

Divide the AMPHR Global setting by 0.1 A (100 mA) to determine if the battery is charging for “too long a period of time.” The “bad battery” state is exited (Relay Word bit BADBAT deasserts) if one of the following occurs:

- A manual battery discharge test is performed (via a front-panel or serial port command), with the battery subsequently starting to charge again
(Relay Word bit CHRGG asserts)
- 120 Vac power is lost and the battery starts discharging to pickup the SEL-351R recloser control load
(Relay Word bit DISCHG asserts)

Limits on Battery Discharging

Time Limits

If adequate source power (e.g., 120 Vac power) is lost, the SEL-351R operates off of battery power in the discharge state (Relay Word bit DISCHG asserts) for a set time period or until battery voltage gets too low. The time period is one of the following:

- Setting Power-off Delay After AC Loss (PWR_AC).

  This time period operates if adequate source power (Vac or Vdc—see side-bar note at the beginning of this subsection) is lost and the battery monitor/charger goes from the charging state (CHRRG Relay Word bit asserted) to the control operating on battery power in the discharge state.
- Setting Power-off Delay After Wake Up (PWR_WU).

  This time period operates if the SEL-351R was asleep (adequate source power is lost and the unit is not operating on battery power), then the **WAKE UP** pushbutton is pressed and the control awakens and operates on battery power in the discharge state.

If there is less than 10 minutes of time left for the unit to operate on battery power in the discharge state and there is any sign of either of the following:

- serial port activity
- front-panel top-row pushbutton activity

then the timer reloads with 10 minutes of time, extending the time operating on battery power in the discharge state.

To signal the last minute of timing, while operating on battery power in the discharge state, the TOSLPT Relay Word bit asserts. After this minute of time, the SEL-351R turns itself off (internally disconnects the battery and goes to sleep).

Voltage Limits

If at any time the battery voltage goes below certain thresholds, while operating on battery power in the discharge state, the SEL-351R turns itself off (internally disconnects the battery and goes to sleep) after five seconds of qualification time. These independent low-voltage thresholds are as shown below:

- Setting Power-off Voltage Level 1 (V_LOW1)
- Fixed 19.2 Vdc voltage threshold

Monitor these two thresholds with respective Relay Word bits BATVL1 and BATVL2 (these Relay Word bits assert for battery voltage going below their respective thresholds).

To signal the last second before the SEL-351R turns itself off (internally disconnects the battery and goes to sleep) because of low battery voltage, Relay Word bit TOSLPV asserts.

Factors that contribute to low battery voltage (and thus effectively shorten the expected battery discharge time) are listed below:

- Extreme temperature
- Defective battery (or one nearing the end of its useful life)
- Recloser trip and close operations

Battery Discharge Testing

Battery discharge test procedures (automatic and manual) are covered in Section 6 in the *SEL-351R-4 Quick-Start Installation and User's Guide*. The DISTST Relay Word bit asserts when the battery charger is in the battery discharge test mode (internal 1 A load put on the battery). If the battery discharge test fails (battery voltage goes below 22 Vdc), the test stops immediately (DISTST Relay Word bit deasserts) and the DTFAIL Relay Word bit asserts and stays asserted till the next successful battery discharge test is performed. Assign DTFAIL to an output contact for alarming purposes.

Whether the battery fails the discharge test or not, the control will return to one of the following states:

- Charging state (Relay Word bit CHRGG asserts), if adequate source power is present, and resume charging
- Discharge state (Relay Word bit DISCHRG asserts), if adequate source power is lost, and continue discharging

Battery Cannot Supply Power

If the battery cannot supply power or is temporarily removed for replacement, the adequate source power (e.g., 120 Vac power) source and battery charger/monitor is a sufficient source to trip and close most reclosers. However, the 120 Vac may dip significantly during a fault, reducing or eliminating the source needed to power the SEL-351R and trip the recloser. Internal capacitance is therefore included on the 24 Vdc circuit to maintain power to the control and provide energy to trip the recloser (see *Figure 7.29*). The internal capacitor is sized to provide about 0.5 seconds of control power and trip energy after adequate source power is lost (and with the battery unable to supply power or temporarily disconnected). This is usually enough time for a high-current instantaneous or fast curve operation.

Battery-Related Relay Word Bits

The following Relay Word bits (most discussed in the preceding text) help visualize the battery charger states and are found in *Table 9.5* (starting at Row 34) and defined in *Table 9.6*:

> BADBAT, CHRGG, TOSLPV, TOSLPT, DISTST, DTFAIL, HICHRG, DISCHG, IDSCHG, BATVL1, BATVL2

Include Relay Word bits in the SER settings (command **SET R**) to perform the following functions:

- ➤ Help diagnose battery problems (BADBAT and DTFAIL)
- ➤ Observe the control going to sleep because of low battery voltage (TOSLPV, BATVL1, and BATVL2) while operating on battery power in the discharge state
- ➤ Observe the control going to sleep because of time constraints (TOSLPT) while operating on battery power in the discharge state

Battery-Related Factory-Default Settings

AC SUPPLY and BATTERY PROBLEM LEDs

> *Figure 1.51* shows the factory-default programming for the **AC SUPPLY** and **BATTERY PROBLEM** LEDs.

Reclose Supervision Logic

> *Figure 1.30* shows the factory-default programming for the reclose supervision logic setting 79CLS.

Metering

The SEL-351R reports metered values in several formats through the front panel and through serial communication port interrogation. You can use the front-panel **METER** pushbutton and select `INST`, or use the serial port **METER** command to view instantaneous values of phase and residual current, phase voltage, per phase and three phase real and reactive power, per phase and three-phase power factor, current and voltage sequence components, and frequency.

If you need accurate voltage and power metering, you must connect three-phase voltage to the control from a set of potential instrument transformers. You use the EZ Level **SET EZ** command to set the PT Ratio to reflect the ratio of these potential instrument transformers. If you connect only single phase, 120 Vac voltage to power the SEL-351R, the factory-wired terminal strip jumpers route this voltage to the **V1** phase voltage input. The **V1** phase voltage input is needed to measure system frequency, but the 120 Vac power source may not reflect accurately the primary voltage. Therefore, with only single-phase voltage connected to the SEL-351R, the voltage and power metering values reported by the SEL-351R will not represent accurately primary voltage and power flow. See *Phantom Voltages*.

The metered values of current reflect the primary current scaled through the current transformers in, or on, the recloser. You use the EZ Level **SET EZ** command to set the CT Ratio of these current transformers. The factory settings in the SEL-351R assume that the Phase 1-2 recloser bushings are connected to primary Phase A, Phase 3-4 to primary Phase B, and Phase 5-6 to primary Phase C. If this is not the case, you will need to modify the SEL-351R VPCONN, IPCONN, and CTPOL settings to obtain the proper phase and phase polarity.

In addition to instantaneous metering, the SEL-351R metering functions include Demand Metering, Energy Metering, and Maximum/Minimum Metering.

Phantom Voltages

The SEL-351R can generate phantom voltages from a single voltage connected to the V1 input. For details on enabling phantom voltages, see Factory Global EZ Settings in Section 4 of the *SEL-351R-4 Quick-Start Installation and User's Guide* or *Other Global Settings on page SET.23*.

Global setting PHANTV is set as shown in *Table 8.7*, depending on the connected voltage signal. The magnitude adjustment factor is 1 for phase-to-neutral signals, and 1/(√3) to convert phase-to-phase signals to phase-to-neutral signals.

When the phantom voltage V_{phnt} signal created through use of *Table 8.7* is VA, the recloser control derives B- and C-phase signals by rotating V_{phnt} by either 120 or –120 degrees, depending on the phase rotation setting PHROT.

Figure 8.9 shows an example of the phantom voltage function with ABC phase rotation.

Table 8.7 Phantom Voltage Adjustments

Voltage Connected V1 (Becomes "Reference" Voltage)	Setting PHANTV	Magnitude and Phase Displacement Adjustment, Multiplied by Reference Voltage to Create V_{phnt}	
		Systems With ABC Rotation	Systems With ACB Rotation
V_A	A	$1 \angle 0°$	$1 \angle 0°$
V_B	B	$1 \angle 120°$	$1 \angle (-120)°$
V_C	C	$1 \angle (-120)°$	$1 \angle 120°$
V_{AB}	AB	$1/\sqrt{3} \angle -30°$	$1/\sqrt{3} \angle 30°$
V_{BC}	BC	$1/\sqrt{3} \angle 90°$	$1/\sqrt{3} \angle -90°$
V_{CA}	CA	$1/\sqrt{3} \angle -150°$	$1/\sqrt{3} \angle 150°$

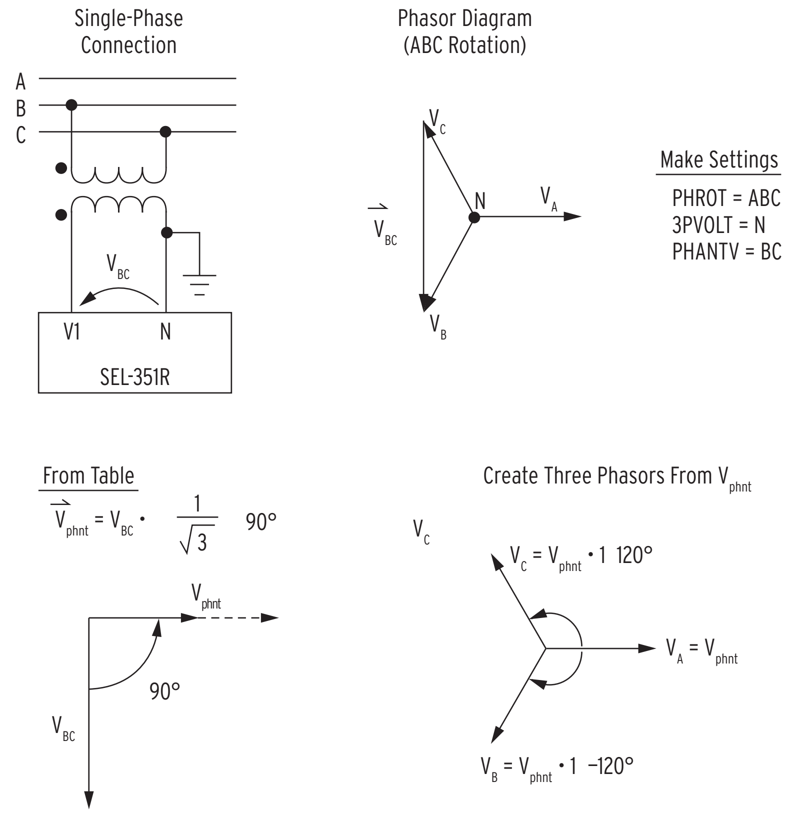


Figure 8.9 Example Phasor Diagram of Phantom Voltage Adjustment

NOTE: The phantom voltage settings have no effect on the protection elements in the SEL-351R. See Voltage Elements on page 3.23.

When the phantom voltage option is being used (i.e., 3PVOLT = N, PHANTV ≠ OFF, the fundamental power and energy quantities are based on the derived phantom voltages.

When the phantom voltage option is being used (i.e., 3PVOLT = N, PHANTV ≠ OFF, the Symmetric Component voltages are still calculated for the phantom voltages. In the example shown in *Figure 8.9*, 3PVOLT = N, PHANTV = B, V2 and 3V0 equal zero, and they are displayed in the **MET** command. These values look like a perfectly balanced three-phase system, which may be misleading.

Phantom Voltage Option Not in Service

If phantom voltage generation is not enabled (i.e., PHANTV = OFF), and three-phase voltages are connected, Global setting VPCONN selects the voltage input terminals that are used to calculate power and energy quantities.

If Global setting VPCONN = OFF when PHANTV = OFF, power and energy metering is calculated as if V123 is connected VABC.

Demand Metering

The SEL-351R factory-default settings enable the control to provide Thermal Demand Metering. The SEL-351R offers the choice between two types of demand metering, set with the Access Level 2 enable setting:

- EDEM = THM (Thermal Demand Meter)

or

- EDEM = ROL (Rolling Demand Meter)

The demand metering settings in *Table 8.8* are available via the Access Level 2 **SET** command (see *Table 9.1* and also *Demand Metering Settings on page SET.11*. Also, refer to *MET D—Demand Metering on page 10.22*).

With either Thermal Demand, or Rolling Average Demand enabled, the SEL-351R provides demand and peak demand metering for the following values:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
	$3I_2$	Negative-sequence current (A primary)
Power	$MW_{A,B,C,3P}$	Single- and three-phase MW
	$MVAR_{A,B,C,3P}$	Single- and three-phase MVAR

Depending on enable setting EDEM, these demand and peak demand values are thermal demand or rolling demand values. The differences between thermal and rolling demand metering are explained in the following discussion.

Comparison of Thermal and Rolling Demand Meters

The example in *Figure 8.10* shows the response of thermal and rolling demand meters to a step current input. The current input is at a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit (a “step”).

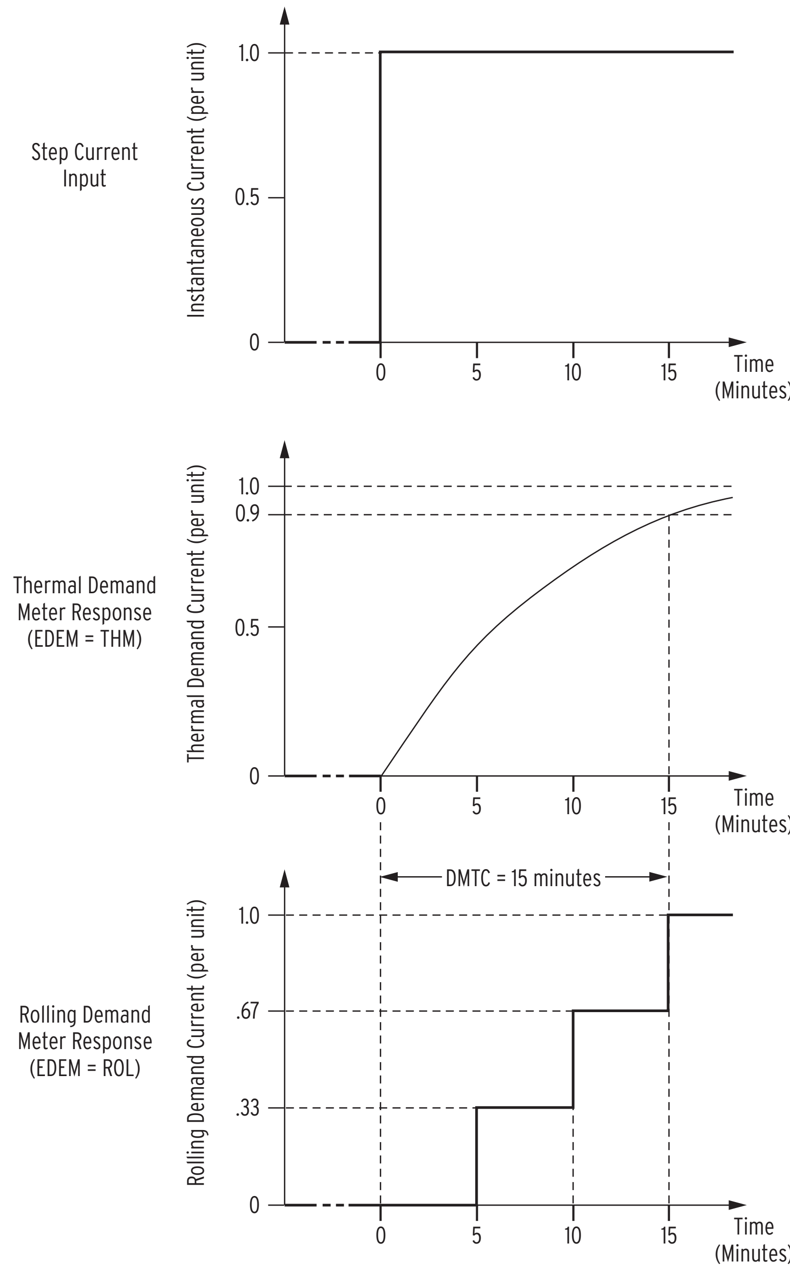


Figure 8.10 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in *Figure 8.10* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 8.11*.

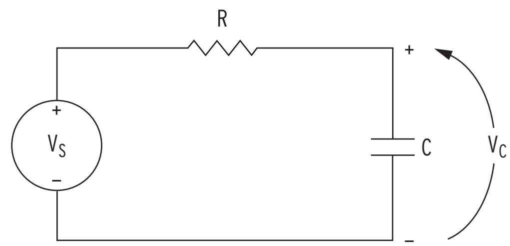


Figure 8.11 Voltage V_S Applied to Series RC Circuit

In the analogy:

Voltage V_S in *Figure 8.11* corresponds to the step current input in *Figure 8.10* (top).

Voltage V_C across the capacitor in *Figure 8.11* corresponds to the response of the thermal demand meter in *Figure 8.10* (middle).

If voltage V_S in *Figure 8.11* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 8.11* is also at zero (V_C = 0.0 per unit). If voltage V_S is suddenly stepped up to some constant value (V_S = 1.0 per unit), voltage V_C across the capacitor starts to rise toward the 1.0 per unit value. This voltage rise across the capacitor is analogous to the response of the thermal demand meter in *Figure 8.10* (middle) to the step current input (top).

In general, since voltage V_C across the capacitor in *Figure 8.11* cannot change instantaneously, the thermal demand meter response is not immediate either for the increasing or decreasing applied instantaneous current. The thermal demand meter response time is based on the demand meter time constant setting DMTC (see *Table 8.8*). Note in *Figure 8.10*, the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The SEL-351R updates thermal demand values approximately every two seconds. The factory-default Access Level 2 Demand Meter Time Constant setting is DMTC = 5 minutes.

Rolling Demand Meter Response (EDEM = ROL)

The response of the rolling demand meter in *Figure 8.10* (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see *Table 8.8*). Note in *Figure 8.10*, the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The rolling demand meter integrates the applied signal (e.g., step current) input in five-minute intervals. The integration is performed approximately every two seconds. The average value for an integrated five-minute interval is derived and stored as a five-minute total. The rolling demand meter then averages a number of the five-minute totals to produce the rolling demand meter response. In the *Figure 8.10* example, the rolling demand meter averages the three latest five-minute totals because setting DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every 5 minutes, after a new five-minute total is calculated.

The following is a step-by-step calculation of the rolling demand response example in *Figure 8.10* (bottom).

Time = 0 Minutes

Presume that the instantaneous current has been at zero for quite some time before “Time = 0 minutes” (or the demand meters were reset). The three five-minute intervals in the sliding time-window at “Time = 0 minutes” each integrate into the following five-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–15 to –10 minutes
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
0.0 per unit	

Rolling demand meter response at “Time = 0 minutes” = 0.0/3 = 0.0 per unit.

Time = 5 Minutes

The three five-minute intervals in the sliding time-window at “Time = 5 minutes” each integrate into the following five-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	

Rolling demand meter response at “Time = 5 minutes” = 1.0/3 = 0.33 per unit.

Time = 10 Minutes

The three five-minute intervals in the sliding time-window at “Time = 10 minutes” each integrate into the following five-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
2.0 per unit	

Rolling demand meter response at “Time = 10 minutes” = 2.0/3 = 0.67 per unit.

Time = 15 Minutes

The three five-minute intervals in the sliding time-window at “Time = 15 minutes” each integrate into the following five-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
1.0 per unit	10 to 15 minutes
3.0 per unit	

Rolling demand meter response at “Time = 15 minutes” = 3.0/3 = 1.0 per unit.

Demand Meter Settings

NOTE: Changing setting EDEM or DMTC resets the demand meter values to zero. This also applies to changing the active setting group, and setting EDEM or DMTC is different in the new active setting group. Demand current pickup settings PDEMP, NDEMP, GDEMP, and QDEMP can be changed without affecting the demand meters.

The examples in this section discuss demand current, but MW and MVAR demand values are also available, as stated at the beginning of this subsection.

Table 8.8 Demand Meter Settings and Settings Range

Setting	Definition	Range
EDEM	Demand meter type	THM = thermal ROL = rolling
DMTC	Demand meter time constant	5, 10, 15, 30, or 60 minutes
PDEMP	Phase demand current pickup	OFF
NDEMP[a]	Neutral ground demand current pickup	0.10–3.20 A (1 A nominal)
GDEMP	Residual ground demand current pickup	in 0.01 A steps
QDEMP	Negative-sequence demand current pickup	

[a] 0.005–0.160 A (0.05 A nominal channel IN current input).

The demand current pickup settings in *Table 8.8* are applied to demand current meter outputs as shown in *Figure 8.12*. For example, when residual ground demand current $I_{G(DEM)}$ goes above corresponding demand pickup GDEMP, Relay Word bit GDEM asserts to logical 1. Use these demand current logic outputs (PDEM, NDEM, GDEM, and QDEM) to alarm for high loading or unbalance conditions. Use in other schemes such as the following example.

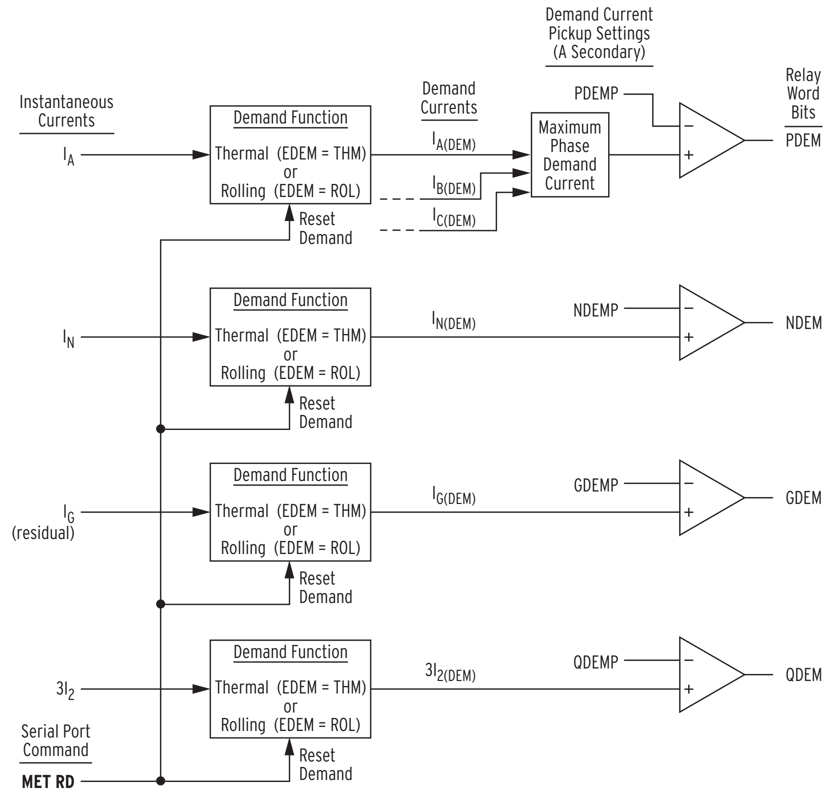


Figure 8.12 Demand Current Logic Outputs

Demand Current Logic Output Application—Raise Pickup for Unbalance Current

During times of high loading, the residual ground overcurrent elements can see relatively high unbalance current I_G ($I_G = 3I_0$). To avoid tripping on unbalance current I_G, use Relay Word bit GDEM to detect the residual ground (unbalance) demand current $I_{G(DEM)}$ and effectively raise the pickup of the residual ground time-overcurrent element 51G1T. This is accomplished with the following settings from *Table 8.8*, pertinent residual ground overcurrent element settings, and SELOGIC control equation torque control setting 51G1TC:

EDEM = **THM**

DMTC = **5**

GDEMP = **1.0**

51G1P = **1.50**

50G5P = **2.30**

51G1TC = **!GDEM + GDEM * 50G5**

Refer to *Figure 8.12*, *Figure 8.13*, and *Figure 3.19*.

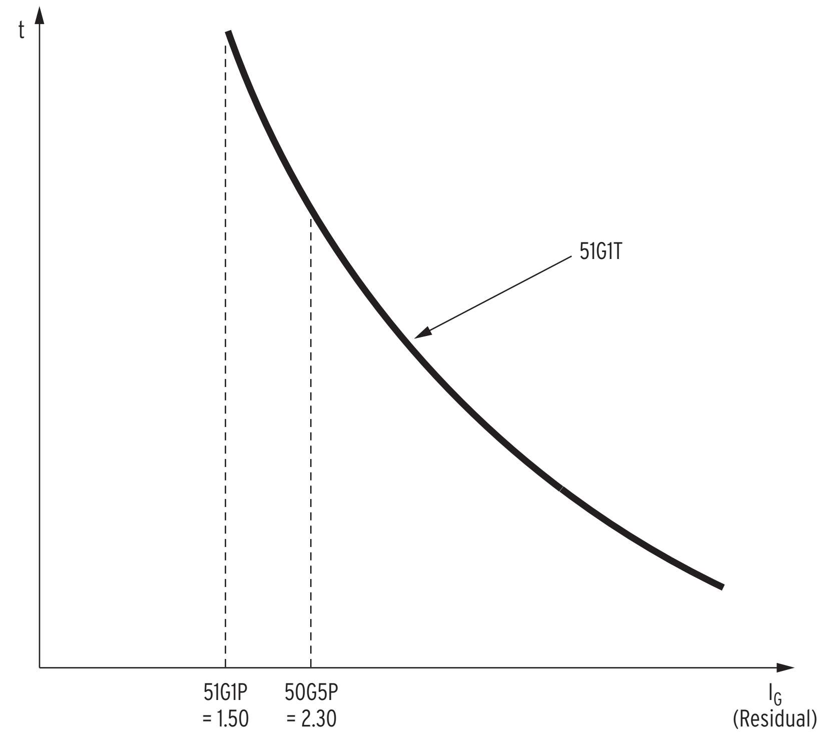


Figure 8.13 Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

Residual Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(DEM)}$ is below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM is deasserted to logical 0. This results in SELOGIC control equation torque control setting 51G1TC being in the state:

51G1TC = **!GDEM + GDEM * 50G5** = NOT(GDEM) + GDEM * 50G5 = NOT(logical 0) + (logical 0) * 50G5 = logical 1

Thus, the residual ground time-overcurrent element 51G1T operates on its standard pickup:

51G1P = **1.50 A secondary**

If a ground fault occurs, the residual ground time-overcurrent element 51G1T operates with the sensitivity provided by pickup 51G1P = 1.50 A secondary. The thermal demand meter, even with setting DMTC = 5 minutes, does not respond fast enough to the ground fault to make a change to the effective residual ground time-overcurrent element pickup—it remains at 1.50 A secondary. Demand meters respond to more “slow moving” general trends.

Residual Ground Demand Current Goes Above Pickup GDEMP

When unbalance current I_G increases, unbalance demand current $I_{G(DEM)}$ follows, going above corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM asserts to logical 1. This results in SELOGIC control equation torque control setting 51G1TC being in the state:

51G1TC = **!GDEM + GDEM * 50G5** = NOT(GDEM) + GDEM * 50G5 = NOT(logical 1) + (logical 1) * 50G5 = logical 0 + 50G5 = 50G5

Thus, the residual ground time-overcurrent element 51G1T operates with an effective, less-sensitive pickup:

50G5P = **2.30 A secondary**

The reduced sensitivity keeps the residual ground time-overcurrent element 51G1T from tripping on higher unbalance current I_G.

Residual Ground Demand Current Goes Below Pickup GDEMP Again

When unbalance current I_G decreases again, unbalance demand current $I_{G(DEM)}$ follows, going below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM deasserts to logical 0. This results in SELOGIC control equation torque control setting 51G1TC being in the state:

51G1TC = **!GDEM + GDEM * 50G5** = NOT(GDEM) + GDEM * 50G5 = NOT(logical 0) + (logical 0) * 50G5 = logical 1

Thus, the residual ground time-overcurrent element 51G1T operates on its standard pickup again:

51G1P = **1.50 A secondary**

View or Reset Demand Metering Information

Via Serial Port

See *MET D—Demand Metering on page 10.22*. The **MET D** command displays demand and peak demand metering for the following values:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
	$3I_2$	Negative-sequence current (A primary)
Power	$MW_{A,B,C}$	Single-phase MW (wye-connected voltages only)
	$MVAR_{A,B,C}$	Single-phase MVAR (wye-connected voltages only)
	MW_{3P}	Three-phase MW
	$MVAR_{3P}$	Three-phase MVAR

The **MET RD** command resets the demand metering values. The **MET RP** command resets the peak demand metering values.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET D**, **MET RD**, and **MET RP** are also available via the front-panel METER pushbutton. See the METER pushbutton in Pushbutton Primary Functions in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide.*

Demand Metering Updating and Storage

The SEL-351R updates demand values approximately every two seconds.

The control stores peak demand values to nonvolatile storage once per day (it overwrites the previous stored value if it is exceeded). Should the control completely lose control power or go into the "sleep" mode, when power is restored, the control will restore the peak demand values saved at 23:50 hours on the previous day.

Demand metering peak recording is momentarily suspended when SELOGIC control equation setting FAULT is asserted (= logical 1). See the explanation for the FAULT setting in *Maximum/Minimum Metering on page 8.29*.

Energy Metering

View or Reset Energy Metering Information

Via Serial Port

See *MET E—Energy Metering on page 10.23*. The **MET E** command displays accumulated single- and three-phase megawatt and megavar hours. The **MET RE** command resets the accumulated single- and three-phase megawatt and megavar hours.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET E** and **MET RE** are also available via the front-panel METER pushbutton. See the METER pushbutton in Pushbutton Primary Functions in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Energy Metering Updating and Storage

The SEL-351R updates energy values approximately every two seconds.

The control stores energy values to nonvolatile memory once per day (it overwrites the previous stored value). Should the control completely lose control power or go into the "sleep" mode, when power is restored, the control will restore the energy values saved at 23:50 hours on the previous day.

Accumulated energy metering values function like those in an electromechanical energy meter. When the energy meter reaches 99999 MWh or 99999 MVARh, it starts over at zero. In firmware versions released prior to November 2004, the SEL-351R energy meter registered dollar signs ($$) after reaching the upper metering limit.

Maximum/Minimum Metering

View or Reset Maximum/Minimum Metering Information

Via Serial Port

See *MET M—Maximum/Minimum Metering on page 10.24*. The **MET M** command displays maximum/minimum metering for the following values:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C}$	Phase voltages (kV primary)
	V_S	Synchronism voltage (kV primary)
Power	MW_{3P}	Three-phase MW
	$MVAR_{3P}$	Three-phase MVAR

The **MET RM** command resets the maximum/minimum metering values.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET M** and **MET RM** are also available via the front-panel METER pushbutton. See the METER pushbutton in the Pushbutton Primary Functions in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Maximum/Minimum Metering Updating and Storage

The SEL-351R updates maximum/minimum values, if the following conditions are met:

- Access Level 2 SELOGIC control equation setting FAULT is deasserted (= logical 0).

  [The factory-default setting is set with time-overcurrent element pickups:

  FAULT = **51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2 + 67N3**

  If a fault picks up any of the elements in the above FAULT setting, the control blocks updating of maximum/minimum metering values.

  SELOGIC control equation setting FAULT also has control over front-panel target LEDs **A**, **B**, and **C** (see *Additional Front-Panel Status and Target LED Information on page 5.26*).]
- The metering value is above the previous maximum or below the previous minimum for two cycles.
- For voltage values, the voltage is above 13 V secondary.
- For current values, the currents are above:
  - 0.05 A secondary (1 A nominal)
- Megawatt and megavar values are subject to the above voltage and current thresholds.

The SEL-351R stores maximum/minimum values to nonvolatile memory once per day (it overwrites the previous stored value if it is exceeded). Should the control completely lose control power or go into the “sleep” mode, when power is restored, the control will restore the maximum/minimum values saved at 23:50 hours on the previous day.

Load Profile Report

At the interval given by load profile acquisition rate setting LDAR, the SEL-351R adds a record to the load profile buffer. This record contains the time stamp, the present value of each of the analog quantities listed in the load profile list setting LDLIST and a checksum. These settings are made and reviewed with the **SET R** and **SHO R** serial port commands, respectively. LDAR can be set to any of the following values: 5, 10, 15, 30, and 60 minutes. LDLIST may contain any of the following labels.

Label	Quantity Recorded
IA, IB, IC, IN	Phase and neutral current magnitudes
VA, VB, VC, VS	Phase and sync voltage magnitudes
VAB, VBC, VCA	Phase-to-phase voltage magnitudes
IG, I1, 3I2, 3V0, V1, V2	Sequence current and voltage magnitudes
FREQ	Phase frequency
MWA, MWB, MWC, MW3	Phase and three-phase MW
MVARA, MVARB, MVARC, MVAR3	Phase and three-phase MVAR
PFA, PFB, PFC, PF3	Phase and three-phase power factor
LDPFA, LDPFB, LDPFC, LDPF3	Phase and three-phase power factor lead/lag status (0 = lag, 1= lead)

Label	Quantity Recorded
IADEM, IBDEM, ICDEM, INDEM, IGDEM, 3I2DEM	Demand ammeter quantities
MWADI, MWBDI, MWCDI, MW3DI	Phase and three-phase demand MW in
MWADO, MWBDO, MWCDO, MW3DO	Phase and three-phase demand MW out
MVRADI, MVRBDI, MVRCDI, MVR3DI	Phase and three-phase demand MVAR in
MVRADO, MVRBDO, MVRCDO, MVR3DO	Phase and three-phase demand MVAR out
MWHAI, MWHBI, MWHCI, MWH3I	Phase and three-phase MW hours in
MWHAO, MWHBO, MWHCO, MWH3O	Phase and three-phase MW hours out
MVRHAI, MVRHBI, MVRHCI, MVRH3I	Phase and three-phase MVAR hours in
MVRHAO, MVRHBO, MVRHCO, MVRH3O	Phase and three-phase MVAR hours out

Labels are entered into the setting, either comma or space delimited, but are displayed as space delimited. Load profiling is disabled if the LDLIST setting is empty (i.e., set to NA or 0), which is displayed as LDLIST = 0. The load buffer is stored in nonvolatile memory and the acquisition is synchronized to the time of day, with a resolution of ±5 seconds. Changing the LDAR setting may result in up to two acquisition intervals before resynchronization occurs. If the LDAR setting is increased, the next acquisition time does not have a complete interval, therefore, no record is saved until the second acquisition time, which is a complete cycle. When the buffer fills up, newer records overwrite older records. The SEL-351R is able to store at least 13 days of data at an LDAR of 5 minutes, if all 15 values are used. If less than 15 values are specified, the SEL-351R will be able to store more days of data before data overwrite occurs. Likewise, if the interval is set longer, the SEL-351R will be able to store more days of data before data overwrite occurs.

The load profile report is retrieved via the **LDP** command, which has the following format:

LDP [a] [b]

If the command is entered without parameters (i.e., **LDP**), the SEL-351R displays all records in the load buffer. If the command is entered with a single numeric parameter [a] (i.e., **LDP 10**), the SEL-351R displays the most recent [a] records in the buffer. If the command is entered with two numeric parameters [a] [b] (i.e., **LDP 10 20**), the SEL-351R displays load buffer records [a] through [b]. If the command is entered with a single data parameter [a] (i.e., **LDP 7/7/12**), the SEL-351R displays all load buffer records for the specified date. If the command is entered with two date parameters [a] [b] (i.e., **LDP 7/7/12 8/8/12**), the SEL-351R displays all load records occurring from date [a] through date [b] inclusive.

Example LDP Serial Port Commands	Format
LDP	If **LDP** is entered with no numbers following it, all available rows are displayed. They display with the oldest row at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
LDP 17	If **LDP** is entered with a single number following it (**17** in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (row 17) at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
LDP 10 33	If **LDP** is entered with two numbers following it (**10** and **33** in this example; 10 < 33), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the oldest row (row 33) at the beginning (top) of the report and the latest row (row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
LDP 47 22	If **LDP** is entered with two numbers following it (**47** and **22** in this example; 47 > 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (row 22) at the beginning (top) of the report and the oldest row (row 47) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.
LDP 3/30/12	If **LDP** is entered with one date following it (date **3/30/12** in this example), all the rows on that date are displayed, if they exist. They display with the oldest row at the beginning (top) of the report and the latest row at the end (bottom) of the report, for the given date. Chronological progression through the report is down the page and in descending row number.
LDP 2/17/12 3/23/12	If **LDP** is entered with two dates following it (date **2/17/12** chronologically *precedes* date **3/23/12** in this example), all the rows between (and including) dates 2/17/12 and 3/23/12 are displayed, if they exist. They display with the oldest row (date 2/17/12) at the beginning (top) of the report and the latest row (date 3/23/12) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
LDP 3/16/12 1/5/12	If **LDP** is entered with two dates following it (date **3/16/12** chronologically *follows* date **1/5/12** in this example), all the rows between (and including) dates 1/5/12 and 3/16/12 are displayed, if they exist. They display with the latest row (date 3/16/12) at the beginning (top) of the report and the oldest row (date 1/5/12) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.

The date entries in the above example **LDP** commands are dependent on the Date Format setting DATE_F. If setting DATE_F = MDY, then the dates are entered as in the above examples (Month/Day/Year). If setting DATE_F = YMD, then the dates are entered Year/Month/Day.

The load profile output has the following format:

```
=>LDP 7/23/12 <Enter>
<STX>
FEEDER 1                     Date: mm/dd/yy    Time: hh:mm:ss.sss
STATION A

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxxxx           CID=xxxx

#     DATE     TIME     label1    label2    label3    label4    label5    ... labeln
512   07/23/12 07:00:35 xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx ...
    xxxxx.xxx
511   07/23/12 08:00:15 xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx ...
    xxxxx.xxx
510   07/23/12 09:00:01 xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx ...
    xxxxx.xxx
<ETX>
=>
```

If the requested load profile report rows do not exist, the control responds:

```
No Load Profile Data
```

Determining the Size of the Load Profile Buffer

The **LDP D** command displays maximum number of days of data the SEL-351R may acquire with the present settings, before data overwrite will occur.

```
=>LDP D <Enter>
There is room for a total of 45 days of data in the load profile buffer,
with room for 21 days of data remaining.
```

Clearing the Load Profile Buffer

Clear the load profile report from nonvolatile memory with the **LDP C** command as shown in the following example:

```
=>LDP C <Enter>
Clear the load profile buffer
Are you sure (Y/N) ? Y <Enter>
Clearing Complete
```

Changing the LDLIST setting also will clear the buffer.

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Section 9

Setting the SEL-351R Recloser Control

Overview

Change or view settings with the **SET** and **SHOWSET** serial port commands and the front-panel SET pushbutton. *Table 9.1* lists the serial port **SET** commands.

Table 9.1 Serial Port SET Commands

Command	Settings Type	Description	Settings Sheets
SET *n*	Group	"Regular" settings (e.g., overcurrent elements, voltage elements, reclose timers) for Setting Group *n* (*n* = 1, 2, 3, 4, 5, 6).	1–13[a]
SET L *n*	Logic	SELOGIC® control equations for Setting Group *n* (*n* = 1, 2, 3, 4, 5, 6).	14–21[a]
SET G	Global	Breaker monitor, battery monitor, optoisolated input debounce timers, etc.	22–24[a]
SET R	SER	Sequential Events Recorder trigger conditions and Load Profile settings.	25–26[a]
SET T	Text	Front-panel default display and local control text.	27–30[a]
SET P *n*	Port	Serial port settings for serial port *n* (*n* = 1, 2, 3, or F).	31[a]
SET EZ *n*	EZ Recloser Control	Traditional recloser control settings (e.g., minimum trips, fast/delay curves, reclose intervals) for Setting Group *n* (*n* = 1, 2, 3, 4, 5, 6)	1–3[b]
SET FZ	EZ Global	Automatic recloser monitor, battery monitor, etc.	3[b]

[a] Located at the end of this section.
[b] Located at the end of Section 4 in the SEL-351R-4 Quick-Start Installation and User's Guide.

View settings with the respective serial port **SHOWSET** commands (**SHO**, **SHO L**, **SHO G**, **SHO R**, **SHO T**, **SHO P**, **SHO EZ**, **SHO FZ**). See *SHO Command (Show/View Settings) on page 10.25*.

Refer to Section 4 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for information on setting traditional recloser control settings with the **SET EZ *n*** and **SET FZ** commands. See **SET EZ** and **SET FZ** commands (Change EZ Settings) in *Access Level E (EZ) on page 10.9* for information on EZ recloser control and EZ global settings (**SET EZ *n*** and **SET FZ**, respectively), and on overriding certain "regular" group settings and global settings (**SET *n*** and **SET G**, respectively).

See *Appendix J: PC Software* for ACSELERATOR QuickSet® SEL-5030 Software information.

Settings Changes Via the Front Panel

Most of the settings that can be made with the **SET** commands in *Table 9.1* also can be made with the SEL-351R front-panel SET pushbutton. The exceptions are settings corresponding to the **SET L *n***, **SET R**, and **SET T** commands. See the SET pushbutton in Pushbutton Primary Functions in Section 3: Front-Panel Interface of the *SEL-351R-4 Quick Start Installation and User's Guide* for more information on making settings via the front-panel interface.

Settings Changes Via the Serial Port

See *Section 10: Serial Port Communications and Commands* for information on serial port communications and access levels. The **SET EZ *n*** and **SET FZ** commands in *Table 9.1* operate at Access Level E (screen prompt: =+>). All other **SET** commands in *Table 9.1* operate at Access Level 2 (screen prompt: =>>). To change a specific setting, enter the command:

SET *m n s* TERSE

where

m	=	L, G, R, T, P, EZ, or FZ (parameter *m* is not entered for the Group settings).
n	=	group (1....6) or port (1, 2, 3, F). The SEL-351R selects the active group or port if *n* is not specified.
s	=	the name of the specific setting you wish to jump to and begin setting. If *s* is not entered, the control starts at the first setting (does not work with the EZ or FZ parameters).
TERSE	=	instructs the control to skip the **SHOWSET** display after the last setting. Use this parameter to speed up the **SET** command. If you wish to review the settings before saving, do not use the TERSE option.

When you issue the **SET** command, the SEL-351R presents a list of settings, one at a time. Enter a new setting, or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 9.2*.

Table 9.2 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next setting.
^ <Enter>	Returns to previous setting.
< <Enter>	Returns to previous settings category.
> <Enter>	Moves to next settings category.
END <Enter>	Exits editing session, then prompts you to save the settings.
<Ctrl> X	Aborts editing session without saving changes.

The SEL-351R checks each entry to ensure that it is within the setting range. If it is not, an `Out of Range` message is generated, and the control prompts for the setting again.

If a given setting is beyond 80 characters (like an SER trigger list setting, set with **SET R** command), then a backslash (\) and carriage return have to be made to complete the setting on the next line. The backslash doesn't have to be entered right at character position 81—it can be entered earlier and then the setting continued on the next line.

When all the settings are entered, the control displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. If changes are made to Global, EZ Global, SER, Text, or Port settings (see *Table 9.1*), the SEL-351R is disabled while it saves the new settings. If changes are made to the EZ Recloser Control, Group, or Logic settings for the active setting group (see *Table 9.1*), the SEL-351R is disabled while it saves the new settings. The ALARM contact closes momentarily for b contact (opens for an a; see *Figure 7.26*), and the CONTROL ENABLED LED extinguishes while the control is disabled. The SEL-351R is disabled for about one second. If Logic settings are changed for the active group, the SEL-351R can be disabled for up to 15 seconds.

If changes are made to the EZ Recloser Control, Group, or Logic settings for a setting group other than the active setting group (see *Table 9.1*), the SEL-351R is not disabled while it saves the new settings. The ALARM contact closes momentarily for b contact (opens for an a; see *Figure 7.26*), but the CONTROL ENABLED LED remains on while the new settings are saved.

Settings Changes Via PC Software

ACSELERATOR QuickSet® SEL-5030 Software provides easy-to-use settings management tools, including the ability to develop settings off line. This software application is a great way to transfer settings between devices or develop new settings based on an existing settings database.

Refer to *Appendix J: PC Software* for more information on using ACSELERATOR QuickSet.

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 3.14–Figure 3.20*). The time-overcurrent relay curves in *Figure 9.1–Figure 9.3* conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

where:

T_p = Operating time in seconds
T_R = Electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)
TD = Time-dial setting
M = Applied multiples of pickup current [for operating time (T_p), $M > 1$; for reset time (T_R), $M \leq 1$]

Table 9.3 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$T_p = TD \bullet \left(0.0226 + \frac{0.0104}{(M^{0.02} - 1)}\right)$	$T_R = TD \bullet \left(\frac{1.08}{(1 - M^2)}\right)$	*Figure 9.1*
U2 (Inverse)	$T_p = TD \bullet \left(0.180 + \frac{5.95}{(M^2 - 1)}\right)$	$T_R = TD \bullet \left(\frac{5.95}{(1 - M^2)}\right)$	*Figure 9.2*
U3 (Very Inverse)	$T_p = TD \bullet \left(0.0963 + \frac{3.88}{(M^2 - 1)}\right)$	$T_R = TD \bullet \left(\frac{3.88}{(1 - M^2)}\right)$	*Figure 9.3*
U4 (Extremely Inverse)	$T_p = TD \bullet \left(0.0352 + \frac{5.67}{(M^2 - 1)}\right)$	$T_R = TD \bullet \left(\frac{5.67}{(1 - M^2)}\right)$	*Figure 9.4*
U5 (Short-Time Inverse)	$T_p = TD \bullet \left(0.00262 + \frac{0.00342}{(M^{0.02} - 1)}\right)$	$T_R = TD \bullet \left(\frac{0.323}{(1 - M^2)}\right)$	*Figure 9.5*

Table 9.4 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$T_p = TD \bullet \left(\frac{0.14}{(M^{0.02} - 1)}\right)$	$T_R = TD \bullet \left(\frac{13.5}{(1 - M^2)}\right)$	*Figure 9.6*
C2 (Very Inverse)	$T_p = TD \bullet \left(\frac{13.5}{(M - 1)}\right)$	$T_R = TD \bullet \left(\frac{47.3}{(1 - M^2)}\right)$	*Figure 9.7*
C3 (Extremely Inverse)	$T_p = TD \bullet \left(\frac{80}{(M^2 - 1)}\right)$	$T_R = TD \bullet \left(\frac{80}{(1 - M^2)}\right)$	*Figure 9.8*
C4 (Long-Time Inverse)	$T_p = TD \bullet \left(\frac{120}{(M - 1)}\right)$	$T_R = TD \bullet \left(\frac{120}{(1 - M)}\right)$	*Figure 9.9*
C5 (Short-Time Inverse)	$T_p = TD \bullet \left(\frac{0.05}{(M^{0.04} - 1)}\right)$	$T_R = TD \bullet \left(\frac{4.85}{(1 - M^2)}\right)$	*Figure 9.10*

All 38 traditional recloser control response curves are available and shown in *Figure 9.11–Figure 9.20*. Each curve has two designations. For example, the bottom curve in *Figure 9.11* has the following two designations:

- ➤ Older electronic control designation: A
- ➤ Newer microprocessor-based control designation: 101

Use either designation in making curve settings in the SEL-351R.

See Table 4.1 and Table 4.2 and following text in the *SEL-351R-4 Quick-Start Installation and User's Guide* for more information on available time-overcurrent curves, including user-programmable curves.

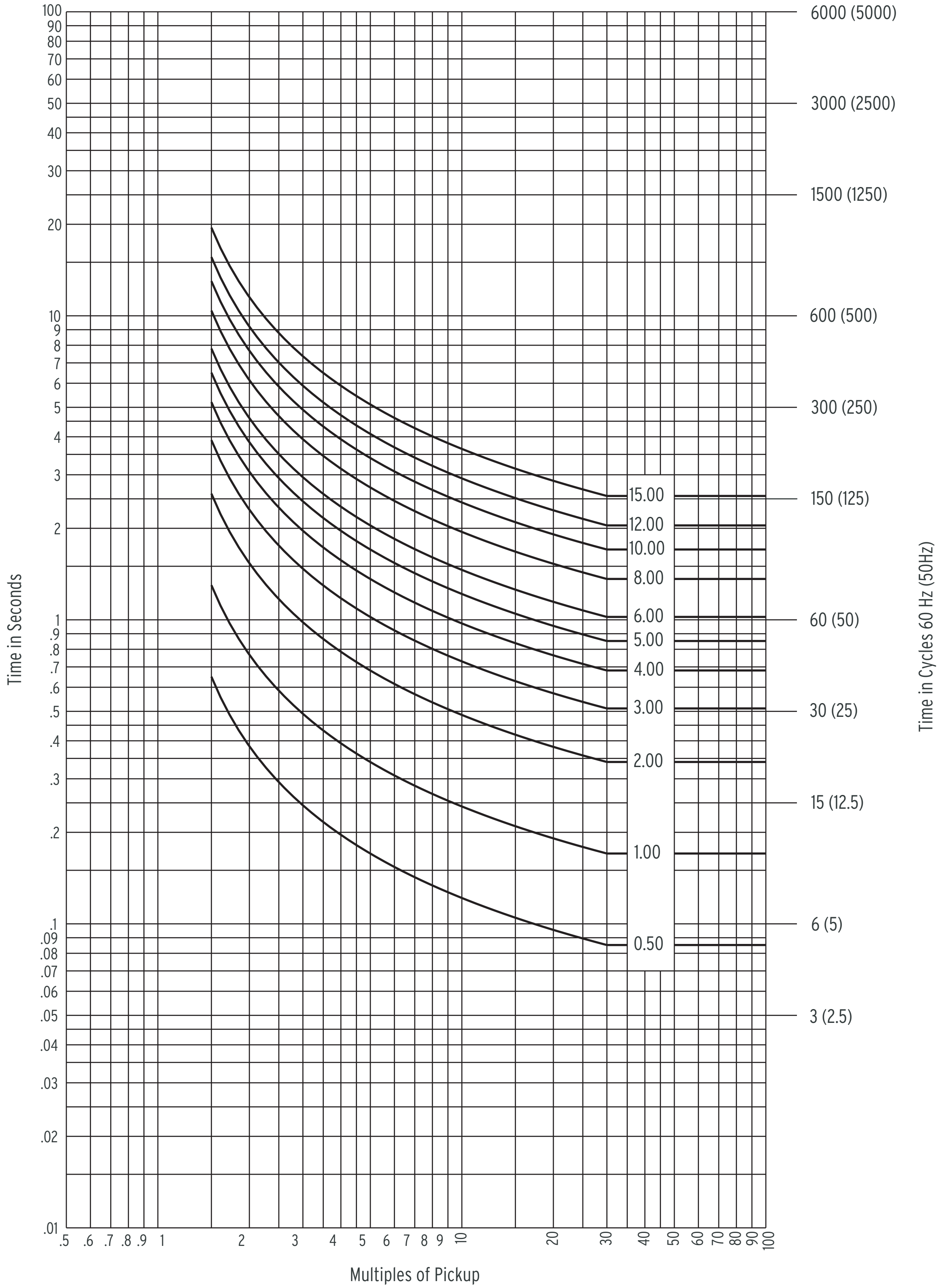

Figure 9.1 U.S. Moderately Inverse Curve: U1

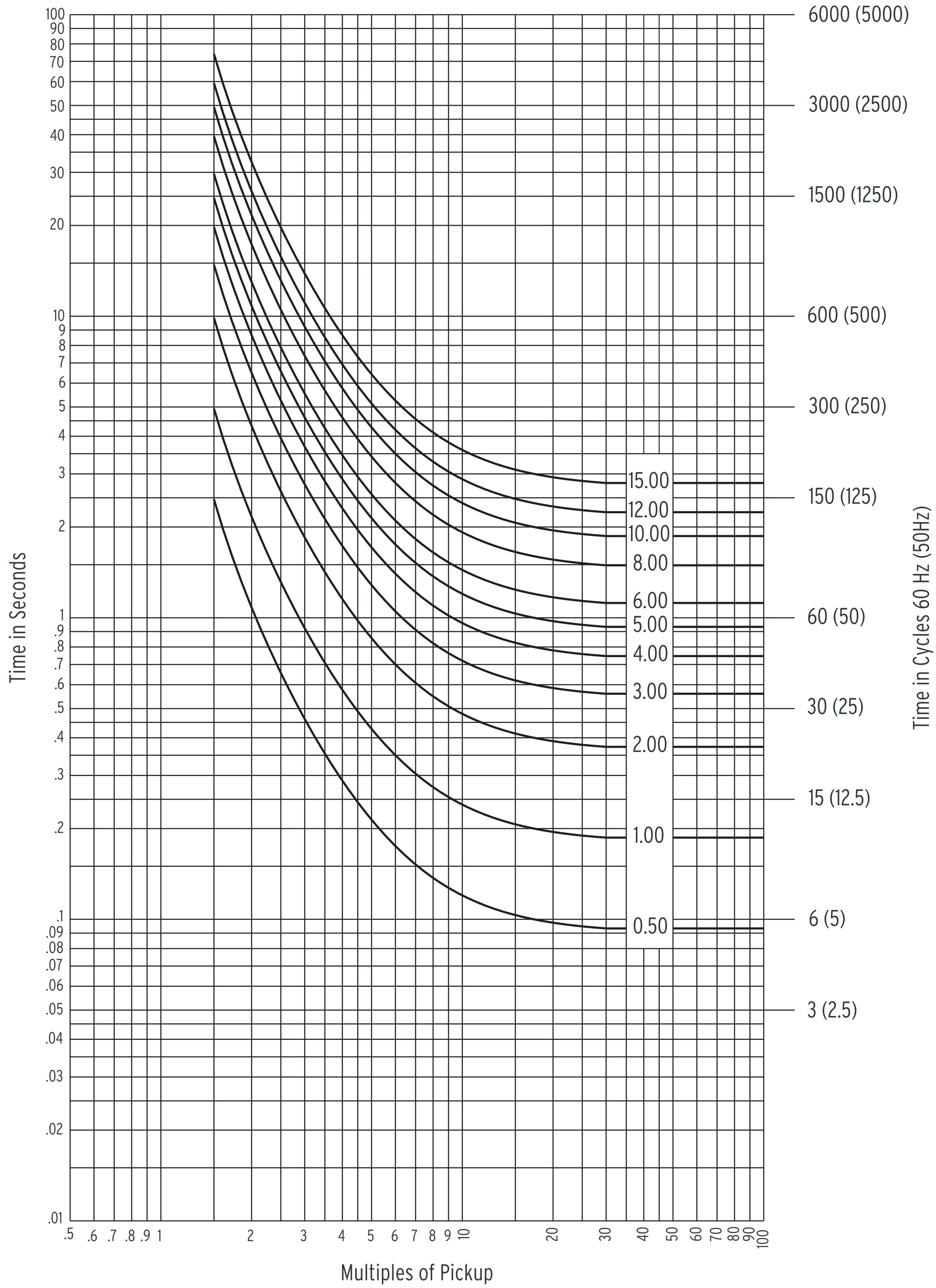

Figure 9.2 U.S. Inverse Curve: U2

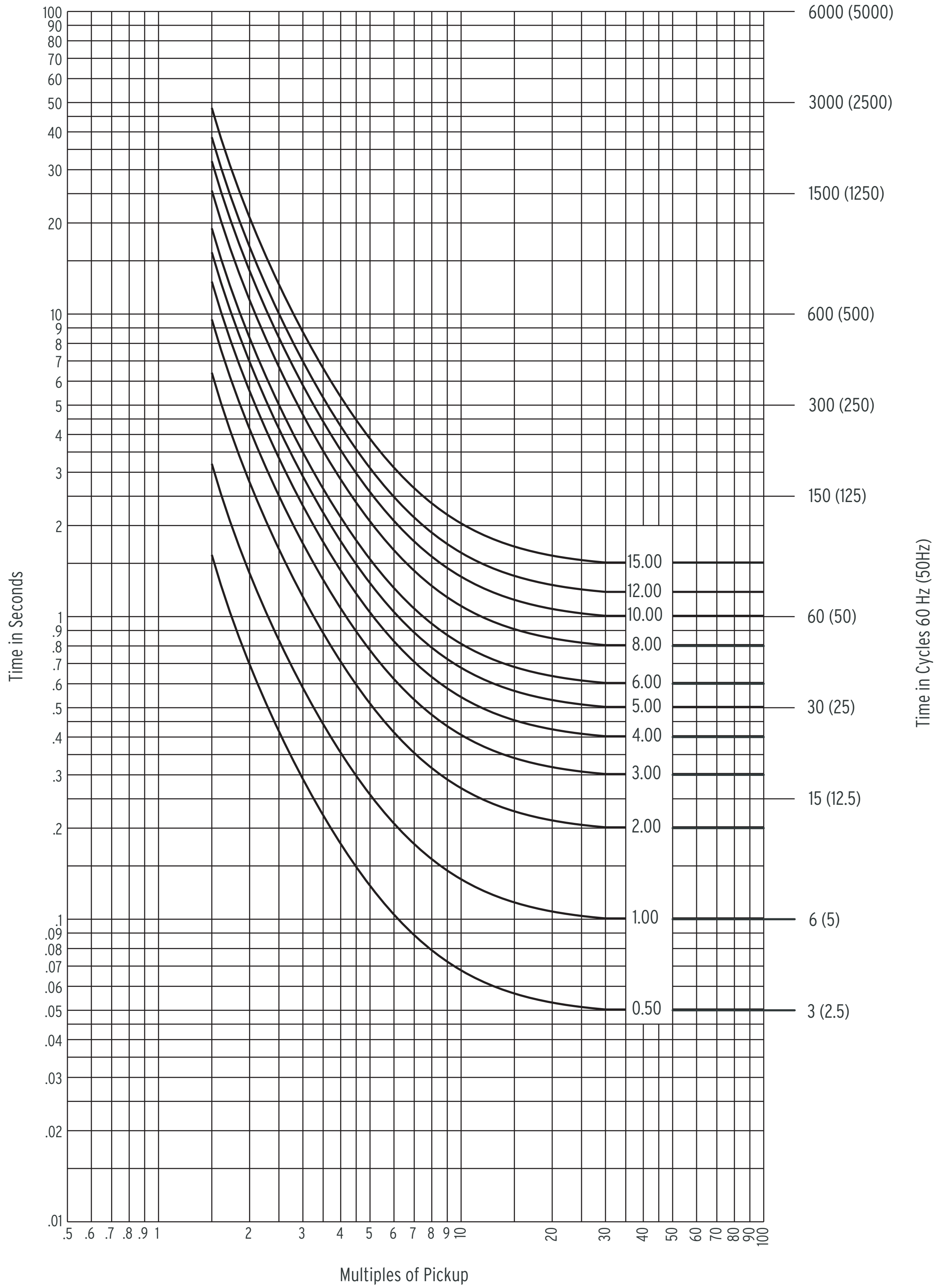

Figure 9.3 U.S. Very Inverse Curve: U3

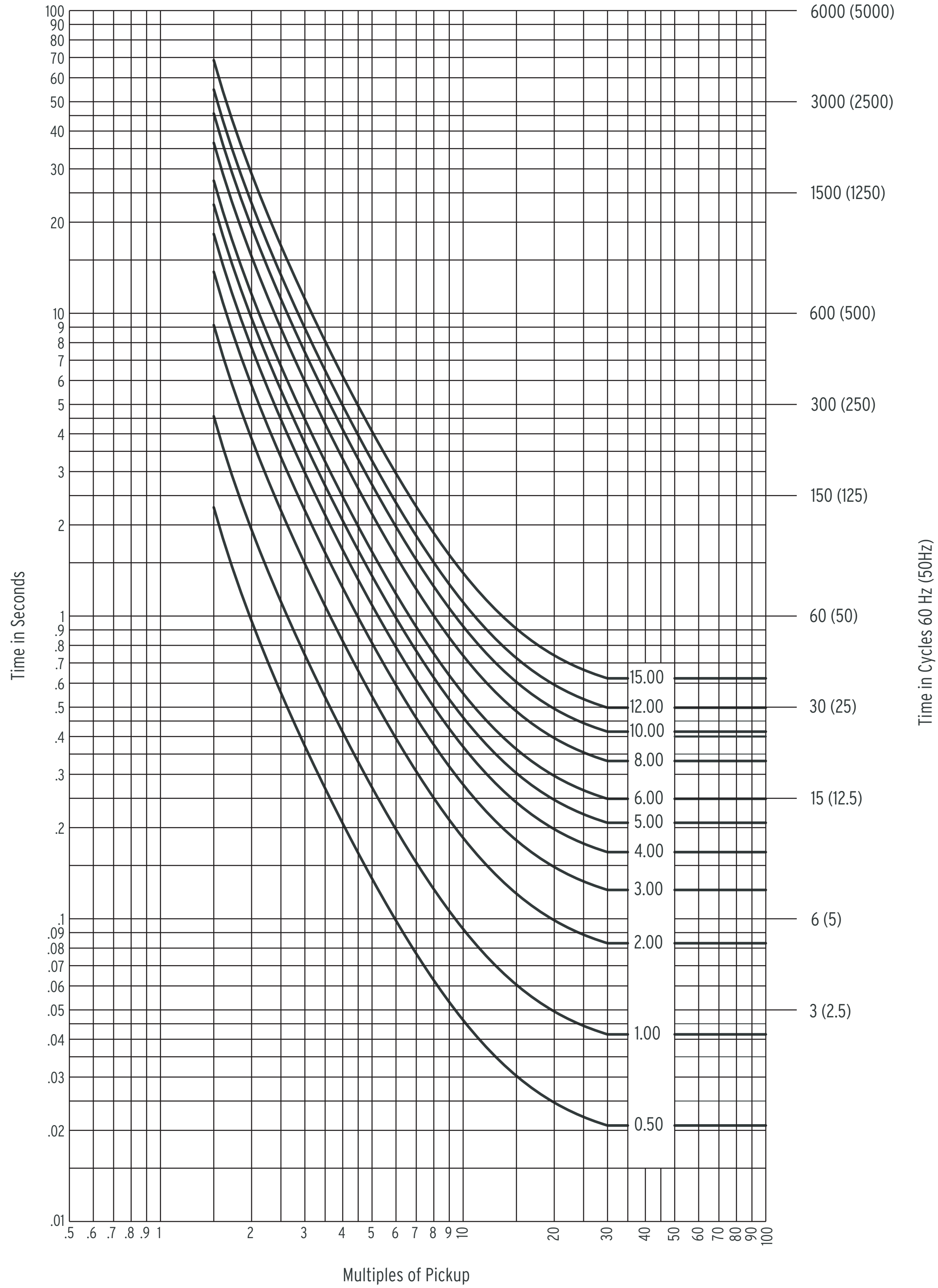

Figure 9.4 U.S. Extremely Inverse Curve: U4

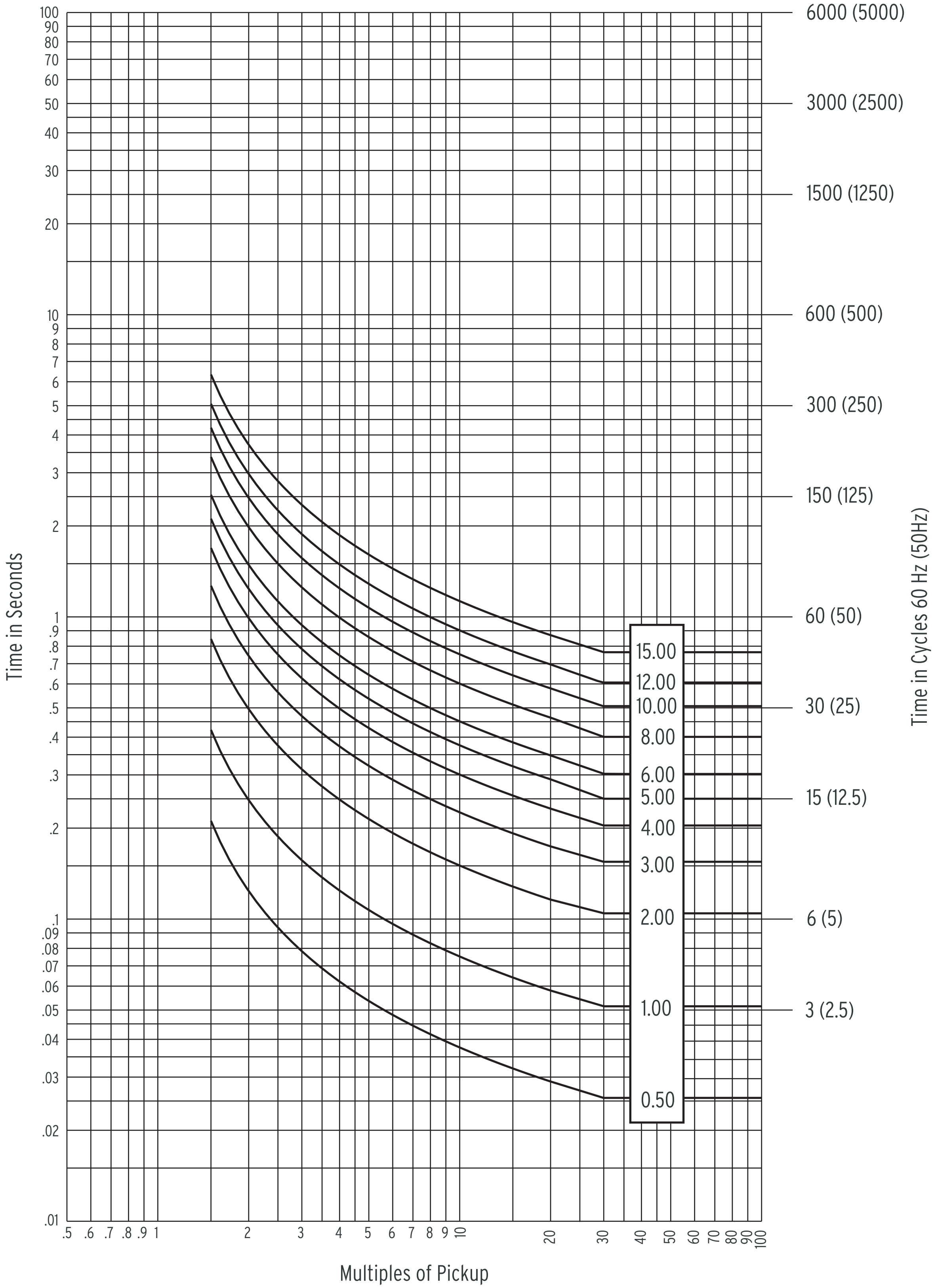

Figure 9.5 U.S. Short-Time Inverse Curve: U5

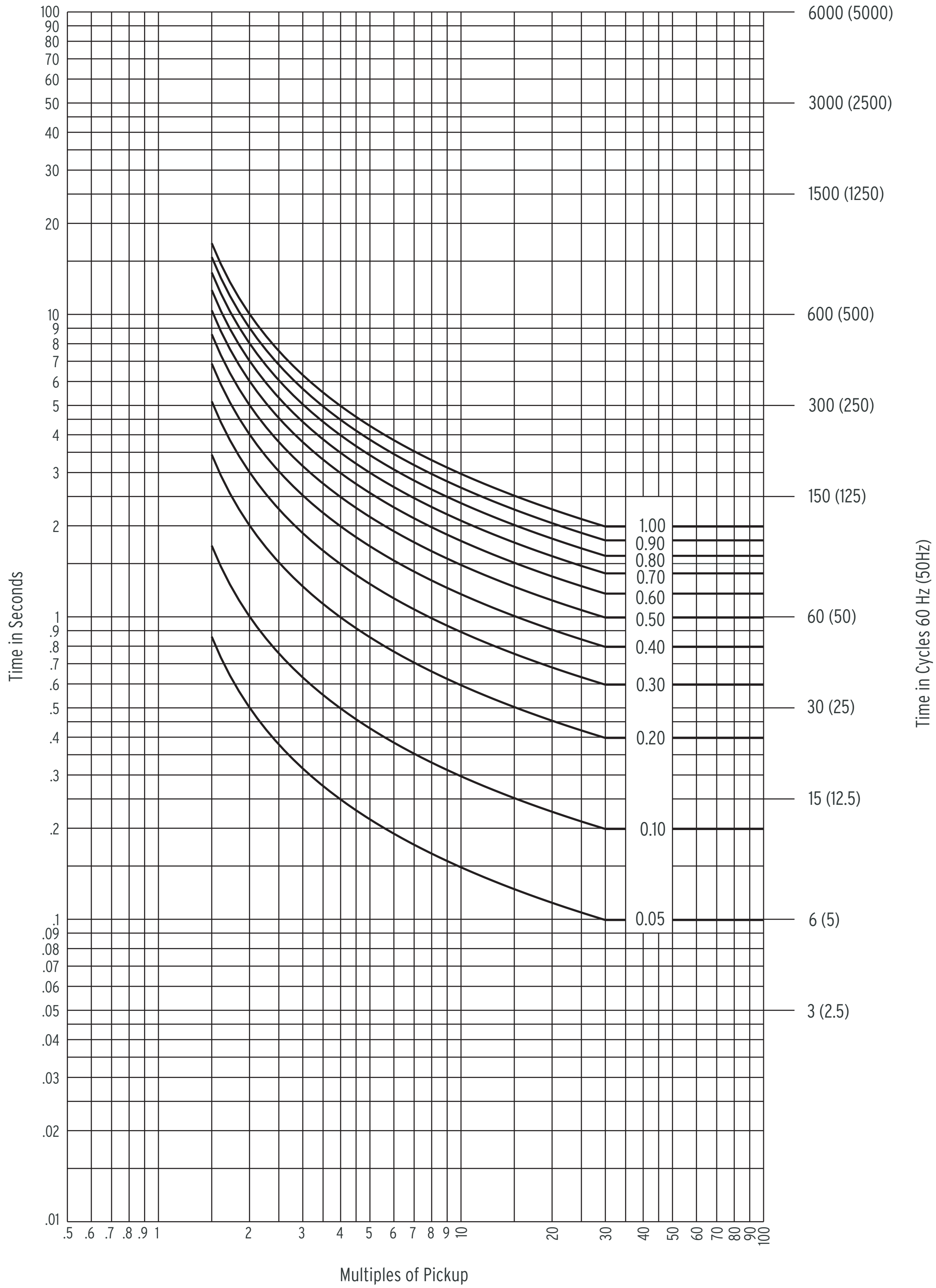

Figure 9.6 IEC Class A Curve (Standard Inverse): C1

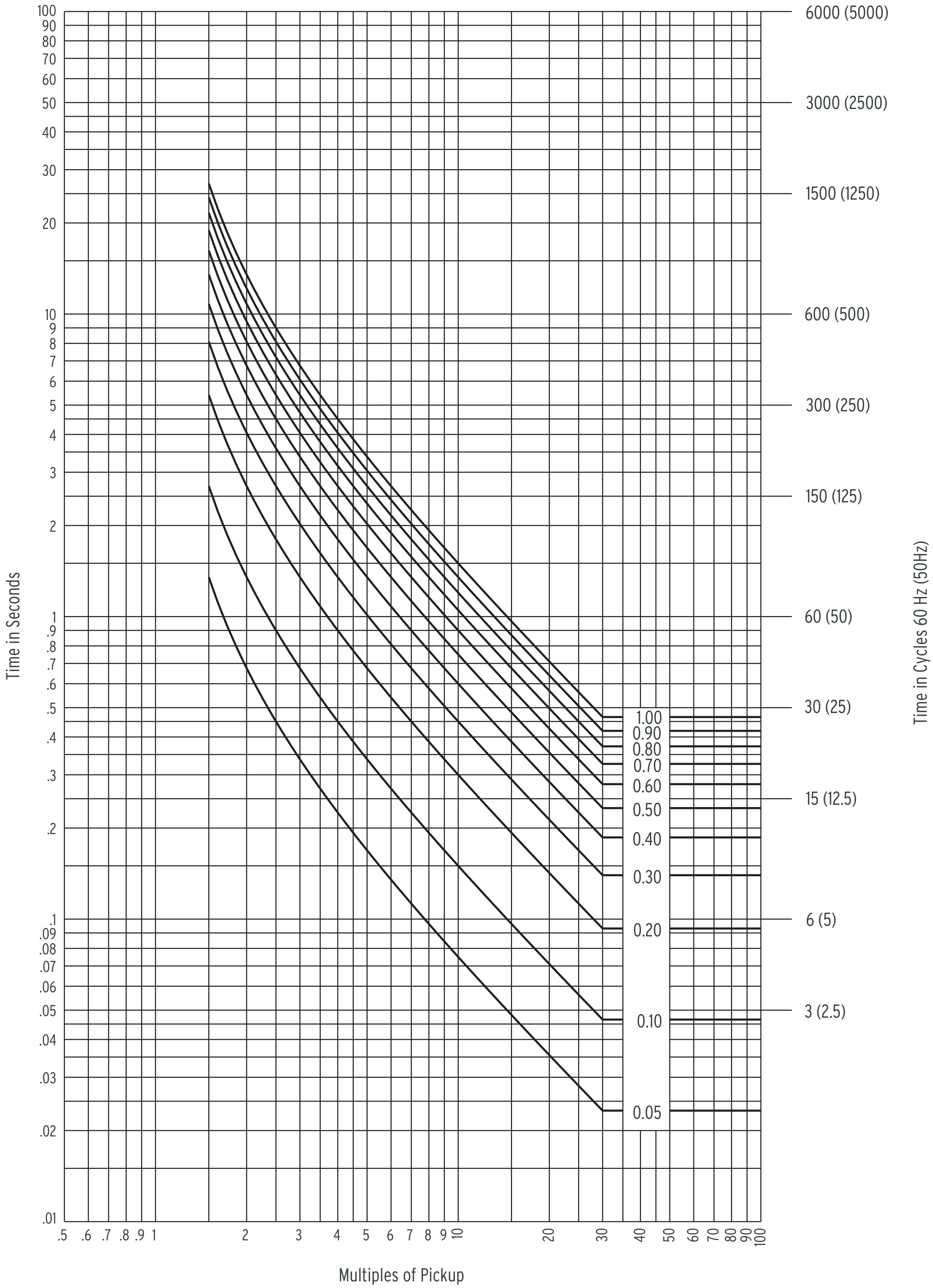

Figure 9.7 IEC Class B Curve (Very Inverse): C2

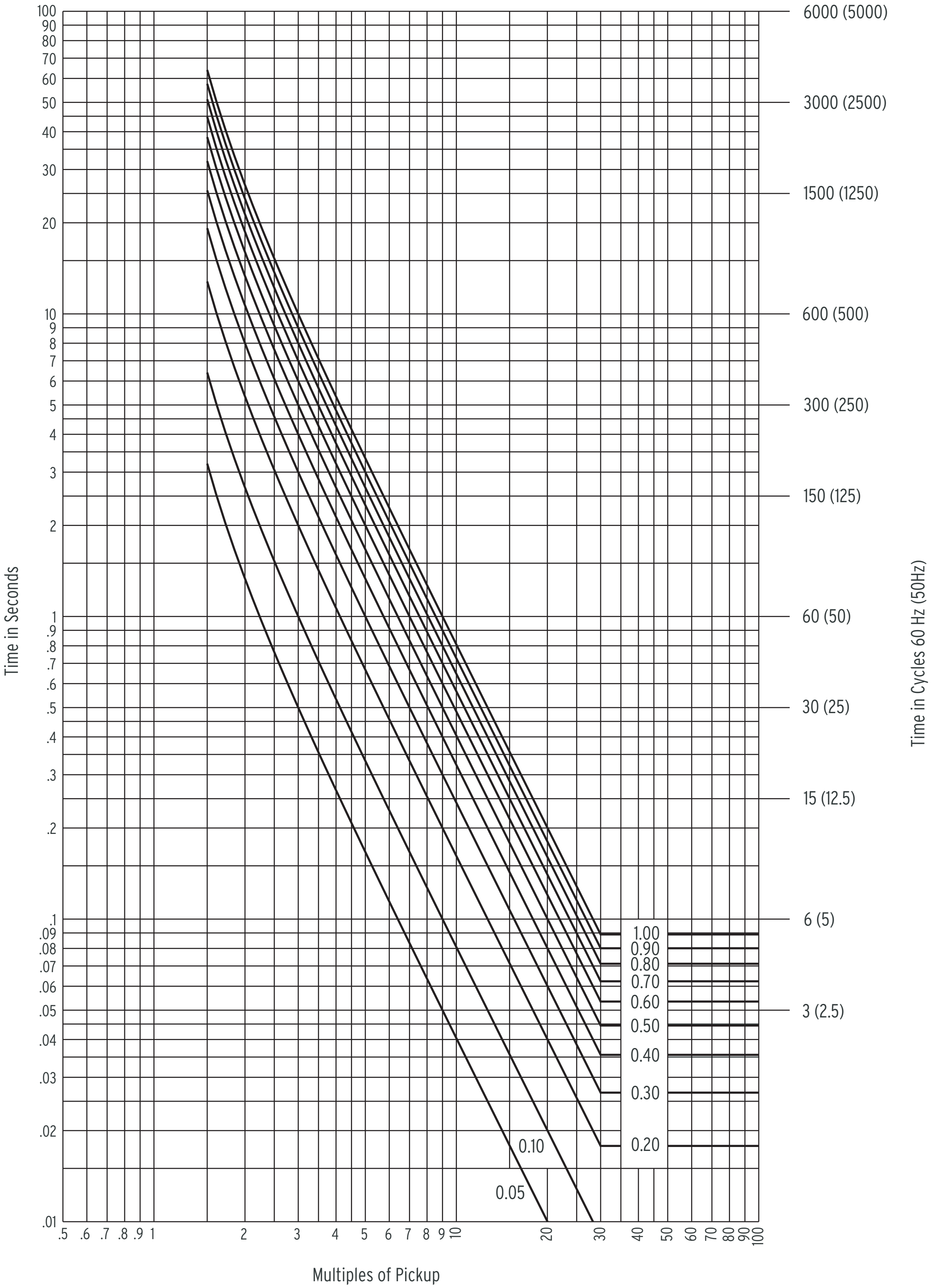

Figure 9.8 IEC Class C Curve (Extremely Inverse): C3

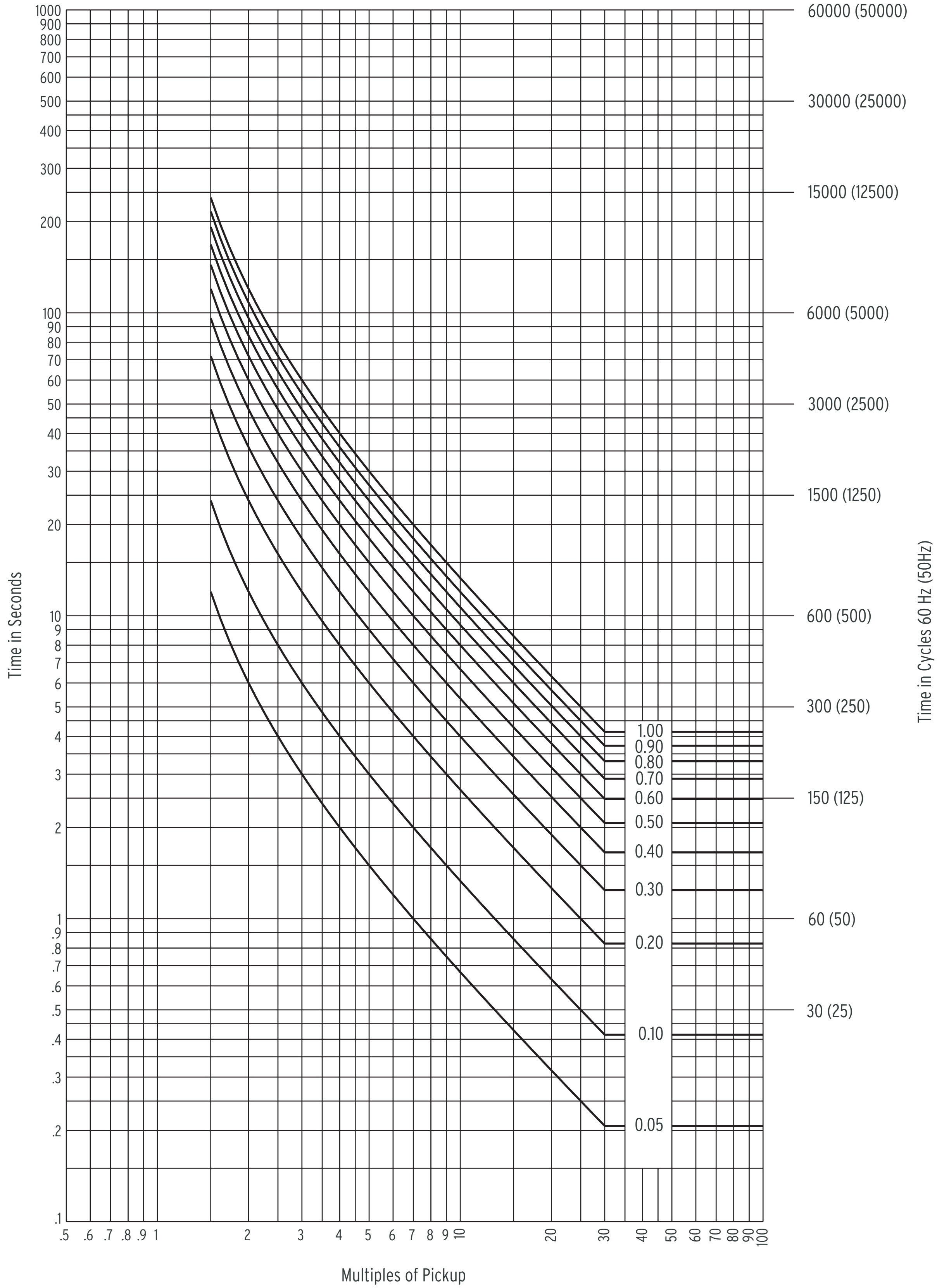

Figure 9.9 IEC Long-Time Inverse Curve: C4

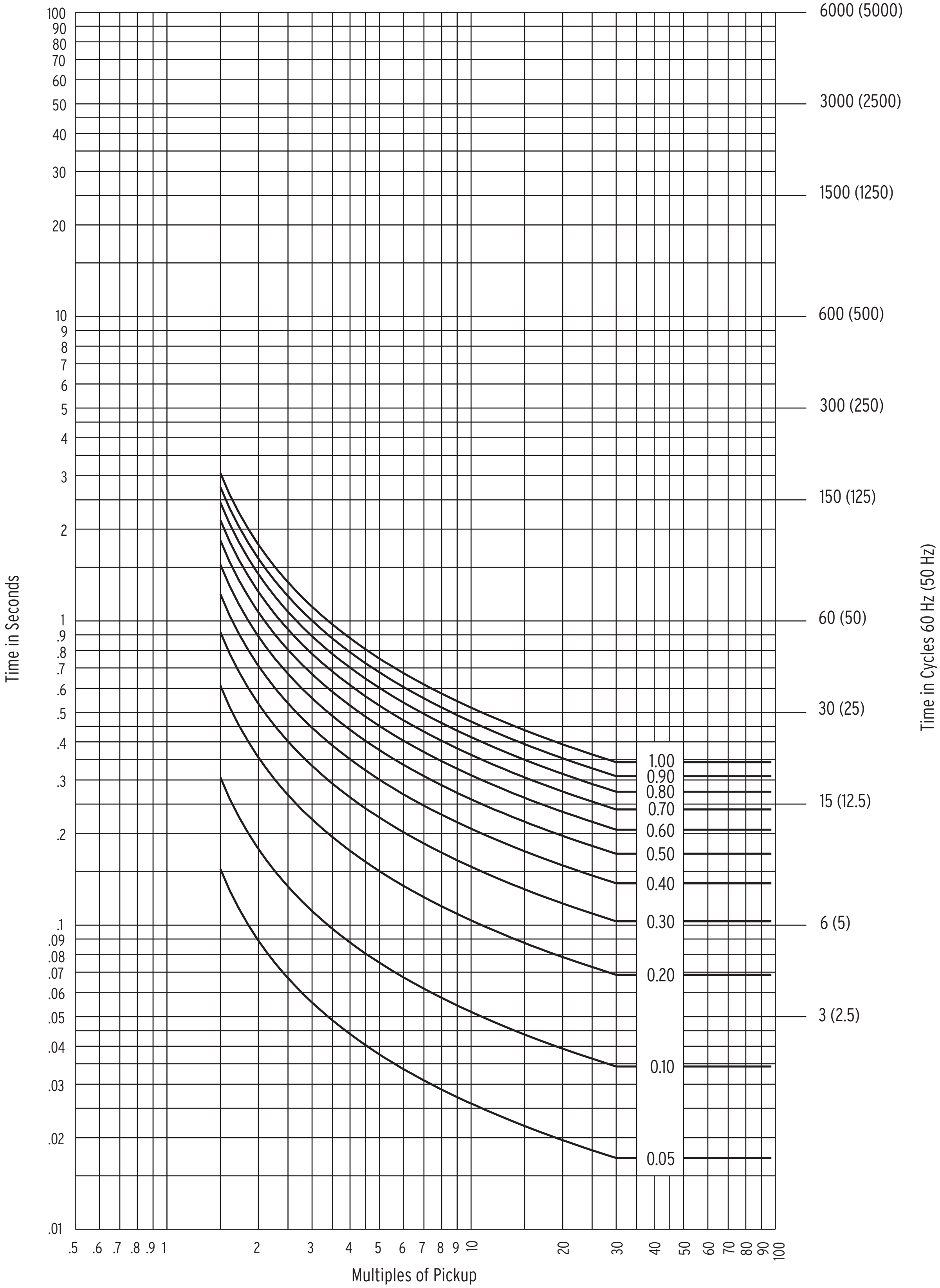

Figure 9.10 IEC Short-Time Inverse Curve: C5

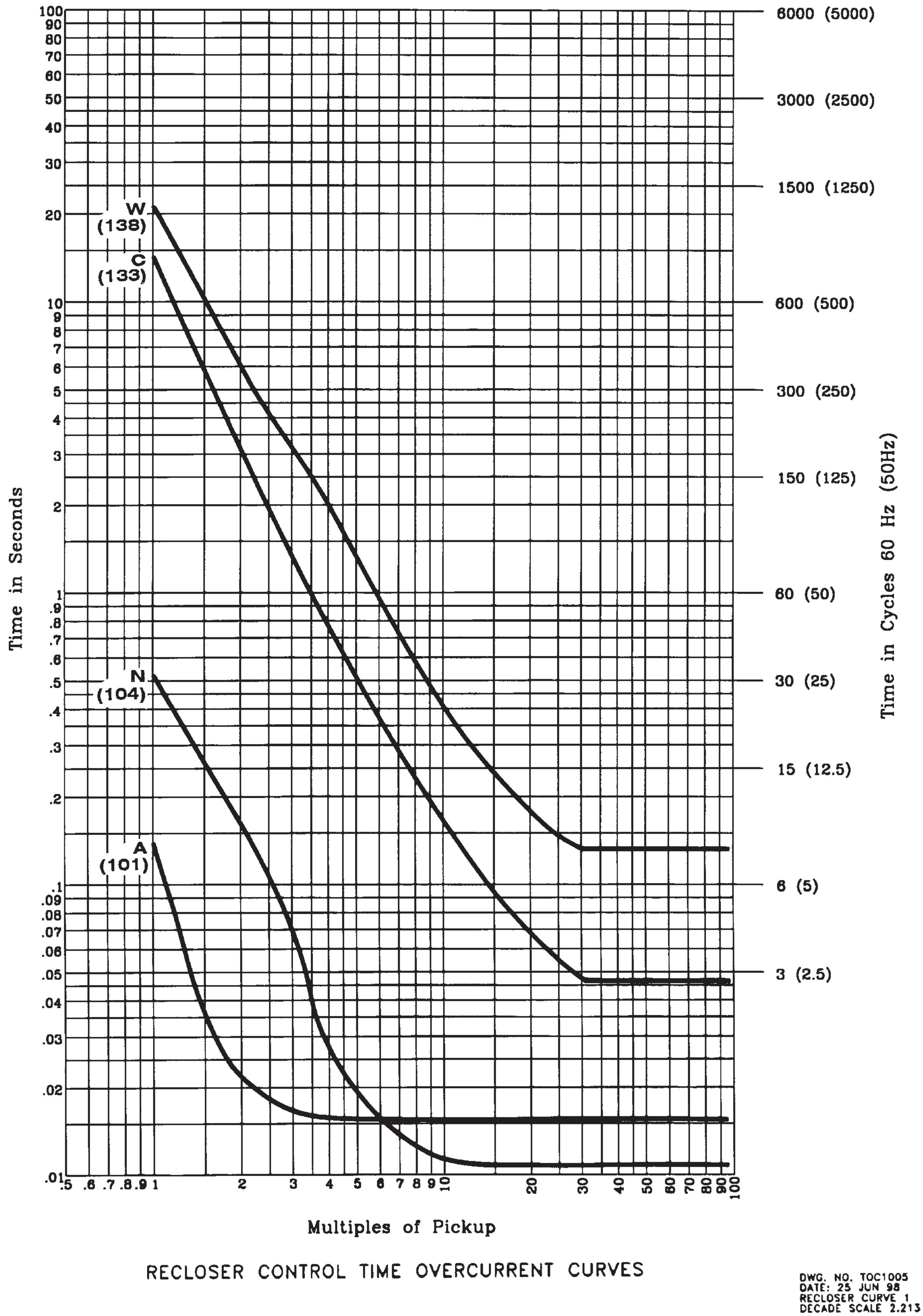

Figure 9.11 Recloser Control Response Curves A, C, N, and W

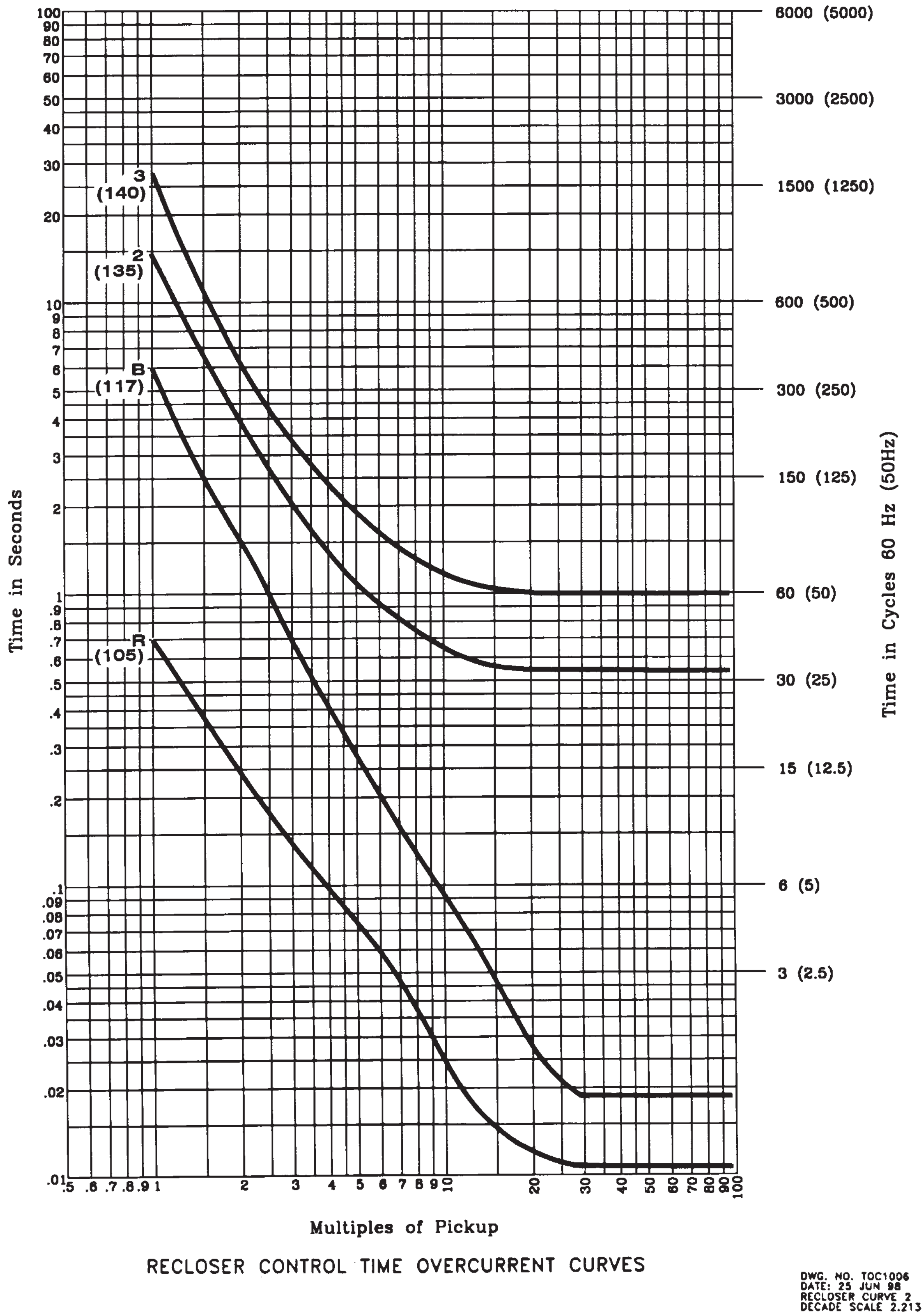

Figure 9.12 Recloser Control Response Curves B, R, 2, and 3

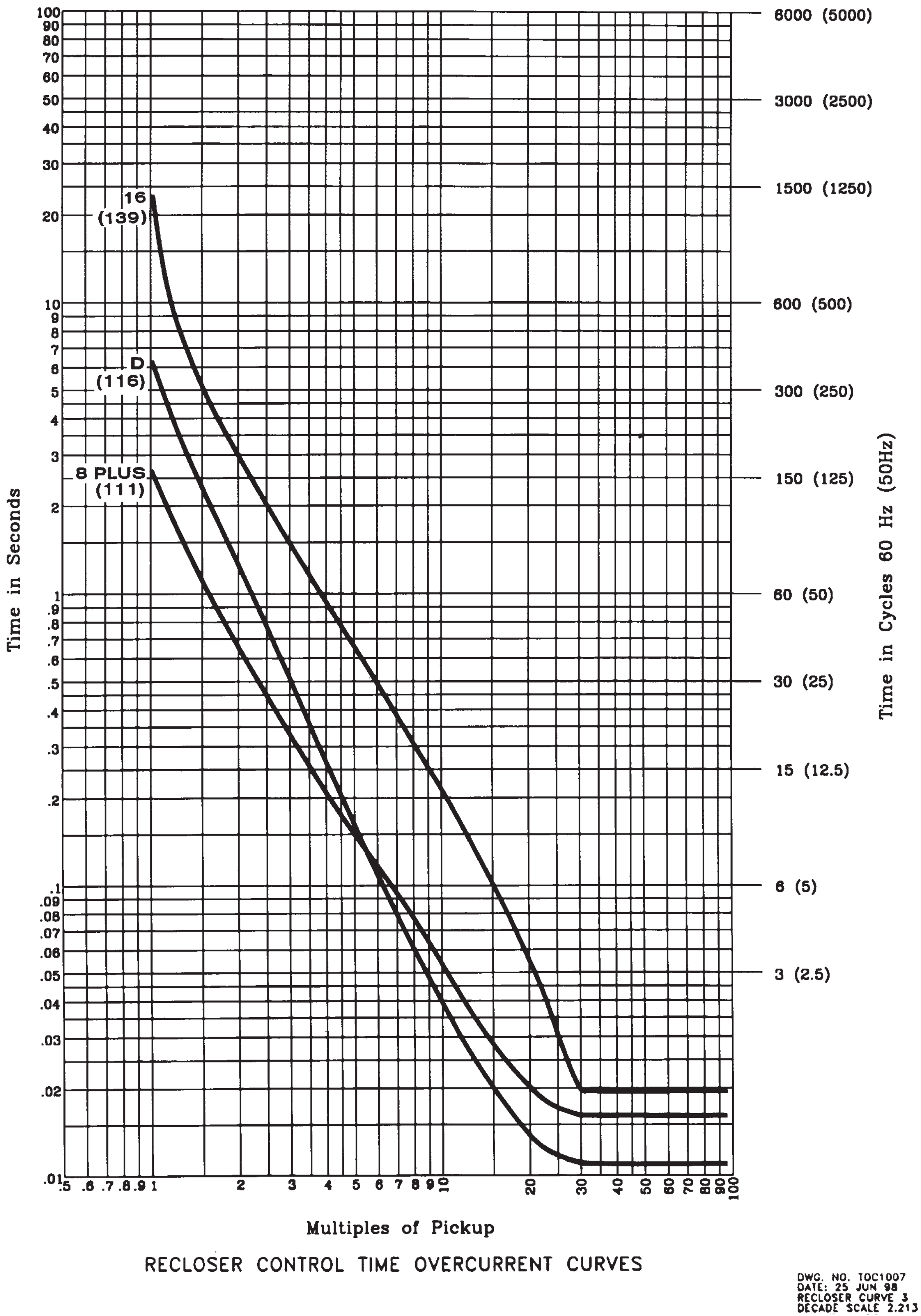

Figure 9.13 Recloser Control Response Curves D, 8PLUS, and 16

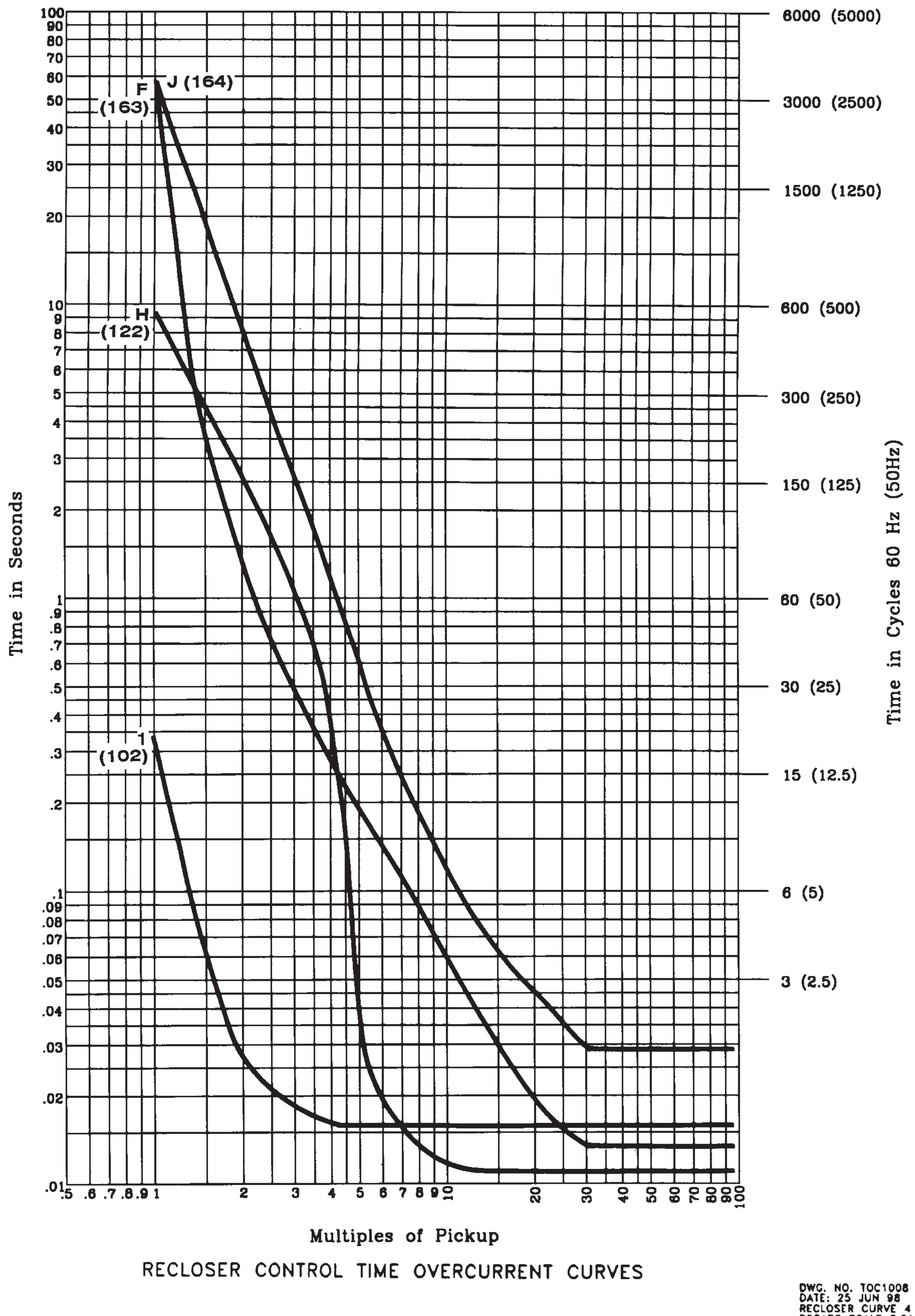

Figure 9.14 Recloser Control Response Curves F, H, J, and 1

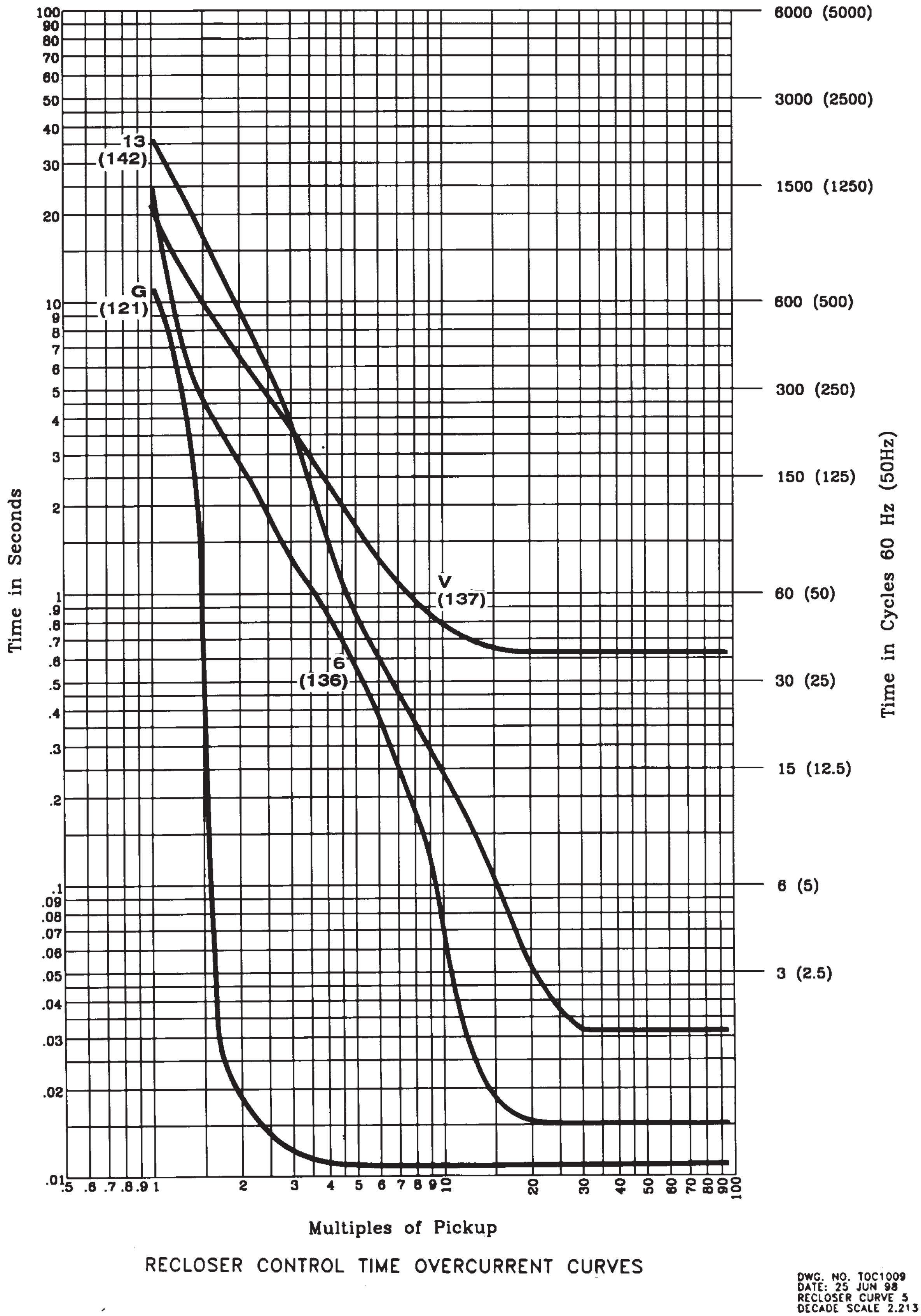

Figure 9.15 Recloser Control Response Curves G, V, 6, and 13

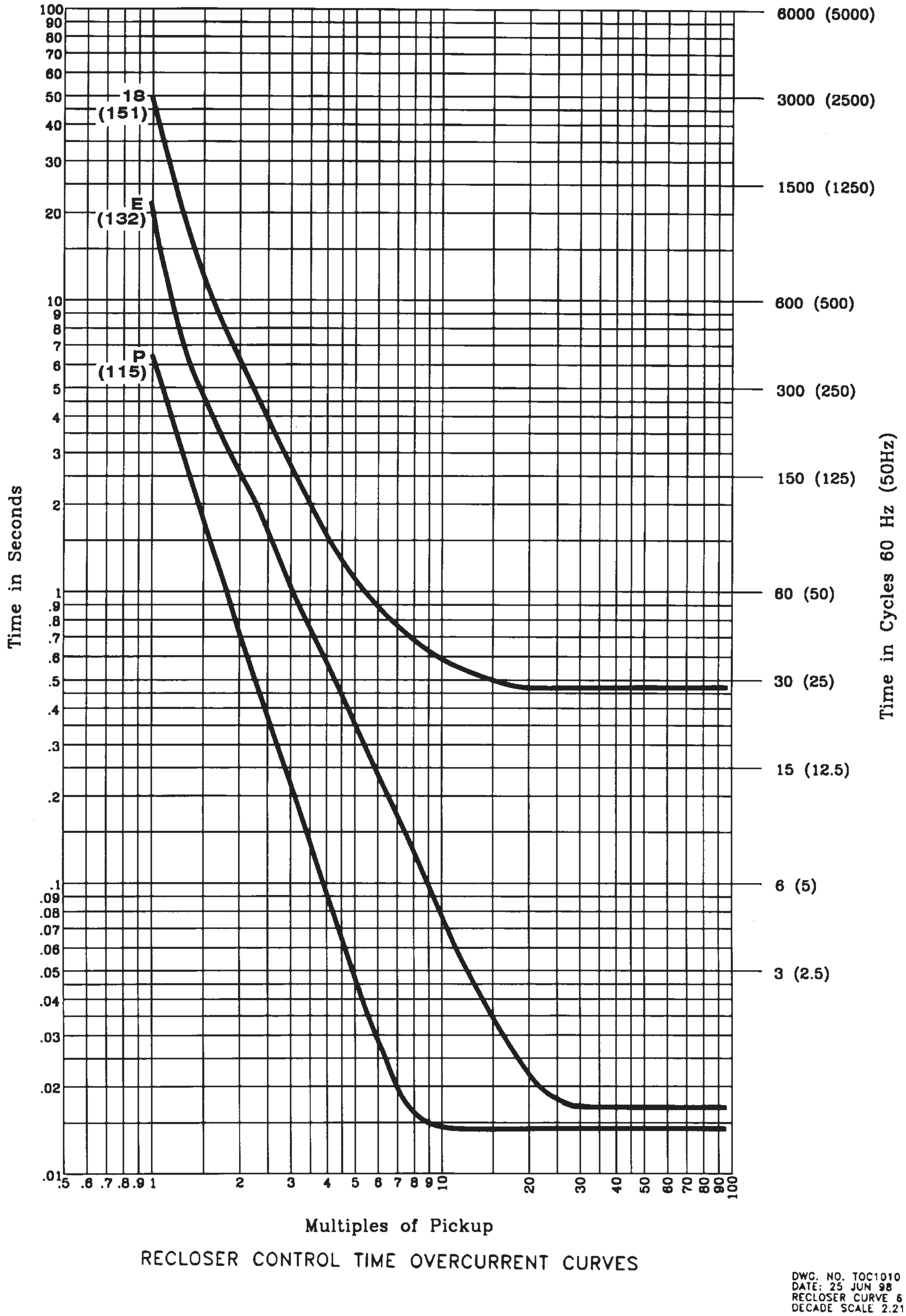

Figure 9.16 Recloser Control Response Curves E, P, and 18

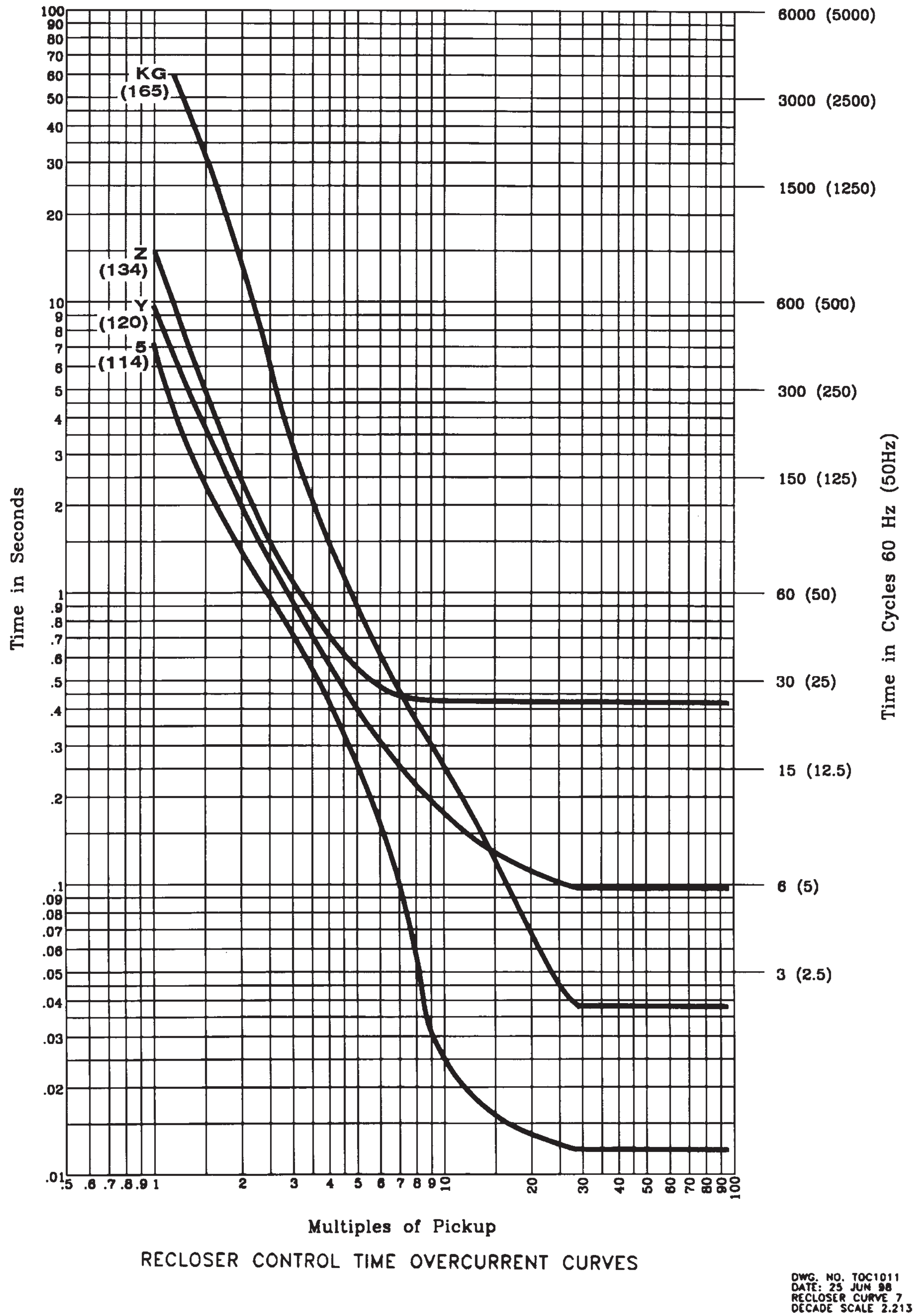

Figure 9.17 Recloser Control Response Curves KG, Y, Z, and 5

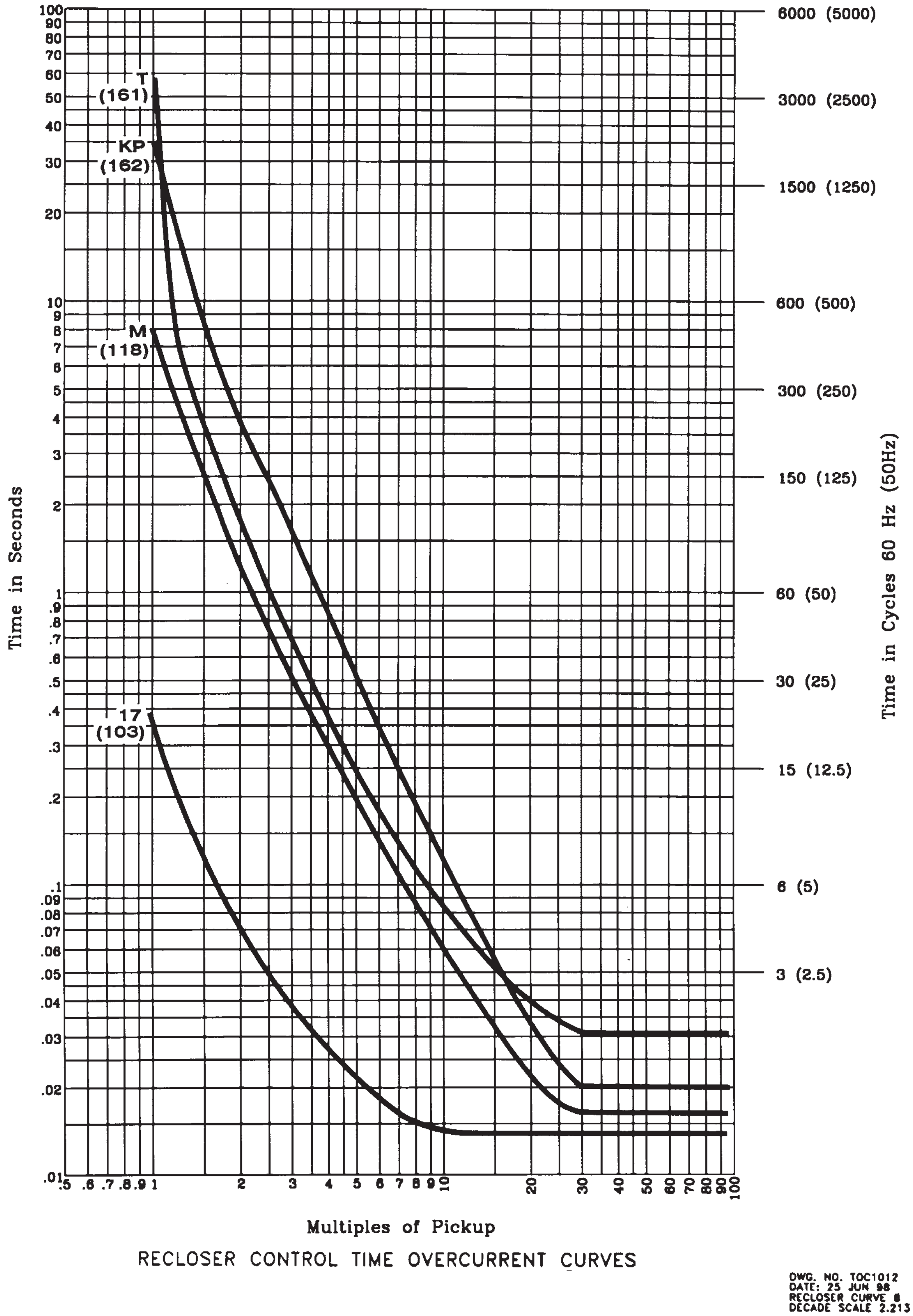

Figure 9.18 Recloser Control Response Curves KP, M, T, and 17

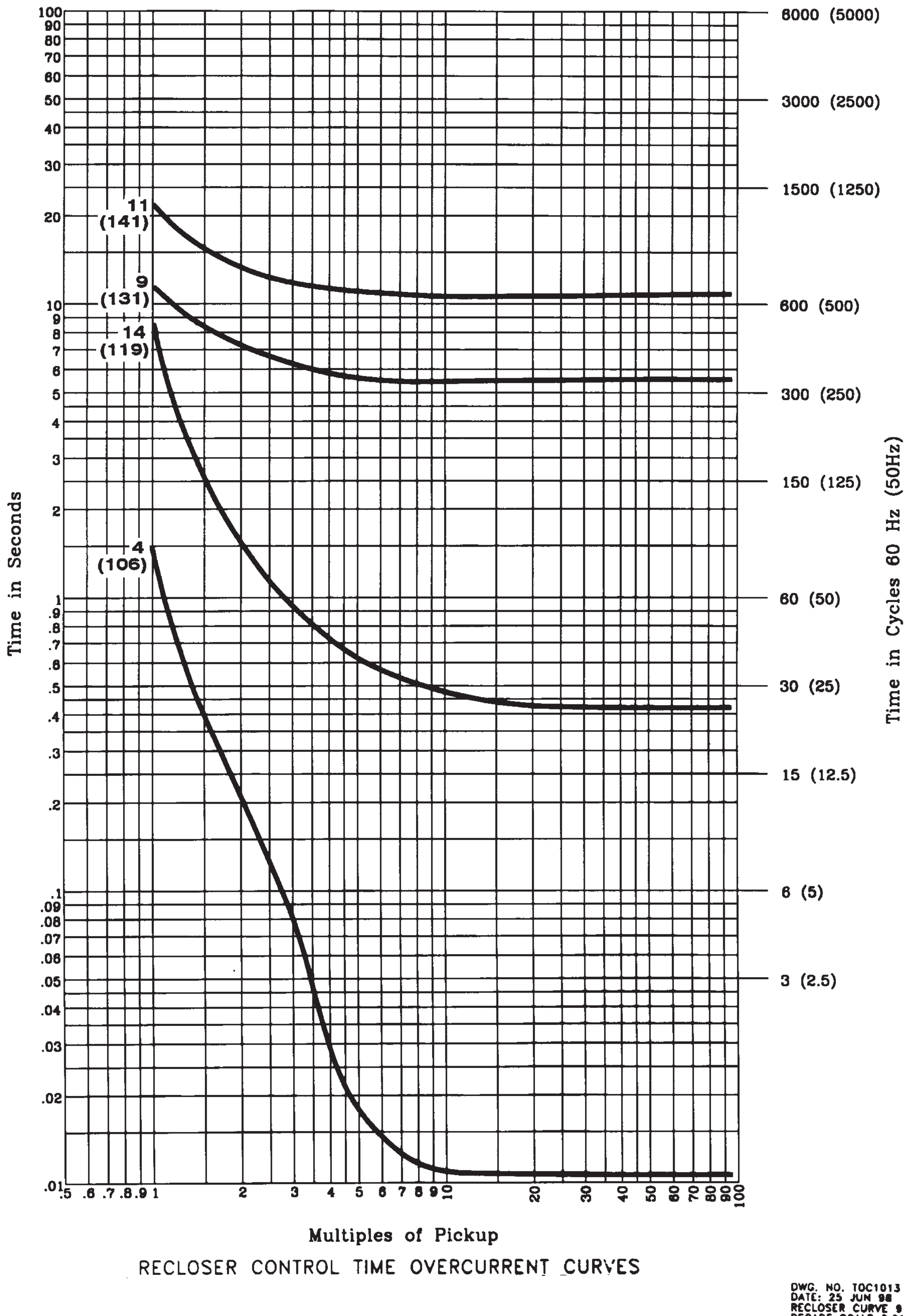

Figure 9.19 Recloser Control Response Curves 4, 9, 11, and 14

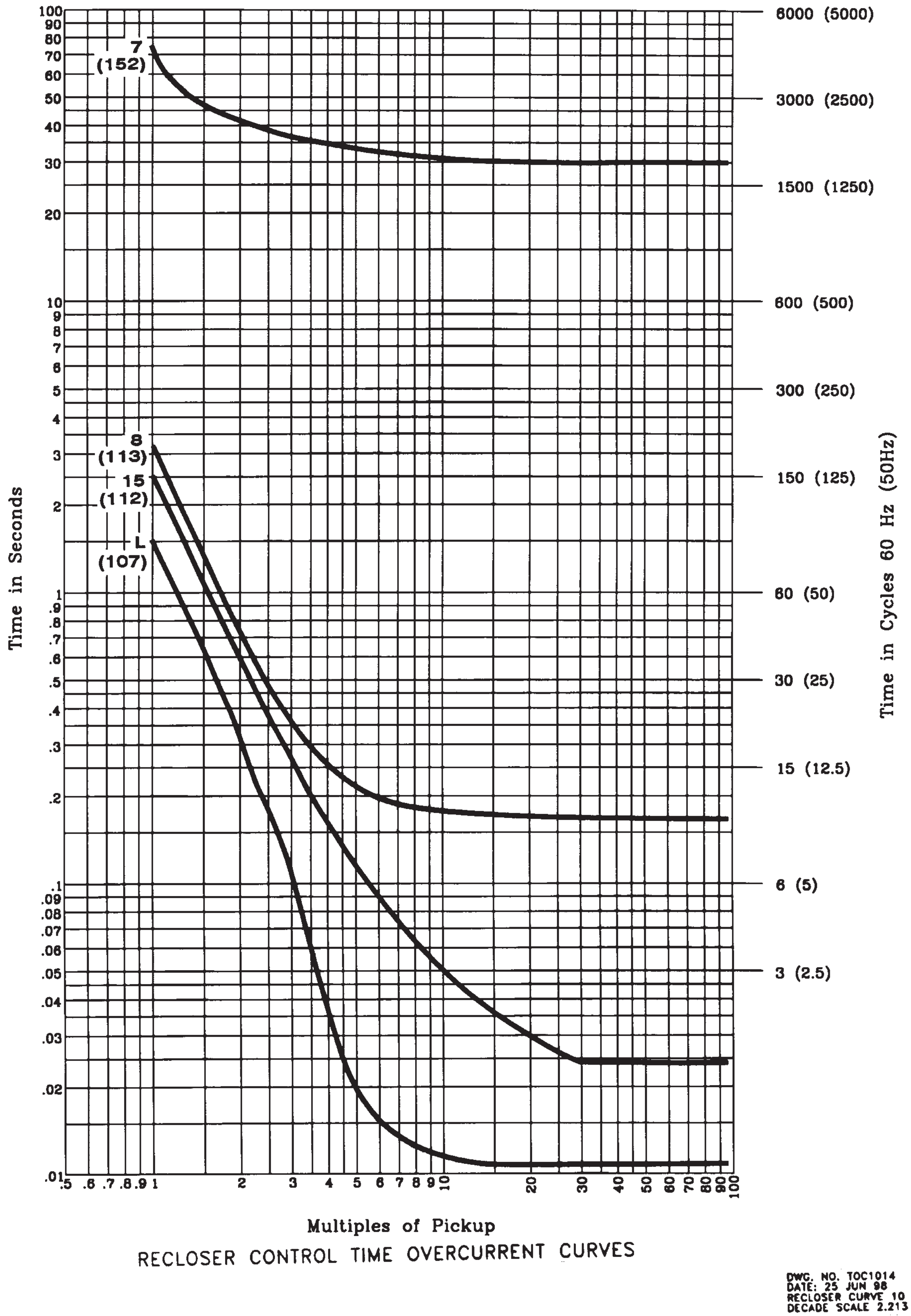

Figure 9.20 Recloser Control Response Curves L, 7, 8, and 15

Relay Word Bits (Used in SELOGIC Control Equations)

Relay Word bits are used in SELOGIC control equation settings. Factory-set SELOGIC control equation settings are explained in *Section 1: Factory-Set Logic*. Numerous SELOGIC control equation settings examples are given in *Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements* through *Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions*. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). *Appendix G: Setting SELOGIC Control Equations* gives SELOGIC control equation details, examples, and limitations.

The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command [see *TAR Command (Display Relay Word Bit Status) on page 10.33*]. Rows 0 and 1 are reserved for the display of the two front-panel target LED rows.

Table 9.5 SEL-351R Recloser Control Relay Word Bits (Sheet 1 of 2)

Row	Relay Word Bits							
2	50A1	50B1	50C1	50A2	50B2	50C2	50A3	50B3
3	50C3	50A4	50B4	50C4	50AB1	50BC1	50CA1	50AB2
4	50BC2	50CA2	50AB3	50BC3	50CA3	50AB4	50BC4	50CA4
5	50A	50B	50C	51P1	51P1T	51P1R	51N1	51N1T
6	51N1R	51G1	51G1T	51G1R	51P2	51P2T	51P2R	51N2
7	51N2T	51N2R	51G2	51G2T	51G2R	51Q	51QT	51QR
8	50P1	50P2	50P3	50P4	50N1	50N2	50N3	50N4
9	67P1	67P2	67P3	67P4	67N1	67N2	67N3	67N4
10	67P1T	67P2T	67P3T	67P4T	67N1T	67N2T	67N3T	67N4T
11	50G1	50G2	50G3	50G4	50Q1	50Q2	50Q3	50Q4
12	67G1	67G2	67G3	67G4	67Q1	67Q2	67Q3	67Q4
13	67G1T	67G2T	67G3T	67G4T	67Q1T	67Q2T	67Q3T	67Q4T
14	50P5	50P6	50N5	50N6	50G5	50G6	50Q5	50Q6
15	50QF	50QR	50GF	50GR	32VE	32QGE	32NE	32QE
16	F32P	R32P	F32Q	R32Q	F32QG	R32QG	F32V	R32V
17	F32N	R32N	32PF	32PR	32QF	32QR	32GF	32GR
18	27A1	27B1	27C1	27A2	27B2	27C2	59A1	59B1
19	59C1	59A2	59B2	59C2	27AB	27BC	27CA	59AB
20	59BC	59CA	59N1	59N2	59Q	59V1	27S	59S1
21	59S2	59VP	59VS	SF	25A1	25A2	3P27	3P59
22	81D1	81D2	81D3	81D4	81D5	81D6	27B81	50L
23	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	VPOLV	LOP
24	RCTR	RCCL	IN106	IN105	IN104	IN103	IN102	IN101
25	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
26	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
27	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8
28	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
29	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T

Table 9.5 SEL-351R Recloser Control Relay Word Bits (Sheet 2 of 2)

Row	Relay Word Bits						
30	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
31	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
32	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
33	CLOSE	CF	RCSF	OPTMN	RSTMN	FSA	FSB	FSC
34	BCW	50P32	BADBAT	59VA	TRGTR	52A	COMMT	CHRGG
35	SG1	SG2	SG3	SG4	SG5	SG6	ZLOUT	ZLIN
36	ZLOAD	BCWA	BCWB	BCWC	TOSLPV	TOSLPT	DISTST	DTFAIL
37	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
38	3PO	SOTFE	Z3RB	KEY	EKEY	ECTT	WFC	PT
39	PTRX2	PTRX	PTRX1	UBB1	UBB2	UBB	Z3XT	DSTRT
40	NSTRT	STOP	BTX	TRIP	OC	CC	CLG	H1CHRG
41	67P2S	67N2S	67G2S	67Q2S	PDEM	NDEM	GDEM	QDEM
42	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8
43	PB9	PINBD	PINC	PINE	PINF	SW1	DISCHG	LED9
44	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
45	OCP	OCG	OLP	OLG	OLS	HTP	HTG	HLP
46	HLG	CLP	RPP	RPG	RPS	SEQC	3PHV	GTP
47	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
48	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
49	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
50	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
51	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
52	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
53	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
54	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
55	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
56	50NF	50NR	32NF	32NR	59L1	IDSCHG	DCONN	DDATA
57	BATVL1	BATVL2	*[a]	*[a]	*[a]	*[a]	*[a]	LOCAL
58	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16
59	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
60	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16

[a] Reserved for future use.

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 1 of 15)

Row	Bit	Definition	Primary Application
2	50A1	Level 1 A-phase instantaneous overcurrent element (A-phase current above pickup setting 50P1P; see *Figure 3.1*)	Tripping, Control
	50B1	Level 1 B-phase instantaneous overcurrent element (B-phase current above pickup setting 50P1P; see *Figure 3.1*)	
	50C1	Level 1 C-phase instantaneous overcurrent element (C-phase current above pickup setting 50P1P; see *Figure 3.1*)	
	50A2	Level 2 A-phase instantaneous overcurrent element (A-phase current above pickup setting 50P2P; see *Figure 3.1*)	
	50B2	Level 2 B-phase instantaneous overcurrent element (B-phase current above pickup setting 50P2P; see *Figure 3.1*)	
	50C2	Level 2 C-phase instantaneous overcurrent element (C-phase current above pickup setting 50P2P; see *Figure 3.1*)	
	50A3	Level 3 A-phase instantaneous overcurrent element (A-phase current above pickup setting 50P3P; see *Figure 3.1*)	
	50B3	Level 3 B-phase instantaneous overcurrent element (B-phase current above pickup setting 50P3P; see *Figure 3.1*)	
3	50C3	Level 3 C-phase instantaneous overcurrent element (C-phase current above pickup setting 50P3P; see *Figure 3.1*)	
	50A4	Level 4 A-phase instantaneous overcurrent element (A-phase current above pickup setting 50P4P; see *Figure 3.1*)	
	50B4	Level 4 B-phase instantaneous overcurrent element (B-phase current above pickup setting 50P4P; see *Figure 3.1*)	
	50C4	Level 4 C-phase instantaneous overcurrent element (C-phase current above pickup setting 50P4P; see *Figure 3.1*)	
	50AB1	Level 1 AB-phase-to-phase instantaneous overcurrent element (AB-phase-to-phase current above pickup setting 50PP1P; see *Figure 3.7*)	
	50BC1	Level 1 BC-phase-to-phase instantaneous overcurrent element (BC-phase-to-phase current above pickup setting 50PP1P; see *Figure 3.7*)	
	50CA1	Level 1 CA-phase-to-phase instantaneous overcurrent element (CA-phase-to-phase current above pickup setting 50PP1P; see *Figure 3.7*)	
	50AB2	Level 2 AB-phase-to-phase instantaneous overcurrent element (AB-phase-to-phase current above pickup setting 50PP2P; see *Figure 3.7*)	
4	50BC2	Level 2 BC-phase-to-phase instantaneous overcurrent element (BC-phase-to-phase current above pickup setting 50PP2P; see *Figure 3.7*)	
	50CA2	Level 2 CA-phase-to-phase instantaneous overcurrent element (CA-phase-to-phase current above pickup setting 50PP2P; see *Figure 3.7*)	
	50AB3	Level 3 AB-phase-to-phase instantaneous overcurrent element (AB-phase-to-phase current above pickup setting 50PP3P; see *Figure 3.7*)	
	50BC3	Level 3 BC-phase-to-phase instantaneous overcurrent element (BC-phase-to-phase current above pickup setting 50PP3P; see *Figure 3.7*)	
	50CA3	Level 3 CA-phase-to-phase instantaneous overcurrent element (CA-phase-to-phase current above pickup setting 50PP3P; see *Figure 3.7*)	
	50AB4	Level 4 AB-phase-to-phase instantaneous overcurrent element (AB-phase-to-phase current above pickup setting 50PP4P; see *Figure 3.7*)	
	50BC4	Level 4 BC-phase-to-phase instantaneous overcurrent element (BC-phase-to-phase current above pickup setting 50PP4P; see *Figure 3.7*)	
	50CA4	Level 4 CA-phase-to-phase instantaneous overcurrent element (CA-phase-to-phase current above pickup setting 50PP4P; see *Figure 3.7*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 2 of 15)

Row	Bit	Definition	Primary Application
5	50A	50A1 + 50A2 + 50A3 + 50A4 (see *Figure 3.4*)	
	50B	50B1 + 50B2 + 50B3 + 50B4 (see *Figure 3.4*)	
	50C	50C1 + 50C2 + 50C3 + 50C4 (see *Figure 3.4*)	
	51P1	Maximum phase current above pickup setting 51P1P for phase time-overcurrent element 51P1T (see *Figure 3.14*)	Testing, Control
	51P1T	Phase time-overcurrent element 51P1T timed out (see *Figure 3.14*)	Tripping
	51P1R	Phase time-overcurrent element 51P1T reset (see *Figure 3.14*)	Testing
	51N1	Neutral ground current (channel IN) above pickup setting 51N1P for neutral ground time-overcurrent element 51N1T (see *Figure 3.16*)	Testing, Control
	51N1T	Neutral ground time-overcurrent element 51N1T timed out (see *Figure 3.16*)	Tripping
6	51N1R	Neutral ground time-overcurrent element 51N1T reset (see *Figure 3.16*)	Testing
	51G1	Residual ground current above pickup setting 51G1P for residual ground time-overcurrent element 51G1T (see *Figure 3.18*)	Testing, Control
	51G1T	Residual ground time-overcurrent element 51G1T timed out (see *Figure 3.18*)	Tripping
	51G1R	Residual ground time-overcurrent element 51G1T reset (see *Figure 3.18*)	Testing
	51P2	Maximum phase current above pickup setting 51P2P for phase time-overcurrent element 51P2T (see *Figure 3.15*)	Testing, Control
	51P2T	Phase time-overcurrent element 51P2T timed out (see *Figure 3.15*)	Tripping
	51P2R	Phase time-overcurrent element 51P2T reset (see *Figure 3.15*)	Testing
	51N2	Neutral ground current (channel IN) above pickup setting 51N2P for neutral ground time-overcurrent element 51N2T (see *Figure 3.17*)	Testing, Control
7	51N2T	Neutral ground time-overcurrent element 51N2T timed out (see *Figure 3.17*)	Tripping
	51N2R	Neutral ground time-overcurrent element 51N2T reset (see *Figure 3.17*)	Testing
	51G2	Residual ground current above pickup setting 51G2P for residual ground time-overcurrent element 51G2T (see *Figure 3.19*)	Testing, Control
	51G2T	Residual ground time-overcurrent element 51G2T timed out (see *Figure 3.19*)	Tripping
	51G2R	Residual ground time-overcurrent element 51G2T reset (see *Figure 3.19*)	Testing
	51Q[a]	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see *Figure 3.20*)	Testing, Control
	51QT[a]	Negative-sequence time-overcurrent element 51QT timed out (see *Figure 3.20*)	Tripping
	51QR	Negative-sequence time-overcurrent element 51QT reset (see *Figure 3.20*)	Testing
8	50P1	Level 1 phase instantaneous overcurrent element (= 50A1 + 50B1 + 50C1; see *Figure 3.1*)	Tripping, Testing, Control
	50P2	Level 2 phase instantaneous overcurrent element (= 50A2 + 50B2 + 50C2; see *Figure 3.1*)	
	50P3	Level 3 phase instantaneous overcurrent element (= 50A3 + 50B3 + 50C3; see *Figure 3.1*)	
	50P4	Level 4 phase instantaneous overcurrent element (= 50A4 + 50B4 + 50C4; see *Figure 3.1*)	
	50N1	Level 1 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N1P; see *Figure 3.8*)	
	50N2	Level 2 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N2P; see *Figure 3.8*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 3 of 15)

Row	Bit	Definition	Primary Application
	50N3	Level 3 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N3P; see *Figure 3.8*)	
	50N4	Level 4 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N4P; see *Figure 3.8*)	
9	67P1	Level 1 phase instantaneous overcurrent element (derived from 50P1; see *Figure 3.3*)	
	67P2	Level 2 phase instantaneous overcurrent element (derived from 50P2; see *Figure 3.3*)	
	67P3	Level 3 phase instantaneous overcurrent element (derived from 50P3; see *Figure 3.3*)	
	67P4	Level 4 phase instantaneous overcurrent element (derived from 50P4; see *Figure 3.3*)	
	67N1	Level 1 neutral ground instantaneous overcurrent element (derived from 50N1; see *Figure 3.8*)	
	67N2	Level 2 neutral ground instantaneous overcurrent element (derived from 50N2; see *Figure 3.8*)	
	67N3	Level 3 neutral ground instantaneous overcurrent element (derived from 50N3; see *Figure 3.8*)	
	67N4	Level 4 neutral ground instantaneous overcurrent element (derived from 50N4; see *Figure 3.8*)	
10	67P1T	Level 1 phase definite-time overcurrent element 67P1T timed out (derived from 67P1; see *Figure 3.3*)	Tripping
	67P2T	Level 2 phase definite-time overcurrent element 67P2T timed out (derived from 67P2; see *Figure 3.3*)	
	67P3T	Level 3 phase definite-time overcurrent element 67P3T timed out (derived from 67P3; see *Figure 3.3*)	
	67P4T	Level 4 phase definite-time overcurrent element 67P4T timed out (derived from 67P4; see *Figure 3.3*)	
	67N1T	Level 1 neutral ground definite-time overcurrent element 67NIT timed out (derived from 67N1; see *Figure 3.8*)	
	67N2T	Level 2 neutral ground definite-time overcurrent element 67N2T timed out (derived from 67N2; see *Figure 3.8*)	
	67N3T	Level 3 neutral ground definite-time overcurrent element 67N3T timed out (derived from 67N3; see *Figure 3.8*)	
	67N4T	Level 4 neutral ground definite-time overcurrent element 67N4T timed out (derived from 67N4; see *Figure 3.8*)	
11	50G1	Level 1 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G1P; see *Figure 3.10*)	Tripping, Testing, Control
	50G2	Level 2 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G2P; see *Figure 3.10*)	
	50G3	Level 3 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G3P; see *Figure 3.10*)	
	50G4	Level 4 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G4P; see *Figure 3.10*)	
	50Q1[a]	Level 1 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q1P; see *Figure 3.12*)	Testing, Control
	50Q2[a]	Level 2 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q2P; see *Figure 3.12*)	
	50Q3[a]	Level 3 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q3P; see *Figure 3.12*)	
	50Q4[a]	Level 4 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q4P; see *Figure 3.12*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 4 of 15)

Row	Bit	Definition	Primary Application
12	67G1	Level 1 residual ground instantaneous overcurrent element (derived from 50G1; see *Figure 3.10*)	Tripping, Testing, Control
	67G2	Level 2 residual ground instantaneous overcurrent element (derived from 50G2; see *Figure 3.10*)	
	67G3	Level 3 residual ground instantaneous overcurrent element (derived from 50G3; see *Figure 3.10*)	
	67G4	Level 4 residual ground instantaneous overcurrent element (derived from 50G4; see *Figure 3.10*)	
	67Q1[a]	Level 1 negative-sequence instantaneous overcurrent element (derived from 50Q1; see *Figure 3.12*)	Testing, Control
	67Q2[a]	Level 2 negative-sequence instantaneous overcurrent element (derived from 50Q2; see *Figure 3.12*)	
	67Q3[a]	Level 3 negative-sequence instantaneous overcurrent element (derived from 50Q3; see *Figure 3.12*)	
	67Q4[a]	Level 4 negative-sequence instantaneous overcurrent element (derived from 50Q4; see *Figure 3.12*)	
13	67G1T	Level 1 residual ground definite-time overcurrent element 67G1T timed out (derived from 67G1; see *Figure 3.10*)	Tripping
	67G2T	Level 2 residual ground definite-time overcurrent element 67G2T timed out (derived from 67G2; see *Figure 3.10*)	
	67G3T	Level 3 residual ground definite-time overcurrent element 67G3T timed out (derived from 67G3; see *Figure 3.10*)	
	67G4T	Level 4 residual ground definite-time overcurrent element 67G4T timed out (derived from 67G4; see *Figure 3.10*)	
	67Q1T[a]	Level 1 negative-sequence definite-time overcurrent element 67Q1T timed out (derived from 67Q1; see *Figure 3.12*)	
	67Q2T[a]	Level 2 negative-sequence definite-time overcurrent element 67Q2T timed out (derived from 67Q2; see *Figure 3.12*)	
	67Q3T[a]	Level 3 negative-sequence definite-time overcurrent element 67Q3T timed out (derived from 67Q3; see *Figure 3.12*)	
	67Q4T[a]	Level 4 negative-sequence definite-time overcurrent element 67Q4T timed out (derived from 67Q4; see *Figure 3.12*)	
14	50P5	Level 5 phase instantaneous overcurrent element (maximum phase current above pickup setting 50P5P; see *Figure 3.2*)	Tripping, Control
	50P6	Level 6 phase instantaneous overcurrent element (maximum phase current above pickup setting 50P6P; see *Figure 3.2*)	
	50N5	Level 5 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N5P; see *Figure 3.9*)	
	50N6	Level 6 neutral ground instantaneous overcurrent element (neutral ground current [channel IN] above pickup setting 50N6P; see *Figure 3.9*)	
	50G5	Level 5 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G5P; see *Figure 3.11*)	
	50G6	Level 6 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G6P; see *Figure 3.11*)	
	50Q5[a]	Level 5 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q5P; see *Figure 3.13*)	Control
	50Q6[a]	Level 6 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q6P; see *Figure 3.13*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 5 of 15)

Row	Bit	Definition	Primary Application
15	50QF	Forward direction negative-sequence overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.5*, *Figure 4.9*, *Figure 4.16*, and *Figure 4.17*)	Testing
	50QR	Reverse direction negative-sequence overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.5*, *Figure 4.9*, *Figure 4.16*, and *Figure 4.17*)	
	50GF	Forward direction residual ground overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.6*, and *Figure 4.10*)	
	50GR	Reverse direction residual ground overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.6*, and *Figure 4.10*)	
	32VE	Internal enable for zero-sequence voltage-polarized, residual-current directional element (see *Figure 4.4*, *Figure 4.6*, *Figure 4.8*, and *Figure 4.10*)	
	32QGE	Internal enable for negative-sequence voltage-polarized directional element (for ground; see *Figure 4.4*, *Figure 4.5*, and *Figure 4.8*)	
	32NE	Internal enable for zero-sequence voltage-polarized, neutral-current directional element (see *Figure 4.4*, *Figure 4.7*, and *Figure 4.11*)	
	32QE	Internal enable for negative-sequence voltage-polarized neutral-current directional element (see *Figure 4.4*, *Figure 4.5*, *Figure 4.16*, and *Figure 4.17*)	
16	F32P	Forward positive-sequence voltage-polarized directional element (see *Figure 4.16*, *Figure 4.18*, and *Figure 4.19*)	Testing, Special directional control schemes
	R32P	Reverse positive-sequence voltage-polarized directional element (see *Figure 4.16*, *Figure 4.18*, and *Figure 4.19*)	
	F32Q	Forward negative-sequence voltage-polarized directional element (see *Figure 4.16*, *Figure 4.17*, and *Figure 4.19*)	
	R32Q	Reverse negative-sequence voltage-polarized directional element (see *Figure 4.16*, *Figure 4.17*, and *Figure 4.19*)	
	F32QG	Forward negative-sequence voltage-polarized directional element (for ground; see *Figure 4.4*, *Figure 4.9*, *Figure 4.12*, and *Figure 4.13*)	
	R32QG	Reverse negative-sequence voltage-polarized directional element (for ground; see *Figure 4.4*, *Figure 4.9*, *Figure 4.12*, and *Figure 4.13*)	
	F32V	Forward zero-sequence voltage-polarized residual-current directional element (see *Figure 4.4*, *Figure 4.10*, *Figure 4.12*, and *Figure 4.13*)	
	R32V	Reverse zero-sequence voltage-polarized residual-current directional element (see *Figure 4.4*, *Figure 4.10*, *Figure 4.12*, and *Figure 4.13*)	
17	F32N	Forward zero-sequence, voltage-polarized, neutral current directional element (see *Figure 4.4*, *Figure 4.11*, and *Figure 4.13*)	
	R32N	Reverse zero-sequence, voltage-polarized, neutral current directional element (see *Figure 4.4*, *Figure 4.11*, and *Figure 4.13*)	
	32PF	Forward directional control routed to phase overcurrent elements (see *Figure 4.19* and *Figure 4.21*)	
	32PR	Reverse directional control routed to phase overcurrent elements (see *Figure 4.19* and *Figure 4.21*)	
	32QF	Forward directional control routed to negative-sequence overcurrent elements (see *Figure 4.19* and *Figure 4.20*)	
	32QR	Reverse directional control routed to negative-sequence overcurrent elements (see *Figure 4.19* and *Figure 4.20*)	
	32GF	Forward directional control routed to residual ground overcurrent elements (see *Figure 4.4*, *Figure 4.12*, and *Figure 4.14*)	
	32GR	Reverse directional control routed to residual ground overcurrent elements (see *Figure 4.4*, *Figure 4.12*, and *Figure 4.14*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 6 of 15)

Row	Bit	Definition	Primary Application
18	27A1	A-phase instantaneous undervoltage element A-phase voltage below pickup setting 27P1P; see *Figure 3.21*)	Control
	27B1	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P1P; see *Figure 3.21*)	
	27C1	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P1P; see *Figure 3.21*)	
	27A2	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P2P; see *Figure 3.21*)	
	27B2	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P2P; see *Figure 3.21*)	
	27C2	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P2P; see *Figure 3.21*)	
	59A1	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P1P; see *Figure 3.21*)	
	59B1	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P1P; see *Figure 3.21*)	
19	59C1	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P1P; see *Figure 3.21*)	
	59A2	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P2P; see *Figure 3.21*)	
	59B2	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P2P; see *Figure 3.21*)	
	59C2	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P2P; see *Figure 3.21*)	
	27AB	AB-phase-to-phase instantaneous undervoltage element (AB-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.22*)	
	27BC	BC-phase-to-phase instantaneous undervoltage element (BC-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.22*)	
	27CA	CA-phase-to-phase instantaneous undervoltage element (CA-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.22*)	
	59AB	AB-phase-to-phase instantaneous overvoltage element (AB-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.22*)	
20	59BC	BC-phase-to-phase instantaneous overvoltage element (BC-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.22*)	
	59CA	CA-phase-to-phase instantaneous overvoltage element (CA-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.22*)	
	59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P; see *Figure 3.22*)	
	59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P; see *Figure 3.22*)	
	59Q	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59QP; see *Figure 3.22*)	
	59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P; see *Figure 3.22*)	
	27S	Channel **VS** instantaneous undervoltage element (channel **VS** voltage below pickup setting 27SP; see *Figure 3.23*)	
	59S1	Channel **VS** instantaneous overvoltage element (channel **VS** voltage above pickup setting 59S1P; see *Figure 3.23*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 7 of 15)

Row	Bit	Definition	Primary Application
21	59S2	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59S2P; see *Figure 3.23*)	
	59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI; see *Figure 3.24*)	Testing
	59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see *Figure 3.24*)	
	SF	Slip frequency between voltages VP and VS less than setting 25SF (see *Figure 3.24*)	
	25A1	Synchronism-check element (see *Figure 3.25*)	Control
	25A2	Synchronism-check element (see *Figure 3.25*)	
	3P27	27A1 * 27B1 * 27C1 (see *Figure 3.21*)	
	3P59	59A1 * 59B1 * 59C1 (see *Figure 3.21*)	
22	81D1	Level 1 instantaneous frequency element (with corresponding pickup setting 81D1P; see *Figure 3.28*)	Testing
	81D2	Level 2 instantaneous frequency element (with corresponding pickup setting 81D2P; see *Figure 3.28*)	
	81D3	Level 3 instantaneous frequency element (with corresponding pickup setting 81D3P; see *Figure 3.28*)	
	81D4	Level 4 instantaneous frequency element (with corresponding pickup setting 81D4P; see *Figure 3.28*)	
	81D5	Level 5 instantaneous frequency element (with corresponding pickup setting 81D5P; see *Figure 3.28*)	
	81D6	Level 6 instantaneous frequency element (with corresponding pickup setting 81D6P; see *Figure 3.28*)	
	27B81	Undervoltage element for frequency element blocking (any phase voltage below pickup setting 27B81P; see *Figure 3.27*)	
	50L	Phase instantaneous overcurrent element for load detection (maximum phase current above pickup setting 50LP; see *Figure 5.3*)	
23	81D1T	Level 1 definite-time frequency element 81D1T timed out (derived from 81D1; see *Figure 3.28*)	Tripping, Control
	81D2T	Level 2 definite-time frequency element 81D2T timed out (derived from 81D2; see *Figure 3.28*)	
	81D3T	Level 3 definite-time frequency element 81D3T timed out (derived from 81D3; see *Figure 3.28*)	
	81D4T	Level 4 definite-time frequency element 81D4T timed out (derived from 81D4; see *Figure 3.28*)	
	81D5T	Level 5 definite-time frequency element 81D5T timed out (derived from 81D5; see *Figure 3.28*)	
	81D6T	Level 6 definite-time frequency element 81D6T timed out (derived from 81D6; see *Figure 3.28*)	
	VPOLV	Positive-sequence polarization voltage valid (see *Figure 4.18*)	Testing
	LOP	Loss-of-potential (see *Figure 4.1*)	Testing, Special directional control schemes

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 8 of 15)

Row	Bit	Definition	Primary Application
24	RCTR	High-voltage FET trip (see *Figure 7.29*)	Recloser Trip
	RCCL	High-voltage FET close (see *Figure 7.29*)	Recloser Close
	IN106	Optoisolated input **IN106** asserted (see *Figure 7.1*)	Circuit breaker status, Control via optoisolated inputs
	IN105	Optoisolated input **IN105** asserted (see *Figure 7.1*)	
	IN104	Optoisolated input **IN104** asserted (see *Figure 7.1*)	
	IN103	Optoisolated input **IN103** asserted (see *Figure 7.1*)	
	IN102	Optoisolated input **IN102** asserted (see *Figure 7.1*)	
	IN101	Optoisolated input **IN101** asserted (see *Figure 7.1*)	
25	LB1	Local Bit 1 asserted (see *Figure 7.3*)	Control via front panel—replacing traditional panel-mounted control switches
	LB2	Local Bit 2 asserted (see *Figure 7.3*)	
	LB3	Local Bit 3 asserted (see *Figure 7.3*)	
	LB4	Local Bit 4 asserted (see *Figure 7.3*)	
	LB5	Local Bit 5 asserted (see *Figure 7.3*)	
	LB6	Local Bit 6 asserted (see *Figure 7.3*)	
	LB7	Local Bit 7 asserted (see *Figure 7.3*)	
	LB8	Local Bit 8 asserted (see *Figure 7.3*)	
26	RB1	Remote Bit 1 asserted (see *Figure 7.9*)	Control via serial port
	RB2	Remote Bit 2 asserted (see *Figure 7.9*)	
	RB3	Remote Bit 3 asserted (see *Figure 7.9*)	
	RB4	Remote Bit 4 asserted (see *Figure 7.9*)	
	RB5	Remote Bit 5 asserted (see *Figure 7.9*)	
	RB6	Remote Bit 6 asserted (see *Figure 7.9*)	
	RB7	Remote Bit 7 asserted (see *Figure 7.9*)	
	RB8	Remote Bit 8 asserted (see *Figure 7.9*)	
27	LT1	Latch Bit 1 asserted (see *Figure 7.11*)	Control—replacing traditional latching relays
	LT2	Latch Bit 2 asserted (see *Figure 7.11*)	
	LT3	Latch Bit 3 asserted (see *Figure 7.11*)	
	LT4	Latch Bit 4 asserted (see *Figure 7.11*)	
	LT5	Latch Bit 5 asserted (see *Figure 7.11*)	
	LT6	Latch Bit 6 asserted (see *Figure 7.11*)	
	LT7	Latch Bit 7 asserted (see *Figure 7.11*)	
	LT8	Latch Bit 8 asserted (see *Figure 7.11*)	
28	SV1	SELOGIC control equation variable timer input SV1 asserted (see *Figure 7.23*)	Testing, Seal-in functions, etc. (see *Figure 7.24*)
	SV2	SELOGIC control equation variable timer input SV2 asserted (see *Figure 7.23*)	
	SV3	SELOGIC control equation variable timer input SV3 asserted (see *Figure 7.23*)	
	SV4	SELOGIC control equation variable timer input SV4 asserted (see *Figure 7.23*)	
	SV1T	SELOGIC control equation variable timer output SV1T asserted (see *Figure 7.23*)	Control
	SV2T	SELOGIC control equation variable timer output SV2T asserted (see *Figure 7.23*)	
	SV3T	SELOGIC control equation variable timer output SV3T asserted (see *Figure 7.23*)	
	SV4T	SELOGIC control equation variable timer output SV4T asserted (see *Figure 7.23*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 9 of 15)

Row	Bit	Definition	Primary Application
29	SV5	SELOGIC control equation variable timer input SV5 asserted (see *Figure 7.23*)	Testing, Seal-in functions, etc. (see *Figure 7.24*)
	SV6	SELOGIC control equation variable timer input SV6 asserted (see *Figure 7.23*)	
	SV7	SELOGIC control equation variable timer input SV7 asserted (see *Figure 7.23*)	
	SV8	SELOGIC control equation variable timer input SV8 asserted (see *Figure 7.23*)	
	SV5T	SELOGIC control equation variable timer output SV5T asserted (see *Figure 7.23*)	Control
	SV6T	SELOGIC control equation variable timer output SV6T asserted (see *Figure 7.23*)	
	SV7T	SELOGIC control equation variable timer output SV7T asserted (see *Figure 7.23*)	
	SV8T	SELOGIC control equation variable timer output SV8T asserted (see *Figure 7.23*)	
30	SV9	SELOGIC control equation variable timer input SV9 asserted (see *Figure 7.23*)	Testing, Seal-in functions, etc. (see *Figure 7.24*)
	SV10	SELOGIC control equation variable timer input SV10 asserted (see *Figure 7.23*)	
	SV11	SELOGIC control equation variable timer input SV11 asserted (see *Figure 7.23*)	
	SV12	SELOGIC control equation variable timer input SV12 asserted (see *Figure 7.23*)	
	SV9T	SELOGIC control equation variable timer output SV9T asserted (see *Figure 7.23*)	Control
	SV10T	SELOGIC control equation variable timer output SV10T asserted (see *Figure 7.23*)	
	SV11T	SELOGIC control equation variable timer output SV11T asserted (see *Figure 7.23*)	
	SV12T	SELOGIC control equation variable timer output SV12T asserted (see *Figure 7.23*)	
31	SV13	SELOGIC control equation variable timer input SV13 asserted (see *Figure 7.23*)	Testing, Seal-in functions, etc. (see *Figure 7.24*)
	SV14	SELOGIC control equation variable timer input SV14 asserted (see *Figure 7.23*)	
	SV15	SELOGIC control equation variable timer input SV15 asserted (see *Figure 7.23*)	
	SV16	SELOGIC control equation variable timer input SV16 asserted (see *Figure 7.23*)	
	SV13T	SELOGIC control equation variable timer output SV13T asserted (see *Figure 7.23*)	Control
	SV14T	SELOGIC control equation variable timer output SV14T asserted (see *Figure 7.23*)	
	SV15T	SELOGIC control equation variable timer output SV15T asserted (see *Figure 7.23*)	
	SV16T	SELOGIC control equation variable timer output SV16T asserted (see *Figure 7.23*)	
32	79RS	Reclosing relay in the Reset State (see *Figure 6.5* and *Table 6.1*)	
	79CY	Reclosing relay in the Reclose Cycle State (see *Figure 6.5* and *Table 6.1*)	
	79LO	Reclosing relay in the Lockout State (see *Figure 6.5* and *Table 6.1*)	
	SH0	Reclosing relay shot counter = 0 (see *Table 6.3*)	
	SH1	Reclosing relay shot counter = 1 (see *Table 6.3*)	
	SH2	Reclosing relay shot counter = 2 (see *Table 6.3*)	
	SH3	Reclosing relay shot counter = 3 (see *Table 6.3*)	
	SH4	Reclosing relay shot counter = 4 (see *Table 6.3*)	
33	CLOSE	Close logic output asserted (see *Figure 6.1*)	Output contact assignment
	CF	Close Failure condition (asserts for 1/4 cycle; see *Figure 6.1*)	Indication
	RCSF	Reclose supervision failure (asserts for 1/4 cycle; see *Figure 6.2*)	
	OPTMN	Open interval timer is timing (see *Reclosing Relay on page 6.9*)	Testing
	RSTMN	Reset timer is timing (see *Reclosing Relay on page 6.9*)	
	FSA	A-phase fault identification logic output used in A phase targeting	Control
	FSB	B-phase fault identification logic output used in B phase targeting	
	FSC	C-phase fault identification logic output used in C phase targeting	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 10 of 15)

Row	Bit	Definition	Primary Application
34	BCW	BCWA + BCWB + BCWC	Indication
	50P32	Three-phase overcurrent threshold exceeded (see *Figure 4.18*)	Testing
	BADBAT	Battery had been charging at a high current level (HICHRG = logical 1) for too long—battery can't take a charge (charger now turned off; see *Battery System Monitor on page 8.15*)	Indication
	59VA	Channel V1 voltage window element (channel V1 voltage between threshold settings 25VLO and 25VHI; see *Figure 3.24*)	
	TRGTR	Target Reset. TRGTR pulses to logical 1 for one processing interval when either the TARGET RESET pushbutton is pushed or the **TAR R** (Target Reset) serial port command is executed (see *Figure 5.1* and *Figure 5.17*)	Control
	52A	Circuit breaker status (asserts to logical 1 when recloser is closed; see *Figure 6.1*)	Indication
	COMMT	Communication Scheme Trip (see *Figure 5.1*)	Tripping
	CHRGG	Battery is Charging (see *Battery System Monitor on page 8.15*)	Indication
35	SG1	Setting Group 1 active (see *Table 7.3*)	Indication
	SG2	Setting Group 2 active (see *Table 7.3*)	
	SG3	Setting Group 3 active (see *Table 7.3*)	
	SG4	Setting Group 4 active (see *Table 7.3*)	
	SG5	Setting Group 5 active (see *Table 7.3*)	
	SG6	Setting Group 6 active (see *Table 7.3*)	
	ZLOUT	Load encroachment "load out" element (see *Figure 4.2*)	Special phase overcurrent element control
	ZLIN	Load encroachment "load in" element (see *Figure 4.2*)	
36	ZLOAD	ZLOUT + ZLIN (see *Figure 4.2*)	
	BCWA	A-phase breaker contact wear has reached 100% wear level (see *Breaker/Recloser Contact Wear Monitor on page 8.1*)	Indication
	BCWB	B-phase breaker contact wear has reached 100% wear level (see *Breaker/Recloser Contact Wear Monitor on page 8.1*)	
	BCWC	C-phase breaker contact wear has reached 100% wear level (see *Breaker/Recloser Contact Wear Monitor on page 8.1*)	
	TOSLPV	Indication that only 1 second remains until the control "goes to sleep" (battery disconnects and control de-energizes) because of low battery voltage condition (see *Battery System Monitor on page 8.15*)	Indication, event or SER trigger
	TOSLPT	Indication that only 1 minute remains until the power down timer times out and the control "goes to sleep" (battery disconnects and control de-energizes), unless some serial port or front-panel activity takes place (see *Battery System Monitor on page 8.15*)	
	DISTST	Battery discharge test in progress (see *Battery System Monitor on page 8.15*)	Indication
	DTFAIL	Battery discharge test has failed (see *Battery System Monitor on page 8.15*)	Alarm, indication
37	ALARM	Output contact ALARM asserted (see *Figure 7.26*)	
	OUT107	Output contact OUT107 asserted (see *Figure 7.26*)	
	OUT106	Output contact OUT106 asserted (see *Figure 7.26*)	
	OUT105	Output contact OUT105 asserted (see *Figure 7.26*)	
	OUT104	Output contact OUT104 asserted (see *Figure 7.26*)	
	OUT103	Output contact OUT103 asserted (see *Figure 7.26*)	
	OUT102	Output contact OUT102 asserted (see *Figure 7.26*)	
	OUT101	Output contact OUT101 asserted (see *Figure 7.26*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 11 of 15)

Row	Bit	Definition	Primary Application
38	3PO	Three pole open condition (see *Figure 5.3*)	Testing
	SOTFE	Switch-onto-fault logic enable (see *Figure 5.3*)	
	Z3RB	Zone (level) 3 reverse block (see *Figure 5.6*)	
	KEY	Key permissive trip signal start (see *Figure 5.6*)	Output contact assignment
	EKEY	Echo key (see *Figure 5.6*)	Testing
	ECTT	Echo conversion to trip condition (see *Figure 5.6*)	
	WFC	Weak infeed condition (see *Figure 5.6*)	
	PT	Permissive trip signal to POTT logic (see *Figure 5.5*)	
39	PTRX2	Permissive trip 2 signal from DCUB logic (see *Figure 5.10*)	
	PTRX	Permissive trip signal to Trip logic (see *Figure 5.7*)	
	PTRX1	Permissive trip 2 signal from DCUB logic (see *Figure 5.10*)	
	UBB1	Unblocking block 1 from DCUB logic (see *Figure 5.10*)	
	UBB2	Unblocking block 2 from DCUB logic (see *Figure 5.10*)	
	UBB	Unblocking block to Trip logic (see *Figure 5.11*)	
	Z3XT	Logic output from zone (level) 3 extension timer (see *Figure 5.14*)	
	DSTRT	Directional carrier start (see *Figure 5.14*)	Output contact assignment
40	NSTRT	Nondirectional carrier start (see *Figure 5.14*)	
	STOP	Carrier stop (see *Figure 5.14*)	
	BTX	Block trip input extension (see *Figure 5.14*)	Testing
	TRIP	Trip logic output asserted (see *Figure 5.1*)	Output contact assignment
	OC[a]	Asserts 1/4 cycle for **OPEN** Command execution (see *Figure 1.19*)	Tripping, Control
	CC[a]	Asserts 1/4 cycle for **CLOSE** Command execution (see *Figure 1.20*)	
	CLG	Ground cold load pickup scheme enabled (see *Figure 1.3* and *Figure 1.4*)	Control
	HICHRG	Charging current above 100 mA (with 5% hysteresis; see *Battery System Monitor on page 8.15*)	Indication
41	67P2S	Level 2 directional phase definite-time (short delay) overcurrent element 67P2S timed out (derived from 67P2; see *Figure 3.3* and *Figure 5.14*)	Tripping in DCB schemes
	67N2S	Level 2 directional neutral ground definite-time (short delay) overcurrent element 67N2S timed out (derived from 67N2; see *Figure 3.8* and *Figure 5.14*)	
	67G2S	Level 2 directional residual ground definite-time (short delay) overcurrent element 67G2S timed out (derived from 67G2; see *Figure 3.10* and *Figure 5.14*)	
	67Q2S	Level 2 directional negative-sequence definite-time (short delay) overcurrent element 67Q2S timed out (derived from 67Q2; see *Figure 3.12* and *Figure 5.14*)	
	PDEM	Phase demand current above pickup setting PDEMP (see *Figure 8.11*)	Indication
	NDEM	Neutral ground demand current above pickup setting NDEMP (see *Figure 8.11*)	
	GDEM	Residual ground demand current above pickup setting GDEMP (see *Figure 8.11*)	
	QDEM	Negative-sequence demand current above pickup setting QDEMP (see *Figure 8.11*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 12 of 15)

Row	Bit	Definition	Primary Application
42	PB1	GROUND ENABLED pushbutton output (see *Figure 1.35*)	Control
	PB2	RECLOSE ENABLED pushbutton output (see *Figure 1.35*)	
	PB3	REMOTE ENABLED pushbutton output (see *Figure 1.35*)	
	PB4	ALTERNATE SETTINGS pushbutton output (see *Figure 1.35*)	
	PB5	LOCK pushbutton output (see *Figure 1.35*)	
	PB6	AUX 1 pushbutton output (see *Figure 1.36*)	
	PB7	AUX 2 pushbutton output (see *Figure 1.36*)	
	PB8	CLOSE pushbutton output (see *Figure 1.36*)	
43	PB9	TRIP pushbutton output (see *Figure 1.36*)	
	PINBD	Control cable pin BD input asserted (see *Figure 7.29*)	Indication
	PINC	Control cable pin C input asserted (see *Figure 7.29*)	
	PINE	Control cable pin E input asserted (see *Figure 7.29*)	
	PINF	Control cable pin F input asserted (see *Figure 7.29*)	
	SW1	Internally derived recloser breaker status (see *Figure 1.22*)	
	DISCHG	Battery is discharging (see *Battery System Monitor on page 8.15*)	
	LED9	RECLOSER OPEN LED (see *Figure 1.36*)	
44	LED1	GROUND ENABLED LED (see *Figure 1.35*)	
	LED2	RECLOSE ENABLED LED (see *Figure 1.35*)	
	LED3	REMOTE ENABLED LED (see *Figure 1.35*)	
	LED4	ALTERNATE SETTINGS LED (see *Figure 1.35*)	
	LED5	LOCK LED (see *Figure 1.35*)	
	LED6	AUX 1 LED (see *Figure 1.36*)	
	LED7	AUX 2 LED (see *Figure 1.36*)	
	LED8	RECLOSER CLOSED LED (see *Figure 1.36*)	
45	OCP	Operations—phase fast curve (see *Figure 1.6*)	Control
	OCG	Operations—ground fast curve (see *Figure 1.7*)	
	OLP	Operations to lockout—phase (see *Figure 1.8*)	
	OLG	Operations to lockout—ground (see *Figure 1.9*)	
	OLS	Operations to lockout—Sensitive earth fault (see *Figure 1.10*)	
	HTP	High current trip—phase (see *Figure 1.11*)	
	HTG	High current trip—ground (see *Figure 1.12*)	
	HLP	High current lockout—phase (see *Figure 1.13*)	
46	HLG	High current lockout—ground (see *Figure 1.14*)	
	CLP	Phase cold load pickup scheme enabled (see *Figure 1.2*)	
	RPP	Restore pickup—phase (see *Figure 1.1* and *Figure 1.2*)	
	RPG	Restore pickup—ground (see *Figure 1.1* and *Figure 1.3*)	
	RPS	Restore pickup—Sensitive earth fault (see *Figure 1.1* and *Figure 1.4*)	
	SEQC	Sequence coordination enabled (see *Figure 1.27*)	
	3PHV	Three-phase voltage hooked up to control (see *Figure 4.1*)	
	GTP	Ground trip precedence enabled (see *Figure 1.24*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 13 of 15)

Row	Bit	Definition	Primary Application
NOTE: **Refer to Appendix I: Mirrored Bits for a description of the following Relay Word bits.**			
47	RMB8A	Channel A, received bit 8	Mirrored Bits (only operable in firmware versions 1 and greater)
	RMB7A	Channel A, received bit 7	
	RMB6A	Channel A, received bit 6	
	RMB5A	Channel A, received bit 5	
	RMB4A	Channel A, received bit 4	
	RMB3A	Channel A, received bit 3	
	RMB2A	Channel A, received bit 2	
	RMB1A	Channel A, received bit 1	
48	TMB8A	Channel A, transmit bit 8	
	TMB7A	Channel A, transmit bit 7	
	TMB6A	Channel A, transmit bit 6	
	TMB5A	Channel A, transmit bit 5	
	TMB4A	Channel A, transmit bit 4	
	TMB3A	Channel A, transmit bit 3	
	TMB2A	Channel A, transmit bit 2	
	TMB1A	Channel A, transmit bit 1	
49	RMB8B	Channel B, received bit 8	
	RMB7B	Channel B, received bit 7	
	RMB6B	Channel B, received bit 6	
	RMB5B	Channel B, received bit 5	
	RMB4B	Channel B, received bit 4	
	RMB3B	Channel B, received bit 3	
	RMB2B	Channel B, received bit 2	
	RMB1B	Channel B, received bit 1	
50	TMB8B	Channel B, transmit bit 8	
	TMB7B	Channel B, transmit bit 7	
	TMB6B	Channel B, transmit bit 6	
	TMB5B	Channel B, transmit bit 5	
	TMB4B	Channel B, transmit bit 4	
	TMB3B	Channel B, transmit bit 3	
	TMB2B	Channel B, transmit bit 2	
	TMB1B	Channel B, transmit bit 1	
51	LBOKB	Channel B, looped back ok	
	CBADB	Channel B, channel unavailability over threshold	
	RBADB	Channel B, outage duration over threshold	
	ROKB	Channel B, received data ok	
	LBOKA	Channel A, looped back ok	
	CBADA	Channel A, channel unavailability over threshold	
	RBADA	Channel A, outage duration over threshold	
	ROKA	Channel A, received data ok	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 14 of 15)

Row	Bit	Definition	Primary Application
52–55		Reserved for future use	
56	50NF	Forward direction neutral ground overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.7*, and *Figure 4.11*)	Testing
	50NR	Reverse direction neutral ground overcurrent threshold exceeded (see *Figure 4.4*, *Figure 4.7*, and *Figure 4.11*)	
	32NF	Forward directional control routed to neutral ground overcurrent elements (see *Figure 4.4*, *Figure 4.13*, and *Figure 4.15*)	Testing, Special Directional Control Schemes
	32NR	Reverse directional control routed to neutral ground overcurrent elements (see *Figure 4.4*, *Figure 4.13*, and *Figure 4.15*)	
	59L1	Voltage input V1 instantaneous overvoltage element (V1 voltage above pickup setting 59P1P)	Control
	IDSCHG	Battery discharge current above 50 mA (see *Battery System Monitor on page 8.15*)	Indication
	DCONN	DNP port is connected	Automatic Dial Out
	DDATA	DNP has unsolicited data ready to send	
57	BATVL1	Battery voltage below global setting V_LOW1 (see *Battery System Monitor on page 8.15*)	Indication
	BATVL2	Battery voltage below 19.2 Vdc (see *Battery System Monitor on page 8.15*)	
	LOCAL	Controlled by SELogic control equation LOCAL, for use with DNP Internal Indicator Local_Control (IIN1.5)	Control
58	LB9	Local Bit 9 asserted (see *Figure 7.3*)	Control via front panel—replacing traditional panel-mounted control switches
	LB10	Local Bit 10 asserted (see *Figure 7.3*)	
	LB11	Local Bit 11 asserted (see *Figure 7.3*)	
	LB12	Local Bit 12 asserted (see *Figure 7.3*)	
	LB13	Local Bit 13 asserted (see *Figure 7.3*)	
	LB14	Local Bit 14 asserted (see *Figure 7.3*)	
	LB15	Local Bit 15 asserted (see *Figure 7.3*)	
	LB16	Local Bit 16 asserted (see *Figure 7.3*)	
59	RB9	Remote Bit 9 asserted (see *Figure 7.9*)	Control via serial port
	RB10	Remote Bit 10 asserted (see *Figure 7.9*)	
	RB11	Remote Bit 11 asserted (see *Figure 7.9*)	
	RB12	Remote Bit 12 asserted (see *Figure 7.9*)	
	RB13	Remote Bit 13 asserted (see *Figure 7.9*)	
	RB14	Remote Bit 14 asserted (see *Figure 7.9*)	
	RB15	Remote Bit 15 asserted (see *Figure 7.9*)	
	RB16	Remote Bit 16 asserted (see *Figure 7.9*)	

Table 9.6 Relay Word Bit Definitions for SEL-351R Recloser Control (Sheet 15 of 15)

Row	Bit	Definition	Primary Application
60	LT9	Latch Bit 9 asserted (see *Figure 7.11*)	Control—replacing traditional latching relays
	LT10	Latch Bit 10 asserted (see *Figure 7.11*)	
	LT11	Latch Bit 11 asserted (see *Figure 7.11*)	
	LT12	Latch Bit 12 asserted (see *Figure 7.11*)	
	LT13	Latch Bit 13 asserted (see *Figure 7.11*)	
	LT14	Latch Bit 14 asserted (see *Figure 7.11*)	
	LT15	Latch Bit 15 asserted (see *Figure 7.11*)	
	LT16	Latch Bit 16 asserted (see *Figure 7.11*)	

[a] IMPORTANT: See Appendix F: Setting Negative-Sequence Overcurrent Elements for special instructions on setting negative-sequence overcurrent elements.

Settings Explanations

Note that most of the settings in the settings sheets that follow include references for additional information. The following explanations are for settings that do not have reference information anywhere else in the instruction manual.

Identifier Labels

Refer to *Identifier Labels on page SET.1*.

The SEL-351R has two identifier labels:

- the Recloser Identifier (RID)
- the Terminal Identifier (TID)

The Recloser Identifier typically is used to identify the recloser control or the type of protection scheme. Typical Terminal Identifiers include an abbreviation of the substation name and line terminal.

The SEL-351R tags each report (event report, meter report, etc.) with the Recloser Identifier and Terminal Identifier. This allows you to distinguish the report as one generated for a specific breaker and substation.

RID and TID settings may include the following characters:

- 0–9
- A–Z
- -
- /
- .
- space

These two settings cannot be made via the front-panel interface.

Current Transformer Ratios

Refer to *Current and Potential Transformer Ratios on page SET.1*.

Neutral current channel IN is internally connected residually with phase current channels I1, I2, and I3, as shown in *Figure 2.1*. Thus, group setting CTR applies to all overcurrent elements in the SEL-351R, whether derived from neutral current channel IN or from the phase current channels I1, I2, and I3.

Group setting CTR is set to the ratio of the current transformers on the primary phases of the recloser (see Figure 1.14 in the *SEL-351R-4 Quick-Start Installation and User's Guide*).

Line Settings

Refer to *Line Settings on page SET.1*.

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in the fault locator (see *Fault Location on page 12.4*) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see *Settings Made Automatically on page 4.26*). A corresponding line length setting (LL) is also used in the fault locator.

The line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are set in Ω secondary. Line impedance (Ω primary) is converted to Ω secondary:

Ω primary • (CTR/PTR) = Ω secondary

where:

CTR = current transformer ratio setting

PTR = Phase (VA, VB, VC) potential transformer ratio setting

Line length setting LL is unitless and corresponds to the line impedance settings. For example, if a particular line length is 15 miles, enter the line impedance values (Ω secondary) and then enter the corresponding line length:

LL = **15.00** (miles)

If this length of line is measured in kilometers rather than miles, then enter:

LL = **24.14** (kilometers)

Enable Settings

Refer to *Instantaneous/Definite-Time Overcurrent Enable Settings on page SET.1* through *Other Enable Settings on page SET.2* and *Breaker Monitor Settings on page SET.22*.

The enable settings (E50P–EDEM) control the settings that follow, through *SELOGIC Control Equation Variable Timers on page SET.12*. Enable setting EBMON in *Breaker Monitor Settings on page SET.22* controls the settings that immediately follow it. This helps limit the number of settings that need to be made.

Each setting subgroup refers back to the controlling enable setting. For example, the neutral ground time-overcurrent elements settings (settings 51N1P–51N1RS and 51N2P–51N2RS) are controlled by enable setting E51N.

Other System Parameters

Refer to *Global Settings (Serial Port Command SET G and Front Panel) on page SET.21*.

The global settings NFREQ and PHROT allow you to configure the SEL-351R to your specific system.

Set NFREQ equal to your nominal power system frequency, either 50 Hz or 60 Hz.

Set PHROT equal to your power system phase rotation, either ABC or ACB.

The PHROT setting describes the electrical rotation of the power system phases, as opposed to the IPCONN and VPCONN settings, which describe the connections to the SEL-351R current and voltage terminals.

Set DATE_F to format the date displayed in control reports and the front-panel display. Set DATE_F to MDY to display dates in Month/Day/Year format; set DATE_F to YMD to display dates in Year/Month/Day format.

The UTCOFF setting shifts the relay time by adding an offset to the incoming IRIG-B or DNP master source time. UTCOFF is settable from –24.00 to 24.00 hours, in 0.25 hour increments.

Current and Voltage Connection Settings

NOTE: V1, V2, I1, and I2 should not be confused with calculated sequence positive and negative values V_1, V_2, I_1, and I_2.

See *Current and Voltage Connection Settings on page SET.23*.

The SEL-351R includes Current and Voltage Connections Settings for the analog input terminals V1, V2, V3, I1, I2, and I3. Wiring to the power system can be random, but correct power system “A-B-C” designation is still needed within the SEL-351R recloser control algorithm. Using the following settings designates the power system A-B-C wiring to the control terminal V1-V2-V3 connections for the control algorithms.

The SEL-351R side-panel terminals are shown in Figure 1.12 in the *SEL-351R-4 Quick-Start Installation and User’s Guide*. The side-panel terminal markings are designated with numeric labels and terminal labels. For the purpose of explaining the current and voltage connection settings, a simplified list of the SEL-351R current and voltage input terminals is used:

- For currents: I1, I2, I3, IN
- For voltages: V1, V2, V3

See Figure 1.14 in the *SEL-351R-4 Quick-Start Installation and User’s Guide* for current connections and Figure 1.8 in the *SEL-351R-4 Quick-Start Installation and User’s Guide* for voltage connections.

Phantom Voltage Setting (PHANTV)

The SEL-351R can be configured to create phantom three-phase voltage signals from an applied single-phase voltage. *Table 9.7* shows the setting choices for PHANTV setting to be made. See *Phantom Voltages on page 8.19*.

The phantom voltage signals created are used only in fundamental metering functions (voltages, power, power factor, energy). The protection functions, including the under- and overvoltage elements, power elements, and event reports, are unaffected by the PHANTV setting.

Voltage Connection Setting (VPCONN)

The SEL-351R has three analog voltage inputs called V1, V2, V3. Figure 1.8 in the *SEL-351R-4 Quick-Start Installation and User’s Guide* covers the actual wiring for these inputs. This section deals with the settings that determine how the SEL-351R processes the signals measured on these terminals.

The SEL-351R can be used with all three voltage inputs connected or with one voltage connected. The voltage input terminals are labeled numerically (1, 2, 3) instead of by phase letter (A, B, C). This allows settings to be used that assign the measured signal to the correct phase quantity inside the SEL-351R. This reassignment is sometimes called phase rolling. It is much easier to change a setting than to change wiring, so the setting VPCONN has been provided in the SEL-351R.

Voltage Terminal Designations (Simplified)

Voltage terminals: V1, V2, V3

NOTE: In Table 9.7, the phase-to-phase connections shown (AB, BC, CA) are single-phase measurements.

Unlike the CT connections shown in *Table 9.8*, it is possible to operate the recloser control with less than three voltages on the set of terminals. *Table 9.7* shows the six combinations of three-phase voltage connections on the voltage terminals, plus six more single-phase voltage connection variations, with or without phantom voltages.

Table 9.7 Voltage Connection Setting VPCONN and Affected Settings

Global Setting True Three-Phase Voltages	Global Setting Phantom Voltages	Voltage Terminal Signal Connections			Global Setting Voltage Terminal
3PVOLT	PHANTV	V1	V2	V3	VPCONN
Y	Hidden, set to OFF	V_A	V_B	V_C	ABC
Y	Hidden, set to OFF	V_A	V_C	V_B	ACB
Y	Hidden, set to OFF	V_B	V_A	V_C	BAC
Y	Hidden, set to OFF	V_B	V_C	V_A	BCA
Y	Hidden, set to OFF	V_C	V_A	V_B	CAB
Y	Hidden, set to OFF	V_C	V_B	V_A	CBA
N	VA	V_A			Hidden, set to A
N	VB	V_B			Hidden, set to B
N	VC	V_C			Hidden, set to C
N	VAB	V_{AB}			Hidden, set to AB
N	VBC	V_{BC}			Hidden, set to BC
N	VCA	V_{CA}			Hidden, set to CA
N	OFF	V_A			A
N	OFF	V_B			B
N	OFF	V_C			C
N	OFF	V_{AB}			AB
N	OFF	V_{BC}			BC
N	OFF	V_{CA}			CA
N	OFF	V_A	V_B	V_C	OFF

Single-Phase and Phase-Phase Voltage Connections

The bottom half of *Table 9.7* lists single-phase and phase-phase connection options for voltage input V1. These voltage input V1 connections are between terminals V1–N (see Figure 1.12 in the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Figure 9.21 shows the voltage terminal assignments for these single-phase and phase-phase voltage connections. Voltage terminals V2 and V3 are assigned.

The internal voltages in *Figure 9.21* are used in the voltage elements (see *Voltage Elements*, *Figure 3.28*, *Figure 3.21*, and *Figure 3.22*) and in the event report columns (see *Figure 12.2*). Even though single-phase and phase-to-phase connections to V1 are shown in *Figure 9.21* (and "no connections" are shown at the bottom of *Figure 9.21*), all the voltage terminals and subsequent internal voltages are active for the aforementioned voltage elements and event report columns.

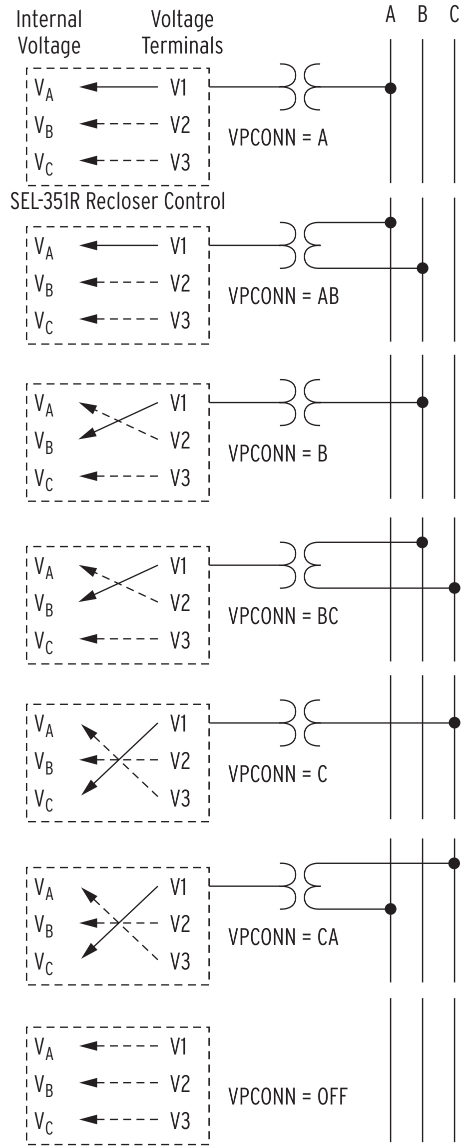

Figure 9.21 Terminal Assignments for Single-Phase and Phase-to-Phase Voltage Connections

Troubleshooting Voltage and Current Connections

The ability to make setting changes instead of wiring changes is convenient. However, some tools are necessary to help troubleshoot problems resulting from any mistakes in either the wiring or the setting of the SEL-351R current and voltage inputs.

The serial port **MET** command is a convenient troubleshooting tool because one can use the command to quickly see how the SEL-351R is interpreting signals. *Section 10: Serial Port Communications and Commands* contains a sample **MET** command capture. Metering Check in Section 1 of the *SEL-351R-4 Quick-Start Installation and User's Guide* gives a quick troubleshooting routine.

Event reports are also powerful diagnostic tools (See *Section 12: Standard Event Reports and SER*. ACSELERATOR® Analytic Assistant SEL-5601 Software allows graphical representation of compressed event report data, including oscillography and phasor display.

The ACSELERATOR QuickSet® SEL-5030 Software contains a phasor display function that operates directly from a serial port connection to the SEL-351R. It is found under the HMI menu.

Current Connection Setting (IPCONN)

As with the voltage inputs, the current input terminals are labeled numerically (1, 2, 3) instead of by phase letters (A, B, C).

The current signals are normally brought into the SEL-351R cabinet via a prewired control cable. Neutral current channel IN is internally connected residually with phase current channels I1, I2, and I3, as shown in Figure 1.14 in the *SEL-351R-4 Quick-Start Installation and User's Guide*.

The electrical phase orientation of the power system overhead line is usually not easy to change, so the resulting CT secondary signals coming from the recloser are not the same in every installation. To eliminate the need to make wiring changes at the back panel, a Global setting, IPCONN, can be used to designate which phases are connected to each of the terminals I1, I2, and I3. *Table 9.8* shows the required setting for IPCONN for the various CT signal connections.

Table 9.8 Current Connection Setting IPCONN

Phase CT Signal Connections			Required Global Setting
I1 Terminals	I2 Terminals	I3 Terminals	IPCONN
I_A	I_B	I_C	ABC
I_A	I_C	I_B	ACB
I_B	I_A	I_C	BAC
I_B	I_C	I_A	BCA
I_C	I_A	I_B	CAB
I_C	I_B	I_A	CBA

CT Polarity Setting (CTPOL)

The SEL-351R uses directional information contained in current and voltage signals in these functions:

- Power measurement
- Power elements
- Load encroachment
- Fault locator
- Directional control

The direction of the calculated power or impedance depends on the relative phase of the current measurements as compared to the voltage signals, which is normally a function of switchgear orientation. The CTPOL = (POS or NEG) setting provides an easy way to change the polarity of the measured current signals, and thus the resulting power direction and impedances.

Figure 1.14 in the *SEL-351R-4 Quick-Start Installation and User's Guide* shows the SEL-351R factory CT circuit wiring for a 14-pin recloser. The directional arrows shown in the primary bus inside the switchgear identify the forward or OUT direction when Global setting CTPOL = POS.

The CTPOL setting functions by negating (or multiplying by –1) the current signals being read on the I1, I2, and I3 current inputs and the channel **IN** current if setting CTPOL = NEG. The event report shows the polarity after the CTPOL adjustment is made, so any analysis tools, such as the ACSELERATOR Analytic Assistant® SEL-5601 Software, extract the same phase information that the SEL-351R is using.

Transition Between Power System A-B-C and Terminals 1-2-3

In *Figure 9.22*, the SEL-351R "1-2-3" connections provide a transition between the:

"A-B-C" power system outside

and the

"A-B-C" algorithm inside the SEL-351R.

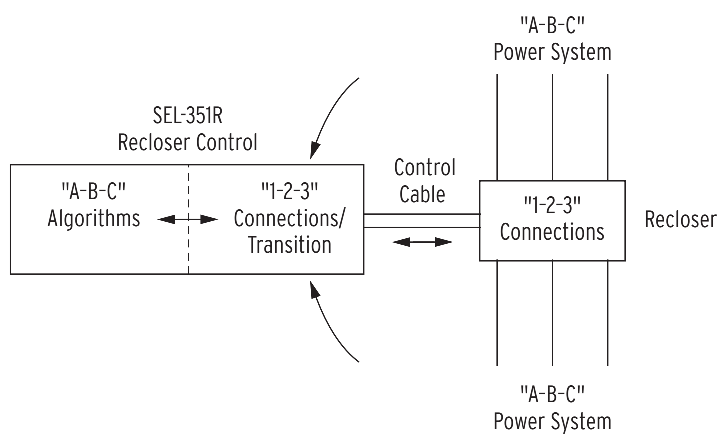

Figure 9.22 Overview of Transition Between A-B-C Inside and Outside the SEL-351R

Wiring to the power system (potential transformer connections and recloser primary bushing connections) can be random, but correct power system "A-B-C" designation is still needed within the SEL-351R algorithms. Preceding *Table 9.7*, *Table 9.8*, and *Figure 9.21* list the settings and all the possible settings combinations that realize the correct "A-B-C" designations within the SEL-351R for the numerous possible power system connections.

Figure 9.23 and *Figure 9.24* are a more in-depth look at the transition idea given in *Figure 9.22*. The underlying assumption in *Figure 9.23* and *Figure 9.24* is that the wiring from the 14-pin control cable is factory-standard in the way it connects to both the SEL-351R and the 14-pin recloser (i.e., there is no rearrangement of the factory-standard cable wiring).

Straight-Through Phase Connections

From inspection of the SEL-351R settings and connections in *Figure 9.23*, one can see that the correspondence between the power system and the SEL-351R connection is as follows:

A ←→ 1

B ←→ 2

C ←→ 3

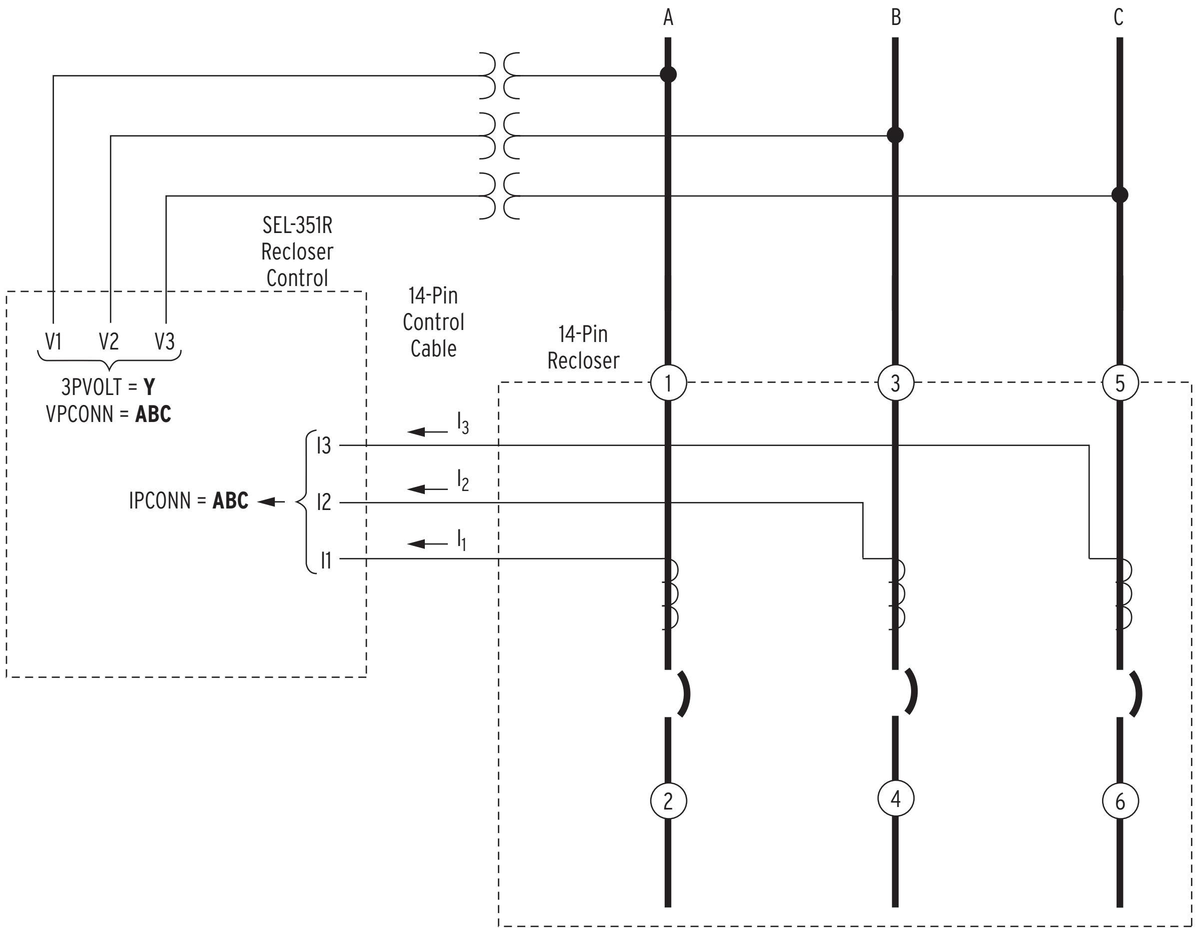

Figure 9.23 14-Pin Recloser With Straight-Through Connections

Complex Phase Connections

Figure 9.24 is similar to *Figure 9.23*, but it has the added complication of primary phase swapping. The correspondence between the power system and the SEL-351R connections is first, at the top of *Figure 9.24*:

$A \longleftrightarrow 1$

$B \longleftrightarrow 2$

$C \longleftrightarrow 3$

With VPCONN = ABC

(voltage terminals: **V1** • A-phase, **V2** • B-phase, **V3** • C-phase)

Then, after the first primary phase swap at the top of the recloser, the correspondence between the power system and the SEL-351R connections is as follows:

$C \longleftrightarrow 1$

$A \longleftrightarrow 2$

$B \longleftrightarrow 3$

With IPCONN = CAB

(current terminals: **I1** • C-phase, **I2** • A-phase, **I3** • B-phase)

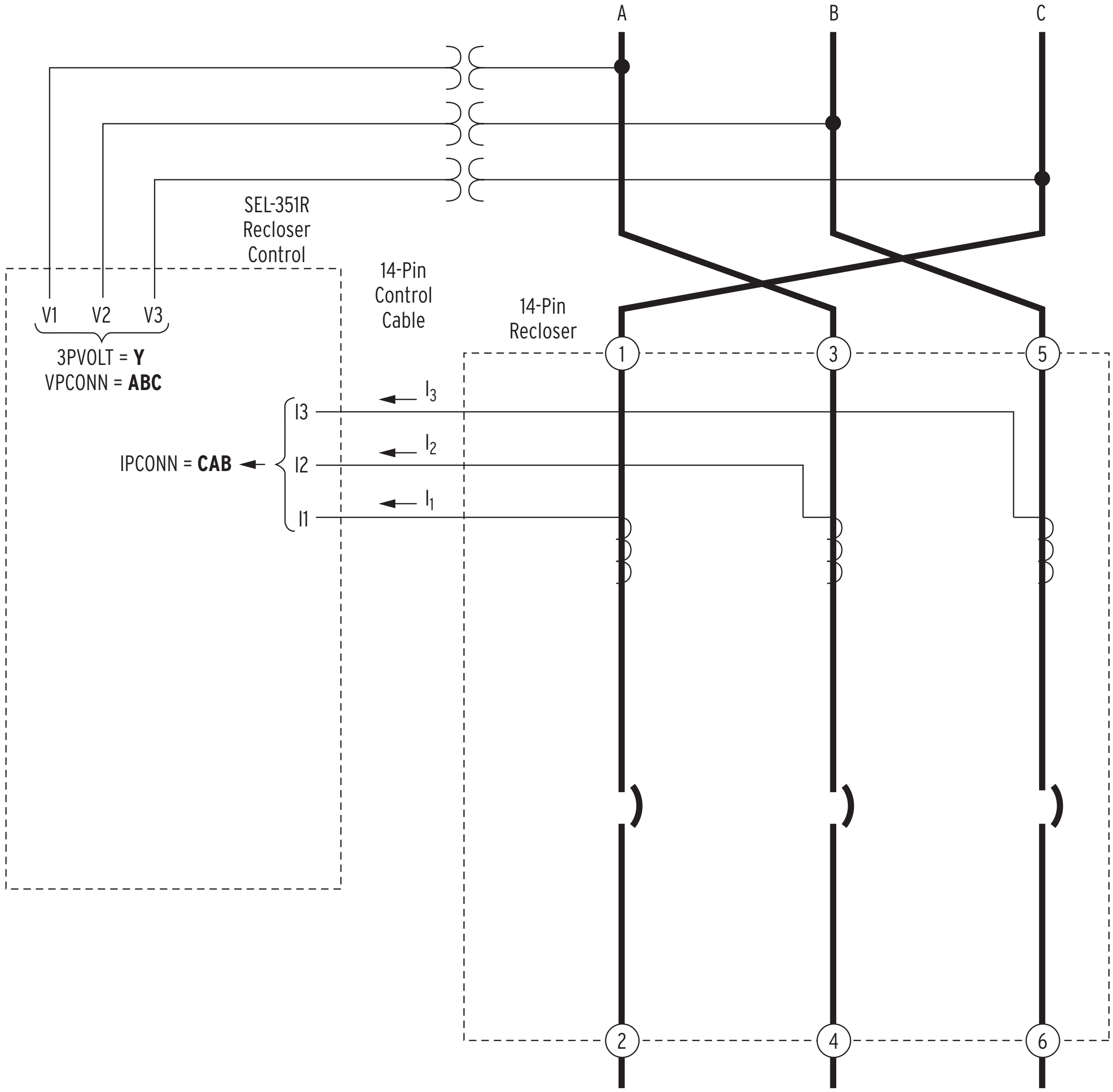

Figure 9.24 14-Pin Recloser With Complex Connections

Settings Sheets

The settings sheets that follow include the definition and input range for most of the settings in the SEL-351R. The settings sheets for the EZ settings are located at the end of Section 4 in the *SEL-351R-4 Quick-Start Installation and User's Guide*. See *Table 9.1* for settings sheets references.

SEL-351R Recloser Control Settings Sheets

Group Settings (Serial Port Command SET and Front Panel)

Identifier Labels

See Identifier Labels on page 9.41.

Recloser Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Current and Potential Transformer Ratios

See Current Transformer Ratios on page 9.41.

Current Transformer Ratio (1.0–6000.0)	**CTR**	= ________
Phase (VA, VB, VC) Potential Transformer Ratio (1.0–10000.0)	**PTR**	= ________
Synchronism Voltage (VS) Potential Transformer Ratio (1.0–10000.0)	**PTRS**	= ________

Line Settings

See Line Settings on page 9.42.

Positive-sequence line impedance magnitude (0.50–2550.00 Ω secondary)	**Z1MAG**	= ________
Positive-sequence line impedance angle (40.00–90.00 degrees)	**Z1ANG**	= ________
Zero-sequence line impedance magnitude (0.50–2550.00 Ω secondary)	**Z0MAG**	= ________
Zero-sequence line impedance angle (40.00–90.00 degrees)	**Z0ANG**	= ________
Line length (0.10–999.00, unitless)	**LL**	= ________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–6) (see *Figure 3.1*, *Figure 3.2*, *Figure 3.3*, and *Figure 3.7*)	**E50P**	= ________
Neutral-ground element levels—channel IN (N, 1–6) (see *Figure 3.8* and *Figure 3.9*)	**E50N**	= ________

Residual-ground element levels (N, 1–6) (see *Figure 3.10* and *Figure 3.11*)	**E50G**	= ________
Negative-sequence element levels (N, 1–6) (see *Figure 3.12* and *Figure 3.13*)	**E50Q**	= ________

Time-Overcurrent Enable Settings

Phase elements (N, 1, 2) (See *Table 3.1*, *Figure 3.14* and *Figure 3.15*)	**E51P**	= ________
Neutral-ground elements—channel IN (N, 1, 2) (see *Figure 3.16* and *Figure 3.17*)	**E51N**	= ________
Residual-ground elements (N, 1, 2) (see *Figure 3.18* and *Figure 3.19*)	**E51G**	= ________
Negative-sequence elements (Y, N) (see *Figure 3.20*)	**E51Q**	= ________

Other Enable Settings

Directional control (Y, AUTO, N) (see *Directional Control Settings on page 4.25*)	**E32**	= ________
Load encroachment (Y, N) (see *Figure 4.2*)	**ELOAD**	= ________
Switch-onto-fault (Y, N) (see *Figure 5.3*)	**ESOTF**	= ________
Voltage elements (Y, N) (see *Figure 3.21*, *Figure 3.22*, and *Figure 3.23*)	**EVOLT**	= ________
Synchronism check (Y, N) (see *Figure 3.24* and *Figure 3.25*)	**E25**	= ________
Fault location (Y, N) (see *Table 12.1* and *Fault Location on page 12.4*)	**EFLOC**	= ________
Loss-of-potential (Y, Y1, N) (see *Figure 4.1*)	**ELOP**	= ________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.7*)	**ECOMM**	= ________
Frequency elements (N, 1–6) (see *Figure 3.28*)	**E81**	= ________
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.9*)	**E79**	= ________
SELOGIC® control equation Variable Timers (N, 1–16) (see *Figure 7.23*)	**ESV**	= ________
Demand Metering (THM = Thermal; ROL = Rolling) (see *Figure 8.9*)	**EDEM**	= ________

Phase Inst./Def.-Time Overcurrent Elements

See Figure 3.1–Figure 3.3.

Number of phase element pickup settings dependent on preceding enable setting E50P = 1–6.

Pickup (OFF, 0.05–20.00 A)	**50P1P**	= ________
Pickup (OFF, 0.05–20.00 A)	**50P2P**	= ________
Pickup (OFF, 0.05–20.00 A)	**50P3P**	= ________

Pickup (OFF, 0.05–20.00 A)	**50P4P**	= ________
Pickup (OFF, 0.05–20.00 A)	**50P5P**	= ________
Pickup (OFF, 0.05–20.00 A)	**50P6P**	= ________

Phase Definite-Time Overcurrent Elements

See Figure 3.3.

Number of phase element time delay settings dependent on preceding enable setting E50P = 1–6; all four time delay settings are enabled if E50P ≥ 4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P2D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P3D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P4D**	= ________

Phase-to-Phase Instantaneous Overcurrent Elements

See Figure 3.7.

Number of phase-to-phase element pickup settings dependent on preceding enable setting E50P = 1–6; all four pickup settings are enabled if E50P ≥ 4.

Pickup (OFF, 0.20–34.00 A)	**50PP1P**	= ________
Pickup (OFF, 0.20–34.00 A)	**50PP2P**	= ________
Pickup (OFF, 0.20–34.00 A)	**50PP3P**	= ________
Pickup (OFF, 0.20–34.00 A)	**50PP4P**	= ________

Neutral-Ground Inst./Def.-Time Overcurrent Elements—Channel IN

See Figure 3.8 and Figure 3.9.

Number of neutral-ground element pickup settings dependent on preceding enable setting E50N = 1–6.

Pickup (OFF, 0.005–1.500 A)	**50N1P**	= ________
Pickup (OFF, 0.005–1.500 A)	**50N2P**	= ________
Pickup (OFF, 0.005–1.500 A)	**50N3P**	= ________
Pickup (OFF, 0.005–1.500 A)	**50N4P**	= ________
Pickup (OFF, 0.005–1.500 A)	**50N5P**	= ________
Pickup (OFF, 0.005–1.500 A)	**50N6P**	= ________

Neutral-Ground Definite-Time Overcurrent Elements

See Figure 3.8.

Number of neutral-ground element time delay settings dependent on preceding enable setting E50N = 1–6; all four time delay settings are enabled if E50N ≥ 4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67N1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67N2D**	= ________

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67N3D**	=________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67N4D**	=________

Residual-Ground Inst./Def.-Time Overcurrent Elements

See Figure 3.10 and Figure 3.11.

Number of residual-ground element pickup settings dependent on preceding enable setting E50G = 1–6).

Pickup (OFF, 0.05–20.00 A)	**50G1P**	=________
Pickup (OFF, 0.05–20.00 A)	**50G2P**	=________
Pickup (OFF, 0.05–20.00 A)	**50G3P**	=________
Pickup (OFF, 0.05–20.00 A)	**50G4P**	=________
Pickup (OFF, 0.05–20.00 A)	**50G5P**	=________
Pickup (OFF, 0.05–20.00 A)	**50G6P**	=________

Residual-Ground Definite-Time Overcurrent Elements

See Figure 3.10.

Number of residual-ground element time delay settings dependent on preceding enable setting E50G = 1–6; all four time delay settings are enabled if E50G ≥ 4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G1D**	=________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G2D**	=________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G3D**	=________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G4D**	=________

Negative-Sequence Inst./Def.-Time Overcurrent Elements

See Figure 3.12 and Figure 3.13.

IMPORTANT: See Appendix F for information on setting negative-sequence overcurrent elements.

Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–6.

Pickup (OFF, 0.05–20.00 A)	**50Q1P**	=________
Pickup (OFF, 0.05–20.00 A)	**50Q2P**	=________
Pickup (OFF, 0.05–20.00 A)	**50Q3P**	=________
Pickup (OFF, 0.05–20.00 A)	**50Q4P**	=________
Pickup (OFF, 0.05–20.00 A)	**50Q5P**	=________
Pickup (OFF, 0.05–20.00 A)	**50Q6P**	=________

Negative-Sequence Definite-Time Overcurrent Elements

See Figure 3.12.

IMPORTANT: See Appendix F for information on setting negative-sequence overcurrent elements.

Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–6; all four time delay settings are enabled if E50Q ≥ 4).

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q2D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q3D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q4D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q5D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q6D**	= ________

Phase Time-Overcurrent Elements

See Figure 3.14 and Figure 3.15.

Make the following settings if preceding enable setting E51P = 1 or 2.

Pickup (OFF, 0.05–3.20 A)	**51P1P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51P1C**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51P1TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51P1RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51P1CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51P1MR**	= ________

Make the following settings if preceding enable setting E51P = 2.

Pickup (OFF, 0.10–3.20 A)	**51P2P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51P2C**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51P2TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51P2RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51P2CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51P2MR**	= ________

Neutral-Ground Time-Overcurrent Elements—Channel IN

See Figure 3.16 and Figure 3.17.

Make the following settings if preceding enable setting E51N = 1 or 2.

Pickup (OFF, 0.005–0.160 A)	**51N1P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51N1C**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51N1TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51N1RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51N1CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51N1MR**	= ________

Make the following settings if preceding enable setting E51N = 2.

Pickup (OFF, 0.005–0.160 A)	**51N2P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51N2C**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51N2TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51N2RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51N2CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51N2MR**	= ________

Residual-Ground Time-Overcurrent Elements

See Figure 3.18 and Figure 3.19.

Make the following settings if preceding enable setting E51G = 1 or 2.

Pickup (OFF, 0.05–3.20 A)	**51G1P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51G1C**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51G1TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51G1RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51G1CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51G1MR**	= ________

Make the following settings if preceding enable setting E51G = 2.

Pickup (OFF, 0.10–3.20 A)	**51G2P**	= ________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51G2C**	= ________

Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51G2TD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51G2RS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51G2CT**	= ________
Minimum response (0.00–60.00 cyc.)	**51G2MR**	= ________

Negative-Sequence Time-Overcurrent Element

See Figure 3.20.

IMPORTANT: See Appendix F for information on setting negative-sequence overcurrent elements.

Make the following settings if preceding enable setting E51Q = Y.

Pickup (OFF, 0.05–3.20 A)	**51QP**	________
Curve (U1–U5, C1–C5, recloser or user curve; see *Figure 9.1–Figure 9.20*)	**51QC**	= ________
Time-Dial (0.50–15.00 for curves U1–U5, 0.05–1.00 for curves C1–C5, 0.10–2.00 for recloser and user curves)	**51QTD**	= ________
Electromechanical Reset (Y, N; applicable only to curves U1–U5, C1–C5)	**51QRS**	= ________
Constant time adder (0.00–60.00 cyc.)	**51QCT**	= ________
Minimum response (0.00–60.00 cyc.)	**51QMR**	= ________

Load-Encroachment Elements

See Figure 4.2.

Make the following settings if preceding enable setting ELOAD = Y.

Forward load impedance (0.05–64.00 Ω secondary 5 A nom.)	**ZLF**	= ________
Reverse load impedance (0.05–64.00 Ω secondary 5 A nom.)	**ZLR**	= ________
Positive forward load angle (–90.00° to +90.00°)	**PLAF**	= ________
Negative forward load angle (–90.00° to +90.00°)	**NLAF**	= ________
Positive reverse load angle (+90.00° to +270.00°)	**PLAR**	= ________
Negative reverse load angle (+90.00° to +270.00°)	**NLAR**	= ________

Directional Elements

See Directional Control Settings on page 4.25.

Make settings DIR1–DIR4 and ORDER if preceding enable setting E32 = Y or AUTO.

Level 1 direction: Forward, Reverse, None (F, R, N)	**DIR1**	= ________
Level 2 direction: Forward, Reverse, None (F, R, N)	**DIR2**	= ________
Level 3 direction: Forward, Reverse, None (F, R, N)	**DIR3**	= ________

Level 4 direction: Forward, Reverse, None (F, R, N)	**DIR4**	=__________
Ground directional element priority: combination of OFF, Q, V, or I	**ORDER**	=__________

Make setting 50P32P if preceding enable setting E32 = Y or AUTO and ELOAD = N.

Phase directional element 3-phase current pickup (0.10–2.00 A)	**50P32P**	=__________

Make settings Z2F, Z2R, 50QFP, 50QRP, a2 and k2 if preceding enable setting E32 = Y. If E32 = AUTO, these settings are made automatically.

Forward directional Z2 threshold (–640.00 to +640.00 Ω secondary)	**Z2F**	=__________
Reverse directional Z2 threshold (–640.00 to +640.00 Ω secondary)	**Z2R**	=__________
Forward directional negative-sequence current pickup (0.05–1.00 A secondary)	**50QFP**	=__________
Reverse directional negative-sequence current pickup (0.05–1.00 A secondary)	**50QRP**	=__________
Positive-sequence current restraint factor, I2/I1 (0.02–0.50, unitless)	**a2**	=__________
Zero-sequence current restraint factor, I2/I0 (0.10–1.20, unitless)	**k2**	=__________

Make settings 50GFP, 50GRP, a0, Z0F, and Z0R if preceding enable setting E32 = Y and preceding setting ORDER contains V. If E32 = AUTO and ORDER contains V, these settings are made automatically.

Forward directional residual-ground pickup (0.05–1.00 A secondary)	**50GFP**	=__________
Reverse directional residual-ground pickup (0.05–1.00 A secondary)	**50GRP**	=__________
Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless)	**a0**	=__________
Forward directional Z0 threshold (–640.00–640.00 Ω secondary)	**Z0F**	=__________
Reverse directional Z0 threshold (–640.00–640.00 Ω secondary)	**Z0R**	=__________

Voltage Elements

See Figure 3.21–Figure 3.23.

Make the following settings if preceding enable setting EVOLT = Y

Phase undervoltage pickup (OFF, 0.0–300.0 V secondary)	**27P1P**	=__________
Phase undervoltage pickup (OFF, 0.0–300.0 V secondary)	**27P2P**	=__________
Phase overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59P1P**	=__________
Phase overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59P2P**	=__________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59N1P**	=__________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59N2P**	=__________

Negative-sequence (V2) overvoltage pickup (OFF, 0.0–200.0 V secondary)	**59QP**	= ________
Positive-sequence (V1) overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59V1P**	= ________
Channel VS undervoltage pickup (OFF, 0.0–300.0 V secondary)	**27SP**	= ________
Channel VS overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59S1P**	= ________
Channel VS overvoltage pickup (OFF, 0.0–300.0 V secondary)	**59S2P**	= ________
Phase-to-phase undervoltage pickup (OFF, 0.0–520.0 V secondary)	**27PP**	= ________
Phase-to-phase overvoltage pickup (OFF, 0.0–520.0 V secondary)	**59PP**	= ________

Synchronism-Check Elements

See Figure 3.24 and Figure 3.25.

Make the following settings if preceding enable setting E25 = Y.

Voltage window—low threshold (0.00–300.00 V secondary)	**25VLO**	= ________
Voltage window—high threshold (0.00–300.00 V secondary)	**25VHI**	= ________
Maximum slip frequency (0.005–0.500 Hz)	**25SF**	= ________
Maximum angle 1 (0°–80° in one-degree steps)	**25ANG1**	= ________
Maximum angle 2 (0°–80° in one-degree steps)	**25ANG2**	= ________
Synchronizing phase (VA, VB, VC, or 0°–330°, in 30-degree steps; degree option is for VS not in phase with VA, VB, or VC—set with respect to VS constantly lagging VA)	**SYNCP**	= ________
Breaker close time for angle compensation (0.00–60.00 cycles in 0.25-cycle steps)	**TCLOSD**	= ________

Frequency Elements

See Figure 3.27 and Figure 3.28.

Make the following settings if preceding enable setting E81 = Y.

Phase undervoltage block (20.00–300.00 V secondary)	**27B81P**	= ________
Level 1 pickup (OFF, 40.10–65.00 Hz)	**81D1P**	= ________
Level 1 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D1D**	= ________
Level 2 pickup (OFF, 40.10–65.00 Hz)	**81D2P**	= ________
Level 2 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D2D**	= ________
Level 3 pickup (OFF, 40.10–65.00 Hz)	**81D3P**	= ________
Level 3 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D3D**	= ________
Level 4 pickup (OFF, 40.10–65.00 Hz)	**81D4P**	= ________
Level 4 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D4D**	= ________

Level 5 pickup (OFF, 40.10–65.00 Hz)	**81D5P**	= ________
Level 5 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D5**	= ________
Level 6 pickup (OFF, 41.00–65.00 Hz)	**81D6P**	= ________
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D6D**	= ________

Reclosing Relay

See Table 6.2 and Table 6.3.

Make the following settings if preceding enable setting E79 = Y.

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI1**	= ________
Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI2**	= ________
Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI3**	= ________
Open interval 4 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI4**	= ________
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps)	**79RSD**	= ________
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps)	**79RSLD**	= ________
Reclose supervision time limit (OFF, 0.00–999999.00 cycles in 0.25-cycle steps) (see *Figure 6.2*)	**79CLSD**	= ________

Switch-Onto-Fault

See Figure 5.3.

Make the following settings if preceding enable setting ESOTF = Y.

Close enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**CLOEND**	= ________
52A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**52AEND**	= ________
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps)	**SOTFD**	= ________

POTT Trip Scheme Settings (Also Used in DCUB Trip Schemes)

See Figure 5.6.

Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2.

Zone (level) 3 reverse block time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3RBD**	= ________
Echo block time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**EBLKD**	= ________
Echo time delay pickup (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**ETDPU**	= ________

Echo duration time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**EDURD**	= ________
Weak-infeed enable (Y, N)	**EWFC**	= ________

Additional DCUB Trip Scheme Settings

See Figure 5.10.

Make the following settings if preceding enable setting ECOMM = DCUB1 or DCUB2.

Guard present security time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**GARD1D**	= ________
DCUB disabling time delay (0.25–16000.00 cycles in 0.25-cycle steps)	**UBDURD**	= ________
DCUB duration time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**UBEND**	= ________

DCB Trip Scheme Settings

See Figure 5.14.

Make the following settings if preceding enable setting ECOMM = DCB.

Zone (level) 3 reverse pickup time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3XPU**	= ________
Zone (level) 3 reverse dropout extension (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3XD**	= ________
Block trip receive extension (0.00–16000.00 cycles in 0.25-cycle steps)	**BTXD**	= ________
Level 2 phase short delay (0.00–60.00 cycles in 0.25-cycle steps)	**67P2SD**	= ________
Level 2 neutral-ground short delay (0.00–60.00 cycles in 0.25-cycle steps)	**67N2SD**	= ________
Level 2 residual-ground short delay (0.00–60.00 cycles in 0.25-cycle steps)	**67G2SD**	= ________
Level 2 negative-sequence short delay (0.00–60.00 cycles in 0.25-cycle steps)	**67Q2SD**	= ________

Demand Metering Settings

See Figure 8.9 and Figure 8.11.

Make the following settings, whether preceding enable setting EDEM = THM or ROL.

Time constant (5, 10, 15, 30, 60 minutes)	**DMTC**	= ________
Phase pickup: (OFF, 0.10–3.20 A)	**PDEMP**	= ________
Neutral-ground pickup—channel IN: (OFF, 0.005–0.160 A)	**NDEMP**	= ________
Residual-ground pickup: (OFF, 0.10–3.20 A)	**GDEMP**	= ________
Negative-sequence pickup: (10–3.20 A)	**QDEMP**	= ________

Other Settings

Make the following settings—they have no controlling enable setting.

Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 5.1*)	**TDURD**	= ________
Close failure time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 6.1*)	**CFD**	= ________
Three-pole open time delay (0.00–60.00 cycles in 0.25-cycle steps) (usually set for no more than a cycle; see *Figure 5.3*)	**3POD**	= ________
Load detection phase pickup (OFF, 0.05–20.00 A) (see *Figure 5.3*)	**50LP**	= ________

SELogic Control Equation Variable Timers

See Figure 7.23.

Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________
SV7 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV7PU**	= ________
SV7 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV7DO**	= ________
SV8 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV8PU**	= ________
SV8 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV8DO**	= ________
SV9 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV9PU**	= ________
SV9 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV9DO**	= ________
SV10 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV10PU**	= ________
SV10 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV10DO**	= ________
SV11 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV11PU**	= ________

SV11 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV11DO**	= ________
SV12 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV12PU**	= ________
SV12 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV12DO**	= ________
SV13 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV13PU**	= ________
SV13 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV13DO**	= ________
SV14 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV14PU**	= ________
SV14 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV14DO**	= ________
SV15 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV15PU**	= ________
SV15 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV15DO**	= ________
SV16 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV16PU**	= ________
SV16 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV16DO**	= ________

Recloser Control Logic Enable Settings

See Section 1.

Operations—phase fast curve (OFF, 1–5)	**OPPH**	= ________
Operations—ground fast curve (OFF, 1–5)	**OPGR**	= ________
Operations to lockout—phase (OFF, 1–5)	**OPLKPH**	= ________
Operations to lockout—ground (OFF, 1–5)	**OPLKGR**	= ________
Operations to lockout—SEF (OFF, 1–5)	**OPLKSF**	= ________
Activate High current trip—phase (OFF, 1–5)	**HITRPH**	= ________
Activate High current trip—ground (OFF, 1–5)	**HITRGR**	= ________
Activate high current lockout—phase (OFF, 1–5)	**HILKPH**	= ________
Activate high current lockout—ground (OFF, 1–5)	**HILKGR**	= ________
Cold load pickup scheme—phase (Y, N)	**ECOLDP**	= ________
Cold load pickup scheme—ground (Y, N)	**ECOLDG**	= ________
Restore min. trip—phase (Y, N)	**RPPH**	= ________
Restore min. trip—ground (Y, N)	**RPGR**	= ________
Restore min. trip—SEF (Y, N)	**RPSEF**	= ________
Sequence coordination (Y, N)	**ESEQ**	= ________
Ground trip precedence (Y, N)	**PRECED**	= ________

SELOGIC Control Equation Settings (Serial Port Command SET L)

SELOGIC control equation settings consist of Relay Word bits (see Table 9.6 and Table 9.7) and SELOGIC control equation operators * (AND), + (OR), ! (NOT), / (rising edge), \ (falling edge), and ( ) (parentheses). Numerous SELOGIC control equation settings examples are given in Section 1, and Section 3–Section 8. SELOGIC control equation settings can also be **set directly** to 1 (logical 1) or 0 (logical 0). Appendix G: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations

See Figure 5.1.

Other trip conditions	**TR**	= ____________
Communications-assisted trip conditions	**TRCOMM**	= ____________
Switch-onto-fault trip conditions	**TRSOTF**	= ____________
Direct transfer trip conditions	**DTT**	= ____________
Unlatch trip conditions	**ULTR**	= ____________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.5*, *Figure 5.7*, and *Figure 5.10*)	**PT1**	= ____________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.10*)	**LOG1**	= ____________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.5* and *Figure 5.10*)	**PT2**	= ____________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.10*)	**LOG2**	= ____________
Block trip (used for ECOMM = DCB; see *Figure 5.14*)	**BT**	= ____________

Close Logic Equations

See Figure 6.1.

Circuit breaker status (used in *Figure 5.3*, also)	**52A**	= ____________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	= ____________
Unlatch close conditions	**ULCL**	= ____________

Reclosing Relay Equations

See Reclosing Relay on page 6.9.

Reclose initiate	**79RI**	= ____________
Reclose initiate supervision	**79RIS**	= ____________
Drive-to-lockout	**79DTL**	= ____________
Drive-to-last shot	**79DLS**	= ____________

Skip shot	**79SKP**	= ______________
Stall open interval timing	**79STL**	= ______________
Block reset timing	**79BRS**	= ______________
Sequence coordination	**79SEQ**	= ______________
Reclose supervision (see *Figure 6.2*)	**79CLS**	= ______________

Latch Bits Set/Reset Equations

See Figure 7.11.

Set Latch Bit LT1	**SET1**	= ______________
Reset Latch Bit LT1	**RST1**	= ______________
Set Latch Bit LT2	**SET2**	= ______________
Reset Latch Bit LT2	**RST2**	= ______________
Set Latch Bit LT3	**SET3**	= ______________
Reset Latch Bit LT3	**RST3**	= ______________
Set Latch Bit LT4	**SET4**	= ______________
Reset Latch Bit LT4	**RST4**	= ______________
Set Latch Bit LT5	**SET5**	= ______________
Reset Latch Bit LT5	**RST5**	= ______________
Set Latch Bit LT6	**SET6**	= ______________
Reset Latch Bit LT6	**RST6**	= ______________
Set Latch Bit LT7	**SET7**	= ______________
Reset Latch Bit LT7	**RST7**	= ______________
Set Latch Bit LT8	**SET8**	= ______________
Reset Latch Bit LT8	**RST8**	= ______________
Set Latch Bit LT9	**SET9**	= ______________
Reset Latch Bit LT9	**RST9**	= ______________
Set Latch Bit LT10	**SET10**	= ______________
Reset Latch Bit LT10	**RST10**	= ______________
Set Latch Bit LT11	**SET11**	= ______________
Reset Latch Bit LT11	**RST11**	= ______________
Set Latch Bit LT12	**SET12**	= ______________
Reset Latch Bit LT12	**RST12**	= ______________
Set Latch Bit LT13	**SET13**	= ______________

Reset Latch Bit LT13	**RST13**	=	______________
Set Latch Bit LT14	**SET14**	=	______________
Reset Latch Bit LT14	**RST14**	=	______________
Set Latch Bit LT15	**SET15**	=	______________
Reset Latch Bit LT15	**RST15**	=	______________
Set Latch Bit LT16	**SET16**	=	______________
Reset Latch Bit LT16	**RST16**	=	______________

Torque-Control Equations for Inst./Def.-Time Overcurrent Elements

NOTE: Torque control equation settings cannot be set directly to logical 0.

Level 1 phase (see *Figure 3.3*)	**67P1TC**	=	______________
Level 2 phase (see *Figure 3.3*)	**67P2TC**	=	______________
Level 3 phase (see *Figure 3.3*)	**67P3TC**	=	______________
Level 4 phase (see *Figure 3.3*)	**67P4TC**	=	______________
Level 1 neutral-ground (see *Figure 3.8*)	**67N1TC**	=	______________
Level 2 neutral-ground (see *Figure 3.8*)	**67N2TC**	=	______________
Level 3 neutral-ground (see *Figure 3.8*)	**67N3TC**	=	______________
Level 4 neutral-ground (see *Figure 3.8*)	**67N4TC**	=	______________
Level 1 residual-ground (see *Figure 3.10*)	**67G1TC**	=	______________
Level 2 residual-ground (see *Figure 3.10*)	**67G2TC**	=	______________
Level 3 residual-ground (see *Figure 3.10*)	**67G3TC**	=	______________
Level 4 residual-ground (see *Figure 3.10*)	**67G4TC**	=	______________
Level 1 negative-sequence (see *Figure 3.12*)	**67Q1TC**	=	______________
Level 2 negative-sequence (see *Figure 3.12*)	**67Q2TC**	=	______________
Level 3 negative-sequence (see *Figure 3.12*)	**67Q3TC**	=	______________
Level 4 negative-sequence (see *Figure 3.12*)	**67Q4TC**	=	______________

Torque-Control Equations for Time-Overcurrent Elements

NOTE: Torque control equation settings cannot be set directly to logical 0.

Phase (see *Figure 3.14*)	**51P1TC**	=	______________
Neutral-ground (see *Figure 3.16*)	**51N1TC**	=	______________
Residual-ground (see *Figure 3.18*)	**51G1TC**	=	______________
Phase (see *Figure 3.15*)	**51P2TC**	=	______________
Neutral-ground (see *Figure 3.17*)	**51N2TC**	=	______________

Residual-ground (see *Figure 3.19*)	**51G2TC**	= ____________
Negative-sequence element (see *Figure 3.20*)	**51QTC**	= ____________

SELOGIC Control Equation Variable Timer Input Equations

See Figure 7.23.

SELOGIC control equation Variable SV1	**SV1**	= ____________
SELOGIC control equation Variable SV2	**SV2**	= ____________
SELOGIC control equation Variable SV3	**SV3**	= ____________
SELOGIC control equation Variable SV4	**SV4**	= ____________
SELOGIC control equation Variable SV5	**SV5**	= ____________
SELOGIC control equation Variable SV6	**SV6**	= ____________
SELOGIC control equation Variable SV7	**SV7**	= ____________
SELOGIC control equation Variable SV8	**SV8**	= ____________
SELOGIC control equation Variable SV9	**SV9**	= ____________
SELOGIC control equation Variable SV10	**SV10**	= ____________
SELOGIC control equation Variable SV11	**SV11**	= ____________
SELOGIC control equation Variable SV12	**SV12**	= ____________
SELOGIC control equation Variable SV13	**SV13**	= ____________
SELOGIC control equation Variable SV14	**SV14**	= ____________
SELOGIC control equation Variable SV15	**SV15**	= ____________
SELOGIC control equation Variable SV16	**SV16**	= ____________

SELOGIC Control Equation Counter Variable Input Equations

See Figure 7.25.

SELOGIC Counter Reset Equation SC1R	**SC1R**	= ____________
SELOGIC Counter Increment Equation SC1I	**SC1I**	= ____________
SELOGIC Counter Decrement Equation SC1D	**SC1D**	= ____________
SELOGIC Counter Reset Equation SC2R	**SC2R**	= ____________
SELOGIC Counter Increment Equation SC2I	**SC2I**	= ____________
SELOGIC Counter Decrement Equation SC2D	**SC2D**	= ____________
SELOGIC Counter Reset Equation SC3R	**SC3R**	= ____________
SELOGIC Counter Increment Equation SC3I	**SC3I**	= ____________
SELOGIC Counter Decrement Equation SC3D	**SC3D**	= ____________
SELOGIC Counter Reset Equation SC4R	**SC4R**	= ____________

SELOGIC Counter Increment Equation SC4I	**SC4I**	= ________
SELOGIC Counter Decrement Equation SC4D	**SC4D**	= ________
SELOGIC Counter Reset Equation SC5R	**SC5R**	= ________
SELOGIC Counter Increment Equation SC5I	**SC5I**	= ________
SELOGIC Counter Decrement Equation SC5D	**SC5D**	= ________
SELOGIC Counter Reset Equation SC6R	**SC6R**	= ________
SELOGIC Counter Increment Equation SC6I	**SC6I**	= ________
SELOGIC Counter Decrement Equation SC6D	**SC6D**	= ________
SELOGIC Counter Reset Equation SC7R	**SC7R**	= ________
SELOGIC Counter Increment Equation SC7I	**SC7I**	= ________
SELOGIC Counter Decrement Equation SC7D	**SC7D**	= ________
SELOGIC Counter Reset Equation SC8R	**SC8R**	= ________
SELOGIC Counter Increment Equation SC8I	**SC8I**	= ________
SELOGIC Counter Decrement Equation SC8D	**SC8D**	= ________

Recloser Control Equations

See Figure 7.29.

Recloser Trip via control cable	**RCTR**	= ________
Recloser Close via control cable	**RCCL**	= ________

Output Contact Equations

See Figure 7.26.

Output Contact OUT101	**OUT101**	= ________
Output Contact OUT102	**OUT102**	= ________
Output Contact OUT103	**OUT103**	= ________
Output Contact OUT104	**OUT104**	= ________
Output Contact OUT105	**OUT105**	= ________
Output Contact OUT106	**OUT106**	= ________
Output Contact OUT107	**OUT107**	= ________

Operator Control LED Equations

See Figure 1.35, Figure 1.36, and Figure 1.51–Figure 1.54.

LED1 (GROUND ENABLED)	**LED1**	= ________
LED2 (RECLOSE ENABLED)	**LED2**	= ________
LED3 (REMOTE ENABLED)	**LED3**	= ________

LED4 (ALTERNATE SETTINGS)	**LED4**	= ______________
LED5 (LOCK)	**LED5**	= ______________
LED6 (AUX 1)	**LED6**	= ______________
LED7 (AUX 2)	**LED7**	= ______________
LED8 (RECLOSER CLOSED)	**LED8**	= ______________
LED9 (RECLOSER OPEN)	**LED9**	= ______________
LED11 (AC SUPPLY)	**LED11**	= ______________
LED12 (BATTERY PROBLEM)	**LED12**	= ______________
LED13 (HOT LINE TAG)	**LED13**	= ______________
LED14 (TRIP)	**LED14**	= ______________
LED15 (FAST CURVE)	**LED15**	= ______________
LED16 (HIGH CURRENT)	**LED16**	= ______________
LED17 (81)	**LED17**	= ______________
LED18 (RESET)	**LED18**	= ______________
LED19 (CYCLE)	**LED19**	= ______________
LED20 (LOCKOUT)	**LED20**	= ______________
LED24 (G)	**LED24**	= ______________
LED25 (SEF)	**LED25**	= ______________

Display Point Equations

See Rotating Default Display on page 7.29 and Rotating Default Display on page 11.6.

Display Point DP1	**DP1**	= ______________
Display Point DP2	**DP2**	= ______________
Display Point DP3	**DP3**	= ______________
Display Point DP4	**DP4**	= ______________
Display Point DP5	**DP5**	= ______________
Display Point DP6	**DP6**	= ______________
Display Point DP7	**DP7**	= ______________
Display Point DP8	**DP8**	= ______________
Display Point DP9	**DP9**	= ______________
Display Point DP10	**DP10**	= ______________
Display Point DP11	**DP11**	= ______________
Display Point DP12	**DP12**	= ______________

Display Point DP13	**DP13**	= ____________
Display Point DP14	**DP14**	= ____________
Display Point DP15	**DP15**	= ____________
Display Point DP16	**DP16**	= ____________

Setting Group Selection Equations

See Table 7.4.

Select Setting Group 1	**SS1**	= ____________
Select Setting Group 2	**SS2**	= ____________
Select Setting Group 3	**SS3**	= ____________
Select Setting Group 4	**SS4**	= ____________
Select Setting Group 5	**SS5**	= ____________
Select Setting Group 6	**SS6**	= ____________

Other Equations

Event report trigger conditions (see *Section 12*)	**ER**	= ____________
Fault indication (see **A**, **B**, **C** target LED discussion at end of *Section 5*; used also to suspend demand metering updating and peak recording and block max./min. metering [see *Demand Metering on page 8.21* and *Maximum/Minimum Metering on page 8.29*])	**FAULT**	= ____________
Block synchronism-check elements (see *Figure 3.24*)	**BSYNCH**	= ____________
Close bus monitor (see *Figure 5.3*)	**CLMON**	= ____________
Breaker monitor initiation (see *Figure 8.3*)	**BKMON**	= ____________
Enable for zero-sequence voltage-polarized directional elements (see *Figure 4.6*)	**E32IV**	= ____________

MIRRORED BITS® Transmit Equations

(Only Available in Firmware Versions 1 and Higher) (See Appendix I: MIRRORED BITS)

Channel A, transmit bit 1	**TMB1A**	= ____________
Channel A, transmit bit 2	**TMB2A**	= ____________
Channel A, transmit bit 3	**TMB3A**	= ____________
Channel A, transmit bit 4	**TMB4A**	= ____________
Channel A, transmit bit 5	**TMB5A**	= ____________
Channel A, transmit bit 6	**TMB6A**	= ____________
Channel A, transmit bit 7	**TMB7A**	= ____________
Channel A, transmit bit 8	**TMB8A**	= ____________

Channel B, transmit bit 1	**TMB1B**	= ______________
Channel B, transmit bit 2	**TMB2B**	= ______________
Channel B, transmit bit 3	**TMB3B**	= ______________
Channel B, transmit bit 4	**TMB4B**	= ______________
Channel B, transmit bit 5	**TMB5B**	= ______________
Channel B, transmit bit 6	**TMB6B**	= ______________
Channel B, transmit bit 7	**TMB7B**	= ______________
Channel B, transmit bit 8	**TMB8B**	= ______________

Global Settings (Serial Port Command SET G and Front Panel)

Settings Group Change Delay

See Multiple Setting Groups on page 7.15.

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	= ______________

Power System Configuration and Date Format

See Settings Explanations on page 9.41.

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	= ______________
Phase rotation (ABC, ACB)	**PHROT**	= ______________
Date format (MDY, YMD)	**DATE_F**	= ______________

Front-Panel Display Time-Out

See Section 11: Additional Front-Panel Interface Details.

Front-panel display time-out (0.00–30.00 minutes in 1-minute steps)	**FP_TO**	= ______________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Event Report Parameters

See Section 12: Standard Event Reports and SER.

Length of event report (15, 30 cycles)	**LER**	= ______________
Length of pre-fault in event report (1 to LER-1 cycles in 1-cycle steps)	**PRE**	= ______________

Optoisolated Input Timers

See Figure 7.1.

Input IN101 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN101D**	= ______
Input IN102 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN102D**	= ______
Input IN103 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN103D**	= ______
Input IN104 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN104D**	= ______
Input IN105 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN105D**	= ______
Input IN106 debounce time (AC, 0.00–1.00 cycles in 0.25-cycle steps)	**IN106D**	= ______

Breaker Monitor Settings

See Breaker/Recloser Contact Wear Monitor on page 8.1.

Breaker monitor enable (Y, N)	**EBMON**	= ______

Make the following settings if preceding enable setting EBMON = Y.

Close/Open set point 1—max. (0–65000 operations)	**COSP1**	= ______
Close/Open set point 2—mid. (0–65000 operations)	**COSP2**	= ______
Close/Open set point 3—min. (0–65000 operations)	**COSP3**	= ______
kA Interrupted set point 1—min. (0.00–999.00 kA primary in 0.01 kA steps)	**KASP1**	= ______
kA Interrupted set point 2—mid. (0.00–999.00 kA primary in 0.01 kA steps)	**KASP2**	= ______
kA Interrupted set point 3—max. (0.00–999.00 kA primary in 0.01 kA steps)	**KASP3**	= ______

Trip Latch LEDs Settings

See Figure 1.51–Figure 1.54.

Trip latch LED11 (Y, N)	**LED11L**	= ______
Trip latch LED12 (Y, N)	**LED12L**	= ______
Trip latch LED13 (Y, N)	**LED13L**	= ______
Trip latch LED14 (Y, N)	**LED14L**	= ______
Trip latch LED15 (Y, N)	**LED15L**	= ______
Trip latch LED16 (Y, N)	**LED16L**	= ______
Trip latch LED17 (Y, N)	**LED17L**	= ______
Trip latch LED18 (Y, N)	**LED18L**	= ______

Trip latch LED19 (Y, N)	**LED19L**	= ____________
Trip latch LED20 (Y, N)	**LED20L**	= ____________
Trip latch LED24 (Y, N)	**LED24L**	= ____________
Trip latch LED25 (Y, N)	**LED25L**	= ____________
Reset trip-latched LEDs on close (Y, Y1, N, N1) The numeral “1” appended to settings options “Y1” and “N1” disables the embedded 3-second qualifying time delay on the LOCK operator control (the LOCK operator control effectively operates as the other operator controls, with no time delay).	**RSTLED**	= ____________

Other Global Settings

CLOSE operator control time delay (0–3600 cyc) (see *Figure 1.39*)	**PB8D**	= ____________
TRIP operator control time delay (0–3600 cyc) (see *Figure 1.40*)	**PB9D**	= ____________

Current and Voltage Connection Settings

See Current and Voltage Connection Settings on page 9.43

True three-phase voltage connected (Y, N) (see *Figure 4.1* and A, B, C target LED discussion at end of *Section 5*)	**3PVOLT**	= ____________
(Set the following PHANTV setting when preceding setting 3PVOLT = N)		
Phantom voltages from (VA,VB,VC,VAB,VBC,VCA,OFF)	**PHANTV**	= ____________
(Set the following VPCONN setting when preceding setting 3PVOLT = Y)		
V1, V2, V3 Voltage Terminal Connections (ABC, ACB, BAC, BCA, CAB, CBA)	**VPCONN**	= ____________
(Set the following VPCONN setting when preceding setting 3PVOLT = N or PHANTV = OFF)		
V1, V2, V3,Voltage Terminal Connections (A, B, C, AB, BC, CA, OFF)	**VPCONN**	= ____________
I1, I2, I3,Current Terminal Connections		
(ABC, ACB, BAC, BCA, CAB, CBA)	**IPCONN**	= ____________
Current Transformer Polarity (POS, NEG)	**CTPOL**	= ____________
# of EZ settings groups enabled (0–6) [see *SET EZ and SET FZ Commands (Change EZ Settings) on page 10.37*]	**EZGRPS**	= ____________

Battery and 12 V Power Settings

See Battery System Monitor on page 8.15.

Battery Amp-hours (6.5–20)	**AMPHR**	= ____________
Power-off Delay After AC Loss (OFF,1–1440 min)	**PWR_AC**	= ____________

Power-off Delay After Wake Up (OFF,1–1440 min) **PWR_WU** = ________________

Power-off Voltage Level 1 (19.2–24 Vdc) **V_LOW1** = ________________

Time and Date Management

Offset from UTC (–24.00 to 24.00 hours) **UTC_OFF** = ________________

Sequential Events Recorder and Load Profile Settings (Serial Port Command SET R)

See Sequential Events Recorder (SER) Report on page 12.16.

SER Chatter Criteria (settings enabled when ESERDL = Y)

Auto-Removal EN (Y, N) **ESERDL** = ________________

Number of Counts (2–100) **SRDLCT** = ________________

Removal Time (0.5–90.0 sec) **SRDLTM** = ________________

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by spaces or commas. Enter NA to remove a list of these Relay Word bit settings.

SER Trigger List 1
SER1 = ____

SER Trigger List 2
SER2 = ____

SER Trigger List 3
SER3 = ____

Load Profile settings are only available in firmware versions 1 and greater. See Load Profile Report on page 8.30.

Load profile list: (15 elements max., enter NA to null) **LDLIST** = ________________

Load profile acquisition rate (5,10,15,30,60 min) **LDAR** = ________________

LDLIST may contain any of the following elements
(delimit with spaces or commas):

Label	Quantity Recorded
IA, IB, IC, IN	Phase and neutral current magnitudes
VA, VB, VC	Phase and sync voltage magnitudes
VAB, VBC, VCA	Phase-to-phase voltage magnitudes
IG, I1, 3I2, 3V0, V1, V2	Sequence current and voltage magnitudes
FREQ	Phase frequency
MWA, MWB, MWC, MW3	Phase and 3-phase megawatts
MVARA, MVARB, MVARC, MVAR3	Phase and 3-phase megaVARs
PFA, PFB, PFC, PF3	Phase and 3-phase power factor
LDPFA, LDPFB, LDPFC, LDPF3	Phase and 3-phase power factor lead/lag status (0 = lag, 1 = lead)

Label	Quantity Recorded
IADEM, IBDEM, ICDEM, INDEM, IGDEM, 3I2DEM	Demand ammeter quantities
MWADI, MWBDI, MWCDI, MW3DI	Phase and 3-phase demand megawatts in
MWADO, MWBDO, MWCDO, MW3DO	Phase and 3-phase demand megawatts out
MVRADI, MVRBDI, MVRCDI, MVR3DI	Phase and 3-phase demand megaVARs in
MVRADO, MVRBDO, MVRCDO, MVR3DO	Phase and 3-phase demand megaVARs out
MWHAI, MWHBI, MWHCI, MWH3I	Phase and 3-phase megawatt-hours in
MWHAO, MWHBO, MWHCO, MWH3O	Phase and 3-phase megawatt-hours out
MVRHAI, MVRHBI, MVRHCI, MVRH3I	Phase and 3-phase megaVAR hours in
MVRHAO, MVRHBO, MVRHCO, MVRH3O	Phase and 3-phase megaVAR hours out

Text Label Settings (Serial Port Command SET T)

Enter the following characters: 0–9, A–Z, #, &, @, -, /, ., space for each text label setting, subject to the specified character limit. Enter NA to null a label.

Local Bit Labels

See Table 7.1 and Table 7.2.

Local Bit LB1 Name (14 characters)	**NLB1**	= ____________
Clear Local Bit LB1 Label (7 characters)	**CLB1**	= ____________
Set Local Bit LB1 Label (7 characters)	**SLB1**	= ____________
Pulse Local Bit LB1 Label (7 characters)	**PLB1**	= ____________
Local Bit LB2 Name (14 characters)	**NLB2**	= ____________
Clear Local Bit LB2 Label (7 characters)	**CLB2**	= ____________
Set Local Bit LB2 Label (7 characters)	**SLB2**	= ____________
Pulse Local Bit LB2 Label (7 characters)	**PLB2**	= ____________
Local Bit LB3 Name (14 characters)	**NLB3**	= ____________
Clear Local Bit LB3 Label (7 characters)	**CLB3**	= ____________
Set Local Bit LB3 Label (7 characters)	**SLB3**	= ____________
Pulse Local Bit LB3 Label (7 characters)	**PLB3**	= ____________
Local Bit LB4 Name (14 characters)	**NLB4**	= ____________
Clear Local Bit LB4 Label (7 characters)	**CLB4**	= ____________
Set Local Bit LB4 Label (7 characters)	**SLB4**	= ____________
Pulse Local Bit LB4 Label (7 characters)	**PLB4**	= ____________
Local Bit LB5 Name (14 characters)	**NLB5**	= ____________
Clear Local Bit LB5 Label (7 characters)	**CLB5**	= ____________
Set Local Bit LB5 Label (7 characters)	**SLB5**	= ____________

Pulse Local Bit LB5 Label (7 characters)	**PLB5**	=
Local Bit LB6 Name (14 characters)	**NLB6**	=
Clear Local Bit LB6 Label (7 characters)	**CLB6**	=
Set Local Bit LB6 Label (7 characters)	**SLB6**	=
Pulse Local Bit LB6 Label (7 characters)	**PLB6**	=
Local Bit LB7 Name (14 characters)	**NLB7**	=
Clear Local Bit LB7 Label (7 characters)	**CLB7**	=
Set Local Bit LB7 Label (7 characters)	**SLB7**	=
Pulse Local Bit LB7 Label (7 characters)	**PLB7**	=
Local Bit LB8 Name (14 characters)	**NLB8**	=
Clear Local Bit LB8 Label (7 characters)	**CLB8**	=
Set Local Bit LB8 Label (7 characters)	**SLB8**	=
Pulse Local Bit LB8 Label (7 characters)	**PLB8**	=
Local Bit LB9 Name (14 characters)	**NLB9**	=
Clear Local Bit LB9 Label (7 characters)	**CLB9**	=
Set Local Bit LB9 Label (7 characters)	**SLB9**	=
Pulse Local Bit LB9 Label (7 characters)	**PLB9**	=
Local Bit LB10 Name (14 characters)	**NLB10**	=
Clear Local Bit LB10 Label (7 characters)	**CLB10**	=
Set Local Bit LB10 Label (7 characters)	**SLB10**	=
Pulse Local Bit LB10 Label (7 characters)	**PLB10**	=
Local Bit LB11 Name (14 characters)	**NLB11**	=
Clear Local Bit LB11 Label (7 characters)	**CLB11**	=
Set Local Bit LB11 Label (7 characters)	**SLB11**	=
Pulse Local Bit LB11 Label (7 characters)	**PLB11**	=
Local Bit LB12 Name (14 characters)	**NLB12**	=
Clear Local Bit LB12 Label (7 characters)	**CLB12**	=
Set Local Bit LB12 Label (7 characters)	**SLB12**	=
Pulse Local Bit LB12 Label (7 characters)	**PLB12**	=
Local Bit LB13 Name (14 characters)	**NLB13**	=
Clear Local Bit LB13 Label (7 characters)	**CLB13**	=
Set Local Bit LB13 Label (7 characters)	**SLB13**	=

Pulse Local Bit LB13 Label (7 characters)	**PLB13**	= ______________
Local Bit LB14 Name (14 characters)	**NLB14**	= ______________
Clear Local Bit LB14 Label (7 characters)	**CLB14**	= ______________
Set Local Bit LB14 Label (7 characters)	**SLB14**	= ______________
Pulse Local Bit LB14 Label (7 characters)	**PLB14**	= ______________
Local Bit LB15 Name (14 characters)	**NLB15**	= ______________
Clear Local Bit LB15 Label (7 characters)	**CLB15**	= ______________
Set Local Bit LB15 Label (7 characters)	**SLB15**	= ______________
Pulse Local Bit LB15 Label (7 characters)	**PLB15**	= ______________
Local Bit LB16 Name (14 characters)	**NLB16**	= ______________
Clear Local Bit LB16 Label (7 characters)	**CLB16**	= ______________
Set Local Bit LB16 Label (7 characters)	**SLB16**	= ______________
Pulse Local Bit LB16 Label (7 characters)	**PLB16**	= ______________

Display Point Labels

See Rotating Default Display on page 7.29 and Rotating Default Display on page 11.6.

Display if DP1 = logical 1 (16 characters)	**DP1_1**	= ______________
Display if DP1 = logical 0 (16 characters)	**DP1_0**	= ______________
Display if DP2 = logical 1 (16 characters)	**DP2_1**	= ______________
Display if DP2 = logical 0 (16 characters)	**DP2_0**	= ______________
Display if DP3 = logical 1 (16 characters)	**DP3_1**	= ______________
Display if DP3 = logical 0 (16 characters)	**DP3_0**	= ______________
Display if DP4 = logical 1 (16 characters)	**DP4_1**	= ______________
Display if DP4 = logical 0 (16 characters)	**DP4_0**	= ______________
Display if DP5 = logical 1 (16 characters)	**DP5_1**	= ______________
Display if DP5 = logical 0 (16 characters)	**DP5_0**	= ______________
Display if DP6 = logical 1 (16 characters)	**DP6_1**	= ______________
Display if DP6 = logical 0 (16 characters)	**DP6_0**	= ______________
Display if DP7 = logical 1 (16 characters)	**DP7_1**	= ______________
Display if DP7 = logical 0 (16 characters)	**DP7_0**	= ______________
Display if DP8 = logical 1 (16 characters)	**DP8_1**	= ______________
Display if DP8 = logical 0 (16 characters)	**DP8_0**	= ______________
Display if DP9 = logical 1 (16 characters)	**DP9_1**	= ______________

Display if DP9 = logical 0 (16 characters)	**DP9_0**	= ______________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	= ______________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	= ______________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	= ______________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	= ______________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	= ______________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	= ______________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	= ______________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	= ______________
Display if DP14 = logical 1 (16 characters)	**DP14_1**	= ______________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	= ______________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	= ______________
Display if DP15 = logical 0 (16 characters)	**DP15_0**	= ______________
Display if DP16 = logical 1 (16 characters)	**DP16_1**	= ______________
Display if DP16 = logical 0 (16 characters)	**DP16_0**	= ______________

Reclosing Relay Labels

See Functions Unique to the Front-Panel Interface on page 11.1.

Reclosing Relay Last Shot Label (14 char.)	**79LL**	= ______________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	= ______________

Port Settings (Serial Port Command SET P and Front Panel)

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, DNPE, MBA, MBB, MB8A, MB8B)	**PROTO**	= ______________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP or DNPE. Refer to Appendix H for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to Appendix I for details on MIRRORED BITS.

The following three settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &)	**PREFIX**	= ______________
LMD Address (01–99)	**ADDR**	= ______________
LMD Settling Time (0–30 seconds)	**SETTLE**	= ______________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	**SPEED**	= ___________
Data Bits (6, 7, 8)	**BITS**	= ___________
Parity (O, E, N) Odd, Even, None	**PARITY**	= ___________
Stop Bits (1, 2)	**STOP**	= ___________

Other Port Settings

Time-out (0–30 minutes)	**T_OUT**	= ___________
Send Auto Messages to Port (Y, N)	**AUTO**	= ___________
Enable Hardware Handshaking (Y, N)	**RTSCTS**	= ___________
Fast Operate Enable (Y, N)	**FASTOP**	= ___________

Other Port Settings Set T_OUT to the number of minutes of serial port inactivity for an automatic log out. Set T_OUT = 0 for no port time out.

Set AUTO = Y to allow automatic messages at the serial port. Set AUTO = DTA to use the serial port with an SEL-DTA2 Display/Transducer Adapter.

Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the recloser control will not send characters until the CTS input is asserted. Also, if the control is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to SERIAL PORT 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.

Set FASTOP = Y to enable binary Fast Operate messages at the serial port. Set FASTOP = N to block binary Fast Operate messages. Refer to *Appendix D* for the description of the SEL-351R Recloser Control Fast Operate commands.

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Section 10

Serial Port Communications and Commands

Overview

The SEL-351R Recloser Control comes equipped with three EIA-232 serial ports and an optional EIA-485 4-wire serial port, if ordered. **SERIAL PORT 1** (EIA-485, 4-wire), **SERIAL PORT 2** (EIA-232), and **SERIAL PORT 3** (EIA-232) are located on the side panel of the recloser controller. **SERIAL PORT F** (EIA-232) is located on the front panel.

Connect any of the SEL-351R serial ports to a computer serial port for local communication or to a modem for remote communication. Other devices useful for communications include the SEL-PRTU Port Switch and the SEL-2032, SEL-2030, and SEL-2020 Communications Processors. You can use a variety of terminal emulation programs on your personal computer to communicate with the SEL-351R.

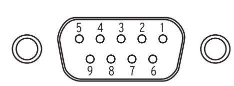
Typically, VT-100 terminal emulation provides the best display.

Serial Port Default Settings (for All Ports)

- Baud Rate = 2400
- Data Bits = 8
- Parity = N
- Stop Bits = 1
- RTS/CTS = N

To change the port settings, use the Access Level 2 **SET P** command (see *Section 9: Setting the SEL-351R Recloser Control*) or the front-panel **SET** pushbutton.

Port Connector and Communications Cables



Female chassis connector, as viewed from outside panel.

Figure 10.1 DB-9 Connector Pinout for EIA-232 Serial Ports

IRIG-B Time Code

Table 10.1 shows that you can input demodulated IRIG-B time synchronization code into SEL-351R **SERIAL PORT 2** to synchronize the recloser control's built-in clock to a synchronized master clock. This is handled adeptly by connecting **SERIAL PORT 2** of the SEL-351R to an

SEL communications processor with Cable C273A (see cable diagrams that follow in this section). The SEL communications processor distributes demodulated IRIG-B time code through all of its rear EIA-232 serial ports.

Demodulated IRIG-B time code can also be input into the **SERIAL PORT 1** compression connector. If demodulated IRIG-B time code is input into this connector, it should not be input into **SERIAL PORT 2** and vice versa.

Table 10.1 Pinout Functions for EIA-232 Serial Ports 2, 3, and F

Pin	Port 2	Port 3	Port F
1	N/C or +5 Vdc[a]	N/C or +5 Vdc[a]	N/C
2	RXD	RXD	RXD
3	TXD	TXD	TXD
4	+IRIG-B	N/C	N/C
5	GND	GND	GND
6	–IRIG-B	N/C	N/C
7	RTS	RTS	RTS
8	CTS	CTS	CTS
9	GND	GND	GND

[a] See Table 2.6 and Section 2: Communications in the SEL-351R-4 Quick-Start Installation and User's Guide.

Table 10.2 Terminal Functions for EIA-485 Serial Port 1 (Optional)

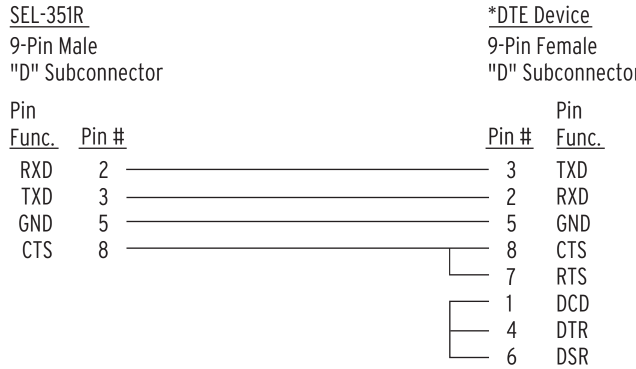
Terminal	Function
1	+TX
2	–TX
3	+RX
4	–RX
5	SHIELD
6	N/C
7	+IRIG-B
8	–IRIG-B

The following cable diagrams show several types of EIA-232 serial communications cables that you can use to connect the SEL-351R to other devices. The male/female references in the cable diagrams refer to the cable connectors, not the device they are connected to (which would be the opposite gender). These and other cables are available from SEL.

Permanently connected metallic communication cables should be restricted to use inside a substation control house to reduce the hazards of ground potential rise. SEL recommends that the metallic cable length be limited to 100 feet or less. If your devices require more than 100 feet of cable, you should use fiber-optic cable and transceivers to provide complete electrical isolation and electrical noise immunity. Contact the factory if you need more information, or refer to the SEL-5801 Cable Selector program.

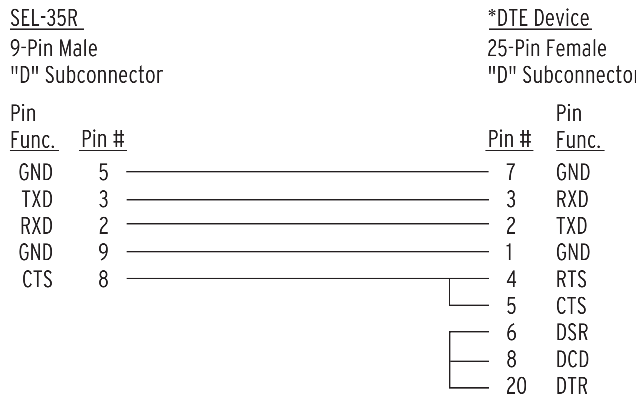
SEL-351R Recloser Control to Computer

Cable SEL-C234A



*DTE = Data Terminal Equipment (Computer, Terminal, etc.)

Cable SEL-C227A



*DTE = Data Terminal Equipment (Computer, Terminal, etc.)

SEL-351R Recloser Control to Modem

Cable SEL-C222 (externally powered modem)

SEL-351R 9-Pin Male "D" Subconnector Pin Func.	Pin #		**DCE Device 25-Pin Female "D" Subconnector Pin #	Pin Func.
GND	5	—	7	GND
TXD	3	—	2	TXD (IN)
RTS	7	—	20	DTR (IN)
RXD	2	—	3	RXD (OUT)
CTS	8	—	8	CD (OUT)
GND	9	—	1	GND

**DCE = Data Communications Equipment (Modem, etc.)

Cable SEL-C220 (modem powered from Pin 1 [5 Vdc]①)

SEL-351R 9-Pin Male "D" Subconnector Pin Func.	Pin #		**DCE Device 25-Pin Female "D" Subconnector Pin #	Pin Func.
GND	5	—	7	GND
TXD	3	—	2	TXD (IN)
RTS	7	—	20	DTR (IN)
RXD	2	—	3	RXD (OUT)
CTS	8	—	8	CD (OUT)
+5 VDC	1	—	10	10 PWR (IN)
GND	9	—	1	GND

① See Table 2.6 for jumper information.

SEL-351R Recloser Control to SEL-PRTU

Cable SEL-C231

SEL-PRTU 9-Pin Male Round Conxall Pin Func.	Pin #		SEL-351R 9-Pin Male "D" Subconnector Pin #	Pin Func.
GND	1	—	5	GND
TXD	2	—	2	RXD
RXD	4	—	3	TXD
CTS	5	—	7	RTS
+12	7	—	8	CTS
GND	9	—	9	GND

SEL-351R Recloser Control to SEL-2032, SEL-2030, SEL-2020, or SEL-2100

Cable SEL-C273A

SEL Communications Processors and SEL-2100 9-Pin Male "D" Subconnector Pin Func.	Pin #		SEL-351R 9-Pin Male "D" Subconnector Pin #	Pin Func.
RXD	2	—	3	TXD
TXD	3	—	2	RXD
IRIG+	4	—	4	IRIG+
GND	5	—	5	GND
IRIG–	6	—	6	IRIG–
RTS	7	—	8	CTS
CTS	8	—	7	RTS

SEL-351R Recloser Control to SEL-DTA2

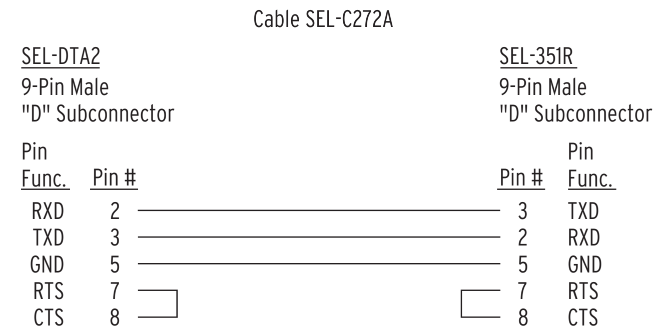


Table 10.3 Serial Communications Port Pin/Terminal Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc (0.5 A limit)	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Shielded Ground
RTS	Request To Send
CTS	Clear To Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

Communications Protocol

Hardware Protocol

All EIA-232 serial ports on the SEL-351R support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 **SERIAL PORT 1** (Optional).

To enable hardware handshaking, use the **SET P** command (or front-panel **SET** pushbutton) to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS = N.

If RTSCTS = N, the SEL-351R permanently asserts the RTS line.

If RTSCTS = Y, the SEL-351R deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the SEL-351R does not send characters until the CTS input is asserted.

Software Protocols

The SEL-351R provides standard SEL protocols: SEL ASCII, SEL Distributed Port Switch Protocol (LMD), SEL Fast Meter, SEL Fast SER Protocol, and SEL Compressed ASCII. In addition, you can order the SEL-351R with Distributed Network Protocol (DNP3) as an option. The SEL-351R activates protocols on a per-port basis.

To select SEL ASCII protocol, use the Access Level 2 **SET P** command to set the port PROTO setting to SEL. To select SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. To select DNP protocol, set PROTO = DNP.

SEL Fast Meter and SEL Compressed ASCII commands are active when PROTO is set to either SEL or LMD. The commands are not active when PROTO is set to DNP.

SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

NOTE: The Enter key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the Enter key after commands, which should send the proper ASCII code to the recloser control.

1. All commands received by the control must be of the form:

   <command><CR> or <command><CRLF>

   A command transmitted to the control should consist of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You may truncate commands to the first three characters. For example, **EVENT 1 <Enter>** would become **EVE 1 <Enter>**. Upper- and lowercase characters may be used without distinction, except in passwords.

2. The SEL-351R serial port transmits all messages in the following format:

   <STX><MESSAGE LINE 1><CRLF>

   <MESSAGE LINE 2><CRLF>

   •

   •

   •

   <LAST MESSAGE LINE><CRLF>< ETX>

   Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

3. The control implements XON/XOFF flow control.

   The serial port transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking enabled) when the serial port input buffer drops below 25 percent full.

   The serial port transmits XOFF (ASCII hex 13) when the buffer is over 75 percent full. If hardware handshaking is enabled, the serial port deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the serial port sends XON.

4. You can use the XON/XOFF protocol to control the SEL-351R during data transmission. When the serial port receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the serial port receives XOFF, it blocks transmission of any message

presented to its buffer. Messages will be accepted after the serial port receives XON.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

Control characters can be sent from most keyboards with the following keystrokes:

XON:	**<Ctrl + Q>**	(hold down the Control key and press Q)
XOFF:	**<Ctrl + S>**	(hold down the Control key and press S)
CAN:	**<Ctrl + X>**	(hold down the Control key and press X)

SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL devices to share a common communications channel. You select this protocol with the Access Level 2 **SET P** command by setting PROTO = LMD. See *Appendix C: SEL Distributed Port Switch Protocol* for more information on SEL Distributed Port Switch Protocol (LMD).

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. The protocol is described in *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*. There are no settings required to implement or control this protocol. It is available on any SEL-351R port that is set for SEL or LMD protocol.

SEL Fast SER Protocol

SEL Fast Sequential Events Recorder (SER) Protocol, also known as SEL Unsolicited Sequential Events Recorder, provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any serial port. The protocol is described in *Appendix K: Fast SER Protocol*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the recloser control ASCII commands. The protocol is described in *Appendix E: Compressed ASCII Commands*. There are no settings required to implement or control this protocol. It is available on any SEL-351R port that is set for SEL or LMD protocol.

Distributed Network Protocol (DNP3)

The control provides Distributed Network Protocol (DNP3), Level 2 outstation support. DNP is described in *Appendix H: Distributed Network Protocol*.

Mirrored Bits Communications

The SEL-351R supports Mirrored Bits® relay-to-relay communications on two ports simultaneously (see *Appendix I: Mirrored Bits*).

Serial Port Automatic Messages

When the serial port AUTO setting is Y, the recloser control sends automatic messages to indicate specific conditions. The automatic messages are described in *Table 10.4*.

When the serial port AUTO setting is DTA, the SEL-351R is compatible with the SEL-DTA2 on that port. The **MET** and **MET D** command responses are modified to comply with the DTA2 data format for that port.

Table 10.4 Serial Port Automatic Messages

Condition	Description
Power Up	The control sends a message containing the present date and time, Recloser and Terminal Identifiers, and the Access Level 0 prompt (=) when the control is turned on.
Event Trigger	The control sends an event summary each time an event report is triggered. See *Section 12: Standard Event Reports and SER*.
Group Switch	The control displays the active settings group after a group switch occurs. See *GRO n Command (Change Active Setting Group) on page 10.40*.
Self-Test Warning or Failure	The control sends a status report each time a self-test warning or failure condition is detected. See *STA Command (Recloser Control Self-Test Status) on page 10.31*.

Serial Port Access Levels

You can issue commands to the SEL-351R via the serial communication ports to view metering values, change control settings, etc. The available serial port commands are listed in *Table 10.5*. A summary of commands is also included at the end of this section of the instruction manual. The commands can be accessed only from the corresponding access level as shown in *Table 10.5*. The access levels are:

- Access Level 0 (the lowest access level)
- Access Level 1 (interrogation only level)
- Access Level E (EZ settings level)
- Access Level B (Breaker/recloser control level)
- Access Level 2 (the highest access level)
- Access Level C (restricted access level, should be used under direction of SEL only)

Access Level 0

After serial port communication is established with the control, the control sends the following prompt:

```
=
```

This is referred to as Access Level 0. From Access Level 0, you can go to Access Level 1 by sending the **ACC** command (see *Table 10.5*), or to Access Level E (EZ) by sending the **EZA** command. Enter the **ACC** or the **EZA** command at the Access Level 0 prompt:

=**ACC <Enter>**

or

=**EZA <Enter>**

If passwords are enabled, the SEL-351R prompts you for the Level 1 or Level E passwords, respectively.

Access Level 1

When the recloser control is in Access Level 1, the control sends the following prompt:

```
=>
```

Commands **2AC**–**TRI** in *Table 10.5* are available from Access Level 1. For example, enter the **MET** command at the Access Level 1 prompt to view metering data:

=>**MET <Enter>**

From Access Level 1, you can access other access levels, such as Access Level E, Access Level 2, and Access Level B. If passwords are enabled, you must enter passwords to reach these other access levels.

The **EZA** (EZAccess) command allows the control to go to Access Level E [see *ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C) on page 10.13* for more detail]. Enter the **EZA** command at the Access Level 1 prompt:

=>**EZA <Enter>**

The **2AC** command allows the control to go to Access Level 2 [see *ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C) on page 10.13* for more detail]. Enter the **2AC** command at the Access Level 1 prompt:

=>**2AC <Enter>**

The **BAC** command allows the control to go to Access Level B [see *ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C)* for more detail]. Enter the **BAC** command at the Access Level 1 prompt:

=>**BAC <Enter>**

When you are in Access Level E, B, or 2, you can return to Access Level 1 by sending the **ACC** command. The control does not prompt you for the Level 1 password because you have already accessed a higher level with passwords.

Access Level E (EZ)

When the SEL-351R is in Access Level E, the control sends the prompt:

```
=+>
```

Commands **BTT–SET FZ** in *Table 10.5* are available from Access Level E. Access Level E is intended to allow operators, testing, and protection personnel to make EZ level setting changes and check and test the battery system. For example, enter the **SET EZ** command at the Access Level E prompt to set the EZ Level settings:

=+>**SET EZ <Enter>**

While you are in Access Level E, any of the Access Level 1 commands are also available (commands **2AC–TRI** in *Table 10.5*).

Access Level B

When the SEL-351R is in Access Level B, the control sends the prompt:

```
==>
```

Commands **BRE *n*–PUL** in *Table 10.5* are available from Access Level B. Access Level B is intended to allow operators to perform control functions without being able to change settings. For example, enter the **CLO** command at the Access Level B prompt to close the recloser:

==>**CLO <Enter>**

While you are in Access Level B, any of the Access Level 1 and Access Level E commands are also available (commands **2AC–SET FZ** in *Table 10.5*).

Access Level 2

When the control is in Access Level 2, the recloser control sends the prompt:

```
=>>
```

Commands **CON–SET** in *Table 10.5* are available from Access Level 2. Access Level 2 is intended to allow protection and testing personnel to make higher level setting and logic changes. For example, enter the **SET** command at the Access Level 2 prompt to make control settings:

=>>**SET <Enter>**

While you are in Access Level 2, any of the Access Level 1, Access Level E, and Access Level B commands are also available (commands **2AC–PUL** in *Table 10.5*).

Access Level C

The CAL access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request. Do not enter the CAL access level except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C (see *ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C) on page 10.13* for more detail). Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

Command Summary

Table 10.5 alphabetically lists the serial port commands within a given access level. Much of the information available from the serial port commands is also available via the front-panel pushbuttons. The correspondence between the serial port commands and the front-panel pushbuttons is also given in *Table 10.5*. See *Section 11: Additional Front-Panel Interface Details* for more information on the front-panel pushbuttons.

The serial port commands at the different access levels offer varying levels of control:

- The Access Level 1 commands primarily allow you to look at information only (settings, metering, etc.), not change it.
- The Access Level E (EZ) commands allow you to check and test the battery and change recloser control EZ settings.
- The Access Level B commands primarily allow the user to open and close the recloser, operate output contacts, or change the active setting group.
- The Access Level 2 commands primarily allow the user to change control settings and logic.
- The Access Level C commands are restricted and should be used under the direction of SEL only.

Again, a higher access level can access the serial port commands in a lower access level. The commands are shown in uppercase letters, but you can also enter them with lowercase letters.

Table 10.5 Serial Port Command Summary (Sheet 1 of 2)

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
0	=	**ACC**	Go to Access Level 1	
0	=	**EZA**	Go to Access Level E (EZ)	
1	=>	**BAC**	Go to Access Level B	
1	=>	**2AC**	Go to Access Level 2	
1	=>	**BRE**	Breaker monitor data	
1	=>	**BRE A**	Breaker monitor data, including per-phase trip operation counters	OTHER
1	=>	**COM**	MIRRORED BITS communications statistics	
1	=>	**COU**	Display SELOGIC® counter values	
1	=>	**DAT**	View/change date	OTHER
1	=>	**DNP**[a] ***type***	Show DNP map	
1	=>	**EVE**	Event reports	
1	=>	**EZA**	Go to Access Level E (EZ)	
1	=>	**GRO**	Display active setting group number	GROUP
1	=>	**HIS**	Event summaries/histories	EVENTS
1	=>	**IRI**	Synchronize to IRIG-B	
1	=>	**LDP**	Load profile report	
1	=>	**MET**	Metering data	METER

Table 10.5 Serial Port Command Summary (Sheet 2 of 2)

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**QUI**	Quit access level	
1	=>	**SER**	Sequential Events Report	
1	=>	**SHO**	Show/view settings	SET
1	=>	**STA**	Recloser control self-test status	STATUS
1	=>	**TAR**	Display recloser control element status	OTHER
1	=>	**TIM**	View/change time	OTHER
1	=>	**TRI**	Trigger an event report	
E	=+>	**BTT**	Display latest battery discharge test results and time remaining until next discharge test	
E	=+>	**BTT NOW**	Force battery discharge test	OTHER
E	=+>	**SET EZ**	Change EZ group settings	SET
E	=+>	**SET FZ**	Change EZ global settings	SET
B	==>	**BRE *n***	Preload/reset breaker/recloser wear and trip operation counters	OTHER
B	==>	**CLO**	Close breaker/recloser	CLOSE
B	==>	**GRO *n***	Change active setting group	GROUP
B	==>	**OPE**	Open breaker/recloser	TRIP
B	==>	**PUL**	Pulse output contact	CNTRL
2	=>>	**CAL**	Go to Access Level C	
2	=>>	**CON**	Control remote bit	
2	=>>	**COP**	Copy setting group	
2	=>>	**DNP**[a] ***type***	Set DNP map	
2	=>>	**LOO**	MIRRORED BITS loopback	
2	=>>	**PAS 1**	Change Access Level 1 password	SET
2	=>>	**PAS E**	Change Access Level E password	SET
2	=>>	**PAS B**	Change Access Level B password	SET
2	=>>	**PAS 2**	Change Access Level 2 password	SET
2	=>>	**PAS C**	Change Access Level C password	SET
2	=>>	**SET**	Change group settings	SET
2	=>>	**SET L**	Change logic settings	
2	=>>	**SET G**	Change global settings	SET
2	=>>	**SET R**	Change sequence of event triggering settings	
2	=>>	**SET P**	Change serial port settings	SET
2	=>>	**SET T**	Change text label settings	
2	=>>	**STA C**	Clear Status Report	
2	=>>	**VER**	Show version information	

[a] The **DNP** command is only available when the protocol of one of the serial ports is set to DNP. See Point Remapping on page H.16 for examples of the **DNP** command format.

The recloser control responds with `Invalid Access Level` if a command is entered from an access level lower than the specified access level for the command. If the command you entered does not match any of the commands in the SEL-351R command set shown in *Table 10.5*, the control responds:

```
Invalid Command
```

Many of the command responses display the following header at the beginning:

```
RECLOSER R1                         Date: 03/05/12 Time: 17:03:26.484
FEEDER 2101
```

The definitions are:

Control Response	Definition
`RECLOSER R1:`	This is the Recloser ID, RID, setting (the control is shipped with the default setting RID = RECLOSER R1; see *Identifier Labels on page 9.41*).
`FEEDER 2101:`	This is the Terminal ID, TID, setting (the control is shipped with the default setting TID = FEEDER 2101; see *Identifier Labels on page 9.41*).
`Date:`	This is the date the command response was given [except for recloser control response to the **EVE** command (Event), where it is the date the event occurred]. You can modify the date display format (Month/Day/Year or Year/Month/Day) by changing the DATE_F recloser control setting with the **SET G** command.
`Time:`	This is the time the command response was given (except for control response to the **EVE** command, where it is the time the event occurred).

The serial port command explanations that follow in the *Command Explanations on page 10.13* are in the same order as the commands listed in *Table 10.5*.

Command Explanations

Access Level 0 Commands

ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C)

The **ACC**, **EZA**, **BAC**, **2AC**, and **CAL** commands provide entry to the multiple access levels. Different commands are available at the different access levels as shown in *Table 10.5*. Commands **ACC**, **EZA**, **BAC**, **2AC**, and **CAL** are explained together because they operate similarly.

- **ACC** moves from Access Level 0, E, 2, or B to Access Level 1.
- **EZA** moves from Access Level 0, 1, 2, or B to Access Level E (EZ).
- **BAC** moves from Access Level 1, 2, or E to Access Level B.
- **2AC** moves from Access Level 1, E, or B to Access Level 2.
- **CAL** moves from Access Level 2 to Access Level C.

Password Requirements and Default Passwords

Passwords are required if the main board Password jumper is not in place (Password jumper = OFF). Passwords are not required if the main board Password jumper is in place (Password jumper = ON). Refer to *Table 2.4* and *Table 2.5* for Password jumper information. See *PAS Command (Change Passwords) on page 10.42* for the list of default passwords and for more information on changing passwords.

Access Level Attempt (Password Required)

Assume the following conditions:

- Password jumper = OFF (not in place)
- Access Level = 0

At the Access Level 0 prompt, enter the **ACC** command:

=**ACC <Enter>**

Because the Password jumper is not in place, the control asks for the Access Level 1 password to be entered:

```
Password: ?
```

The control is shipped with the default Access Level 1 password shown in the table under the *PAS Command (Change Passwords)*. At the above prompt enter the default password and press the **<Enter>** key.

The control responds:

```
RECLOSER R1                              Date: 03/05/12 Time: 08:31:10.361
FEEDER 2101


Level 1
=>
```

The => prompt indicates the control is now in Access Level 1.

If the entered password is incorrect, the control asks for the password again `Password: ?`. The control will ask up to three times. If the requested password is incorrectly entered three times, the control pulses the **ALARM** contact for one second and remains at Access Level 0 (= prompt).

Access Level Attempt (Password Not Required)

Assume the following conditions:

- Password jumper = ON (in place)
- Access Level = 0

At the Access Level 0 prompt, enter the **ACC** command:

=**ACC <Enter>**

Because the Password jumper is in place, the control does not ask for a password; it goes directly to Access Level 1. The SEL-351R responds:

```
RECLOSER R1                              Date: 03/05/12 Time: 08:31:10.361
FEEDER 2101


Level 1
=>
```

The => prompt indicates the control is now in Access Level 1.

The above two examples demonstrate how to go from Access Level 0 to Access Level 1. The procedure to go from Access Level 0 to Access Level E, Access Level 1 to Access Level B, Access Level 1 to Access Level 2, or Access Level B to Access Level 2 is similar, with command **EZA**, **BAC**, or **2AC** entered at the access level screen prompt. The recloser control pulses the ALARM contact for one second after a successful Level E, Level B, Level 2, or Level C access. If access is denied, the ALARM contact also pulses for one second. Passwords are not required to go from Level E, Level B, or Level 2 to Level 1. Passwords are also not required to go from Level 2 or Level B to Level E or Level 1.

Access Level 1 Commands

BRE and BRE A Commands (Breaker Monitor Data)

Use the **BRE** command to view the breaker /recloser contact wear monitor report.

```
=>BRE <Enter>

RECLOSER R1                                 Date: 02/02/12 Time: 08:40:14.802
FEEDER 2101

Ctrl Trips=      9
 IA=       40.7 IB=       41.4 IC=       53.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=   4 B=   4 C=   6

LAST RESET 12/27/11 15:32:59
=>
```

The **BRE A** command displays the same information as the **BRE** command, plus per-phase and ground trip operation counters.

```
=>BRE A <Enter>

RECLOSER R1                                Date: 02/02/12 Time: 08:40:28.529
FEEDER 2101

Ctrl Trips=      9
 IA=       40.7 IB=       41.4 IC=       53.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=   4 B=   4 C=   6

A-phase Trips=   6
B-phase Trips=   5
C-phase Trips=   8
EF/G Trips=      7
SEF Trips=       0

LAST RESET 12/27/11 15:32:59
=>
```

See *BRE W Command (Preload) on page 10.38* and *Breaker/Recloser Contact Wear Monitor on page 8.1* for further details on the breaker monitor.

COMM Command (Communication Data)

The **COMM** command displays integral relay-to-relay (MIRRORED BITS) communications data. For more information on MIRRORED BITS, see *Appendix I: MIRRORED BITS*. To view a summary report, enter the command with the channel parameter (A or B).

```
=>COMM A <Enter>

FEEDER 1                          Date: 04/20/12 Time: 18:36:11.748
STATION A

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Summary for Mirrored Bits channel A

For 04/20/12 18:36:09.279 to 04/20/12 18:36:11.746

    Total failures      1                   Last error  Relay Disabled
    Relay Disabled      1
    Data error          0                   Longest Failure     2.458 sec.
    Re-Sync             0
    Underrun            0                   Unavailability  0.996200
    Overrun             0
    Parity error        0
    Framing error       0                   Loopback     0
=>
```

If only one MIRRORED BITS port is enabled, the channel specifier may be omitted. Use the L parameter to get a summary report, followed by a listing of the COMM records.

```
=>COMM L <Enter>

FEEDER 1                          Date: 02/20/12    Time: 18:37:36.125
STATION A

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Summary for Mirrored Bits channel A

For 02/05/12 17:18:12.993 to 02/20/12 18:37:36.123

    Total failures      4                   Last error  Relay Disabled
    Relay Disabled      2
    Data error          0                   Longest Failure     2.835 sec.
    Re-Sync             0
    Underrun            1                   Unavailability  0.000003
    Overrun             0
    Parity error        1
    Framing error       0                   Loopback     0

    Failure                Recovery
#   Date     Time          Date     Time          Duration  Cause
1   02/20/12 18:36:09.279  02/20/12 18:37:36.114     2.835  Relay Disabled
2   02/14/12 13:18:09.236  02/14/12 13:18:09.736     0.499  Parity error
3   02/08/12 11:43:35.547  02/08/12 11:43:35.637     0.089  Underrun
4   02/05/12 17:18:12.993  02/05/12 17:18:13.115     0.121  Relay Disabled

=>
```

There may be up to 255 records in the extended report. To limit the number of COMM records displayed in the report to the 10 most recent records, type **COMM 10 L <Enter>**. To select lines 10–20 of the COMM records for display in the report, type **COMM 10 20 L <Enter>**. To reverse the order of the COMM records in the report, supply a range of row numbers, with the larger number first, i.e., **COMM 40 10 L <Enter>**. To display all the COMM records that started on a particular day, supply that date as a parameter, i.e., **COMM 2/8/12 L <Enter>**. To display all the COMM records that started between a range of dates, supply both dates as parameters, i.e., **COMM 2/21/12 2/7/12 L <Enter>**. Reversing the order of the dates will reverse the order of the records in the report. To receive a summary report for a subset of the records, use one of the above methods while omitting the L parameter.

To clear the COMM records, type **COMM C <Enter>**. The prompting message `Are you sure (Y/N) ?` is displayed. Typing **N <Enter>** aborts the clearing operation with the message `Canceled`. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the clear command will cause both channels to be cleared.

COU Command (Counter Variable Values)

The **COU** command displays the present values for the SELOGIC counter variables. To view the values, enter the command:

=>**COU *k* <Enter>**

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the counter display. If *k* is not specified, the counter values are displayed once.

```
=>COU <Enter>

RECLOSER R1                        Date: 02/15/12    Time: 12:21:48.226
FEEDER 2101

      SC1     SC2     SC3     SC4     SC5     SC6     SC7     SC8
       10       2       0    1335       0       0       0       0

=>
```

DAT Command (View/Change Date)

DAT displays the date stored by the internal calendar/clock. If the date format setting DATE_F is set to MDY, the date is displayed as month/day/year. If the date format setting DATE_F is set to YMD, the date is displayed as year/month/day.

To set the date, type **DATE mm/dd/yy <Enter>** if the DATE_F setting is MDY. If the DATE_F is set to YMD, enter **DATE yy/mm/dd <Enter>**. To set the date to June 1, 2012, enter:

```
=>DATE 6/1/12 <Enter>
6/1/12
```

You can separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons.

EVE Command (Event Reports)

Use the Event command, **EVE**, to view event reports. See *Section 12: Standard Event Reports and SER* for further details on retrieving event reports.

GRO Command (Display Active Setting Group Number)

Use the Group command, **GRO**, to display the active settings group number. See *GRO n Command (Change Active Setting Group) on page 10.40* and *Multiple Setting Groups on page 7.15* for further details on settings groups.

HIS Command (Event Summaries/History)

HIS *x* displays event summaries or allows you to clear event summaries (and corresponding event reports) from nonvolatile memory.

If no parameters are specified with the **HIS** command:

=> **HIS <Enter>**

the control displays the most recent event summaries in reverse chronological order.

If *x* is a number (1–28):

=> **HIS 6 <Enter>**

the control displays the *x* most recent event summaries. The maximum number of available event summaries is a function of the LER (length of event report) setting. The control saves up to twenty-eight 15-cycle event reports if setting LER = 15 and fourteen 30-cycle event reports if setting LER = 30.

If *x* is “C” or “c”, the recloser control clears the event summaries and all corresponding event reports from nonvolatile memory.

The event summaries include the date and time the event was triggered, the type of event, the fault location, the maximum phase current in the event, the power system frequency, the number of the active setting group, the reclose shot count, and the front-panel targets.

To display the recloser control event summaries, enter the following command:

```
=>HIS <Enter>
RECLOSER R1                          Date: 02/01/12    Time: 08:40:16.740
FEEDER 2101

#     DATE      TIME     EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS

1  02/01/12 08:33:00.365 TRIG  $$$$$$$     1 60.00  3    2  11000000 10000000
2  01/31/12 20:32:58.361 ER    $$$$$$$   231 60.00  2    2  11000000 10000000
3  01/29/12 07:30:11.055 AG T     9.65  2279 60.00  3    2  10001010 01010010

=>
```

The fault locator function influences information in the EVENT and LOCAT columns. If the fault locator is enabled (Access Level 2 **SET** command enable setting EFLOC = Y), the fault locator will attempt to run if the event report is generated by a trip (assertion of TRIP Relay Word bit) or other programmable event report trigger condition (Access Level 2 **SET L** SELOGIC control equation setting ER). The fault locator should not be enabled unless three-phase voltage is connected to the control.

If the fault locator runs successfully, the location is listed in the LOCAT column, and the event type is listed in the EVENT column:

Control Response	Description
AG	for A-phase to ground faults
BG	for B-phase to ground faults
CG	for C-phase to ground faults
AB	for A-B phase-to-phase faults
BC	for B-C phase-to-phase faults
CA	for C-A phase-to-phase faults
ABG	for A-B phase-to-phase to ground faults
BCG	for B-C phase-to-phase to ground faults
CAG	for C-A phase-to-phase to ground faults
ABC	for three-phase faults

If a trip occurs in the same event report, a T is appended to the event type (e.g., AG T).

If the fault locator does not run successfully, or if the fault locator is disabled (enable setting EFLOC = N), `$$$$$$$` is shown in the `LOCAT` column. In either case, the event type listed in the `EVENT` column is one of the following:

Control Response	Description
TRIP	event report generated by assertion of Relay Word bit TRIP
ER	event report generated by assertion of SELOGIC control equation event report trigger condition setting ER
PULSE	event report generated by execution of the **PUL** (Pulse) command
TRIG	event report generated by execution of the **TRI** (Trigger) command

The `TARGETS` column displays the front-panel LED status during the event in binary format. The top row of LEDs is shown first and the bottom row of LEDs is shown next under the `TARGETS` column. A `1` means the LED was illuminated during the event and a `0` means the LED was deasserted.

For example, `11001010 00001100` under the `TARGETS` column would be interpreted as follows (first three digits):

Control Response	Description
1	**CONTROL ENABLED** LED illuminated
1	**AC SUPPLY** LED illuminated
0	**BATTERY PROBLEM** LED not illuminated
•	•
•	•
•	•
0	**SEF** LED not illuminated

For more information on front-panel target LEDs, see *Front-Panel Status and Trip Target LEDS on page 1.56*. For more information on event reports, see *Section 12: Standard Event Reports and SER*.

IRI Command (Synchronize to IRIG-B Time Code)

IRI forces the SEL-351R to read the demodulated IRIG-B time code at the serial port input to force the control to synchronize to IRIG-B. Enter the following command:

=>**IRI <Enter>**

If the SEL-351R successfully synchronizes to IRIG, it sends the following header and access level prompt:

```
RECLOSER R1                         Date: 03/05/12    Time: 10:15:09.609
FEEDER 2101

=>
```

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the control responds:

```
IRIG-B DATA ERROR

=>
```

If an IRIG-B signal is present, the SEL-351R synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRI** command to synchronize the SEL-351R internal clock with IRIG-B. You can use the **IRI** command to determine if the SEL-351R is properly reading the IRIG-B signal.

LDP Command (Load Profile Report)

Use the **LDP** command to view the Load Profile Report. For more information on Load Profile Reports, see *Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions*.

MET Command (Metering Data)

The **MET** commands provide access to the control metering data. Metered quantities include phase voltages and currents, sequence component voltages and currents, power, frequency, energy, demand, and maximum/minimum logging of selected quantities. To make the extensive amount of meter information manageable, the recloser control divides the displayed information into four groups: Instantaneous, Demand, Energy, and Maximum/Minimum.

MET k—Instantaneous Metering

The **MET *k*** command displays instantaneous magnitudes (and angles if applicable) of the following quantities:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage (kV primary)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single- and three-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C,3P}$	Single- and three-phase power factor; leading or lagging
Sequence	I_1, $3I_2$, $3I_0$	Positive-, negative-, and zero-sequence currents (A primary)
	V_1, V_2	Positive- and negative-sequence voltages (kV primary)
	$3V_0$	Zero-sequence voltage (kV primary, wye-connected voltage inputs only)
Frequency	FREQ (Hz)	Instantaneous power system frequency (measured on voltage channel input V1)

The angles are referenced to the A-phase voltage if it is greater than 13 V secondary; otherwise, the angles are referenced to A-phase current. The angles range from –179.99 to 180.00 degrees. If phantom voltages are enabled through the **SET F** or **SET G** commands, the control measures only one voltage. In this case the control copies the measured amplitude to the remaining two voltages and rotates the phase angles to generate balanced voltages. If the phantom voltage selection is a phase-to-phase quantity, the control also scales the phase-to-ground quantities and rotates the phase angles appropriately.

To view instantaneous metering values, enter the command:

=>**MET k <Enter>**

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *k* is not specified, the meter report is displayed once. The output from an SEL-351R with three-phase wye-connected voltage inputs is shown:

```
=>MET <Enter>

RECLOSER R1                          Date: 02/01/12    Time: 15:00:52.615
FEEDER 2101
                 A         B         C         N         G
I MAG (A)      195.146   192.614   198.090     0.302     4.880
I ANG (DEG)     -8.03   -128.02    111.89     52.98     81.22

                 A         B         C         S
V MAG (KV)      11.691    11.686    11.669    11.695
V ANG (DEG)      0.00   -119.79    120.15      0.05

                 A         B         C         3P
MW               2.259     2.228     2.288     6.774
MVAR             0.319     0.322     0.332     0.123
PF               0.990     0.990     0.990     0.990
                 LAG       LAG       LAG       LAG

                 I1        3I2       3I0       V1        V2        3V0
MAG            195.283     4.630     4.880    11.682     0.007     0.056
ANG   (DEG)     -8.06   -103.93     81.22      0.12    -80.25    -65.83

FREQ (Hz)      60.00

=>
```

MET X k—Extended Instantaneous Metering

The **MET X *k*** command displays the same data as the **MET *k*** command with the addition of calculated phase-to-phase voltage quantities Vab, Vbc, and Vca.

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected phase-to-neutral voltage (kV primary)
	$V_{AB,BC,CA}$	Calculated phase-to-phase voltages (kV primary)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single- and three-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C,3P}$	Single- and three-phase power factor; leading or lagging
Sequence	I_1, $3I_2$, $3I_0$	Positive-, negative-, and zero-sequence currents (A primary)
	V_1, V_2	Positive- and negative-sequence voltages (kV primary)
	$3V_0$	Zero-sequence voltage (kV primary, wye-connected voltage inputs only)
Frequency	FREQ (Hz)	Instantaneous power system frequency (measured on voltage channel input **V1**)

The angles are referenced to the A-phase voltage if it is greater than 13 V secondary; otherwise, the angles are referenced to A-phase current. The angles range from –179.99 to 180.00 degrees.

To view instantaneous metering values, enter the command:

=>**MET X *k* <Enter>**

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *k* is not specified, the meter report is displayed once. The output from an SEL-351R is shown:

```
=>MET X <Enter>

FEEDER 12                           Date: 12/12/12    Time: 11:31:22.626
SUB B
                 A         B         C         N         G
I MAG (A)       30.302    36.558    29.254     7.454     7.526
I ANG (DEG)     -2.02   -121.88    119.60   -115.20   -117.52

                 A         B         C         S
V MAG (KV)      14.761    14.636    14.880    15.235
V ANG (DEG)      0.00   -119.95    120.94     29.93

                 AB        BC        CA
V MAG (KV)      25.452    25.448    25.790
V ANG (DEG)     29.98    -89.23    150.34

                 A         B         C         3P
MW               0.447     0.535     0.435     1.417
MVAR             0.016     0.018     0.010     0.044
PF               0.999     0.999     1.000     1.000
                 LAG       LAG       LAG       LAG

                 I1       3I2       3I0        V1        V2       3V0
MAG             32.036     6.196     7.526    14.759     0.131     0.212
ANG   (DEG)     -1.47    106.38   -117.52      0.33    -59.08    157.40

FREQ (Hz)      60.00

=>
```

MET D—Demand Metering

The **MET D** command displays the demand and peak demand values of the following quantities:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
	$3I_2$	Negative-sequence current (A primary)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Reset Time	Demand, Peak	Last time the demands and peak demands were reset

To view demand metering values, enter the command:

=>**MET D <Enter>**

The output from an SEL-351R with three-phase wye-connected voltage inputs is shown:

```
=>MET D <Enter>

RECLOSER R1                        Date: 02/01/12    Time: 15:08:05.615
FEEDER 2101
            IA        IB        IC        IN        IG        3I2
DEMAND     188.6     186.6     191.8       0.2       4.5       4.7
PEAK       188.6     186.6     191.8       0.3       4.5       4.7

              MWA      MWB      MWC      MW3P     MVARA    MVARB    MVARC    MVAR3P
DEMAND IN      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
PEAK IN        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
DEMAND OUT     2.2      2.2      2.2      6.6      0.3      0.3      0.3      0.9
PEAK OUT       3.1      3.1      3.1      9.3      0.4      0.4      0.4      1.2
LAST DEMAND RESET 01/27/12 15:31:51.238   LAST PEAK RESET 01/27/12 15:31:56.239

=>
```

Reset the accumulated demand values using the **MET RD** command. Reset the peak demand values using the **MET RP** command. For more information on demand metering, see *Demand Metering on page 8.21*.

MET E—Energy Metering

The **MET E** command displays the following quantities:

Energy	$MWh_{A,B,C}$	Single-phase megawatt hours (in and out; wye-connected voltage inputs only)
	MWh_{3P}	Three-phase megawatt hours (in and out)
	$MVARh_{A,B,C}$	Single-phase megawatt hours (in and out; wye-connected voltage inputs only)
	$MVARh_{3P}$	Three-phase megawatt hours (in and out)
Reset Time		Last time the energy meter was reset

To view energy metering values, enter the command:

=>**MET E <Enter>**

The output from an SEL-351R with three-phase wye-connected voltage inputs is shown:

```
=>MET E <Enter>

RECLOSER R1                        Date: 02/01/12    Time: 15:11:24.056
FEEDER 2101
         MWhA     MWhB     MWhC     MWh3P    MVARhA   MVARhB   MVARhC   MVARh3P
IN        0.0      0.0      0.0      0.0       0.0      0.0      0.0      0.0
OUT      36.0     36.6     36.7    109.2       5.1      5.2      5.3     15.6
LAST RESET 01/31/12 23:31:28.864

=>
```

Reset the energy values using the **MET RE** command. For more information on energy metering, see *Energy Metering on page 8.29*.

MET M—Maximum/Minimum Metering

The **MET M** command displays the maximum and minimum values of the following quantities:

Currents	$I_{A,B,C,N}$	Phase and neutral currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltages (kV primary)
Power	MW_{3P}	Three-phase megawatts
	$MVAR_{3P}$	Three-phase megavars
Reset Time		Last time the maximum/minimum meter was reset

To view maximum/minimum metering values, enter the command:

=>**MET M <Enter>**

The output from an SEL-351R with three-phase wye-connected voltage inputs is shown:

```
=>MET M <Enter>

RECLOSER R1                        Date: 02/01/12    Time: 15:16:00.239
FEEDER 2101
           Max    Date      Time             Min    Date      Time
IA(A)      196.8  02/01/12  15:00:42.574     30.0  02/01/12  14:51:02.391
IB(A)      195.0  02/01/12  15:05:19.558     31.8  02/01/12  14:50:55.536
IC(A)      200.4  02/01/12  15:00:42.578     52.2  02/01/12  14:51:02.332
IN(A)       42.6  02/01/12  14:51:02.328     42.6  02/01/12  14:51:02.328
IG(A)       42.0  02/01/12  14:50:55.294     42.0  02/01/12  14:50:55.294
VA(kV)      11.7  02/01/12  15:01:01.576      3.4  02/01/12  15:00:42.545
VB(kV)      11.7  02/01/12  15:00:42.937      2.4  02/01/12  15:00:42.541
VC(kV)      11.7  02/01/12  15:00:42.578      3.1  02/01/12  15:00:42.545
VS(kV)      11.7  02/01/12  15:01:01.576      3.4  02/01/12  15:00:42.545
MW3P         6.9  02/01/12  15:00:44.095      0.4  02/01/12  15:00:42.545
MVAR3P       1.0  02/01/12  15:00:42.578      0.1  02/01/12  15:00:42.545
LAST RESET 01/27/12 15:31:41.237
=>
```

Reset the maximum/minimum values using the **MET RM** command. All values will display RESET until new maximum/minimum values are recorded. For more information on maximum/minimum metering, see *Maximum/Minimum Metering on page 8.29*.

QUI Command (Quit Access Level)

The **QUI** command returns the control to Access Level 0.

To return to Access Level 0, enter the command:

=>**QUI <Enter>**

The SEL-351R sets the port access level to 0 and responds:

```
RECLOSER R1                        Date: 03/05/12    Time: 08:55:33.986
FEEDER 2101

=
```

The = prompt indicates the control is back in Access Level 0.

The **QUI** command terminates the SEL Distributed Port Switch Protocol (LMD) connection if it is established [see *Appendix C: SEL Distributed Port Switch Protocol* for details on SEL Distributed Port Switch Protocol (LMD)].

SER Command (Sequential Events Recorder Report)

Use the **SER** command to view the Sequential Events Recorder report. For more information on SER reports, see *Section 12: Standard Event Reports and SER*.

SHO Command (Show/View Settings)

Use the **SHO** command to view "regular" settings, EZ recloser control settings, global settings, SELOGIC control equations settings, serial port settings, Sequential Events Recorder (SER) settings, and text label settings. Below are the **SHO** command options.

Command	Description
SHO *n*	Show "regular" settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO EZ *n*	Show EZ recloser control settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO FZ	Show EZ global settings.
SHO G	Show global settings.
SHO L *n*	Show SELOGIC control equation settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed.
SHO P *n*	Show serial port settings. *n* specifies the port (1, 2, 3, or F); *n* defaults to the active port if not listed.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings for the front-panel display points.

Also, see *Table 9.1* for settings sheet references.

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 1 E50P** displays the setting Group 1 control settings starting with setting E50P). The default is the first setting.

The **SHO** commands display only the enabled settings. To display all settings, including disabled/hidden settings, append an A to the **SHO** command (e.g., **SHO 1 A**).

Below are sample **SHOWSET** commands for the SEL-351R showing all the *factory-default settings*. Setting Groups 1–6 have the same settings for **SHO *n***, **SHO EZ *n***, and **SHO L *n***.

```
=>SHO <Enter>

Group 1
Group Settings:

RID   =RECLOSER R1                  TID   =FEEDER 2101
CTR   = 1000.0   PTR   = 100.0    PTRS  = 100.0
Z1MAG = 32.10    Z1ANG = 68.86
Z0MAG = 95.70    Z0ANG = 72.47    LL    = 4.84
E50P  = 6        E50N  = 6        E50G  = 6        E50Q  = N
E51P  = 2        E51N  = 2        E51G  = 2        E51Q  = N
E32   = N        ELOAD = N        ESOTF = N        EVOLT = Y
E25   = N        EFLOC = N        ELOP  = N        ECOMM = N
E81   = 6        E79   = 4        ESV   = 16
EDEM  = THM
50P1P = OFF      50P2P = OFF      50P3P = OFF      50P4P = 0.40
50P5P = OFF      50P6P = 0.40
67P1D = 0.00     67P2D = 0.00     67P3D = 0.00     67P4D = 0.00
50PP1P= OFF      50PP2P= OFF      50PP3P= OFF      50PP4P= OFF
50N1P = OFF      50N2P = OFF      50N3P = OFF      50N4P = OFF
50N5P = OFF      50N6P = OFF
67N1D = 0.00     67N2D = 0.00     67N3D = 0.00     67N4D = 0.00
50G1P = OFF      50G2P = OFF      50G3P = OFF      50G4P = OFF
```

```
Press RETURN to continue
50G5P = OFF      50G6P = 0.10
67G1D = 0.00     67G2D = 0.00     67G3D = 0.00     67G4D = 0.00
51P1P = 0.40     51P1C = A        51P1TD= 1.00
51P1CT= 0.00     51P1MR= 0.00
51P2P = 0.40     51P2C = C        51P2TD= 1.00
51P2CT= 0.00     51P2MR= 0.00
51N1P = OFF      51N1C = 1        51N1TD= 1.00
51N1CT= 0.00     51N1MR= 0.00
51N2P = OFF      51N2C = 13       51N2TD= 1.00
51N2CT= 0.00     51N2MR= 0.00
51G1P = 0.10     51G1C = 1        51G1TD= 1.00
51G1CT= 0.00     51G1MR= 0.00
51G2P = 0.10     51G2C = 13       51G2TD= 1.00
51G2CT= 0.00     51G2MR= 0.00
27P1P = OFF      27P2P = OFF      59P1P = 104.0    59P2P = OFF
59N1P = OFF      59N2P = OFF      59QP  = OFF      59V1P = OFF
27SP  = OFF      59S1P = OFF      59S2P = OFF      27PP  = OFF
59PP  = OFF
81D2P = OFF      81D2D = 2.00     81D3P = OFF      81D3D = 2.00

Press RETURN to continue
81D4P = OFF      81D4D = 2.00     81D5P = OFF      81D5D = 2.00
81D6P = OFF      81D6D = 2.00
79OI1 = 300.00   79OI2 = 600.00   79OI3 = 600.00   79OI4 = 0.00
79RSD = 1800.00  79RSLD= 600.00   79CLSD= 900.00
DMTC  = 5
PDEMP = OFF      NDEMP = OFF      GDEMP = OFF      QDEMP = OFF
TDURD = 12.00    CFD   = 60.00    3POD  = 1.50     50LP  = 0.05
SV1PU = 0.00     SV1DO = 0.00     SV2PU = 0.00     SV2DO = 0.00
SV3PU = 0.00     SV3DO = 0.00     SV4PU = 0.00     SV4DO = 0.00
SV5PU = 0.00     SV5DO = 0.00     SV6PU = 0.00     SV6DO = 0.00
SV7PU = 900.00   SV7DO = 0.00     SV8PU = 0.00     SV8DO = 0.00
SV9PU = 900.00   SV9DO = 0.00     SV10PU= 0.00     SV10DO= 0.00
SV11PU= 900.00   SV11DO= 0.00     SV12PU= 0.00     SV12DO= 0.00
SV13PU= 0.00     SV13DO= 0.00     SV14PU= 0.00     SV14DO= 0.00
SV15PU= 0.00     SV15DO= 0.00     SV16PU= 0.00     SV16DO= 0.00
OPPH  = 2        OPGR  = 2        OPLKPH= 4        OPLKGR= 4
OPLKSF= OFF      HITRPH= OFF      HITRGR= OFF      HILKPH= OFF
HILKGR= OFF      ECOLDP= N        ECOLDG= N        RPPH  = N
RPGR  = N        RPSEF = N        ESEQ  = N        PRECED= N

=>
```

```
=>SHO EZ <Enter>

EZ Group 1

Control Identifier (30 chars)                          =RECLOSER R1

Circuit Identifier (30 chars)                          =FEEDER 2101

CT Ratio (1.0-6000)                                    = 1000.0
PT Ratio (1.0-10000)                                   = 100.0
Min. trip - phase (OFF,50.00-3199.99 A pri.)           = 400.00
Min. trip - ground (OFF,5.00-3199.99 A pri.)           = 100.00
Min. trip - SEF (OFF,5.00-1499.99 A pri.)              = OFF
Fast curve - phase
(OFF,U1-U5,C1-C5,recloser or user curve)               = A
Fast curve - ground
(OFF,U1-U5,C1-C5,recloser or user curve)               = 1
Delay curve - phase
(OFF,U1-U5,C1-C5,recloser or user curve)               = C
Delay curve - ground
(OFF,U1-U5,C1-C5,recloser or user curve)               = 13
Operations - phase fast curve (OFF,1-5)                = 2
Operations - ground fast curve (OFF,1-5)               = 2
Operations to lockout - phase (2-5)                    = 4
Operations to lockout - ground (2-5)                   = 4
Reclose interval 1 (0.00-999999cyc)                   = 300.00
Reclose interval 2 (0.00-999999cyc)                   = 600.00
Reclose interval 3 (0.00-999999cyc)                   = 600.00

Press RETURN to continue
Reset time for auto-reclose (0.00-999999cyc)           = 1800.00
Reset time from lockout (0.00-999999cyc)               = 600.00
Close power wait time (OFF,0.00-999999cyc)             = 900.00
Complex fast curve - phase (Y/N)                       = N
Complex fast curve - ground (Y/N)                      = N
Complex delay curve - phase (Y/N)                      = N
Complex delay curve - ground (Y/N)                     = N
High current trip - phase (Y/N)                        = N
High current trip - ground (Y/N)                       = N
```

```
High current lockout - phase (Y/N)                = N
High current lockout - ground (Y/N)               = N
Cold load pickup scheme (Y/N)                     = N
Sequence coordination (Y/N)                       = N
Underfrequency loadshedding (Y/N)                 = N
Demand meter time constant                        = 5

=>
```

```
=>SHO FZ <Enter>

Global EZ Settings:
System Frequency (50,60 Hz)                       = 60
Phase Rotation (ABC,ACB)                          = ABC
Recloser Wear Monitor (AUTO,Y,N)                  = AUTO
Recloser type (OIL,VAC1,VAC2)                     = OIL
Interrupt rating (500-20000)                      = 6000
Reset trip-latched LEDs on close (Y,Y1,N,N1)      = Y
True three-phase voltage connected (Y,N)          = N
Phantom voltages from (VA,VB,VC,VAB,VBC,VCA,OFF)  = OFF
V123 Terminal Conn. (A,B,C,AB,BC,CA,OFF)          = A
I123 Terminal Conn. (ABC,ACB,BAC,BCA,CAB,CBA)     = ABC
CT Polarity (POS,NEG)                             = POS
Battery Amp-hours (6.5-20)                        = 16.0
Power-off Delay After AC Loss (OFF,1-1440min)     = 45
Power-off Delay After Wake Up (OFF,1-1440min)     = 5
Power-off Voltage Level 1 (19.2-24Vdc)            = 19.2

=>
```

```
=>SHO G <Enter>

Global Settings:
TGR   = 0.00     NFREQ = 60       PHROT = ABC
DATE_F= MDY      FP_TO = 15
LER   = 15       PRE   = 4
IN101D= 0.50     IN102D= 0.50     IN103D= 0.50     IN104D= 0.50
IN105D= 0.50     IN106D= 0.50
EBMON = Y        COSP1 = 10000    COSP2 = 20       COSP3 = 20
KASP1 = 0.10     KASP2 = 6.00     KASP3 = 6.00
LED11L= N        LED12L= N        LED13L= N        LED14L= Y
LED15L= Y        LED16L= Y        LED17L= Y        LED18L= N
LED19L= N        LED20L= N        LED24L= Y        LED25L= Y
RSTLED= Y        PB8D  = 0.00     PB9D  = 0.00
3PVOLT= N        PHANTV= OFF      VPCONN= A
IPCONN= ABC      CTPOL = POS
EZGRPS= 2        AMPHR = 16.0
PWR_AC= 45       PWR_WU= 5        V_LOW1= 19.2
UTCOFF= 0.00

=>
```

```
=>SHO L <Enter>

SELogic group 1

SELogic Control Equations:
TR    =51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T
        + 67N2T + 67N3T + 81D1T + PB9 + OC
TRCOMM=0
TRSOTF=0
DTT   =0
ULTR  =!52A
PT1   =0
LOG1  =0
PT2   =0
LOG2  =0
BT    =0
52A   =SW1 * !CLOSE
CL    =PB8 * LT4 * LT7 + CC * LT7
ULCL  =TRIP + !PINF * SW1 + !(LT7 + CLOSE) + !(LT4 + CLOSE + CC + 79CY)
79RI  =TRIP
79RIS =52A + 79CY
79DTL =67N3T * OLS + (67P1 + 67G1 + 67N1) * TRIP + (!LT2 + !LT7) * (TRIP
        + !52A) + 81D1T + SV16 + PB9 + OC

Press RETURN to continue
79DLS =79LO
79SKP =0
```

```
79STL =TRIP
79BRS =51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2 + 67N3 + TRIP
79SEQ =79RS * SEQC * (51P1 + 51G1 + 51N1)
79CLS =59L1 * !BADBAT * !DTFAIL
SET1  =PB1 * !LT1 * LT4
RST1  =PB1 * LT1 * LT4
SET2  =PB2 * !LT2 * LT4
RST2  =PB2 * LT2 * LT4 + !(79RS + 79CY + 79LO)
SET3  =PB3 * !LT3 * LT4
RST3  =PB3 * LT3 * LT4
SET4  =PB5 * !LT4
RST4  =PB5 * LT4
SET5  =PB6 * !LT5 * LT4
RST5  =PB6 * LT5 * LT4
SET6  =PB7 * !LT6 * LT4
RST6  =PB7 * LT6 * LT4
SET7  =1
RST7  =0

Press RETURN to continue
SET8  =0
RST8  =0
SET9  =0
RST9  =0
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0
67P1TC=HLP
67P2TC=HTP

Press RETURN to continue
67P3TC=1
67P4TC=1
67N1TC=HLG * LT1
67N2TC=HTG * LT1
67N3TC=LT1 * !(51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2) * (!SV12 + SV12
        * 50G5 + SV12 * 50N5)
67N4TC=1
67G1TC=HLG * LT1
67G2TC=HTG * LT1
67G3TC=1
67G4TC=1
67Q1TC=1
67Q2TC=1
67Q3TC=1
67Q4TC=1
51P1TC=!SV8 * OCP
51N1TC=!SV10 * OCG * LT1
51G1TC=!SV10 * OCG * LT1
51P2TC=!SV8 + SV8 * 50P5
51N2TC=(!SV10 + SV10 * 50G5 + SV10 * 50N5) * LT1

Press RETURN to continue
51G2TC=(!SV10 + SV10 * 50G5) * LT1
51QTC =1
SV1   =0
SV2   =0
SV3   =0
SV4   =0
SV5   =52A * (SV8 + SV10 + SV12) * (RPP + RPG + RPS)
SV6   =!52A * (79LO + !79RS * !79CY * !79LO) * (CLP + CLG)
SV7   =52A * !50P6 * SV8
SV8   =(SV8 + SV6T) * !(SV7T + SV5T * RPP + !CLP)
SV9   =52A * !50G6 * !50N6 * SV10
SV10  =(SV10 + SV6T) * !(SV9T + SV5T * RPG + !CLG)
SV11  =52A * !50N4 * SV12
SV12  =(SV12 + SV6T) * !(SV11T + SV5T * RPS + !CLG)
SV13  =51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T
        + 67N2T
SV14  =50G6 + 50N6 + 51N1 + 51N2
SV15  =/SV13 * (OLG * GTP * SV14 + OLG * !GTP * SV14 * !50P6 + OLP * !GTP
        * 50P6 + OLP * GTP * 50P6 * !SV14)
SV16  =SV15 + SV13 * OLP * OLG

Press RETURN to continue
SC1R  =1
SC1I  =0
SC1D  =0
```

```
SC2R  =1
SC2I  =0
SC2D  =0
SC3R  =1
SC3I  =0
SC3D  =0
SC4R  =1
SC4I  =0
SC4D  =0
SC5R  =1
SC5I  =0
SC5D  =0
SC6R  =1
SC6I  =0
SC6D  =0
SC7R  =1
SC7I  =0

Press RETURN to continue
SC7D  =0
SC8R  =1
SC8I  =0
SC8D  =0
RCTR  =TRIP
RCCL  =CLOSE
OUT101=0
OUT102=0
OUT103=0
OUT104=0
OUT105=0
OUT106=0
OUT107=0
LED1  =LT1
LED2  =LT2
LED3  =0
LED4  =!SG1
LED5  =!LT4
LED6  =0
LED7  =0

Press RETURN to continue
LED8  =52A
LED9  =!52A * PINBD
LED11 =!DISCHG
LED12 =BADBAT + DTFAIL
LED13 =!LT7
LED14 =TRIP
LED15 =51P1T + 51G1T + 51N1T
LED16 =67P2T + 67G2T + 67N2T
LED17 =81D1T
LED18 =79RS
LED19 =79CY
LED20 =79LO
LED24 =50G6 + 50N6 + 51N1 + 51N2
LED25 =67N3T
LOCAL =0
DP1   =0
DP2   =0
DP3   =0
DP4   =0
DP5   =0

Press RETURN to continue
DP6   =0
DP7   =0
DP8   =0
DP9   =0
DP10  =0
DP11  =0
DP12  =0
DP13  =0
DP14  =0
DP15  =0
DP16  =0
SS1   =PB4 * LT4 * !SG1
SS2   =PB4 * LT4 * SG1
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/51P1 + /51P2 + /51G1 + /51G2 + /51N1 + /51N2 + /67N3
FAULT =51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2 + 67N3
BSYNCH=52A

Press RETURN to continue
CLMON =0
BKMON =TRIP
E32IV =1
TMB1A =0
```

```
TMB2A =0
TMB3A =0
TMB4A =0
TMB5A =0
TMB6A =0
TMB7A =0
TMB8A =0
TMB1B =0
TMB2B =0
TMB3B =0
TMB4B =0
TMB5B =0
TMB6B =0
TMB7B =0
TMB8B =0

=>
```

```
=>SHO P 1 <Enter>

Port 1

PROTO = SEL
SPEED = 2400      BITS  = 8      PARITY= N      STOP  = 1
T_OUT = 15        AUTO  = N      FASTOP= N
```

```
=>SHO P 2 <Enter>

Port 2

PROTO = SEL
SPEED = 2400      BITS  = 8      PARITY= N      STOP  = 1
T_OUT = 15        AUTO  = N      RTSCTS= N      FASTOP= N
```

```
=>SHO P 3 <Enter>

Port 3

PROTO = SEL
SPEED = 2400      BITS  = 8      PARITY= N      STOP  = 1
T_OUT = 15        AUTO  = N      RTSCTS= N      FASTOP= N
```

```
=>SHO P 4 <Enter>

Port 4

PROTO = SEL
SPEED = 2400      BITS  = 8      PARITY= N      STOP  = 1
T_OUT = 15        AUTO  = N      RTSCTS= N      FASTOP= N
```

Port F settings are displayed by either **SHO P 4** or **SHO P F** command.

```
=>SHO P F <Enter>

Port F

PROTO = SEL
SPEED = 2400    BITS  = 8      PARITY= N      STOP  = 1
T_OUT = 15      AUTO  = N      RTSCTS= N      FASTOP= N
```

```
=>>SHO R <Enter>

SER Chatter Criteria:
ESERDL= N

Sequential Events Recorder trigger lists:
SER1  =TRIP,51P1T,51P2T,51G1T,51G2T,51N1T,51N2T,67P2T,67G2T,67N2T,67N3T,81D1T
PB9,67P1,67G1,67N1
SER2  =CLOSE,52A,CF,79CY,79LO,79RS,SH0,SH1,SH2,SH3,SH4,PB8,59A1
SER3  =TOSLPT,TOSLPV,BADBAT,DTFAIL


Load Profile settings:
LDLIST=0
LDAR  =5

=>
```

```
=>SHO T <Enter>

Text Labels:
NLB1  =              CLB1  =        SLB1  =        PLB1  =
NLB2  =              CLB2  =        SLB2  =        PLB2  =
NLB3  =              CLB3  =        SLB3  =        PLB3  =
NLB4  =              CLB4  =        SLB4  =        PLB4  =
NLB5  =              CLB5  =        SLB5  =        PLB5  =
NLB6  =              CLB6  =        SLB6  =        PLB6  =
NLB7  =              CLB7  =        SLB7  =        PLB7  =
NLB8  =              CLB8  =        SLB8  =        PLB8  =
NLB9  =              CLB9  =        SLB9  =        PLB9  =
NLB10 =              CLB10 =        SLB10 =        PLB10 =
NLB11 =              CLB11 =        SLB11 =        PLB11 =
NLB12 =              CLB12 =        SLB12 =        PLB12 =
NLB13 =              CLB13 =        SLB13 =        PLB13 =
NLB14 =              CLB14 =        SLB14 =        PLB14 =
NLB15 =              CLB15 =        SLB15 =        PLB15 =
NLB16 =              CLB16 =        SLB16 =        PLB16 =
DP1_1 =                DP1_0 =

Press RETURN to continue
DP2_1 =                DP2_0 =
DP3_1 =                DP3_0 =
DP4_1 =                DP4_0 =
DP5_1 =                DP5_0 =
DP6_1 =                DP6_0 =
DP7_1 =                DP7_0 =
DP8_1 =                DP8_0 =
DP9_1 =                DP9_0 =
DP10_1=                DP10_0=
DP11_1=                DP11_0=
DP12_1=                DP12_0=
DP13_1=                DP13_0=
DP14_1=                DP14_0=
DP15_1=                DP15_0=
DP16_1=                DP16_0=
79LL  =SET RECLOSURES 79SL  =RECLOSE COUNT

=>
```

STA Command (Recloser Control Self-Test Status)

The **STA** command displays the status report, showing the recloser control self-test information.

To view a status report, enter the command:

=>**STA *n* <Enter>**

where *n* is an optional parameter to specify the number of times (1–32767) to repeat the status display. If *n* is not specified, the status report is displayed once. A typical SEL-351R status report output appears as shown below:

```
=>STA <Enter>

RECLOSER R1                       Date: 04/24/12    Time: 14:39:10.556
FEEDER 2101

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
```

```
SELF TESTS

W=Warn    F=Fail

       I1      I2      I3      IN      V1      V2      V3      VS      MOF
OS     -1       0       1       1      -0      -2      -1      -1      -1

       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      5.13    5.01   -4.96    12.10  -11.87   15.28  -15.25

       TEMP    RAM     ROM     A/D     CR_RAM  EEPROM
        32.5   OK      OK      OK      OK      OK

       MODE    HRS_LFT 12V_AUX VBAT    IBAT
BATT   CHARGE  XX:XX    12.32   27.33   9

Relay Enabled
Battery Discharge Test OK

=>
```

STA Command Row and Column Definitions

Control Response	Description
FID	FID is the firmware identifier string. It identifies the firmware revision.
CID	CID is the recloser control firmware checksum identifier.
W-Warn or F-Fail	Is appended to the values to indicate an out-of-tolerance condition.
OS	OS = Offset; displays measured dc offset voltages in millivolts for the current and voltage channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.
PS	PS = Power Supply; displays power supply output voltages in dc volts.
TEMP	Displays the internal relay module temperature in degrees Celsius.
RAM, ROM, CR_RAM (critical RAM), and EEPROM	These results verify the relay module memory component status. The columns display OK if memory is functioning properly, or FAIL if the memory area has failed.
A/D	Analog to Digital convert status.
BATT	Displays status and mode of the battery charger board:
MODE	Mode that battery charger is in: CHARGE Battery is charging. DISCHG Battery is discharging. DISTST Battery discharge test at 1 Amp for as long as 5 seconds duration. BADBAT Battery cannot charge.
HRS_LFT	The HRS_LFT column shows the amount of time left (in hours and minutes) until the control is put into sleep mode, when in discharge mode. If the control is in charge mode, this column reads XX:XX.
12V_AUX	Voltage level in Vdc of the 12-volt supply, available at terminals Z19–Z20 (+) and Z21–Z22 (-; return).
VBAT	Voltage level of the 24-volt battery in Vdc.
IBAT	Charge or discharge current in milliamps dc. If current is discharging, value is preceded by a minus sign –; if current is charging, value is displayed with no preceding character.

TAR Command (Display Relay Word Bit Status)

The **TAR** command displays the status of front-panel target LEDs or recloser control elements, whether they are asserted or deasserted. The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. Refer to *Table 10.7* (note the correspondence with *Table 9.6*).

A Relay Word bit is either at a logical 1 (asserted) or a logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations. See *Section 9: Setting the SEL-351R Recloser Control* and *Appendix G: Setting SELOGIC Control Equations*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays. However, the execution of the equivalent **TAR** command via the front-panel display does remap the bottom row of the front-panel target LEDs (see **OTHER** pushbutton in Pushbutton Primary Functions in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*).

The **TAR** command options are:

NOTE: The **TAR R** command cannot reset the latched target LEDs if a TRIP condition is present.

Command	Description
TAR *n k*	Shows Relay Word row number *n* (0–44). *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once.
TAR *name k*	Shows Relay Word row containing Relay Word bit name (e.g., **TAR 50C** displays Relay Word Row 5 containing the Relay Word bit 50C). Valid names are shown in *Table 10.7*. *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once.
TAR R	Clears front-panel tripping target LEDs **TRIP**, **FAST CURVE**, **HIGH CURRENT**, **81**, **A**, **B**, **C**, **G**, and **SEF**. Unlatches the trip logic for testing purposes (see *Figure 5.1*). Shows Relay Word Row 0.

Table 10.6 SEL-351R Recloser Control Relay Word and Its Correspondence to TAR Command (Sheet 1 of 3)

TAR Command	Relay Word Bits							
TAR 0 (Front-Panel LEDs)	LED10 (EN)	LED11 (AC SUPPLY)	LED12 (BATTERY PROBLEM)	LED13 (HOT LINE TAG)	LED14 (TRIP)	LED15 (FAST CURVE)	LED16 (HIGH CURRENT)	LED 17 (81)
TAR 1 (Front-Panel LEDs)	LED18 (RESET)	LED19 (CYCLE)	LED20 (LOCKOUT)	LED21 (A)	LED22 (B)	LED23 (C)	LED24 (G)	LED25 (SEF)
TAR 2	50A1	50B1	50C1	50A2	50B2	50C2	50A3	50B3
TAR 3	50C3	50A4	50B4	50C4	50AB1	50BC1	50CA1	50AB2
TAR 4	50BC2	50CA2	50AB3	50BC3	50CA3	50AB4	50BC4	50CA4
TAR 5	50A	50B	50C	51P1	51P1T	51P1R	51N1	51N1T
TAR 6	51N1R	51G1	51G1T	51G1R	51P2	51P2T	51P2R	51N2
TAR 7	51N2T	51N2R	51G2	51G2T	51G2R	51Q	51QT	51QR
TAR 8	50P1	50P2	50P3	50P4	50N1	50N2	50N3	50N4
TAR 9	67P1	67P2	67P3	67P4	67N1	67N2	67N3	67N4
TAR 10	67P1T	67P2T	67P3T	67P4T	67N1T	67N2T	67N3T	67N4T

Table 10.6 SEL-351R Recloser Control Relay Word and Its Correspondence to TAR Command (Sheet 2 of 3)

TAR Command	Relay Word Bits							
TAR 11	50G1	50G2	50G3	50G4	50Q1	50Q2	50Q3	50Q4
TAR 12	67G1	67G2	67G3	67G4	67Q1	67Q2	67Q3	67Q4
TAR 13	67G1T	67G2T	67G3T	67G4T	67Q1T	67Q2T	67Q3T	67Q4T
TAR 14	50P5	50P6	50N5	50N6	50G5	50G6	50Q5	50Q6
TAR 15	50QF	50QR	50GF	50GR	32VE	32QGE	32NE	32QE
TAR 16	F32P	R32P	F32Q	R32Q	F32QG	R32QG	F32V	R32V
TAR 17	F32N	R32N	32PF	32PR	32QF	32QR	32GF	32GR
TAR 18	27A1	27B1	27C1	27A2	27B2	27C2	59A1	59B1
TAR 19	59C1	59A2	59B2	59C2	27AB	27BC	27CA	59AB
TAR 20	59BC	59CA	59N1	59N2	59Q	59V1	27S	59S1
TAR 21	59S2	59VP	59VS	SF	25A1	25A2	3P27	3P59
TAR 22	81D1	81D2	81D3	81D4	81D5	81D6	27B81	50L
TAR 23	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	VPOLV	LOP
TAR 24	RCTR	RCCL	IN106	IN105	IN104	IN103	IN102	IN101
TAR 25	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
TAR 26	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
TAR 27	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8
TAR 28	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
TAR 29	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T
TAR 30	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
TAR 31	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
TAR 32	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
TAR 33	CLOSE	CF	RCSF	OPTMN	RSTMN	FSA	FSB	FSC
TAR 34	BCW	50P32	BADBAT	59VA	TRGTR	52A	COMMT	CHRGG
TAR 35	SG1	SG2	SG3	SG4	SG5	SG6	ZLOUT	ZLIN
TAR 36	ZLOAD	BCWA	BCWB	BCWC	TOSLPV	TOSLPT	DISTST	DTFAIL
TAR 37	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
TAR 38	3PO	SOTFE	Z3RB	KEY	EKEY	ECTT	WFC	PT
TAR 39	PTRX2	PTRX	PTRX1	UBB1	UBB2	UBB	Z3XT	DSTRT
TAR 40	NSTRT	STOP	BTX	TRIP	OC	CC	CLG	H1CHRG
TAR 41	67P2S	67N2S	67G2S	67Q2S	PDEM	NDEM	GDEM	QDEM
TAR 42	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8
TAR 43	PB9	PINBD	PINC	PINE	PINF	SW1	DISCHG	LED9
TAR 44	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
TAR 45	OCP	OCG	OLP	OLG	OLS	HTP	HTG	HLP

Table 10.6 SEL-351R Recloser Control Relay Word and Its Correspondence to TAR Command (Sheet 3 of 3)

TAR Command	Relay Word Bits							
TAR 46	HLG	CLP	RPP	RPG	RPS	SEQC	3PHV	GTP
TAR 47	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
TAR 48	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
TAR 49	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
TAR 50	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
TAR 51	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
TAR 52	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
TAR 53	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
TAR 54	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
TAR 55	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]
TAR 56	50NF	50NR	32NF	32NR	59L1	IDSCHG	DCONN	DDATA
TAR 57	BATVL1	BATVL2	*[a]	*[a]	*[a]	*[a]	*[a]	LOCAL
TAR 58	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16
TAR 59	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
TAR 60	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16

[a] Reserved for future use.

Command **TAR SH1 10** is executed in the following example:

```
=>TAR SH1 10 <Enter>

79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

=>
```

Note that Relay Word row containing the SH1 bit is repeated 10 times. In this example, the reclosing function is in the Lockout State (79LO = logical 1) and the shot is at shot = 2 (SH2 = logical 1). Command **TAR 32** will report the same data since the SH1 bit is in Row 32 of the Relay Word.

TIM Command (View/Change Time)

TIM displays the recloser control clock. To set the clock, type **TIM** and the desired setting, then press **<Enter>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. For example, to set the clock to 23:30:00, enter:

```
=>TIM 23:30:00 <Enter>
23:30:00
=>
```

TRI Command (Trigger Event Report)

Issue the **TRI** (Trigger) command to generate an event report:

```
=>TRI <Enter>
Triggered

=>
```

If the serial port AUTO setting = Y, the control sends the summary event report:

```
RECLOSER R1                        Date: 02/02/12    Time: 12:57:01.737
FEEDER 2101

Event: TRIG  Location: $$$$$$$  Shot: 2  Frequency:  60.00
Targets: 11000000 10000000
Currents (A Pri), ABCNGQ:    235   236   237     0     2     0
=>>
```

See *Section 12: Standard Event Reports and SER* for more information on event reports.

Access Level E (EZ) Commands

Access Level E commands primarily allow you to test the battery and set EZ settings and global EZ settings. All Access Level 1 commands can also be executed from Access Level E. The screen prompt is: =+>.

BTT Command (Battery Test)

You can use the **BTT** command to view the results of the last battery discharge test, and the time remaining until the next automatic battery discharge test or you can force an immediate battery discharge test. The command format is:

BTT *x*

where:

x is blank or NOW

If a battery test is in progress when the **BTT** command is executed, the control responds:

```
=+>BTT <Enter>
Battery test in progress
=+>
```

If the last battery passed the last load test, the control responds as follows:

```
=+>BTT <Enter>
Battery test state is: OK
Time until next battery test:  XX.X hours
```

If the battery failed the previous load test, the DTFAIL Relay Word element is asserted and the response is:

```
=>>BTT <Enter>
Battery test state is: FAILED
Time until next battery test:  XX.X hours
```

The `XX.X hours` in the above responses is the time until the next automatic load test is performed (24.0 hours or less). Automatic load testing can only occur if the battery is charging (ac power is present). If the response is `24+ hours`, that is indicative of an indeterminate amount of time until the next automatic load test for the following reasons:

- ➤ The battery is discharging (e.g., ac power is lost)
- ➤ The battery is still charging at a relatively high level (above 100 mA, indicated by Relay Word bit HICHRG asserting)

If the **BTT NOW** command is entered, the control forces an immediate battery test and shows the status of the battery test:

```
=+>BTT NOW <Enter>
Battery test initiated. Duration up to 5 seconds
.
.
.
.
.
Battery test state is: OK
=+>
```

Each period is displayed at about one-second intervals as the control times through the test.

See *Battery System Monitor on page 8.15*.

SET EZ and SET FZ Commands (Change EZ Settings)

The **SET EZ *n*** command allows you to change the EZ recloser control settings for Setting Group *n* (*n* specifies the setting group—1, 2, 3, 4, 5, or 6). These settings are the traditional recloser control setting (e.g., min. trip, fast curve, delay curve, operations to lockout settings) and other special recloser control scheme logic (e.g., cold load pickup, sequence coordination logic).

The EZ recloser control settings for a given Setting Group *n* override and change a number of the “regular” settings in the same Setting Group *n* (set with the **SET *n*** command, in Access Level 2) if the group number *n* is encompassed by the Global setting EZGRPS (set with the **SET G** command, in Access Level 2)—see *Table 1.1*. Global setting EZGRPS enables the EZ settings in the encompassed settings groups.

For example, if EZGRPS = 2 (the factory setting), then you can make EZ recloser control settings for Setting Groups 1 (main settings) and 2 (alternate settings) with the SET EZ 1 and SET EZ 2 commands, respectively. The EZ recloser control settings for Setting Groups 1 and 2 also override a number of the “regular” settings in the respective setting group. If EZGRPS = 2, the EZ settings for Setting Groups 3–6 cannot be made, nor are the EZ settings for Setting Groups 3–6 active (none of the “regular” settings in Setting Groups 3–6 are overridden).

The **SET FZ** command allows you to change the EZ global settings. The EZ global settings also override a number of the “regular” global settings (set with the **SET G** command, in Access Level 2) if Global Setting EZGRPS > 0—see end of *Table 1.1*.

Access Level B Commands

Access Level B commands primarily allow you to operate control parameters and output contacts without allowing you access to change settings. All Access Level 1 and Access Level E commands can also be executed from Access Level B. The screen prompt is: ==>.

BRE W Command (Preload)

Use the **BRE W** command to preload breaker/recloser contact wear. For example, to preload the breaker/recloser wear to 25 percent, 28 percent, and 24 percent for the respective phases, issue the following command.

```
==>BRE W <Enter>
Breaker Wear Percent Preload

A-phase % = 13 ? 25 <Enter>
B-phase % = 13 ? 28 <Enter>
C-phase % = 13 ? 24 <Enter>
Are you sure (Y/N) ? Y <Enter>

RECLOSER R1                        Date: 02/02/12    Time: 08:44:33.920
FEEDER 2101

Cntrl Trips=     11
 IA=       40.7 IB=       40.8 IC=       40.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=  25 B=  28 C=  24

LAST RESET 01/27/11 15:32:59
==>
```

Use the **BRE W A** command to preload breaker/recloser contact wear and trip operation counters. For example, to preload the breaker/recloser wear to 8 percent, 7 percent, and 10 percent for the respective phases and preload some trip operation counters, issue the following command:

```
==>BRE W A <Enter>
Breaker Wear Percent Preload

A-phase % =    4 ?  8 <Enter>
B-phase % =    4 ?  7 <Enter>
C-phase % =    6 ? 10 <Enter>

Trip Counter Preload

Ext Trips=     3 ?
Cntrl Trips=   9 ? 16
A-phase Trips= 6 ? 14
B-phase Trips= 5 ?  9
C-phase Trips= 8 ? 10
EF/G Trips=    7 ? 12
SEF Trips=     0 ?

Are you sure (Y/N) ? Y <Enter>

RECLOSER R1                        Date: 02/02/12    Time: 08:44:33.920
FEEDER 2101

Cntrl Trips=     16
 IA=       40.7 IB=       41.4 IC=       53.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=   8 B=   7 C=  10

A-phase Trips=   14
B-phase Trips=    9
C-phase Trips=   10
EF/G Trips=      12
SEF Trips=        0

LAST RESET 12/27/11 15:32:59
==>
```

BRE R (Reset Breaker Wear)

Use the **BRE R** command to reset the breaker/recloser contact wear monitor and trip operation counters:

```
==>BRE R <Enter>

RECLOSER R1                         Date: 02/03/12    Time: 08:44:20.802
FEEDER 2101

Ctrl Trips=      16
 IA=       40.7 IB=       41.4 IC=       53.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=    8 B=    7 C=   10

A-phase Trips=   14
B-phase Trips=    9
C-phase Trips=   10
EF/G Trips=      12
SEF Trips=        0

LAST RESET 12/27/11 15:32:59

Reset Trip Counters and Accumulated Currents/Wear
Are you sure (Y/N) ? Y <Enter>

RECLOSER R1                         Date: 02/03/12    Time: 08:44:33.920
FEEDER 2101

Cntrl Trips=      0
 IA=        0.0 IB=        0.0 IC=        0.0 kA

Ext Trips=      0
 IA=        0.0 IB=        0.0 IC=        0.0 kA

Percent wear: A=   0 B=   0 C=   0

A-phase Trips=   0
B-phase Trips=   0
C-phase Trips=   0
EF/G Trips=      0
SEF Trips=       0

LAST RESET 02/03/12 08:44:28
```

See *Breaker/Recloser Contact Wear Monitor on page 8.1* for further details on the breaker monitor.

CLO Command (Close Breaker)

The **CLO** (CLOSE) command asserts Relay Word bit CC for 1/4 cycle when it is executed. You can program Relay Word bit CC into the CL SELOGIC control equation (see *Figure 1.20*) to assert the CLOSE Relay Word bit, and, in turn, to assert an output (RCCL = CLOSE; see *Figure 7.29*) contact to close a recloser.

See *Close Logic on page 6.1* for more information concerning Relay Word bit CC and its recommended use.

To issue the **CLO** command, enter the following:

```
==>CLO <Enter>
Close Breaker  (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

Typing **N <Enter>** after either of the above prompts will abort the command.

The **CLO** command is supervised by the main board Breaker jumper (see *Table 2.4* and *Table 2.5*). If the Breaker jumper is not in place (Breaker jumper = OFF), the control does not execute the **CLO** command and responds:

```
Aborted: No Breaker Jumper
```

GRO n Command (Change Active Setting Group)

The **GRO *n*** command changes the active setting group to Setting Group *n*. For example, to change to Setting Group 2, enter the following:

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
Active Group = 2
==>
```

The SEL-351R switches to Group 2 and pulses the ALARM contact. The control automatically outputs the Group Switch Report on all ports with the serial port setting AUTO = Y. An example Group Switch Report is shown below:

```
==>
RECLOSER R1                        Date: 02/02/12   Time: 09:40:34.611
FEEDER 2101

Active Group = 2
==>
```

The SELOGIC control equations Group Selector Switch elements, SS1–SS6, have priority over the **GRO** command in active setting group control. If any of the Group Selector Switch elements, SS1–SS6, are asserted (logical 1), the **GRO *n*** command has no effect on the active group setting. For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to Setting Group 2 with the **GRO 2** command is not accepted:

```
==>GRO 2 <Enter>
No group change (see manual)
Active Group = 1
==>
```

For more information on setting group selection, see *Multiple Setting Groups on page 7.15*.

OPE Command (Open Breaker)

The **OPE** (OPEN) command asserts Relay Word bit OC for 1/4 cycle when it is executed. You can program Relay Word bit OC into the TR (Trip conditions) SELOGIC control equation (see *Figure 1.19*) to assert the TRIP Relay Word bit, and, in turn, to assert an output (RCTR = TRIP; see *Figure 7.29*) to trip a recloser.

See *Trip Logic on page 5.1* for more information concerning Relay Word bit OC and its recommended use.

To issue the **OPE** command, enter the following:

```
==>OPE <Enter>
Open Breaker  (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

Typing **N <Enter>** after either of the above prompts will abort the command.

The **OPE** command is supervised by the main board Breaker jumper (see *Table 2.4* and *Table 2.5*). If the Breaker jumper is not in place (Breaker jumper = OFF), the SEL-351R does not execute the **OPE** command and responds:

```
Aborted: No Breaker Jumper
```

PUL Command (Pulse Output Contact)

The **PUL** command allows you to pulse any of the output contacts for a specified length of time. The command format is:

PUL ***x y***

where:

x is the output name (e.g., OUT107, ALARM—see *Figure 7.26*).

y is the pulse duration (1–30) in seconds. If *y* is not specified, the pulse duration defaults to one second.

To pulse OUT101 for five seconds:

```
==>PUL OUT101 5 <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

If the response to the `Are you sure (Y/N) ?` prompt is **N** or **n**, the command is aborted.

The **PUL** command is supervised by the main board Breaker jumper (see *Table 2.4* and *Table 2.5*). If the Breaker is not in place (Breaker jumper = OFF), the recloser control does not execute the **PUL** command and responds:

```
Aborted:  No Breaker Jumper
```

The control generates an event report if any of the OUT101–OUT107 contacts are pulsed. The **PULSE** command is primarily used for testing purposes.

Access Level 2 Commands

Access Level 2 commands allow unlimited access to recloser control settings, parameters, and output contacts. All Access Level 1, Access Level E (EZ), and Access Level B commands are available from Access Level 2. The screen prompt for Access Level 2 is: =>>.

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1–RB16. See Row 26 and Row 59 in *Table 9.7*. At the Access Level 2 prompt, type **CON**, a space, and the number of the remote bit you wish to control, 1–16. The control responds by repeating your command followed by a colon. At the colon, type the Control subcommand you wish to perform (see *Table 10.7*).

The following example shows the steps necessary to pulse Remote Bit 5 (RB5):

```
=>>CON 5 <Enter>
CONTROL RB5: PRB 5 <Enter>
=>>
```

You must enter the same remote bit number in both steps in the command. If the bit numbers do not match, the recloser control responds `Invalid Command`.

Table 10.7 SEL-351R Recloser Control Remote Bit Control Subcommands

Subcommand	Description
SRB *n*	Set Remote Bit *n* (“ON” position)
CRB *n*	Clear Remote Bit *n* (“OFF” position)
PRB *n*	Pulse Remote Bit *n* for 1/4 cycle (“MOMENTARY” position)

See *Remote Control Switches on page 7.8* for more information.

COP m n Command (Copy Setting Group)

You can copy EZ, Group, and SELOGIC control equation settings from setting Group *m* to setting Group *n* with the **COPY** command, **COP *m n***. Setting group numbers range from 1 to 6. After entering settings into one setting group with the **SET** and **SET L** commands, copy them to the other groups with the **COP** command. Use the **SET**, **SET EZ**, and **SET L** commands to modify the copied settings. The **ALARM** output pulses if you copy settings into the active group.

For example, to copy settings from Group 1 to Group 3 issue the following command:

```
=>>COP 1 3 <Enter>
Copy 1 to 3
Are you sure (Y/N) ? Y <Enter>

Please wait...
Settings copied
=>>
```

LOO Command (Loop Back)

The **LOO** (LOOP) command is used for testing the MIRRORED BITS communications channel. For more information on MIRRORED BITS, see *Appendix I: MIRRORED BITS*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data are received.

PAS Command (Change Passwords)

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

You can use the Password command, **PAS**, to change existing passwords. The factory-default passwords for Access Levels 1, E, B, and 2 are:

Access Level	Factory-Default Password
1	OTTER
E	DAKOTA
B	EDITH
2	TAIL
C	CLARKE

The **PAS** command allows you to change existing Level 1, E, B, and 2 passwords at Access Level 2 and allows you to change the Level C password at Level C. To change passwords, enter **PAS *x***, where *x* is the access level of the password you want to change. The control will prompt for the old password and the new password. It will then confirm the change to the new password as follows:

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: ************
Confirm New Password: ************

Password Changed
=>>
```

The new password will not echo on the screen, so type slowly and carefully. Record the new password in a safe place for future reference.

To prevent unauthorized access to your SEL device, the device does not display passwords. Passwords can include as many as 12 characters. Valid characters are listed in *Table 10.8*.

Table 10.8 Valid Password Characters

<table>
<tr><td>Alpha</td><td>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * + , – . / : ; < = > ? @ [\ ] ^ _ ` | ~</td></tr>
</table>

Upper- and lowercase letters are treated as different characters. Strong passwords consist of the maximum allowable characters, with at least one special character, number, lowercase letter, and uppercase letter. Strong passwords do not include a name, date, acronym, or word. The control issues a weak password warning (as shown below) if you can strengthen the new password.

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: *****
Confirm New Password: *****

Password Changed

CAUTION: This password can be strengthened.  Strong passwords do not include a name,
    date, acronym, or word.  They consist of the maximum allowable characters, with
    at least one special character, number, lower-case letter, and upper-case
    letter.  A change in password is recommended.

=>>
```

Examples of valid, distinct passwords include:

- SDFdfa098&^#
- &*LKJoi09873
- m,nYIO689&(*

If the passwords are lost or you wish to operate the recloser control without password protection, put the main board Password jumper in place (Password jumper = ON). Refer to *Table 2.4* and *Table 2.5* for Password jumper information.

If you wish to disable password protection for a specific access level [even if Password jumper is not in place (Password jumper = OFF)], simply set the password to DISABLE.

SET Command (Change Settings)

Use the **SET** command to change “regular” settings, EZ recloser control settings, global settings, SELOGIC control equations settings, serial port settings, Sequential Events Recorder (SER) settings, and text label settings. Below are the **SET** command options.

SET Command	Description
SET *n*	Change “regular” settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed.
SET EZ *n*	Change EZ recloser control settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed. See additional information in *Access Level E (EZ) on page 10.9*.
SET FZ	Change EZ global settings. See additional information in *Access Level E (EZ)*.
SET G	Change global settings.
SET L *n*	Change SELOGIC control equation settings for Setting Group *n*. *n* specifies the Setting Group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed.
SET P *n*	Change serial port settings. *n* specifies the port (1, 2, 3, or F); *n* defaults to the active port if not listed.
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings for the front-panel display points.

The **SET EZ *n*** and **SET FZ** commands are available from Access Level E (EZ), too.

See *Table 9.1* for settings sheet references. See *Settings Changes Via the Serial Port on page 9.2* for more setting command information.

STA C Command (Status Clear Command)

The recloser control latches all main board self-test warnings and failures in order to capture transient out-of-tolerance conditions. To reset the self-test status, use the **STA C** command:

=>>**STA C <Enter>**

The control responds:

```
Reboot the relay and clear status
Are you sure (Y/N) ?
```

If you select **N** or **n**, the control displays:

```
Canceled
```

and aborts the command.

If you select **Y**, the control displays:

```
Rebooting the relay
```

The control then restarts (just like powering down, then powering up control), and all diagnostics are rerun before the recloser control is enabled.

Refer to *Table 13.1* for self-test thresholds and corrective actions.

VER Command (Show Version Information)

The Version command, **VER**, allows you to view information about the recloser control battery charger board firmware versions. A typical **VER** command response is shown below:

```
=>>VER <Enter>
Partnumber: 0351R41281115XXXX

Mainboard: 0311
Data FLASH Size:  1024 KBytes
Analog Input Voltage (PT): 300 Vac, wye-connected
Analog Input Current (CT): 1 Amp Phase, 0.05 Amp Neutral
Extended Relay Features:
  DNP
  Mirrored Bits
  Load Profile

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx

SELboot checksum 440D OK
SELboot-35R-R101

If above information is unexpected. . .
contact SEL for assistance
```

SELBOOT is the bootstrap program.

Access Level C Commands

The CAL access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request. Do not enter the CAL access level except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C (see *ACC, EZA, BAC, 2AC, and CAL Commands (go to Access Level 1, E, B, 2, or C) on page 10.13* for more detail). Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

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SEL-351R Recloser Control Command Summary

Access Level 0 Command	From Access Level 0, you can go to Access Level 1 or to Access Level E (EZ). The Access Level 0 screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the control prompts you for the Access Level 1 password to enter Access Level 1.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper is not in place, the control prompts you for the Access Level 2 password to enter Access Level 2.
BAC	Enter Access Level B (Breaker). If the main board password jumper is not in place, the control prompts you for the Access Level B password.
BRE	Display breaker/recloser contact wear report.
BRE A	Display breaker/recloser contact wear and trip operation report.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS® channel *p*.
COM *p d1 d2*	Show a communications summary for events occurring between dates *d1* and *d2* on MIRRORED BITS channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS channel *p* (where *p* = A or B).
COU *k*	Show the SELOGIC® counter values. Enter *k* for repeat count.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP[a] *type*	Show DNP map.
EVE *n*	Show event report number *n* with 1/4 cycle resolution.
EVE C *n*	Show compressed event report number *n* for use with ACSELERATOR® Analytic Assistant SEL-5601 Software.
EVE L *n*	Show event report number *n* with 1/16 cycle resolution.
EVE R *n*	Show raw event report number *n* with 1/16 cycle resolution.
EVE *XX f*	Append parameter *f* to any of the above **EVE** commands, where *f* is A or D. Use A to show only the analog portion of the event report. Use D to show only the digital protection and control portion of the event report.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.
GRO	Display active settings group number.
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
IRI	Force synchronization of internal control clock to IRIG-B time-code input.
LDP *d1*	Show rows in the Load Profile report from date *d1*.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
LDP *d1 d2*	Show rows in the Load Profile report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP *n*	Show the latest *n* rows in the Load Profile report.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear SER records from nonvolatile memory.
SER D	List active chattering elements from the SER records and present auto-removal settings.
SHO *n*	Show “regular” settings for settings group *n* (*n* = 1–6).
SHO EZ *n*	Show EZ recloser control settings for settings group *n* (*n* = 1–6).
SHO FZ	Show EZ global settings.
SHO G	Show global settings.
SHO L *n*	Show SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SHO P *n*	Show port settings for port *n* (*n* = 1, 2, 3, F).
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings for front-panel display points and extra local control.
STA	Show recloser control self-test status.
TAR *n k*	Display Relay Word row. If *n* = 0–60, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
TAR R	Reset the front-panel tripping targets.
TIM	Show or set time (24 hour time). Show time presently in the recloser control by entering just **TIM**. Example time 22:47:36 is entered with command **TIM 22:47:36**.
TRI	Trigger an event report.

[a] The **DNP** command is only available when the protocol of one of the serial ports is set to DNP.

Access Level E Commands	Access Level E (EZ) commands primarily allow you to set EZ settings and global EZ settings. All Access Level 1 commands can also be executed from Access Level E. The Access Level E screen prompt is: =+>
BTT	Display latest battery load test results and time remaining until next discharge test.
BTT NOW	Initiate battery load test immediately.
SET EZ *n*	Change EZ recloser control settings for settings group *n* (*n* = 1–6). EZ recloser control settings override and change a number of the “regular” settings made with the **SET *n*** command (Access Level 2).
SET FZ	Change EZ global settings. EZ global settings override and change a number of the global settings made with the **SET G** command (Access Level 2).

Access Level B Commands	Access Level B commands primarily allow you to operate control parameters and output contacts. All Access Level 1 and Access Level E commands can also be executed from Access Level B. The screen prompt is: ==>
BRE R	Reset breaker/recloser contact wear and trip operation counters.
BRE W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
CLO	Close the recloser or circuit breaker.
GRO *n*	Change active settings group to settings group *n* (*n* = 1–6).
OPE	Open the recloser or circuit breaker.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.

Access Level 2 Commands	Access Level 2 commands allow unlimited access to control settings, parameters, and output contacts. All Access Level 1, Access Level E, and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON *n*	Control Relay Word bit RB*n*, Remote Bit *n* where *n* = 1–16. Execute **CON *n*** and the control responds: `CONTROL RBn`. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* [assert RB*n* for 1/4 cycle].
COP *m n*	Copy settings and logic equations from settings group *m* to settings group *n*.
DNP[a] ***type***	Set DNP map.
LOO	Set MIRRORED BITS port to loopback.
PAS 1	Change Access Level 1 password.
PAS E	Change Access Level E (EZ) password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change Access Level C password.
SET *n*	Change “regular” settings for settings group *n* (*n* = 1–6).
SET G	Change global settings.
SET L *n*	Change SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SET P *n*	Change port settings for port *n* (*n* = 1, 2, 3, F).
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings for front-panel display and extra local control.
STA C	Clears status warning or failure and reboots recloser control.
VER	Show firmware version and options.

[a] The DNP command is only available when the protocol of one of the serial ports is set to DNP.

Access Level C Commands	Access Level C is reserved for SEL use only.
PAS C	Change the Access Level C password.

Key Stroke Commands	Description
<Ctrl+Q>	Send **XON** command to restart communication port output previously halted by **XOFF**.
<Ctrl+S>	Send **XOFF** command to pause communication port output.
<Ctrl+X>	Send **CANCEL** command to abort current command and return to current access level prompt.

Key Stroke Commands When Using SET Command	Description
<Enter>	Retains setting and moves on to next setting.
^ **<Enter>**	Returns to previous setting.
< **<Enter>**	Returns to previous setting section.
> **<Enter>**	Skips to next setting section.
END <Enter>	Exits setting editing session, then prompts user to save settings.
<Ctrl + X>	Aborts setting editing session without saving changes.

Section 11

Additional Front-Panel Interface Details

Overview

This section describes additional SEL-351R Recloser Control front-panel interface details not covered in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide*.

Functions Unique to the Front-Panel Interface

Two front-panel primary functions do *not* have serial port command equivalents. These are:

- ➤ Reclosing relay shot counter screen (accessed via the **OTHER** pushbutton)
- ➤ Extra local control (accessed via the **CNTRL** pushbutton; this is not the control available via the operator control pushbuttons on the bottom half of the SEL-351R front panel)

Reclosing Relay Shot Counter Screen

Use this screen to see the progression of the shot counter during reclosing relay testing.

Access the reclosing relay shot counter screen via the **OTHER** pushbutton. The following screen appears:

```
BTT DATE TIME
79  TAR  BRK_MON
```

Scroll down with the down arrow button and select function `79`. Upon selecting function `79`, the following screen appears (shown here with factory-default settings):

```
SET RECLOSURES=3
RECLOSE COUNT =0
```

If the reclosing function does not exist (see *Reclosing Relay on page 6.9*), the following screen appears:

```
No Reclosing set
```

The corresponding text label settings (shown with factory-default settings) are:

79LL = **SET RECLOSURES** (Last Shot Label—limited to 14 characters)

79SL = **RECLOSE COUNT** (Shot Counter Label—limited to 14 characters)

These text label settings are set with the **SET T** command or viewed with the **SHOWSET T** command via the serial port [see *Section 9: Setting the SEL-351R Recloser Control* and *SHO Command (Show/View Settings) on page 10.25*].

The top numeral in the above example screens (SET RECLOSURES=3) corresponds to the "last shot" value, which is a function of the number of set open intervals. There are three set open intervals in the factory-default settings, thus three reclosures (shots) are possible in a reclose sequence.

The bottom numeral in the above example screens [RECLOSE COUNT = 0 (or = 3)] corresponds to the "present shot" value. If the breaker is closed and the reclosing relay is reset (**RESET** LED on front panel is illuminated), RECLOSE COUNT = 0. If the breaker is open and the reclosing relay is locked out after a reclose sequence (**LOCKOUT** LED on front panel is illuminated), RECLOSE COUNT = 3.

SEL-351R Recloser Control Shot Counter Screen Operation (With Factory Settings)

With the recloser closed and the SEL-351R Recloser Control in the reset state (front-panel **RESET** LED illuminated), the shot counter screen appears as:

```
SET RECLOSURES=3
RECLOSE COUNT =0
```

The SEL-351R trips the recloser open and goes to the reclose cycle state (front-panel **CYCLE** LED illuminates). The shot counter screen still appears as:

```
SET RECLOSURES=3
RECLOSE COUNT =0
```

The first open interval (79OI1 = 300) times out, the shot counter increments from 0 to 1, and the SEL-351R recloses the recloser. The shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=3
RECLOSE COUNT =1
```

The SEL-351R trips the recloser open again. The shot counter screen still appears as:

```
SET RECLOSURES=3
RECLOSE COUNT =1
```

The second open interval (79OI2 = 600) times out, the shot counter increments from 1 to 2, and the SEL-351R recloses the recloser. The shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=3
RECLOSE COUNT =2
```

If the SEL-351R trips, recloses, then trips again, the SEL-351R goes to the lockout state (front-panel **LOCKOUT** LED illuminates). The shot counter screen then appears as:

```
SET RECLOSURES=3
RECLOSE COUNT =3
```

If the recloser is closed, the reset timer times out (79RSLD = 600), the SEL-351R goes to the reset state (front-panel **LOCKOUT** LED extinguishes and **RESET** LED illuminates), and the shot counter returns to 0. The shot counter screen appears as:

```
SET RECLOSURES=3
RECLOSE COUNT =0
```

Extra Local Control

Use extra local control to enable/disable schemes, trip/close breakers, etc., via the front panel.

In more specific terms, local control asserts (sets to logical 1) or deasserts (sets to logical 0) what are called local bits LB1–LB16. These local bits are available as Relay Word bits and are used in SELOGIC® control equations (see Rows 25 and 58 in *Table 9.7*).

Local control can emulate the following switch types in *Figure 11.1–Figure 11.3*.

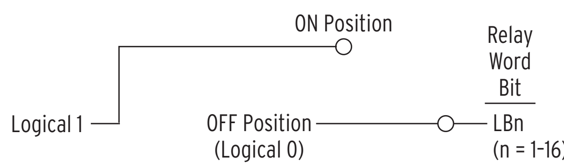


Figure 11.1 Local Control Switch Configured as an ON/OFF Switch

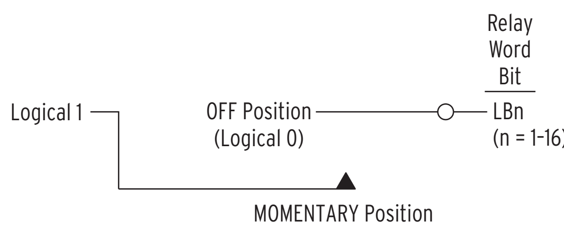


Figure 11.2 Local Control Switch Configured as an OFF/MOMENTARY Switch

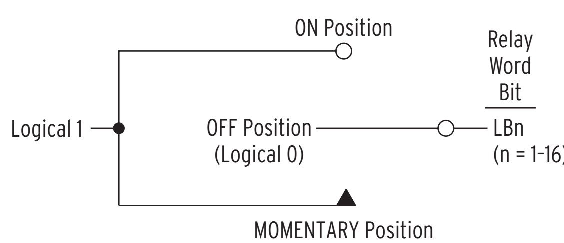


Figure 11.3 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Local control switches are created by making corresponding switch position label settings. These text label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port [see *Section 9: Setting the SEL-351R Recloser Control* and *SHO Command (Show/View Settings) on page 10.25*]. See *Local Control Switches on page 7.4* for more information on local control.

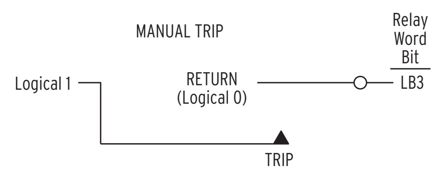
View Extra Local Control (With Factory Settings)

Access extra local control via the **CNTRL** pushbutton. If local control switches exist (i.e., corresponding switch position label settings were made), the following message displays with the rotating default display messages.

```
Press CNTRL for
Extra Control
```

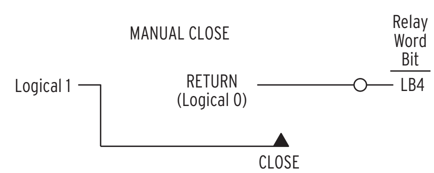
Press the **CNTRL** pushbutton, and the first set local control switch displays (shown here with example settings):

```
MANUAL TRIP ←→
Extra Control
```



Press the **Right Arrow** pushbutton, and scroll to the next set local control switch:

```
MANUAL CLOSE ←→
Position: RETURN
```



The `MANUAL TRIP: RETURN/TRIP` and `MANUAL CLOSE: RETURN/CLOSE` switches are both OFF/MOMENTARY switches (see *Figure 11.2*).

There are no more local control switches in the example settings. Press the **Right Arrow** pushbutton, and scroll to the `Output Contact Testing` function:

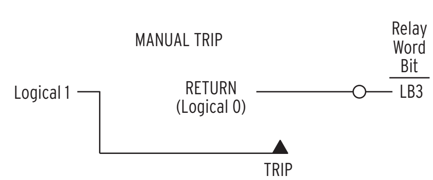
```
Output Contact←→
Testing
```

This front-panel function provides the same function as the serial port **PUL** command.

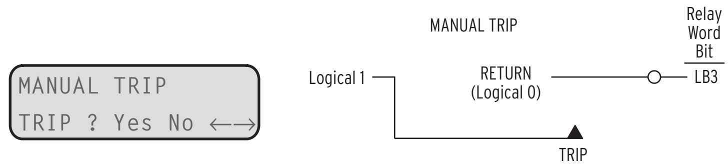
Operate Extra Local Control (Example Settings)

Press the **Right Arrow** pushbutton, and scroll back to the first set local control switch in the example settings:

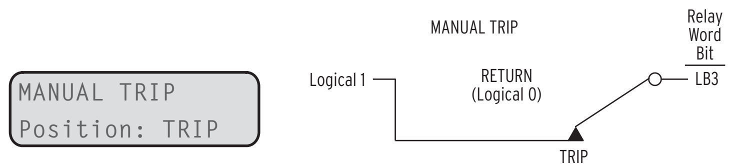
```
MANUAL TRIP ←→
Position: RETURN
```



Press the **SELECT** pushbutton, and the operate option for the displayed local control switch displays:



Scroll left with the **Left Arrow** button and then select `Yes`. The display then shows the new local control switch position:



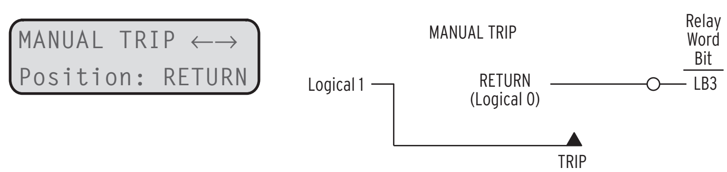
Because this is an OFF/MOMENTARY type switch, the `MANUAL TRIP` switch returns to the `RETURN` position after momentarily being in the `TRIP` position. Technically, the `MANUAL TRIP` switch (being an OFF/MOMENTARY type switch) is in the:

> `TRIP` position for one processing interval (1/4 cycle; long enough to assert the corresponding local bit LB3 to logical 1).

and then returns to the:

> `RETURN` position (local bit LB3 deasserts to logical 0 again).

On the display, the `MANUAL TRIP` switch is shown to be in the `TRIP` position for two seconds (long enough to be seen), and then it returns to the `RETURN` position:



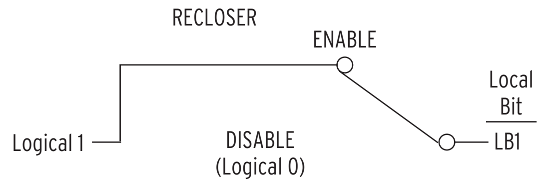
The `MANUAL CLOSE` switch is an OFF/MOMENTARY type switch, like the `MANUAL TRIP` switch, and operates similarly.

See *Local Control Switches on page 7.4* for details on how local bit outputs LB3 and LB4 are set in SELOGIC control equation settings to respectively trip and close a circuit breaker.

Local Control State Retained When Control De-Energized

Local bit states are stored in nonvolatile memory, so when power to the control is turned off, the local bit states are retained.

For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see *Figure 11.1*). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:

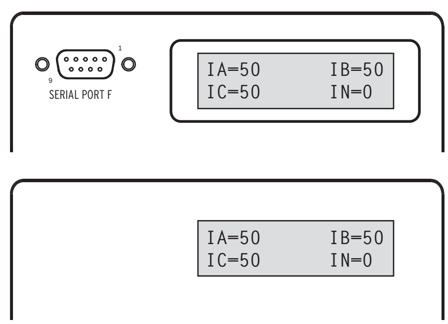


If power to the control is turned off and then turned on again, local bit LB1 remains at logical 1, and reclosing is still enabled. This is akin to a traditional panel, where enabling/disabling of reclosing and other functions is accomplished by panel-mounted switches. If dc control voltage to the panel is lost and then restored again, the switch positions are still in place. If the reclosing switch is in the enable position (switch closed) before the power outage, it will be in the same position after the outage when power is restored.

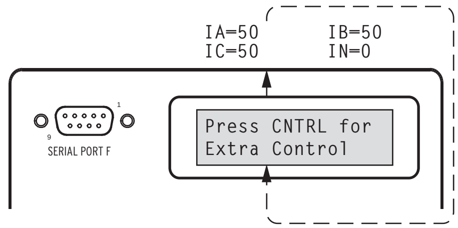
See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, respectively) on page 6.17* for more information on setting 79DTL.

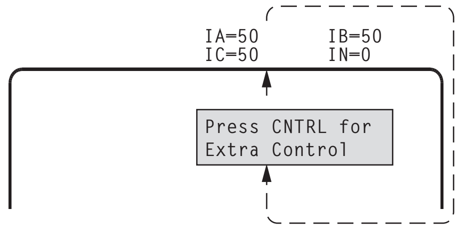
Rotating Default Display

The channel `IA`, `IB`, `IC`, and `IN` current values (in A primary) display continually if no local control is operational (i.e., no corresponding switch position label settings were made) and no display point labels are enabled for display.

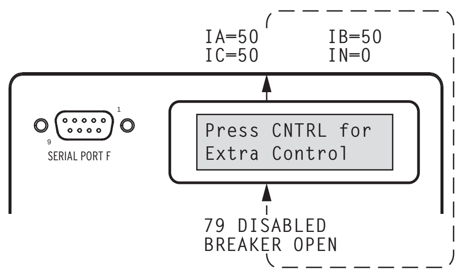


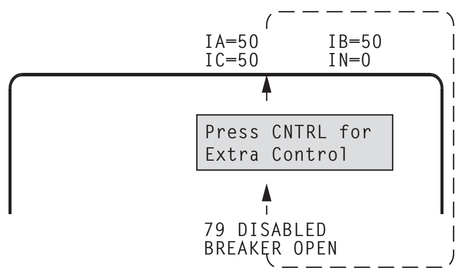
The `Press CNTRL for Extra Control` message displays in a “2 seconds per screen” rotation with the default metering screen if at least one local control switch is operational. It is a reminder of how to access the local control function. See the preceding discussion in this section and *Local Control Switches on page 7.4* for more information on local control.





If display point labels (e.g., `79 DISABLED` and `BREAKER OPEN`) are enabled for display, they also enter into the "2 seconds per screen" rotation.





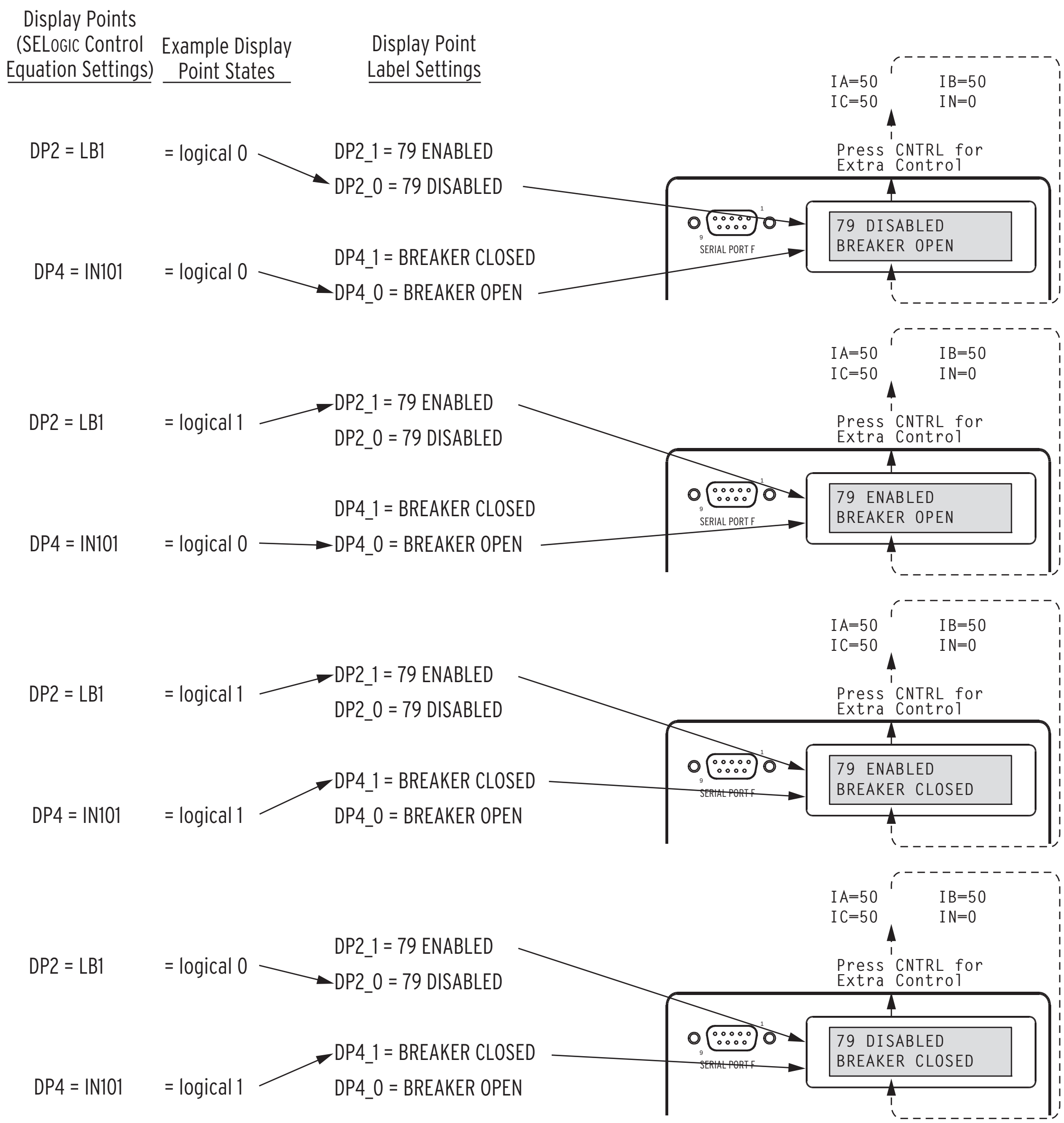
The following table and figures demonstrate the correspondence between changing display point states (e.g., DP2 and DP4) and enabled display point labels (DP2_1/DP2_0 and DP4_1/DP4_0, respectively). The display is on a two-second rotation for each screen.

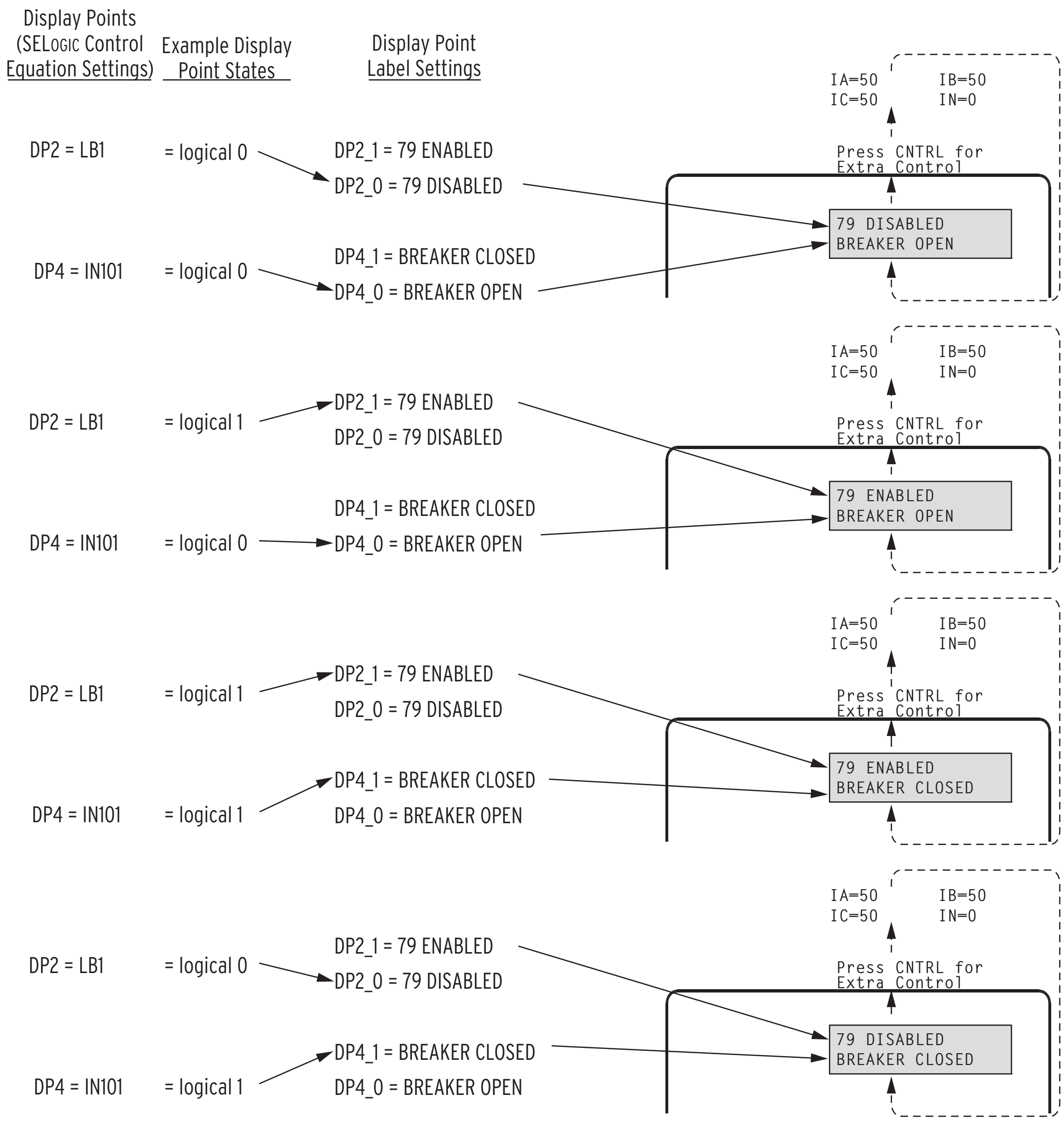
The display point example settings are:

DP2 = **LB1** (local bit LB1)

DP4 = **IN101** (optoisolated input IN101)

Local bit LB1 is used as a recloser enable/disable in this example. Optoisolated input IN101 is used as a circuit breaker status input in this example (a 52a circuit breaker auxiliary contact is connected to input IN101; see *Optoisolated Inputs on page 7.1*).


Display Points (SELOGIC Control Equation Settings)
Example Display Point States
Display Point Label Settings
DP2 = LB1
= logical 0
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 0
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50 IN=0
Press CNTRL for Extra Control
SERIAL PORT F
79 DISABLED
BREAKER OPEN
DP2 = LB1
= logical 1
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 0
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50 IN=0
Press CNTRL for Extra Control
SERIAL PORT F
79 ENABLED
BREAKER OPEN
DP2 = LB1
= logical 1
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 1
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50 IN=0
Press CNTRL for Extra Control
SERIAL PORT F
79 ENABLED
BREAKER CLOSED
DP2 = LB1
= logical 0
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 1
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50 IN=0
Press CNTRL for Extra Control
SERIAL PORT F
79 DISABLED
BREAKER CLOSED



In the preceding example, only two display points (DP2 and DP4) and their corresponding display point labels are set. If additional display points and corresponding display point labels are set, the additional enabled display point labels join the “2 seconds per screen” rotation on the front-panel display.

Display point label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port [see *Section 9: Setting the SEL-351R Recloser Control* and *SHO Command (Show/View Settings) on page 10.25*].

For more detailed information on the logic behind the rotating default display, see *Rotating Default Display on page 7.29*.

Additional Rotating Default Display Example

See *Figure 5.17* and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the TARGET RESET pushbutton.

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Section 12
Standard Event Reports and SER

Overview

The SEL-351R Recloser Control offers two styles of event reports:

- Standard 15- or 30-cycle event reports
- Sequential Events Recorder (SER) Report

Resolution: 1 ms

Accuracy: +1/4 cycle

These event reports contain the following information:

- date
- time
- current
- voltage
- frequency
- relay element
- optoisolated input
- output contact
- fault location

The control generates (triggers) standard 15/30-cycle event reports by fixed and programmable conditions. These reports show information for 15 or 30 continuous cycles. As many as twenty-eight 15-cycle or fourteen 30-cycle reports are stored in nonvolatile memory; if more reports are triggered, the newest event report overwrites the oldest event report. See *Figure 12.2* for an example standard 15-cycle event report.

The control adds lines in the SER report for a change of state of a programmable condition. The SER lists date and time-stamped lines of information each time a programmed condition changes state. The control stores the latest 512 lines of the SER report in nonvolatile memory. If the report fills up, newer rows overwrite the oldest rows in the report. See *Figure 12.5* for an example SER report.

Standard 15/30-Cycle Event Reports

NOTE: Figure 12.2 is on multiple pages.

See *Figure 12.2* for an example event report.

Event Report Length (Settings LER and PRE)

The SEL-351R provides user-programmable event report length and prefault length. Event report length is either 15 or 30 cycles. Prefault length ranges from 1 to 29 cycles. Prefault length is the first part of the event report that precedes the event report triggering point.

Set the event report length with the Access Level 2 global (**SET G**) LER setting and the prefault length with the PRE setting. See the **SET G** command in *Table 9.1* and corresponding *Global Settings (Serial Port Command SET G and Front Panel) on page SET.21* for instructions on setting the LER and PRE settings.

Changing the LER setting erases all events stored in nonvolatile memory. Changing the PRE setting has no effect on the nonvolatile reports. The factory-default settings are LER = 15 and PRE = 4.

Standard Event Report Triggering

The control triggers (generates) a standard event report when any of the following occur:

- Relay Word bit TRIP asserts
- Programmable SELOGIC® control equation setting ER asserts to logical 1
- **TRI** (Trigger Event Reports) serial port command executed
- Output contacts OUT101–OUT107 pulsed via the serial port or front-panel **PUL** (Pulse Output Contact) command

Relay Word Bit TRIP

Refer to *Figure 5.1*. If Relay Word bit TRIP asserts to logical 1, an event report is generated automatically. Thus, any condition that causes a trip does not have to be entered in SELOGIC control equation setting ER.

For example, SELOGIC control equation trip setting TR is unsupervised. Any trip condition that asserts in setting TR causes the TRIP Relay Word bit to assert immediately. The factory setting for trip setting TR is:

TR = **SV1 + 51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T + PB9 + OC**

If any of the individual conditions assert, Relay Word bit TRIP asserts, and an event report is generated automatically. All of the 51*xx*T and 67*xx*T Relay Word bits represent time-delayed overcurrent tripping functions; 81D1T is a time-delayed underfrequency tripping function that is turned off in the factory-default settings; PB9 is the front-panel control TRIP pushbutton; and OC is the serial port **OPEN** command output. Because the TRIP function automatically triggers an event report, these conditions do not have to be entered in SELOGIC control equation Event Report trigger setting ER.

In the factory-default settings, Relay Word bit TRIP (in *Figure 5.1*) is assigned to the RCTR SELOGIC control equation setting for tripping the recloser (e.g., SELOGIC control equation setting RCTR = TRIP; see *Figure 7.29*).

Programmable SELOGIC Control Equation Setting ER

The programmable Access Level 2 (**SET L**) SELOGIC control equation event report trigger setting ER is set to trigger standard event reports for conditions other than trip conditions. When the ER function goes from logical 0 to logical 1, it generates an event report if the SEL-351R is not already generating a report that encompasses the new transition. The factory-default ER setting is:

ER = **/51P1 + /51P2 + /51G1 + /51G2 + /51N1 + /51N2 + /67N3**

With this setting, the SEL-351R triggers an event on the pickup (rising edge) of any of the time-overcurrent elements, 51*xx*, or the pickup of the sensitive earth fault element 67N3.

Note the rising-edge operator / in front of each of these elements. See *Appendix G: Setting SELOGIC Control Equations* for more information on rising-edge operators and SELOGIC control equations in general.

Rising-edge operators are especially useful in generating an event report at fault inception and then generating another later if a breaker failure condition occurs. For example, at the inception of a ground fault, 51G1 picks up, generating an event report:

```
ER = ... + /51G1 + ... = logical 1 (for one processing
interval)
```

Even though the 51G1 pickup indicator remains asserted for the duration of the ground fault, the rising-edge operator, /, in front of 51G1 (/51G1) causes setting ER to assert for only one processing interval.

Falling-edge operators, \, also may be used to generate event reports. See *Figure G.2* for more information on falling-edge operators.

TRI (Trigger Event Report) and PUL (Pulse Output Contact) Commands

The sole function of the serial port Trigger command, **TRI**, is to generate standard event reports, primarily for testing purposes.

The Pulse Output command, **PUL**, asserts the output contacts for testing purposes or for remote control. If output contact OUT101–OUT107 asserts via the **PUL** command, the control automatically triggers a standard event report. The **PUL** command is available through serial port communication and the control front-panel CNTRL pushbutton.

See *Section 10: Serial Port Communications and Commands* and Pushbutton Primary Functions, CNTRL pushbutton in Section 3 of the *SEL-351R-4 Quick-Start Installation and User's Guide* for more information on the **TRI** and **PUL** commands.

Standard Event Report Summary

Each time the control generates a standard event report, it also generates a corresponding event summary (see *Figure 12.1*). Event summaries contain the following information:

- Control and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Fault location
- Recloser shot count at the trigger time
- System frequency at the front of the event report

- Front-panel fault type targets at the time of trip
- Phase (IA, IB, IC), neutral ground (IN), calculated residual ground ($I_G = 3I_0$), and negative-sequence ($3I_2$) currents

The control includes the event summary in the standard event report. The identifiers, date, and time information are at the top of the standard event report, and the other information follows. See *Figure 12.2*.

NOTE: Figure 12.2 is on multiple pages.

The example event summary in *Figure 12.1* corresponds to the full-length standard 15-cycle event report in *Figure 12.2*:

```
RECLOSER R1                        Date: 06/01/12 Time:  12:23:52.527
FEEDER 2101

Event:  AG T  Location:    3.89  Shot:  0  Frequency:  60.01
Targets:  11001100 01010010
Currents (A Pri), ABCNGQ:   991   160   159     0   986   984
```

Figure 12.1 Example Event Summary

The control sends event summaries to all serial ports with setting AUTO = Y each time an event triggers.

The latest twenty-eight 15-cycle or fourteen 30-cycle event summaries are stored in nonvolatile memory and are accessed by the **HIS** (Event Summaries/History) command.

Event Type

The `Event:` field shows the event type. The possible event types and their descriptions are shown in *Table 12.1*. Note the correspondence to the preceding event report triggering conditions (see *Standard Event Report Triggering on page 12.2*).

Table 12.1 Event Types

Event Type	Description
AG, BG, CG	Single phase-to-ground faults. Appends T if TRIP asserted.
ABC	Three-phase faults. Appends T if TRIP asserted.
AB, BC, CA	Phase-to-phase faults. Appends T if TRIP asserted.
ABG, BCG, CAG	Two phase-to-ground faults. Appends T if TRIP asserted.
TRIP	Assertion of Relay Word bit TRIP (phase involvement indeterminate, so only TRIP is displayed).
ER	SELOGIC control equation setting ER. Phase involvement is indeterminate.
TRIG	Execution of **TRIGGER** command.
PULSE	Execution of **PULSE** command.

The event type designations `AG`–`CAG` in *Table 12.1* only are entered in the `Event:` field if the fault type is determined successfully. If the fault type is not determined successfully, just `TRIP` or `ER` is displayed.

Fault Location

The control reports the fault location if the EFLOC setting = Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully or if EFLOC = N (Fault Locator is not enabled), `$$$$$$` is listed in the field. Fault location is based upon the Access Level 2 line impedance settings Z1MAG, Z1ANG, Z0MAG, Z0ANG, and corresponding line length setting LL. Three-phase voltages need to be applied to the SEL-351R for proper operation of the fault locator. This requires the optional three-phase potential transformers be installed in the recloser control. The EZ Level Global setting, True three-phase voltage connected (Y,N) must be set to Y (yes), which forces Access Level 2 Global setting, 3PVOLT, (three-phase voltages connected) to Y (yes). See the **SET** command in *Table 9.1* and corresponding *Line Settings on page SET.1* for information on the line parameter settings.

Targets

The control reports the targets at the rising edge of TRIP. The targets are displayed in binary format. See *Front-Panel Status and Trip Target LEDS on page 1.56*.

Currents

The `Currents (A pri), ABCNGQ:` field shows the currents present in the event report row containing the maximum phase current. The listed currents are:

- Phase (A = channel IA, B = channel IB, C = channel IC)
- Neutral ground (N = channel IN)
- Calculated residual ($I_G = 3I_0$; calculated from channels IA, IB, and IC)
- Negative-sequence ($Q = 3I_2$; calculated from channels IA, IB, and IC)

Retrieving Full-Length Standard Event Reports

The latest twenty-eight 15-cycle or fourteen 30-cycle event reports are stored in nonvolatile memory. Each event report includes four sections:

- Current, voltage, frequency, contact outputs, optoisolated inputs
- Protection and control elements
- Event summary
- Group, SELOGIC control equations, and global settings

Use the **EVE** command to retrieve the reports. There are several options to customize the report format. The general command format is:

EVE [*n* Sx L*y* L R A D C]

where:

n	Event number (1–28) if LER = 15; (1–14) if LER = 30. Defaults to 1 if not listed, where 1 is the most recent event.
S*x*	Display *x* samples per cycle (4 or 16); defaults to 4 if not listed.
L*y*	Display *y* cycles of data (1–LER). Defaults to LER value if not listed. Unfiltered reports (R parameter) display an extra cycle of data.
L	Display 16 samples per cycle; same as the S16 parameter.
R	Specify the unfiltered (raw) event report. Defaults to 16 samples per cycle unless overridden with the S*x* parameter.
A	Specify that only the analog section of the event is displayed (current, voltage, frequency, contact outputs, optoisolated inputs).

D Specify that only the digital section (Protection and Control Elements) of the event is displayed.

M Display only the communication/MIRRORED BITS® portion of the event report.

C Display the report in Compressed ASCII format for use by the ACSELERATOR Analytic Assistant® SEL-5601 Software.

Below are example **EVE** commands.

Serial Port Command	Description
EVE	Display the most recent event report at 1/4 cycle resolution.
EVE 2	Display the second event report at 1/4 cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16 cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at 1/4 cycle resolution.
EVE L	Display the most recent report at 1/16 cycle resolution.
EVE R	Display the most recent report at 1/16 cycle resolution; analog and digital data are unfiltered (raw).
EVE 2 D L10	Display 10 cycles of the protection and control elements section of the second event report at 1/4 cycle resolution.
EVE 2 A R S4	Display the unfiltered analog section of the second event report at 1/4 cycle resolution.

If an event report is requested that does not exist, the control responds: `Invalid Event`.

Compressed ASCII Event Reports

The SEL-351R provides Compressed ASCII event reports to facilitate event report storage and display. The SEL-2032, SEL-2030, and SEL-2020 Communications Processor and the ACSELERATOR Analytic Assistant software take advantage of the Compressed ASCII format. Use the **EVE C** command or **CEVENT** command to display Compressed ASCII event reports. See the **CEVENT** command discussion in *Appendix E: Compressed ASCII Commands* for further information.

Filtered and Unfiltered Event Reports

The SEL-351R samples the basic power system measurands (ac voltage, ac current, and optoisolated inputs) 16 times per power system cycle. The control filters the measurands to remove transient signals, operates on the filtered values, and reports them in the event report.

To view the raw inputs to the control, select the unfiltered event report (e.g., **EVE R**). Use the unfiltered event reports to observe:

- Power system harmonics on channels IA, IB, IC, IG, VA, VB, VC, VS
- Decaying dc offset during fault conditions on IA, IB, IC
- Optoisolated input contact bounce on channels IN101–IN106

The filters for ac current and voltage are fixed. You can adjust the optoisolated input debounce via debounce settings (see *Figure 7.1*).

Raw event reports display one extra cycle of data at the beginning of the report.

Clearing Standard Event Report Buffer

The **HIS C** command clears the event summaries and corresponding standard event reports from nonvolatile memory. See *Section 10: Serial Port Communications and Commands* for more information on the **HIS** (Event Summaries/History) command.

Standard Event Report Column Definitions

NOTE: Figure 12.2 is on multiple pages.

Refer to the example event report in *Figure 12.2* to view event report columns. This example event report displays rows of information each 1/4 cycle retrieved with the **EVE** command.

The columns contain ac current, ac voltage, frequency, output, input, and protection and control element information.

Current, Voltage, and Frequency Columns

Table 12.2 summarizes the event report current, voltage, and frequency columns.

Table 12.2 Standard Event Report Current, Voltage, and Frequency Columns

Column Heading	Definition
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Calculated residual current IG = $3I_0$ = IA + IB + IC (primary A)
VA	Voltage measured by channel VA (primary kV, wye-connected)
VB	Voltage measured by channel VB (primary kV, wye-connected)
VC	Voltage measured by channel VC (primary kV, wye-connected)
VS	Voltage measured by input **VS** (primary kV)
Freq	Frequency of voltage input **V1** (Hz)

Note that the ac values change from plus to minus (–) values in *Figure 12.2*, indicating the sinusoidal nature of the waveforms.

Other figures help explain the information available in the event report current columns:

Figure 12.3: shows how event report current column data relates to the actual sampled current waveform and rms current values.

Figure 12.4: shows how event report current column data can be converted to phasor rms current values.

Output, Input, Protection, and Control Columns

Table 12.3 summarizes the event report output, input, protection, and control columns. See *Table 9.6* and *Table 9.7* for more information on Relay Word bits shown in *Table 12.3*.

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated.
Analog Section of Event Report			
Out 12[a]	OUT101, OUT102	1	Output contact OUT101 asserted
		2	Output contact OUT102 asserted
		b	Both OUT101 and OUT102 asserted
Out 34[a]	OUT103, OUT104	3	Output contact OUT103 asserted
		4	Output contact OUT104 asserted
		b	Both OUT103 and OUT104 asserted
Out 56[a]	OUT105, OUT106	5	Output contact OUT105 asserted
		6	Output contact OUT106 asserted
		b	Both OUT105 and OUT106 asserted
Out 7A[a]	OUT107, ALARM	7	Output contact OUT107 asserted
		A	Output contact ALARM asserted
		b	Both OUT107 and ALARM asserted
Out TC	RCTR, RCCL (see *Figure 7.29*)	T	High voltage trip FET (RCTR) asserted
		C	High voltage close FET (RCCL) asserted
		b	Both RCTR and RCCL asserted
In 12	IN101, IN102	1	Optoisolated input IN101 asserted
		2	Optoisolated input IN102 asserted
		b	Both IN101 and IN102 asserted
In 34	IN103, IN104	3	Optoisolated input IN103 asserted
		4	Optoisolated input IN104 asserted
		b	Both IN103 and IN104 asserted
In 56	IN105, IN106	5	Optoisolated input IN105 asserted
		6	Optoisolated input IN106 asserted
		b	Both IN105 and IN106 asserted
In BC	PINBD, PINC (see *Figure 7.29*)	B	Control cable pin BD input (PINBD) asserted
		C	Control cable pin C input (PINC) asserted
		b	Both PINBD and PINC asserted
In EF	PINE, PINF (see *Figure 7.29*)	E	Control cable pin E input (PINE) asserted
		F	Control cable pin F input (PINF) asserted
		b	Both PINE and PINF asserted
Digital Protection and Control Section of Event Report			
51P1 51P2	51P1, 51P1T, 51P1R 51P2, 51P2T, 51P2R	.	Time-overcurrent element reset (51_R)
51N1 51N2	51N1, 51N1T, 51N1R 51N2, 51N2T, 51N2R	p	Time-overcurrent element picked up and timing (51_)
51G1 51G2	51G1, 51G1T, 51G1R 51G2, 51G2T, 51G2R	T	Time-overcurrent element timed out (51_T)

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
51Q	51Q, 51QT, 51QR	r	Time-overcurrent element timing to reset
		1	Time-overcurrent element timing to reset after having timed out (when element reset is set for 1 cycle, not electromechanical reset).
50 P	50A, 50B, 50C	A	Single-phase instantaneous overcurrent Element 50A picked up
		B	Single-phase instantaneous overcurrent Element 50B picked up
		C	Single-phase instantaneous overcurrent Element 50C picked up
		a	Both 50A and 50B picked up
		b	Both 50B and 50C picked up
		c	Both 50C and 50A picked up
		3	50A, 50B, and 50C picked up
50 PP	50AB1, 50AB2, 50AB3, 50AB4, 50BC1, 50BC2,	A	Phase-to-phase instantaneous overcurrent Element 50AB1, 50AB2, 50AB3, or 50AB4 picked up
	50BC3, 50BC4, 50CA1, 50CA2, 50CA3, 50CA4	B	Phase-to-phase instantaneous overcurrent Element 50BC1, 50BC2, 50BC3, or 50BC4 picked up
		C	Phase-to-phase instantaneous overcurrent Element 50CA1, 50CA2, 50CA3, or 50CA4 picked up
		a	50AB_ and 50CA_ picked up
		b	50AB_ and 50BC_ picked up
		c	50BC_ and 50CA_ picked up
		3	50AB_, 50BC_, and 50CA_ picked up
32 PQ	F32P	P	Forward phase directional Element F32P picked up
	R32P	p	Reverse phase directional Element R32P picked up
	F32Q	Q	Forward negative-sequence directional Element F32Q picked up
	R32Q	q	Reverse negative-sequence directional Element R32Q picked up
32 NG	F32QG	Q	Forward negative-sequence directional Element F32QG picked up
	R32QG	q	Reverse negative-sequence R32QG picked up
	F32V	V	Forward zero-sequence voltage-polarized, residual-current Element F32V picked up
	R32V	v	Reverse zero-sequence voltage-polarized, residual-current R32V picked up
	F32N	N	Forward zero-sequence voltage-polarized, neutral current directional Element F32N picked up
	R32N	n	Reverse zero-sequence voltage-polarized, neutral current directional Element R32N picked up
67 P 67N 67G 67 Q	67P1–67P4 67N1–67N4 67G1–67G4 67Q1–67Q4	4	Level 4 instantaneous Element 67_4 picked up; Levels 1, 2, and 3 not picked up
		3	Level 3 instantaneous Element 67_3 picked up; Levels 1 and 2 not picked up
		2	Level 2 instantaneous Element 67_2 picked up; Level 1 not picked up
		1	Level 1 instantaneous Element 67_1 picked up

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 3 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
DM PQ	PDEM, QDEM	P	Phase demand ammeter Element PDEM picked up
		Q	Negative-sequence demand ammeter Element QDEM picked up
		b	Both PDEM and QDEM picked up
DM NG	NDEM, GDEM	N	Neutral ground demand ammeter Element NDEM picked up
		G	Residual ground demand ammeter Element GDEM picked up
		b	Both NDEM and GDEM picked up
27 P	27A1, 27A2, 27B1, 27B2, 27C1, 27C2	A	A-phase instantaneous undervoltage Element 27A1 or 27A2 picked up
		B	B-phase instantaneous undervoltage Element 27B1 or 27B2 picked up
		C	C-phase instantaneous undervoltage Element 27C1 or 27C2 picked up
		a	27A_ and 27B_ elements picked up
		b	27B_ and 27C_ elements picked up
		c	27C_ and 27A_ elements picked up
		3	27A_, 27B_, and 27C_ elements picked up
27 PP	27AB, 27BC, 27CA	A	AB phase-to-phase instantaneous undervoltage Element 27AB picked up
		B	BC phase-to-phase instantaneous undervoltage Element 27BC picked up
		C	CA phase-to-phase instantaneous undervoltage Element 27CA picked up
		a	27AB and 27CA elements picked up
		b	27AB and 27BC elements picked up
		c	27BC and 27CA elements picked up
		3	27AB, 27BC, and 27CA elements picked up
27 S	27S	*	Channel VS instantaneous undervoltage Element 27S picked up
59 P	59A1, 59A2, 59B1, 59B2, 59C1, 59C2	A	A-phase instantaneous overvoltage Element 59A1 or 59A2 picked up
		B	B-phase instantaneous overvoltage Element 59B1 or 59B2 picked up
		C	C-phase instantaneous overvoltage Element 59C1 or 59C2 picked up
		a	59A_ and 59B_ elements picked up
		b	59B_ and 59C_ elements picked up
		c	59C_ and 59A_ elements picked up
		3	59A_, 59B_, and 59C_ elements picked up

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 4 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
59 PP	59AB, 59BC, 59CA	A	AB phase-to-phase instantaneous overvoltage Element 59AB picked up
		B	BC phase-to-phase instantaneous overvoltage Element 59BC picked up
		C	CA phase-to-phase instantaneous overvoltage Element 59CA picked up
		a	59AB and 59CA elements picked up
		b	59AB and 59BC elements picked up
		c	59BC and 59CA elements picked up
		3	59AB, 59BC, and 59CA elements picked up
59 V1Q	59V1, 59Q	1	Positive-sequence instantaneous overvoltage Element 59V1 picked up
		Q	Negative-sequence instantaneous overvoltage Element 59Q picked up
		b	Both 59V1 and 59Q picked up
59 N	59N1, 59N2	1	First ground instantaneous overvoltage Element 59N1 picked up
		2	Second ground instantaneous overvoltage Element 59N2 picked up
		b	Both 59N1 and 59N2 picked up
59 S	59S1, 59S2	1	First channel VS instantaneous overvoltage Element 59S1 picked up
		2	Second channel VS instantaneous overvoltage Element 59S2 picked up
		b	Both 59S1 and 59S2 picked up
59 V	59VP, 59VS	P	Phase voltage window Element 59VP picked up (used in synchronism check)
		S	Channel VS voltage window Element 59VS picked up (used in synchronism check)
		b	Both 59VP and 59VS picked up
25 SF	SF	*	Slip frequency element SF picked up (used in synchronism check)
25 A	25A1, 25A2	1	First synchronism-check element 25A1 element picked up
		2	Second synchronism-check element 25A2 element picked up
		b	Both 25A1 and 25A2 picked up
81 27B	27B81	*	Frequency logic instantaneous undervoltage Element 27B81 picked up
81 12	81D1, 81D2	1	Frequency Element 81D1 picked up
		2	Frequency Element 81D2 picked up
		b	Both 81D1 and 81D2 picked up
81 34	81D3, 81D4	3	Frequency Element 81D3 picked up
		4	Frequency Element 81D4 picked up
		b	Both 81D3 and 81D4 picked up

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 5 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
81 56	81D5, 81D6	5	Frequency Element 81D5 picked up
		6	Frequency Element 81D6 picked up
		b	Both 81D5 and 81D6 picked up
79	RCSF, CF, 79RS,	.	Reclosing function disabled
	79CY, 79LO	S	Reclose supervision failure condition (RCSF asserts for only 1/4 cycle)
		F	Close failure condition (CF asserts for only 1/4 cycle)
		R	Reclosing relay in Reset State (79RS)
		C	Reclosing relay in Reclose Cycle State (79CY)
		L	Reclosing relay in Lockout State (79LO)
Time	OPTMN, RSTMN	o	Recloser open interval timer is timing
		r	Recloser reset interval timer is timing
Shot	SH0, SH1, SH2	.	Reclosing function disabled
	SH3, SH4	0	shot = 0 (SH0)
		1	shot = 1 (SH1)
		2	shot = 2 (SH2)
		3	shot = 3 (SH3)
		4	shot = 4 (SH4)
Zld	ZLIN, ZLOUT	i	Load encroachment “load in” element ZLIN picked up
		o	Load encroachment “load out” element ZLOUT picked up
LOP	LOP	*	Loss-of-potential element LOP picked up
Lcl 12	LB1, LB2	1	Local bit LB1 asserted
		2	Local bit LB2 asserted
		b	Both LB1 and LB2 asserted
Lcl 34	LB3, LB4	3	Local bit LB3 asserted
		4	Local bit LB4 asserted
		b	Both LB3 and LB4 asserted
Lcl 56	LB5, LB6	5	Local bit LB5 asserted
		6	Local bit LB6 asserted
		b	Both LB5 and LB6 asserted
Lcl 78	LB7, LB8	7	Local bit LB7 asserted
		8	Local bit LB8 asserted
		b	Both LB7 and LB8 asserted
Rem 12	RB1, RB2	1	Remote bit RB1 asserted
		2	Remote bit RB2 asserted
		b	Both RB1 and RB2 asserted
Rem 34	RB3, RB4	3	Remote bit RB3 asserted
		4	Remote bit RB4 asserted
		b	Both RB3 and RB4 asserted

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 6 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Rem 56	RB5, RB6	5	Remote bit RB5 asserted
		6	Remote bit RB6 asserted
		b	Both RB5 and RB6 asserted
Rem 78	RB7, RB8	7	Remote bit RB7 asserted
		8	Remote bit RB8 asserted
		b	Both RB7 and RB8 asserted
Rem OC	OC, CC	o	**OPE** (Open) command executed
		c	**CLO** (Close) command executed
Ltch 12	LT1, LT2	1	Latch bit LT1 asserted
		2	Latch bit LT2 asserted
		b	Both LT1 and LT2 asserted
Ltch 34	LT3, LT4	3	Latch bit LT3 asserted
		4	Latch bit LT4 asserted
		b	Both LT3 and LT4 asserted
Ltch 56	LT5, LT6	5	Latch bit LT5 asserted
		6	Latch bit LT6 asserted
		b	Both LT5 and LT6 asserted
Ltch 78	LT7, LT8	7	Latch bit LT7 asserted
		8	Latch bit LT8 asserted
		b	Both LT7 and LT8 asserted
SELOGIC Var 1 SELOGIC Var 2 SELOGIC Var 3 SELOGIC Var 4 SELOGIC Var 5 SELOGIC Var 6 SELOGIC Var 7 SELOGIC Var 8 SELOGIC Var 9 SELOGIC Var 10 SELOGIC Var 11 SELOGIC Var 12 SELOGIC Var 13 SELOGIC Var 14 SELOGIC Var 15 SELOGIC Var 16	SV1, SV1T SV2, SV2T SV3, SV3T SV4, SV4T SV5, SV5T SV6, SV6T SV7, SV7T SV8, SV8T SV9, SV9T SV10, SV10T SV11, SV11T SV12, SV12T SV13, SV13T SV14, SV14T SV15, SV15T SV16, SV16T	P	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
		T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
		d	SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.
3 PO	3PO	*	Three Pole Open element asserted (used in Switch-Onto-Fault logic)
SOTF	SOTFE	*	Switch-Onto-Fault Enabled element asserted
PT	PT	*	Permissive Trip received (POTT logic)
PTRX	PTRX1, PBTX2	1	Permissive Trip Received input 1 asserted and Permissive Trip Received input 2 deasserted (DCUB logic)
		2	Permissive Trip Received input 1 deasserted and Permissive Trip Received input 2 asserted (DCUB logic)
		b	Permissive Trip Received input 1 asserted and Permissive Trip Received input 2 asserted (DCUB logic)

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 7 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Z3RB	Z3RB	*	Zone 3 Reverse Block element asserted
KEY	KEY	*	KEY permissive trip element asserted
EKEY	EKEY	*	Echo KEY permissive trip element asserted
ECTT	ECTT	*	Echo Conversion To Trip element asserted
WFC	WFC	*	Weak inFeed Conditional element asserted
UBB	UBB1, UBB2	1	UnBlocking Block Element 1 asserted and UnBlocking Block Element 2 deasserted
		2	UnBlocking Block Element 1 deasserted and UnBlocking Block Element 2 asserted
		b	UnBlocking Block Element 1 asserted and UnBlocking Block Element 2 asserted
Z3XT	Z3XT	*	Zone 3 eXTension element asserted.
DSTR	DSTR	*	Directional carrier StarT element asserted
NSTR	NSTR	*	Nondirectional carrier STarT element asserted
STOP	STOP	*	STOP carrier element asserted
BTX	BTX	*	Block Trip eXtension element asserted
TMB A 12	TMB1A, TMB2A	1	Transmit MIRRORED BIT 1 Channel A asserted and Transmit MIRRORED BIT 2 Channel A deasserted
		2	Transmit MIRRORED BIT 1 Channel A deasserted and Transmit MIRRORED BIT 2 Channel A asserted
		b	Transmit MIRRORED BIT 1 Channel A asserted and Transmit MIRRORED BIT 2 Channel A asserted
TMB A 34	TMB3A, TMB4A	3	Transmit MIRRORED BIT 3 Channel A asserted and Transmit MIRRORED BIT 4 Channel A deasserted
		4	Transmit MIRRORED BIT 3 Channel A deasserted and Transmit MIRRORED BIT 4 Channel A asserted
		b	Transmit MIRRORED BIT 3 Channel A asserted and Transmit MIRRORED BIT 4 Channel A asserted
TMB A 56	TMB5A, TMB6A	5	Transmit MIRRORED BIT 5 Channel A asserted and Transmit MIRRORED BIT 6 Channel A deasserted
		6	Transmit MIRRORED BIT 5 Channel A deasserted and Transmit MIRRORED BIT 6 Channel A asserted
		b	Transmit MIRRORED BIT 5 Channel A asserted and Transmit MIRRORED BIT 6 Channel A asserted
TMB A 78	TMB7A, TMB8A	7	Transmit MIRRORED BIT 7 Channel A asserted and Transmit MIRRORED BIT 8 Channel A deasserted
		8	Transmit MIRRORED BIT 7 Channel A deasserted and Transmit MIRRORED BIT 8 Channel A asserted
		b	Transmit MIRRORED BIT 7 Channel A asserted and Transmit MIRRORED BIT 8 Channel A asserted
RMB A 12	RMB1A, RMB2A	1	Receive MIRRORED BIT 1 Channel A asserted and Receive MIRRORED BIT 2 Channel A deasserted
		2	Receive MIRRORED BIT 1 Channel A deasserted and Receive MIRRORED BIT 2 Channel A asserted
		b	Receive MIRRORED BIT 1 Channel A asserted and Receive MIRRORED BIT 2 Channel A asserted

Table 12.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 8 of 8)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
RMB A 34	RMB3A, RMB4A	3	Receive MIRRORED BIT 3 Channel A asserted and Receive MIRRORED BIT 4 Channel A deasserted
		4	Receive MIRRORED BIT 3 Channel A deasserted and Receive MIRRORED BIT 4 Channel A asserted
		b	Receive MIRRORED BIT 3 Channel A asserted and Receive MIRRORED BIT 4 Channel A asserted
RMB A 56	RMB5A, RMB6A	5	Receive MIRRORED BIT 5 Channel A asserted and Receive MIRRORED BIT 6 Channel A deasserted
		6	Receive MIRRORED BIT 5 Channel A deasserted and Receive MIRRORED BIT 6 Channel A asserted
		b	Receive MIRRORED BIT 5 Channel A asserted and Receive MIRRORED BIT 6 Channel A asserted
RMB A 78	RMB7A, RMB8A	7	Receive MIRRORED BIT 7 Channel A asserted and Receive MIRRORED BIT 8 Channel A deasserted
		8	Receive MIRRORED BIT 7 Channel A deasserted and Receive MIRRORED BIT 8 Channel A asserted
		b	Receive MIRRORED BIT 7 Channel A asserted and Receive MIRRORED BIT 8 Channel A asserted
ROK	ROKA, ROKB	A	Receive Channel A OK element asserted and Receive Channel B OK element deasserted
		B	Receive Channel A OK element deasserted and Receive Channel B OK element asserted
		b	Receive Channel A OK element asserted and Receive Channel B OK element asserted
RBAD	RBADA, RBADB	A	Receive Channel A BAD for certain time element asserted and Receive Channel B BAD for certain time element deasserted.
		B	Receive Channel A BAD for certain time element deasserted and Receive Channel B BAD for certain time element asserted.
		b	Receive Channel A BAD for certain time element asserted and Receive Channel B BAD for certain time element asserted.
CBAD	CBADA, CBADB	A	Channel A communications availability BAD element asserted and Channel B communications availability BAD element deasserted.
		B	Channel A communications availability BAD element deasserted and Channel B communications availability BAD element asserted.
		b	Channel A communications availability BAD element asserted and Channel B communications availability BAD element asserted.
PB1	PB1 (see *Figure 1.35*)	*	GROUND ENABLED pushbutton output
PB2	PB2	*	RECLOSE ENABLED pushbutton output
PB3	PB3	*	REMOTE ENABLED pushbutton output
PB4	PB4	*	ALTERNATE SETTINGS pushbutton output
PB5	PB5	*	LOCK pushbutton output
PB6	PB6 (see *Figure 1.36*)	*	AUX 1 pushbutton output
PB7	PB7	*	AUX 2 pushbutton output
PB8	PB8	*	{CLOSE} pushbutton output
PB9	PB9	*	{TRIP} pushbutton output

[a] Output contacts can be a- or b-type contacts (see Table 2.1 and Figure 7.26).

Sequential Events Recorder (SER) Report

See *Figure 12.5* for an example SER report.

SER Triggering

The control triggers (generates) an entry in the SER report for a change of state of any one of the elements listed in the SER1, SER2, and SER3 trigger settings. The factory-default settings are:

SER1 = **TRIP 51P1T 51P2T 51G1T 51G2T 51N1T 51N2T 67P2T 67G2T 67N2T 67N3T 81D1T PB9 67P1 67G1 67N1**

SER2 = **CLOSE 52A CF 79CY 79LO 79RS SH0 SH1 SH2 SH3 SH4 PB8 59A1**

SER3 = **TOSLPT TOSLPV BADBAT DTFAIL**

The elements are Relay Word bits referenced in *Table 9.5*. The control monitors each element in the SER lists every 1/4 cycle. If an element changes state, the control time-tags the changes in the SER. For example, setting SER1 contains:

- Time-overcurrent element trips (51P1T, 51P2T, 51G1T, 51G2T, 51N1T, and 51N2T)
- Definite-time overcurrent element trips (67P2T, 67G2T, 67N2T, 67N3T)
- Definite-time frequency element (81D1T)
- Manual **TRIP** from front-panel pushbutton (PB9)
- Instantaneous overcurrent element pickups (67P1, 67G1, 67N1)

Any time one of these elements picks up or drops out, the control time-tags the change in the SER.

The other two SER factory settings (SER2 and SER3) trigger rows in the SER event report for the following conditions:

- Changes in breaker status (52A) and reclose operations
- When control is powered down because of low battery (TOSLP)
- Other battery and battery-charger status-related Relay Word Elements

The control adds a message to the SER to indicate power up or settings change (to active setting group) conditions:

```
Relay newly powered up or settings changed
```

Each entry in the SER includes SER row number, date, time, element name, and the new element state.

Automatic Deletion and Reinsertion

The SER includes an automatic deletion and reinsertion function to prevent overfilling of the SER buffer with chattering information. Each processing interval the control checks the elements in the three SER reports for any changes of state. When detecting a change of state, the control adds a record to the SER report containing the elements, new state, time stamp, and checksum.

When detecting oscillating SER items, the control automatically deletes these oscillating items from SER recording. *Table 12.4* shows the auto-removal settings.

Table 12.4 Auto-Removal Settings

Setting Prompt	Setting Range	Factory Default
Auto-Removal EN	(Y,N)	ESERDL = N
Number of Counts	2–100	SRDLCT = 5
Removal Time	0.5–90.0 seconds	SRDLTM = 1.0

To use the automatic deletion and reinsertion function, proceed with the following:

Step 1. Set Report setting ESERDL (Enable SER Delete) to Y to enable this function.

Step 2. Select values for the setting SRDLCT (SER Delete Count) and the setting SRDLTM (SER Delete Time) that mask the chattering SER element.

Setting SRDLTM declares a time interval during which the control qualifies an input by comparing the changes of state of each input against the SRDLCT setting. When an item changes state more than SRDLCT times in an SRDLTM interval, the control automatically removes these elements from SER recording. Once deleted from recording, the item(s) will be ignored for the next nine intervals. At the ninth interval, the chatter criteria will again be checked and, if the point does not exceed the criteria, it will be automatically reinserted into recording at the starting of the tenth interval.

Making SER Trigger Settings

You can enter up to 24 element names in each of the SER settings via the **SET R** command. See *Table 9.5* for references to valid recloser control element (Relay Word bit) names. See the **SET R** command in *Table 9.1* and corresponding *Sequential Events Recorder and Load Profile Settings (Serial Port Command SET R) on page SET.24*. Use either spaces or commas to delimit the elements. For example, if you enter setting SER1 as:

SER1 = **51P1T, 51G1T 51P2T,,51G2T , 50P1, , 50P2**

The control displays the setting as:

```
SER1 = 51P1T  51G1T  51P2T  51G2T  50P1  50P2
```

The control can monitor up to 72 elements in the SER (24 in each of SER1, SER2, and SER3).

Retrieving SER Reports

The control saves the latest 512 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and Row 512 is the oldest. View the SER report by date or SER row number as outlined in the examples below.

Example SER Serial Port Commands	Format
SER	If you enter only **SER <Enter>**, all available rows are displayed (from Row 1 to Row 512). The rows display with the oldest row at the beginning (top) of the report and the newest row (Row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 17	If you enter the **SER** command followed by a single number (**17** in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (Row 17) at the beginning (top) of the report and the newest row (Row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 10 33	If you enter the **SER** command followed by two numbers (**10** and **33** in this example; 10 < 33), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the older row (Row 33) at the beginning (top) of the report and the newer row (Row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 47 22	If you enter the **SER** command followed by two numbers (**47** and **22** in this example; 47 > 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newer row (Row 22) at the beginning (top) of the report and the older row (Row 47) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.
SER 12/25/12	If you enter the **SER** command followed by a date (date **12/25/12** in this example), all the rows on that date are displayed, if they exist. They display with the oldest row at the beginning (top) of the report and the newest row at the end (bottom) of the report, for the given date. Chronological progression through the report is down the page and in descending row number.
SER 11/11/12 12/12/12	If you enter the **SER** command followed by two dates (date **11/11/12** chronologically *precedes* date **12/12/12** in this example), all the rows between and including dates 11/11/12 and 12/12/12 are displayed, if they exist. They display with the oldest row (date 11/11/12) at the beginning (top) of the report and the newest row (date 12/12/12) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 1/17/12 12/15/11	If you enter the **SER** commands followed by two dates (date **1/17/12** chronologically *follows* date **12/15/11** in this example), all the rows between and including dates 12/15/11 and 1/17/12 are displayed, if they exist. They display with the latest row (date 1/17/12) at the beginning (top) of the report and the oldest row (date 12/15/11) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.

The date entries in the previous example **SER** commands are dependent on the Access Level 2 global Date Format setting DATE_F. If setting DATE_F = MDY, then the dates are entered, as in the previous examples, Month/Day/Year. If setting DATE_F = YMD, then the dates are entered Year/Month/Day.

If the requested SER event report rows do not exist, the control responds: `No SER Data`.

View List of Active "Chattering" Elements

The **SER D** command lists the active chattering SER elements that the control removes from the SER records and the present auto-removal settings. If automatic removal is not enabled (ESERDL = N), the control responds: `Automatic removal of chattering SER elements not enabled`.

Clearing SER Report

Clear the SER report from nonvolatile memory with the Access Level 2 command, **SER C**, as shown in the following example:

```
=>SER C <Enter>
Clear the SER
Are you sure (Y/N) ? Y <Enter>
Clearing Complete
```

Example Standard 15-Cycle Event Report

The following example standard 15-cycle event report in *Figure 12.2* also corresponds to the example Sequential Events Recorder (SER) report in *Figure 12.5*. The circled numbers in *Figure 12.2* correspond to the SER row numbers in *Figure 12.5*. The row explanations follow *Figure 12.5*.

In *Figure 12.2*, the arrow (>) in the column following the `Freq` column identifies the "trigger" row. This is the row that corresponds to the `Date` and `Time` values at the top of the event report.

The asterisk (*) in the column following the `Freq` column identifies the row with the maximum phase current. The maximum phase current is calculated from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 12.3* and *Figure 12.4*). These currents are listed at the end of the event report in the event summary. If the "trigger" row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence.

```
=+>EVE <Enter>
RECLOSER R1                          Date:  06/01/12    Time:  12:23:52.527
FEEDER 2101
FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx        CID=xxxx
                                                            Out   In
      Currents (Amps Pri)       Voltages (kV Pri)           1357T 135BE
   IA    IB    IC    IG     VA     VB     VC     VS  Freq 246AC 246CF
[1]
   120  -152    29    -3    3.3   -6.7    3.4   -0.0 60.01 ..... ...b.
   104    53  -158    -1    5.9   -0.1   -5.8    0.0 60.01 ..... ...b
  -122   150   -30    -2   -3.3    6.7   -3.4   -0.0 60.01 ..... ...b
  -105   -55   157    -3   -5.9    0.1    5.8    0.0 60.01 ..... ...b.
[2]
   121  -151    29    -1    3.3   -6.7    3.4    0.0 60.01 ..... ...b.
   104    54  -158     0    5.9   -0.1   -5.8    0.0 60.01 ..... ...b.
  -122   151   -30    -1   -3.3    6.7   -3.4    0.0 60.01 ..... ...b.
  -105   -55   157    -3   -5.9    0.1    5.8    0.0 60.01 ..... ...b.
[3]
   122  -152    29    -1    3.3   -6.7    3.4   -0.0 60.01 ..... ...b.
   104    53  -158    -1    5.8   -0.1   -5.8   -0.0 60.01 ..... ...b.
  -123   151   -30    -2   -3.3    6.7   -3.4    0.0 60.01 ..... ...b.
  -105   -54   157    -2   -5.8    0.1    5.8    0.0 60.01 ..... ...b.
[4]
   121  -152    29    -2    3.3   -6.7    3.4   -0.0 60.01 ..... ...b.
   190    54  -158    86    4.4   -0.6   -6.3    0.0 60.01 ..... ...b.
   146   150   -29   267   -2.5    7.0   -3.1    0.0 60.01 ..... ...b.
  -551   -55   157  -449   -2.1    1.5    7.2    0.0 60.01>....T ...b.
```

See Figure 12.1

firmware identifier

firmware checksum

one cycle of data

11

```
[5]
  -484  -151    28  -607    1.3   -7.6    2.5   -0.0 60.01 ....T ...b.
   824    54  -158   720    1.2   -1.9   -7.5    0.0 60.01 ....T ...b.
   549   150   -29   670   -0.8    7.8   -2.3    0.0 60.01 ....T ...b.
  -825   -55   157  -723   -1.2    1.9    7.5    0.0 60.01 ....T ...b.
[6]
  -550  -151    28  -673    0.8   -7.8    2.3   -0.0 60.01*....T ...B.
   824    55  -158   721    1.2   -1.8   -7.5    0.0 60.01 ....T ...B.
   548   150   -29   669   -0.8    7.8   -2.3    0.0 60.01 ....T ...Bb
  -826   -56   157  -725   -1.2    1.8    7.5   -0.0 60.01 ....T ...Bb
[7]
  -548  -151    28  -671    0.8   -7.8    2.3    0.0 60.07 ....T ...Bb
   702    64  -123   643    2.7   -1.2   -6.9    0.0 60.07 ....T ...Bb
   299    82   -15   366   -1.9    7.3   -2.8    0.0 60.07 ....T ...Bb
  -291   -37    44  -284   -5.1    0.3    6.1    0.0 60.07 ....T ...Bb
[8]
   -27    -8     0   -35    3.2   -6.8    3.3   -0.0 60.07 ....T ...Bb
     0     0     0     0    5.8   -0.0   -5.8    0.0 60.07 ....T ...Bb
     0     0     0     0   -3.3    6.7   -3.4    0.0 60.07 ....T ...Bb
    -1    -1    -1    -3   -5.8    0.0    5.8   -0.0 60.07 ....T ...Bb
[9]
    -1     0     0    -1    3.3   -6.7    3.4    0.0 60.00 ....T ...Bb
     0     0     0     0    5.8   -0.0   -5.8   -0.0 60.00 ....T ...Bb
     0    -1     0    -1   -3.3    6.7   -3.4    0.0 60.00 ....T ...Bb
     0    -1    -1    -2   -5.8    0.0    5.8    0.0 60.00 ....T ...Bb
[10]
    -1     0    -1    -2    3.3   -6.7    3.4   -0.0 60.01 ....T ...Bb
    -1     0     0    -1    5.8   -0.0   -5.8   -0.0 60.01 ....T ...Bb
     0     0     0     0   -3.4    6.7   -3.4    0.0 60.01 ....T ...Bb
     0    -1     0    -1   -5.8    0.0    5.8   -0.0 60.01 ....T ...Bb
[11]
    -1    -1    -1    -3    3.4   -6.7    3.4    0.0 60.01 ....T ...Bb
     0     0    -1    -1    5.8   -0.0   -5.8   -0.0 60.01 ....T ...Bb
     0     0     0     0   -3.4    6.7   -3.4    0.0 60.01 ....T ...Bb
    -1    -1     0    -2   -5.8   -0.0    5.8    0.0 60.01 ....T ...Bb
[12]
    -1    -1    -1    -3    3.4   -6.7    3.3   -0.0 60.01 ....T ...Bb
     0     0     0     0    5.8    0.0   -5.8    0.0 60.01 ....T ...Bb
    -1     0    -1    -2   -3.4    6.7   -3.3    0.0 60.01 ....T ...Bb
    -1    -1     0    -2   -5.8   -0.0    5.8    0.0 60.01 ....T ...Bb
[13]
     0    -1     0    -1    3.4   -6.7    3.3   -0.0 60.01 ....T ...Bb
     0     0    -1    -1    5.8    0.0   -5.8   -0.0 60.01 ....T ...Bb
     0     0    -1    -1   -3.4    6.7   -3.3    0.0 60.01 ....T ...Bb
     0    -1     0    -1   -5.8   -0.0    5.8    0.0 60.01 ....T ...Bb
[14]
    -1    -1    -1    -3    3.4   -6.7    3.3   -0.0 60.01 ....T ...Bb
     0     0     0     0    5.8    0.0   -5.8    0.0 60.01 ....T ...Bb
     0     0     0     0   -3.4    6.7   -3.3    0.0 60.01 ....T ...Bb
    -1    -1    -1    -3   -5.8   -0.0    5.8    0.0 60.01 ....T ...Bb
[15]
     0    -1    -1    -2    3.4   -6.7    3.3   -0.0 60.01 ....T ...Bb
     0     0     0     0    5.8    0.0   -5.8   -0.0 60.01 ....T ...Bb
    -1    -1     0    -2   -3.4    6.7   -3.3    0.0 60.01 ....T ...Bb
     0    -1    -1    -2   -5.8   -0.0    5.8    0.0 60.01 ....T ...Bb

Protection and Control Elements

51      50 32 67   Dm 27 59      25  81   TS    Lcl Rem  Ltch SELogic Variable
                             V   5   2     ih ZL                   Timers
PPNNGG  P PN       PN  P  P1   9S  7135 7mo lO 1357135701357          1111111
121212QPP QG PNGQ QG PPSPPQNS VFA B246 9et dP 24682468C2468 1234567890123456
[1]
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
[2]
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
[3]
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
[4]
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
......... .. .... .. ........ ... *... R.O .. .........b..7 ................
....pp... .. .... .. ........ ... *... R.O .. .........b..7 .............T..
pp..Tp... .. .... .. ........ ... *... C.O .. .........b..7 ............TT..>
```

see Figure 12.3 and Figure 12.4 for details on this example one cycle of phase A (channel IA) current

14, 13, 12

```
[5]
pp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
[6]                                                                            ⑧, ⑦
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
[7]
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
Tp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
[8]
1r..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..
1r..1r... .. .... .. ........ ... *... C.0 .. .........b..7 ............T...
1r..1r... .. .... .. ........ ... *... C.0 .. .........b..7 ............T...
1r..1r... .. .... .. ........ ... *... C.0 .. .........b..7 ............T...

....1r... .. .... .. ........ ... *... C.0 .. .........b..7 ............T...
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[10]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[11]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[12]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[13]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[14]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
[15]
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................
......... .. .... .. ........ ... *... C.0 .. .........b..7 ................

Communication Elements

 S  PZ EE   ZDNS  TMB  RMB  TMB  RMB  RRC
3O  T3KKCWU 3SSTB A    A    B    B    OBB PPPPPPPPP
PT PRREETFB XTTOT 1357 1357 1357 1357 KAA BBBBBBBBB
OF TXBYYTCB TRRPX 2468 2468 2468 2468  DD 123456789
[1]
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[14]
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*. ........ ..... .... .... .... .... ... .........
[15]
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
Event:  AG T  Location:    3.89  Shot:  0  Frequency:  60.01
Targets:  10101100 01010010
Currents (A Pri), ABCNGQ:    991   160   159     0   986   984

(settings follow, but are not shown in this example)
```

Figure 12.2 Example Standard 15-Cycle Event Report 1/4 Cycle Resolution

Figure 12.3 and *Figure 12.4* look in detail at 1 cycle of A-phase current (channel IA) identified in *Figure 12.2*. *Figure 12.3* shows how the event report ac current column data relates to the actual sampled waveform and rms values. *Figure 12.4* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

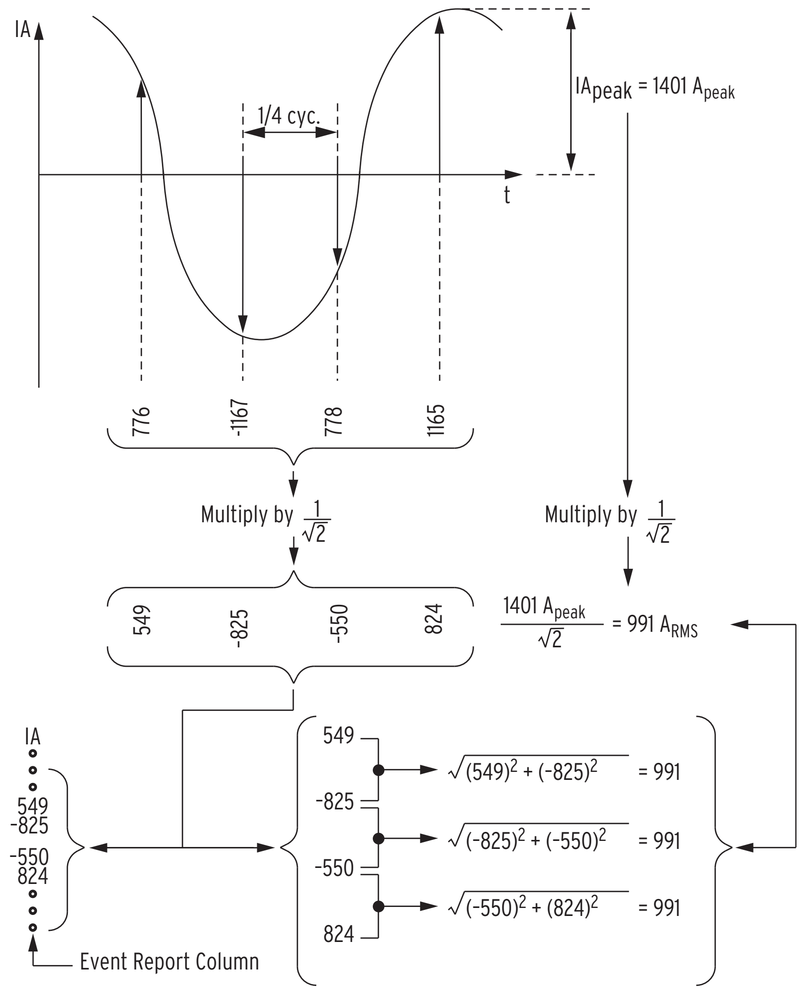

Figure 12.3 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 12.3*, note that any two rows of current data from the event report in *Figure 12.2*, 1/4 cycle apart, can be used to calculate rms current values.

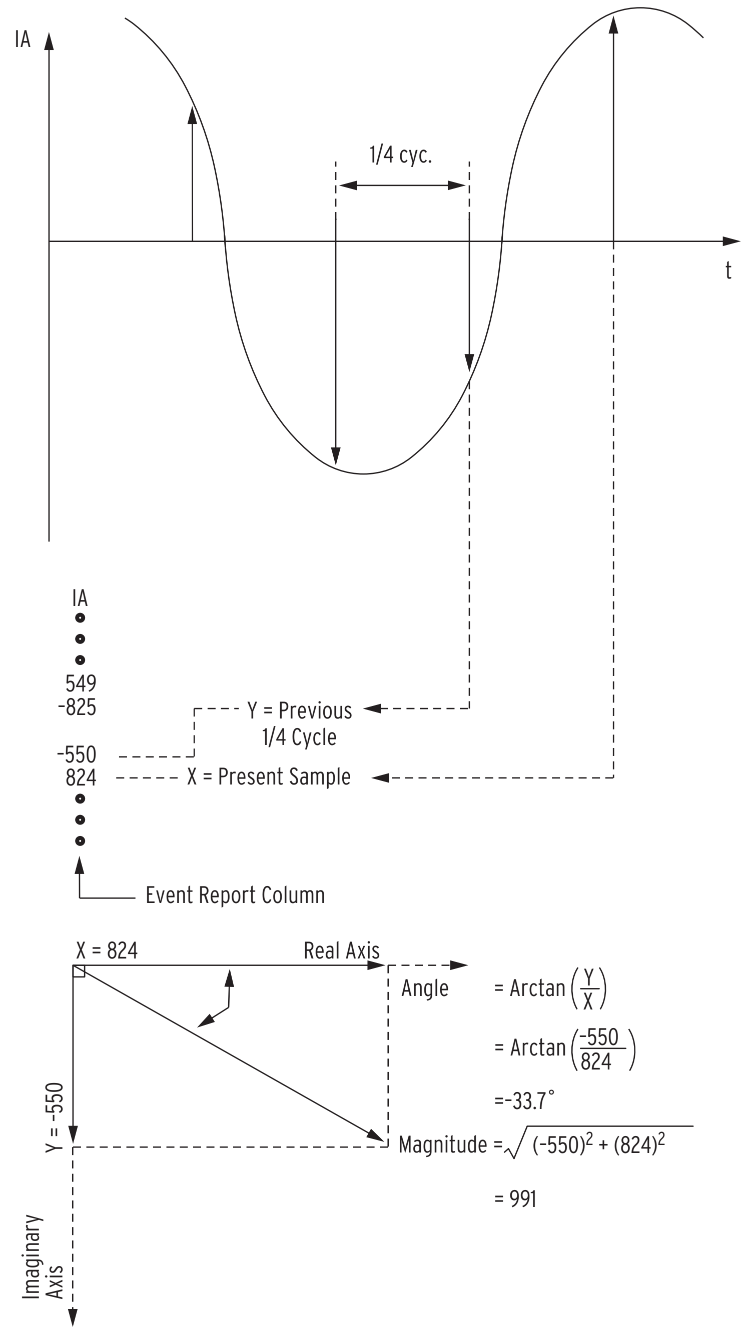

Figure 12.4 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 12.4*, note that two rows of current data from the event report in *Figure 12.2*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 12.4*, at the present sample, the phasor rms current value is:

$$IA = 991\text{ A} \angle -33.7°$$

The present sample (IA = 824 A) is a real rms current value that relates to the phasor rms current value:

$$991\text{ A} \bullet \cos(-33.7°) = 824\text{ A}$$

Example Sequential Events Recorder (SER) Report

The following example sequential events recorder (SER) report in *Figure 12.5* also corresponds to the example standard 15-cycle event report in *Figure 12.2*.

```
RECLOSER R1                        Date:  06/01/12    Time:  12:24:25.371
FEEDER 2101

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx


#     DATE      TIME           ELEMENT            STATE

24    06/01/12  12:00:00.000   Relay newly powered up or settings changed
23    06/01/12  12:23:26.915   CLOSE              Asserted
22    06/01/12  12:23:26.915   PB8                Asserted
21    06/01/12  12:23:26.920   PB8                Deasserted
20    06/01/12  12:23:26.961   CLOSE              Deasserted
19    06/01/12  12:23:26.965   52A                Asserted
18    06/01/12  12:23:36.971   79LO               Deasserted
17    06/01/12  12:23:36.971   79RS               Asserted
16    06/01/12  12:23:36.975   SH3                Deasserted
15    06/01/12  12:23:36.975   SH0                Asserted
14    06/01/12  12:23:52.527   51G1T              Asserted
13    06/01/12  12:23:52.527   79CY               Asserted
12    06/01/12  12:23:52.527   79RS               Deasserted
11    06/01/12  12:23:52.527   TRIP               Asserted
10    06/01/12  12:23:52.535   51P1T              Asserted
9     06/01/12  12:23:52.560   52A                Deasserted
8     06/01/12  12:23:52.598   51P1T              Deasserted
7     06/01/12  12:23:52.602   51G1T              Deasserted
6     06/01/12  12:23:52.727   TRIP               Deasserted
5     06/01/12  12:23:57.721   CLOSE              Asserted
4     06/01/12  12:23:57.721   SH1                Asserted
3     06/01/12  12:23:57.721   SH0                Deasserted
2     06/01/12  12:23:57.767   CLOSE              Deasserted
1     06/01/12  12:23:57.771   52A                Asserted
```

Figure 12.5 Example Sequential Events Recorder (SER) Event Report

The SER event report rows in *Figure 12.5* are explained in the following text, numbered in correspondence to the # column. The circled, numbered comments in *Figure 12.2* also correspond to the # column numbers in *Figure 12.5*. The SER event report in *Figure 12.5* contains records of events that occurred before and after the standard event report in *Figure 12.2*.

#	Explanation
24	Recloser control newly powered up or settings changed
23, 22, 21, 20	Recloser manually closed from front-panel **CLOSE** pushbutton.
19	Recloser closes. Related setting: 52A = **SW1 * !CLOSE**
18, 17, 16, 15	Recloser control goes from the reclose lockout (79LO) state to the reclose reset (79RS) state and the recloser shot counter goes from shot 3 (SH3) to shot 0 (SH0) indicating three shots of reclosing are now available. Related settings: Reclose Interval 1, Reclose Interval 2, Reclose Interval 3, Reset time from lockout

#	Explanation
14, 13, 12, 11	Ground time-overcurrent element time-delayed output, 51G1T, causing a control trip. Related settings: Min. Trip—ground, Fast curve—ground The control starts the reclose cycle state (79CY) and moves off of reset (79RS). Related setting: Reclose Initiate (79RI = **TRIP**) The control TRIP output asserts. Related setting: TR = **51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T + PB9 + OC**
10	Phase time-overcurrent element time-delayed output, 51P1T. Trip is already in progress because of ground time-overcurrent element.
9	Recloser opens.
8, 7	Phase and ground time-overcurrent elements deassert.
6	Trip output deasserts after being asserted a minimum of 12 cycles. Related settings: TDURD = **12.00 cycles** Time difference: 12:23:52.727–12:23:52.527 = 0.20 seconds (= 12 cycles) Reclose interval 1 does not start timing until trip output deasserts. Related settings: 79STL = **TRIP**
5	Close output asserts for first automatic reclose. Related settings: Reclose interval 1 = **300.00** Time difference: 12:23:57.721–12:23:52.727 = 4.994 seconds (= 300 cycles)
4, 3	Reclose control increments reclose shot counter from 0 to 1 (SH1 asserted, SH0 deasserted).
2, 1	Close output deasserts as recloser closes.

Section 13

Testing and Troubleshooting

Overview

This section provides guidelines for determining and establishing test routines for the SEL-351R Recloser Control. Included are discussions on testing philosophies, methods, and tools. SEL-351R self-tests and troubleshooting procedures are shown at the end of the section.

Testing Philosophy

Recloser control testing may be divided into three categories: acceptance, commissioning, and maintenance testing. The categories are differentiated by when they take place in the life cycle of the SEL-351R as well as in the test complexity.

The paragraphs below describe when to perform each type of test, the goals of testing at that time, and the control functions that you need to test at each point. This information is intended as a guideline for testing the SEL-351R.

Acceptance Testing

When: When qualifying an SEL-351R model to be used on the utility system.

Goals:

1. Ensure that the SEL-351R meets published critical performance specifications such as operating speed and element accuracy.
2. Ensure that the SEL-351R meets the requirements of the intended application.
3. Gain familiarity with SEL-351R settings and capabilities.

What to test: All protection elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all new recloser control models and versions. We are certain the recloser controls we ship meet their published specifications. It is important for you to perform acceptance testing on a recloser control if you are unfamiliar with its operating theory, protection scheme logic, or settings. This helps ensure the accuracy and correctness of the control settings when you issue them.

Refer to Section 5 in the *SEL-351R-4 Quick-Start Installation and User's Guide* for test procedures using the Type MET Electronic Recloser Control Tester.

Commissioning Testing

When: When installing a new protection system.

Goals:

1. Ensure that all system ac and dc connections are correct.
2. Ensure that the SEL-351R functions as intended using your settings.
3. Ensure that all auxiliary equipment operates as intended.

What to test: All connected or monitored inputs and outputs, polarity and phase rotation of ac connections, simple check of protection elements.

SEL performs a complete functional check and calibration of each SEL-351R before it is shipped. This helps ensure that you receive a unit that operates correctly and accurately. Commissioning tests should verify that the SEL-351R is properly connected to the power system and all auxiliary equipment. Verify SEL-351R signal inputs and outputs. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs. Use an ac connection check to verify that the SEL-351R current and voltage inputs are of the proper magnitude and phase rotation.

Brief fault tests ensure that the SEL-351R settings are correct. It is not necessary to test every element, timer, and function in these tests.

At commissioning time, use the SEL-351R **METER** command to verify the ac current and voltage magnitude and phase rotation. Use the **PULSE** command to verify SEL-351R output contact operation. Use the **TARGET** command to verify optoisolated input operation. The event report also will report control cable connection between the recloser and the SEL-351R.

Maintenance Testing

When: At regularly scheduled intervals or when there is an indication of a problem with the SEL-351R or system.

Goals:

1. Ensure that the SEL-351R is measuring ac quantities accurately.
2. Ensure that scheme logic and protection elements are functioning correctly.
3. Ensure that auxiliary equipment is functioning correctly.

What to test: Anything not shown to have operated during an actual fault within the past maintenance interval.

The SEL-351R uses extensive self-testing capabilities and features detailed metering and event reporting functions that lower the utility dependence on routine maintenance testing.

Use the SEL-351R reporting functions as maintenance tools. Periodically verify that the control is making correct and accurate current and voltage measurements by comparing the control METER output to other meter readings on that line. Review control event reports in detail after each fault. Using the event report current, voltage, and SEL-351R element data, you can determine that the SEL-351R protection elements are operating properly. Using the event report input and output data, you can determine that the control is asserting outputs at the correct instants and that auxiliary equipment is operating properly. At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

The basis of this testing philosophy is simple: If the control is set correctly and connected, is measuring properly, and no self-test has failed, there is no reason to test it further.

Each time a fault occurs, the protection system is tested. Use event report data to determine areas requiring attention. Slow recloser auxiliary contact operations and increasing or varying recloser operating time can be detected through detailed analysis of control event reports.

Because SEL-351R Recloser Controls are microprocessor-based, their operating characteristics do not change over time. Time-overcurrent operating times are affected only by the SEL-351R settings and applied signals. It is not necessary to verify operating characteristics as part of maintenance checks.

At SEL, we recommend that maintenance tests on SEL-351R Recloser Controls be limited under the guidelines provided above. The time saved may be spent analyzing event data and thoroughly testing those systems that require more attention.

Testing Methods and Tools

Test Features Provided by the SEL-351R

The following features assist you during SEL-351R testing.

Command	Description
METER Command	The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the control in primary values. In addition, the command shows power system frequency (FREQ). Compare these quantities against other devices of known accuracy. The **METER** command is available at the serial ports and front-panel display. See *Section 10: Serial Port Communications and Commands* and *Section 11: Additional Front-Panel Interface Details*.
EVENT Command	The control generates a 15- or 30-cycle event report in response to faults or disturbances. Each report contains current and voltage information, SEL-351R element states, control cable pin statuses, and input/output contact information. If you question the control response or your test method, use the event report for more information. The **EVENT** command is available at the serial ports. See *Section 12: Standard Event Reports and SER*.
SER Command	The control provides a Sequential Events Recorder (SER) event report that time tags changes in control element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the control. The **SER** command is available at the serial ports. See *Section 12: Standard Event Reports and SER*.
TARGET Command	Use the **TARGET** command to view the state of control inputs, outputs, and SEL-351R elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 10: Serial Port Communications and Commands* and *Section 11: Additional Front-Panel Interface Details*.
PULSE Command	Use the **PULSE** command to test the contact output circuits. The **PULSE** command is available at the serial ports and the front panel. See *Section 10: Serial Port Communications and Commands*.

Test Methods

Test the pickup and dropout of the SEL-351R elements using one of three methods:

- ➤ target command indication
- ➤ output contact closure
- ➤ Sequential Events Recorder (SER)

The examples below show the settings necessary to route the phase time-overcurrent element 51P1T to the output contacts and the SER. The 51PT element, like many in the SEL-351R, is controlled by enable settings and/or torque control SELOGIC® control equations. To enable the 51P1T element, set the E51P enable setting and 51PTC torque control settings to the following:

E51P = **1** (via the **SET** command)

51P1TC = **1** (set directly to logical 1, via the **SET L** command)

Testing Via Front-Panel Indicators

Display the state of the SEL-351R elements, inputs, and outputs using the front-panel or serial port **TAR** commands. Use this method to verify the pickup settings of protection elements.

Access the front-panel **TAR** command from the front-panel **OTHER** pushbutton menu. To display the state of the 51PT element on the front-panel display, press the **OTHER** pushbutton, cursor to the `TAR` option, and press **SELECT**. Press the **Up Arrow** pushbutton until `TAR 6` is displayed on the top row of the LCD. The bottom row of the LCD displays all elements asserted in Relay Word Row 6. The SEL-351R maps the state of the elements in Relay Word Row 6 on the bottom row of LEDs. The 51P1T element state is reflected on the LED labeled **RS**. See *Table 9.6* for the correspondence between the Relay Word elements and the **TAR** command.

To view the 51P1T element status from the serial port, issue the **TAR 51P1T** command. The SEL-351R will display the state of all elements in the Relay Word row containing the 51P1T element.

Review **TAR** command descriptions in *Section 10: Serial Port Communications and Commands* and *Section 11: Additional Front-Panel Interface Details* for further details on displaying element status via the **TAR** commands.

Testing Via Output Contacts

You can set the SEL-351R to operate an output contact for testing a single element. Use the **SET L** command (SELOGIC control equations) to set an output contact (e.g., **OUT104**) to the element under test. The available elements are the Relay Word bits referenced in *Table 9.6*.

Use this method especially for time testing time-overcurrent elements. For example, to test the phase time-overcurrent element 51P1T via output contact **OUT104**, make the following setting:

OUT104 = **51P1T**

Time-overcurrent curve and time-dial information can be found in *Section 9: Setting the SEL-351R Recloser Control*. Do not forget to reenter the correct SEL-351R settings when you are finished testing and ready to place the SEL-351R in service.

Testing Via Sequential Events Recorder

You can set the SEL-351R to generate an entry in the Sequential Events Recorder (SER) for testing SEL-351R elements. Use the **SET R** command to include the element(s) under test in any of the SER trigger lists (SER1–SER3). See *Section 12: Standard Event Reports and SER*.

To test the phase time-overcurrent element 51P1T with the SER, make the following setting:

SER1 = **51P1** 51P1T

Element 51P1 asserts when phase current is above the pickup of the phase time-overcurrent element. Element 51P1T asserts when the phase time-overcurrent element times out. The assertion and deassertion of these elements is time-stamped in the SER report. Use this method to verify timing associated with time-overcurrent elements, reclosing relay operation, etc. Do not forget to reenter the correct SEL-351R settings when you are ready to place the SEL-351R in service.

SEL-351R Self-Tests

The SEL-351R runs a variety of self-tests. The SEL-351R takes the following corrective actions for out-of-tolerance conditions (see *Table 13.1*):

- Protection Disabled: The SEL-351R disables overcurrent elements and trip/close logic. All output contacts and FETs driving the trip and close pins of the control cable are de-energized. The EN front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its de-energized state. If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the SEL-351R is de-energized. If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the SEL-351R is de-energized. Alarm condition signaling can be a single five-second pulse (Pulsed) or permanent (Latched).
- The SEL-351R generates automatic STATUS reports at the serial port for warnings and failures.
- The SEL-351R displays failure messages on the LCD display for failures.

Use the serial port **STATUS** command or front-panel STATUS pushbutton to view control self-test status.

Table 13.1 SEL-351R Recloser Control Self-Tests (Sheet 1 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
I1, I2, I3, IN, V1, V2, V3, VS Offset	Warning	30 mV	No	Pulsed	Measures the dc offset at each of the input channels every 10 seconds.
Master Offset	Warning	20 mV	No	Pulsed	Measures the dc offset at the A/D every 10 seconds.
	Failure	30 mV	Yes	Latched	

Table 13.1 SEL-351R Recloser Control Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
+5 V PS	Warning	+4.80 V +5.30 V	No	Pulsed	Measures the +5 V power supply every 10 seconds.
	Failure	+4.65 V +5.40 V	Yes	Latched	
±5 V REG	Warning	±4.75 V +5.20, –5.25 V	No	Pulsed	Measures the regulated 5 V power supply every 10 seconds.
	Failure	±4.50 V +5.40, –5.50 V	Yes	Latched	
±12 V PS	Warning	±11.50 V ±12.50 V	No	Pulsed	Measures the 12 V power supply every 10 seconds.
	Failure	±11.20 V ±14.00 V	Yes	Latched	
±15 V PS	Warning	±14.40 V ±15.60 V	No	Pulsed	Measures the 15 V power supply every 10 seconds.
	Failure	±14.00 V ±16.00 V	Yes	Latched	
TEMP	Warning	–40°C +85°C	No		Measures the temperature at the A/D voltage reference every 10 seconds.
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the SEL-351R program memory every 10 seconds.
A/D	Failure		Yes	Latched	Validates proper number of conversions each 1/4 cycle.
CR_RAM	Failure	checksum	Yes	Latched	Performs a checksum test on the active copy of the SEL-351R settings every 10 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the SEL-351R settings every 10 seconds.
The following two self-tests are performed by dedicated circuitry in the microprocessor and the SEL-351R main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Microprocessor Crystal	Failure		Yes	Latched	The SEL-351R monitors the microprocessor crystal. If the crystal fails, the control displays `CLOCK STOPPED` on the LCD display. The test runs continuously.
Microprocessor (main circuit board)	Failure		Yes	Latched	The microprocessor on the main circuit board examines each program instruction, memory access, and interrupt. The SEL-351R displays `VECTOR nn` on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.
Aux +12 V	Warning	+11.20 V +14.00 V	No	Pulsed	Measures the +12 V power supply on the **AUX** port every 10 seconds.
Battery Voltage	Warning	18.00 V 39.00 V	No	Pulsed	Measures battery voltage every 10 seconds.
Battery Current	Warning	–5 A 185 mA	No	Pulsed	Measures battery charge/discharge current every 10 seconds.

SEL-351R Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the SEL-351R. After you finish the inspection, proceed to *Table 13.2*.

Step 1. Measure and record the ac power supply voltage at the power input terminal positions Z25 and Z27 on the terminal block.

Step 2. Record battery voltage of the two series-connected batteries at the battery terminals.

Step 3. Measure and record the voltage at all SEL-351R inputs (if used).

Step 4. Measure and record the state of all output contacts (if used).

Table 13.2 Troubleshooting Procedure

Problem	Procedure
All Front-Panel LEDs Dark	➤ Input ac power not present and battery discharged. ➤ Input ac power not present and battery disconnected or otherwise defective. ➤ Self-test failure.
Cannot See Characters on LCD Screen	➤ SEL-351R is de-energized. Check to see if the ALARM contact is closed. ➤ LCD contrast is out of adjustment. Use the following steps to adjust the contrast. a. Press and hold down the OTHER front-panel pushbutton. b. Use the Up Arrow to darken the contrast and Down Arrow to lighten the contrast.
SEL-351R Does Not Respond to Commands From Device Connected to Serial Port	➤ Communications device not connected to SEL-351R. ➤ SEL-351R or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error. ➤ SEL-351R serial port has received an XOFF, halting communications. Type **<Ctrl + Q>** to send control an XON and restart communications.
SEL-351R Does Not Respond to Faults	➤ SEL-351R improperly set. ➤ Improper test source settings. ➤ CT or PT input wiring error. ➤ Analog input cable between transformer secondary and main board loose or defective. ➤ Failed SEL-351R self-test.

Calibration

The SEL-351R is factory-calibrated. If you suspect that the control is out of calibration, please contact the factory.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890
Fax: +1.509.332.7990
Internet: selinc.com
E-mail: info@selinc.com

Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Recloser Control

To find the firmware revision number in your SEL-351R Recloser Control, view the status report using the serial port **STATUS** command or the front-panel STATUS pushbutton. The status report displays the Firmware Identification (FID) label:

FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx

The firmware revision number follows the R and the release date follows the D.

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

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-351R-4-R503-V0-Z002001-D20140207	➤ Added per-point class assignment capabilities to DNP analog and binary inputs. ➤ Revised port setting UNSAOV to apply to all Object 32 responses and to be visible regardless of UNSOL setting value. In previous firmware, UNSAOV applied only to unsolicited responses. ➤ Setting PSTDLY in DNP setting to 0 time delay was improved to end communications faster.	20140207
SEL-351R-4-R502-V0-Z001001-D20131025	➤ Corrected issue with DNP analog inputs that could cause either Index 128, VCA angle, or Index 129, IA magnitude at time of fault, to be unavailable to read. ➤ Corrected issue where DNP per-point scaling values were incorrectly applied for demand and peak demand quantities. ➤ Corrected issue where DNP analog input Fault Location was using incorrect scaling.	20131025
SEL-351R-4-R501-V0-Z001001-D20120625	➤ Initial version.	20120625

Instruction Manual

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

Table A.2 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

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

Revision Date	Summary of Revisions
20160715	Section 4 ➤ Enhanced the *Directional Control Settings* subsection to include a description of specific applications for the E32 setting.
20140207	Section 4 ➤ Corrected symbols in forward and reverse threshold comparisons for directional element in *Figure 4.9: Negative-Sequence Voltage-Polarized Directional Element for Neutral and Residual Overcurrent Elements*, *Figure 4.10: Zero-Sequence Voltage-Polarized, Residual-Current Directional Element for Neutral and Residual Overcurrent Elements*, *Figure 4.11: Zero-Sequence Voltage-Polarized, Neutral-Current Directional Elements for Neutral Ground Overcurrent Elements*, and *Figure 4.17: Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements*. Appendix A ➤ Updated for firmware version R503. Appendix H ➤ Updated for new per-point class assignment capability for DNP analog and binary inputs. ➤ Clarified purpose of LOCAL SELOGIC control equation. ➤ Corrected order of DNP port settings. ➤ Updated UNSAOV setting description.
20131025	Section 3 ➤ Corrected reference to *Figure 3.21: Single-Phase and Three-Phase Voltage Elements.* ➤ Corrected wiring in *Figure 3.24: Synchronism-Check Voltage Window and Slip Frequency Elements*. Section 4 ➤ Removed incorrect references to 32IE. Settings Sheets ➤ Removed reference to Wake-Up Port. Section 10 ➤ Removed Wake-Up Port from *Table 10.1: Pinout Functions for EIA-232 Serial Ports 2, 3, and F.* Appendix A ➤ Updated for firmware version R502. Appendix G ➤ Removed reference to 32IE and changed reference F32I and R32I to F32N and R32N, respectively, in *Table G.3: Processing Order of Relay Elements and Logic*. Appendix H ➤ Added dead-band description for analog input 114.
20130131	Section 2 ➤ Revised *Table 2.6: EIA-232 Serial Port Voltage Jumper Positions for Standard Recloser Control Shipments* to show Port 3 (rear panel) jumper now shipped in "ON" position to enable +5 Vdc on Pin 1. ➤ Added note to specify that new standard jumper configuration is shipped with a label identifying Port 3 with +5 Vdc enabled on Pin 1.

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

Revision Date	Summary of Revisions
20121116	Section 6 ➤ Updated *Table 6.4: Reclosing Relay SELOGIC Control Equation Settings* to correct 79CLS setting entry.
20120625	➤ Initial version.

Appendix B
Firmware Upgrade Instructions

Overview

NOTE: SEL recommends that you upgrade all firmware to the latest revisions provided on the upgrade CD. Use the **STATUS** command to the relay to compare firmware revision numbers between the files provided on the upgrade CD and those present in the relay prior to starting the upgrade process.

From time to time, SEL issues firmware upgrades for this relay. The instructions that follow explain how you can install new firmware in your SEL-300 series relay.

Relay Firmware Upgrade Instructions

Introduction

These firmware upgrade instructions apply to all SEL-300 series relays except the SEL-321 series relays (which use EPROM instead of Flash) and SEL-351 relays equipped with Ethernet.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Changing physical components is unnecessary because the relay stores firmware in Flash memory.

A firmware loader program called SELBOOT resides in the relay. To upgrade firmware, use the SELBOOT program to download an SEL-supplied file from a personal computer to the relay via any communications port. This procedure is described in the following steps.

NOTE: SEL strongly recommends that you upgrade firmware at the location of the relay and with a *direct connection* from the personal computer to one of the relay serial ports. Do not load firmware from a remote location; problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the relay through an SEL communications processor.

Perform the firmware upgrade process in the following sequence:

A. Prepare the Relay

B. Establish a Terminal Connection

C. Save Settings and Other Data

D. Start SELBOOT

E. Download Existing Firmware

F. Upload New Firmware

G. Check Relay Self-Tests

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

I. Return the Relay to Service

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- ➤ Personal computer (PC)
- ➤ Terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal® from a Microsoft® Windows® operating system)
- ➤ Serial communications cable (SEL Cable C234A or equivalent)
- ➤ Disk containing the firmware upgrade file
- ➤ Firmware Upgrade Instructions (these instructions)

Optional Equipment

These items help you manage relay settings and understand firmware upgrade procedures:

- ➤ SEL-5010 Relay Assistant software or ACSELERATOR QuickSet® SEL-5030 Software.

  The SEL-5010 Relay Assistant software has a feature that guides you through the conversion process. This upgrade guide will assist you with steps C, D, E, F, and G of these upgrade instructions. If you do not have the latest SEL-5010 software, please contact your customer service representative or the factory for details on getting the SEL-5010 Relay Assistant software.
- ➤ Your relay instruction manual

Upgrade Procedure

A. Prepare the Relay

Step 1. If the relay is in use, follow your company practices for removing a relay from service.

Typically, these include changing settings, or disconnecting external voltage sources or output contact wiring, to disable relay control functions.

Step 2. Apply power to the relay.

Step 3. From the relay front panel, press the **SET** pushbutton.

Step 4. Use the arrow pushbuttons to navigate to `PORT`.

Step 5. Press the **SELECT** pushbutton.

Step 6. Use the arrow pushbuttons to navigate to the relay serial port you plan to use (usually the front port).

Step 7. Press the **SELECT** pushbutton.

Step 8. With `SHOW` selected, press the **SELECT** pushbutton.

Step 9. Press the **Down Arrow** pushbutton to scroll through the port settings; write down the value for each setting.

Step 10. At the `EXIT SETTINGS?` prompt, select `Yes` and press the **SELECT** pushbutton.

Step 11. Connect an SEL Cable C234A (or equivalent) serial communications cable to the relay serial port selected in *Step 6* above.

B. Establish a Terminal Connection

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

Step 1. Connect a serial communications cable to the computer serial port:

a. Check the computer for a label identifying the serial communications ports.

b. Choose a port and connect an SEL Cable C234A (or equivalent) serial communications cable to the PC serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you might later change this computer serial port to a different port in order to establish communication between the relay and the computer.

Step 2. Disconnect any other serial port connection(s).

Step 3. From the computer, open **HyperTerminal**.

On a PC running Windows, you would typically click **Start** > **Programs** > **Accessories**.

Step 4. Enter a name, select any icon, and click **OK** (*Figure B.1*).

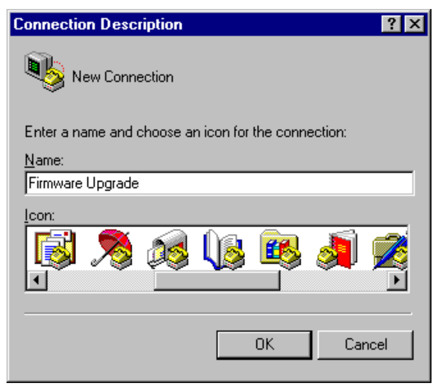

Figure B.1 Establishing a Connection

Step 5. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**. This port matches the port connection that you made in *Step 1* under *B. Establish a Terminal Connection*.

Figure B.2 Determining the Computer Serial Port

Step 6. Establish serial port communications parameters.

The settings for the computer (*Figure B.3*) must match the relay settings you recorded earlier.

a. Enter the serial port communications parameters (*Figure B.3*) that correspond to the relay settings you recorded in *Step 9 on page B.2*.

If the computer settings do not match the relay settings, change the computer settings to match the relay settings.

b. Click **OK**.

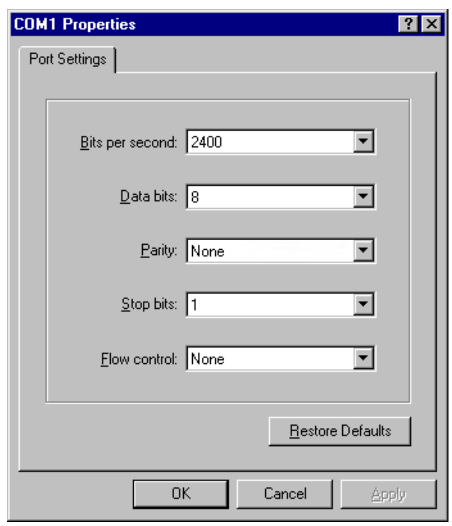

Figure B.3 Determining Communications Parameters for the Computer

Step 7. Set the terminal emulation to VT100.

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

b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).

c. Select **VT100** from the **Emulation** list box and click **OK**.

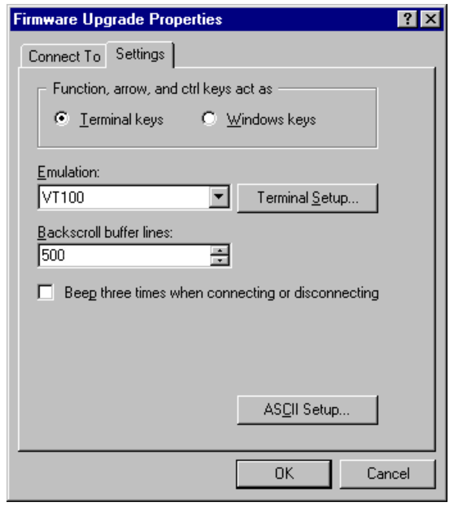

Figure B.4 Setting Terminal Emulation

Step 8. Confirm serial communication.

Press **<Enter>**. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

If this is successful, proceed to *C. Save Settings and Other Data on page B.6*.

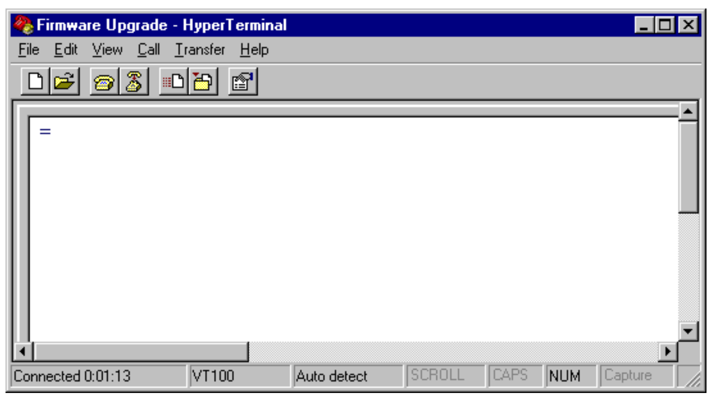

Figure B.5 Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the Access Level 0 = prompt, press **<Enter>** again. If you still do not see the Access Level 0 = prompt, you have either selected the incorrect serial communications port on the computer, or the computer speed setting does not match the data transmission rate of the relay. Perform the following steps to reattempt a connection.

Step 9. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 10. Correct the port setting.

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

You should see a dialog box similar to *Figure B.6*.

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

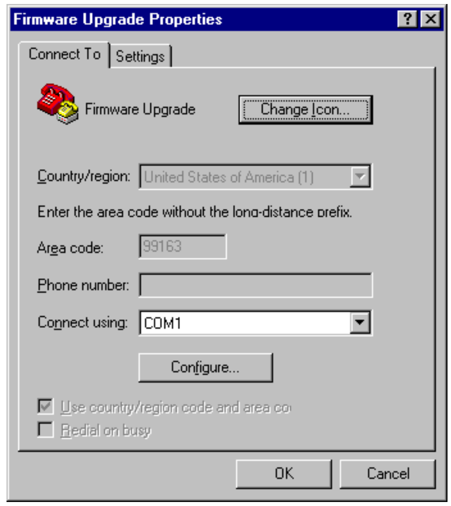

Figure B.6 Correcting the Port Setting

Step 11. Correct the communications parameters.

a. From the filename **Properties** dialog box shown in *Figure B.6*, click **Configure**.

   You will see a dialog box similar to *Figure B.7*.

b. Change the settings in the appropriate list boxes to match the settings you recorded in *Step 9 on page B.2* and click **OK** twice to return to the terminal emulation window.

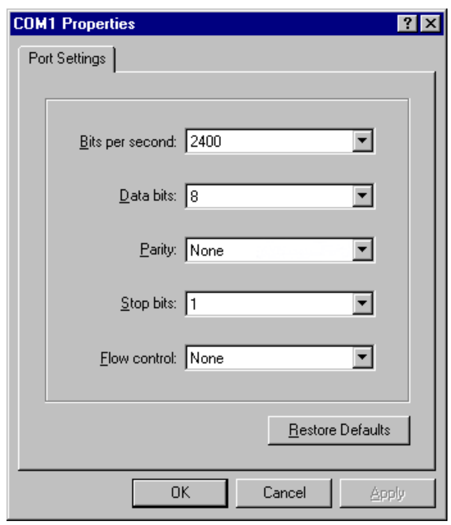

Figure B.7 Correcting the Communications Parameters

Step 12. Press <**Enter**>. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

C. Save Settings and Other Data

Before upgrading firmware, retrieve and record any History (**HIS**), Event (**EVE**), Metering (**MET**), Breaker Wear Monitor (**BRE**), Communications Log Summary (**COM X** or **COM Y**), or Sequential Events Recorder (**SER**) data that you want to retain (see the relay instruction manual for these procedures).

Enter Access Level 2

Step 1. Type **ACC <Enter>** at the Access Level 0 = prompt.

Step 2. Type the Access Level 1 password and press **<Enter>**.

You will see the Access Level 1 => prompt.

NOTE: If the relay does not prompt you for Access Level 1 and Access Level 2 passwords, check whether the relay has a password jumper in place. With this jumper in place, the relay is unprotected from unauthorized access (see the relay instruction manual).

Step 3. Type **2AC <Enter>**.

Step 4. Type the Access Level 2 password and press **<Enter>**.

You will see the Access Level 2 =>> prompt.

Backup Relay Settings

The relay preserves settings and passwords during the firmware upgrade process. However, interruption of relay power during the upgrade process can cause the relay to lose settings. Make a copy of the original relay settings in case you need to reenter the settings. Use either the SEL-5010 Relay Assistant software or QuickSet to record the existing relay settings and proceed to *D. Start SELBOOT*. Otherwise, perform the following steps.

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

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

Step 3. Click **Start**.

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

Step 4. Execute the Show Calibration (**SHO C**) command to retrieve the relay calibration settings.

Use the following Show commands to retrieve the relay settings: **SHO G**, **SHO 1**, **SHO L 1**, **SHO 2**, **SHO L 2**, **SHO 3**, **SHO L 3**, **SHO 4**, **SHO L 4**, **SHO 5**, **SHO L 5**, **SHO 6**, **SHO L 6**, **SHO P 1**, **SHO P 2**, **SHO P 3**, **SHO P F**, **SHO R**, and **SHO T**.

NOTE: Settings classes can vary among SEL relays. See the relay instruction manual for a listing.

Step 5. From the **Transfer** menu in **HyperTerminal**, select **Capture Text** and click **Stop**.

The computer saves the text file you created to the directory you specified in *Step 2* under *Backup Relay Settings*.

Step 6. Write down the present relay data transmission setting (SPEED).

This setting is SPEED in the **SHO P** relay settings output. The SPEED value should be the same as the value you recorded in *A. Prepare the Relay on page B.2*.

D. Start SELBOOT

Step 1. Find and record the firmware identification string (FID).

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

b. Select the **Settings** tab in the **Properties** dialog box (*Figure B.4*).

c. Click **ASCII Setup**.

You should see a dialog box similar to *Figure B.8*.

d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

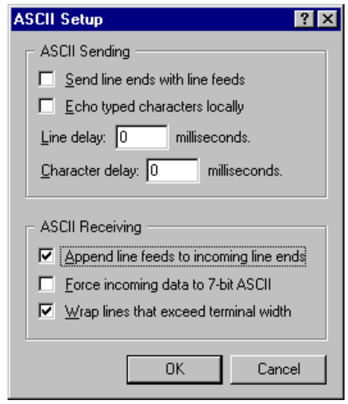

Figure B.8 Preparing HyperTerminal for ID Command Display

e. Click **OK** twice to go back to the terminal emulation window.

f. Type **ID <Enter>** and record the FID number the relay displays.

g. Repeat *Step a–Step c*, then uncheck the **Append line feeds to incoming line ends** check box. (This feature can cause problems when uploading firmware to the relay.)

Step 2. From the computer, start the SELBOOT program.

a. From the Access Level 2 `=>>` prompt, type **L_D <Enter>**.

The relay responds with the following:

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

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

The relay responds with the following:

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

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

The relay responds with the following:

```
Relay Disabled
```

Step 3. Wait for the SELBOOT program to load.

The front-panel LCD screen displays the SELBOOT firmware number (e.g., `SLBT-3xx-R100`). The number following the `R` is the SELBOOT revision number. This number is different from the relay firmware revision number.

After SELBOOT loads, the computer will display the SELBOOT `!>` prompt.

Step 4. Press **<Enter>** to confirm that the relay is in SELBOOT.

You will see another SELBOOT `!>` prompt.

Commands Available in SELBOOT

For a listing of commands available in SELBOOT, type **HELP <Enter>**. You should see a screen similar to *Figure B.9*.

```
!>HELP <Enter>

SELboot-3xx-R100

SELboot-3xx-Rxxx

bau "rate"  ; Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, or 38400 baud

era         ; Erase the existing relay firmware

exi         ; Exit this program and restart the device

fid         ; Print the relays firmware id

rec         ; Receive new firmware for the relay using xmodem

sen         ; Send the relays firmware to a pc using xmodem

hel         ; Print this list

FLASH Type : 040         Checksum = 370E  OK
```

Figure B.9 List of Commands Available in SELBOOT

Establish a High-Speed Connection

Step 5. Type **BAU 38400 <Enter>** at the SELBOOT `!>` prompt.

Match Computer Communications Speed to the Relay

Step 6. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 7. Correct the communications parameters:

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

b. Choose **Configure**.

c. Change the computer communications speed to match the new data transmission rate in the relay (*Figure B.10*).

d. Click **OK** twice.

Step 8. Press **<Enter>** to check for the SELBOOT `!>` prompt indicating that serial communication is successful.

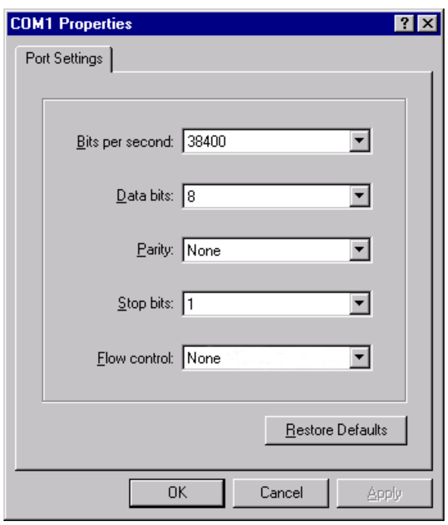

Figure B.10 Matching Computer to Relay Parameters

E. Download Existing Firmware

Copy the firmware presently in the relay, in case the new firmware upload is unsuccessful. To make a backup of the existing firmware, the computer will need as much as 3 MB of free disk space. This backup procedure takes 5–10 minutes at 38400 bps.

Step 1. Type **SEN <Enter>** at the SELBOOT !> prompt to initiate the firmware transfer from the relay to the computer.

Step 2. From the **Transfer** menu in **HyperTerminal**, select **Receive File**.

You should see a dialog box similar to *Figure B.11*.

Step 3. Enter the path of a folder on the computer hard drive where you want to record the existing relay firmware.

Step 4. Select **1K Xmodem** if this protocol is available on the PC.

If the computer does not have **1K Xmodem**, choose **Xmodem**.

Step 5. Click **Receive**.

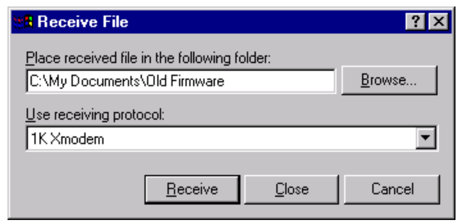

Figure B.11 Example Receive File Dialog Box

Step 6. Enter a filename that clearly identifies the existing firmware version (*Figure B.12*), using the version number from the FID you recorded earlier in *Step 1 on page B.7* and click **OK**.

SEL lists the firmware revision number first, then the product number.

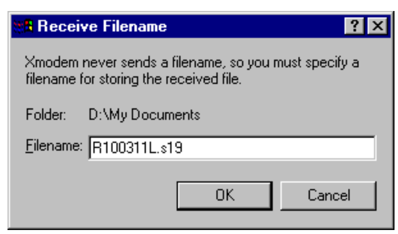

Figure B.12 Example Filename Identifying Old Firmware Version

If Xmodem times out before the download completes, repeat the process from *Step 1 on page B.10*.

NOTE: HyperTerminal stored any path you entered in Step 3 and any filename you entered in Step 6 during the earlier download attempt; this saves you from reentering these on a subsequent attempt.

For a successful download, you should see a dialog box similar to *Figure B.13*. After the transfer, the relay responds with the following:

```
Download completed successfully!
```

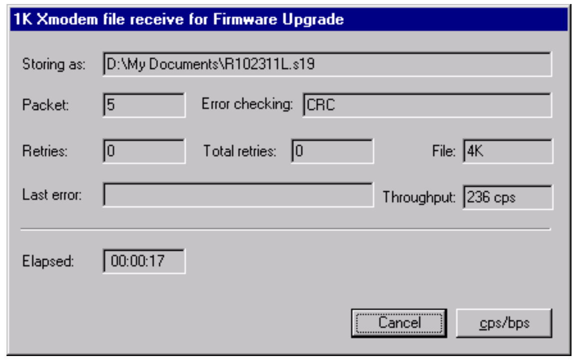

Figure B.13 Downloading Old Firmware

F. Upload New Firmware

Step 1. Prepare to load the firmware:

a. Insert the disk containing the new firmware into the appropriate disk drive on the computer.

b. Some firmware is in self-extracting compressed files (files with .exe extensions). For firmware in such files, from Windows Explorer double-click on the file and select the directory on the hard drive where you want to access the uncompressed files. Verify that these uncompressed files have an .s19 extension.

NOTE: This example shows uploading new firmware directly from a disk. For a faster upload (and less potential for file corruption), copy the new firmware to the local hard drive and upload the new firmware from the hard drive.

Step 2. Type **REC <Enter>** at the SELBOOT !> prompt to command the relay to receive new firmware.

```
!>REC <Enter>

Caution! -  This command erases the relays firmware.

If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.
```

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

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

Step 3. Type **Y** to erase the existing firmware and load new firmware. (To abort, type **N** or press <**Enter**>).

The relay responds with the following:

```
Erasing

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

Step 4. Press <**Enter**> to start the file transfer routine.

Step 5. Send new firmware to the relay.

a. From the **Transfer** menu in **HyperTerminal**, choose **Send File** (*Figure B.14*).

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

c. In the **Protocol** text box, select **1K Xmodem** if this protocol is available.

If the computer does not have **1K Xmodem**, select **Xmodem**.

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

You should see a dialog box similar to *Figure B.14*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate that a transfer is in progress.

Receiving software takes 10–15 minutes at 38400 bps, depending on the relay. If you see no indication of a transfer in progress within a few minutes after clicking **Send**, use the **REC** command again and reattempt the transfer.

NOTE: Unsuccessful uploads can result from Xmodem time-out, a power failure, loss of communication between the relay and the computer, or voluntary cancellation. Check connections, reestablish communication, and start again at Step 2 on page B.11.

If you want to reload the previous firmware, begin at Step 2 on page B.11 and use the firmware you saved in E. Download Existing Firmware on page B.10. Contact the factory for assistance in achieving a successful firmware upgrade.

After the transfer completes, the relay displays the following:

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

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

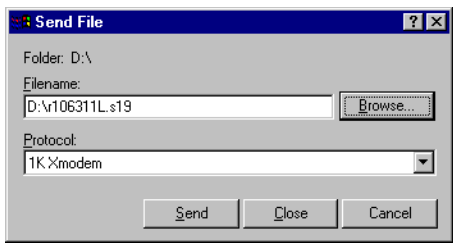

Figure B.14 Selecting New Firmware to Send to the Relay

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware. Upon power-up, the relay serial port will be at the default 2400 baud. Perform the steps beginning in B. Establish a Terminal Connection on page B.3 to increase the serial connection data speed. Then resume the firmware upgrade process at F. Upload New Firmware on page B.11.

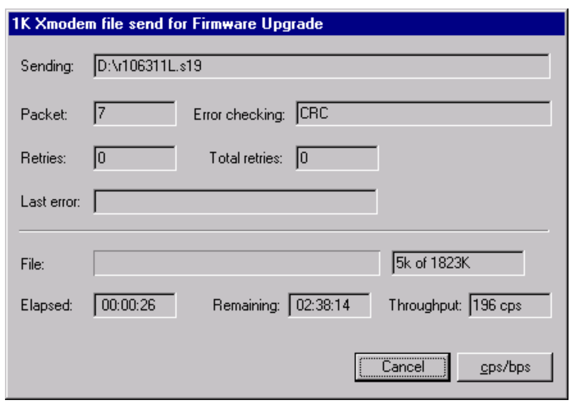

Figure B.15 Transferring New Firmware to the Relay

Step 6. Press <**Enter**> and confirm that the Access Level 0 = prompt appears on the computer screen.

Step 7. If you see the Access Level 0 = prompt, proceed to *G. Check Relay Self-Tests on page B.13*.

No Access Level 0 = Prompt

If no Access Level 0 = prompt appears in the terminal emulation window, one of three things could have occurred. Refer to *Table B.1* to determine the best solution:

Table B.1 Troubleshooting New Firmware Upload

Problem	Solution
The restart was successful, but the relay data transmission rate reverted to the rate at which the relay was operating prior to entering SELBOOT (the rate you recorded in *A. Prepare the Relay on page B.2*).	Change the computer terminal speed to match the relay data transmission rate you recorded in *A. Prepare the Relay* (see *Match Computer Communications Speed to the Relay on page B.9*): Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to the values you recorded in *A. Prepare the Relay*. Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful. Step 5. If you get no response, proceed to *Match Computer Communications Speed to the Relay*.
The restart was successful, but the relay data transmission rate reverted to 2400 bps (the settings have been reset to default).	Match the computer terminal speed to a relay data transmission rate of 2400 bps: Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to 2400 bps, 8 data bits, no parity, and 1 stop bit (see *Match Computer Communications Speed to the Relay*). Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating successful serial communication. If you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. Check for the Access Level 0 = prompt. If you see the Access Level 0 = prompt, proceed to *G. Check Relay Self-Tests*.
The restart was unsuccessful, in which case the relay is in SELBOOT.	Reattempt to upload the new firmware (beginning at *Step 5* under *Establish a High-Speed Connection on page B.9*) or contact the factory for assistance.

G. Check Relay Self-Tests

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

Step 1. Type **ACC <Enter>**.

Step 2. Type the Access Level 1 password and press **<Enter>**.

You will see the Access Level 1 => prompt.

Step 3. Enter the **STATUS** command (**STA <Enter>**) to view relay status messages.

If the relay displays no fail status message, proceed to *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering on page B.15*.

IO_BRD Fail Status Message

Perform this procedure only if you have only an IO_BRD Fail Status message; for additional fail messages, proceed to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.15*.

Step 1. From Access Level 2, type **INI <Enter>** to reinitialize the I/O board(s). If this command is unavailable, go to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages*.

The relay asks the following:

```
Are the new I/O board(s) correct (Y/N)?
```

a. Type **Y <Enter>**.

b. After a brief interval (as long as a minute), the EN LED will illuminate.

If the EN LED does not illuminate and you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. After a brief interval, the EN LED will illuminate. Check for Access Level 0 = prompt.

c. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

NOTE: Depending upon the relay, n can be 1–6, G, P, L, T, R, X, or Y.

d. Enter the **SHO *n*** command to view relay settings and verify that these match the settings you saved (see *Backup Relay Settings on page B.7*).

Step 2. If the settings do not match, reenter the settings you saved earlier.

a. If you have SEL-5010 Relay Assistant software or QuickSet, restore the original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 Relay Assistant software or QuickSet, restore the original settings by issuing the necessary **SET *n*** commands, where ***n*** can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes in the relay).

Step 3. Use the **PAS** command to set the relay passwords.

For example, type **PAS 1 <Enter>** to set the Access Level 1 password.

Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.

Step 4. Go to *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering*.

CR_RAM, EEPROM, and IO_BRD Fail Status Messages

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

The factory-default passwords are in effect; use the default relay passwords listed in the **PAS** command description in the relay instruction manual.

Step 2. Type **R_S <Enter>** to restore factory-default settings in the relay (type **R_S 1 <Enter>** for a 1 A SEL-387 or 1 A SEL-352 relay).

The relay asks whether to restore default settings. If the relay does not accept the **R_S** (or **R_S 1**) command, contact your customer service representative or the factory for assistance.

NOTE: If the relay prompts you to enter a part number, use either the number from the firmware envelope label or the number from the new part number sticker (if supplied).

Step 3. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the EN LED illuminates.

Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.

Step 5. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

Step 6. Restore the original settings:

a. If you have SEL-5010 Relay Assistant software or QuickSet, restore the original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 Relay Assistant software or QuickSet, restore the original settings by issuing the necessary **SET** ***n*** commands, where ***n*** can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes available in the relay).

Step 7. Use the **PAS** command to set the relay passwords.

For example, type **PAS 1 <Enter>** to set the Access Level 1 password.

Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.

Step 8. If any failure status messages still appear on the relay display, see *Section 13: Testing and Troubleshooting* or contact your customer service representative or the factory for assistance.

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

Step 2. Use the **SHO** command to view the relay settings and verify that these match the settings you saved earlier (see *Backup Relay Settings on page B.7*).

If the settings do not match, reenter the settings you saved earlier (see *Step 6* under *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.15*).

Step 3. Type **SHO C <Enter>** to verify the relay calibration settings.

If the settings do not match the settings contained in the text file you recorded in *C. Save Settings and Other Data on page B.6*, contact your customer service representative or the factory for assistance.

Step 4. Use the firmware identification string (FID) to verify download of the correct firmware:

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

b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).

c. Click **ASCII Setup**.

You should see a dialog box similar to *Figure B.16*.

d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

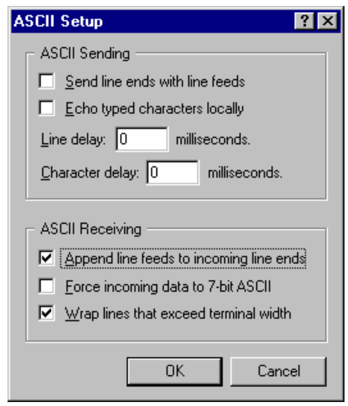

Figure B.16 Preparing HyperTerminal for ID Command Display

e. Click **OK** twice to return to the terminal emulation window.

f. Type **ID <Enter>** and compare the number the relay displays against the number from the firmware envelope label.

g. If the label FID and part number match the relay display, proceed to *Step 5*.

h. For a mismatch between a displayed FID or part number, and the firmware envelope label, reattempt the upgrade or contact the factory for assistance.

Step 5. Type **STA <Enter>** and verify that all relay self-test parameters are within tolerance.

Step 6. If you use the Breaker Wear Monitor, type **BRE <Enter>** to check the data and see if the relay retained breaker wear data through the upgrade procedure.

If the relay did not retain these data, use the **BRE W*n*** command to reload the percent contact wear values for each pole of Circuit Breaker ***n*** (***n*** = 1, 2, 3, or 4) you recorded in *C. Save Settings and Other Data on page B.6*.

Step 7. Apply current and voltage signals to the relay.

Step 8. Type **MET <Enter>** and verify that the current and voltage signals are correct.

Step 9. Use the **TRIGGER** and **EVENT** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report.

If these values do not match, check the relay settings and wiring.

I. Return the Relay to Service

Step 1. Follow your company procedures for returning a relay to service.

Step 2. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay.

This step reestablishes automatic data collection between the SEL communications processor and the relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

The relay is now ready for your commissioning procedure.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890
Fax: +1.509.332.7990
Internet: selinc.com
Email: info@selinc.com

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Appendix C
SEL Distributed Port Switch Protocol

Overview

SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. It is appropriate for low-cost, low-speed port switching applications where updating a real-time database is not a requirement.

Settings

Use the front-panel **SET** pushbutton or the serial port **SET P** command to activate the LMD protocol. Change the port PROTO setting from the default SEL to LMD to reveal the following settings:

Settings	Description
PREFIX:	One character to precede the address. This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following: “@”, “#”, “$”, “%”, “&”. The default is “@”.
ADDR:	Two-character ASCII address. The range is “01” to “99”. The default is “01”.
SETTLE:	Time in seconds that transmission is delayed after the request to send (RTS line) asserts. This delay accommodates transmitters with a slow rise time.

Operation

NOTE: You can use the front-panel **SET** pushbutton to change the port settings to return to SEL protocol.

1. The relay ignores all input from this port until it detects the prefix character and the two-byte address.
2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.
4. Until the relay connection terminates, you can use the standard commands that are available when PROTO is set to SEL.
5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port time-out period, it automatically terminates the connection.
6. Enter the sequence **Ctrl+X QUIT <CR>** before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

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Appendix D

Configuration, Fast Meter, and Fast Operate Commands

Overview

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

SEL Application Guide AG95-10, *Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-351R Recloser Control.

Message Lists

Binary Message List

Table D.1 Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	Fast Meter Configuration Block
A5D1	Fast Meter Data Block
A5C2	Demand Fast Meter Configuration Block
A5D2	Demand Fast Meter Data Message
A5C3	Peak Demand Fast Meter Configuration Block
A5D3	Peak Demand Fast Meter Data Message
A5B9	Fast Meter Status Acknowledge
A5CE	Fast Operate Configuration Block
A5E0	Fast Operate Remote Bit Control
A5E3	Fast Operate Breaker Control

Table D.2 ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the A5B9 Status Byte

Message Definitions

A5C0 Relay Definition Block

In response to the A5C0 request, the SEL-351R sends the block shown in *Table D.3*.

Table D.3 A5C0 Relay Definition Block

Data	Description
A5C0	Command
34	Length
04	Support two protocols, SEL, MIRRORED BITS®, DNP, and LMD
03	Support three Fast Meter messages
03	Support three status flag commands
A5C1	Fast Meter configuration command
A5D1	Fast Meter command
A5C2	Demand Fast Meter configuration command
A5D2	Demand Fast Meter command
A5C3	Peak Demand Fast Meter configuration command
A5D3	Peak Demand Fast Meter command
0004	Settings change bit
A5C100000000	Fast Meter configuration message
0004	Settings change bit
A5C200000000	Demand Fast Meter configuration message
0004	Settings change bit
A5C300000000	Peak Demand Fast Meter configuration message
0300	SEL protocol, Fast Operate
0301	LMD protocol, Fast Operate
0005	DNP3 protocol, No Fast Operate
0006	MIRRORED BITS protocol, No Fast Operate
00	Reserved
checksum	1-byte checksum of preceding bytes

A5C1 Fast Meter Configuration Block

In response to the A5C1 request, the SEL-351R sends the block shown in *Table D.4*.

Table D.4 A5C1 Fast Meter Configuration Block (Sheet 1 of 2)

Data	Description
A5C1	Fast Meter command
7A	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	No scale factors
09	# of analog input channels
02	# of samples per channel
3D	# of digital banks (number of visible rows as defined by the Relay Word—in hex)
01	One calculation block
0004	Analog channel offset
004C	Time stamp offset
0054	Digital offset
494100000000	Analog channel name (IA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name (IB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name (IC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494E00000000	Analog channel name (IN)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564100000000	Analog channel name (VA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564200000000	Analog channel name (VB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

Table D.4 A5C1 Fast Meter Configuration Block (Sheet 2 of 2)

Data	Description
564300000000	Analog channel name (VC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
565300000000	Analog channel name (VS)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
465245510000	Analog channel name (FREQ)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Line Configuration (0–ABC, 1–ACB)
00	Standard Power Calculations
FFFF	No Deskew angle
FFFF	No Rs compensation (–1)
FFFF	No Xs compensation (–1)
00	IA channel index
01	IB channel index
02	IC channel index
04	VA channel index
05	VB channel index
06	VC channel index
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5D1 Fast Meter Data Block

In response to the A5D1 request, the SEL-351R sends the block shown in *Table D.5*.

Table D.5 A5D1 Fast Meter Data Block

Data	Description
A5D1	Command
148	Length
1-byte	1 Status Byte
72-bytes	X and Y components of: IA, IB, IC, IN, VA, VB, VC,
	VS and Freq in 4-byte IEEE FPS
8-bytes	Time stamp
61-bytes	61 Digital banks: TAR0–TAR60
2-bytes	Reserved
checksum	1-byte checksum of all preceding bytes

A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages

In response to the A5C2 or A5C3 request, the relay sends the block shown in *Table D.6*.

Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 1 of 3)

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
EE	Length
01	# of status flag bytes
00	Scale factors in meter message
00	# of scale factors
16	# of analog input channels
01	# of samples per channel
00	# of digital banks
00	# of calculation blocks
0004	Analog channel offset
00B4	Time stamp offset
FFFF	Digital offset
494100000000	Analog channel name (IA)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name (IB)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name (IC)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494E00000000	Analog channel name (IN)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494700000000	Analog channel name (IG)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
334932000000	Analog channel name (3I2)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 2 of 3)

Data	Description
50412B000000	Analog channel name (PA+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422B000000	Analog channel name (PB+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50432B000000	Analog channel name (PC+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332B000000	Analog channel name (P3+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412B000000	Analog channel name (QA+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422B000000	Analog channel name (QB+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51432B000000	Analog channel name (QC+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332B000000	Analog channel name (Q3+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50412D000000	Analog channel name (PA–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422D000000	Analog channel name (PB–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 3 of 3)

Data	Description
50432D000000	Analog channel name (PC–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332D000000	Analog channel name (P3–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412D000000	Analog channel name (QA–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422D000000	Analog channel name (QB–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51432D000000	Analog channel name (QC–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332D000000	Analog channel name (Q3–)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Reserved
checksum	1-byte checksum of preceding bytes

A5D2/A5D3 Demand/Peak Demand Fast Meter Message

In response to the A5D2 or A5D3 request, the relay sends the block shown in *Table D.7*.

Table D.7 A5D2/A5D3 Demand/Peak Demand Fast Meter Message

Data	Description
A5D2 or A5D3	Command
BE	Length
1-byte	1 Status Byte
176-bytes	Demand: IA, IB, IC, IN, IG, 3I2, MWA I, MWB I, MWC I, MW3PI,
	MVA I, MVB I, MVC I, MV3PI, MWA O, MWB O, MWC O,
	MW3PO, MVA O, MVB O, MVC O, MV3PO in 8-byte IEEE FPS
8-bytes	Time stamp
1-byte	Reserved
1-byte	1-byte checksum of all preceding bytes

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the relay clears the Fast Meter (message A5D1) Status Byte. The SEL-351R Status Byte contains one active bit, STSET (bit 4). The bit is set on power up and on settings changes. If the STSET bit is set, the external device should request the A5C1, A5C2, and A5C3 messages. The external device can then determine if the scale factors or line configuration parameters have been modified.

A5CE Fast Operate Configuration Block

In response to the A5CE request, the relay sends the block shown in *Table D.8*.

Table D.8 A5CE Fast Operate Configuration Block (Sheet 1 of 2)

Data	Description
A5CE	Command
24	Length
01	Support 1 circuit breaker
0010	Support 16 remote bit set/clear commands
0100	Allow remote bit pulse commands
31	Operate code, open breaker 1
11	Operate code, close breaker 1
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9

Table D.8 A5CE Fast Operate Configuration Block (Sheet 2 of 2)

Data	Description
48	Operate code, pulse remote bit RB9
09	Operate code, clear remote bit RB10
29	Operate code, set remote bit RB10
49	Operate code, pulse remote bit RB10
0A	Operate code, clear remote bit RB11
2A	Operate code, set remote bit RB11
4A	Operate code, pulse remote bit RB11
0B	Operate code, clear remote bit RB12
2B	Operate code, set remote bit RB12
4B	Operate code, pulse remote bit RB12
0C	Operate code, clear remote bit RB13
2C	Operate code, set remote bit RB13
4C	Operate code, pulse remote bit RB13
0D	Operate code, clear remote bit RB14
2D	Operate code, set remote bit RB14
4D	Operate code, pulse remote bit RB14
0E	Operate code, clear remote bit RB15
2E	Operate code, set remote bit RB15
4E	Operate code, pulse remote bit RB15
0F	Operate code, clear remote bit RB16
2F	Operate code, set remote bit RB16
4F	Operate code, pulse remote bit RB16
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

The external device sends the message shown in *Table D.9* to perform a remote bit operation.

Table D.9 A5E0 Fast Operate Remote Bit Control

Data	Description
A5E0	Command
06	Length
1-byte	Operate code:
	00–0F clear remote bit RB1–RB16
	20–2F set remote bit RB1–RB16
	40–4F pulse remote bit for RB1–RB16 for one processing interval
1-byte	Operate validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified remote bit operation if the following conditions are true:

1. The Operate code is valid.
2. The Operate validation = 4 • Operate code + 1.
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval (1/4 cycle).

It is common practice to route remote bits to output contacts to provide remote control of the relay outputs. If you wish to pulse an output contact closed for a specific duration, SEL recommends using the remote bit pulse command and SELOGIC® control equations to provide secure and accurate contact control. The remote device sends the remote bit pulse command; the relay controls the timing of the output SELOGIC contact assertion. You can use any remote bit, RB1–RB16, and any control equation timer (SV1–SV16) to control any of the output contacts (**OUT101–OUT107**). For example, to pulse output contact **OUT104** for 30 cycles with Remote Bit RB4 and SELOGIC control equation timer SV4, issue the following relay settings:

via the **SET L** command,

SV4 = **RB4** SV4 input is RB4

OUT104 = **SV4T** route SV4 timer output to **OUT104**

via the **SET** command,

SV4PU = **0** SV4 pickup time = 0

SV4DO = **30** SV4 dropout time is 30 cycles

To pulse the contact, send the **A5E006430DDB** command to the relay.

A5E3 Fast Operate Breaker Control

The external device sends the message shown in *Table D.10* to perform a fast breaker open/close.

Table D.10 A5E3 Fast Operate Breaker Control

Data	Description
A5E3	Command
06	Length
1-byte	Operate code:
	31—OPEN breaker
	11—CLOSE breaker
1-byte	Operate Validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified breaker operation if the following conditions are true:

1. Conditions 1–5 defined in the A5E0 message are true.
2. The breaker jumper (JMP6) is in place on the SEL-351R main board.

ID Message

In response to the **ID** command, the relay sends the firmware ID (FID), boot firmware ID (BFID), firmware checksum (CID), relay TID setting (DEVID), Modbus® device code (DEVCODE)—for use by the SEL-2032, SEL-2030, and SEL-2020 Communications Processors, relay part number (PARTNO), and configuration string (CONFIG)—for use by other IEDs or software. A sample response is shown below; responses will differ depending on relay model, settings, and firmware.

```
<STX>

"FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx","yyyy"<CR>
"BFID=SELboot-35R-R101","yyyy"<CR>
"CID=xxxx","yyyy"<CR>
"DEVID=FEEDER 2101","yyyy"<CR>
"DEVCODE=30","yyyy"<CR>
"PARTNO=0351R41281115XXXX","yyyy"<CR>
"CONFIG=112322","yyyy"<CR>

<ETX>
```

where:

<STX>	is the STX character (02)
<ETX>	is the ETX character (03)
yyyy	is the 4-byte ASCII hex representation of the checksum for each line.

The **ID** message is available from Access Level 0 and higher.

DNA Message

In response to the **DNA** command, the relay sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the MSB, the last name with the LSB. These names are listed in *Table 9.6*. The **DNA** command is available from Access Level 1 and higher.

The DNA message for the SEL-351R is:

```
<STX>

"LED10","LED11","LED12","LED13","LED14","LED15","LED16","LED17","yyyy"
"LED18","LED19","LED20","LED21","LED22","LED23","LED24","LED25","yyyy"
"50A1","50B1","50C1","50A2","50B2","50C2","50A3","50B3","yyyy"
"50C3","50A4","50B4","50C4","50AB1","50BC1","50CA1","50AB2","yyyy"
"50BC2","50CA2","50AB3","50BC3","50CA3","50AB4","50BC4","50CA4","yyyy"
"50A","50B","50C","51P1","51P1T","51P1R","51N1","51N1T","yyyy"
"51N1R","51G1","51G1T","51G1R","51P2","51P2T","51P2R","51N2","yyyy"
"51N2T","51N2R","51G2","51G2T","51G2R","51Q","51QT","51QR","yyyy"
"50P1","50P2","50P3","50P4","50N1","50N2","50N3","50N4","yyyy"
"67P1","67P2","67P3","67P4","67N1","67N2","67N3","67N4","yyyy"
"67P1T","67P2T","67P3T","67P4T","67N1T","67N2T","67N3T","67N4T","yyyy"
"50G1","50G2","50G3","50G4","50Q1","50Q2","50Q3","50Q4","yyyy"
"67G1","67G2","67G3","67G4","67Q1","67Q2","67Q3","67Q4","yyyy"
"67G1T","67G2T","67G3T","67G4T","67Q1T","67Q2T","67Q3T","67Q4T","yyyy"
"50P5","50P6","50N5","50N6","50G5","50G6","50Q5","50Q6","yyyy"
"50QF","50QR","50GF","50GR","32VE","32QGE","32NE","32QE","yyyy"
"F32P","R32P","F32Q","R32Q","F32QG","R32QG","F32V","R32V","yyyy"
"F32N","R32N","32PF","32PR","32QF","32QR","32GF","32GR","yyyy"
"27A1","27B1","27C1","27A2","27B2","27C2","59A1","59B1","yyyy"
"59C1","59A2","59B2","59C2","27AB","27BC","27CA","59AB","yyyy"
"59BC","59CA","59N1","59N2","59Q","59V1","27S","59S1","yyyy"
"59S2","59VP","59VS","SF","25A1","25A2","3P27","3P59","yyyy"
"81D1","81D2","81D3","81D4","81D5","81D6","27B81","50L","yyyy"
"81D1T","81D2T","81D3T","81D4T","81D5T","81D6T","VPOLV","LOP","yyyy"
"RCTR","RCCL","IN106","IN105","IN104","IN103","IN102","IN101","yyyy"
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","yyyy"
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","yyyy"
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","yyyy"
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","yyyy"
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","yyyy"
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","yyyy"
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","yyyy"
"79RS","79CY","79LO","SH0","SH1","SH2","SH3","SH4","yyyy"
"CLOSE","CF","RCSF","OPTMN","RSTMN","FSA","FSB","FSC","yyyy"
"BCW","50P32","BADBAT","59VA","TRGTR","52A","COMMT","CHRGG","yyyy"
"SG1","SG2","SG3","SG4","SG5","SG6","ZLOUT","ZLIN","yyyy"
"ZLOAD","BCWA","BCWB","BCWC","TOSLPV","TOSLPT","DISTST","DTFAIL","yyyy"
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101","yyyy"
"3PO","SOTFE","Z3RB","KEY","EKEY","ECTT","WFC","PT","yyyy"
```

```
"PTRX2","PTRX","PTRX1","UBB1","UBB2","UBB","Z3XT","DSTRT","yyyy"
"NSTRT","STOP","BTX","TRIP","OC","CC","CLG","HICHRG","yyyy"
"67P2S","67N2S","67G2S","67Q2S","PDEM","NDEM","GDEM","QDEM","yyyy"
"PB1","PB2","PB3","PB4","PB5","PB6","PB7","PB8","yyyy"
"PB9","PINBD","PINC","PINE","PINF","SW1","DISCHG","LED9","yyyy"
"LED1","LED2","LED3","LED4","LED5","LED6","LED7","LED8","yyyy"
"OCP","OCG","OLP","OLG","OLS","HTP","HTG","HLP","yyyy"
"HLG","CLP","RPP","RPG","RPS","SEQC","3PHV","GTP","0B42"
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","yyyy"
"TMB8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","yyyy"
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","yyyy"
"TMB8B","TMB7B","TMB6B","TMB5B","TMB4B","TMB3B","TMB2B","TMB1B","yyyy"
"LBOKB","CBADB","RBADB","ROKB","LBOKA","CBADA","RBADA","ROKA","yyyy"
"*","*","*","*","*","*","*","*","yyyy"
"*","*","*","*","*","*","*","*","yyyy"
"*","*","*","*","*","*","*","*","yyyy"
"*","*","*","*","*","*","*","*","yyyy"
"50NF","50NR","32NF","32NR","59L1","IDSCHG","DCONN","DDATA","yyyy"
"BATVL1","BATVL2","*","*","*","*","*","LOCAL","yyyy"
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","yyyy"
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","yyyy"
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","yyyy"

<ETX>
```

where:

<STX>	is the STX character (02).
<ETX>	is the ETX character (03).
the last field in each line (yyyy)	is the 4-byte ASCII hex representation of the checksum for the line.
"*"	indicates an unused bit location.

BNA Message

In response to the **BNA** command, the relay sends names of the bits transmitted in the Status Byte in the A5D1 message. The first name is the MSB, the last name is the LSB. The BNA message is:

```
<STX>"*","*","*","STSET","*","*","*","*","yyyy"<ETX>
```

where:

"yyyy"	is the 4-byte ASCII representation of the checksum.
"*"	indicates an unused bit location.

The **BNA** command is available from Access Level 1 and higher.

SNS Message

In response to the **SNS** command, the relay sends the name string of the SER (SER1 SER2 SER3) settings. The **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example, if

SER1 = 50A1 OUT101

SER2 = 67P1T 81D1T

SER3 = OUT102 52A

The name string will be

“50A1”,”OUT101”,”67P1T”,”81D1T”,”OUT102”,”52A”.

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and carriage return. The last row may have less than eight strings.

The SNS message for the SEL-351R is shown below:

```
<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
     "xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
     "xxxx","xxxx","xxxx",<CR><LF><ETX>
```

where:

xxxx is a string from the settings in SER (SER1, SER2 and SER3)

yyyy is the 4-byte ASCII representation of the checksum

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Appendix E
Compressed ASCII Commands

Overview

The SEL-351R Recloser Control provides Compressed ASCII versions of some of the control's ASCII commands. The Compressed ASCII commands allow an external device to obtain data from the control, in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-351R provides the following Compressed ASCII commands:

Command	Description
CASCII	Configuration message
CSTATUS	Status message
CHISTORY	History message
CEVENT	Event message

CASCII Command—General Format

The Compressed ASCII configuration message provides data for an external computer to extract data from other Compressed ASCII commands. To obtain the configuration message for the Compressed ASCII commands available in an SEL relay, type:

CAS <CR>

The relay sends:

```
<STX>"CAS",n,"yyyy"<CR>
"COMMAND 1",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
"COMMAND 2",ll,"yyyy"<CR>
"#h","ddd","ddd",......,"ddd","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
      .
      .
      .
"COMMAND n",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><ETX>
```

where:

n is the number of Compressed ASCII command descriptions to follow.

`COMMAND` is the ASCII name for the Compressed ASCII command as sent by the requesting device. The naming convention for the Compressed ASCII commands is a C preceding the typical command. For example, **CSTATUS** (abbreviated to **CST**) is the compressed **STATUS** command.

`ll` is the minimum access level at which the command is available.

`#H` identifies a header line to precede one or more data lines; "#" is the number of subsequent ASCII names. For example, "`21H`" identifies a header line with 21 ASCII labels.

`#h` identifies a header line to precede one or more data lines; "#" is the number of subsequent format fields. For example, "`8h`" identifies a header line with 8 format fields.

`xxxxx` is an ASCII name for corresponding data on following data lines. Maximum ASCII name width is 10 characters.

`#D` identifies a data format line; "#" is the maximum number of subsequent data lines.

`ddd` identifies a format field containing one of the following type designators:
I Integer data
F Floating point data
*m*S String of maximum *m* characters (e.g., 10S for a 10-character string)

`yyyy` is the 4-byte hex ASCII representation of the checksum.

A Compressed ASCII command may require multiple header and data configuration lines.

If a Compressed ASCII request is made for data that are not available, (e.g., the history buffer is empty or invalid event request), the relay responds with the following message:

```
<STX>"No Data Available","0668"<CR><ETX>
```

CASCII COMMAND—SEL-351R

Display the SEL-351R Compressed ASCII configuration message by sending:

CAS <CR>

The SEL-351R sends:

```
<STX>
"CAS",5,"yyyy"<CR>
"CST",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","48S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"15H","I1","I2","I3","IN","V1","V2","V3","VS","MOF","+5V_PS","+5V_REG","-5V_REG",
"+12V_PS","-12V_PS","+15V_PS","yyyy"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"yyyy"<CR>
"12H","-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","MODE","HRS_LFT",
"12V_AUX","VBAT","IBAT","yyyy"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","yyyy"<CR>
"CHI",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","48S","yyyy"<CR>
"15H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","LOCATION",
"CURR","FREQ","GROUP","SHOT","TARGETS","yyyy"<CR>
"30D","I","I","I","I","I","I","I","I","6S","F","I","F","I","I","17S","yyyy"<CR>
"CEV",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","48S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION","SHOT",
"TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","F","I","I","I","6S","F","I","17S","I","I","I","I","I","I","yyyy"<CR>
"12H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","FREQ","TRIG",
"Names of elements in the Relay Word, separated by spaces","yyyy"<CR>
"60D","I","I","I","I","I","F","F","F","F","F","2S","116S","yyyy"<CR>
"CEV C",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","48S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION","SHOT",
"TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","F","I","I","I","6S","F","I","17S","I","I","I","I","I","I","yyyy"<CR>
"12H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","FREQ","TRIG",
"Names of elements in the Relay Word, separated by spaces","yyyy"<CR>
"240D","I","I","I","I","I","F","F","F","F","F","2S","116S","yyyy"<CR>
"CEV R",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","48S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION","SHOT",
"TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","F","I","I","I","6S","F","I","17S","I","I","I","I","I","I","yyyy"<CR>
"12H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","FREQ","TRIG",
"Names of elements in the Relay Word, separated by spaces","yyyy"<CR>
"256D","I","I","I","I","I","F","F","F","F","F","2S","116S","yyyy"<CR>
<ETX>
```

The 4-byte hex ASCII representation of the checksum is `yyyy`. See the **CEVENT** command for definition of the *"Names of elements in the Relay Word, separated by spaces"* field.

CSTATUS Command—SEL-351R

Display status data in Compressed ASCII format by sending:

CST <CR>

The SEL-351R sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"I1","I2","I3","IN","V1","V2","V3","VS","MOF","+5V_PS","+5V_REG","-5V_REG","+12V_PS
","-12V_PS","+15V_PS","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx"
,"xxxx","xxxx","xxxx","yyyy"<CR>
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","MODE","HRS_LFT","12V_AUX","VB
AT","IBAT","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx"
,"yyyy"<CR>
<ETX>
```

where:

`xxxx` are the data values corresponding to the first line labels and

`yyyy` is the 4-byte hex ASCII representation of the checksum.

CHISTORY Command—SEL-351R

Display history data in Compressed ASCII format by sending:

CHI <CR>

The relay sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","LOCATION","CURR",
"FREQ","GROUP","SHOT","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx","yyy
y"<CR>
<ETX>
```

(the last line is then repeated for each record)

where:

`xxxx` are the data values corresponding to the first line labels

`yyyy` is the 4-byte hex ASCII representation of the checksum.

If the history buffer is empty, the relay responds:

```
<STX>"No Data Available","0668"<CR><ETX>
```

CEVENT Command—SEL-351R

Display event report in Compressed ASCII format by sending:

CEV [*n* S*x* L*y* L R C] (parameters in [ ] are optional)

where:

- *n* event number (1–30) if LER = 15, (1–15) if LER = 30, defaults to 1
- S*x* *x* samples per cycle (4 or 16); defaults to 4. If S*x* parameter is present, it overrides the L parameter
- L*y* *y* cycles event report length (1-LER) for filtered event reports, (1-LER+1) for raw event reports, defaults to 15 if not specified
- L 16 samples per cycle; overridden by the S*x* parameter, if present
- R specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to 16 cycles in length unless overridden with the L*y* parameter.
- C specifies 16 samples per cycle, 15-cycle length

The relay responds to the **CEV** command with the *n*th event report as shown below. Items in italics will be replaced with the actual relay data.

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION","SHOT","TARGETS","IA
","IB","IC","IN","IG","3I2","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR
>
"IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","FREQ","TRIG","Names of
elements in the Relay Word, separated by spaces","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"HEX-ASCII Relay
Word","yyyy"<CR>
"SETTINGS","yyyy"<CR>
"EZ group,group,logic group,EZ global, and global settings as displayed with the SHO
command (surrounded by quotes)","yyyy"<CR>
<ETX>
```

where:

- `xxxx` are the data values corresponding to the line labels.
- `yyyy` is the 4-byte hex ASCII representation of the checksum.
- `FREQ` is the power system frequency at the trigger instant.
- `SAM/CYC_A` is the number of analog data samples per cycle (4 or 16).
- `SAM/CYC_D` is the number of digital data samples per cycle (4 or 16).
- `NUM_OF_CYC` is the number of cycles of data in the event report.
- `EVENT` is the event type.
- `LOCATION` is the fault location.
- `SHOT` is the recloser shot counter.
- `TARGETS` are the front-panel tripping targets.
- `IA, IB, IC, IN, IG, 3I2` is the fault current.
- `TRIG` refers to the trigger record.

z	is ">" for the trigger row, "*" for the fault current row and empty for all others. If the trigger row and fault current row are the same, both characters are included (e.g., ">*").
HEX-ASCII Relay Word	is the hex ASCII format of the Relay Word. The first element in the Relay Word is the most significant bit in the first character.

If samples per cycle are specified as 16, the analog data are displayed at 1/16-cycle intervals and digital data at 1/4-cycle intervals. The digital data are displayed as a series of hex ASCII characters. The relay displays digital data only when they are available. When no data are available, the relay sends only the comma delimiter in the digital data field.

If the specified event does not exist, the relay responds:

```
<STX>"No Data Available","0668"<CR><ETX>
```

The "*Names of elements in the Relay Word, separated by spaces*" names are listed in the Relay Word bits table, *Table 9.6*.

A typical HEX-ASCII Relay Word is shown below:

"100000049861000000000000000F120280000000001020100000000000000002
40C0080000000000000000000000"

Each bit in the HEX-ASCII Relay Word reflects the status of a Relay Word bit. The order of the labels in the "*Names of elements in the relay word separated by spaces*" field matches the order of the HEX-ASCII Relay Word. In the example above, the first two bytes in the HEX-ASCII Relay Word are "10." In binary, this evaluates to 00010000. Mapping the labels to the bits yields:

Labels	50A1	50B1	50C1	50A2	50B2	50C2	50A3	50B3
Bits	0	0	0	1	0	0	0	0

In this example, the 50A2 element is asserted (logical 1); all others are deasserted (logical 0).

Appendix F
Setting Negative-Sequence Overcurrent Elements

Setting Negative-Sequence Definite-Time Overcurrent Elements

Negative-sequence instantaneous overcurrent elements 50Q1–50Q6 and 67Q1–67Q4 should not be set to trip directly. This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears.

To avoid tripping for this transient condition, use negative-sequence definite-time overcurrent elements 67Q1T–67Q4T with at least 1.5 cycles of time delay (transient condition lasts less than 1.5 cycles). For example, make time delay setting:

67Q1D = **1.50**

for negative-sequence definite-time overcurrent element 67Q1T. Refer to *Figure 3.12* and *Figure 3.13* for more information on negative-sequence instantaneous and definite-time overcurrent elements.

Negative-sequence instantaneous overcurrent elements 50Q5 and 50Q6 do not have associated timers (compare *Figure 3.13* to *Figure 3.12*). If 50Q5 or 50Q6 need to be used for tripping, run them though SELOGIC® control equation variable timers (see *Figure 7.24* and *Figure 7.25*) and use the outputs of the timers for tripping.

Continue reading in *Coordinating Negative-Sequence Overcurrent Elements on page F.2* for guidelines on coordinating negative-sequence definite-time overcurrent elements and a following coordination example. The coordination example uses time-overcurrent elements, but the same principles can be applied to definite-time overcurrent elements.

Setting Negative-Sequence Time-Overcurrent Elements

Negative-sequence time-overcurrent element 51QT should not be set to trip directly when it is set with a low time-dial setting 51QTD, that results in curve times below 3 cycles (see curves in *Figure 9.1–Figure 9.20*). This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. Refer to *Figure 3.20* for more information on negative-sequence time-overcurrent element 51QT.

To avoid having negative-sequence time-overcurrent element 51QT with such low time-dial settings trip for this transient negative-sequence current condition, make corresponding minimum response time setting:

51QMR = **1.50 cycles** (minimum response time; transient condition lasts less than 1.5 cycles)

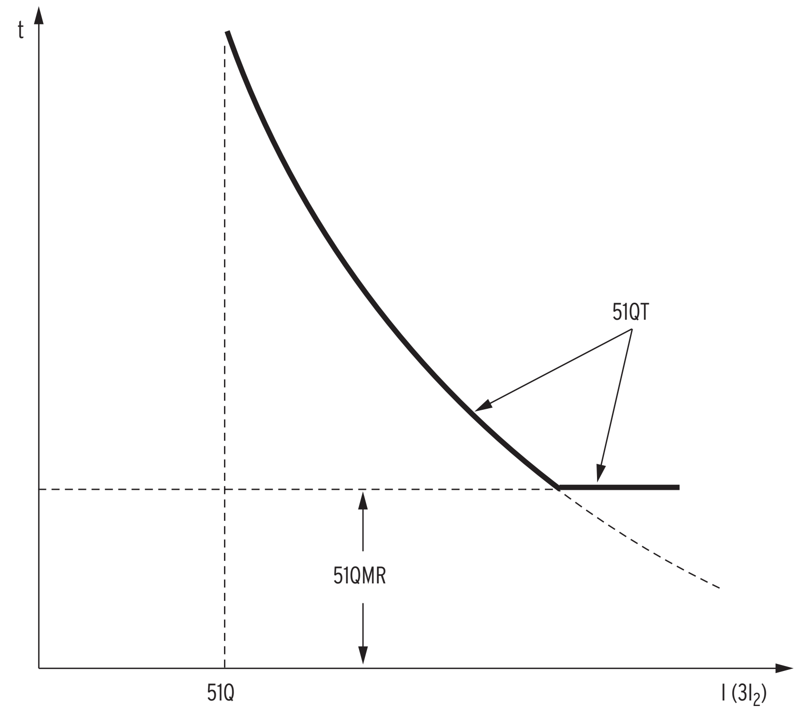

Figure F.1 Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

Continue reading in *Coordinating Negative-Sequence Overcurrent Elements on page F.2* for guidelines on coordinating negative-sequence time-overcurrent elements and a following coordination example.

Coordinating Negative-Sequence Overcurrent Elements

The following coordination guidelines and example assume that the negative-sequence overcurrent elements operate on $3I_2$ magnitude negative-sequence current and that the power system is radial. The negative-sequence overcurrent elements in the SEL-351R Recloser Control operate on $3I_2$ magnitude negative-sequence current.

The coordination example is a generic example that can be used with any relay containing negative-sequence overcurrent elements that operate on $3I_2$ magnitude negative-sequence current. The SEL-351R can be inserted as the feeder relay in this example. Note that the overcurrent element labels in the example are not the same as the labels of the corresponding SEL-351R overcurrent elements.

Coordination Guidelines

1. Start with the farthest downstream negative-sequence overcurrent element (e.g., distribution feeder relay in a substation).
2. Identify the phase overcurrent device (e.g., line recloser, fuse) downstream from the negative-sequence overcurrent element that is of greatest concern for coordination. This is usually the phase overcurrent device with the longest clearing time.
3. Consider the negative-sequence overcurrent element as an "equivalent" phase overcurrent element. Derive pickup, time dial (lever), curve type, or time-delay settings for this "equivalent" element to coordinate with the downstream phase overcurrent device, as any phase coordination would be performed. Load considerations can be disregarded when deriving the "equivalent" phase overcurrent element settings.
4. Multiply the "equivalent" phase overcurrent element pickup setting by $\sqrt{3}$ to convert it to the negative-sequence overcurrent element pickup setting in terms of $3I_2$ current.

$$\left.\begin{array}{c}\text{Negative-}\\\text{sequence}\\\text{overcurrent}\\\text{element}\\\text{pickup}\end{array}\right\} = \sqrt{3} \cdot (\text{"equivalent" phase overcurrent element pickup})$$

   Any time dial (lever), curve type, or time delay calculated for the "equivalent" phase overcurrent element is also used for the negative-sequence overcurrent element with no conversion factor applied.

5. Set the next upstream negative-sequence overcurrent element to coordinate with the first downstream negative-sequence overcurrent element and so on. Again, coordination is not influenced by load considerations.

Coordination Example

In *Figure F.2* the phase and negative-sequence overcurrent elements of the feeder relay (51F and 51QF, respectively) must coordinate with the phase overcurrent element of the line recloser (51R).

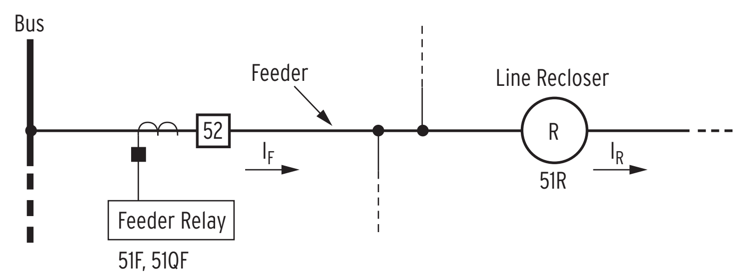

Figure F.2 Distribution Feeder Protective Devices

where:

I_F	=	Maximum load current through feeder relay = 450 A
I_R	=	Maximum load current through line recloser = 150 A
51F	=	Feeder relay phase time-overcurrent element
51QF	=	Feeder relay negative-sequence time-overcurrent element
51R	=	Line recloser phase time-overcurrent element (phase "slow curve")

Traditional Phase Coordination

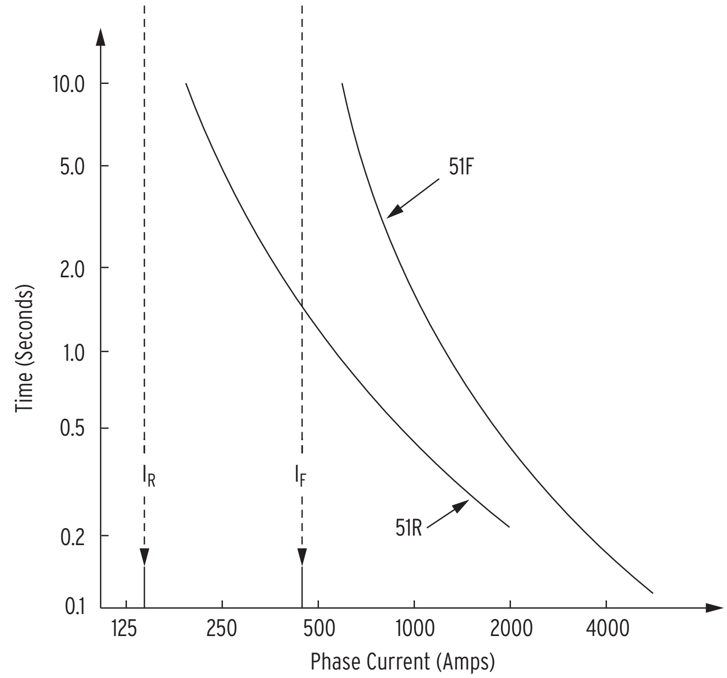

Figure F.3 Traditional Phase Coordination

where:

51F:	pickup	=	600 A (above max. feeder load, I_F)
51R:	pickup	=	200 A (above max. line recloser load, I_R)

Figure F.3 shows traditional phase overcurrent element coordination between the feeder relay and line recloser phase overcurrent elements. Phase overcurrent elements must accommodate load and cold load pickup current. The 450 A maximum feeder load current limits the sensitivity of the feeder phase overcurrent element, 51F, to a pickup of 600 A. The feeder relay cannot back up the line recloser for phase faults below 600 A.

Apply the Feeder Relay Negative-Sequence Overcurrent Element (Guidelines 1 to 3)

Applying negative-sequence overcurrent element coordination Guidelines 1 to 3 results in the feeder relay “equivalent” phase overcurrent element (51EP) in *Figure F.4*. Curve for 51F is shown for comparison only.

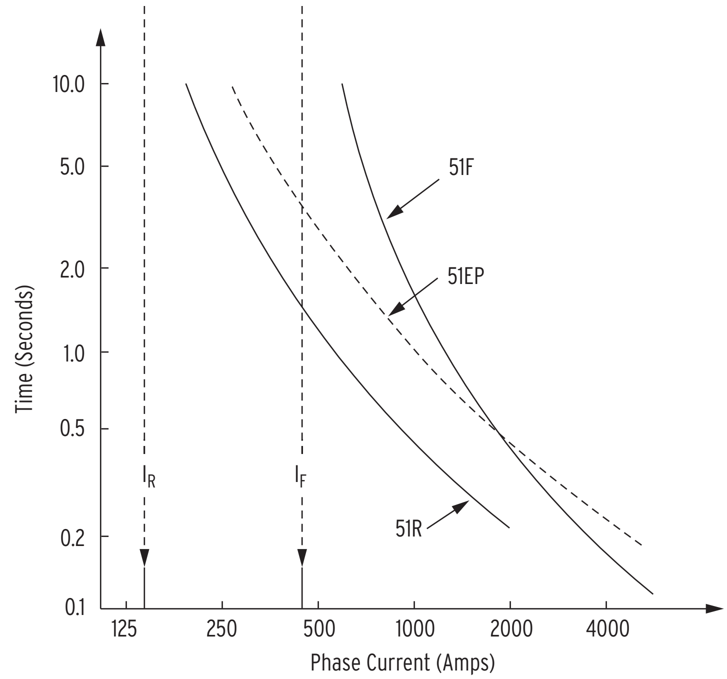

Figure F.4 Phase-to-Phase Fault Coordination

where:

51EP: pickup = 300 A (below max. feeder load, I_F)

Considerable improvement in sensitivity and speed of operation for phase-to-phase faults is achieved with the 51EP element. The 51EP element pickup of 300 A has twice the sensitivity of the 51F element pickup of 600 A. The 51EP element speed of operation for phase-to-phase faults below about 2000 A is faster than that for the 51F element.

Convert "Equivalent" Phase Overcurrent Element Settings to Negative-Sequence Overcurrent Element Settings (Guideline 4)

The "equivalent" phase overcurrent element (51EP element in *Figure F.4*) converts to true negative-sequence overcurrent element settings (51QF in *Figure F.5*) by applying the equation given in Guideline 4. The time dial (lever) and curve type of the element remain the same (if the element is a definite-time element, the time delay remains the same).

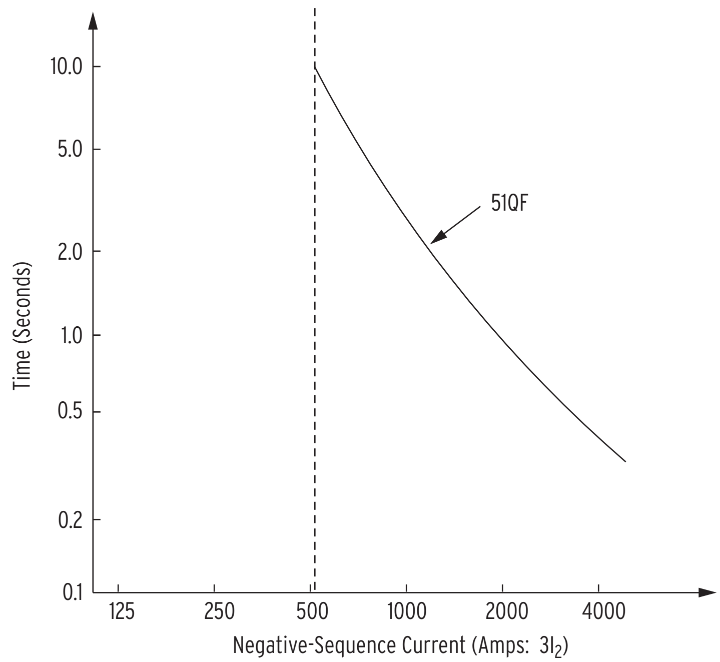

Figure F.5 Negative-Sequence Overcurrent Element Derived From "Equivalent" Phase Overcurrent Element, 51EP

where:

$$51QF\ :pickup = \sqrt{3} \cdot (300\ A) = 520\ A$$

Having achieved coordination between the feeder relay negative-sequence overcurrent element (51QF) and the downstream line recloser phase overcurrent element (51R) for phase-to-phase faults, coordination between the two devices for other fault types is also achieved.

Negative-Sequence Overcurrent Element Applied at a Distribution Bus (Guideline 5)

The preceding example was for a distribution feeder. A negative-sequence overcurrent element protecting a distribution bus provides an even more dramatic improvement in phase-to-phase fault sensitivity.

The distribution bus phase overcurrent element pickup must be set above the combined load of all the feeders on the bus, plus any emergency load conditions. The bus phase overcurrent element pickup is often set at least four times greater than the pickup of the feeder phase overcurrent element it backs up. Thus, sensitivity to both bus and feeder phase faults is greatly reduced. Feeder relay backup by the bus relay is limited.

Negative-sequence overcurrent elements at the distribution bus can be set significantly below distribution bus load levels and provide dramatically increased sensitivity to phase-to-phase faults. It is coordinated with the distribution feeder phase or negative-sequence overcurrent elements and provides more-sensitive and faster phase-to-phase fault backup.

Ground Coordination Concerns

If the downstream protective device includes ground overcurrent elements, in addition to phase overcurrent elements, there should be no need to check the coordination between the ground overcurrent elements and the upstream negative-sequence overcurrent elements. The downstream phase overcurrent element, whether it operates faster or slower than its complementary ground overcurrent element, will operate faster than the upstream negative-sequence overcurrent element for all faults, including those that involve ground.

Other Negative-Sequence Overcurrent Element References

A. F. Elneweihi, E. O. Schweitzer, M. W. Feltis, “Negative-Sequence Overcurrent Element Application and Coordination in Distribution Protection,” IEEE Transactions on Power Delivery, Volume 8, Number 3, July 1993, pp. 915–924.

> This IEEE paper is the source of the coordination guidelines and example given in this appendix. The paper also contains analyses of system unbalances and faults and the negative-sequence current generated by such conditions.

A. F. Elneweihi, “Useful Applications for Negative-Sequence Overcurrent Relaying,” 22nd Annual Western Protective Relay Conference, Spokane, Washington, October 24–26, 1995.

> This conference paper gives many good application examples for negative-sequence overcurrent elements. The focus is on the transmission system, where negative-sequence overcurrent elements provide better sensitivity than zero-sequence overcurrent elements in detecting some single-line-to-ground faults.

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Appendix G
Setting SELOGIC Control Equations

Overview

SELOGIC® control equations combine relay protection and control elements with logic operators to create custom protection and control schemes. This appendix shows how to set the protection and control elements (Relay Word bits) in the SELOGIC control equations.

Additional SELOGIC control equation setting details are available in *Section 9: Setting the SEL-351R Recloser Control* (see also *SELOGIC Control Equation Settings (Serial Port Command SET L) on page SET.14*). See the *SHO Command (Show/View Settings) on page 10.25* for a list of the factory settings shipped with the SEL-351R Recloser Control in a standard relay shipment.

Relay Word Bits

Most of the protection and control element *logic outputs* shown in the various figures in *Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements* through *Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions* are Relay Word bits (labeled as such in the figures). Each Relay Word bit has a label name and can be in either of the following states:

- ➤ 1 (logical 1)
- ➤ 0 (logical 0)

Logical 1 represents an element being picked up, timed out, or otherwise asserted.

Logical 0 represents an element being dropped out or otherwise deasserted.

A complete listing of Relay Word bits and their descriptions are referenced in *Table 9.6*.

Relay Word Bit Operation Example—Phase Time-Overcurrent Element 51P1T

As an example of protection element operation via the logic output of Relay Word bits, a phase time-overcurrent element is examined. Refer to phase time-overcurrent element 51PIT in *Figure 3.14*. Read the text that accompanies *Figure 3.14* (*Table 3.3* and following text). The following Relay Word bits are the logic outputs of the phase time-overcurrent element:

Relay Word Bit	Description
51P1	Indication that the maximum phase current magnitude is above the level of the phase time-overcurrent pickup setting 51P1P
51P1T	Indication that the phase time-overcurrent element has timed out on its curve
51P1R	Indication that the phase time-overcurrent element is fully reset

Phase Time-Overcurrent Element 51P1T Pickup Indication

If the maximum phase current is *at or below* the level of the phase time-overcurrent pickup setting 51P1P, Relay Word bit 51P is in the following state:

51P1 = 0 (logical 0)

If the maximum phase current is *above* the level of the phase time-overcurrent pickup setting 51P1P, Relay Word bit 51P is in the following state:

51P1 = 1 (logical 1)

If the maximum phase current is *above* the level of the phase time-overcurrent pickup setting 51P1P, phase time-overcurrent element 51P1T is either timing on its curve or is already timed out.

Phase Time-Overcurrent Element 51P1T Time-Out Indication

If phase time-overcurrent element 51P1T is *not timed out* on its curve, Relay Word bit 51P1T is in the following state:

51P1T = 0 (logical 0)

If phase time-overcurrent element 51P1T is *timed out* on its curve, Relay Word bit 51P1T is in the following state:

51P1T = 1 (logical 1)

Phase Time-Overcurrent Element 51P1T Reset Indication

If phase time-overcurrent element 51P1T is *not fully reset*, Relay Word bit 51P1R is in the following state:

51P1R = 0 (logical 0)

If phase time-overcurrent element is *fully reset*, Relay Word bit 51P1R is in the following state:

51P1R = 1 (logical 1)

If phase time-overcurrent element 51P1T is *not fully reset*, the element is either:

- Timing on its curve
- Already timed out
- Is timing to reset (one-cycle reset or electromechanical emulation-see setting 51P1RS)

Relay Word Bit Application Examples—Phase Time-Overcurrent Element 51P1T

Common uses for Relay Word bits 51P1, 51P1T, and 51P1R:

Relay Word Bit	Description
51P1	Testing (e.g., assign to an output contact for pickup testing)
	Trip unlatch logic (see *Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses) on page G.5*)
51P1T	Trip logic (see *SELOGIC Control Equation Operation Example—Tripping on page G.8*)
51P1R	Used in testing (e.g., assign to an output contact for reset indication)

Other Relay Word Bits

The preceding example was for a phase time-overcurrent element, demonstrating Relay Word bit operation for pickup, time-out, and reset conditions. Other Relay Word bits (e.g., those for definite-time overcurrent elements, voltage elements, frequency elements) behave similarly in their assertion or deassertion to logical 1 or logical 0, respectively. The time-overcurrent elements (like the preceding phase time-overcurrent element example) are rather unique because they have a Relay Word bit (e.g., 51P1R) that asserts for the reset state of the element.

Relay Word bits are used in SELOGIC control equations, which are explained in the following subsection.

SELOGIC Control Equations

Many of the protection and control element logic inputs shown in the various figures in *Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements* through *Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions* are SELOGIC control equations (labeled “SELOGIC Settings” in most of the figures). SELOGIC control equations are set with combinations of Relay Word bits to accomplish such functions as:

- Tripping reclosers
- Assigning functions to optoisolated inputs
- Operating output contacts
- Torque-controlling overcurrent elements
- Switching active setting groups
- Enabling/disabling reclosing

Traditional or advanced custom schemes can be created with SELOGIC control equations.

SELOGIC Control Equation Operators

SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together using one or more of the six SELOGIC control equation operators listed in *Table G.1*.

Table G.1 SELOGIC Control Equation Operators (Listed in Processing Order)

Operator	Logic Function
/	rising-edge detect
\	falling-edge detect
()	parentheses
!	NOT
*	AND
+	OR

Operators in a SELOGIC control equation setting are processed in the order shown in *Table G.1*.

SELOGIC Control Equation Parentheses Operator ( )

More than one set of parentheses ( ) can be used in a SELOGIC control equation setting. For example, the following SELOGIC control equation setting has two sets of parentheses:

SV7 = **(SV7 + IN101) * (50P1 + 50N1)**

In the above example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. The above example is from *Figure 7.24*. Parentheses cannot be "nested" (parentheses within parentheses) in a SELOGIC control equation setting.

SELOGIC Control Equation NOT Operator !

The NOT operator ! is applied to a single Relay Word bit and also to multiple elements (within parentheses). Following are examples of both.

Example of NOT Operator ! Applied to Single Element

The internal circuit breaker status logic in the SEL-351R operates on 52a circuit breaker auxiliary contact logic. The SELOGIC control equation circuit breaker status setting is labeled 52A. See *Optoisolated Inputs on page 7.1* and *Close Logic on page 6.1* for more information on SELOGIC control equation circuit breaker status setting 52A.

When a circuit breaker is closed, the 52a circuit breaker auxiliary contact is closed. When a circuit breaker is open, the 52a contact is open.

The opposite is true for a 52b circuit breaker auxiliary contact. When a circuit breaker is closed, the 52b circuit breaker auxiliary contact is open. When the circuit breaker is open, the 52b contact is closed.

If a 52a contact is connected to optoisolated input **IN101**, the SELOGIC control equation circuit breaker status setting 52A is set:

52A = **IN101**

Conversely, if a 52b contact is connected to optoisolated input **IN101**, the SELOGIC control equation circuit breaker status setting 52A is set:

52A = **!IN101** [= NOT(IN101)]

With a 52b contact connected, if the circuit breaker is closed, the 52b contact is open and input **IN101** is de-energized [IN101 = 0 (logical 0)]:

52A = **!IN101** = NOT(IN101) = NOT(0) = 1

Thus, the SELOGIC control equation circuit breaker status setting 52A sees a closed circuit breaker.

With a 52b contact connected, if the circuit breaker is open, the 52b contact is closed and input **IN101** is energized [IN101 = 1 (logical 1)]:

52A = **!IN101** = NOT(IN101) = NOT(1) = 0

Thus, the SELOGIC control equation circuit breaker status setting 52A sees an open circuit breaker.

Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses)

The SELOGIC control equation trip unlatch setting is set as follows:

ULTR = **!(51P1 + 51G1)**

Refer also to *Trip Logic on page 5.1*.

In this setting example, the unlatch condition comes true only when both the 51P1 (phase time-overcurrent element pickup indication) and 51G1 (residual ground time-overcurrent element pickup indication) Relay Word bits deassert:

ULTR = **!(51P1 + 51G1)** = NOT(51P1 + 51G1)

As stated previously, the logic within the parentheses is performed first. In this example, the states of Relay Word bits 51P1 and 51G1 are ORed together. Then the NOT operator is applied to the logic resultant from the parentheses.

If either one of 51P1 or 51G1 is still asserted [e.g., 51G1 = 1 (logical 1)], the unlatch condition is not true:

ULTR = **NOT(51P1 + 51G1)** = NOT(0 + 1) = NOT(1) = 0

If *both* 51P1 and 51G1 are deasserted [i.e., 51P1 = 0 and 51G1 = 0 (logical 0)], the unlatch condition is true:

ULTR = **NOT(51P1 + 51G1)** = NOT(0 + 0) = NOT(0) = 1

and the trip condition can unlatch, subject to other conditions in the trip logic (see *Figure 5.1*).

SELOGIC Control Equation Rising-Edge Operator /

The rising-edge operator / is applied to individual Relay Word bits only—not to groups of elements within parentheses. For example, the SELOGIC control equation event report generation setting uses rising-edge operators:

ER = **/51P1 + /51G1 + /OUT103**

The Relay Word bits in this setting example are:

Relay Word Bit	Description
51P1	Maximum phase current above pickup setting 51P1P for phase time-overcurrent element 51P1T (see *Figure 3.14*)
51G1	Maximum residual ground current above pickup setting 51G1P for residual ground time-overcurrent element 51G1T (see *Figure 3.19*)
OUT103	Output contact **OUT103** is set as a breaker failure trip output (see *Output Contacts on page 7.27*)

When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the relay is not already generating a report that encompasses the new transition). The rising-edge operators in the above factory-setting example allow setting ER to see each transition individually.

Suppose a ground fault occurs and a breaker failure condition finally results. *Figure G.1* demonstrates the action of the rising-edge operator / on the individual elements in setting ER.

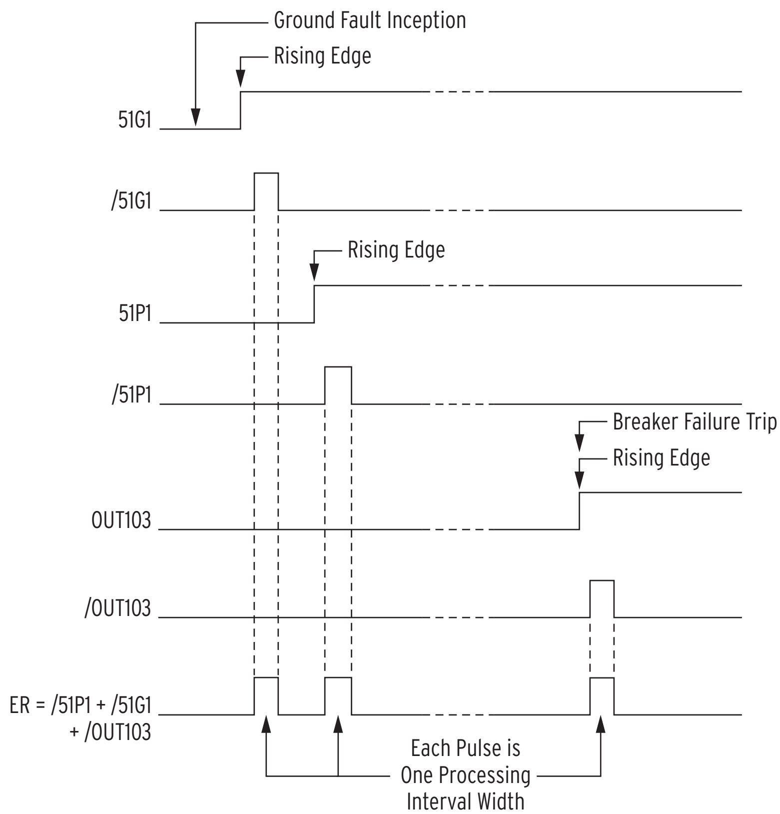

Figure G.1 Result of Rising-Edge Operators on Individual Elements in Setting ER

Note in *Figure G.1* that setting ER sees three separate rising edges, because of the application of rising-edge operators /. The rising-edge operator / in front of a Relay Word bit sees this logical 0 to logical 1 transition as a "rising edge" and the resultant asserts to logical 1 for one processing interval. The assertions of 51G1 and 51P1 are close enough that they will be on the same event report (generated by 51G1 asserting first). The assertion of OUT103 for a breaker failure condition is some appreciable time later and will generate another event report, if the first event report capture has ended when OUT103 asserts.

If the rising-edge operators / were not applied and setting ER was:

ER = **51P1 + 51G1 + OUT103**

the ER setting would not see the assertion of OUT103, because 51G1 and 51P1 would continue to be asserted at logical 1, as shown in *Figure G.1*.

SELOGIC Control Equation Falling-Edge Operator \

The falling-edge operator \ is applied to individual Relay Word bits only—not to groups of elements within parentheses. The falling-edge operator \ operates similarly to the rising-edge operator, but looks for Relay Word bit deassertion (element going from logical 1 to logical 0). The falling-edge operator \ in front of a Relay Word bit sees this logical 1 to logical 0 transition as a “falling edge” and asserts to logical 1 for one processing interval.

For example, suppose the SELOGIC control equation event report generation setting is set with the detection of the falling edge of an underfrequency element:

ER = **... + \81D1T**

When frequency goes above the corresponding pickup level 81D1P, Relay Word bit 81D1T deasserts and an event report is generated (if the relay is not already generating a report that encompasses the new transition). This allows a recovery from an underfrequency condition to be observed. See *Figure 3.28* and *Table 3.10*. *Figure G.2* demonstrates the action of the falling-edge operator \ on the underfrequency element in setting ER.

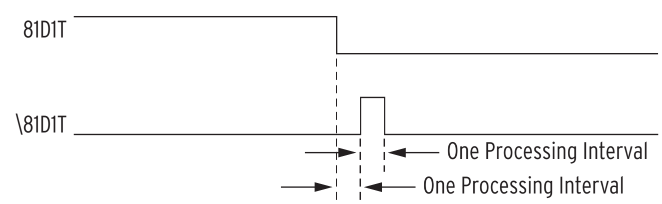

Figure G.2 Result of Falling-Edge Operator on a Deasserting Underfrequency Element

SELOGIC Control Equation Analog Compares

The SEL-351R is capable of interpreting SELOGIC control equations that contain a special type of element, the Analog Compare. Use these elements in any SELOGIC control equation in the same manner as a Relay Word bit, except that the “/” and “\” operators may not be used with Analog Compares, nor may the “!” operator be used to modify a SELOGIC variable or value within a comparison statement. The Analog Compare outputs a logical 1 when the compare statement is true, and a logical 0 when it is false. Compares are evaluated prior to any other SELOGIC operator in the equation. A SELOGIC control equation Analog Compare has the following format:

VARIABLE OP VALUE

where:

VARIABLE is SC1, SC2, SC3, SC4, SC5, SC6, SC7, or SC8.

OP is a comparison operator (<, <=, >, >=, =, !=); see *Table G.2* for descriptions.

VALUE is either a fixed numerical value or another VARIABLE.

Table G.2 Comparison Operator Descriptions

Comparison Operator	Logic Function
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
=	equal to
!=	not equal to

Examples of Analog Compare statements are SC1 > 2 or SC5 ! = SC1. An equation using an Analog Compare might be written as OUT101 = SC1 > 2 * SV1T, for example. Inverting a comparison statement within parentheses produces a reduced expression when displayed later. For example, entering !(SC3 >= 4) produces the equivalent equation SC3 < 4.

Although evaluated effectively to a single element, the Analog Compare counts as two elements in determining the size of a SELOGIC control equation.

SELOGIC Control Equation Operation Example—Tripping

If tripping does not involve communications-assisted or switch-onto-fault trip logic, the SELOGIC control equation trip setting TR is the only trip setting needed. Refer to *Trip Logic on page 5.1*.

Note that *Figure 5.1* appears quite complex. But since tripping does not involve communications-assisted or switch-onto-fault trip logic in this example, respective SELOGIC control equation trip settings TRCOMM and TRSOTF are not used. The only effective input into logic gate OR-1 in *Figure 5.1* is SELOGIC control equation trip setting TR.

TR = **51P1T + 51G1T + 50P1 * SH0** (fuse saving example)

TRCOMM = **0** (not used—set directly to logical 0)

TRSOTF = **0** (not used—set directly to logical 0)

ULTR = **!(51P1 + 51G1)** (discussed in preceding subsection)

Analysis of SELOGIC Control Equation Trip Setting TR

Again, the example trip equation is:

TR = **51P1T + 51G1T + 50P1 * SH0**

The Relay Word bit definitions are:

Relay Word Bit	Description
51P1T	Phase time-overcurrent element timed out
51G1T	Residual ground time-overcurrent element timed out
50P1	Phase instantaneous overcurrent element asserted
SH0	Reclosing relay shot counter at shot = 0

In the trip equation, the AND operator * is executed before the OR operators +, *Table G.1*:

50P1 * SH0

Element 50P1 can only cause a trip if the reclosing relay shot counter is at shot = 0. When the reclosing relay shot counter is at shot = 0 (see *Table 6.3*), Relay Word bit SH0 is in the following state:

SH0 = 1 (logical 1)

If maximum phase current is *above* the phase instantaneous overcurrent element pickup setting 50P1P (see *Figure 3.1*), Relay Word bit 50P1 is in the following state:

50P1 = 1 (logical 1)

With SH0 = 1 and 50P1 = 1, the ANDed combination results in:

50P1 * SH0 = 1 * 1 = 1 (logical 1)

and an instantaneous trip results. This logic is commonly used in fuse saving schemes for distribution feeders.

If the reclosing relay shot counter advances to shot = 1 for the reclose that follows the trip, Relay Word bit SH0 is in the following state:

SH0 = 0 (logical 0)

If maximum phase current is *above* the phase instantaneous overcurrent element pickup setting 50P1P for the reoccurring fault, Relay Word bit 50P1 is in the following state:

50P1 = 1 (logical 1)

With SH0 = 0 and 50P1 = 1, the ANDed combination results in:

50P1 * SH0 = 1 * 0 = 0 (logical 0)

and no trip results from phase instantaneous overcurrent element 50P1.

A trip will eventually result if time-overcurrent element 51P1T or 51G1T times out. If residual ground time-overcurrent element 51G1T times out, Relay Word bit 51G1T is in the following state:

51G1T = 1 (logical 1)

When shot = 1, SH0 = 0 and the result is:

TR = **51P1T + 51G1T + 50P1 * SH0** = 0 + 1 + 1 * 0 = 0 + 1 + 0 = 1

and a time-delayed trip results from residual ground time-overcurrent element 51G1T.

Set an Output Contact for Tripping

To assert output contact **OUT101** to trip a circuit breaker, make the following SELOGIC control equation output contact setting (see *Output Contacts on page 7.27*):

OUT101 = **TRIP**

All SELOGIC Control Equations Must Be Set

All SELOGIC control equations must be set one of the following ways (they cannot be “blank”):

- ➤ Single Relay Word bit (e.g., 52A = IN101)
- ➤ Combination of Relay Word bits (e.g., TR = 51P1T + 51G1T + 50P1 * SH0)
- ➤ Directly to logical 1 (e.g., 67P1TC = 1)
- ➤ Directly to logical 0 (e.g., TRCOMM = 0)

Set SELOGIC Control Equations Directly to 1 or 0

SELOGIC control equations can be set directly to:

NOTE: SELOGIC control equation torque control settings (e.g., 67P1TC, 51P1TC) cannot be set to logical 0.

- 1 (logical 1), or
- 0 (logical 0)

instead of with Relay Word bits. If a SELOGIC control equation setting is set directly to 1, it is always “asserted/on/enabled.” If a SELOGIC control equation setting is set equal to 0, it is always “deasserted/off/disabled.”

Under the *SHO Command (Show/View Settings) on page 10.25*, note that a number of the factory SELOGIC control equation settings are set directly to 1 or 0.

The individual SELOGIC control equation settings explanations (referenced in *SELOGIC Control Equation Settings (Serial Port Command SET L) on page SET.14*) discuss whether it makes logical sense to set the given SELOGIC control equation setting to 0 or 1 for certain criteria.

Set SELOGIC Control Equations Directly to 1 or 0—Example

Of special concern are the SELOGIC control equation torque control settings 67P1TC–51QTC for the overcurrent elements. The factory settings shipped with the SEL-351R in a standard relay shipment are all set directly to logical 1. See these factory settings in *SHO Command (Show/View Settings) on page 10.25*.

If one of these torque control settings is set directly to logical 1, e.g.,

51P1TC = **1** (set directly to logical 1)

then the corresponding overcurrent element (e.g., phase time-overcurrent element 51P1T) is subject only to the directional control. See *Figure 3.14* for phase time-overcurrent element 51P1T logic.

If the directional control enable setting E32 = N (and 51P1TC = 1), then time-overcurrent element 51P1T is enabled (assuming pickup setting 51P1P is made) and nondirectional.

SELOGIC Control Equation Limitations

Any single SELOGIC control equation setting is *limited to 15 Relay Word bits* that can be combined together with the SELOGIC control equation operators listed in *Table G.1*. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1–SV12) as an intermediate setting step.

For example, assume that the trip equation (SELOGIC control equation trip setting TR) needs more than 15 Relay Word bits in its equation setting. Instead of placing all Relay Word bits into TR, program some of them into the SELOGIC control equation setting SV1. Next, use the resultant SELOGIC control equation variable output (Relay Word bit SV1) in the SELOGIC control equation trip setting TR.

Note in *Table G.3* that the SELOGIC control equation variables (SELOGIC control equation settings SV1–SV16) are processed after the trip equation (SELOGIC control equation trip setting TR). Thus, any tripping via Relay Word bits SV1–SV16 can be delayed as much as one-quarter cycle. For most applications, this is probably of no consequence.

All the SELOGIC control equation settings for a particular settings group have a *combined limit of 630 Relay Word bits* that can be combined together with the SELOGIC control equation operators listed in *Table G.1*. SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) also have to be included in this combined limit-each such setting is counted as one Relay Word bit.

All the SELOGIC control equation settings for a particular settings group have a combined limit of 54 edges (rising or falling edges) that may be applied to individual Relay Word bits within the SELOGIC control equation settings.

After SELOGIC control equations settings changes have been made and the settings are saved, the SEL-351R responds with the following message:

```
xxx Elements and yy Edges remain available
```

indicating that *xxx* Relay Word bits can still be used and yy rising- or falling-edge operators can still be applied in the SELOGIC control equations for the particular settings group.

Processing Order and Processing Interval

The relay elements and logic (and corresponding SELOGIC control equation settings and resultant Relay Word bits) are processed in the order shown in *Table G.3* (top to bottom). They are processed every quarter-cycle, and the Relay Word bit states (logical 1 or logical 0) are updated with each quarter-cycle pass. Thus, the relay processing interval is one-quarter cycle. Once a Relay Word bit is asserted, it retains the state (logical 1 or logical 0) until it is updated again in the next processing interval.

Table G.3 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 1 of 2)

Relay Elements and Logic (Corresponding SELOGIC Control Equations Listed in Parentheses)	Resultant Relay Word Bits	Reference Instruction Manual Section
Optoisolated Inputs	IN101–IN106	*Section 7*
Polarizing Voltage	VPOLV	*Section 4*
Receive MIRRORED BITS®	RMB1A. . .RMB8A, RMB1B. . .RMB8B	*Appendix I*
Miscellaneous Instantaneous Overcurrent Elements	50A1–50A4, 50B1–50B4, 50C1–50C4, 50A, 50B, 50C, 50AB1–50AB4, 50BC1–50BC4, 50CA1–50CA4, 50QF, 50QR, 50GF, 50GR, 50L	*Section 3*
Demand Ammeters	PDEM, NDEM, GDEM, QDEM	*Section 8*
Open Breaker Logic (52A)	3PO	*Section 5*
Loss-of-Potential	LOP, ILOP	*Section 4*
Load Encroachment	ZLOUT, ZLIN, ZLOAD	*Section 4*
Local Control Switches	LB1–LB16	*Section 7*
Remote Control Switches	RB1–RB16	*Section 7*
Latch Control Switches (SET1–SET16, RST1–RST16)	LT1–LT16	*Section 7*
Voltage Elements	27A1, 27B1, 27C1, 27A2, 27B2, 27C2, 59A1, 59B1, 59C1, 59L1, 59A2, 59B2, 59C2, 27AB, 27BC, 27CA, 59AB, 59BC, 59CA, 59N1, 59N2, 59Q, 59V1, 27S, 59S1, 59S2, 59VP, 59VS, 3P27, 3P59, 27B81, 27AB1, 27BC1, 27CA1, 27AB2, 27BC2, 27CA2, 59AB1, 59BC1, 59CA1, 59AB2, 59BC2, 59CA2, 59Q1, 59Q2	*Section 3*

Table G.3 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 2 of 2)

Relay Elements and Logic (Corresponding SELogic Control Equations Listed in Parentheses)	Resultant Relay Word Bits	Reference Instruction Manual Section
Frequency Elements	81D1, 81D2, 81D3, 81D4, 81D5, 81D6, 81D1T, 81D2T, 81D3T, 81D4T, 81D5T, 81D6T	*Section 3*
Synchronism-Check Elements (BSYNCH)	SF, 25A1, 25A2	*Section 3*
Directional Elements (E32IV)	32QE, 32QGE, 32VE, 32NE, F32P, R32P, F32Q, R32Q, F32QG, R32QG, F32V, R32V, F32N, R32N, 32PF, 32PR, 32QF, 32QR, 32GF, 32GR	*Section 4*
Instantaneous/Definite-Time Overcurrent Elements (67P1TC–67P4TC, 67N1TC–67N4TC, 67G1TC–67G4TC, 67Q1TC–67Q4TC)	50P1–50P6, 50N1–50N6, 50G1–50G6, 50Q1–50Q6, 67P1–67P4, 67P1T–67P4T, 67N1–67N4, 67N1T–67N4T, 67G1–67G4, 67Q1T–67Q4T, 67P2S, 67N2S, 67G2S, 67Q2S	*Section 3*
Time-Overcurrent Elements (51P1TC, 51P1TC, 51N1TC, 51N2TC, 51G1TC, 51G2TC, 51QTC)	51P1, 51P2, 51N1, 51N2, 51G1, 51G2, 51Q, 51P1T, 51P2T, 51N1T, 51N2T, 51G1T, 51G2T, 51QT, 51P1R, 51P2R, 51N1R, 51N2R, 51G1R, 51G2R, 51QR	*Section 3*
Switch-onto-Fault Logic (CLMON)	SOTFE	*Section 5*
Communications-Assisted Trip Schemes (PT1, LOG1, PT2, LOG2, BT)	PT, PTRX1, PTRX2, PTRX, UBB1, UBB2, UBB, Z3RB, KEY, EKEY, ECTT, WFC, Z3XT, DSTRT, NSTRT, STOP, BTX	*Section 5*
Trip Logic (TR, TRSOTF, TRCOMM, DTT, ULTR)	TRIP	*Section 5*
Close Logic (CL, ULCL) Reclosing Relay (79RI, 79RIS, 79DTL, 79DLS, 79SKP, 79STL, 79BRS, 79SEQ, 79CLS)	CLOSE, CF, RCSF, OPTMN, RSTMN, 79RS, 79CY, 79LO, SH0, SH1, SH2, SH3, SH4	*Section 6*
Recloser Control Relay Word Bits	OCP, OCG, OLP, OLG, OLS, HTP, HTG, HLP, HLG, CLP, RPP, RPG, RPS, SEQC, GTP	*Section 1*
Breaker Monitor (BKMON)	BCWA, BCWB, BCWC, BCW	*Section 8*
SELogic counter values (SC1–SC8)		*Section 7*
SELogic Control Equation Variables/Timers (SV1–SV16)	SV1–SV16, SV1T–SV16T	*Section 7*
Output Contact (OUT101–OUT107) Recloser Control Cable Trip (RCTR) and Close (RCCL)	OUT101–OUT107 RCTR, RCCL	*Section 7*
Targeting (Front-Panel LED) Logic	LED1–9, LED11–20, LED24, LED25	*Section 5*
Display Points (DP1–DP16)		*Section 7*
Transmit Mirrored Bits	TMB1A. . .TMB8A TMB1B. . .TMB8B	*Appendix I*
Setting Group (SS1–SS6)	SG1–SG6	*Section 7*
Event Report Trigger (ER)		*Section 12*
Recloser Breaker Status	P1NBD, P1NC, P1NE, P1NF, SW1	*Section 7*

Appendix H

Distributed Network Protocol

Overview

NOTE: The response to the **VER** command will indicate "DNP" if the SEL-351R has DNP.

The SEL-351R Recloser Control supports Distributed Network Protocol (DNP3) L2 Slave protocol. This includes access to metering data, protection elements (Relay Word), contact I/O, targets, Sequential Events Recorder, breaker monitor, relay summary event reports, settings groups, and time synchronization. The SEL-351R supports DNP point remapping. Two modes of operation are available: Standard, for backwards and cross-platform compatibility, and Extended, with additional features that are detailed in this appendix.

Configuration

Although standard or extended mode DNP may be selected on any of the available ports, DNP may not be enabled on more than one port at a time.

Standard Mode DNP Operation

NOTE: Masters may experience intermittent communications at 38400 baud rate. SEL recommends baud rates of 19200 or lower.

To configure a port for Standard Mode DNP, set the port PROTO setting to DNP. The following settings configure a port for DNP operation:

Label	Description	Default
SPEED	Baud rate (300–38400)	2400
DNPADR	DNP address (0–65534)	0
DNPTOF	DNP time offset in hours (–24.00–24)	0
TIMERQ	Minutes for request interval (0–32767 min.)	0
ECLASS	Class for event data (0–3)	2
DECPLA	Currents scaling decimal places (0–3)	1
DECPLV	Voltages scaling decimal places (0–3)	1
DECPLM	Miscellaneous data scaling decimal places (0–3)	1
STIMEO	Seconds to select/operate time-out (0.0–30)	1.0
DRETRY	Data link retries (0–15)	0
DTIMEO	Seconds to data link time-out (0–5)	1
MINDLY	Minimum seconds from DCD to Tx (0.00–1)	0.05
MAXDLY	Maximum seconds from DCD to Tx (0.00–1)[a]	0.10
PREDLY	Settle time from RTS ON to Tx (OFF, 0.00–30 sec.)	0.00
PSTDLY	Settle time from Tx to RTS OFF (0.00–30 sec.)	0.00
ANADB	Analog reporting dead band counts (0–32767)	100
UNSOL	Enable unsolicited reporting (Y,N,DIAL)	N

Label	Description	Default
PUNSOL	Enable unsolicited reporting at power-up (Y,N)	N
REPADR	DNP address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Seconds until oldest event to Tx on (0–60)	2.0
ETIMEO	Unsolicited confirmation time-out (1–50 sec.)	2
URETRY	Unsolicited message maximum retry attempts (2–10)	3
UTIMEO	Unsolicited message offline time-out (1–86400 sec.)	2
RESPSZ	Maximum response fragment Size (512, 1024, 2048)	2048
ACHRPT	Analog input change reporting (Last, All)	All

[a] When Port 1 communications are configured for DNP, MAXDLY must be set > 0.00.

Extended Mode DNP Operation

NOTE: Masters may experience intermittent communications at 38400 baud rate. SEL recommends baud rates of 19200 or lower.

To configure a port for extended mode DNP, set the port PROTO setting to DNPE (extended mode). The following settings configure a port for DNPE operation:

Label	Description	Default
SPEED	Baud rate (300–38400)	2400
DNPADR	DNP address (0–65534)	0
DNPTOF	DNP time offset in hours (–24.00–24)	0
TIMERQ	Time-set request interval (0–32767 min.)	0
CLASSA	Class for analog event data (0–3)	2
CLASSB	Class for binary event data (0–3)	2
CLASSC	Class for counter event data (0–3)	2
DECPLA	Currents scaling (0–3 decimal places)	1
DECPLV	Voltages scaling (0–3 decimal places)	1
DECPLM	Miscellaneous data scaling (0–3 decimal places)	1
STIMEO	Select/operate time-out (0–30 sec.)	1.0
DRETRY	Data link retries (0–15)	0
DTIMEO	Data link time-out (0–5 sec.)	1
MINDLY	Minimum time from DCD to Tx (0–1 sec.)	0.05
MAXDLY	Maximum time from DCD to Tx (0–1 sec.)[a]	0.10
PREDLY	Settle time from RTS on to Tx (OFF, 0.00–30 sec.)	0.00
PSTDLY	Settle time after Tx to RTS off (0.00–30 sec.)	0.00
ANADBA	Amps reporting dead band, counts (0–32767 counts)	100
ANADBV	Volts reporting dead band, counts (0–32767 counts)	100
ANADBM	Miscellaneous data reporting dead band, counts (0–32767)	100
UNSOL	Enable unsolicited reporting (Y,N,DIAL)	N
PUNSOL	Enable unsolicited reporting at power-up (Y,N)	N
UNSOFH	Enable unsolicited fault history reporting (Y,N)	N
UNSAOV	Analog change event default variation (2,4)	2
REPADR	DNP address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Seconds until oldest event to transmit on (0.0–60.0 sec.)	2.0

Label	Description	Default
ETIMEO	Unsolicited confirmation time-out (1–50 sec.)	2
URETRY	Unsolicited message maximum retry attempts (2–10)	3
UTIMEO	Unsolicited message offline time-out (1–86400 sec.)	2
RESPSZ	Maximum response fragment size (512, 1024, 2048)	2048
ACHRPT	Analog input change reporting (Last, All)	All

[a] When Port 1 communications are configured for DNPE, MAXDLY must be set > 0.00.

Set DNPTOF to adjust the time reported in the DNP time stamp. The value of DNPTOF is combined with the relay time to calculate the adjusted DNP time stamp.

Set UNSOFH = Y to report all relay event summary data on an unsolicited basis.

Set UNSAOV to select the variation to use when reporting Object 32 data.

Set RESPSZ to select the maximum size of the application fragment size. Note that when the relay cannot fit the response in the size allowed by the setting, the DNP request will fail and the Parameter_Error IIN2.1 bit will be set.

Set ACHRPT = LAST to report only the most recent DNP analog change event message for each analog point. Set ACHRPT = ALL to report all of the DNP analog change event messages for each analog point.

EIA-232 Physical Layer Operation

The RTS signal may be used to control an external transceiver. The CTS signal is used as a DCD input, indicating when the medium is in use. Transmissions are only initiated if DCD is deasserted. When DCD drops, the next pending outgoing message may be sent once an idle time is satisfied. This idle time is randomly selected between the minimum and maximum allowed idle times (i.e., MAXDLY and MINDLY). In addition, the SEL-351R monitors received data and treats receipt of data as a DCD indication. This allows RTS to be looped back to CTS in cases where the external transceiver does not support DCD. When the SEL-351R transmits a DNP message, it delays transmitting after asserting RTS by at least the time in the PREDLY setting. After transmitting the last byte of the message, the SEL-351R delays for at least PSTDLY milliseconds before deasserting RTS. If the PSTDLY time delay is in progress (RTS still high) following a transmission, and another transmission is initiated, the SEL-351R transmits the message without completing the PSTDLY delay and without any preceding PREDLY delay. The RTS/CTS handshaking may be completely disabled by setting PREDLY to OFF. In this case, RTS is forced high and CTS is ignored, with only received characters acting as a DCD indication. The timing is the same as above, but PREDLY functions as if it were set to 0, and RTS is not actually deasserted after the PSTDLY time delay expires.

Automatic Dial-Out

To support automatic dial-out via DNP, Relay Word bits DDATA and DCONN are available for use in SELOGIC® control equations. When unsolicited event data are available, DNP asserts the DDATA Relay Word bit. If setting UNSOL = Y or DIAL and a connection has been made, the SEL-351R begins transmitting the unsolicited event data and asserts Relay word bit DCONN. If setting UNSOL = DIAL, the SEL-351R further checks to see that the CTS serial port line is asserted (e.g., from an external modem), before beginning the transmission of the unsolicited event data.

Data-Link Operation

It is necessary to make two important decisions about the data-link layer operation. One is how to handle data-link confirmation, the other is how to handle data-link access. If a highly reliable communications link exists, the data-link access can be disabled altogether, which significantly reduces communications overhead. Otherwise, it is necessary to enable confirmation and determine how many retries to allow and what the data-link time-out should be. The noisier the communications channel, the more likely a message will be corrupted. Thus, the number of retries should be set higher on noisy channels. Set the data-link time-out long enough to allow for the worst-case response of the master plus transmission time. When the SEL-351R decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-351R monitors physical connections by using CTS input (treated as a Data Carrier Detect) and monitoring character receipt. Once the physical link goes idle, as indicated by CTS being deasserted and no characters being received, the SEL-351R will wait a configurable amount of time before beginning a transmission. This hold-off time will be a random value between the MINDLY and MAXDLY setting values. The hold-off time is random which prevents multiple devices waiting to communicate on the network from continually colliding.

Data Access Method

Based on the capabilities of the system, it is necessary to determine which method is desired to retrieve data on the DNP connection. The following table summarizes the main options, listed from least to most efficient, and corresponding key related settings are indicated.

Table H.1 Date Access Methods

Data Retrieval Method	Description	Relevant SEL-351R DNP (Standard) Settings	Relevant SEL-351R DNPE (Extended) Settings
Polled Static	The master polls for static (Class 0) data only.	Set ECLASS = 0, Set UNSOL = N.	Set CLASSA = 0 Set CLASSB = 0 Set CLASSC = 0 Set per-point class assignment = 0 Set UNSOL = N
Polled Report-by-Exception	The master polls frequently for event data and occasionally for static data.	Set ECLASS to a non-zero value, Set UNSOL = N.	Set CLASSA = to a non-zero value Set CLASSB = to a non-zero value Set CLASSC = to a non-zero value Set per-point class assignment = to a non-zero value Set UNSOL = N
Unsolicited Report-by-Exception	The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data.	Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.	Set CLASSA = to a non-zero value Set CLASSB = to a non-zero value Set CLASSC = to a non-zero value Set per-point class assignment = to a non-zero value Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent
Quiescent	The master never polls and relies on unsolicited reports only.	Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.	Set CLASSA = to a non-zero value Set CLASSB = to a non-zero value Set CLASSC = to a non-zero value Set per-point class assignment = to a non-zero value Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent

Device Profile

Table H.2 summarizes the device profile as specified in the *DNP3 Subset Definitions* document.

Table H.2 SEL-351R DNP3 Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-351R
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	Supports enabling/disabling of unsolicited reports on a class basis
Maximum data link frame size transmitted/received (octets)	292
Maximum data link retries	Configurable, range 0 to 15
Requires data link layer confirmation	Configurable by setting
Maximum application fragment size transmitted/received (octets)	Configurable by setting (default 2048)
Maximum application layer retries	None

Table H.2 SEL-351R DNP3 Device Profile (Sheet 2 of 2)

Parameter	Value
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE–NO ACK	Always
Executes control count greater than 1	Never
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch On	Always
Executes control Latch Off	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only time-tagged
Reports time-tagged binary input change events when no specific variation requested	Binary Input change with time
Sends unsolicited responses	Configurable with enable/disable unsolicited
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	16 bits
Sends multifragment responses	No

In all cases within the device profile that an item is configurable, it is controlled by SEL-351R settings.

Object Table

The supported object, function, and qualifier code combinations are given by *Table H.3*.

Table H.3 SEL-351R DNP Object Table (Sheet 1 of 4)

Object			Request[a]		Response[b]	
Obj	Var	Description	Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
1	0	Binary Input—All Variations	1	0,1,6,7,8		
1	1	Binary Input	1	0,1,6,7,8	129	0,1,7,8
1	2[e]	Binary Input with Status	1	0,1,6,7,8	129	0,1,7,8
2	0	Binary Input Change—All Variations	1	6,7,8		
2	1	Binary Input Change without Time	1	6,7,8	129	17,28

Table H.3 SEL-351R DNP Object Table (Sheet 2 of 4)

Object			Request[a]		Response[b]	
Obj	Var	Description	Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
2	2[e]	Binary Input Change with Time	1	6,7,8	129,130	17,28
2	3	Binary Input Change with Relative Time	1	6,7,8	129	17,28
10	0	Binary Output—All Variations	1	0,1,6,7,8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0,1,6,7,8	129	0,1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3,4,5,6	17,28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter—All Variations	1	0,1,6,7,8		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter without Flag	1	0,1,6,7,8	129	0,1,7,8
20	6[e]	16-Bit Binary Counter without Flag	1	0,1,6,7,8	129	0,1,7,8
20	7	32-Bit Delta Counter without Flag				
20	8	16-Bit Delta Counter without Flag				
21	0	Frozen Counter—All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter with Time of Freeze				
21	6	16-Bit Frozen Counter with Time of Freeze				
21	7	32-Bit Frozen Delta Counter with Time of Freeze				
21	8	16-Bit Frozen Delta Counter with Time of Freeze				
21	9	32-Bit Frozen Counter without Flag				
21	10	16-Bit Frozen Counter without Flag				
21	11	32-Bit Frozen Delta Counter without Flag				
21	12	16-Bit Frozen Delta Counter without Flag				
22	0	Counter Change Event—All Variations	1	6,7,8		
22	1	32-Bit Counter Change Event without Time	1	6,7,8	129	17,28
22	2[e]	16-Bit Counter Change Event without Time	1	6,7,8	129,130	17,28
22	3	32-Bit Delta Counter Change Event without Time				
22	4	16-Bit Delta Counter Change Event without Time				
22	5	32-Bit Counter Change Event with Time	1	6,7,8	129	17,28
22	6	16-Bit Counter Change Event with Time	1	6,7,8	129	17,28
22	7	32-Bit Delta Counter Change Event with Time				

Table H.3 SEL-351R DNP Object Table (Sheet 3 of 4)

Object			Request[a]		Response[b]	
Obj	Var	Description	Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
22	8	16-Bit Delta Counter Change Event with Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event without Time				
23	2	16-Bit Frozen Counter Event without Time				
23	3	32-Bit Frozen Delta Counter Event without Time				
23	4	16-Bit Frozen Delta Counter Event without Time				
23	5	32-Bit Frozen Counter Event with Time				
23	6	16-Bit Frozen Counter Event with Time				
23	7	32-Bit Frozen Delta Counter Event with Time				
23	8	16-Bit Frozen Delta Counter Event with Time				
30	0	Analog Input—All Variations	1	0,1,6,7,8		
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	3	32-Bit Analog Input without Flag	1	0,1,6,7,8	129	0,1,7,8
30	4[e]	16-Bit Analog Input without Flag	1	0,1,6,7,8	129	0,1,7,8
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input with Time of Freeze				
31	4	16-Bit Frozen Analog Input with Time of Freeze				
31	5	32-Bit Frozen Analog Input without Flag				
31	6	16-Bit Frozen Analog Input without Flag				
32	0	Analog Change Event—All Variations	1	6,7,8		
32	1	32-Bit Analog Change Event without Time	1	6,7,8	129	17,28
32	2[e]	16-Bit Analog Change Event without Time	1	6,7,8	129,130	17,28
32	3	32-Bit Analog Change Event with Time	1	6,7,8	129	17,28
32	4	16-Bit Analog Change Event with Time	1	6,7,8	129	17,28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event without Time				
33	2	16-Bit Frozen Analog Event without Time				
33	3	32-Bit Frozen Analog Event with Time				
33	4	16-Bit Frozen Analog Event with Time				
40	0	Analog Output Status—All Variations	1	0,1,6,7,8		
40	1	32-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8
40	2[e]	16-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
50	0	Time and Date—All Variations				

Table H.3 SEL-351R DNP Object Table (Sheet 4 of 4)

Object			Request[a]		Response[b]	
Obj	Var	Description	Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
50	1	Time and Date	1,2	7,8, index = 0	129	07, quantity = 1
50	2	Time and Date with Interval				
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quantity = 1
52	0	Time Delay—All Variations				
52	1	Time Delay Coarse				
52	2	Time Delay Fine			129	07, quantity = 1
60	0	All Classes of Data	1,20,21	6		
60	1	Class 0 Data	1	6		
60	2	Class 1 Data	1,20,21	6,7,8		
60	3	Class 2 Data	1,20,21	6,7,8		
60	4	Class 3 Data	1,20,21	6,7,8		
70	1	File Identifier				
80	1	Internal Indications	2	0,1, index = 7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
		No Object	13,14,23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.

Data Map

The following is the default object map supported by the SEL-351R (FID = SEL-351R-4-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx).

Table H.4 SEL-351R DNP Data Map (Sheet 1 of 3)

DNP Object Type	Index	Description
01,02	000–499	Relay Word, where 50B3 is 0 and LT9 is 471
01,02	500–999	Relay Word from the SER, encoded same as inputs 000–499 with 500 added
01,02	1000–1015	Relay front-panel targets, where 1015 is RESET, 1008 is SEF, 1007 is CONTROL ENABLED, and 1000 is 81
01,02	1016–1019	Power factor leading for A-, B-, C-, and 3-phase
01,02	1020	Relay Disabled
01,02	1021	Relay diagnostic failure
01,02	1022	Relay diagnostic warning
01,02	1023	New relay event available
01,02	1024	Settings change or relay restart
01,02[a]	1025	A more recent unread relay event is available
10,12	00–15	Remote bits RB1–RB16
10,12	16	Pulse Open command OC
10,12	17	Pulse Close command CC
10,12	18	Reset demands
10,12	19	Reset demand peaks
10,12	20	Reset energies
10,12	21	Reset breaker monitor
10,12	22	Reset front-panel targets
10,12	23	Read next relay event
10,12	24–31	Remote bit pairs RB1–RB16
10,12	32	Open/Close pair OC & CC
20,22	00	Active settings group
20,22	01	Internal breaker trips.
20,22	02	External breaker trips
20,22[b]	03–10	SELOGIC counters SC1–SC8
30,32	00,01	IA magnitude and angle
30,32	02,03	IB magnitude and angle
30,32	04,05	IC magnitude and angle
30,32	06,07	IN magnitude and angle
30,32	08,09	VA magnitude (kV) and angle
30,32	10,11	VB magnitude (kV) and angle
30,32	12,13	VC magnitude (kV) and angle
30,32	14,15	VS magnitude (kV) and angle
30,32	16,17	IG magnitude and angle
30,32	18,19	I1 magnitude and angle
30,32	20,21	3I2 magnitude and angle
30,32	22,23	3V0 magnitude (kV) and angle
30,32	24,25	V1 magnitude (kV) and angle
30,32	26,27	V2 magnitude (kV) and angle

Table H.4 SEL-351R DNP Data Map (Sheet 2 of 3)

DNP Object Type	Index	Description
30,32	28–31	MW A-, B-, C-, and 3-phase
30,32	32–35	MVAR A-, B-, C-, and 3-phase
30,32	36–39	Power factor A-, B-, C-, and 3-phase
30,32	40	Frequency
30,32	41	Always read as 0
30,32	42,43	A-phase MWhr in and out
30,32	44,45	B-phase MWhr in and out
30,32	46,47	C-phase MWhr in and out
30,32	48,49	3-phase MWhr in and out
30,32	50,51	A-phase MVARhr in and out
30,32	52,53	B-phase MVARhr in and out
30,32	54,55	C-phase MVARhr in and out
30,32	56,57	3-phase MVARhr in and out
30,32	58–63	Demand IA, IB, IC, IN, IG, and 3I2 magnitudes
30,32	64–67	A-, B-, C-, and 3-phase demand MW in
30,32	68–71	A-, B-, C-, and 3-phase demand MVAR in
30,32	72–75	A-, B- C-, and 3-phase demand MW out
30,32	76–79	A-, B-, C-, and 3-phase demand MVAR out
30,32	80–85	Peak demand IA, IB, IC, IN, IG, and 3I2 magnitudes
30,32	86–89	A-, B-, C-, and 3-phase peak demand MW in
30,32	90–93	A-, B-, C-, and 3-phase peak demand MVAR in
30,32	94–97	A-, B-, C-, and 3-phase peak demand MW out
30,32	98–101	A-, B-, C-, and 3-phase peak demand MVAR out
30,32	102–104	Breaker contact wear percentage (A, B, C)
30,32[c]	105	Fault type (see table for definition)
30,32[c]	106	Fault location
30,32[c]	107	Fault current
30,32[c]	108	Fault frequency
30,32[c]	109	Fault settings group
30,32[c]	110	Fault recloser shot counter
30,32[c]	111–113	Fault time in DNP format (high, middle, and low 16 bits)
30,32[a]	114	Relay internal temperature
30,32[a]	115	Number of unread faults
30,32[a]	116	51P1P setting in primary units
30,32[a]	117	51P2P setting in primary units
30,32[a]	118	51G1P setting in primary units
30,32[a]	119	51G2P setting in primary units
30,32[a]	120	51QP setting in primary units
30,32[a]	121	51N1P setting in primary units
30,32[a]	122	51N2P setting in primary units

Table H.4 SEL-351R DNP Data Map (Sheet 3 of 3)

DNP Object Type	Index	Description
30,32[a]	123,124	VAB magnitude and angle
30,32[a]	125,126	VBC magnitude and angle
30,32[a]	127,128	VCA magnitude and angle
30,32[a]	129	IA magnitude at the time of the fault
30,32[a]	130	IB magnitude at the time of the fault
30,32[a]	131	IC magnitude at the time of the fault
30, 32[a]	132	VBAT battery voltage
40,41	00	Active settings group

[a] Extended mode (DNPE) only.
[b] Only positive SELOGIC counter values can be viewed in DNP. Negative counter values are displayed as 0 (zero) in DNP.
[c] Object type 32 event messages are generated for these points in DNP extended mode (DNPE) only.

Binary inputs (Objects 1 and 2) are supported as defined by the previous table. Binary inputs 0–499 and 1000–1023 and 1025 are scanned approximately once every five seconds to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination.

In order to determine an elements point index, consult *Table H.5*. Locate the element in question in the table and determine its index by counting up right to left. Binary Inputs 500–999 are derived from the Sequential Events Recorder (SER) and carry the time stamp of actual occurrence. Static reads from these inputs will show the same data as a read from the corresponding index in the 0–499 group. Only points that are actually in the SER list (**SET R**) will generate events in the 500–999 group.

Table H.5 SEL-351R Recloser Control Relay Word Bits (Sheet 1 of 2)

Row	Relay Word Bits								DNP Index
2	50A1	50B1	50C1	50A2	50B2	50C2	50A3	50B3	7–0
3	50C3	50A4	50B4	50C4	50AB1	50BC1	50CA1	50AB2	15–8
4	50BC2	50CA2	50AB3	50BC3	50CA3	50AB4	50BC4	50CA4	23–16
5	50A	50B	50C	51P1	51P1T	51P1R	51N1	51N1T	31–24
6	51N1R	51G1	51G1T	51G1R	51P2	51P2T	51P2R	51N2	39–32
7	51N2T	51N2R	51G2	51G2T	51G2R	51Q	51QT	51QR	47–40
8	50P1	50P2	50P3	50P4	50N1	50N2	50N3	50N4	55–48
9	67P1	67P2	67P3	67P4	67N1	67N2	67N3	67N4	63–56
10	67P1T	67P2T	67P3T	67P4T	67N1T	67N2T	67N3T	67N4T	71–64
11	50G1	50G2	50G3	50G4	50Q1	50Q2	50Q3	50Q4	79–72
12	67G1	67G2	67G3	67G4	67Q1	67Q2	67Q3	67Q4	87–80
13	67G1T	67G2T	67G3T	67G4T	67Q1T	67Q2T	67Q3T	67Q4T	95–88
14	50P5	50P6	50N5	50N6	50G5	50G6	50Q5	50Q6	103–96
15	50QF	50QR	50GF	50GR	32VE	32QGE	32NE	32QE	111–104
16	F32P	R32P	F32Q	R32Q	F32QG	R32QG	F32V	R32V	119–112
17	F32N	R32N	32PF	32PR	32QF	32QR	32GF	32GR	127–120
18	27A1	27B1	27C1	27A2	27B2	27C2	59A1	59B1	135–128
19	59C1	59A2	59B2	59C2	27AB	27BC	27CA	59AB	143–136
20	59BC	59CA	59N1	59N2	59Q	59V1	27S	59S1	151–144
21	59S2	59VP	59VS	SF	25A1	25A2	3P27	3P59	159–152

Table H.5 SEL-351R Recloser Control Relay Word Bits (Sheet 2 of 2)

Row	Relay Word Bits							DNP Index
22	81D1	81D2	81D3	81D4	81D5	81D6	27B81	50L	167–160
23	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	VPOLV	LOP	175–168
24	RCTR	RCCL	IN106	IN105	IN104	IN103	IN102	IN101	183–176
25	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	191–184
26	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8	199–192
27	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8	207–200
28	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T	215–208
29	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T	223–216
30	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T	231–224
31	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T	239–232
32	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4	247–240
33	CLOSE	CF	RCSF	OPTMN	RSTMN	FSA	FSB	FSC	255–248
34	BCW	50P32	BADBAT	59VA	TRGTR	52A	COMMT	CHRGG	263–256
35	SG1	SG2	SG3	SG4	SG5	SG6	ZLOUT	ZLIN	271–264
36	ZLOAD	BCWA	BCWB	BCWC	TOSLPV	TOSLPT	DISTST	DTFAIL	279–272
37	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101	287–280
38	3PO	SOTFE	Z3RB	KEY	EKEY	ECTT	WFC	PT	295–288
39	PTRX2	PTRX	PTRX1	UBB1	UBB2	UBB	Z3XT	DSTRT	303–296
40	NSTRT	STOP	BTX	TRIP	OC	CC	CLG	H1CHRG	311–304
41	67P2S	67N2S	67G2S	67Q2S	PDEM	NDEM	GDEM	QDEM	319–312
42	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8	327–320
43	PB9	PINBD	PINC	PINE	PINF	SW1	DISCHG	LED9	335–328
44	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8	343–336
45	OCP	OCG	OLP	OLG	OLS	HTP	HTG	HLP	351–344
46	HLG	CLP	RPP	RPG	RPS	SEQC	3PHV	GTP	359–352
47	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A	367–360
48	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A	375–368
49	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B	383–376
50	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B	391–384
51	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA	399–392
52	*	*	*	*	*	*	*	*	407–400
53	*	*	*	*	*	*	*	*	415–408
54	*	*	*	*	*	*	*	*	423–416
55	*	*	*	*	*	*	*	*	431–424
56	50NF	50NR	32NF	32NR	59L1	IDSCHG	DCONN	DDATA	439–432
57	BATVL1	BATVL2	*	*	*	*	*	LOCAL	447–440
58	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16	455–448
59	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16	463–456
60	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16	471–464

Analog Inputs (Objects 30 and 32) are supported as defined by *Table H.4*. The values are reported in primary units. Analog inputs 28–35, 42–57, 64–79, 86–104, and 106 are further scaled according to the DECPLM setting (e.g., if DECPLM is 3, then the value is multiplied by 1000). Analog inputs 58–63, 80–85, 107, 115–119, 129–131 and the even-numbered points in 0–7 and 16–21 (current magnitudes) are scaled according to the DECPLA setting. The even-numbered points in 8–15 and 22–27 (voltage magnitudes) are scaled according to the DECPLV setting. Analog inputs 36–41, 108, and the odd-numbered points in 0–27 (angles) are scaled by 100, and input 114 (relay temperature) is scaled by 10 and has a hard-coded dead band of 5 (1/2 of a degree). The remaining analogs are not scaled.

Event-class messages are generated whenever an input changes beyond the value given by the ANADB setting. The dead-band check is done after any scaling is applied. The angles (the odd numbered points in 0–27) will only generate an event if, in addition to their dead-band check, the corresponding magnitude (the preceding point) contains a value greater than the value given by the ANADB setting. Analogs that are scaled or have dead bands can be set individually using the **DNP** command syntax described in *Point Remapping on page H.16*.

In standard mode, analog inputs are scanned at approximately a five-second rate, except for analogs 105–113. During a scan, all events generated will use the time the scan was initiated. Analogs 105–113 are derived from the history queue data for the most recently read fault. In standard mode, analogs 105–113 do not generate event messages. In extended mode, events for these inputs, as well as 129–131, will use the time the scan was initiated. Analog input 115 is derived from the history queue. Analog 105 is a 16-bit composite value, where the upper byte is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	Trip element
8	ER element

And the lower byte is defined as follows:

Value	Fault Type
0	Indeterminate
1	A-Phase
2	B-Phase
4	C-Phase
8	Ground

The upper and lower bytes may contain any combination of the above bits (e.g., a 6 is a B to C fault and a 9 is an A-to-Ground fault). If Analog 105 is 0, fault information has not been read and the related analogs (106–113 and 129–131) do not contain valid data. When UNSOL = Y and UNSOFH = Y, fault history data in analogs 105–113 and 129–131 will be reported as unsolicited DNP events. When UNSAOV = 4, Object 32 will be reported as Variation 4 (with a DNP time stamp). The time stamp for analogs 105–113 and 129–131 will be the actual time of the fault. All other DNP time stamps will be the time of the DNP scan. When UNSAOV = 2, Object 32 will be reported as Variation 2 (no time stamps). Analog inputs 116–122 are derived from the present active group settings. If the associated setting is set to OFF, the value will be reported as –1.

Control Relay Output Blocks (Object 12, Variation 1) are supported. The control relays correspond to the remote bits and other functions, as shown below. The Trip/Close bits take precedence over the control field. The control field is interpreted as follows for SEL-351R Recloser Controls.

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–15	Set	Clear	Set	Clear	Pulse	Clear
16–22	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
23	Read Oldest	Read Newest[a]	Read Oldest	Read Newest[a]	Read Oldest	Read Newest[a]
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

[a] This function is only available in extended mode (DNPE). It functions as "Do Nothing" in standard mode (DNP).

The Status field is used exactly as defined. All other fields are ignored. A pulse operation asserts a point for a single processing interval. Caution should be exercised with multiple remote bit pulses in a single message (i.e., point count > 1), as this may result in some of the pulse commands being ignored and returning an already active status.

Analog outputs (Objects 40 and 41) are supported as defined by the preceding table. Flags returned with Object 40 responses are always set to 0. The Control Status field of Object 41 requests are ignored. If the value written to index 0 is outside of the range 1–6, the relay will not accept the value and will return a hardware error status.

Internal Indications (Object 80) are as defined in the DNP specification with the following qualifications:

1. Time-synchronization (IIN1.4) is requested in accordance with the TIMERQ setting, with 0 meaning never.
2. Local_Control (IIN1.5) is set equal to the SELOGIC control equation LOCAL or set to 1 if the relay is disabled.

The SEL-351R-4 does not block any operation if Local_Control is set to 1. To prevent remote operations if the LOCAL Relay Word bit is asserted, it must be used in SELOGIC control equations. For example, to assert TRIP for a trip condition or via remote operations, the following settings could be used.

TRIP = **51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T + PB9 + OC*!LOCAL**

SET8 = **PB3*!LT8**

RST8 = **PB3*LT8**

LOCAL = **!LT8**

Note that PB3 is the **REMOTE ENABLED** pushbutton in this case.

Relay Event Summary Data

In standard mode (DNP) the Relay Event Summary data are available on a first in, first out (FIFO) basis. In extended mode (DNPE), the Relay Event Summary data can be read in two ways: first in, first out (FIFO); or last in, first out (LIFO).

To use the FIFO method, the master should monitor binary input Point 1023, which will be on when there is an unread relay event summary. To read the oldest relay event summary, the master should Pulse-On binary output Point 23. This will load the relay event summary analogs (Points 105–113 and 129–131 in DNPE) with information from the oldest relay event summary, discarding the values from the previous load. After reading the analogs, the master should again check binary input Point 1023, which will be on if there is another unread relay event summary. The master should continue this process until binary input Point 1023 is off. If the master attempts to load values using output Point 23 when binary input Point 1023 is off, the relay event type analog (Point 105) will be loaded with zero. With the FIFO method the relay event summaries will always be collected in chronological order.

In extended mode (DNPE) *only*, the LIFO method is available. To use the LIFO method the master should monitor binary input Point 1023, which will be set when there is an unread relay event summary. To read the newest relay event summary, the master should Pulse-Off binary output Point 23. This will load the relay event summary analogs (Points 105–113 and 129–131) with information from the newest relay event summary, discarding the values from the previous load. After reading the analogs, the master should again check binary input Point 1023, which will still be on if there is another unread relay event summary. The master should continue this process until binary input Point 1023 is off. If the master attempts to load values using output Point 23 when binary input Point 1023 is off, the event type analog (Point 105) will be loaded with zero. With the LIFO method the relay event summaries will be collected in reverse chronological order, unless binary input Point 1025 is set, which the master can use to identify when a newer relay event summary is available.

In extended mode (DNPE), DNP events are generated whenever the values in Points 105–113 and 129–131 change. Events are detected every five seconds by the scanning process. The master can collect relay event summaries using event data rather than the static data polling described above. In order for this to work successfully, binary output 23 must be pulsed no faster than once every ten seconds. If binary output 23 is pulsed faster, some data may not be recognized and processed by the DNP event scanner.

It is also possible to receive unsolicited reports for relay event summary data by setting UNSOFH = Y. The SEL-351R will report all relay event summary data as events occur.

Point Remapping

The analog and binary input points (Objects 1, 2, 30, and 32) may be remapped via the **DNP** command. The map is composed of 2 lists of indices, one for the analogs (30 and 32) and the other for the binaries (1 and 2). The indices correspond to those given by the recloser control default DNP data map. The order they occur in the list determines the index that the corresponding value is reported as to the DNP master. If a value is not in the list, it is not available to the DNP master. All 1026 binaries and 132 analogs may be included in the list, but may occur only once. The maps are stored in nonvolatile memory. The DNP command is only available if DNP or DNPE has been selected on one of the ports. The **DNP** command has the following format:

DNP [type]

where type may be A, B, S, T, or omitted.

If the **DNP** command is issued without parameters, the relay displays both the analog and binary maps, which have the following format:

```
==>DNP <Enter>
Analogs  = 112 28 17 35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102  \
           0:1:200:1 2:::2 4:2:1000
Binaries = 28:1 29:1 30:1 31:1 35 38 42 45 48 49 50 51 52 53 54 55 72 73 74 75  \
           76 77 78 79 96 97 98 99 100 101 102 103 152 153 160 168 182:3  \
           183:3 330:3 331:3 332:3 333:3 334:3
==>
```

If the **DNP** command is issued with an S parameter, the relay displays only the analog map; likewise, a T causes the relay to display only the binary map. If the map checksum is determined to be invalid, the map will be reported as corrupted during a display command, as follows:

```
==>DNP T <Enter>
Binaries = Map Corrupted <ETX>
==>
```

NOTE: The scale factor must precede the dead band when both parameters are specified for setting a point.

If the map is determined to be corrupted, DNP will respond to all master data requests with an unknown point error. If the **DNP** command is issued with an A or B parameter at Level 2 or greater, the relay requests the user enter indices for the corresponding list, where a parameter of A specifies the analog list and B specifies the binary list. The relay accepts lines of indices until a line without a final continuation character (\ ) is entered. Each line of input is constrained to 80 characters, but all the points may be re-mapped, using multiple lines with continuation characters (\ ) at the end of the intermediate lines. If a single blank line is entered as the first line, the re-mapping is disabled for that type (i.e., the relay uses the default analog or binary map). Scaling and dead-band parameters may be applied on a point-by-point basis to a majority of the analog input points. Per-point dead-band assignments cannot be made for angles, fault data, and settings. Class assignments may also be applied on a point-by-point basis to both the analog and binary input points. The examples below show the required syntax.

Analog Per-Point Assignments

Scaling, dead band, and class assignment	22:3:500:1
Scaling only	22:3
Dead band only	22::500
Class assignment only	22:::1

Binary Per-Point Assignments

Class assignment	28:1

For example, to produce the DNP map shown in the **DNP** command response above, enter the following commands:

```
==>DNP A <Enter>

Enter the new DNP Analog map
112 28 17 \
35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102 \
0:1:200:1 2:::2 4:2:1000

Save Changes (Y/N)? Y <CR>

==>DNP B <Enter>

Enter the new DNP Binary map
28:1 29:1 30:1 31:1 35 38 42 45 \
48 49 50 51 52 53 54 55 72 73 74 75 76 77 78 79 \
96 97 98 99 100 101 102 103 \
152 153 160 168 182:3 183:3 \
330:3 331:3 332:3 333:3 334:3

Save Changes (Y/N)? Y <CR>
==>
```

SEL-351R DNP Settings Sheets

Standard Mode DNP Port—SET P

NOTE: Masters may experience intermittent communications at 38400 baud rate. SEL recommends baud rates of 19200 or lower.

Protocol (SEL, LMD, DNP, DNPE, MBA, MBB, MB8A, MB8B)	**PROTO**	= DNP
Baud rate (300, 600, 1200, 2400, 4800, 9600, 19200, 38400)	**SPEED**	= ________
DNP Address (0–65534)	**DNPADR**	= ________
DNP Time Offset in hours (–24.00–24)	**DNPTOF**	= ________
Minutes for request interval (0 for never, 1–32767)	**TIMERQ**	= ________
Class for event data (0 for no event, 1–3)	**ECLASS**	= ________
Currents scaling decimal places (0–3)	**DECPLA**	= ________
Voltages scaling decimal places (0–3)	**DECPLV**	= ________
Misc data scaling decimal places (0–3)	**DECPLM**	= ________
Seconds to select/operate time-out (0.0–30)	**STIMEO**	= ________
Data-link retries (0 for no confirm, 1–15)	**DRETRY**	= ________
Seconds to data link time-out (0–5)	**DTIMEO**	= ________
Minimum seconds from DCD to Tx (0.00–1)	**MINDLY**	= ________
Maximum seconds from DCD to Tx (0.00–1)[1]	**MAXDLY**	= ________
Settle time from RTS ON to Tx (OFF, 0.00–30 sec)	**PREDLY**	= ________
Settle time from Tx to RTS OFF (0.00–30 sec)	**PSTDLY**	= ________
Analog reporting dead band counts (0–32767)	**ANADB**	= ________
Enable unsolicited reporting (Y,N, DIAL)	**UNSOL**	= ________
Enable unsolicited reporting at power-up (Y,N)	**PUNSOL**	= ________
DNP address to report to (0–65534)	**REPADR**	= ________
Number of events to transmit on (1–200)	**NUMEVE**	= ________
Seconds until oldest event to Tx on (0.0–60)	**AGEEVE**	= ________
Seconds to event message confirm time-out (1–50)	**ETIMEO**	= ________
Maximum number of retry attempts at ETIMEO interval (2–10)	**URETRY**	= ________

[1] When Port 1 communications are configured for DNP, MAXDLY must be set > 0.00.

Offline time-out for confirmation of unsolicited message, seconds (1–86400)	**UTIMEO**	= ____________
Maximum Response Fragment Size (512, 1024, 2048)	**RESPSZ**	= ____________
Analog Input Change Reporting (Last, All)	**ACHRPT**	= ____________

Extended Mode DNP Port—SET P

NOTE: Masters may experience intermittent communications at 38400 baud rate. SEL recommends baud rates of 19200 or lower.

Protocol (SEL, LMD, DNP, DNPE, MBA, MBB, MB8A, MB8B)	**PROTO**	= DNPE
Baud rate (300, 600, 1200, 2400, 4800, 9600, 19200, 38400)	**SPEED**	=
DNP Address (0–65534)	**DNPADR**	=
DNP Time Offset in hours (–24.00–24)	**DNPTOF**	=
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	=
Class for analog event data (0 for no event, 1–3)	**CLASSA**	=
Class for binary event data (0 for no event, 1–3)	**CLASSB**	=
Class for counter event data (0 for no event, 1–3)	**CLASSC**	=
Currents scaling (0–3 decimal places)	**DECPLA**	=
Voltages scaling (0–3 decimal places)	**DECPLV**	=
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	=
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	=
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	=
Data Link Time-out interval, seconds (0–5)	**DTIMEO**	=
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	=
Maximum Delay from DCD to transmission, seconds (0.00–1.00)[2]	**MAXDLY**	=
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	=
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	=
Amps reporting dead band, counts (0–32767)	**ANADBA**	=
Volts reporting dead band, counts (0–32767)	**ANADBV**	=
Miscellaneous data reporting dead band, counts (0–32767)	**ANADBM**	=
Allow Unsolicited Reporting (Y, N, DIAL)	**UNSOL**	=
Enable unsolicited messages on power-up (Y,N)	**PUNSOL**	=
Enable Unsolicited Fault History Reporting (Y,N)	**UNSOFH**	=
Analog Change Event Default Variation (2,4)	**UNSAOV**	=
Address of master to Report to (0–65534)	**REPADR**	=
Number of events to transmit on (1–200)	**NUMEVE**	=

[2] When Port 1 communications are configured for DNPE, MAXDLY must be set > 0.00.

Seconds until oldest event to transmit on, seconds (0.0–60.0)	**AGEEVE**	= ______________
Seconds to event message confirm time-out (1–50)	**ETIMEO**	= ______________
Maximum number of retry attempts at ETIMEO interval (2–10)	**URETRY**	= ______________
Offline time-out for confirmation of unsolicited message, seconds (1–86400)	**UTIMEO**	= ______________
Maximum Response Fragment Size (512, 1024, 2048)	**RESPSZ**	= ______________
Analog Input Change Reporting (Last, All)	**ACHRPT**	= ______________

Appendix I

MIRRORED BITS

Overview

MIRRORED BITS® is a direct relay-to-relay communications protocol that allows protective relays to exchange information quickly and securely, and with minimal expense. The information exchanged can facilitate remote control, remote sensing, or communications-assisted protection schemes such as POTT, DCB, etc. The SEL-351R Recloser Control supports two MIRRORED BITS channels, differentiated by the channel specifiers A and B. Bits transmitted are called TMB1*x*–TMB8*x*, where *x* is the channel specifier (e.g., A or B), and are controlled by the corresponding SELOGIC® control equations. Bits received are called RMB1*x*–RMB8*x* and are usable as inputs to any SELOGIC control equations. Channel status bits are called ROK*x*, RBAD*x*, CBAD*x*, and LBOK*x* and are also usable as inputs to any SELOGIC control equations. Further channel status information is available via the **COM** command.

Operation

Message Transmission

All messages are transmitted without idle bits between characters. Idle bits are allowed between messages.

At 4800 baud, one message is transmitted each 1/2 power system cycle.

At 9600 baud, one message is transmitted each 1/4 power system cycle.

At 19200 and 38400 baud, one message is transmitted each 1/8 power system cycle for the SEL-321 and 1/4 power system cycle for the SEL-351 and the SEL-351R.

Message Decoding and Integrity Checks

The control will deassert a user-accessible flag per channel (hereafter called ROK*x*) upon failing any of the following received-data checks:

- Parity, framing, or overrun errors.
- Receive data redundancy error.
- Receive message identification error.
- No message received in the time three messages have been sent.

NOTE: When MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting.

While ROK*x* is not asserted, the relay will:

1. Prevent new data from being transferred to the pickup dropout security counters described later. Instead, the relay will send one of the following user selectable values (hereafter called default values) to the security counter inputs:

   1

   0

   The last valid value

   The user will be allowed to select one of the default values for each RMB.

2. Enter the synchronization process described below.

The relay will assert ROK*x* only after successful synchronization as described below and two consecutive messages pass all of the data checks described above. After ROK*x* is reasserted, received data may be delayed while passing through the security counters described below.

Transfer of received data to RMB1*x*–RMB8*x* is supervised by eight user-programmable pickup/dropout security counters settable from 1 (allow every occurrence to pass) to at least eight (require eight consecutive occurrences to pass). The pickup and dropout security count settings are separate.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that it is set in counts of received messages instead of time. An SEL-351R talking to another SEL-351R sends and receives MIRRORED BITS messages four times per power system cycle. Therefore, a security counter set to two counts will delay a bit by about 1/2 power system cycle. Things become slightly more complicated when two relays of different processing rates are connected via MIRRORED BITS (for instance, an SEL-321 talking to an SEL-351R). The SEL-321 processes power system information each 1/8 power system cycle but processes the pickup/dropout security counters as messages are received. Since the SEL-321 is receiving messages from the SEL-351R, it will receive a message per 1/4 cycle processing interval. So, a counter set to two will again delay a bit by about 1/2 cycle. However, in that same example, a security counter set to two on the SEL-351R will delay a bit by 1/4 cycle, because the SEL-351R is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Synchronization

When a node detects a communications error, it deasserts ROK*x*. If a node detects two consecutive communications errors, it transmits an attention message, which includes its TX_ID setting.

When a node receives an attention message, it checks to see if its TX_ID is included.

If its own TX_ID is included and at least one other TX_ID is included, the node transmits data.

If its own TX_ID is not included, the node deasserts ROK*x*, includes its TX_ID in the attention message, and transmits the new attention message.

If its own TX_ID is the only TX_ID included, the relay assumes the message is corrupted unless the loopback mode has been enabled. If loopback is not enabled, the node deasserts ROKx and transmits the attention message with its TX_ID included. If loopback is enabled, the relay transmits data.

In summary, when a node detects two consecutive errors, it transmits attention until it receives an attention with its own TX_ID included. If three or four relays are connected in a ring topology, then the attention message will go all the way around the loop, and eventually will be received by the originating node. It will then be killed and data transmission will resume. This method of synchronization allows the relays to determine reliably which byte is the first byte of the message. It also forces mis-synchronized UARTs (Universal Asynchronous Receiver and Transmitter) to become re-synchronized. On the down side, this method takes down the entire loop for a receive error at any node in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOOP** command to enable loopback testing.

While in loopback mode, ROK*x* is deasserted, and another user-accessible flag, LBOK*x*, will assert and deassert based on the received data checks.

Channel Monitoring

Based on the results of data checks described above, the relay will collect information regarding the 255 most recent communications errors. Each record will contain at least the following fields:

- Dropout Time/Date
- Pickup Time/Date
- Time elapsed during dropout
- Reason for dropout (see *Table I.1*)

Table I.1 Error Types Reported by the Communications Report

Error Type	Description
Parity error	Data failed UART parity check.
Underrun	Three MIRRORED BIT messages transmitted without one being received.
Overrun	UART data buffer overrun.
Re-sync	The MIRRORED BITS device at the other end of the link detected an error.
Data error	Received data were not self-consistent, or the address was wrong.
Relay disabled	Relay protection functions disabled as during power up or change in settings or settings group.
Loopback	Loopback enabled. Error conditions followed by "(L)" occurred while the system was in loopback.
Framing error	The UART did not detect a stop bit in the received MIRRORED BIT data.

Use the **COMM** command to generate a long or summary report of the communications errors.

NOTE: The user typically will combine RBADx with other alarm conditions using SELOGIC control equations.

NOTE: The user typically will combine CBADx with other alarm conditions using SELOGIC control equations.

There is only a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but the outage can be perpetuated by framing errors. If the channel is presently down, the COMM record will only show the initial cause, but the COMM summary will display the present cause of failure.

When the duration of an outage exceeds a user-settable threshold, the relay will assert a user-accessible flag, hereafter called RBAD*x*.

When channel unavailability exceeds a user-settable threshold, the relay will assert a user accessible flag, hereafter called CBAD*x*.

MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem

NOTE: An idle processing interval guarantees at least 19 idle bits at 9600 baud in an SEL-321 Relay with the system frequency at 65 Hz.

The user indicates that a Pulsar MBT modem is to be used by responding "MBT" to the RTS/CTS setting prompt. When the user selects MBT, the baud rate setting will be limited to 9600 baud.

The MIRRORED BITS protocol compatible with the Pulsar MBT-9600 modem is identical to the standard MIRRORED BITS protocol with the following exceptions:

The relay injects a delay (idle time) between messages. The length of the delay is one relay processing interval.

The relay resets RTS (to a negative voltage at the EIA-232 connector) for MIRRORED BITS communications using this specification. The relay sets RTS (to a positive voltage at the EIA-232 connector) for MIRRORED BITS communications using the R6 or original R version of MIRRORED BITS.

Settings

```
protocol (SEL,LMD,MBA,MBB,MB8A,MB8B)                    PROTO = MBA  ?
```

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 7-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communication channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed.

```
baud rate (300-38400)                        SPEED = 9600   ?
```

Use the SPEED setting to control the rate at which the MIRRORED BITS messages are transmitted, in power system cycles (~), based on the following table:

Speed	SEL-321	SEL-351
38400	1 message per 1/8 cycle	1 message per 1/4 cycle
19200	1 message per 1/8 cycle	1 message per 1/4 cycle
9600	1 message per 1/4 cycle	1 message per 1/4 cycle
4800	1 message per 1/2 cycle	1 message per 1/2 cycle

```
enable hardware handshaking (Y,N,MBT)        RTS_CTS= N     ?
```

Use the MBT option if you are using a Pulsar MBT 9600 baud modem. With this option set, the relay will transmit a message every 1/2 power system cycle and the relay will deassert the RTS signal on the EIA-232 connector. Also, the relay will monitor the CTS signal on the EIA-232 connector, which the modem will deassert if the channel has too many errors. The modem uses the relay's RTS signal to determine whether the new or old MIRRORED BITS protocol is in use.

```
Mirrored Bits Receive bad pickup (1- 10000 sec)   RBADPU= 60     ?
```

Use the RBADPU setting to determine how long a channel error must last before the relay element RBADA is asserted. RBADA is deasserted when the channel error is corrected. RBADPU is accurate to ±1 second.

```
Mirrored Bits Channel bad pickup (1- 10000 10E-6) CBADPU= 1000   ?
```

Use the CBADPU setting to determine the ratio of channel down time to the total channel time before the relay element CBADA is asserted. The times used in the calculation are those that are available in the COMM records. See the **COMM** command in the SEL-321, SEL-351, or SEL-351R manuals for a description of the COMM records.

```
Mirrored Bits transmit identifier(1 - 4)          TX_ID = 1      ?
Mirrored Bits receive identifier(1 - 4)           RX_ID = 2      ?
```

Set the RX_ID of the local relay to match the TX_ID of the remote relay. For example, in the three-terminal case, where Relay X transmits to Relay Y, Relay Y transmits to Relay Z, and Relay Z transmits to Relay X:

	TX_ID	RX_ID
Relay X	1	3
Relay Y	2	1
Relay Z	3	2

```
Mirrored Bits receive default state (string of 1s, 0s or Xs)
       87654321
RXDFLT=00000X11
     ?
```

Use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if an error condition is detected. The setting is a mask of 1s, 0s and/or Xs, for RMB1A–RMB8A, where X represents the most recently received valid value. When MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting.

```
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB1PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB1DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB2PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB2DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB3PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB3DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB4PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB4DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB5PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB5DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB6PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB6DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB7PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB7DO= 1      ?
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB8PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB8DO= 1      ?
```

Supervise the transfer of received data (or default data) to RMB1A–RMB8A with the MIRRORED BITS pickup and dropout security counters. Set the pickup and dropout counters individually for each bit.

Appendix J
PC Software

Overview

NOTE: PC software is updated more frequently than relay firmware. As a result, the descriptions in this section may differ slightly from the software. Select **Help** in the PC software for information.

SEL provides many PC software solutions (applications) that support SEL devices. These software solutions are listed in *Table J.1*.

Table J.1 SEL Software Solutions

Product Name	Description
SEL Compass®	This application provides an interface for web-based notification of product updates and automatic software updating.
ACSELERATOR QuickSet® SEL-5030 Software	ACSELERATOR QUICKSET is a powerful setting, event analysis, and measurement tool that aids in applying and using the recloser control. See the ACSELERATOR QUICKSET *SEL-5030 Software Instruction Manual* for information about the various ACSELERATOR QUICKSET applications.[a]
ACSELERATOR TEAM® SEL-5045 Software	The TEAM system provides custom data collection and movement of a wide variety of device information. The system provides tools for device communication, automatic collection of data, and creation of reports, warnings and alarms. See the ACSELERATOR *Team SEL-5045 Software Instruction Manual* for information about the various ACSELERATOR TEAM applications.
ACSELERATOR Analytic Assistant® SEL-5601 Software	Converts SEL compressed ASCII event reports files to oscillography
Cable Selector SEL-5801 Software	Selects the proper SEL cables for your application.

[a] The SEL-351R-4 does not support the Design Templates or free form logic described in the SEL-5030 Instruction Manual.

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Appendix K
Fast SER Protocol

Introduction

This appendix describes special binary Fast Sequential Events Recorder (SER) messages that are not included in *Section 10: Serial Port Communications and Commands*. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary Fast SER messages from the SEL-351R Relay.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data. To exploit this feature, the device connected to the other end of the link requires software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

Make Sequential Events Recorder (SER) Settings With Care

The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of writes. Exceeding the limit can result in an EEPROM self-test failure. **An average of one state change every three minutes can be made for a 25-year relay service life.**

Recommended Message Usage

Use the following sequence of commands to enable unsolicited binary Fast SER messaging in the SEL-351R:

1. On initial connection, send the **SNS** command (see *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*) to retrieve and store the ASCII names for the digital I/O points assigned to trigger SER records.

   The order of the ASCII names matches the point indices in the unsolicited binary Fast SER messages. Send the "Enable Unsolicited Fast SER Data Transfer" message to enable the SEL-351R to transmit unsolicited binary Fast SER messages.

2. When SER records are triggered in the SEL-351R, the relay responds with an unsolicited binary Fast SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as contained in the original message. The relay will wait approximately 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited Fast SER message with the same response number.

3. Upon receiving an acknowledge message with a matching response number, the relay increments the response number, and continues to send and seek acknowledgment for unsolicited Fast SER messages, if additional SER records are available. When the response number reaches three it wraps around to zero on the next increment.

Functions and Function Codes

In the messages shown below, all numbers are in hexadecimal, unless otherwise noted.

01—Function Code: Enable Unsolicited Fast SER Data Transfer, Sent From Master to Relay

Upon power-up, the SEL-351R disables its own unsolicited transmissions. This function enables the SEL-351R to begin sending unsolicited data to the device that sent the enable message, if the SEL-351R has such data to transfer. The message format for function code 01 is shown in *Table K.1*.

Table K.1 Function Code 01 Message Format (Sheet 1 of 2)

Data	Description
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (18—unsolicited SER messages)

Table K.1 Function Code 01 Message Format (Sheet 2 of 2)

Data	Description
0000	Reserved for future use as function code data
nn	Maximum number of SER records per message, 01–20 hex
cccc	Two byte CRC-16 check code for message

The SEL-351R verifies the message by checking the header, length, function code, and enabled function code against the expected values. It also checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to enable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

The "nn" field is used to set the maximum number of SER records per message. The relay checks for SER records approximately every 500 ms. If there are new records available, the relay immediately creates a new unsolicited Fast SER message and transmits it. If there are more than "nn" new records available, or if the first and last record are separated by more than 16 seconds, the relay will break the transmission into multiple messages so that no message contains more than "nn" records, and the first and last record of each message are separated by no more than 16 seconds.

If the function to enable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing a response code 01 (function code unrecognized), and no functions are enabled. If the SER triggers are disabled (SER1, SER2, and SER3 are all set to NA), the unsolicited Fast SER messages are still enabled, but the only SER records generated are because of settings changes and power being applied to the relay. If the SER1, SER2, or SER3 settings are subsequently changed to any non-NA value and SER entries are triggered, unsolicited SER messages will be generated with the new SER records.

02—Function Code: Disable Unsolicited Fast SER Data Transfer, Sent From Master to Relay

This function disables the SEL-351R from transferring unsolicited data. The message format for function code 02 is shown in *Table K.2*.

Table K.2 02 Function Code Message Format

Data	Description
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (18 = Unsolicited SER)
00	Reserved for future use as function code data
cccc	Two byte CRC-16 check code for message

The SEL-351R verifies the message by checking the header, length, function code, and disabled function code against the expected values, and checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to disable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

If the function to disable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing the response code 01 (function code unrecognized) and no functions are disabled.

18—Function: Unsolicited Fast SER Response, Sent From Relay to Master

The function 18 is used for the transmission of unsolicited Fast Sequential Events Recorder (SER) data from the SEL-351R. This function code is also passed as data in the “Enable Unsolicited Data Transfer” and the “Disable Unsolicited Data Transfer” messages to indicate which type of unsolicited data should be enabled or disabled. The message format for function code 18 is shown in *Table K.3*.

Table K.3 Function Code 18 Message Format (Sheet 1 of 2)

Data	Description
A546	Message header
ZZ	Message length (Up to 34 + 4 • *nn* decimal, where *nn* is the maximum number of SER records allowed per message as indicated in the “Enable Unsolicited Data Transfer” message.)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment. If YY=03, the master should re-read the SNS data because the element index list may have changed.)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366)
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
.	
.	
.	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.

Table K.3 Function Code 18 Message Format (Sheet 2 of 2)

Data	Description
FFFFFFFE	Four-byte end-of-records flag
ssssssss	Packed four-byte element status for up to 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the relay determines that SER records have been lost, it sends a message with the following format:

Table K.4 Message Format for Lost SER Records

Data	Description
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366) of overflow message generation
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex) of overflow message generation.
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFE	Four-byte end-of-records flag
00000000	Element status (unused)
cccc	Two byte CRC-16 checkcode for message

Acknowledge Message Sent from Master to Relay, and From Relay to Master

The acknowledge message is constructed and transmitted for every received message that contains a status byte with the LSB set (except another acknowledge message), and that passes all other checks, including the CRC. The acknowledge message format is shown in *Table K.5*.

Table K.5 Acknowledge Message Format

Data	Description
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address.
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.)
cccc	Two byte CRC-16 checkcode for message

The SEL-351R supports the response codes in *Table K.6*.

Table K.6 Supported Response Codes

RR	Response
00	Success.
01	Function code not recognized.

Examples

1. Successful acknowledge for “Enable Unsolicited Fast SER Data Transfer” message from a relay with at least one of SER1, SER2, or SER3 not set to NA:

   A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc (XX is the same as the Response Number in the “Enable Unsolicited Data Transfer” message to which it responds)

2. Unsuccessful acknowledge for “Enable Unsolicited Fast SER Data Transfer” message from a relay with all of SER1, SER2, and SER3 set to NA:

   A5 46 0E 00 00 00 00 00 00 81 02 XX cc cc (XX is the same as the response number in the “Enable Unsolicited Data Transfer” message to which it responds.)

3. Disable Unsolicited Fast SER Data Transfer message, acknowledge requested:

   A5 46 10 00 00 00 00 00 01 02 C0 XX 18 00 cc cc (XX = 0, 1, 2, 3)

4. Successful acknowledge from the relay for the “Disable Unsolicited Fast SER Data Transfer” message:

   A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc (XX is the same as the response number in the “Disable Unsolicited Fast SER Data Transfer” message to which it responds.)

5. Successful acknowledge message from the master for an unsolicited Fast SER message:

   A5 46 0E 00 00 00 00 00 00 98 00 XX cccc (XX is the same as the response number in the unsolicited Fast SER message to which it responds.)

Notes

Once the relay receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in fast meter, if that bit is asserted.

An element index of FE indicates that the SER record is because of power up. An element index of FF indicates that the SER record is because of a setting change. An element index of FD indicates that the element identified in this SER record is no longer in the SER trigger settings.

When the relay sends an SER message packet, it will put a sequential number (0, 1, 2, 3, 0, 1, ...) into the response number. If the relay does not receive an acknowledge from the master before approximately 500 mS, the relay will resend the same message packet with the same response number until it receives an acknowledge message with that response number. For the next SER message, the relay will increment the response number (it will wrap around to zero from three).

A single Fast SER message packet from the relay can have a maximum number of 32 records and the data may span a time period of no more than 16 seconds. The master can limit the number of records in a packet with the third byte of function code data in the “Enable Unsolicited Data Transfer” message (function code 01). The relay can generate an SER packet with fewer than the requested number of records, if the record time stamps span more than 16 seconds.

The relay always requests acknowledgment in unsolicited Fast SER messages (LSB of the status byte is set).

Unsolicited Fast SER messages can be enabled on multiple ports simultaneously.

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SEL-351R Recloser Control Command Summary

Access Level 0 Command	From Access Level 0, you can go to Access Level 1 or to Access Level E (EZ). The Access Level 0 screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the control prompts you for the Access Level 1 password to enter Access Level 1.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper is not in place, the control prompts you for the Access Level 2 password to enter Access Level 2.
BAC	Enter Access Level B (Breaker). If the main board password jumper is not in place, the control prompts you for the Access Level B password.
BRE	Display breaker/recloser contact wear report.
BRE A	Display breaker/recloser contact wear and trip operation report.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS® channel *p*.
COM *p d1 d2*	Show a communications summary for events occurring between dates *d1* and *d2* on MIRRORED BITS channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS channel *p* (where *p* = A or B).
COU *k*	Show the SELOGIC® counter values. Enter *k* for repeat count.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP[a] *type*	Show DNP map.
EVE *n*	Show event report number *n* with 1/4 cycle resolution.
EVE C *n*	Show compressed event report number *n* for use with ACSELERATOR® Analytic Assistant SEL-5601 Software.
EVE L *n*	Show event report number *n* with 1/16 cycle resolution.
EVE R *n*	Show raw event report number *n* with 1/16 cycle resolution.
EVE *XX f*	Append parameter *f* to any of the above **EVE** commands, where *f* is A or D. Use A to show only the analog portion of the event report. Use D to show only the digital protection and control portion of the event report.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.
GRO	Display active settings group number.
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
IRI	Force synchronization of internal control clock to IRIG-B time-code input.
LDP *d1*	Show rows in the Load Profile report from date *d1*.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
LDP *d1 d2*	Show rows in the Load Profile report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP *n*	Show the latest *n* rows in the Load Profile report.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear SER records from nonvolatile memory.
SER D	List active chattering elements from the SER records and present auto-removal settings.
SHO *n*	Show “regular” settings for settings group *n* (*n* = 1–6).
SHO EZ *n*	Show EZ recloser control settings for settings group *n* (*n* = 1–6).
SHO FZ	Show EZ global settings.
SHO G	Show global settings.
SHO L *n*	Show SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SHO P *n*	Show port settings for port *n* (*n* = 1, 2, 3, F).
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings for front-panel display points and extra local control.
STA	Show recloser control self-test status.
TAR *n k*	Display Relay Word row. If *n* = 0–60, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
TAR R	Reset the front-panel tripping targets.
TIM	Show or set time (24 hour time). Show time presently in the recloser control by entering just **TIM**. Example time 22:47:36 is entered with command **TIM 22:47:36**.
TRI	Trigger an event report.

[a] The **DNP** command is only available when the protocol of one of the serial ports is set to DNP.

Access Level E Commands	Access Level E (EZ) commands primarily allow you to set EZ settings and global EZ settings. All Access Level 1 commands can also be executed from Access Level E. The Access Level E screen prompt is: =+>
BTT	Display latest battery load test results and time remaining until next discharge test.
BTT NOW	Initiate battery load test immediately.
SET EZ *n*	Change EZ recloser control settings for settings group *n* (*n* = 1–6). EZ recloser control settings override and change a number of the “regular” settings made with the **SET *n*** command (Access Level 2).
SET FZ	Change EZ global settings. EZ global settings override and change a number of the global settings made with the **SET G** command (Access Level 2).

Access Level B Commands	Access Level B commands primarily allow you to operate control parameters and output contacts. All Access Level 1 and Access Level E commands can also be executed from Access Level B. The screen prompt is: ==>
BRE R	Reset breaker/recloser contact wear and trip operation counters.
BRE W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
CLO	Close the recloser or circuit breaker.
GRO *n*	Change active settings group to settings group *n* (*n* = 1–6).
OPE	Open the recloser or circuit breaker.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.

Access Level 2 Commands	Access Level 2 commands allow unlimited access to control settings, parameters, and output contacts. All Access Level 1, Access Level E, and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON *n*	Control Relay Word bit RB*n*, Remote Bit *n* where *n* = 1–16. Execute **CON *n*** and the control responds: `CONTROL RBn`. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* [assert RB*n* for 1/4 cycle].
COP *m n*	Copy settings and logic equations from settings group *m* to settings group *n*.
DNP[a] ***type***	Set DNP map.
LOO	Set MIRRORED BITS port to loopback.
PAS 1	Change Access Level 1 password.
PAS E	Change Access Level E (EZ) password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change Access Level C password.
SET *n*	Change “regular” settings for settings group *n* (*n* = 1–6).
SET G	Change global settings.
SET L *n*	Change SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SET P *n*	Change port settings for port *n* (*n* = 1, 2, 3, F).
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings for front-panel display and extra local control.
STA C	Clears status warning or failure and reboots recloser control.
VER	Show firmware version and options.

[a] The DNP command is only available when the protocol of one of the serial ports is set to DNP.

Access Level C Commands	Access Level C is reserved for SEL use only.
PAS C	Change the Access Level C password.

Key Stroke Commands	Description
<Ctrl+Q>	Send **XON** command to restart communication port output previously halted by **XOFF**.
<Ctrl+S>	Send **XOFF** command to pause communication port output.
<Ctrl+X>	Send **CANCEL** command to abort current command and return to current access level prompt.

Key Stroke Commands When Using SET Command	Description
<Enter>	Retains setting and moves on to next setting.
^ <Enter>	Returns to previous setting.
< <Enter>	Returns to previous setting section.
> <Enter>	Skips to next setting section.
END <Enter>	Exits setting editing session, then prompts user to save settings.
<Ctrl + X>	Aborts setting editing session without saving changes.

SEL-351R Recloser Control Command Summary

Access Level 0 Command	From Access Level 0, you can go to Access Level 1 or to Access Level E (EZ). The Access Level 0 screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the control prompts you for the Access Level 1 password to enter Access Level 1.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper is not in place, the control prompts you for the Access Level 2 password to enter Access Level 2.
BAC	Enter Access Level B (Breaker). If the main board password jumper is not in place, the control prompts you for the Access Level B password.
BRE	Display breaker/recloser contact wear report.
BRE A	Display breaker/recloser contact wear and trip operation report.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS® channel *p*.
COM *p d1 d2*	Show a communications summary for events occurring between dates *d1* and *d2* on MIRRORED BITS channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS channel *p* (where *p* = A or B).
COU *k*	Show the SELOGIC® counter values. Enter *k* for repeat count.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP[a] *type*	Show DNP map.
EVE *n*	Show event report number *n* with 1/4 cycle resolution.
EVE C *n*	Show compressed event report number *n* for use with ACSELERATOR® Analytic Assistant SEL-5601 Software.
EVE L *n*	Show event report number *n* with 1/16 cycle resolution.
EVE R *n*	Show raw event report number *n* with 1/16 cycle resolution.
EVE *XX f*	Append parameter *f* to any of the above **EVE** commands, where *f* is A or D. Use A to show only the analog portion of the event report. Use D to show only the digital protection and control portion of the event report.
EZA	Enter Access Level E (EZ). If the main board password jumper is not in place, the control prompts you for the Access Level E password to enter Access Level E.
GRO	Display active settings group number.
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
IRI	Force synchronization of internal control clock to IRIG-B time-code input.
LDP *d1*	Show rows in the Load Profile report from date *d1*.

Access Level 1 Command	The Access Level 1 commands primarily allow you to look at information (e.g., settings, metering), not change it. The Access Level 1 screen prompt is: =>
LDP *d1 d2*	Show rows in the Load Profile report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP *n*	Show the latest *n* rows in the Load Profile report.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear SER records from nonvolatile memory.
SER D	List active chattering elements from the SER records and present auto-removal settings.
SHO *n*	Show “regular” settings for settings group *n* (*n* = 1–6).
SHO EZ *n*	Show EZ recloser control settings for settings group *n* (*n* = 1–6).
SHO FZ	Show EZ global settings.
SHO G	Show global settings.
SHO L *n*	Show SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SHO P *n*	Show port settings for port *n* (*n* = 1, 2, 3, F).
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings for front-panel display points and extra local control.
STA	Show recloser control self-test status.
TAR *n k*	Display Relay Word row. If *n* = 0–60, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
TAR R	Reset the front-panel tripping targets.
TIM	Show or set time (24 hour time). Show time presently in the recloser control by entering just **TIM**. Example time 22:47:36 is entered with command **TIM 22:47:36**.
TRI	Trigger an event report.

[a] The **DNP** command is only available when the protocol of one of the serial ports is set to DNP.

Access Level E Commands	Access Level E (EZ) commands primarily allow you to set EZ settings and global EZ settings. All Access Level 1 commands can also be executed from Access Level E. The Access Level E screen prompt is: =+>
BTT	Display latest battery load test results and time remaining until next discharge test.
BTT NOW	Initiate battery load test immediately.
SET EZ *n*	Change EZ recloser control settings for settings group *n* (*n* = 1–6). EZ recloser control settings override and change a number of the “regular” settings made with the **SET *n*** command (Access Level 2).
SET FZ	Change EZ global settings. EZ global settings override and change a number of the global settings made with the **SET G** command (Access Level 2).

Access Level B Commands	Access Level B commands primarily allow you to operate control parameters and output contacts. All Access Level 1 and Access Level E commands can also be executed from Access Level B. The screen prompt is: ==>
BRE R	Reset breaker/recloser contact wear and trip operation counters.
BRE W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
CLO	Close the recloser or circuit breaker.
GRO *n*	Change active settings group to settings group *n* (*n* = 1–6).
OPE	Open the recloser or circuit breaker.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.

Access Level 2 Commands	Access Level 2 commands allow unlimited access to control settings, parameters, and output contacts. All Access Level 1, Access Level E, and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON *n*	Control Relay Word bit RB*n*, Remote Bit *n* where *n* = 1–16. Execute **CON *n*** and the control responds: `CONTROL RBn`. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* [assert RB*n* for 1/4 cycle].
COP *m n*	Copy settings and logic equations from settings group *m* to settings group *n*.
DNP[a] ***type***	Set DNP map.
LOO	Set MIRRORED BITS port to loopback.
PAS 1	Change Access Level 1 password.
PAS E	Change Access Level E (EZ) password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change Access Level C password.
SET *n*	Change “regular” settings for settings group *n* (*n* = 1–6).
SET G	Change global settings.
SET L *n*	Change SELOGIC control equation settings for settings group *n* (*n* = 1–6).
SET P *n*	Change port settings for port *n* (*n* = 1, 2, 3, F).
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings for front-panel display and extra local control.
STA C	Clears status warning or failure and reboots recloser control.
VER	Show firmware version and options.

[a] The DNP command is only available when the protocol of one of the serial ports is set to DNP.

Access Level C Commands	Access Level C is reserved for SEL use only.
PAS C	Change the Access Level C password.

Key Stroke Commands	Description
<Ctrl+Q>	Send **XON** command to restart communication port output previously halted by **XOFF**.
<Ctrl+S>	Send **XOFF** command to pause communication port output.
<Ctrl+X>	Send **CANCEL** command to abort current command and return to current access level prompt.

Key Stroke Commands When Using SET Command	Description
<Enter>	Retains setting and moves on to next setting.
^ **<Enter>**	Returns to previous setting.
< **<Enter>**	Returns to previous setting section.
> **<Enter>**	Skips to next setting section.
END <Enter>	Exits setting editing session, then prompts user to save settings.
<Ctrl + X>	Aborts setting editing session without saving changes.